SPECIES ACCOUNT: *Anaea troglodyta floridalis* (Florida leafwing Butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/11/2014; Southeast Region (R4) (USFWS, 2016)

Physical Description

Butterfly, Nymphalidae. Florida Leaf Wing is a medium-large butterfly reddish above, mostly gray beneath. With a tial on each HW and pointed apex on FWs. Rather like an anglewing but with far less pattern above (NatureServe, 2015).

Taxonomy

Anaea troglodyta floridalis is a taxon considered to be both endemic to south Florida and clearly derived from Antillean stock (the islands of the West Indies except for the Bahamas, separating the Caribbean Sea from the Atlantic Ocean) (Comstock 1961, p. 45; Brown and Heineman 1972, p. 124; Minno and Emmel 1993, p. 153; Smith et al. 1994, p. 67; Salvato 1999, p. 117; Hernandez 2004, p. 39; Pelham 2008, p. 393). Some authors (Comstock 1961, p. 44; Miller and Brown 1981, p. 164; Smith et al. 1994, p. 67; Hernandez 2004, p. 39) placed the Florida leafwing as a distinct species, A. floridalis. Others (Brown and Heineman 1972, p. 124; Minno and Emmel 1993, p. 153; Salvato 1999, p. 117; Opler and Warren 2003, p. 40) considered the Florida leafwing as a subspecies of Anaea troglodyta Fabricius (USFWS, 2013).

Historical Range

Historically, the Florida leafwing was locally common throughout the pine rocklands of Miami-Dade County, as well as Big Pine Key (including National Key Deer Refuge (NKDR)) within the lower Florida Keys (Monroe County), while only sporadically occurring as strays in Collier, Palm Beach, and Broward Counties (Figure 2). The subspecies is sporadically encountered (as strays) within the pine rockland fragments adjacent to ENP (USFWS, 2023).

Current Range

The endemic Florida leafwing is currently restricted to the Long Pine Key region of Everglades National Park (ENP) (USFWS, 2023).

Critical Habitat Designated

Yes; 8/12/2014.

Legal Description

On August 12, 2014, the U.S. Fish and Wildlife Service designated critical habitat for the Florida leafwing (Anaea troglodyta floridalis) butterfly under the Endangered Species Act. In total, approximately 4,273 hectares (10,561 acres) in Miami-Dade and Monroe Counties, Florida, fall within the boundaries of the critical habitat designation for the Florida leafwing butterfly.

Critical Habitat Designation

Four units are designated as critical habitat for the Florida leafwing. The four units are: (1) FLB1 Everglades National Park, Miami-Dade County, Florida; (2) FLB2 Navy Wells Pineland Preserve, Miami-Dade County, Florida; (3) FLB3 Richmond Pine Rocklands, Miami-Dade County, Florida; and (4) FLB4 Big Pine Key, Monroe County, Florida.

Unit FLB1: Everglades National Park, Miami-Dade County, Florida. Unit FLB1 consists of 3,235 ha (7,994 ac) in Miami-Dade County. This unit is composed entirely of lands in Federal ownership, 100 percent of which are located within the Long Pine Key region of ENP. This unit is currently occupied and contains all the PBFs required by the subspecies, and contains the PCE of pine rockland. The PBFs in this unit may require special management considerations or protection to address threats of a lack of adequate fire management, habitat fragmentation, poaching, and sea level rise. However, in most cases these threats are being addressed or coordinated with the ENP to implement needed actions. For instance, ENP is currently in the process of updating its fire management plan (FMP) and environmental assessment which will assess the impacts of fire on various environmental factors, including listed, proposed, and candidate species (Land 2011, pers. comm.; Sadle 2013a, pers. comm.). ENP is actively coordinating with the Service, as well as other members of the Imperiled Butterfly Working Group (IBWG), to review and adjust the prescribed burn practices outlined in the FMP to help maintain or increase Florida leafwing population sizes, protect pine rocklands, expand or restore remnant patches of hostplants, and ensure that short-term negative effects from fire (i.e., loss of hostplants, loss of eggs and larvae) can be avoided or minimized.

Unit FLB2: Navy Wells Pineland Preserve, Miami-Dade County, Florida. Unit FLB2 consists of 120 ha (296 ac) in Miami-Dade County. This unit is comprised entirely of conservation lands located within the Navy Wells Pineland Preserve, which is jointly owned by Miami-Dade County (85 ha (211 ac)) and the State (35 ha (85 ac)). State lands are interspersed within Miami-Dade County Parks and Recreation Department lands, which are managed for conservation. This unit is bounded on the north by SW 348 Street, on the south by SW 360 Street, on the east by State Road 9336, and on the west by the vicinity of SW 202 Avenue. The unit was occupied historically by the Florida leafwing and includes some of the largest remaining contiguous fragments of pine rockland habitats outside of ENP. This unit is not currently occupied but is essential for the conservation of the butterfly because it serves to protect habitat needed to recover the subspecies, reestablish wild populations within the historical range of the subspecies, and maintain populations throughout the historic distribution of the subspecies in MiamiDade County, and it provides habitat for recovery in the case of stochastic events if the butterfly is extirpated from the one location where it is presently found.

Unit FLB3: Richmond Pine Rocklands, Miami-Dade County, Florida. Unit FLB3 consists of 359 ha (889 ac) in Miami-Dade County. This unit is comprised of lands in Federal (U.S. Coast Guard (Homeland Security) (29 ha (72 ac)), U.S. Army Corps of Engineers (Department of Defense (DoD) (8 ha (20 ac)), National Oceanic Atmospheric Administration (NOAA) (4 ha (9 ac)), Federal Bureau of Prisons (Department of Justice (DoJ) (9 ha (21 ac))), and private or other (309 ha (767 ac)) ownership. This unit is bordered on the north by Coral Reef Drive, on the south by SW 168 Street, on the east by SW 117 Avenue, and on the west by SW 137 Avenue; then is bordered on the north by SW 168 Street, on the south by SW 184 Street, on the east by SW 122 Avenue, and on the west by SW 137 Avenue.

Unit FLB4: Big Pine Key, Monroe County, Florida. Unit FLB4 consists of 559 ha (1,382 ac) in Monroe County. This unit includes Federal lands within NKDR (365 ha (901 ac)), State lands (90 ha (223 ac)), and property in private or other ownership (104 ha (258 ac)). State lands are interspersed within NKDR lands and managed as part of the Refuge. The unit begins on northern Big Pine Key on the southern side of Gulf Boulevard, and continues south on both sides of Key Deer Boulevard (County Road 940 (CR 940)) to the vicinity of Osprey Lane on the western side of CR 940 and Tea Lane to the east of CR 940; then resumes on both sides of CR 940 from Osprey Lane south of the vicinity of Driftwood Lane; then resumes south of Osceola Street, between Fern Avenue to the west and Baba Lane to the east; then resumes north of Watson Boulevard in the vicinity of Avenue C; then continues south on both sides of Avenue C to South Street; then resumes on both sides of CR 940 south to U.S. 1 between Ships Way to the west and Sands Street to the east; then resumes south of U.S. 1 from Newfound Boulevard to the west and Deer Run Trail to the east; and then resumes south of U.S. 1 from Palomino Horse Trail to the west and Industrial Road to the east. This unit was historically occupied by the Florida leafwing. This unit is not currently occupied but is essential for the conservation of the Florida leafwing because it serves to protect habitat needed to recover the subspecies, reestablish wild populations within the historical range of the subspecies, and maintain populations throughout the historic distribution of the subspecies in the Lower Florida Keys, and it provides area for recovery in the case of stochastic events if the butterfly is extirpated from the one location where it is presently found. In the Lower Florida Keys National Wildlife Refuge’s Comprehensive Conservation Plan (CCP), management objective number 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Florida leafwing butterfly.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Miami-Dade and Monroe Counties, Florida. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Florida leafwing butterfly consist of six components:

(i) Areas of pine rockland habitat, and in some locations, associated rockland hammocks and hydric pine flatwoods. (A) Pine rockland habitat contains: (1) Open canopy, semi-open subcanopy, and understory. (2) Substrate of oolitic limestone rock. (3) A plant community of predominately native vegetation. (B) Rockland hammock habitat associated with pine rocklands contains: (1) Canopy gaps and edges with an open to semi-open canopy, subcanopy, and understory. (2) Substrate with a thin layer of highly organic soil covering limestone or organic matter that accumulates on top of the underlying limestone rock. (3) A plant community of predominately native vegetation. (C) Hydric pine flatwood habitat associated with pine rocklands contains: (1) Open canopy with a sparse or absent subcanopy, and dense understory. (2) Substrate with a thin layer of poorly drained sands and organic materials that accumulates on top of the underlying limestone or calcareous rock. (3) A plant community of predominately native vegetation.

(ii) Competitive nonnative plant species in quantities low enough to have minimal effect on survival of the Florida leafwing butterfly.

(iii) The presence of the butterfly's hostplant, pineland croton, in sufficient abundance for larval recruitment, development, and food resources, and for adult butterfly roosting habitat and reproduction.

(iv) A dynamic natural disturbance regime or one that artificially duplicates natural ecological processes (e.g., fire, hurricanes or other weather events, at appropriate intervals) that maintains the pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities.

(v) Pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities sufficient in size to sustain viable Florida leafwing populations.

(vi) Pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities with levels of pesticide low enough to have minimal effect on the survival of the butterfly or its ability to occupy the habitat.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on September 11, 2014.

The Florida leafwing butterfly has experienced substantial destruction, modification, and curtailment of its habitat and range. The pine rockland community of south Florida, on which both the butterfly and its hostplant depend, is critically imperiled globally (FNAI 2012, p. 27). Destruction of the pinelands for economic development has reduced this habitat community by 90 percent on mainland south Florida (O'Brien 1998, p. 208). All known mainland populations of the Florida leafwing occur on publicly owned land that is managed for conservation, ameliorating some of the threat. However, any unknown extant populations of the butterfly or suitable habitat that may occur on private land or nonconservation public land are vulnerable to habitat loss. In Miami-Dade County, occupied Florida leafwing habitat occurs in the Long Pine Key region of ENP and is actively managed by the National Park Service (NPS) for the Florida leafwing and the pine rockland ecosystem, in general.

In the best case scenario, which assumes low sea level rise, high financial resources, proactive planning, and only trending human population growth, analyses suggest that the extant Florida leafwing population within ENP is susceptible to future losses, with losses attributed to increases in sea level and human population. In the worst case scenario, which assumes high sea level rise, low financial resources, a ''business as usual'' approach to planning, and a doubling of human population, the habitat at Long Pine Key may be lost, resulting in the complete extirpation of the Florida leafwing. Actual impacts may be greater or less than anticipated based upon high variability of factors involved (e.g., sea level rise, human population growth) and assumptions made. Being proactive to address sea level rise may be beyond the feasibility of land owners or managers. However, while land owners or land managers may not be able to be proactive in preventing these events, they may be able to respond with management or protection. Management actions or activities that could ameliorate sea level rise include providing protection of suitable habitats unaffected or less affected by sea level rise.

The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Salvato and Salvato 2010a, p. 91; 2010c, p. 139). Fire management of pine rocklands in NKDR is hampered by the pattern of land ownership and development; residential and commercial properties are embedded within or in close proximity to pineland habitat (Snyder et al. 2005, p. 2; Anderson 2012, pers. comm.). Ongoing management activities designed to ameliorate this threat include the use of small-scale prescribed burns or mechanical clearing to maintain the native vegetative structure in the pine rockland required by the subspecies.

Hurricanes and other significant weather events create openings in the pine rockland habitat (FNAI 2010, p. 3). However, given the substantial reduction in the historical range of the butterfly in the past 50 years, the threat and impact of tropical storms and hurricanes on its remaining populations are much greater than when its distribution was more widespread (Salvato and Salvato 2010a, p. 96; 2010c, p. 139). While land owners or land managers may not be able to be proactive in preventing these events, they may be able to respond with management or protection resulting from these threats. Management actions or activities that could enhance pine rockland recovery following tropical storms include hand removal of damaged vegetation, as well as by other mechanical means or prescribed burns.

Efforts to control salt marsh mosquitoes (Aedes taeniorhynchus, among others) have increased as human activity and population have increased in south Florida. To control mosquito populations, second-generation organophosphate (naled) and pyrethroid (permethrin) adulticides are applied by mosquito control districts throughout south Florida. The use of such pesticides (applied using both aerial and ground-based methods) for mosquito control presents a potential risk to nontarget species, such as the Florida leafwing butterfly. Pesticide spraying practices by the Mosquito Control District at NKDR have changed to reduce pesticide use over the years. Since 2003, expanded larvicide treatments to surrounding islands have significantly reduced adulticide use on Big Pine Key, No Name Key, and the Torch Keys. In addition, the number of aerially applied naled treatments allowed on NKDR has been limited since 2008 (Florida Key Mosquito Control District 2012, pp. 10–11). No spray zones that include the core habitat used by pine rockland butterflies and several linear miles of pine rockland habitat within the Refuge-neighborhood interface were excluded from truck spray applications (Anderson 2012, pers. comm.; Service 2012, p. 32). These exclusions and buffer zones encompass over 95 percent of extant croton distribution on Big Pine Key, and include the majority of known recent and historical Florida leafwing population centers on the island (Salvato 2012, pers. comm.). However, some areas of pine rocklands within NKDR are still sprayed with naled (aerially applied adulticide), and buffer zones remain at risk from drift; additionally, private residential areas and roadsides across Big Pine Key are treated with permethrin (ground-based applied adulticide) (Salvato 2001, p. 10).

Therefore, if extant, the leafwing and their habitat on Big Pine Key may be directly or indirectly (via drift) exposed to adulticides used for mosquito control at some unknown level.

Life History

Feeding Narrative

Adult: Immatures are herbivores; larvae eat leaves of Croton linearis. Adults are frugivores, nectarivores, and coprophagous. Adults feed from rotting fruit, dung, probably sap and at least occasionally flowers such as palmetto. They also sip from damp soil. All stages occur year round. This species exhibits a diurnal phenology (NatureServe, 2015).

Reproduction Narrative

Adult: The Florida leafwing is multivoltine (i.e., produces multiple generations per year), with an entire life cycle of about 2 to 3 months (Hennessey and Habeck 1991, p. 17) and maintains continuous broods throughout the year (Salvato 1999, p. 121). The precise number of broods per year remains unknown, but the leafwing has been recorded in every month (Baggett 1982, p. 78; Opler and Krizek 1984, p. 172; Minno and Emmel 1993, p. 153; Salvato and Hennessey 2003, p. 247; Salvato and Salvato 2010a, p. 96; 2010c, p. 140) (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Successional vegetation (USFWS, 2014)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Adult: Pineland croton (NatureServe, 2015)

Habitat Narrative

Adult: Habitat is tropical dry pine scrub on limestone, usually seen near patches of the foodplant. The environmental specificity is very narrow; its required rocky pinelands habitat is very limited in distribution (NatureServe, 2015). The Florida leafwing occurs only within pine rocklands that retain its hostplant, pineland croton (USFWS, 2016). Pine rockland is dependent on some degree of disturbance, most importantly from natural or prescribed burns (Loope and Dunevitz 1981, p. 5; Snyder et al. 2005, p. 1; Bradley and Saha 2009, p. 4; Saha et al. 2011, pp. 169–184; Florida Natural Areas Inventory (FNAI) 2010, p. 1). These fires are a vital component in maintaining native vegetation, such as croton, within this ecosystem. Without fire, successional climax from tropical pineland to rockland hammock is too rapid, and displacement of native species by invasive, nonnative plants often occurs (USFWS, 2014).

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from USFWS, 2014)

Dispersal

Adult: Moderate (inferred from USFWS, 2014)

Dispersal/Migration Narrative

Adult: The Florida leafwing, with its strong flight abilities, can disperse to make use of appropriate habitat in ENP (Salvato and Salvato 2010a, p. 95). At present, ongoing surveys suggest the Florida leafwing actively disperses throughout the Long Pine Key region of ENP (Salvato and Salvato 2010a, p. 91; 2010c, p. 139) (USFWS, 2014).

Population Information and Trends

Population Trends:

Decline of > 90% (NatureServe, 2015)

Species Trends:

30 - 70% decline (NatureServe, 2015)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

< 100 - several hundred (USFWS, 2013)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

This species is vulnerable because its required rocky pinelands habitat is very limited in distribution while also being subject to destruction due to urbanization as well as stochastic events such as hurricanes (D. K. Jue, 2006). Kimball (1965) noted that historically the Florida leafwing was "common, the records covering every month" in Dade County and it used to be fairly common on Big Pine Key. This species has experienced a long term decline of > 90%. It has experienced a sort term decline of 30 - 70%; there was a steep decline from 1999-2006 at Big Pine Key and none were seen there after that. Glassberg et. al. (2000) notes that the species appears to be declining and may have been eliminated from several areas on the mainland due to a recent hurricane. Cech (2005) notes this species is "rapidly declining," noting that it was reasonably common in southern Florida as recently as the early 1990's. (D. K. Jue, January 2006). The species may be more stable for now in the Everglades. There were no more than 10 adults per day in the Everglades sites in 2006-2007 (Marc Minno, pers. comm., 2008). However, this butterfly probably is harder to detect than most, and it is unlikely that all were found. A reasonable estimate would be no more than a few dozen adults per month in peak season, less at times, so probably a few hundred per year. Number of colonies (subpopulations) needs to be verified (D. K. Jue, January, 2006) but there appears to be only one occurrence now extant. As of

2008 possibly only the Everglades, not seen 2006-2007 on Big Pine Key (Marc Minno, pers. comm., 2008) or 2009-2010 (lep. News January 2011). (NatureServe, 2015). On the mainland, Salvato (pers. comm. 2012) has found that the extant leafwing population within ENP is maintained at several hundred or fewer, although it varies greatly depending upon season and other factors. However, Minno (pers. comm. 2009) estimated the extant leafwing population size at less than 100 at any given period (USFWS, 2013).

Threats and Stressors

Stressor: Development (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The pine rockland community of south Florida, on which both the butterfly and its hostplant depend, is critically imperiled globally (FNAI 2012, p. 27). Destruction of the pinelands for economic development has reduced this habitat community by 90 percent on mainland south Florida (O'Brien 1998, p. 208) (USFWS, 2014).

Stressor: Sea level rise (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The Service used various MIT scenarios in combination with extant and historical Florida leafwing occurrences and remaining hostplant-bearing pine rocklands to predict climate change impacts to the butterfly and its habitat. In the best case scenario, which assumes low sea level rise, high financial resources, proactive planning, and only trending human population growth, analyses suggest that the extant Florida leafwing population within ENP is susceptible to future losses, with losses attributed to increases in sea level and human population. In the worst case scenario, which assumes high sea level rise, low financial resources, a ''business as usual'' approach to planning, and a doubling of human population, the habitat at Long Pine Key may be lost, resulting in the complete extirpation of the Florida leafwing. Actual impacts may be greater or less than anticipated based upon high variability of factors involved (e.g., sea level rise, human population growth) and assumptions made (USFWS, 2014).

Stressor: Fire management (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Salvato and Salvato 2010a, p. 91; 2010c, p. 139). Historically, lightning-induced fires were a vital component in maintaining native vegetation, including pineland croton, within the pine rockland ecosystem (Loope and Dunevitz 1981, p. 5; Slocum et al. 2003, p. 93; Snyder et al. 2005, p. 1; Salvato and Salvato 2010b, p. 154). Resprouting after burns is the primary mechanism allowing for the persistence of perennial shrubs, including

pineland croton, in pine habitat (Olson and Platt 1995, p. 101). Without fire, perennial native vegetation can be displaced by invasive, nonnative plants. Fire management of pine rocklands in NKDR is hampered by the pattern of land ownership and development; residential and commercial properties are embedded within or in close proximity to pineland habitat (Snyder et al. 2005, p. 2; Anderson 2012, pers. comm.) (USFWS, 2014).

Stressor: Tropical storms (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The Florida leafwing, as with other subtropical butterflies, have adapted over time to the influence of tropical storms and other forms of adverse weather conditions (Minno and Emmel 1994, p. 671; Salvato and Salvato 2007, p. 154). Hurricanes and other significant weather events create openings in the pine rockland habitat (FNAI 2010, p. 3). However, given the substantial reduction in the historical range of the butterfly in the past 50 years, the threat and impact of tropical storms and hurricanes on its remaining populations are much greater than when its distribution was more widespread (Salvato and Salvato 2010a, p. 96; 2010c, p. 139) (USFWS, 2014).

Stressor: Mosquito control (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Efforts to control salt marsh mosquitoes (Aedes taeniorhynchus, among others) have increased as human activity and population have increased in south Florida. To control mosquito populations, second-generation organophosphate (naled) and pyrethroid (permethrin) adulticides are applied by mosquito control districts throughout south Florida. The use of such pesticides (applied using both aerial and ground-based methods) for mosquito control presents a potential risk to nontarget species, such as the Florida leafwing butterfly (USFWS, 2014).

Stressor: Collection (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Collection interest of imperiled butterflies is high, and there are ample examples of collection pressure contributing to extirpations. Although the Service does not have information indicating the extent to which the Florida leafwing is being collected, there is evidence of the species being recently offered for sale. Even limited collection from the remaining metapopulations could have deleterious effects on reproductive and genetic viability of the butterfly and could contribute to their extinction. Although the effects of various scientific studies on butterflies vary amongst species, there is limited information to suggest that techniques such as mark–recapture may have deleterious impacts to the Florida leafwing (USFWS, 2013).

Stressor: Disease and predation (USFWS, 2013)

Exposure:
Response:
Consequence:
Narrative: At this time, it is not known to what extent predation, parasitism, or disease may act as threats to the Florida leafwing. Studies have documented a wide array of predators and parasitoids and, in some cases, high levels of mortality amongst immature leafwings, throughout development. Disease, in the form of viruses or fungal pathogens, is known to cause mortality of the young leafwing larvae. Given the leafwing's low numbers and few occurrences, and limited distributions, it is unclear how the leafwing will respond to these factors (USFWS, 2013).

Stressor: Stochastic events (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Effects of small population size, isolation, and loss of genetic diversity are likely significant threats. Given the existing few populations and small size of the populations, environmental stochasticity may also contribute to imperilment (USFWS, 2013).

Stressor: Habitat Loss (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: The Florida leafwing has experienced substantial destruction, modification, and curtailment of its habitat and range. The pine rockland community of south Florida, on which the butterfly and its' hostplant depend, is critically imperiled globally (FNAI 2010; 2019). Between the early 1900s and 1996, this habitat in Miami-Dade County had been reduced by almost 90% (Kernan and Bradley 1996). The largest remaining intact pine rockland (approximately 2,313 ha [5,716 ac]) is Long Pine Key in ENP, which managed for conservation and retains the only extant Florida leafwing population (USFWS, 2023).

Stressor: Climate Change (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Climatic changes, including SLR and shifts in seasonal precipitation, temperature, and storm cycles, are major threats to south Florida, the Florida leafwing and the pine rocklands. National Oceanographic and Atmospheric Administration (Sweet et al. 2022) and other studies (Park and Sweet 2015; University of Florida Geoplan 2015; Rahmstorf et al. 2015; The Nature Conservancy 2011; Zhang et al. 2011; Vargas-Moreno and Flaxman 2010 [Massachusetts Institute of Technology and GeoAdaptive, Inc.]) have developed scenarios that range from 1 foot to 8 feet of SLR by 2100. Based on this, areas supporting the leafwing will become partially or completely inundated (i.e., under water) at some point during this century. For example, approximately 75 percent of land mass in the Florida Keys is predicted to be inundated at 1.9 ft (0.59 m) of sea level rise (The Nature Conservancy 2011) and 94 percent of the Keys would be inundated at 5.9 ft (1.8

m) of sea level rise (Zhang et al. 2011). Benedict et al. (2018) conducted an interagency evaluation of the influence of SLR and climate change to listed species and habitats throughout the Florida Keys, including Florida leafwing. Using the same modeling and analyses outlined in Miller and Traxler (2019), Benedict et al. (2018) concluded the leafwing and pine rockland habitats would be lost from Big Pine, No Name and Little Pines Keys, at 2-feet of SLR. However, decades prior to surface inundation, pine rocklands will undergo vegetation shifts triggered by changes to hydrology (wetter), salinity (higher), and more frequent storm surge and king tide events (pulse events causing massive erosion and salinization of soils) (Saha et al. 2011; Bradley et al. 2013). In other words, pine rocklands will convert to mangroves earlier than expected due to root zone inundation from salt water.

Stressor: Hydrology and Everglades Restoration (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Hydrology is a key ecosystem component that affects plant distribution and viability (Gann et al. 2006), including pineland croton. While projects designed to restore the historical hydrology of the Everglades and other natural systems in southern Florida, such as the Comprehensive Everglades Restoration Plan (CERP) are beneficial to the Everglades ecosystem, some may produce collateral impacts to extant pine rockland and associated habitats within the region through inundation or increased hydroperiods. The effects of changes in regional hydrology through restoration may have impacts on pine rocklands. Sadle (pers. comm. 2012) suggested various CERP projects (such as C-111 spreader canal; L-31N seepage barrier), specifically the operation of pumps and associated detention areas along the ENP boundary, may influence (through excessive water discharges) select portions of eastern Long Pine Key. Increased and longer-duration hydroperiods within the pine rockland habitats where the last extant population of the leafwing occurs may lead to a reduction in the amount of suitable habitat, a potential reduction in the area occupied and a reduction in the number of individuals found in ENP. It is unclear to what extent this may occur, if at all. In an effort to establish a baseline assessment of future hydrologic modifications, long term monitoring transects and plots for several listed species were established in Long Pine Key between 2003 and 2008 (USFWS, 2023).

Stressor: Pesticides (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Efforts to control salt marsh mosquitoes, Aedes taeniorhynchus, among other mosquito species, have increased as human activity and population have increased in south Florida. To control mosquito populations, second-generation organophosphate (naled) and pyrethroid (permethrin) adulticides are applied using both aerial and ground-based methods by mosquito control districts throughout south Florida. The use of such pesticides to control mosquitoes presents a potential risk to non-target species, including the Florida leafwing. The Long Pine Key region of Everglades National Park, however, is not treated with pesticides for mosquito control. Outside of the Everglades, unoccupied butterfly habitat within MiamiDade

County and on Big Pine Key remains vulnerable to the effects of adulticide applications. However, use of mosquito control pesticides within Miami-Dade County pine rockland areas is limited (USFWS, 2023).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 6C

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- In the Lower Key Refuges, CCP (comprehensive conservation plan) management objective no. 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Florida leafwing butterfly (USFWS, 2013).
- Fairchild Tropical Botanic Gardens (FTBG), with the support of various Federal, State, local and nonprofit organizations, has established the ‘‘Connect to Protect Network.’’ The objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping-stone gardens and rights-of-way with native pine rockland species, and restoring isolated pine rockland fragments (USFWS, 2013).

Conservation Measures and Best Management Practices:
- RECOMMENDED FUTURE ACTIVITIES Recovery Activities This species does not have a final recovery plan. In the course of this status review, we have identified the following potential recovery activities which are included below: ● Protect, restore, and manage remnant pine rocklands and associated habitats to increase functionality and connectivity throughout the leafwings range to aid in butterfly dispersal between larger occupied fragments and conservation lands Florida. ● Develop and expand partnerships to acquire and protect larger tracts of degraded or historic pine rocklands. ● Continue to work with the NPS, Miami-Dade and Monroe Counties and other partners to facilitate prescribed fire in pine rockland sites to establish consistent fire-return-intervals (3 to 7 years) ● Continue to coordinate with Mosquito Control Districts in south Florida to evaluate the impacts of pesticide applications, and establish effective no-spray zones, maintain adequate buffer zones, and reduce application dosage and extent of drift, where applicable. ● Conduct management activities to control nonnative parasitoids, and predators (e.g., fire ants) of the Florida leafwing. ● Enhance enforcement of poaching laws to limit illegal collection of the species. Monitoring / Research Activities ● Work with partners to continue to: ○ Expand monitoring efforts of the Florida leafwing population and the butterfly’s response to management activities within Long Pine Key, ENP. ○ Evaluate mechanisms to restore long-disturbed sites within the historic range of the Florida leafwing, including pine rocklands that have been converted to other uses (e.g., agriculture, development). ○ Evaluate the potential effects towards the pine rocklands and listed species within resulting from changes in regional hydrology from Everglades restoration in Everglades National Park. ○ Conduct studies to address

Florida leafwing natural history and ecological requirements. ○ Evaluate the genetic viability of the Florida leafwing within ENP, as well as that of pineland croton throughout Miami-Dade and Monroe Counties. ○ Conduct research on Florida leafwing ecology and habitat requirements, as well as developing reintroduction protocols, are recovery priorities for the subspecies (USFWS, 2023).

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SPECIES ACCOUNT: *Apodemia mormo langei* (Lange's metalmark butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; June 1, 1976 (41 FR 22041).

Physical Description

Adult Lange's metalmark butterflies (Apodemia mormo langei) are small, brightly colored butterflies with a wingspan of 2.5 to 3.8 centimeters (1 to 1.5 inches). The dorsal (upper) surface of the wing is mostly black with a pattern of white spots, and with the forward part of the inner forewing having a red-orange background. Red-orange coloration extends through the inner forward half of the forewing, the hindwing bases, and a small central patch subtended by black. Ventrally, the wings have a more muted pattern of gray, white, black, and orange (USFWS 2008; Xerces 2005). The adult males and females are similar in coloration and size (USFWS 2008). Eggs are gray in color (USFWS 1984). Larvae and pupae are primarily purple and covered in yellow-ringed, brown to black spots (which are tufted in the larvae) (USFWS 2008).

Taxonomy

Lange's metalmark butterfly is one of 15 subspecies of Mormon metalmark (Apodemia mormo) in the state of California. It may be distinguished from other subspecies of A. mormo by a small red-orange central patch on the upper hind wing, unlike the white patch found in all other subspecies (USFWS 2008).

Historical Range

Lange's metalmark butterfly is endemic to the aeolian (windblown) sand dune habitat of the southern bank of the San Joaquin River in Contra Costa County, California (USFWS 2008). This species is assumed to have occupied any available suitable habitat in the historical sand dune system that occurred along a 3.2-kilometer (km) (2-mile [mi.]) stretch of the river shore between the environs of the present-day cities of Antioch and Oakley, California. By the time of listing in 1976, Lange's metalmark butterfly had not been encountered in Oakley for more than 30 years (41 FR 22041; USFWS 2013).

Current Range

Lange's metalmark butterfly inhabits the immediate area in and adjacent to the remnant dune habitat that makes up the 0.27-square-kilometer (km2) (67-acre [ac.]) Antioch Dunes National Wildlife Refuge (NWR), just east of the town of Antioch, California. There, the refuge is made up of the 0.22-km2 (55-ac.) Stamm Unit and the 12-ac. Sardis Unit, which are less than 1.6 km (1 mi.) apart; however, in recent years, the Lange's metalmark butterfly has only been observed in the Sardis Unit and on an adjoining 3-ac. property owned by the Pacific Gas and Electric Company (PG&E). Suitable habitat is present at both units, and adjacent to the refuge where suitable sandy substrate and vegetation is present; however, Lange's metalmark butterfly has only been encountered within a distance of 137 meters (m) (450 feet [ft.]) from the Antioch Dunes NWR, and its present range is limited to the Sardis Unit (NatureServe 2015; USFWS 1984; USFWS 2002; USFWS 2008; USFWS 2013).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: See adult life history.

Adult: Feeding habitat for Lange's metalmark butterfly involves healthy, mature stands of its host plant—naked-stemmed buckwheat (Eriogonum nudum var. auriculatum)—and other plant species native to open sand dunes, ideally with a low density of nonnative or invasive plants (USFWS 1984). Eggs hatch when the fall rainy season prompts new growth of the host plant; larvae crawl to the base of the host plant, where they feed on new foliage through winter and spring until they pupate the following summer (USFWS 2002). Larvae are nocturnal herbivores and feed exclusively on the foliage of naked-stemmed buckwheat; they use only plants of at least 4 to 5 years of age that are capable of supporting larval feeding through winter and spring (NatureServe 2015; USFWS 1984). Adults are diurnal nectarivores and prefer naked-stemmed buckwheat, but may also use butterweed (Senecio aronicoides), Douglas' ragwort (Senecio flaccidus var. douglasii), and California matchweed (Gutierrezia californica) as native-plant nectar sources (USFWS 2008; Xerces 2005).

Reproduction Narrative

Larvae: See adult life history.

Adult: Lange's metalmark butterflies are univoltine (producing one generation per year) and oviparous (USFWS 1984; Xerces 2005). Mating flight season is late July or early August through mid-September (USFWS 2002; Xerces 2005). Adults, both male and female, live for approximately 1 week, during which they feed on nectar, mate, and locate an appropriate host plant—naked-stemmed buckwheat (Eriogonum nudum var. auriculatum)—on which to deposit their eggs (USFWS 1984). This species uses naked-stemmed buckwheat plants of at least 4 to 5 years of age (NatureServe 2015). The peak in male emergence is generally earlier than that of females (USFWS 2002); however, females fly for longer periods than males in search of ovipositing (egg-laying) sites (USFWS 2008). Lange's metalmark butterflies also use silver lupine (Lupinus albifrons) for mating. Females lay eggs throughout the adult flight period (USFWS 2002). The eggs, two to four per clutch, are oviposited on naked-stemmed buckwheat on the petiole (the stalk that attaches the leaf to the stem) of leaves on the lower half the plant, where the foliage is withered. Eggs remain attached and dormant, potentially for several weeks, until the rainy season. Then, as the fall rains begin and new growth of naked-stemmed buckwheat appears, the eggs hatch and the tiny larvae crawl to the base of the plant where they feed on new leaves. Larval feeding and development continues through the spring with four larval instars (growth leading to shedding of their nongrowing skins), and a fifth molt leading to pupation (typically lasting from 6 to 18 days) occurring in the middle of the following summer, in the leaf litter at the base of the host plant (Essig 2016; USFWS 2002; USFWS 2013). Fecundity of the wild individuals is low (Xerces 2005).

Geographic or Habitat Restraints or Barriers

Larvae: Larvae are restricted to the host plant on which they hatched.

Adult: Areas of human development, the absence of suitable underlying dune habitat, and the absence of appropriate native vegetation/host plants (USFWS 2008).

Spatial Arrangements of the Population

Larvae: Clumped according to resources.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: Narrow/specialist.

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Larvae: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: See adult life history.

Adult: Naked-stemmed buckwheat is the sole larval food source and oviposition host plant, and is a nectar source and perch for adults (USFWS 2008).

Habitat Narrative

Larvae: See adult life history.

Adult: The Lange’s metalmark butterfly is endemic to the aeolian (wind-blown) sand dune system of the Antioch Dunes NWR (USFWS 2008; USFWS 2013). The primary limiting factors for suitable habitat are availability of nectar sources for adults and adequate host plants (for oviposition [egg-laying] and as sufficient food for larvae). All the life stages of Lange’s metalmark butterflies are found close to the host plant, naked-stemmed buckwheat (Eriogonum nudum var. auriculatum). Both sexes prefer naked-stemmed buckwheat flowers as perches and as a nectar source, and this species will not use naked-stemmed buckwheat plants for oviposition until the plants are at least 4 to 5 years in age. Larvae are restricted to the host plants on which they hatched. Naked-stemmed buckwheat grows best in relatively open areas of sand (ideally with a low density of invasive or weedy plants and grasses) with good drainage, and its seeds and seedlings require wind-disturbed areas of open sand to germinate and establish (NatureServe 2015; USFWS 2008). Invasion by nonnative weed is detrimental to the Lange's metalmark butterfly because it reduces the amount of suitable buckwheat stands available for habitat (USFWS 2002; USFWS 2008). The Sardis recovery unit, in lands owned by PG&E and managed by USFWS, is most likely to resemble the native topography of the area, given that its topography is relatively undisturbed (USFWS 2002). Areas of human development, the absence of suitable underlying dune habitat, and the absence of appropriate native vegetation/host plants confine the species distribution and range (USFWS 2008).Sand has been imported on several occasions to create artificial dunes as habitat for native plants and wildlife, and to mimic historic conditions on site. In 1991, PG&E assisted the USFWS in transporting sand into the refuge; by May 1992, about 6,116 cubic meters (8,000 cubic yards) of sand had been placed over an area of approximately 1.82 hectares (ha) (4.5 ac.) (0.48 ha [1.18 ac.] in Stamm unit and 1.38 ha [3.33 ac.] in Sardis unit) and sculpted by tractors into dune-like hillocks to create new dune habitat. By 1993, native plants had been planted on all of these new dunes (USFWS 2008). Plans have been developed to continue importing sand and to create new dunes in previously cleared and flattened sectors of the Stamm Unit (USFWS 2013). Native plant species, including naked-stemmed buckwheat, are being propagated in a nursery run by volunteers; work crews of staff and volunteers plant young plants throughout the refuge during the fall and winter months (USFWS 2013). Plantings of naked-stemmed buckwheat have occurred in the Antioch Dunes NWR since 1980, when PG&E planted 445 seedlings to enhance habitat on its property (USFWS 2002).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Larvae and pupae remain on or beneath the single host plant on which they hatched.

Adult: Recapture studies found that the Lange's metalmark butterflies travel greater distances than other local species in the Lycaenidae family, with one male having been recorded traveling just over 1.6 km (1 mi.) (USFWS 2008). Adults of both sexes perch and are capable of flights between perches. The majority of males move locally, approximately less than 30 m (100 ft.), while females may travel up to about 400 m (1,300 ft.). Females tend to be more mobile, visiting a greater variety of secondary nectar sources and searching for egg-laying sites. Males, on the other hand, tend to perch and aggregate more than the females (USFWS 1984; USFWS 2002).

Immigration/Emigration

Larvae: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: Lange's metalmark butterfly is restricted to mature stands (at least 4 to 5 years of age) of its host plant, naked-stemmed buckwheat (USFWS 2008). All life stages remain close to populations of naked-stemmed buckwheat plants; and larvae and pupae remain on or beneath the single host plant on which they hatched (USFWS 1984).

Dispersal/Migration Narrative

Larvae: See adult narrative.

Adult: All life stages of Lange's metalmark butterfly are nonmigratory and do not venture very far from mature populations (featuring plants of at least 4 years in age) of naked-stemmed buckwheat (Eriogonum nudum var. auriculatum) in the sand dune habitat of Antioch Dunes NWR. Larvae and pupae remain on or beneath the single host plant on which they hatched (USFWS 1984; USFWS 2008). Adults of both sexes perch and are capable of flights between perches. Females tend to be more mobile, visiting a greater variety of secondary nectar sources and searching for egg-laying sites. Males, on the other hand, tend to perch and aggregate more than the females. The majority of males move locally, approximately less than 30 m (100 ft.), while females may travel up to about 400 m (1,300 ft.) (USFWS 1984; USFWS 2002). Recapture studies found that the Lange's metalmark butterflies travel greater distances than other local species in the Lycaenidae family, with one male having been recorded traveling just over 1.6 km (1 mi.) (USFWS 2008).

Population Information and Trends

Population Trends:

Decreasing; a decline of greater than 70 percent. The population trend has been observed to steadily decrease since 1999 (NatureServe 2015; USFWS 2008).

Species Trends:

Decreasing; a decline of greater than 90 percent compared to pre-sand-mining numbers (NatureServe 2015; USFWS 2008).

Population Growth Rate:

Slow; population demography has been correlated to the density and health of their host plant, whose habitat quality has been observed in consistent annual decrease (marked by increased cover of weedy, invasive plant species and a decreased number of host plants) (USFWS 2008).

Number of Populations:

One: Sardis Unit, a total area of 10 ha (26 ac.), nearly half of which is owned by PG&E (USFWS 2008).

Population Size:

Peak population count surveys, calculated from weekly visual counts of adult butterfly emergence conducted annually between 1986 and 2006, have revealed large fluctuations in total butterfly numbers; the greatest count being 2,342 adults in 1999 and the lowest being 45 adults in 2006. In 2007, the adult peak count was 89 adults, indicating a continuation of extremely low adult emergence (USFWS 2008). Following the release of 60 captive individuals in 2008, 112 adults were observed during the adult peak count (NatureServe 2015; USFWS 2013). The only extant population of Lange's metalmark is located at ADNWR, a very limited geographic area representing the entirety of the known range-wide native population. The refuge itself is bifurcated by the Georgia Pacific Gypsum Plant, separating the Sardis and Stamm Units by greater than 600 meters. (USFWS, 2020)

Minimum Viable Population Size:

In 1983, the minimum effective population size was considered to be 400 individuals (USFWS 2008).

Resistance to Disease:

Moderate; it does not appear that predation or disease pose a major threat to the species. However, the following parasites are known to exist: tachinid flies (Tachinidae, order Diptera) and parasitic wasps (Braconidae and Encyrtidae, order Hymenoptera). Excessively destructive infestations by any of these insects have not been recorded at the Antioch Dunes NWR, but they remain a possible threat (USFWS 2008).

Adaptability:

Low

Additional Population-level Information:

A captive breeding program and propagation policy for Lange's metalmark butterfly was enacted in 2007, when nine females were captured and more than 300 eggs were oviposited on cultivated host plants. In the winter of 2007 to the spring of 2008, larvae began to emerge. In all, 129 adults were bred in captivity from the initial stock, and butterflies that were not released back onto the refuge in 2008 were bred to increase the breeding population for release in subsequent years. Re-introduction and release protocols were established, and on August 29, 2008, USFWS biologists released 30 adults and 30 larvae in the Antioch Dunes NWR (USFWS

2008; USFWS 2013). It is possible that some pupae remain in diapause (a suspension of development) through unfavorable years, although this is undocumented and should not be assumed. It is also possible that this is in part reflected by very low peak flight counts in some years (NatureServe 2015).

Population Narrative:

A species-level decline of Lange's metalmark butterfly is thought to have begun in the early twentieth century with the rebuilding and subsequent growth of San Francisco following the 1906 earthquake, which led to the dunes being mined heavily for sand for brickmaking. Large-scale sand mining and industrial development, continuing heavily through the 1950s, fragmented the sand dune habitat until only a small portion of the original ecosystem remained (USFWS 2013; Xerces 2005), and resulted in a greater than 90 percent decline in the population of this species compared to pre-sand-mining numbers (NatureServe 2015). Currently, the Lange's metalmark butterfly is only known to exist at the Sardis Unit of the Antioch Dunes NWR. The overall population trend for the species has fluctuated greatly since listing; however, the population-level trends have shown consistent, overall decreases since 1999 (greater than 70 percent) and have not given any indication of stability or recovery (NatureServe 2015). In 1983, the minimum effective population size was considered to be 400 individuals.It does not appear that predation or disease pose a major threat to Lange's metalmark butterfly; however, parasites are known to exist, and excessive infestations may pose a possible threat. As seen in other species of butterflies, population sizes of Lange's metalmark butterflies have been shown to be correlated to the health and density of host plant—naked-stemmed buckwheat (Eriogonum nudum var. auriculatum)—whose habitat quality has been observed in consistent annual decrease (marked by increased cover of weedy, invasive plant species and a decreased number of host plants) (USFWS 2008). Peak population count surveys, calculated from weekly visual counts of adult butterfly emergence conducted annually between 1986 and 2006, have revealed large fluctuations in total butterfly numbers; the greatest count being 2,342 adults in 1999 and the lowest being 45 adults in 2006. In 2007, the adult peak count was 89 adults, indicating a continuation of extremely low adult emergence (USFWS 2008). It is possible that some pupae remain in diapause (a suspension of development) through unfavorable years, although this is undocumented and should not be assumed. It is also possible that in this is in part reflected by very low peak flight counts in some years (NatureServe 2015).The imminent threat of extinction led to the decision to perform captive propagation of the butterfly. A captive breeding program and propagation policy for Lange's metalmark butterfly was enacted in 2007, when nine females were captured and more than 300 eggs were oviposited on cultivated host plants. In the winter of 2007 to the spring of 2008, larvae began to emerge. In all, 129 adults were bred in captivity from the initial stock, and butterflies that were not released into the Antioch Dunes NWR in 2008 were bred for releases in subsequent years. Following the 2008 release of 60 captive individuals (30 adults and 30 larvae), 112 adults were observed during 2008 adult peak count (NatureServe 2015; USFWS 2013). Distributions and abundances of host plants for the Lange's metalmark butterfly are anticipated to increase annually with implementation of the Antioch Dunes NWR's restoration efforts (USFWS 2008).

Threats and Stressors

Stressor: Habitat loss or alteration
Exposure: Reduction in available suitable habitat, including lack of host plants.
Response: Lack of proper conditions (suitable host plants) to mate successfully.
Consequence: Decreased fitness, reproductive capacity, and reproductive success; and decreased carrying capacity of habitat, resulting in population reduction.
Narrative: The primary threat to Lange's metalmark butterfly identified at listing—habitat loss due to industrial and agricultural development—has been eliminated with the designation of the Antioch Dunes NWR in 1980, where almost all occurrences of the species are located (USFWS 2008). However, the formerly dynamic mosaic of open sand dunes and vegetation has slowly been stabilized by the industrial removal of sand and by the introduction of plants which have spread over the remaining sand and now prevent sand movement. Under these conditions, the host plant—naked-stemmed buckwheat (Eriogonum nudum var. auriculatum)—does not reproduce well; its seedlings require open sand to become established. The realization that disturbance was important in the maintenance of the dunes was critical; now through intentional disturbance, efforts at encouraging the host plant have proven more effectual (Essig 2016; USFWS 2013). This species is extremely sensitive to loss of host plant, as it will not use host plants under 4 or 5 years of age (NatureServe 2015). Recreational use of the dunes by the public (including foot traffic, off-road vehicle use, and inadvertent wildfires from campsites) had a large, negative impact on this species; however, following the installation of a gated, chain-link fence around the Antioch Dunes NWR in 1986, recreational use is no longer considered a significant threat (USFWS 2008).

Stressor: Nonnative and invasive plants
Exposure: The stabilization of dune habitat by nonnative and invasive plants.
Response: Lacks adequate nectar sources and proper conditions (suitable host plants) to mate successfully.
Consequence: Decreased fitness, reproductive capacity, and reproductive success; and decreased carrying capacity of habitat, resulting in population reduction.
Narrative: The proliferation and overgrowth of invasive, nonnative grasses and forbs, such as rip-gut brome (Bromus diandrus), star thistle (Centaurea sp.), and hairy vetch (Vicia villosa), affect nearly every acre of the Antioch Dunes NWR. Endemic species at the Antioch Dunes NWR depend on sandy, dune habitat that is constantly disturbed and replenished by winds, and these endemics cannot compete with invasive plants. Over the last two decades, invasive plants have dominated the remaining natural riverine dune habitat and have successively degraded this habitat by stabilizing the shifting sand dunes with organic sediment and dense vegetation, eliminating natural seed germination of the native plants, and encumbering native plants with competition for space (USFWS 2008; Xerces 2005). Invasive and nonnative plants and weeds in the Antioch Dunes NWR are controlled by hand-pulling, prescribed burning, or careful application of herbicides (USFWS 2013). Refuge managers are currently experimenting with different techniques to control the weeds that crowd out naked-stemmed buckwheat. Controlled and closely monitored cattle grazing on 4 ha (10 ac.) of the refuge has cleared major areas of exotic plants and reduced excess duff and vegetation cover, and has provided adequate sand

disturbance to produce a good growth of naked-stemmed buckwheat in some areas (USFWS 2013).

Stressor: Gypsum dust
Exposure: Proximity to gypsum process plant.
Response: Potential for health effects on plants significant to this species, potential for injury or death of butterfly larvae, and insufficient quantity or quality of resources.
Consequence: Decreased survivorship of larvae to adulthood, and injury or fatality.
Narrative: The Georgia-Pacific industrial gypsum processing plant situated on riverfront property between the Stamm and Sardis Units produces airborne gypsum dust from various activities. Gypsum dusting of the rare plants and Lange's metalmark butterfly larvae from the adjacent Georgia-Pacific gypsum plant may inhibit plant growth and may injure or kill butterfly larvae. The dust was believed to threaten the plants at the Antioch Dunes NWR not only because of the layers of dust that build up on the plants, possibly reducing the exposure to sunlight and decreasing photosynthesis, but also because the changes in soil composition that accompany the addition of gypsum minerals (calcium and sulfates) may affect the growth of plants. There is currently no evidence that the gypsum dust is adversely affecting any of the three species; however, Moorpark Zoo is conducting trials on the effect of the gypsum dust on butterfly larvae of a species closely related to Lange's metalmark, the Behr's metalmark butterfly (Apodemia virgulti). At least one study demonstrated that dusts may adversely increase transpiration through the cuticle of insect larvae and cause desiccation and abrasion of the cuticle. Refuge staff have noted that gypsum dust settles primarily on the Sardis unit and that the efforts of Georgia-Pacific to further reduce airborne gypsum dust is notable, but the dust is still entering the unit (USFWS 2008).

Stressor: Wild and human-originated fires
Exposure: Destruction of available and suitable habitat by fire.
Response: Direct mortality of Lange's metalmark host plants and nectar sources, and butterflies, larvae, and eggs.
Consequence: Significant population reduction of all life stages.
Narrative: The Antioch Dunes NWR has largely been protected from direct human disturbance since construction of a perimeter fence in 1986; however, illegal camping and trespassing continue and are potential sources of wildfires and acts of arson. Wildfires are considered a serious threat to the Lange's metalmark butterfly, especially during summer months when a substantial portion of Lange's metalmark butterfly habitat is surrounded by dried thatch (USFWS 2008). Host plants probably need a few years to recover to useable condition, and most individual Lange's metalmarks of any life stage would perish in the area actually burned (NatureServe 2015). With the recent decline in population size and the currently limited distribution of this butterfly, a single wildfire could have devastating effects on the butterfly if it were to occur in the densely populated area of the Sardis Unit. The occurrences of wildfires at the Antioch Dunes NWR have been tracked and recorded since 1980, including date, location, acreage affected, and best determination of the cause of the wildfire (USFWS 2008). Given that fire is one of the major threats to this species, a program to reduce "plant fuels" and build firebreaks throughout the refuge is now underway. Although the firebreaks serve as protection from human disturbance,

they also help facilitate public visits, because they can be used as trails for guided tours (USFWS 2013).

Stressor: Illegal collection of rare or listed butterflies by private collectors
Exposure: High value and demand for illegally collected specimens.
Response: Capture and killing of individuals.
Consequence: Reduced population size and genetic diversity, and difficulty for adults to find mates.
Narrative: Small populations of moths and butterflies are vulnerable to harm from the collection of adults. A population may be reduced below sustainable numbers by removal of females, reducing the probability that adults will find mates (Allee effect) and that new colonies will be founded. The Lange’s metalmark butterfly now is particularly vulnerable to loss of females to collection, because females fly for longer periods than males in search of egg-laying sites (USFWS 1984). Collectors may not always realize they are depleting colonies of butterflies or moths to below threshold limits for the survival or recovery of the colony. Adult specimens of this species are highly valued by private collectors, and an international market exists for illegally collected specimens, as well as other listed and rare butterflies (USFWS 2008).

Stressor: Low population numbers
Exposure: Stochastic or catastrophic events.
Response: Death of individuals, and extirpation.
Consequence: Loss of genetic variability and loss of ability to adapt to future stochastic events.
Narrative: Any organism with a low number of populations is threatened by extinction through a single catastrophic event, such as an abnormally violent storm, a prolonged drought, or other climatic event; or an infectious disease. Any species existing in a small and geographically centralized population is threatened by extinction through “stochastic” demographic fluctuations and other density-dependent effects. Small populations demonstrate decreased genetic variability or heterozygosity, which results in diminished evolutionary potential available to a species for dealing with environmental changes (USFWS 2008).

Stressor: Herbicides
Exposure: Application of herbicides.
Response: Potential health effects on all life stages.
Consequence: Decreased fitness, and reduction in population or survivorship.
Narrative: Selective use of specialized herbicides is needed to remove nonnative invasive plants where they are growing in close association with Antioch Dunes evening-primrose, Contra Costa wallflower, or naked-stemmed buckwheat host plants. However, at present herbicides are not used in the vicinity of any of these plants because the effect of these herbicides on the Lange’s metalmark butterfly at different life stages is not known. A toxicology study to determine the effect of various concentrations of herbicides used at the Antioch Dunes NWR on the larvae of the Lange’s metalmark butterfly is currently being conducted at Washington State University using a proxy subspecies, Behr’s metalmark butterfly (Apodemia mormo) (USFWS 2008).

Stressor: Pesticide Application

Exposure:
Response:
Consequence:
Narrative: Pesticides (both herbicides and insecticides) have the potential to affect the Lange's metalmark. Specialized herbicides are used at the ADNWR to manage non-native plants. Three herbicides used at ADNWR have been tested on a surrogate species, and all had a detrimental effect on larval survival to pupation (Stark et al., 2012; see Appendix A). However, this study only assessed the effects of the direct application to the surrogate species and the indirect effects from consuming host plants undergoing herbicide application, and so it is unclear if herbicide drift would have the same effects. It is also possible that herbicide mixtures (i.e., adjuvants included during application) may have detrimental effects to the butterfly (see Mullin et al., 2016) if similar ecotoxic modes of action exist for Lange's metalmark as exist for honeybees. As herbicides are not currently applied to the Refuge where the butterfly is located (Service, 2008), it is unlikely that this is a threat to the butterfly or its habitat (in fact, the purpose of the applications is invasive control, and therefore beneficial to habitat). (USFWS, 2020)

Recovery

Reclassification Criteria:
At least three populations are established at separate, managed locations. Sites should be separated at sufficient distance to provide for threat abatement from fires, and to provide some level of diversity in ecological setting, but may also benefit from some level of connectivity. It is not possible at this time to provide a reliable, one-size-fits-all quantitative metric for this variable, as the answer will be site and condition dependent. (USFWS, 2019)

All sites have implemented adaptive management plans to provide dune habitat that provides a disturbance regime that supports naked-stem buckwheat (with some degree of natural recruitment) and a diversity of nectar plants to provide adult food source throughout the flight period. Vegetation monitoring has been conducted over a 15-year period. (USFWS, 2019)

As determined by direct monitoring, each population must have a 15-year moving median of 2,600 individuals and minimum effective population size of 50 with a stable or increasing growth rate (lambda). (USFWS, 2019)

Delisting Criteria:
At least five populations are established at separate, managed locations. Sites should be separated at sufficient distance to provide for threat abatement from fires, and to provide some level of diversity in ecological setting, but may also benefit from some level of connectivity. It is not possible at this time to provide a reliable, one-size-fits-all quantitative metric for this variable, as the answer will be site and condition dependent. (USFWS, 2019)

All sites have implemented adaptive management plans to provide dune habitat that provides a natural disturbance regime that supports self-sustaining naked-stem buckwheat (all plants are naturally recruiting) and a diversity of nectar plants to provide adult food source throughout the flight period. Monitoring has been conducted over a 15-year period. (USFWS, 2019)

a) As determined by direct monitoring, each population must have a 15-year moving median of 2,600 individuals and minimum effective population size of 500 with a stable or increasing growth rate (lambda); OR b) population viability analysis determines that Lange's metalmark, range-wide, has a 95% probability of persistence over a 100-year period. (USFWS, 2019)

Recovery Actions:

- Three primary actions were established as the practical means to reach the prime objective outlined in the recovery plan. Since the recovery plan was issued, at least 80 percent of the supporting recovery actions were implemented, and now are either completed or are still ongoing. However, in spite of these activities, the population trend for the species is declining (USFWS 2008). The only recommendation not fully implemented was developing an interpretive and environmental education program. Although the Antioch Dunes NWR has developed some interpretive and environmental education partnerships and programs, funding and staff to fully accomplish this recommendation have not been available (USFWS 2002). A discussion of each of the primary actions included in the recovery plan and progress made toward each of those primary actions is discussed in detail in the 5-Year Review for this species (USFWS 2008). A 15-year Comprehensive Conservation Plan was completed and implemented for Antioch NWR in August 2002, which expands on and goes into specific detail on implementation of the recovery goals outlined in the 1984 recovery plan (USFWS 2002; USFWS 2013).
- Protect, enhance, and maintain habitat for threatened and endangered species, emphasizing species known to inhabit the Antioch Dunes NWR, including the Lange's metalmark butterfly, Antioch Dunes evening-primrose (Oenothera deltoides ssp. howellii), and Contra Costa wallflower (Erysimum capitatum var. angustatum) (USFWS 1984; USFWS 2002).
- Protect, restore, and manage the Antioch Dunes ecosystem for diversity; and increase numbers and improve habitat for Lange's metalmark butterfly, Antioch Dunes evening-primrose, and Contra Costa wallflower (USFWS 1984; USFWS 2002).
- Initiate information and education programs as part of public awareness efforts; establish interpretive and educational programs for the public to foster an appreciation of the natural habitats and endangered species supported by the native riverine dune habitat of the Antioch Dunes NWR (USFWS 1984; USFWS 2002).
- Continue restoration of riverine dune habitat at Antioch Dunes NWR (USFWS 2008).
- Conduct controlled propagation of the Lange's metalmark butterfly until natural populations at Antioch Dunes NWR are at a self-sustainable level (USFWS 2008).
- Continue research into life history, habitat requirements, and population studies, including an annual population monitoring survey (USFWS 2008).
- Acquire the McCulloch/Kemwater property abutting the eastern boundary of the Sardis Unit of the Antioch Dunes NWR (USFWS 2008).
- Consider revising the Recovery Plan for the three endangered species endemic to Antioch Dunes, California (USFWS 2008).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: On December 4, 2019, staff of the Bay-Delta Fish and Wildlife Office met with the staff of the ADNWR and agreed on formally convening a recovery implementation team (RIT) for the listed species within the ADNWR. The primary purpose for convening this RIT is to have experts advise the Service on conservation priorities for the next five years, and how we will adaptively manage and monitor based on objective success criteria. Recommendations for future actions will be provided in the future via the recovery planning process, working with the internal team. It may be useful to consider other approaches to Lange's metalmark abundance estimation, in addition to those used in this 5-year review. It may also be useful, as time and resources allow, to conduct one or more detection probability trials to help clarify the detectability of Lange's metalmark at ADNWR. (USFWS, 2020)

Additional Threshold Information:

- Modification of microclimate at the base of host naked-stemmed buckwheat (Eriogonum nudum var. auriculatum) plants by nonnative species such as ripgut brome (Bromus diandrus) evidently reduces the survivability of larvae (USFWS 1984).
- Modification of microclimate at the base of host naked-stemmed buckwheat (Eriogonum nudum var. auriculatum) plants by nonnative species such as ripgut brome (Bromus diandrus) evidently reduces the survivability of larvae (USFWS 1984).

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SPECIES ACCOUNT: *Atlantea tulita* (Puerto Rico harlequin butterfly)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The Puerto Rican harlequin butterfly is endemic to Puerto Rico, and is one of the four species endemic to the Greater Antilles within the genus Atlantea (Biaggi-Caballero 2009). The Puerto Rican harlequin butterfly has a wing span of about 2 to 2.5 in (6 cm) wide. Female and male harlequin butterflies are similar in color patterns and size. This butterfly is brownish black at the dorsal area with deep orange markings and confused black markings at the half basal anterior wing. The posterior wing has a wide black border enclosing a set of reddish-bronze sub-marginal points. The ventral side of the anterior wing is similar to the dorsal anterior wing, and the posterior is black with orange basal spots and a complete postdiscal beige band with a band of reddish spots distally and sub-marginal white half-moons. The costa, the most anterior (leading) edge of a wing, in males is gray and wide. Females are multivoltine ovipositors (they produce several broods in a single season) (Biaggi-Caballero 2009).

Taxonomy

The species was described in 1877 by the German lepidopterist, Dr.Herman Dewitz , from specimens collected by Dr. Leopold Krug in the Municipality of Quebradillas, Puerto Rico. Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Nymphalidae; Genus: Atlantea; Scientific name: Atlantea tulita

Historical Range

The historic range of the Puerto Rican harlequin butterfly includes the northern and southern karst, and the central western volcanic, regions of Puerto Rico. Within these three regions, the species has been historically reported from five municipalities: (1) In the northern karst region, the harlequin butterfly was reported from the municipalities of Quebradillas and Arecibo; (2) in the central-western volcanic region, the species was reported from the municipalities of Maricao and Sabana Grande; and (3) in the southern karst region, it was reported from the municipality of Peñuelas (Carrión-Cabrera 2003, p. 32).

Current Range

The Puerto Rican harlequin butterfly has been currently reported from two regions: (1) the northern karst region, and (2) the central-western volcanic-serpentine region (Pérez-Asso et al. 2009). At the northern karst region, the species is known to occur in an approximately 144 ha (356 ac) strip of forested habitat located on the northern coastal cliff between the municipalities of Isabela, Quebradillas, and Camuy (Biaggi- Caballero 2009). Here, the species habitat is limited to the east by the Bellacas Creek, to the west by the Royal Isabela Gulf Court, to the north by the Atlantic Ocean, and to the south by Puerto Rico (PR) Highway No. 2 (a state road that runs parallel to the north coast from Aguadilla to San Juan) and deforested areas utilized for agricultural practices such as cattle grazing. Within this area, the Puerto Rican harlequin butterfly occurs in: 10 scattered patches in the Terranova and San José wards in the municipality of Quebradillas that occupy an area of 1.05 ha (2.6 ac) (Monzón- Carmona 2007); One patch that occupies an area of 0.26 ha (0.65 ac) on the forested cliff on eastern side of the Guajataca River mouth in Coto ward in the municipality of Isabela (Monzón-Carmona 2007); One patch (no acrege reported) on the forested cliff along the Pastillo beach at Coto ward in the municipality of Isabela (H. Torres, UPRM, pers. comm., 2012); and One small patch (no acreage reported) at Puerto Ermina in the municipality of Camuy (Biaggi- Caballero, pers. comm., 2010). The Quebradillas population occurs in both private and public lands. Five of the 10 patches known in the Municipality of Quebradillas fall within El Merendero, a public land managed for recreation by the Puerto Rico Department of Sports and Recreation (Monzón-Carmona 2007). The other 8 patches, including the patch in the municipality of Isabela and the patch in the municipality of Camuy, are located on private lands. On December 19, 2012, Jesús Rios, a Service biologist, documented a male imago of the Puerto Rican harlequin butterfly in the Rio Abajo Commonwealth Forest (J. Rios, Service, unpublished data, 2012). This new sighting falls in an area located approximately 29.9 kilometers (20 miles) southeast of the Quebradillas population, and outside of the historical range of the species in the northern karst. The Rio Abajo Commonwealth Forest is a public land managed for conservation and passive recreation by the Commonwealth of Puerto Rico since 1935 (DNR 1976). In the central-western volcanic serpentine region, the Puerto Rican harlequin butterfly occurs in the Maricao Commonwealth Forest, a public forest managed for conservation by the Puerto Rico Department of Natural and Environmental Resources (PRDNER). The Maricao Commonwealth Forest is located between the municipalities of Maricao and Sabana Grande in west-central Puerto Rico to the west of the municipality of Mayagüez, and approximately 108.88 km (67.66 mi)) from San Juan (Pérez-Asso et al. 2009). This discrete population of Puerto Rican harlequin butterflies occurs near PR Highway 120, a state road that provides access from the municipality of Maricao to the municipality of Sabana Grande.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 1/3/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), list the Puerto Rican harlequin butterfly (Atlantea tulita), a species from Puerto Rico, as a threatened species with a rule issued under section 4(d) of the Endangered Species Act of 1973 (Act), as amended. We also designate critical habitat for this species under the Act. In total, approximately 41,266 acres (16,699.8 hectares) in six units in the municipalities of Isabela, Quebradillas, Camuy, Arecibo, Utuado, Florida, Ciales, Maricao, San Germa´n, Sabana Grande, and Yauco are within the boundaries of the critical habitat designation.

Critical Habitat Designation

Critical habitat units are depicted for Isabela, Quebradillas, Camuy, Arecibo, Florida, Ciales, Utuado, Maricao, Yauco, Sabana Grande, and San Germa´n municipalities, Puerto Rico.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the Puerto Rican harlequin butterfly consist of the following components:

(i) Forest habitat types in the Northern Karst region in Puerto Rico: Mature secondary moist limestone evergreen and semi-deciduous forest, or young secondary moist limestone evergreen and semi-deciduous forest, or both forest types, in subtropical moist forest or subtropical wet forest life zones.

(ii) Forest habitat types in the Westcentral Volcanic-serpentine region in Puerto Rico: Mature secondary dry and moist serpentine semi-deciduous forest, or young secondary dry and moist serpentine semi-deciduous forest, or both forest types, in subtropical moist forest or subtropical wet forest life zones.

(iii) Components of forest habitat types: The forest habitat types described in paragraphs (2)(i) and (ii) of this entry contain: (A) Forest area greater than 1 acre that is within 1 kilometer of a water source (stream, pond, puddle, etc.) and other forested area; (B) Canopy cover between 50 to 85 percent and average canopy height ranging from 4 to 8 meters (13.1 to 26.2 feet); and (C) Prickly bush (Oplonia spinosa) covering more than 30 percent of the understory.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the Puerto Rican harlequin butterfly may require special management considerations or protections to reduce or mitigate the following threats: Land conversion for urban and commercial use, road construction and maintenance, utility and communications structures and corridors, and agriculture; fires and garbage dumps (which are often the source of fires); and climate change and drought. In particular, habitat that has at any time supported a subpopulation may require protection from land use change that would permanently remove host plant patches and nectar sources, or that would destroy habitat containing adult nectar sources that connects such host plant patches through which adults are likely to move. Some examples of beneficial management activities would include the following: establishing a reforestation program incorporating the host plant and other native plants to provide sufficient nectar sources; installing fencing enclosures in areas containing hostplants in order to provide protection from maintenance activities; develop an effective educational outreach program to help protect identified Puerto Rican harlequin butterfly habitat. These management activities will protect from losses of habitat large enough to preclude conservation of the species.

Life History

Feeding Narrative

Juvenile: Carrión-Cabrera (2003, p. 40) stated that the species dispersion is limited by the monophagus habit of the larvae, only utilizing the prickly bush to feed.

Adult: Adult butterflies feed from the nectar of the flowers available at the site but have not been observed feeding from the prickly bush. Most individuals have been found feeding on flowers of sea grape, palo de vaca, and cariaquillo.

Reproduction Narrative

Adult: Eggs and larvae have been found only on Oplonia spinosa (Biaggi-Caballero 2010). Its broods generally contain 50 to 150 eggs, with an average of 102 eggs per brood (Carrión-Cabrera 2003). However, the author also found that the number of larvae decreased as the number of adult individuals increased, suggesting that the population dynamic of the species may be synchronized with an undetermined environmental factor (Carrión-Cabrera 2003).

Spatial Arrangements of the Population

Juvenile: Clumped according to suitable resources

Environmental Specificity

Juvenile: Specialist

Adult: Specialist

Tolerance Ranges/Thresholds

Juvenile: unknown

Adult: unknown

Site Fidelity

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Juvenile: Oplonia spinosa

Adult: Oplonia spinosa

Habitat Narrative

Adult: The Puerto Rican harlequin butterfly occurs within thein the Maricao Commonwealth Forest (Ewel and Whitmore 1973, p. 32). The subtropical moist forest life zone on limestone derived soil covers about 1.15 percent (10,338 ha (25,545.75 ac)) of the total area of Puerto Rico (USDA 2008, p. 21), however, the subtropical wet forest on serpentine-derived soil cover about

0.04 percent (358 ha (884.63 ac)) of the total area of Puerto Rico (USDA 2008, p. 20).The species has been observed on a forest associated with coastal cliffs in Quebradillas and on sclerophullous forest (type of vegetation characterized by hard, leathery, evergreen foliage that is specially adapted to prevent moisture loss) in the Maricao Commonwealth Forest. The vegetation in the Puerto Rican harlequin butterflys habitat in Quebradillas consists of Oplonia spinosa (prickly bush), Cocoloba uvifera (sea grape), Boureria suculenta (palo de vaca), Lantana camara (cariaquillo), Lantana imvolucrata (cariaquillo), Randia aculeate (tintillo), Vernonia albicaulis (no common name), Poitea paucifolia (no common name), Leucaena leucocephala (leucaena), Eupatorium odoratum (no common name), Erithalis fructicosa (no common name), Distictis lactifolia (no common name), Bidens pilosa (no common name), Croton rigidus (adormidera), Staehytarpeta jamaicensis (no common name), Stigmaphyllon emargiuatum (bull reed), and Tabebuia heterophylla (roble). The Puerto Rican harlequin butterfly has only been observed utilizing the Oplonia spinosa (prickly bush) as its host plant (plant used for laying the eggs and serves as a food source for the development of the larvae). Oplonia spinosa is a common tropical coastal shrub and is widely distributed in Puerto Rico. The Puerto Rican harlequin butterfly only lays eggs in the vegetative (green) stems on the apical zone (the tenderest zone on Oplonia spinosa new growth) (Biaggi-Caballero 2010, p. 2). No other stage of host plant is used for ovoposition (action of laying eggs). The chrysalis is also attached to dried twigs of the host plant (Biaggi-Caballero 2009, p. 3).

Dispersal/Migration

Motility/Mobility

Juvenile: low

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Juvenile: low

Adult: low

Immigration/Emigration

Juvenile: unlikely

Adult: unlikely

Dependency on Other Individuals or Species for Dispersal

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Juvenile: Carrión-Cabrera (2003, p. 51) further suggests that this butterfly flies slowly and is weak and it is considered relatively sedentary (not able to move or disperse in a given environment).

Adult: Additionally, Monzón-Carmona (2007) suggested that although the species can disperse several hundred meters (approximately 800 meters [2,625 ft]), and has the capacity to colonize adjacent patches of Oplonia spinosa, it also shows the smallest geographic range of any butterfly in Puerto Rico. This information suggests that the current limited distribution of the Puerto Rican harlequin butterfly may be as a result of an undetermined ecological requirement of the species.

Population Information and Trends

Population Trends:

Decreasing

Species Trends:

Decreasing

Population Growth Rate:

unknown

Number of Populations:

2

Population Size:

less than 100 imagoes

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Carrión-Cabrera (2003, p. 60) observed only 235 Puerto Rican harlequin butterfly imagoes (mature adult stage) in 12 months of surveys (2 sample days per month) on 0.82 acre in Quebradillas. However, more recently, Biaggi-Caballero (2009, p. 4) estimated the population to be 45 or fewer adults on any given day in the Municipality of Quebradillas. Larva counts were reported to be between 10 and 100 per census day (2 man-hours of search efforts), and the presence of more than one generation confirms the species multivoltine (producing several broods in a season) nature. From July to December, the larva population is lower thanduring the rest of the year. Since 2002, only 3 imagoes (Biaggi- Caballero 2010, p. 5) and 12 larvae (H. Torres 2010, pers. comm.) of the Puerto Rican harlequin butterfly have been reported in the Maricao Commonwealth Forest between the 16.0-km (9.94-mi) and 16.8-km (10.44-mi) points of PR Highway 120. The Puerto Rican harlequin butterfly population has been estimated at around 50 imagoes in the Northern karst Region (Biaggi-Caballero 2009, p. 4) and fewer than 20 imagoes in the volcanic serpentine central mountains of the island (Carrión-Cabrera 2003, p. 48).

Threats and Stressors

Stressor: Habitat destruction and degradation
Exposure:
Response:
Consequence:
Narrative: Habitat modification and fragmentation have been identified as the main threat to the Puerto Rican harlequin butterfly (Carrión-Cabrera 2003; Monzón- Carmona 2007; Biaggi-Caballero 2009; Pérez-Asso et al. 2009; DNER, unpublished data, 2010). The consequences of the loss and fragmentation of natural habitat for the species is detrimental because: (a) it seems to have low dispersal capabilities, (b) has limited distribution, (c) has highly specialized ecological requirements, and (d) is considered a specialist species because of the larvaes monophagous habit of feeding only on Oplonia spinosa (Carrión-Cabrera 2003). The Puerto Rican harlequin butterfly faces significant threats from the existing and imminent destruction, modification, and curtailment of its habitat and geographic range in the municipalities of Isabela, Quebradillas, and Camuy. Most of the suitable habitat for the species, especially in the municipality of Quebradillas, is currently fragmented by urban development. Dr. Stuart Ramos (University of Puerto Rico, Mayagüez Campus) reported that in 1997 one of the healthiest populations of the species showed a drastic decrease after the use of heavy equipment to clear vegetation in the Puente Blanco area in Quebradillas (Carrión-Cabrera 2003). In areas where undeveloped land remains, the species larval food plant is likely to be affected by existing agricultural practices that result in deforestation to increase grass lands for cattle grazing. Currently, the Puerto Rican harlequin butterfly is threatened by large-scale residential and touristic projects, which are planned within and around its habitat in northern Puerto Rico. For instance, in the municipalities of Isabela and Quebradillas, occupied suitable habitat is within an area classified by both municipalities and the Puerto Rico Planning Board (PRPB) as a Zone of Tourist Interest (PRPB, online data 2009, at http://www.jp.gobierno.pr). A Zone of Tourist Interest is an area that has the potential to be developed to promote tourism due to its natural features and historic value. In 2010, the PRPB website announced 11 residential development projects that were under evaluation around the species habitat, possibly affecting 74.8 cuerdas (29.4 ha [72.6 ac]) in Quebradillas (PRPB, online data 2010). Presently, Esrnesto Estremera (Ecological Alliance of Quebradilla, pers. comm., 2013) reports that over 20 residential and tourist development projects are proposed within the Puerto Rican harlequin butterflys habitat. Urban development in or around the Puerto Rican harlequin

butterflys habitat would directly and indirectly fragment and impact its habitat and would limit its population expansion in the area. Additionally, the establishment of residential and tourist development projects are expected to increase traffic, and therefore, are likely to require road improvements in proximity to the Puerto Rican harlequin butterfly habitat. The biological effects of the existing roads on the species have not been studied and are not understood. However, increasing vehicle traffic on the roads within the essential habitat of a species with difficulties to move or disperse can result in mortality due to collisions and, in some instances, can be catastrophic to the population and should not be underestimated (Glista 2007). The combination of habitat fragmentation and high road density may negatively impact the species and its habitat.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The PRDNER designated the Puerto Rican harlequin butterfly as Critically Endangered under Commonwealth Law No. 241 and Regulation 6766 on February 11, 2004 (DNER 2004, p. 42; DNER 2010, unpublished data, p. 1). Article 2 of Regulation 6766 includes all prohibitions and states that the designation as critically endangered prohibits any person from taking the species; including to harm, possess, transport, destroy, import or export individuals, eggs, or juveniles without previous authorization from the Secretary of DNER (DNER 2004, p. 28). Although, the PRDNER has not designated critical habitat for the species under Regulation 6766, Law No. 241 prohibits modification of any natural habitat without a permit from the PRDNER Secretary. The Service believes that Law No. 241 and Regulation 6766 provide adequate protection for the species. However, the lack of effectiveness of enforcement makes these policies inadequate for the protection of the habitat of the Puerto Rican harlequin butterfly, and particularly its host plant (Biaggi-Caballero 2010, p. 9). Biaggi-Caballero (2010, p. 9) states that constant violation of the law occurs when the species habitat is modified, destroyed, or fragmented by urban development and vegetation-clearing activities. The host plant is considered a common species associated with edges of forested lands and is not directly protected by Law No. 241 or Regulation 6766. Existing regulatory mechanisms may be inadequate to protect the habitat of the Puerto Rican harlequin butterfly.

Stressor: Limited distribution
Exposure:
Response:
Consequence:
Narrative: The Puerto Rican harlequin butterfly is vulnerable to extinction due to low population numbers and restricted distribution (only two isolated colonies), coupled with loss or alteration of habitat, and the monophagus habit of its larvae (Carrión-Cabrera 2003). The Quebradillas population occupies about 0.9 percent of the total area of the forested habitat located on the northern cliff along the municipalities of Isabela, Quebradillas, and Camuy. For instance, in Quebradillas where the most significant population occurs, the species occupies only 2.6 ac [1.05 ha]) distributed in 10 scattered patches that fluctuate from 0.02 ac (0.007 ha) to 0.81 ac (0.387 ha) (Monzón-Carmona 2007). Its small range may reflect a remnant population of a once widely

distributed butterfly whose habitat has been altered or lost due to previous land uses. Although the host plant Oplonia spinosa has been found widely distributed throughout Puerto Rico, the harlequin butterfly has been only detected in two localities (Carrión- Cabreara 2003). Dr. Hernan Torres, (University of Puerto Rico, Mayagüez Campus) suggested that the limited distribution of the species may be an effect of deforestation for agricultural practices and of pesticides use for pests and mosquito control (H. Torres, UPRM, pers. comm., 2010). Additionally, Monzón-Carmona (2007) suggested that although the species can disperse several hundred meters (approximately 800 meters [2,625 ft]), and has the capacity to colonize adjacent patches of Oplonia spinosa, it also shows the smallest geographic range of any butterfly in Puerto Rico. This information suggests that the current limited distribution of the Puerto Rican harlequin butterfly may be as a result of an undetermined ecological requirement of the species.

Stressor: Fire
Exposure:
Response:
Consequence:
Narrative: Human-induced fire is a current threat for the species in Quebradillas and Maricao (Biaggi-Caballero 2009; Biaggi-Caballero 2010). Fire may kill adults, young, and larvae, and eliminates or modifies the habitat of the species either temporarily or permanently. The Maricao Commonwealth Forest has been subjected to human induced fires, potentially affecting the habitat used by the Puerto Rican harlequin butterfly. At the Maricao Commonwealth Forest, the species occurs in the driest section near PR Road No. 120. On February 25, 2005, arson burned more than 400 acres with unknown effects to the harlequin butterfly population (Biaggi-Caballero 2010). This fire likely had at least temporary effects on the butterflys habitat, but we have no information regarding these effects and whether or not they were permanent. In Quebradillas, the species habitat in the Puente Blanco area, where the most significant population occurs, is threatened by fires associated with clandestine garbage dumps on Road 4485 (DNER, unpublished data, 2010).

Stressor: Use of Herbicides, Pesticides, and other Mechanisms to control vegetation
Exposure:
Response:
Consequence:
Narrative: The use of herbicides is a current threat to the species and its host plant, Oplonia spinosa, which is found at the edges of roads and open areas. The use of herbicides is a current practice implemented to eliminate vegetation along the access road to Puente Blanco (Road 4485) and private properties, and affects an undetermined number of Oplonia spinosa plants in Quebradillas (C. Pacheco, USFWS, personal observation 2009). Further, fumigation programs are being implemented by the Commonwealth of Puerto Rico and local health officials at Terranova and San José wards to control dengue fever (a virus-based disease spread by mosquitoes) (Biaggi-Caballero 2010). The area where this population occurs in Quebradillas is surrounded by residential development. No pesticide use guidelines have been developed where the species occurs (Biaggi- Caballero 2010). Vegetation management at El Merendero in Quebradillas (public land managed as a recreational area and where the species currently occurs) may adversely affect

the Puerto Rican harlequin butterfly and its host plant. Oplonia spinosa grows on both sides of the existing hiking trails and around the picnic areas at El Merendero. Maintenance personnel frequently trim the new growth of Oplonia spinosa to remove vegetation from the trails and picnic areas. The Puerto Rican harlequin butterfly uses the tenderest vegetative branches of new growth of the host plant for bearing its eggs and feeding during the larval stages (Biaggi-Caballero 2010). On April 12, 2012, maintenance staff of the Municipality of Quebradillas cleared approximately 1 acre (0.4 ha) of vegetative cover within the species habitat at El Merendero. Trimming the host plant and clearing the vegetation in these areas may result in mortality of the Puerto Rican harlequin butterfly eggs and larvae. Further, the coastline of Isabela and Quebradillas is under pressure for urban and tourist development, only small remnants of coastal vegetation conserved in the steeper areas of the northern cliff still exist. In this area, landowners clear vegetative cover to the edge of the cliff so that potential buyers have a better view of the property and its landscape (Biaggi-Caballero 2010). Currently, no guidelines about vegetation management and clearing have been developed to avoid or minimize effects to the species and its host plant.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2007a). Numerous long-term climate changes have been observed, including changes in arctic temperatures and ice, and widespread changes in precipitation amounts, ocean salinity, wind patterns, and aspects of extreme weather, including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2007b). While continued change is certain, the magnitude and rate of change is unknown in many cases. Species that are dependent on specialized habitat types, that are limited in distribution or that have become restricted to the extreme periphery of their range will be most susceptible to the impacts of climate change. As previously mentioned, the Puerto Rican harlequin butterfly is currently only known from the northern karst region and the west-central volcanic-serpentine region of Puerto Rico, and requires a very unique habitat type, which makes the species susceptible to the effects of climate change. However, we did not find any site-specific climate change information related to the Puerto Rican harlequin butterfly or its habitat. Thus, potential effects of climate change on the species and its habitat are currently unknown. Therefore, at this time, we do not consider climate change to be a threat to the species and its habitat.

Stressor: Low Reproductive Rate and Highly Specialized Ecological Requirements
Exposure:
Response:
Consequence:
Narrative: The low reproductive rate (average lifetime number of offspring produced by a member of a population) of the Puerto Rican harlequin butterfly and its highly specific ecological requirements for completing its life cycle, are a threat to the species. These characteristics make the species less resilient and resistant to stressors that may impact existing populations. Carrión-

Cabrera (2003) conducted a species survey and only observed 235 adult individuals in 12 months. Eggs and larvae have been found only on Oplonia spinosa (Biaggi-Caballero 2010). Its broods generally contain 50 to 150 eggs, with an average of 102 eggs per brood (Carrión-Cabrera 2003). However, the author also found that the number of larvae decreased as the number of adult individuals increased, suggesting that the population dynamic of the species may be synchronized with an undetermined environmental factor (Carrión-Cabrera 2003).

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- Continue to conduct surveys to update species status and distribution.
- Introduce individuals in protected areas (e.g. Maricao Commonwealth Forest) in coordination with the Puerto Rico Department of Natural and Environmental Resources.
- Continue propagation of the host plant (Oplonia spinosa) to plant in protected areas where the Puerto Rican harlequin butterfly will eventually be introduced.
- Initiate efforts to protect populations on private land.
- Recommend measures to protect and minimize effects on the species and the host plant during technical assistance and in consultations (informal or formal).
- Continue public education and outreach.
- The Commonwealth of Puerto Rico currently considers the harlequin butterfly to be critically endangered under Commonwealth Law No. 241 and Regulation 6766. The Service has propagated approximately 40 individuals of Oplonia spinosa (the host plant) to be planted in protected areas where the species can be introduced. In the near future, the Service would work with the Natural Resources Conservation Service (NRCS) to implement a landowners program through the Wildlife Habitat Incentive Program to implement voluntary conservation practices on private lands within the range of the Puerto Rican harlequin butterfly in northern Puerto Rico. Also, the Service has conducted meetings with the Puerto Rico Department of Sports and Recreation to diminish impacts on the vegetation along the trails of El Merendero. The Service will continue monitoring the status of the species.

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U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/16/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/16/2020

SPECIES ACCOUNT: *Boloria acrocnema* (Uncompahgre fritillary butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/24/1991; Mountain-Prairie Region (Region 6) (USFWS, 2016)

Physical Description

A small butterfly, with a 2-3 cm (1 in.) wingspan. Males have rusty brown wings criss-crossed with black bars; females' wings are somewhat lighter (Gall 1983). Underneath, the forewing is light ocher and the hindwing has a bold, white jagged bar dividing the crimson brown inner half from the purple-gray scaling on the outer wing surface. The body has a rusty brown thorax and a brownish black abdomen (Gall and Sperling 1980). (USFWS, 1994)

Current Range

A narrow endemic. Restricted to isolated alpine habitats in the San Juan Mountains of southwestern Colorado. Unverified reports of this species from the Sawatch Range of southcentral Colorado could expand range slightly. (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larva hibernates newly hatched and again as unfed fourth instar. Larvae feed on the snow willow (Salix nivalis) (NatureServe, 2015).

Adult: Adults take nectar from a range of flowering alpine plants (Seidl 1993a). Adults fly about late July into August. Flight is possible only in warm sunny weather. Species is biennial in terms of life history, but flies in both odd and even years. (NatureServe, 2015)

Reproduction Narrative

Adult: The females usually lay their eggs on snow willow (Seidl 1992), which is the larval food plant, or in litter within snow willow patches. Scott (1982) and Brussard and Britten (1989) believe that the species has a biennial life history, which means that it requires 2 years to complete its life cycle. Based on her observations, Seidl (1994, pers. comm.) believes that, at times, larvae hatched early in summer can develop into adults the following year instead of taking an additional year. (USFWS, 1994)

Geographic or Habitat Restraints or Barriers

Adult: Habitat is moist alpine slopes above 12,000 feet with extensive snow willow (Salix nivalis) patches (NatureServe, 2015)

Environmental Specificity

Adult: Narrow. Specialist or community with key requirements common. (NatureServe, 2015)

Habitat Narrative

Adult: Habitat is moist alpine slopes above 12,000 feet with extensive snow willow (Salix nivalis) patches which serve as the larval foodplant. Majority of such habitats lack the species. The species has been found only on northeast—facing slopes, which are the coolest and wettest microhabitat available in the San Juans (Scott 1982, Brussard and Britten 1989). (USFWS, 1994; NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (USFWS, 1994)

Dispersal/Migration Narrative

Adult: Older females occasionally disperse, but species is generally extremely sedentary (Gall, 1984a,b)--in part perhaps due to low ambient temperatures. Wind may be one means of dispersal and the Recovery Team will consider this when conducting surveys for new colonies. (NatureServe, 2015)

Population Information and Trends

Population Trends:

Stable (USFWS, 2023)

Population Growth Rate:

Unknown (NatureServe, 2015)

Number of Populations:

11 (USFWS, 2023)

Population Size:

~10,000 (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Three of the 11 known colonies of the UFB are quantitatively monitored throughout the adult flight season. In 1979 and 1982, the Uncompahgre Peak (UP) and Red Cloud Peak (RC) colonies were discovered, respectively. Those two colonies have been monitored consistently since 1990 (primarily presence/absence prior to 1990), though quantitative techniques changed in 2003. Colony C was discovered in 1988 and has been monitored consistently since 1994. All three colonies have been present since monitoring began, although one of the two sub-colonies at Colony C has not been present every year and a sub-colony or two at UP may not have been present in the early 1980s. The other eight colonies are qualitatively monitored for presence/absence information, typically only once per year. These eight colonies were discovered between 1995 and 2002. UFB has been present in most years; however, only 25 to 75 percent of the colonies may be present in some years. For example, in 2021, only two of the eight qualitatively monitored colonies were present but that increased to four out of eight colonies in 2022. Nonetheless, only a 25 to 50 percent presence of the qualitatively monitored sites in 2021 and 2022 is of concern. Quantitative monitoring at UP's three sub-colonies reveals variation in abundance (recruitment) among the sub-colonies and among years during 2018–2022. For 2018 and 2019, abundance at UP was low compared to other years, but has been near average since 2020. Quantitative monitoring at RC's two sub-colonies revealed variation in abundance among the sub-colonies and among years as well. In contrast to UP, both sub-colonies at RC had higher abundance in 2019, creating its third highest peak abundance since 2003. Abundance dropped in 2020 for both UP and RC but increased again in 2021 and 2022 and were variable compared to each other. Colony C has contributed little to the overall abundance of UFB since 2014. In 2022, 11 butterflies were seen off the population monitoring transect at one of the two sub-colonies that make up Colony C. Comparatively good years for Colony C were 2006-2007 and 2011-2013 with the combined abundance at Colony C appearing to surpass abundance at UP and RC in 2012. Abundance in 2007 was the highest for all three colonies from 2003 to 2022. The combined abundance for all three colonies was variable during 2018–2022 with UFBs from the UP and RC colonies contributing the most to total recruitment since 2014 The overall abundance of UFB at UP and RC over the last two years was within the range of abundance values observed since 2003 (see Figure 1), suggesting a stable trend at those two colonies, although a quantitative trend analysis needs to be completed. However, Colony C has extremely low numbers and its persistence is tentative despite some butterflies seen in 2022 and 2023 at one sub-colony. Having four of the eight qualitatively monitored colonies absent in 2022 is concerning, especially the colony where the 2022 landslide occurred. The same colony's persistence is also tentative due to irregular occurrence since 2008. The UFB illustrates some plasticity through timing of emergence based on yearly snowpack level, ability to nectar on a variety of alpine plants, and ability to shift to nectar sources with higher sugar content as the flight season progresses. It also appears to have the ability to recolonize even or odd-year broods over several years through developmental delays if one of the broods becomes extirpated. However, the near extirpation of Colony C and tentative nature of other qualitatively monitored colonies is cause for concern. Climate change is the biggest threat since it can affect all 11 known colonies, especially as global temperatures continue to rise, and traditional weather patterns are altered. Reduction in snowpack level, shorter duration of snowpack, and reduced water availability from snowmelt have already been observed and these conditions are expected to continue. Expected warmer temperatures will increase evapotranspiration, further reducing water availability. These changes will likely result in reduction of nectar sources and thus reduction in abundance of the UFB despite observed plasticity of the UFB. Climate-induced habitat changes at Colony C are already possibly happening and could be affecting persistence of some of the other qualitatively monitored populations based on lack of presence the last couple years or irregular presence over several years. Without substantial measures to ameliorate impacts, climate is expected to continue changing into the future and may pose increasing threats to the UFB. Consequently, we recommend that the UFB retain its status as endangered (USFWS, 2023).

Threats and Stressors

Stressor: Grazing (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: There also were concerns that sheep may graze at newly discovered colonies. Sheep are the most common domesticated animal that graze in UFB habitat. Instances of cattle or horse grazing are rare. In recognition of this potential threat, the U.S. Forest Service (USFS) avoids sheep grazing within UFB colonies altogether, or allows only trailing through the colonies and suitable habitat, but not bedding or long-term grazing. The only colony with sheep trailing through the colony on a reoccurring (but inconsistent) basis has been Mt. Uncompahgre. The Service determined in a December 16, 2008, informal section 7 consultation with USFS that occasional sheep trailing through Mt. Uncompahgre may affect, but is not likely to adversely affect the UFB colony (Service 2008). (USFWS, 2010)

Stressor: Trails (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: The only activity that has had noticeable impacts to UFB habitat has been hiking trail erosion, widening, and braiding on Mt. Uncompahgre. Given the abundant to medium population levels over the last 3 years, the hiking trail does not appear to cause a population-level effect to the UFB. Trails on both Mt. Uncompahgre and Redcloud were moved several years ago to minimize hiking through the colonies, but portions of the trails skirt the edges of both colonies. Descending hikers have crossed the colonies at Redcloud Peak, but no trails have been formed from this activity (Alexander and Keck 2009). Thus it remains a potential impact. Since the UFB was listed and the Recovery Plan written there have been no other activities that have resulted in destruction, modification, or curtailment of the UFB's habitat at known colony sites. (USFWS, 2010)

Stressor: Collecting (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Collecting was the primary reason stated in the Final Rule for listing the UFB under the ESA. There were only two known locations and apparently small numbers of UFBs documented prior to listing in 1991. Known UFB collection took place a few years prior to listing when the USFS had a Special Order Closure (USFS 1984) to butterfly collecting around Mt. Uncompahgre. The person responsible for the collecting was found in violation of the USFS closure and illegal collecting of other butterflies under the ESA and other laws (U.S. Department of Justice 1993). No illegal UFB collecting is known to have occurred since listing of the UFB. (USFWS, 2010)

Stressor: Climate change (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Increasing temperature and soil moisture changes may shift mountain habitats toward higher elevation (Ray et al. 2008). Because the UFB is restricted to a range of 12,100 to 13,500 feet (Ellingson 2003), climate change could restrict the UFB's habitat to a zone so narrow that the species would be unable to survive. Britten and Brussard (1992) believe that the UFB is a "glacial relict," or a species that was more widespread during or shortly after the last glacial period, but with temperature increase since the last glacial period the range has been restricted to isolated mountain tops. Naturally, this would lead one to believe that increasing temperatures would further compress the UFB's range. However, to date there is no indication that this is happening, and it has not been possible to correlate climatic conditions to increase or decrease in UFB numbers. (USFWS, 2010)

Stressor: Small population size (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Small population numbers could affect the UFB, but as with many insect populations, the UFB appears to experience population fluctuations of up to 10 times over a period of years without recognizable effects to the species (Alexander and Keck 2007; Alexander and Keck 2009; Alexander 2009). Additionally, despite lapses in detection of the UFB at some colonies during some years, low levels of UFBs must remain present to repopulate the colony in subsequent brood years. Alternatively, there may be enough non-biennially developing caterpillars to repopulate both even- and odd-year broods, since all known colonies and sub-colonies have been detected in years subsequent to their apparent disappearances. (USFWS, 2010)

Stressor: Low genetic variability (USFWS, 2010)
Exposure:
Response:
Consequence:

Narrative: Low genetic variability could possibly cause problems, but based on population estimates from the last few years this has not caused a problem as of yet. Low genetic variability has likely existed for hundreds if not thousands of years since the UFB's mountaintop habitat has become isolated. (USFWS, 2010)

Recovery

Reclassification Criteria:
1. Downlisting may be considered if threats are removed and if adequate quality habitat exists to maintain stable colonies of butterflies for 10 consecutive years at Mt. Uncompahgre and Redcloud Peak. (USFWS, 1994)

Recovery Priority Number: 11

Delisting Criteria:
1. Delisting may be considered after stable colonies of butterflies exist for 10 consecutive years at a minimum of 10 sites. (USFWS, 1994)

Recovery Actions:
- Enforce restrictions on Uncompahgre butterfly collection. (USFWS, 1994)
- Search for new colonies. (USFWS, 1994)
- Monitor population status of existing and newly found colonies. (USFWS, 1994)
- Obtain data on habitat requirements and life history. (USFWS, 1994)
- Monitor climatological trends at known colony sites. (USFWS, 1994)
- Determine threats besides collecting. (USFWS, 1994)
- Determine propagation techniques. (USFWS, 1994)
- Reintroduce and transplant butterflies. (USFWS, 1994)
- Prepare a downlisting package when sufficient resources (funding and personnel) are available. (USFWS, 2010)
- Develop a management plan with the USFS and BLM to ensure grazing, collecting, recreation, and other on-the-ground threats remain low or are eliminated. (USFWS, 2010)
- Retain the USFS and BLM butterfly collecting closures around Mt. Uncompahgre and Redcloud Peak and place closures around other colonies or issue collecting on a permit-only basis to control collection of the UFB after delisting. (USFWS, 2010)
- Continue quantitative population monitoring to improve trend analyses and support decisions on eventual delisting. (USFWS, 2010)
- Discuss whether development of a monitoring scheme is necessary to quantitatively monitor populations at the eight sites that have not received quantitative monitoring to date. (USFWS, 2010)
- Develop long-term climate change monitoring processes specific for the UFB, or determine if existing climate change monitoring plans in the San Juan Mountains or other resources can be used to identify the effects of climate change to the UFB and its habitat. (USFWS, 2010)
- Conduct genetic analyses and literature review to determine if gene flow between colonies is, or will, pose a threat to the UFB. (USFWS, 2010)
- Develop a genetics management and monitoring plan if genetic problems are determined to exist. (USFWS, 2010)

- Revise recovery criteria and recovery actions if necessary to address the current status and threats to the UFB as genetic information is analyzed and more information on climate change impacts is available. (USFWS, 2010)
- Use results of a taxonomic study to determine if the UFB should be reclassified as a subspecies under the B. improba group or remain a separate species as Gall and Sperling (1980) recommend and Brussard and Britten (1992) suggest. (USFWS, 2010)
- Create a post-delisting monitoring plan, as required by Section 4(g) of the Act, either separately or in combination with a post-delisting management plan. (USFWS, 2010)

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SPECIES ACCOUNT: *Bombus affinis* (Rusty patched bumble bee)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/21/2017; Proposed endangered; 09/22/2016; Great-Lakes-Big Rivers Region (R3)

Physical Description

Queens and workers differ slightly in size and coloration; queens are larger than workers (Plath 1922, p. 192, Mitchell 1962, p. 518). All rusty patched bumble bees have entirely black heads, but only workers and males have a rusty reddish patch centrally located on the abdomen (USFWS, 2016).

Taxonomy

All bumble bees, including, B. affinis, belong to the genus Bombus (within the family Apidae), which includes approximately 250 species found primarily in temperate regions of North America, Central America, South America, Europe, and Asia. There are 23 Bombus species in the eastern U.S. Bombus affinis belongs to the subgenus, B. sensu stricta, which also includes 3 other species in the U.S. (Williams et al. 2008, p. 53). (USFWS, 2016)

Historical Range

Prior to the mid- to late 1990s, the rusty patched bumble bee was widely distributed across areas of 31 States/Provinces: Connecticut, Delaware, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Ontario, Pennsylvania, Quebec, Rhode Island, South Carolina, South Dakota, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin (USFWS, 2016).

Current Range

Since 2000, the rusty patched bumble bee has been reported from 14 States/Provinces: Illinois, Indiana,Iowa, Maine, Maryland, Massachusetts, Minnesota, North Carolina/Tennessee (single record on the border between the States), Ontario, Ohio, Pennsylvania, Virginia, and Wisconsin (Federal Register, 2017a). Since the Service developed the species status assessment (SSA, USFWS 2016), there have been several new records of the species, most notably in Iowa, Virginia, West Virginia, and Wisconsin (Figure 2, USFWS 2022 unpublished database). Since listing (2017-2021), only one to two individual rusty patched bumble bees have been observed at most of these locations (USFWS, 2022).

Critical Habitat Designated

Yes; 9/1/2020.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), have reconsidered whether designating critical habitat for the rusty patched bumble bee (Bombus affinis) would be prudent. On January 11, 2017, we published a final rule listing the rusty patched bumble bee as an endangered species under the Endangered Species Act of 1973, as amended (Act). In that final rule, we stated that designation of critical habitat may be prudent, but not determinable. We have now determined that such a designation would not be prudent. The present or threatened destruction, modification, or curtailment of habitat is not the primary threat to the species, and the availability of habitat does not limit the conservation of the rusty patched bumble bee now, nor will it in the future. (USFWS, 2020)

Life History

Feeding Narrative

Adult: New queens go into diapause (a form of hibernation) over winter. The following spring, the queen, or foundress, searches for suitable nest sites and collects nectar and pollen from flowers to support the production of her eggs, which are fertilized by sperm she has stored since mating the previous fall (USFWS, 2016).

Reproduction Narrative

Adult: The rusty patched bumble bee's annual cycle begins in early spring with colony initiation by solitary queens and progresses with the production of workers throughout the summer and ending with the production of reproductive individuals (males and potential queens) in mid- to late summer and early fall (Macfarlane et al. 1994, p. 4; Colla and Dumesh 2010, p. 45; Plath 1922, p. 192). The males and new queens disperse to mate and the original founding queen, males, and workers die. At the end of the season the foundress dies and the new queens (gynes, or reproductive females) mate before hibernating. Rusty patched bumble bee nests are typically in abandoned rodent nests or other similar cavities (Plath 1922, pp. 190–191; Macfarlane et al. 1994, p. 4) (USFWS, 2016).

Spatial Arrangements of the Population

Adult: Colonies > 1,000 individuals (USFWS, 2016)

Environmental Specificity

Adult: Broad (NatureServe, 2015)

Habitat Narrative

Adult: The rusty patched bumble bee has been observed and collected in a variety of habitats, including prairies, woodlands, marshes, agricultural landscapes, and residential parks and gardens (Colla and Packer 2008, p. 1381; Colla and Dumesh 2010, p. 46; USFWS rusty patched bumble bee unpublished geodatabase 2016). The species requires areas that support sufficient food (nectar and pollen from diverse and abundant flowers), undisturbed nesting sites in proximity to floral resources, and overwintering sites for hibernating queens (Goulson et al. 2015, p. 2; Potts et al. 2010, p. 349). Rusty patched bumble bees live in temperate climates, and are not likely to survive prolonged periods of high temperatures (over 35 °Celsius (C) (95 °F (F)) (Goulson 2016, pers. comm.).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

The species' range (as measured by the number of counties occupied) has been reduced by 87%, and its current distribution is limited to just one to a few populations in each of 12 States and Ontario, with an 88% decrease in the number of populations known historically. (page 3205; Federal Register, 2017). As of August 2018, we consider the species to be extant in 94 counties and one Canadian District (USFWS, 2018).

Species Trends:

Declining (USFWS, 2016)

Resiliency:

Population health - We received information for 25 of the 69 current populations (Appendix 2). Of these, 18 (72%) have at least one high severity stressor affecting 50% or more of the 25 km2 area analyzed. Two (8%) of the 25 populations have no or only low severity stressors occurring within the 25 km2 area. Pathogens and small population effects are the two most commonly reported stressors in terms of high severity and broad extent (Table 4.2) (USFWS, 2016).

Representation:

Distribution - Recent records (2000-2015) indicate that B. affinis range has declined (Table 4.2.1); it currently exists in 13 states and 1 province (IL, IN, MA, MD, ME, MN, NC, OH, PA, TN, VA, WI, and Ontario), 41 counties, and 6 ecoregions (Figure 4.1). The number of states occupied has declined by 68%, the number of counties occupied by 89%, and the number of ecoregions occupied by 60% (Table 4.3). Spatial Extent- The current spatial extent, EoO, of B. affinis is 8% (i.e., 8% of the total documented range was occupied during the time period of 2000-2015) (Table 4.4). The number of grid occurrences within the ecoregions varies from 0 to 42 (Table 4.5). The percent of the total EoO occupied in the current time period varies from 0% to 50% among the ecoregions (Table 4.5) (USFWS, 2016).

Redundancy:

Probability of Ecoregion Extinction - The frequency of a catastrophic event occurring varies by grid and by event type, but in most cases the frequencies are low. No grids had a high temperature event (>35o C for 14 or more days) (Table 4.6). The frequency of a catastrophic drought occurring varied with among grids and with drought intensity. The frequency of high temperatures was zero for all 66 grids analyzed (Table 4.6). For D3+ intensity drought, all 66 grids had frequencies less than 0.60, and for D4+ intensity drought, all grids had frequencies less than 0.50 (Table 4.6). Due to the low frequency of D4+ intensity drought and high temperature events, the risk of ecoregionwide extirpation is zero for all current ecoregions, except for

Ecoregion 230 (Table 4.3.2). Given the few number of grids occupied and the grid-specific catastrophic event frequencies for Ecoregion 230, the probability of ecoregion-wide extirpation within 25 years is 0.854. Considering a D3+ intensity and high temperature scenario, 4 of the 6 ecoregions have high risk of extirpation due to D3+ intensity drought or high temperature events (Table 4.7) (USFWS, 2016).

Number of Populations:

69 (USFWS, 2016)

Minimum Viable Population Size:

1,000 (USFWS, 2016)

Population Narrative:

Analyses indicate that the resiliency, representation, and redundancy of the rusty patched bumble bee have all declined since the late 1990s and are projected to continue to decline over the next several decades. Since the late 1990s, rusty patched bumble bee abundance and distribution has declined significantly. The number of known populations has declined by 88% and several of the current populations have not been re-confirmed since the early 2000s and may no longer persist. Furthermore, many of the current populations are documented by only a few individuals; 95 percent of the known populations are documented by 5 or fewer individuals; the maximum number found at any site was 30. The number of individuals comprising a healthy colony is typically several hundred, and a healthy population typically contains tens to hundreds of colonies (Macfarlane et al. 1994, pp. 3-4}. Along with the loss of populations, a marked decrease in the range and distribution has occurred in recent times. Historically, the rusty patched bumble bee was broadly distributed across the Eastern United States, upper Midwest, and southern Quebec and Ontario, an area comprising 15 ecoregions, 31 States/Provinces, and 394 U.S. counties and 38 county-equivalents in Canada. Since 2000, the species' distribution has declined across its range. At the time of listing there were records from 6 ecoregions, 14 States or Provinces, and 55 counties, representing an 87% loss of spatial extent (expressed as a loss of counties with the species}. As of August 2018, we consider the species to be extant in 94 counties and one Canadian District. (USFWS, 2018). Since the species was listed in 2017, the number of observations of rusty patched bumble bee has increased in the Upper Midwest and Appalachia, and the total number of individual bees observed across its range increased from 450 to 1,301 in 2021. The number of 10 x 10 km grids with at least one occurrence is now 454 grids, however, we do not know the status of any of these populations. Like the pre-listing records (USFWS 2016), most post-2016 occurrence sites are represented by only one or two individual bees (USFWS unpublished database). Even in areas consistently supporting individuals (i.e., Minnesota Zoo), genetic evidence points to a small (lower than expected) number of colonies with signs of inbreeding and male diploidy. In areas with only one to two individuals observed, we can assume the number of colonies is also low and inbreeding is likely occurring. Furthermore, preliminary studies show a high pathogen prevalence among collected samples (USFWS, 2022).

Threats and Stressors

Stressor: Disease and parasites (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The precipitous decline of several bumble bee species (including the rusty patched) from the mid-1990s to present was contemporaneous with the collapse in populations of commercially bred western bumble bees (B. occidentalis), raised primarily to pollinate greenhouse tomato and sweet pepper crops, beginning in the late 1980s (for example, Szabo et al. 2012, pp. 232–233). This collapse was attributed to the microsporidium (fungus) Nosema bombi. Around the same time, several North American wild bumble bee species also began to decline rapidly (Szabo et al. 2012, p. 232). The temporal congruence and speed of these declines led to the suggestion that they were caused by transmission or ‘‘spillover’’ of N. bombi from the commercial colonies to wild populations through shared foraging resources. In addition to fungi such as N. bombi, other viruses, bacteria, and parasites are being investigated for their effects on bumble bees in North America, such as deformed wing virus, acute bee paralysis, and parasites such as Crithidia bombi and Apicystis bombi (for example, Szabo et al. 2012, p. 237; Manley et al. 2015, p. 2; Tripodi 2016, pers. comm.; Goulson et al. 2015, p. 3). Little is known about these diseases in bumble bees, and no studies specific to the rusty patched bumble bee have been conducted (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016).

Stressor: Pesticides (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: A variety of pesticides are widely used in agricultural, urban, and even natural environments, and native bumble bees are simultaneously exposed to multiple pesticides, including insecticides, fungicides, and herbicides. The pesticides with greatest effects on bumble bees are insecticides and herbicides: Insecticides are specifically designed to directly kill insects, including bumble bees, and herbicides reduce available floral resources, thus indirectly affecting bumble bees. Although the overall toxicity of pesticides to rusty patched or other bumble bees is unknown, pesticides have been documented to have both lethal and sublethal effects (for example, reduced or no male production, reduced or no egg hatch, and reduced queen production and longevity) on bumble bees (for example, Gill et al. 2012, p. 107; Mommaerts et al. 2006, pp. 3–4; Fauser-Misslin et al. 2014, pp. 453–454). Neonicotinoids are a class of insecticides used to target pests of agricultural crops, forests (for example, emerald ash borer), turf, gardens, and pets and have been strongly implicated as the cause of the decline of bees in general (European Food Safety Authority 2015, p. 4211; Pisa et al. 2015, p. 69; Goulson 2013, pp. 7–8), and specifically for rusty patched bumble bees, due to the contemporaneous introduction of neonicotinoid use and the precipitous decline of the species (Colla and Packer 2008, p. 10) (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016).

Stressor: Habitat loss and degradation (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The rusty patched bumble bee historically occupied native grasslands of the Northeast and upper Midwest; however, much of this landscape has now been lost or is fragmented. Estimates of native grassland losses since European settlement of North America are as high as 99.9 percent (Samson and Knofp 1994, p. 418). Habitat loss is commonly cited as a long-term contributor to bee declines through the 20th century, and may continue to contribute to current declines, at least for some species (Goulson et al. 2015, p. 2; Goulson et al. 2008; Potts et al. 2010, p. 348; Brown and Paxton 2009, pp. 411–412). Large monocultures do not support the plant diversity needed to provide food resources throughout the rusty patched bumble bees' long foraging season, and small, isolated patches of habitat may not be sufficient to support healthy bee populations (Hatfield and LeBuhn 2007, pp. 154– 156; Ockinger and Smith 2007, pp. 55– 56) (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016).

Stressor: Small population size (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The rusty patched bumblebee is a eusocial bee species (cooperative brood care, overlapping generations within a colony of adults, and a division of labor into reproductive and non-reproductive groups), and a population is made up of colonies, rather than individuals. Consequently, the effective population size (number of individuals in a population who contribute offspring to the next generation) is much smaller than the census population size (number of individuals in a population). Genetic effects of small population sizes depend on the effective population size (rather than the actual size), and in the rusty patched bumble bee the effective population sizes are inherently small due to their eusocial structure, haplodiploidy reproduction, and the associated ''diploid male vortex.'' This reproductive strategy (haplodiploidy) makes the rusty patched bumble bee particularly vulnerable to the effects of a small population size, as the species can experience a phenomenon called a ''diploid male vortex,'' where the proportion of nonviable males increases as abundance declines, thereby further reducing population size. Given this, due to the size of the current populations, some may no longer persist and others are likely already quasiextirpated (the level at which a population will go extinct, although it is not yet at zero individuals) (Szymanski et al. 2016, p. 66) (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016).

Stressor: Climate change (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The changes in climate likely to have the greatest effects on bumble bees include: Increased drought, increased flooding, increased storm events, increased temperature and

precipitations, early snow melt, late frost, and increased variability in temperatures and precipitation. These climate changes may lead to decreased resource availability (due to mismatches in temporal and spatial co-occurrences, such as availability of floral resources early in the flight period), decreased availability of nesting habitat (due to changes in rodent populations or increased flooding or storms), increased stress from overheating (due to higher temperatures), and increased pressures from pathogens and nonnative species, (Goulson et al. 2015, p. 4; Goulson 2016, pers. comm.; Kerr et al. 2015, pp. 178– 179; Potts et al. 2010, p. 351; Cameron et al. 2011a, pp. 35–37; Williams and Osborne 2009, p. 371) (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016). Additional narrative is provided in the Rusty Patched Bumble Bee Species Status Assessment (USFWS, 2016).

Recovery

Reclassification Criteria:
Downlisting Criteria: Criterion A1: Maintain healthy populations of the rusty patched bumble bee in each of the 5 Conservation Units (Figure 2), as demonstrated by each unit having the following: 1) a minimum number of healthy populations as specified in Table 1 and 2) a stable or increasing trend in percent occupancy over a minimum of 5-10 years. Criterion A2: Ensure population clusters are distributed across a diversity of habitat, ecological, and climate types within each Conservation Unit. A population cluster is three or more healthy populations that are adjacent to each other (USFWS, 2021).

Recovery Priority Number: 2

Delisting Criteria:
Delisting Criteria: Criterion B1: Downlisting criteria A1 and A2 have been met. Criterion B2: Mechanisms are in place that provide a high level of certainty that downlisting criteria will continue to be met into the foreseeable future. Specifically, Conservation Unit-specific mechanisms will ensure that into the foreseeable future: 1) The number and distribution of healthy populations will be maintained at the levels needed to meet downlisting criteria, 2) A sufficient quality and quantity of habitat will be maintained to support those healthy populations, and 3) The negative effects from threats (including but not limited to pathogens, pesticides, climate change, and non-native bees and managed bumble bees) have been reduced such that the population-level effects are negligible (USFWS, 2021).

Recovery Actions:
- Conduct habitat and stressor assessments to determine which stressors are affecting extant populations and what habitat improvements are needed at each high-priority location. (Identify, plan and take action to ameliorate stressors and improve the habitat at priority locations; USFWS, 2018)
- With partners, plan, design, and implement actions based on the priority of locations and of actions at each location. (Identify, plan and take action to ameliorate stressors and improve the habitat at priority locations; USFWS, 2018)
- Monitor each priority location annually to confirm extant rusty patched bumble bee populations, establish baseline Bombus community data for future monitoring and trend

analysis, and to monitor success of habitat improvement projects over time. Use standardized FWS survey protocols and electronic reporting. (Identify, plan and take action to ameliorate stressors and improve the habitat at priority locations; USFWS, 2018)

- Create, restore, and enhance foraging, nesting, and overwinering habitat. (Identify, plan and take action to ameliorate stressors and improve the habitat at priority locations; USFWS, 2018)
- Develop and disseminate guidance for land mangers on improving habitat and reducing stressors. (Identify, plan and take action to ameliorate stressors and improve the habitat at priority locations; USFWS, 2018)
- Understand nesting habit needs of rusty patched bumble bee. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand the current role of pathogens in rusty patched bumble bee survival, fitness, and colony success. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Determine genetic diversity of extant populations and effective population size; develop genetics management plan to inform potential ex-situ efforts. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand the overwintering habitat needs of rusty patched bumble bee. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand foraging habitat needs. Identify the use of preferred floral resources, superfoods, and other nutritional needs. Implement use of these resources. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Develop captive rearing techniques and methods to inform other research questions and possible future actions; including evaluation of various ex-situ options and determining the appropriate courses of action. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand the current role of pesticides in rusty patched bumble been survival, fitness, and colony success. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand insecticide toxicity at various life stages of rusty patched bumble bee (or Bombus surrogate species). (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand rusty patched bumble bee foraging distances. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Understand rusty patched bumble bee male and reproductive female dispersal and foraging distances and connectivity of colonies and populations. (Implement high priority research

projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)

- Understand pesticide risk assessments near agricultural areas, priority locations, and areas that may be used for future reintroduction. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Compare landscape-level habitat attributes between grids with and without extant populations. (Implement high priority research projects to ensure that we are carrying out the most important and appropriate actions to improve species' resiliency, redundancy, and representation; USFWS, 2019)
- Conduct bumble bee surveys in under-surveyed areas to look for additional rusty patched bumble been populations in prioritized areas, focusing first in areas near extant locations. (USFWS, 2018)
- Develop and disseminate outreach to targeted audiences and outreach tools for general audiences to increase awareness and to reduce stressors and improve rusty patched bumble bee habitat across the range. (USFWS, 2018)
- Refine and streamline the standardized survey protocol and standardized electronic reporting. (USFWS, 2018)
- Modify and maintain an existing geodatabase to track the results of the habitat and stressor assessments georeferenced to each area assessed; land ownership; the locations and extents of specific habitat categories; locations of habitat and stressor improvement project and progress of those projects; results of bumble bee population monitoring surveys and other survey data; any other information that would be useful to plan recovery actions. (USFWS, 2018)
- 2019-1: Minimize risks due to pathogens: Successful minimization measures may include: conducting population-specific threats analyses, implementing and enforcing clean stock programs, implementing good practices for production and use of commercial bees (for example, monitoring pathogens in bee stocks and preventing bee escapes), conducting research, and providing education and outreach to the public and commercial bee keepers. (USFWS, 2019b)
- 2019-2: Minimize exposure to harmful pesticides: Successful minimization measures may include: creating pesticide registry programs, executing pollinator-safe labeling on nursery plants, establishing buffers around populations (for example, habitat restoration or land acquisition), implementing integrated pest management, conducting research, and providing education and outreach to the public and agricultural community. (USFWS, 2019b).
- 2019-3: Manage and protect habitat: Successful management and protection measures may include: maintaining, improving, and restoring overwintering, foraging, and nesting habitat; restoring connectivity for dispersal; developing and implementing habitat management plans; creating habitat management incentive programs; conducting research; and providing education and outreach to the public and land managers; and securing permanent protection of habitat through land acquisition and/or conservation easements by land management agencies and nongovernmental organizations. (USFWS, 2019b).
- 2019-4: Manage and protect populations: Successful management and protection measures may include: increasing the number and distribution of populations and improving the health of target populations by increasing effective population sizes, implementing conservation propagation methods (such as augmentation/enhancement, reintroduction, insurance populations, and translocation), and conducting research (for example,

demographics, nesting and overwintering ecology, genetics, dispersal behavior, and effects of climate change). (USFWS, 2019b).

- 2019-5: Assess population status (monitoring) and conduct surveys: This may include: developing and using rigorous standardized protocols and community science to monitor population health, habitat, and threats; conducting surveys at potential new sites; and sharing data among partners. (USFWS, 2019b).
- 2019-6: Ensure effective planning and coordination: This may include: integrating planning and coordination among recovery partners, implementing and reviewing Recovery Implementation Strategies, tracking recovery implementation progress and success, and implementing adaptive management. (USFWS, 2019b).
- In Canada, the species was listed as endangered on Schedule 1 of the Species at Risk Act in 2012, and a recovery strategy has been proposed (Environment and Climate Change Canada 2016, entire). However, the Service is aware of only nine current occurrences (three populations) in Canada. The rusty patched bumble bee is listed as State endangered in Vermont and Special Concern in Connecticut, Michigan, and Wisconsin. Of those four States, Wisconsin is the only State with current records (18 populations). A few organizations have or may soon start monitoring programs, such as Bumble Bee Watch (www.bumble beewatch.org), a collaborative citizen science effort to track North American bumble bees, and the Xerces Society (USFWS, 2016).
- The International Union of Concerned Scientists Conservation Breeding Specialist Group has developed general conservation guidelines for bumble bees (Hatfield et al. 2014b, pp. 11–16; Cameron et al. 2011a, entire). There is an increased awareness on pollinators, in general, and thus efforts to conserve pollinators may have a fortuitous effect on the rusty patched bumble bee. For example, planting appropriate flowers may contribute to pollinator conservation; however, there is a need to develop regionally appropriate, bumble bee-specific recommendations based on evidence of use (Goulson 2015, p. 6) (USFWS, 2016).
- Inventory and monitoring: Inventory and monitoring of Bombus species, including the rusty patched bumble bee, occurs on a large scale in the states of Wisconsin, Maine, Michigan, Minnesota, Illinois, and Indiana and on smaller scales in several states in the historical range. Furthermore, citizen science data are collected on bumble bees throughout the historical range of the species (e.g., through bumblebeewatch or beespotter, and bio blitzes). Additional information on species occurrences arises from site-specific surveys, such as those initiated to complete section 7 consultations.
- Habitat Preferences research: Some research has been conducted to increase understanding of foraging preferences of Bombus species generally; however , only one study has been conducted to examine rusty patched bumble bee specifically. We are aware of one recently funded pilot study of rusty patched bumble bee floral preferences; this study will examine pollen from museum specimens collected throughout the historical range. Further habitat preference research is needed to build on these studies to refine habitat restoration and enhancement of the rusty patched bumble bee throughout its range. These studies may also inform population restoration approaches (e.g., captive rearing and reintroductions) and project reviews. In particular, more studies on the overwintering habitat and nesting habitat preferences are needed.
- Genetics research: Several researchers have foreseen the need to increase our understanding of rusty patched bumble bee population genetics in order to inform population augmentation and reintroduction efforts and to help determine population viability. We are aware of one recently funded pilot study of rusty patched bumble bee

genetics; this study will examine museum specimens collected from throughout the historical range. Further genetics research is needed to build on these studies in order to assess the conservation and population restoration approaches to management of the rusty patched bumble bee throughout its range.

- Habitat Restoration and Protection: Habitat restoration and enhancement to benefit pollinators is ongoing throughout the historical range of the species; however, efforts are only now beginning to focus on the specific needs of the rusty patched bumble bee and in areas where the species is likely to still occur. Most of these efforts focus on the enhancement of floral resources.
- Minimize risks due to disease, pests, pathogens, and parasites. Successful measures to minimize risk of disease, pests, pathogens, and parasites spread from non-native bees, managed bumble bees, and other sources may include the following: a. Conduct population-specific disease, pest, pathogen, and parasite assessments and risk analyses. b. Implement and enforce clean stock programs. c. Implement good practices for production and use of non-native and managed bees (for example, monitoring pathogens in bee stocks and preventing escapes from greenhouses). d. Conduct research on sources, exposure, and impacts of disease, pests, pathogens, and parasites. e. Provide outreach and education to the public, honeybee hobbyists, and commercial beekeepers. Estimated cost: $1,200,000. (USFWS, 2021).
- Minimize exposure to harmful pesticides. Successful minimization measures may include the following: a. Conduct population-specific pesticide assessments and risk analyses. b. Conduct research on sources, exposure, and impacts of pesticides. c. Implement pesticide minimization measures (for example, create pesticide registry programs, implement pollinator-safe labeling on nursery plants, establish buffers around populations, implement integrated pest management). d. Provide outreach and and education to the public and agricultural community. Estimated cost: $855,000 (USFWS, 2021)
- Manage and protect populations. Measures to increase the number and distribution of populations and improve the health of target populations may include the following: a. Increase effective population sizes at target populations. b. Implement conservation propagation methods (such as augmentation or enhancement, reintroduction, insurance populations, and translocation) after weighing the benefits against the risks (for example, spreading of disease and pathogens in the wild, adversely altering genetic composition and adaptation of wild populations). c. Manage populations to improve resiliency to the effects of climate change. d. Conduct research to understand biological and life-history requisites to maintain or restore populations (for example, demographics, nesting and overwintering ecology, genetics, dispersal behavior, and effects of climate change). e. Engage the public to garner support for rusty patched bumble bee conservation. Estimated cost: $3,785,000. (USFWS, 2021).
- Assess population and habitat status and trends through monitoring and surveys. This may include, but is not limited to, the following: a. Develop and use rigorous standardized protocols and community science to monitor population health, habitat, and threats. b. Conduct surveys at potential new sites. c. Engage the public in rusty patched bumble bee monitoring and survey efforts through community science. Estimated cost: $7,977,000. (USFWS, 2021).
- Manage, protect, and enhance habitat. Successful management, protection, and enhancement measures may include the following: a. Maintain, improve, and restore overwintering, foraging, and nesting habitat. b. Restore habitat connectivity to enable

dispersal. c. Develop and implement adaptive habitat management plans, considering monitoring results from Action #4 above, and refine management. d. Create and implement habitat management incentive programs. e. Secure permanent protection of habitat through land acquisition or conservation easements. f. Conduct research to determine efficient and effective habitat management techniques. g. Manage habitat to improve resiliency to the effects of climate change. h. Provide outreach and education to the public and land managers to garner support for habitat conservation at local and regional levels. Estimated cost: $2,692,000 (+ undetermined cost for potential land acquisition). (USFWS, 2021).

- Estimated Date of Recovery: If all actions are fully funded and implemented as outlined, including full cooperation of partners needed to achieve recovery, we anticipate delisting could be achieved as soon as 2061. It is difficult to estimate the time it will take to accomplish recovery actions such that the delisting criteria have been met because the exact causes of population declines remain unclear. Assuming the causes could be identified within the next 10 years, it would likely take at least another 20 years to address the causes, followed by an additional 10 years to monitor the response of populations. Thus, we estimate that recovery could be accomplished in 40 years. We recognize, however, that it may take longer than this estimate to recover and delist the species. Estimated Cost of Delisting: The estimated costs associated with implementing recovery actions for delisting are $16,509,000. Cost estimates reflect costs for actions needed to achieve rusty patched bumble bee recovery. Some cost for recovery actions are not determinable at this time, therefore, the total cost for recovery may be higher than this estimate. (USFWS, 2021).

Conservation Measures and Best Management Practices:

- Temporally, the recovery strategy focuses on a sequence of first halting declines, then reversing declines, and ultimately securing the long-term viability of the species across a specified range. This phased approach involves emphasizing different objectives as recovery proceeds, thereby focusing initially on preventing extinction before moving toward broader, more proactive conservation objectives. The specific objectives include: 1. Preventing further loss of populations by (a) identifying and ameliorating the threats driving the declines, (b) increasing the health of individuals and the number of colonies comprising populations, and (c) ensuring appropriate connectivity between populations. 2. Ameliorating pervasive threats, including those from pathogens, pesticides, habitat loss, managed bees, and effects of climate change. 3. Buffering against catastrophes and environmental stochasticity (may require reintroduction into unoccupied areas within the historical range) by increasing the number of genetically and demographically healthy populations and the spatial distribution of those populations. 4. Buffering against novel changes in its physical and biological environment by restoring populations across the breadth of its natural adaptive diversity. 5. Protecting populations and their habitats and abating threats into the foreseeable future.
- Recommendations for future actions Future actions include additional studies to help determine the demographic, genetic, and body condition (e.g., pathogens and pesticide loads) metrics to document healthy populations, understand key aspects of the species life history, and improve the health of existing populations. The habitat and resource needs and preferences of overwintering, early spring foraging, and nesting queens are priority areas of study. Additional recommendations for near term activities include, but are not limited to the following: • Increase knowledge of disease (harmful pathogens and parasites) prevalence. Conduct pathogen sampling in occupied habitats within a proportion of grids. • Increase knowledge of pesticide exposure and impacts. Conduct pesticide sampling in a proportion of occupied grids. • Identify potential sites to evaluate for potential future reintroductions or augmentations. • Contribute to knowledge of captive rearing techniques. Develop

a propagation and reintroduction plan. • Increase knowledge of rusty patched bumble bee grid occupancies. Annually survey at least 10% of occupied grids and at least 10% of priority unoccupied grids. • Continue work on improving monitoring protocols and data reporting. • Annually implement several Bombus identification workshops. • Annually conduct rusty patched bumble bee habitat assessments in a proportion of occupied grids and priority unoccupied grids. • Implement habitat improvement projects in a proportion of occupied grids. Continue habitat enhancements, including providing attention to overwintering, spring, and nesting habitats. • Study what affects queen survival and nesting success. • Minimize and reduce threats that are negatively contributing to the survival and reproductive success of the species. • Determine baseline genetic information from a subset of existing populations. • Study the nutritional needs of the species. • Continue to provide resources on the USFWS rusty patched bumble bee website. • Continue to refine guidance and resources as new information becomes available. • Continue to engage the public in rusty patched bumble bee conservation.

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SPECIES ACCOUNT: *Bombus franklini* (Franklin's bumble bee)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

As a bumble bee of the subgenus Bombus sensu stricto, B. franklini is corbiculate (females having pollen baskets on the hind legs) (Williams, et al. 2008, entire). In B. franklini, the hind leg tibia outer surface (corbicula) is flat with long black fringes at the sides (Williams et al. 2014, p. 119). The species is short-tongued with a short head and the cheek (area between the bottom of the compound eye to the insertion of the mandible) is shorter than it is wide (Koch et al. 2012, p. 98; Williams et al. 2014, p. 119). Shorter faces and tongues are an adaptation to extracting nectar from flowers with short corollas (Koch et al. 2012, p. 6). Bombus from this subgenus with short tongues also rob nectar from flowers with longer corollas, by biting holes in the base of the corolla to access the nectar. Bombus occidentalis, a closely related species, has mandibles with distinct teeth, possibly to aid in this behavior (Goulson 2010, p. 173). Body size of the queens (22-24 mm, 0.86-0.95 inches) and workers (10-17 mm, 0.40-0.65 inches) is relatively large (Williams et al. 2014, p. 119). Males are 13-16 mm (0.50-0.64 inches) in length. In the field, B. franklini can most easily be distinguished from other similar species in its range (e.g., B. occidentalis, B. vosnesenskii, B. caliginosus, B. vandykei, B. fervidus, B. insularis, B. flavidus), by the inverted U-shape pattern of the yellow hairs on the anterior thorax surrounding a central black patch and extending beyond the bases of the wings, and the lack of yellow hairs on the abdomen (Thorp et al. 2010, p. 5-6; Williams et al. 2014, p. 119). In addition, the hairs on the round face are predominantly black, there are yellow hairs on the top of the head, and there are white hairs in two spots at the tip of the abdomen (Thorp et al. 2010, p. 5-6). For other diagnostic characters that can be seen in the hand and under the microscope, please see Frison (1921, pp. 147-148; 1922, pp. 313-315), Thorp et al. (2010, pp. 5-6), and Williams et al. (2014, pp. 119-120). (USFWS, 2018)

Taxonomy

All of the approximately 250 species of bumble bees found worldwide (Williams et al. 2008, p. 1) belong to the genus Bombus (formerly Bremus), family Apidae, and order Hymenoptera, and thirty species of Bombus are known in the western United States (Koch et al. 2012, entire). Bombus franklini was first described in 1921, based on the collection of two queen specimens on July 7, and July 8, 1917, in Nogales, Arizona (Frison 1921, pp. 147-148). The description of the species was completed in 1922, based on one worker and one male specimen collected from an unspecified locality in Oregon, and deposited in the United States National Museum (Frison 1923, p. 313-315; Thorp et al. 2010, pp. 5, 40). At that time, it was noted that B. franklini was one of the rarer species of the widely distributed Bombus (Bremus) genus (Frison 1923, p. 315). In 1970, based on museum record research and field studies, the actual location of the Nogales, Arizona collection was called into question, and Gold Hill, Oregon, was proposed instead as the type locality for Bombus franklini (Thorp 1970, p. 177-179; Thorp et al. 2010, p. 5, 7). (USFWS, 2018)

Historical Range

Bombus franklini is thought to have the most limited distribution of all known North American bumble bee species (Plowright and Stephen 1980, p. 479; Xerces Society and Thorp, 2010, p. 6), and one of the most limited geographic distributions of any bumble bee in the world (Frison 1923, p. 315; Williams 1998, p.129). Stephen (1957, p. 81) recorded the species from the Umpqua and Rogue River Valleys in Oregon. Thorp et al. (1983, p. 8) also recorded it from northern California and suggested its restriction to the Klamath Mountain region of southern Oregon and northern California. (USFWS, 2018)

Current Range

CA, OR;

Critical Habitat Designated

Yes;

Life History

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2018)

Habitat Narrative

Adult: Bombus franklini requires a constant and diverse supply of flowers that bloom throughout the colony's life cycle, from spring to autumn (Xerces Society and Thorp 2010, p. 11); these resources would typically be found in open (non-forested) meadows in proximity to seeps and other wet meadow environments. Different Bombus species have consistently been observed foraging in the same area visiting similar and different species of flowering plants. During some Oregon surveys, no Bombus species was always consistent in the number of different plants species it visited, nor was any Bombus species tied to just one plant species (Schroeder, pers. comm. 2017). The nectar from flowers provides carbohydrates and the pollen provides protein. Studies of other Bombus species typically exhibit foraging distances of less than 1 km (0.62 miles) from their nesting sites (Knight et al. 2005, p. 1816; Wolf and Moritz 2008, p. 422; Dramstad 1996, pp. 163-182; Osborne et al. 1999, pp. 524-526; Rao and Strange 2012, pp. 909-911; Hatfield, pers. comm. 2017). Bombus franklini may have a foraging distance of up to 10 km (6.2 miles) (Thorp, pers. comm. 2017), but the subgenus' typical dispersal distance is most likely 3 km (1.86 miles) or less (Hatfield, pers. comm. 2017; Goulson 2010, p. 94,). Bombus franklini have been observed collecting pollen from lupine (Lupinus spp.) and California poppy (Eschscholzia californica), and collecting nectar from horsemint or nettle-leaf giant hyssop (Agastache urticifolia) and mountain monardella (Monardella odoratissima) (Xerces Society and Thorp 2010, p. 11). Bombus franklini may also collect both pollen and nectar from vetch (Vicia ssp.) as well as rob nectar from it (Xerces Society and Thorp 2010, p. 11). A shorttongued/cheeked bumble bee, B. franklini has been found to antagonistically rob nectar from flowering plants that it cannot directly reach with its tongue, by chewing a hole in the host plant where the nectar is located (Pool 2014, p. 3; Schroeder, pers. comm. 2017; Hatfield, pers.

comm. 2017). This particular behavior has been known to occur during its visitation to pollinator plants such as Aconitum. Table 1 summarizes ecological requirements of B. franklini at the individual level (USFWS, 2018).

Dispersal/Migration

Dispersal

Adult: Bombus franklini may have a foraging distance of up to 10 km (6.2 miles) (Thorp, pers. comm. 2017), but the subgenus' typical dispersal distance is most likely 3 km (1.86 miles) or less (Hatfield, pers. comm. 2017; Goulson 2010, p. 94,). (USFWS, 2018)

Population Information and Trends

Population Trends:

Declining (USFWS, 2018)

Resiliency:

Resiliency is the ability to sustain populations in the face of environmental variation and transient perturbations. In section 2.2.3 we described that Bombus franklini requires the following for resiliency: (1) populations with large Ne, (2) sufficient floral resources in close proximity to nesting and overwintering sites, (3) connectivity among colonies and populations, and (4) spatial heterogeneity. Historically, the species has always been rare and has one of the narrowest distributions of any Bombus species in the world. Even so, the abundance and distribution of B. franklini has declined significantly (U.S. Fish and Wildlife Service 2018, pp. 10-14); the species has not been observed since 2006 despite an intensive survey effort in some areas of the historical range. Prior to 1998, search efforts for the species were varied in timing, scope, intensity, and methodology. During the more intensive surveys from 1998 until the last observation in 2006, B. franklini was observed at 11 sites, including seven locations where it had not been previously documented. In 1998, 98 bees were found among eight locations. Searchers found fewer and fewer bees after that even though they continued extensive searches in multiple locations with the highest likelihood of finding the species. Twenty bees were located in 1999, nine individuals were observed in 2000, and one individual in 2001. Although 20 B. franklini were observed in 2002, only three were observed in 2003 (all at a single locality), and a single worker bee was observed in 2006. Despite continued intensive search efforts through 2017, there have been no confirmed observations of B. franklini since 2006. There are currently no known healthy B. franklini individuals and therefore no known healthy colonies or populations of B. franklini. Despite the fact that some high quality habitat with diverse floral resources and available nesting and overwintering sites appears to be available in the historic range of B. franklini, no individuals of the species have been found in any habitat since 2006. The resiliency of B. franklini has declined significantly since the late 1990's (USFWS, 2018).

Representation:

Representation is the ability to adapt to changing environmental conditions; it is the species' evolutionary capacity or flexibility. In section 2.2.3 we described that Bombus franklini requires the following for representation: healthy populations distributed across areas of unique adaptive diversity (i.e., ecoregions) to maintain evolutionary drivers (gene flow, natural selection, genetic drift) to mimic historical patterns. Bombus franklini is rare and has always had very small populations (relative to other similar, native bumble bees in the western United States), and likely have low genetic diversity, making the species more vulnerable to environmental factors. As a haplodiploid organism, B. franklini may be more prone to population extinction than diploid-diploid organisms, due to its susceptibility to low population levels and loss of genetic diversity. No B. franklini have been observed since 2006 despite an intensive survey effort and therefore we cannot identify any current populations of B. franklini distributed across any level of ecological conditions. The vulnerability resulting from B. franklini's genetic system and the loss in the spatial extent of its populations suggest the representation of B. franklini has declined significantly since the late 1990's (USFWS, 2018).

Redundancy:

Redundancy protects species against the unpredictable and highly consequential events for which adaptation is unlikely. In section 2.2.3 we described that Bombus franklini requires the following for redundancy: sufficient distribution to guard against catastrophic events wiping out portions of the species adaptive diversity, i.e., to reduce covariance among populations, and an adequate number of healthy populations to buffer against catastrophic losses of adaptive diversity. Bombus franklini has the smallest geographic distribution of any North American bumble bee and possibly the world (Williams 1998, as cited in Xerces Society and Thorp 2010, p. 6), and thus likely had low redundancy prior to its decline. When we look at occurrence data for the species and overlay it with our 6 km2 grid estimating minimum habitat patch to estimate the number of populations present on the landscape, we find that each site where B. franklini has ever been observed could potentially reflect a population. Therefore, data allow us to estimate 43 potential populations of B. franklini since records have been kept. From 1998 to 2006, 14 potential populations could be identified and no B. franklini have been observed since 2006 despite a more intensive survey effort in some areas of the historic range. We cannot identify any current healthy populations distributed across any spatial extent. The losses in both the number of populations and spatial extent indicate that the redundancy of B. franklini has declined significantly since the late 1990's (USFWS, 2018).

Population Narrative:

Bombus franklini has long been considered a rare or vary rare species, with a relatively small population size and relatively small colony size compared to other Bombus species (Thorp, pers. comm. 2017; Hatfield, pers. comm. 2017). No more than 356 individuals have been observed in total, and no more than 98 total individuals at eight separate locations have been observed in any one year (Xerces Soc. and Thorp 2010, p. 7; Occurrence Table, Appendix 1). We have no definitive information on the minimum number of colonies or minimum habitat patch size for a self-sustaining population of B. franklini. Despite the fact that some high quality habitat with diverse floral resources and available nesting and overwintering sites appears to be available in the historic range of B. franklini, no individuals of the species have been found in any habitat since 2006. The resiliency of B. franklini has declined significantly since the late 1990's. The vulnerability resulting from B. franklini's genetic system and the loss in the spatial extent of its populations suggest the representation of B. franklini has declined significantly since the late 1990’s. We cannot identify any current healthy populations distributed across any spatial extent. The losses in both the number of populations and spatial extent indicate that the redundancy of B. franklini has declined significantly since the late 1990’s. (USFWS, 2018)

Threats and Stressors

Stressor: Pathogens
Exposure:
Response:
Consequence:
Narrative: Known pathogens occur within the historical range of Bombus franklini, and we have evidence of several pathogens infecting closely related species within that range. Although we have no direct evidence of pathogens playing a role in the decline of B. franklini, the disappearance of B. franklini occurred soon after a period of potential exposure to introduced pathogens, particularly Nosema bombi which is known to have a more severe impact on rare species like B. franklini. Decline of other closely related pollinators has been associated with these pathogens and it is highly likely the factor has had some negative influence on the health of B. franklini populations. (USFWS, 2018)

Stressor: Pesticides
Exposure: Bumble bee exposure to pesticides can occur from direct spray or drift (Johansen and Mayer 1990), or from gathering or consuming contaminated nectar or pollen (Morandin et al. 2005, p. 619). (USFWS, 2018)
Response:
Consequence:
Narrative: While the rapid decline of Bombus franklini observations occurred shortly after the introduction of neonicotinoid pesticide use within the historic range of the species, the exponential growth of neonicotinoid applications starting in 2011 took place five years after the last observation of the species so it is unlikely that the introduction and use of neonicotinoid pesticides alone can account for the decline in B. franklini. There have been no studies on the effects of pesticide use on B. franklini, no documented discoveries of any B. franklini injured or killed by pesticides. Furthermore, the species is a habitat generalist and is not known to have a close association with agricultural lands so it may have less exposure to pesticides than some other Bombus species. However, pesticide use does occur in the range of B. franklini and confirmed effects to honey bees and other Bombus species suggests that pesticide use could have been a factor in the decline of B. franklini. The similarity in foraging traits that B. franklini has with both honey bees and the other Bombus species (e.g., generalist foragers collecting pollen from similar food sources) allows us to infer that that B. franklini would suffer exposure to and impacts from pesticides in similar measure to other Bombus species when B. franklini is in areas where pesticides are applied. (USFWS, 2018)

Stressor: Small Population Dynamics
Exposure:

Response:
Consequence:
Narrative: Although we have no direct evidence that small population size or a rapid extinction vortex contributed to the decline of the species, the genetic system and historically small population size of B. franklini likely heightened the species' vulnerability to other stressors in the environment.

Stressor: Agricultural Intensification
Exposure:
Response:
Consequence:
Narrative: Agricultural intensification can result in habitat loss for bumble bees, as these practices often result in the planting of monocultures that tend to provide floral resources for a limited period of time, rather than throughout the colony's life cycle. Agricultural intensification can negatively impact wild bees by reducing floral resource diversity and abundance (Service 2018a, p. 32). Agricultural intensification was determined to be a primary factor leading to the local extirpation and decline of bumble bees in Illinois (Grixti et al. 2009, p. 75). An increased use of herbicides often accompanies development and agricultural intensification, and the widespread use of herbicides in agricultural, urban, and even natural landscapes has led to decreases in flowering plants (Potts et al. 2010, p. 350). Within the historical range of the Franklin's bumble bee, total acres in agricultural cropland decreased in all three counties in Oregon (Douglas, Jackson, and Josephine) by greater than 50 percent from 1997 to 2012 (U.S. Department of Agriculture—National Agriculture Statistics Service 2017, pers. comm.; Service 2018a, p. 33). While the total number of acres of agricultural cropland is not synonymous with agricultural intensification (specifically, the expansion of monocultures), a decrease in total acres of agriculture leads us to conclude that agricultural intensification was not likely a factor in the decline of the Franklin's bumble bee. We have no documentation in our files or any direct evidence that agricultural intensification has contributed to the decline of the Franklin's bumble bee or will increase in the future to a degree that may affect the viability of the species. Approximately 42 percent of sites where Franklin's bumble bees have ever been reported (18 of 43) occur on federally owned land, primarily U.S. Forest Service and Bureau of Land Management land; very little habitat on these lands has been permanently altered or lost through agricultural intensification (Service 2018a, p. 32) (USFWS, 2021).

Recovery

Conservation Measures and Best Management Practices:

- Action Plan: The purposes of the actions outlined below are to: (1) locate populations of Franklin's bumble bee on the landscape; (2) reduce known threats to Franklin's bumble bee within the historical range of the species; and (3) fill critical knowledge gaps in our understanding of the species. Species-specific conservation actions could be further developed and implemented when the species is located, based on habitat conditions and land ownership. (1) Locate populations of Franklin's bumble bee. (a) Continue annual surveys. (b) Refine the existing habitat model with feedback from on-the-ground surveys to identify highest priority habitats. (c) Delineate initial high-priority habitats for future surveys. (d) Work with conservation partners and local stakeholders to continue expanding the overall survey effort; this includes support for the Pacific Northwest Bumble Bee Atlas projects and other citizen science efforts. (e) Work with partners to support additional survey methodologies, including the use of eDNA techniques and possibly the use of detection dogs. (2) Reduce known threats to Franklin’s bumble bee. (a) Work with Federal land managers via Section 7 of the ESA to limit habitat disturbance and modification that may impact Franklin’s bumble bees in high-priority habitats. (b) Support the development of State restrictions and regulations on the import, export, and interstate movement of commercial pollinators. (c) Support the development of common-sense pesticide use restrictions. (d) Work closely with stakeholders to limit further spread of pathogens, including but not limited to equipment sterilization protocols between surveys and efforts to minimize the spread of invasive species. (3) Fill critical knowledge gaps in our understanding of the species. (a) Support ongoing research on closely-related species, specifically those projects researching queen bumble bee behavior and ecology. 3) Preliminary Steps for Recovery Planning Will a recovery plan be developed: Yes, a recovery plan for Franklin’s bumble bee will be developed with stakeholder and partner input. Type of recovery plan: Single species Who will develop the recovery plan: Jeff Everett, with input and support from Service staff currently working on status reviews and recovery planning for closely related species, including rusty-patched bumble bee and western bumble bee. Input will also be requested from pollinator conservation experts from non-Federal entities and from Tribes within the species’ range. Plan for stakeholder role/involvement: A draft recovery plan will be reviewed first by agency staff and then by key stakeholders and peer reviewers – including non-agency staff, taxonomic and pollinator conservation experts – before it is made available for public review and comment. Recovery planning milestones: A draft recovery plan is expected to be completed by March 2022, with peer and partner review completed by August 2022, in anticipation of a Notice of Availability being published in the Federal Register in September 2022, giving the public an opportunity to review and provide comments on the draft recovery plan before it is finalized. (USFWS, 2021a)

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SPECIES ACCOUNT: *Brychius hungerfordi* (Hungerford's crawling water Beetle)

Species Taxonomic and Listing Information

Commonly-used Acronym: HCWB

Listing Status: Endangered; Great Lakes-Big Rivers Region (R3) (USFWS, 2015)

Physical Description

Adult Hungerford's crawling water beetles are small, with an average body length of 3.8-4.3 mm. They have a distinctive elongated and streamlined body shape, adapted for swimming or crawling in water (Holmen 1987). They are yellowish-brown in color with irregular dark markings and longitudinal stripes on the elytra (hardened outer wings), each of which is comprised of a series of fine, closely spaced and darkly pigmented indentations. Adults have large hind coxal plates covering the base of their hind legs and abdomen. Hungerford's crawling water beetle larvae are light yellowish brown with cylindrical bodies that taper to a hooked tail. They are stiff-bodied and possess short legs with five-segments and single tarsal hooks (Strand 1989).

Taxonomy

Hungerford's crawling water beetle (Brychius hungerfordi) is a member of the Haliplidae family. All members of the Haliplidae (collectively known as haliplids) are aquatic, with all active life history stages spent in water (Pennak 1953, Roughley and Larson 1991). The Haliplidae includes three genera in North America—Brychius, Haliplus, and Peltodytes.

Current Range

Hungerford's crawling water beetle was discovered only relatively recently, in 1952. The species has a limited geographic range, being known only from a few populations in northern Michigan and across the border in Canada. Whether the species may have historically been more widespread is unknown. In an effort to determine the historical distribution, museums and collections were examined for species of Brychius. The U.S. Geological Survey's Great Lakes Science Center reported finding two Brychius larvae in 1983 in St. Clair River (Hudson et al. 1986). This is a curious record because St. Clair River is not similar to other known Hungerford's crawling water beetle sites and would not be classified as suitable habitat based on our current understanding of the species. Surveys in 2002 were unsuccessful in locating HCWB larvae in St. Clair River (Patrick Hudson, USGS-Great Lakes Science Center, pers. comm. 2002). HCWB is known to occur in eleven streams range-wide; eight of these locations are in northern Michigan and three are in Ontario, Canada. The Service has not designated critical habitat for this species. The status of HCWB at each of its known occupied sites is described below. Charlevoix County, Michigan North Branch of Boyne River – A single HCWB larva was found near a beaver dam on the North Branch of Boyne River in April 2011 (Ebbers, pers. comm. 2011). This was the first record for HCWB in this river. Although the identification of the larva as HCWB was confirmed, subsequent surveys failed to find more individuals—adults or larvae—of this species (Grant et al.

2011b). The status of HCWB in this system is uncertain. Emmet County, Michigan East Branch of Maple River – HCWB was originally discovered in the East Branch of Maple River in 1952 (Spangler 1954). The beetle is found in several areas of the river from the Douglas Lake Road crossing downstream for approximately 2.5 miles until near the pipeline crossing. The majority of occupied portions of this stream occur within and along the boundary of the University of Michigan Biological Station (UMBS). The East Branch of Maple River is the best-studied site and has the largest known population of this species. The results of a mark-recapture study in one pool indicated population numbers near 1,000 (Grant et al. 2002). Because HCWB occurs in several pools in this system, we expect that the population in the East Branch of Maple River is greater than 1,000 individuals. Based on recent studies, populations of HCWB appear to be stable throughout the occupied portions of this stream. Carp Lake River – Hungerford's was discovered at this site in 1997 when four adults were found below the culvert at the Oliver Road crossing. In 1998, the Emmet County Road Commission cleared the vegetation from the road ditches along Oliver Road, which resulted in increased erosion and sedimentation of the stream (Vande Kopple and Grant 2004). This led to a loss of some suitable habitat. Surveys conducted in 1998 did not find any HCWB. One adult was found in a survey in 1999 (Hinz, Jr. and Wiley 1999). None were found during surveys conducted in 2003 (Vande Kopple and Grant 2004). In 2004, only one adult HCWB was found at the Oliver Road crossing on two separate occasions in August and September, despite several hours of searching (Ebbers, pers. comm. 2004). In 2006, 28 beetles were collected from the Oliver Road site and were moved upstream to the Gill Road site as part of bridge construction at Oliver Road. Surveys in 2011 found four adult beetles at this site for the first time since construction of the new bridge in 2006 (Grant et al. 2011b). The Gill Road site, approximately three miles upstream of Oliver Road, was discovered in September 2004. Suitable habitat for HCWB generally extends from just upstream of Gill Road to approximately 0.8 mile downstream. The Gill Road pool is immediately downstream of the perched culverts at Gill Road where the original survey attempt in 2004 found five beetles in approximately ten minutes (Ebbers, pers. comm. 2004). Currently, the habitat at the Gill Road site is better overall and appears to support the greatest number of beetles in Carp Lake River (Ebbers, pers. comm. 2004). Recent surveys in 2009 have since found 29 adults at Gill Road and eight individuals upstream and downstream of Gill Road (Grant et al. 2009a). The overall numbers of beetles in this stream, although small, appear to be stable. Because they are difficult to find during surveys and the Gill Road site has not yet been extensively surveyed, it is likely that there are at least dozens to hundreds of individuals throughout Carp Lake River within suitable habitat. Montmorency County, Michigan East Branch of Black River – This site is approximately 2.5 miles upstream from the Barber Bridge (Strand 1989). Only two adults were found during surveys in 1989 (Strand 1989). Surveys conducted by MNFI in 1996 found two adults at this same location and one adult farther downstream, closer to the Barber Bridge (Legge 1996). The current status of this site is unknown. Van Hellon Creek (Van Hetton Creek) – In July 1999, six adult beetles were found along a stretch of Van Hellon Creek. The beetles were dispersed along a stretch of creek several hundred meters in length (Grant et al. 2000), beginning approximately 30-50 yards downstream of a culvert and county road crossing (Vande Kopple, pers. comm. 1999). Three beetles were found in less than ten minutes at this site in 2004 (Carrie Tansy, U.S. Fish and Wildlife Service, pers. comm. 2004), and one was found during a brief survey effort in 2005 (Bruce Walker, Michigan Department of Environmental Quality, pers.

comm. 2005). In 2010, the culvert at the Roth Road crossing was replaced with a larger culvert. Three adult beetles were removed from the site before construction and relocated 0.5 mile downstream where a population of HCWB had been confirmed. Post-construction surveys in 2011 found five adult beetles immediately below the new culvert. Canada Creek – Two adults and one larva were found in Canada Creek, downstream of Highway 622, in July 2007 (Vande Kopple 2007). Additional information about this site is below under Presque Isle County, Michigan. Stewart Creek – In July 2009, four adults were found in Stewart Creek upstream and downstream of the Blue Lakes Road crossing (Grant et al. 2009b). Searching was confined to the immediate vicinity of the road culvert. Oscoda County, Michigan Middle Branch of Big Creek – In August 2011, ten adults were found in the Middle Branch of Big Creek from the tail end of a plunge pool below the Farrington Road culvert to roughly 20 feet downstream from the culvert end (Grant et al. 2011a). The Big Creek record represents a new watershed (AuSable River) for HCWB, as well as an expansion of its geographic range beyond the outer Port Huron moraine (Grant et al. 2011a). Presque Isle County, Michigan Canada Creek – In June 2005, a new site was discovered that expanded the previously known range for this species. One adult beetle was discovered in Canada Creek, just upstream from the Bear Den Road crossing (Vande Kopple, pers. comm. 2005; Walker, pers. comm. 2005). It is possible that the beetle was washed from an area upstream to the location in which it was discovered, as the beetle was found following a significant rain event (Vande Kopple, pers. comm. 2005). Bruce County, Ontario North Saugeen River – In 1986, 42 specimens were collected at this site in Bruce County in south central Ontario, near the village of Scone (Roughley 1991). This location is downstream from a dam and below an old millrace (Roughley 1991). The last time the species was found was in 2001; this population may be extirpated (Colin Jones, Ontario Ministry of Natural Resources, pers. comm. 2010). Rankin River – This site is below the Rankin Dam. A single adult specimen was found in a survey in 2005 and later identified as HCWB. When the site was visited again in August 2008, ten adults and three larvae were detected in four kick-samples with a D-net (Jones, pers. comm. 2010). Saugeen River – Located at Hanover, this population was discovered in 2008. Only a few adults have been located per visit (Jones, pers. comm. 2010).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Although their dietary requirements are not fully understood, a preliminary study indicates that the most likely food sources for HCWB adults are Spirogyra, lithophilic diatoms or Cocconeis (Grant and Vande Kopple 2003). The diet of adults may change seasonally (Grant and Vande Kopple 2003). Further work by Grant and Vande Kopple (2009) utilized stable isotopes to analyze feeding behavior of HCWB. They found that an alga, Dichotomosiphon, represents the primary food choice for larval HCWB but adults feed more generally than do their larvae.

Reproduction Narrative

Adult: Reproduction in haliplids usually occurs in the spring and early summer. Mating has been observed in June for B. hungerfordi (Scholtens 2002) and B. hornii (Mousseau and Roughley 2003), but optimal breeding activity for HCWB may begin in early to mid-July and continue into early August (Grant et al. 2009b). Other species in the Haliplidae have at least one generation in the summer and likely another in the late summer or fall (Hickman 1931). Observations of HCWB in the East Branch of Maple River suggest that they may have two generations per year, with adults emerging in early spring (May) and a second brood of adults emerging late in the season (August) (Grant et al. 2000; Bert Ebbers, Great Lakes Ecosystems, pers. comm. 2004). Adults of HCWB have been found year round, suggesting that some adults survive the winter, even beneath ice cover (Grant et al. 2000). HCWB, like all beetle species, undergoes complete metamorphosis with a life cycle that consists of four distinct stages. In general, the period of egg laying for haliplids extends from May through June, although there may be another generation in the fall for some species (Hickman 1931, Brigham 1982). Oviposition (egg-laying) has not been observed for any species of Brychius, nor has the egg stage been described. Eggs of haliplids generally hatch 8-14 days after oviposition (Brigham 1982, White et al. 1984). Haliplid larvae pass through three instars and are herbivorous. In Brychius hornii, the first two instars occur in July, and the third instar stage lasts from August to April (Mousseau and Roughley 2003). HCWB larvae have been found in or near direct current in association with algae in the genus Chara, which probably provides cover for the larvae (Grant et al. 2009b). When mature, larvae leave the water in search of a place in damp soil to pupate. In the fall, larvae of HCWB have been found away from the current, buried in an island of damp sand and Chara up to 15 cm above the water line (Strand and Spangler 1994). Other haliplids overwinter in the larval stage in position for spring pupation. The pupal stage is the only one spent in a terrestrial setting. This stage lasts two to three weeks (Pennak 1953), during which time the transformation to adult takes place. The pupal stage of HCWB has not been observed.

Habitat Narrative

Adult: Populations of HCWB are found downstream from culverts, beaver and natural debris dams, and human-made impoundments. They are found in plunge pools created below these structures, as well as in riffles and other well-aerated sections of the stream. In general, HCWB is found in areas of streams characterized by moderate to fast stream flow, good stream aeration, inorganic substrate, and alkaline water conditions (Wilsmann and Strand 1990). The adult beetles are generally found at depths of a few inches to a few feet in streams that are relatively cool (15º C to 25º C) (Wilsmann and Strand 1990). The hydrology of a site appears to be important for this species. HCWB seems to prefer seasonal streams that have some groundwater input. These streams do not dry up completely, but the water level can drop considerably (e.g., several feet in the East Branch of the Maple River) (Vande Kopple and Grant 2004). As the water levels drop, damp river edge sand becomes exposed in the summer and fall (Vande Kopple and Grant 2004). This microhabitat may be important for the pupation stage of the life cycle. Despite some research examining habitat and microhabitat components, the habitat requirements of the species are not fully understood. It has been speculated that beaver are important for creating and maintaining habitat for HCWB. Recently, however, researchers have begun to question whether beaver have positive effects on habitat for HCWB (Bob Vande Kopple, University of Michigan Biological Station, pers. comm. 2004; Ebbers, pers. comm. 2004;

Scholtens, pers. comm. 2004). Although a beaver dam typically creates good habitat immediately below the structure, it often eliminates suitable habitat for many miles upstream and can result in considerable siltation downstream. The two most recently discovered sites -- Middle Branch of Big Creek in Oscoda County, and Portage Creek in Kalkaska County -- are farther south in Michigan than other HCWB populations (Grant et al. 2011; Dingledine 2019). For the first time, these new discoveries put the species outside of the Port Huron Moraine (moraines are landforms created by ridges of glacial till that formed at the edge of retreating glaciers), which may have implications for its historical biogeography. (USFWS, 2021)

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Increasing (USFWS, 2021)

Number of Populations:

13 (USFWS, 2021)

Population Narrative:

Hungerford's crawling water beetle was discovered only relatively recently, in 1952. The species has a limited geographic range, being known only from a few populations in northern Michigan and across the border in Canada. Whether the species may have historically been more widespread is unknown. In an effort to determine the historical distribution, museums and collections were examined for species of Brychius. The U.S. Geological Survey's Great Lakes Science Center reported finding two Brychius larvae in 1983 in St. Clair River (Hudson et al. 1986). This is a curious record because St. Clair River is not similar to other known Hungerford's crawling water beetle sites and would not be classified as suitable habitat based on our current understanding of the species. Surveys in 2002 were unsuccessful in locating HCWB larvae in St. Clair River (Patrick Hudson, USGS-Great Lakes Science Center, pers. comm. 2002). HCWB is known to occur in eleven streams range-wide; eight of these locations are in northern Michigan and three are in Ontario, Canada. The Service has not designated critical habitat for this species. The status of HCWB at each of its known occupied sites is described below. Charlevoix County, Michigan North Branch of Boyne River – A single HCWB larva was found near a beaver dam on the North Branch of Boyne River in April 2011 (Ebbers, pers. comm. 2011). This was the first record for HCWB in this river. Although the identification of the larva as HCWB was confirmed, subsequent surveys failed to find more individuals—adults or larvae—of this species (Grant et al. 2011b). The status of HCWB in this system is uncertain. Emmet County, Michigan East Branch of Maple River – HCWB was originally discovered in the East Branch of Maple River in 1952 (Spangler 1954). The beetle is found in several areas of the river from the Douglas Lake Road crossing downstream for approximately 2.5 miles until near the pipeline crossing. The majority of occupied portions of this stream occur within and along the boundary of the University of Michigan Biological Station (UMBS). The East Branch of Maple River is the best-studied site and has the largest known population of this species. The results of a mark-recapture study in one pool indicated population numbers near 1,000 (Grant et al. 2002). Because HCWB occurs in several pools in this system, we expect that the population in the East Branch of Maple River is greater than 1,000 individuals. Based on recent studies, populations of HCWB appear to be stable throughout the occupied portions of this stream. Carp Lake River – Hungerford's was discovered at this site in 1997 when four adults were found below the culvert at the Oliver Road crossing. In 1998, the Emmet County Road Commission cleared the vegetation from the road ditches along Oliver Road, which resulted in increased erosion and sedimentation of the stream (Vande Kopple and Grant 2004). This led to a loss of some suitable habitat. Surveys conducted in 1998 did not find any HCWB. One adult was found in a survey in 1999 (Hinz, Jr. and Wiley 1999). None were found during surveys conducted in 2003 (Vande Kopple and Grant 2004). In 2004, only one adult HCWB was found at the Oliver Road crossing on two separate occasions in August and September, despite several hours of searching (Ebbers, pers. comm. 2004). In 2006, 28 beetles were collected from the Oliver Road site and were moved upstream to the Gill Road site as part of bridge construction at Oliver Road. Surveys in 2011 found four adult beetles at this site for the first time since construction of the new bridge in 2006 (Grant et al. 2011b). The Gill Road site, approximately three miles upstream of Oliver Road, was discovered in September 2004. Suitable habitat for HCWB generally extends from just upstream of Gill Road to approximately 0.8 mile downstream. The Gill Road pool is immediately downstream of the perched culverts at Gill Road where the original survey attempt in 2004 found five beetles in approximately ten minutes (Ebbers, pers. comm. 2004). Currently, the habitat at the Gill Road site is better overall and appears to support the greatest number of beetles in Carp Lake River (Ebbers, pers. comm. 2004). Recent surveys in 2009 have since found 29 adults at Gill Road and eight individuals upstream and downstream of Gill Road (Grant et al. 2009a). The overall numbers of beetles in this stream, although small, appear to be stable. Because they are difficult to find during surveys and the Gill Road site has not yet been extensively surveyed, it is likely that there are at least dozens to hundreds of individuals throughout Carp Lake River within suitable habitat. Montmorency County, Michigan East Branch of Black River – This site is approximately 2.5 miles upstream from the Barber Bridge (Strand 1989). Only two adults were found during surveys in 1989 (Strand 1989). Surveys conducted by MNFI in 1996 found two adults at this same location and one adult farther downstream, closer to the Barber Bridge (Legge 1996). The current status of this site is unknown. Van Hellon Creek (Van Hetton Creek) – In July 1999, six adult beetles were found along a stretch of Van Hellon Creek. The beetles were dispersed along a stretch of creek several hundred meters in length (Grant et al. 2000), beginning approximately 30-50 yards downstream of a culvert and county road crossing (Vande Kopple, pers. comm. 1999). Three beetles were found in less than ten minutes at this site in 2004 (Carrie Tansy, U.S. Fish and Wildlife Service, pers. comm. 2004), and one was found during a brief survey effort in 2005 (Bruce Walker, Michigan Department of Environmental Quality, pers. comm. 2005). In 2010, the culvert at the Roth Road crossing was replaced with a larger culvert. Three adult beetles were removed from the site before construction and relocated 0.5 mile downstream where a population of HCWB had been confirmed. Post-construction surveys in 2011 found five adult beetles immediately below the new culvert. Canada Creek – Two adults and one larva were found in Canada Creek, downstream of Highway 622, in July 2007 (Vande Kopple 2007). Additional information about this site is below under Presque Isle County, Michigan. Stewart Creek – In July 2009, four adults were found in Stewart Creek upstream and downstream of the Blue Lakes Road crossing (Grant et al. 2009b). Searching was confined to the immediate vicinity of the road culvert. Oscoda County, Michigan Middle Branch of Big Creek – In August 2011, ten adults were found in the Middle Branch of Big Creek from the tail end of a plunge pool below the Farrington Road culvert to roughly 20 feet downstream from the culvert end (Grant et al. 2011a). The Big Creek record represents a new watershed (AuSable River) for HCWB, as well as an expansion of its geographic range beyond the outer Port Huron moraine (Grant et al. 2011a). Presque Isle County, Michigan Canada Creek – In June 2005, a new site was discovered that expanded the previously known range for this species. One adult beetle was discovered in Canada Creek, just upstream from the Bear Den Road crossing (Vande Kopple, pers. comm. 2005; Walker, pers. comm. 2005). It is possible that the beetle was washed from an area upstream to the location in which it was discovered, as the beetle was found following a significant rain event (Vande Kopple, pers. comm. 2005). Bruce County, Ontario North Saugeen River – In 1986, 42 specimens were collected at this site in Bruce County in south central Ontario, near the village of Scone (Roughley 1991). This location is downstream from a dam and below an old millrace (Roughley 1991). The last time the species was found was in 2001; this population may be extirpated (Colin Jones, Ontario Ministry of Natural Resources, pers. comm. 2010). Rankin River – This site is below the Rankin Dam. A single adult specimen was found in a survey in 2005 and later identified as HCWB. When the site was visited again in August 2008, ten adults and three larvae were detected in four kick-samples with a D-net (Jones, pers. comm. 2010). Saugeen River – Located at Hanover, this population was discovered in 2008. Only a few adults have been located per visit (Jones, pers. comm. 2010). Hungerford's crawling water beetle occurs in northern Michigan and the Bruce Peninsula of Ontario. The known distribution of the species has increased from 3 known populations at the time of listing to 13 populations at the time of this 5-year review (Figure 1). The current U.S. populations are distributed across seven watersheds (at the HUC 10 level) (Figure 2). Since the last 5-year review, two new populations have been discovered in northern Michigan in Portage Creek in Kalkaska/Crawford Counties and Mullet Creek in Cheboygan County. The Mullet Creek record is from a specimen collected in 2009 but was not identified as HCWB until 2020 (USFWS, 2021).

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: At the time of listing in 1994 (59 FR 10580), HCWB was known to occur in only three isolated locations, despite extensive surveys in Michigan, Wisconsin, Minnesota, and Ontario. The listing rule cites the research results of Wilsmann and Strand (1990), which indicated the rarity of the species and its geographic isolation. The Service analyzed the status survey, as well as other information, and determined that the beetle is facing serious threats and should be protected as an endangered species (USFWS 1994). The listing rule speculated that human

activities, such as fish management, logging, beaver control, dredging, stream pollution, and general stream degradation, have likely contributed to the reduction of HCWB habitat (Wilsmann and Strand 1990). Other threats could include amateur collections, disease, or predation. More information on the species' habitat requirements and life history is needed to understand the threats to HCWB more fully. In general, threats to the species include any activities that degrade water quality or remove or disrupt the pools and riffle environment of streams in which this species lives.

Stressor: Insect Collections (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Macroinvertebrates are indicators of water quality and are regularly monitored throughout the region where HCWB occurs. Many protocols include collection (specimens are placed in a vial in isopropyl alcohol). Specimens are identified only to family (e.g., Haliplidae), often by volunteers with limited training, and some HCWB may be inadvertently collected. In fact, this has happened at least a couple of times since HCWB was listed (discussed above). Outreach is planned in 2021 to increase awareness of the endangered status of HCWB, how to easily identify HCWB, and encourage survey crews to identify all Haliplids to species before collecting (and instead photo document, if unsure); this could greatly reduce this threat and potentially increase our knowledge of the species' distribution. (USFWS, 2021)

Stressor: Lampricides (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: The use of lampricides for the control of sea lamprey has been identified as a potential concern for HCWB, and the Service has concluded that the lampricide, 3-trifluoromethyl-4-nitrophenol (TFM), is likely to cause harm to HCWB (USFWS 2004). No new TFM treatments have been proposed within known occupied HCWB streams since the last 5-year review, and none are planned currently, but future treatments could be necessary if sea lamprey populations increase in HCWB streams.

Recovery

Reclassification Criteria:
Criterion 1. Life history, ecology, population biology, and habitat requirements are understood well-enough to fully evaluate threats As discussed throughout this Recovery Plan, little is known about important components of the species' life history, ecology, population biology, and habitat requirements. Recovery of this species will require a better understanding of these parameters so that we may gain a better understanding of current threats and develop strategies to minimize threats. To meet this recovery criterion, we must understand the biology of and threats to the species well enough to allow for a current threats assessment. In order to adequately assess threats to the species, further research is necessary (as outlined in Recovery Action 2 of

the Stepdown Outline and Narrative). Based on the additional information on life history, ecology, population biology, genetic variability, and habitat requirements, and the resulting outcome of a complete threats assessment, we will determine if additional Recovery Criteria are necessary for reclassification or delisting. The interim Recovery Criteria will be revised as needed.

Criterion 2. A minimum of five U.S. populations, in at least three different watersheds, have had stable or increasing populations for at least 10 years, and at least one population is considered viable We will consider population numbers as stable or increasing when regression analysis or other appropriate statistical tests reveal a positive trend (e.g., slope greater than 0 for a linear trend) with 95% confidence, or alternatively, sufficient data are available to use population viability analysis. At least three populations must occur in different watersheds—hydrologically distinct areas of the Great Lakes basin—in order to ensure preservation of the species in the event of a catastrophic event in one watershed. The specific characteristics of a viable B. hungerfordi population are unknown and will be the focus of future research. It is likely that “viability” will require consistently large numbers of beetles widely distributed within a stream or watershed, evidence of reproduction, and relatively extensive suitable habitat. Currently, the East Branch of the Maple River is the only stream that appears to support a viable population of B. hungerfordi. Thus, conservation of this stream is critical to recovery of the species. Brychius hungerfordi will be considered for delisting when all of the above Criteria (1-2) are achieved, plus:

Delisting Criteria:
Criterion 3. Habitat necessary for long-term survival and recovery has been identified and conserved Research is needed to fully understand the habitat requirements of the species. For example, we must understand the various microhabitat needs of each stage of the species’ life cycle. Once we understand the habitat requirements of the species, we can identify areas necessary for long-term survival and recovery. Those areas of habitat will be conserved by minimizing physical disturbances. This criterion will be met when land adjacent to populations identified for recovery has been protected from disturbances through long-term voluntary landowner agreements such as stewardship plans, easements, and memorandums of agreement that promote best management practices. It is also prudent to conserve areas upstream from these sites, as sedimentation may also be a threat. In addition to areas adjacent to populations identified for recovery, riparian zones up to 0.25 miles upstream of these areas should be similarly conserved.

Criterion 4. A minimum of five U.S. populations, in at least three different watersheds, are sufficiently secure and adequately managed to assure long-term viability More information is needed to determine what constitutes long-term viability. Each of the five populations must be of sufficient size to persist despite demographic, environmental, and genetic uncertainty and there must be evidence of reproduction, within each, sufficient to maintain a self-sustaining population. At this time we can not identify a minimum population size, nor can we quantify what constitutes reproduction sufficient for a self-sustaining population. This criterion will be revised based on the results of research as appropriate. As new information about the species becomes available, Recovery Criteria will be revised and finalized.

Conservation Measures and Best Management Practices:

- Highest priority recovery actions identified in the Recovery Plan for the next 5 years: • 1.5.2. Conduct restoration activities that result in overall benefits to the watershed after ensuring benefits to HCWB outweigh risks • 2.1. Conduct studies to examine life history and ecology • 2.2. Examine habitat requirements • 2.4. Conduct studies to examine population dynamics and demography • 2.5. Investigate genetic heterogeneity and population viability • 3.2. Continue to survey new locations to identify new populations or areas of suitable habitat • 3.3. Develop and implement a monitoring plan for all known sites • 4. Develop and implement public education and outreach

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SPECIES ACCOUNT: *Callophrys mossii bayensis* (San Bruno elfin butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 1, 1976 (41 FR 22041).

Physical Description

The San Bruno elfin is a small butterfly with a wingspan of 2.0 to 2.4 centimeters (0.75 to 1 inch). In adults, the wings are brown on the dorsal side and coppery brown to purplish brown on the ventral side, marked by an uneven dark line that separates the inner and outer halves of the wings. On the hindwing, the inner half is darker than the outer half. The dorsal side of the male is grayish brown, with a tan patch on hindwing inner margin; on the female, it is light brown to tan with dark borders (USFWS 2010; Xerces Society 2015). Larvae are dichromatic, either red or yellow (USFWS 1984).

Taxonomy

The San Bruno elfin was originally described as Callophrys fotis bayensis, but was later recognized to be the species C. mossii (now genus Incisalia). However, some include Incisalia with Callophrys (USFWS 2010).

Historical Range

San Bruno elfin historically occurred on hilltops and ridges throughout much of northern San Mateo County, up (northward) the San Francisco Peninsula to southern Marin County (USFWS 1984).

Current Range

The San Bruno elfin is now found on San Bruno Mountain, Milagra Ridge, Montara Mountain, Peak Mountain, and Whiting Ridge in San Mateo County (USFWS 1984).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: San Bruno elfin larvae are herbivores, and the caterpillars only eat the larval host plant stonecrop (Sedum spathulifolium). Stonecrop is a low-growing succulent associated with rocky outcrops that occur at 274 to 328 m (900 to 1,075 ft.) elevation, and has a limited distribution in San Bruno elfin habitat. First and second instar larvae start to feed immediately on the succulent leaves. Third and fourth instar move up the plant to feed on the flowers when they bloom (USFWS 2010; Xerces 2015).

Adult: San Bruno elfin butterflies are nectarivores; adults feed on flowering plants with small inflorescences, particularly in the carrot (Apiaceae) and sunflower (Asteraceae) families. However, adult food plants have not been fully determined. Montara Mountain colonies are suspected to use Montara Mountain manzanita (Arctostaphylos montaraensis) and huckleberry (Vaccinium ovatum). Even while feeding, adult San Bruno elfin tend not to wander far from the areas containing the larval host plant (USFWS 2010; USFWS 2015).

Reproduction Narrative

Larvae: By the time the third instar is attained, stonecrop has sprouted flowering stalks that are beginning to bloom. Third instar larvae crawl up the flowering stalks and feed on the flower heads until they mature. Larval development is generally completed by late May or early June, at which time the larvae descend to the ground and enter pupal diapause in loose soil and leaf litter. The larval stage lasts 2 to 4 months; the pupal stage lasts 9 to 10 months. They lie dormant until the following February or March, when they emerge as adult butterflies. Larvae spend their entire time on the larval host plant, stonecrop (Sedum spathulifolium) (USFWS 2010; USFWS 1984).

Adult: The breeding season for San Bruno elfin occurs during the later part of the rainy season in northern California, in late February to mid-April, but before the onset of persistent summer fog. Adults typically appear after the first extended warm sunny period of the season, as early as the first week in February, or as late as April. The window of sunny, calm conditions during the flight season is highly variable from year to year, and adults run the risk of being grounded by inclement weather for weeks on end. Peak emergence occurs in mid-March. Courtship, mating, and reproduction are all carried out in the immediate space around the only known larval host plant, stonecrop (Sedum spathulifolium). Males perch on exposed and elevated surfaces, particularly branches of nearby coastal chaparral species, and fly out to encounter passing insects and contact receptive females. When contact occurs, the male releases a pheromone, and both sexes perch on the stonecrop together and copulate. Males then resume the "perch/encounter" behavior, seeking subsequent mates. Both sexes may mate more than once. Several dozen eggs are laid on the upper or lower surface of the stonecrop. Males tend to live longer (range of means: 3.1 to 8.3 days) than females (range of means: 2.5 to 10.8 days).Reproductive asynchrony, which occurs when individuals are reproductively active at different times within a larger population-level reproductive period, as is the case with the San Bruno elfin, can decrease the number of males a female overlaps with in her lifetime. This in turn decreases the average probability of mating per male/female pair that does overlap, and may leave some females completely isolated (USFWS 1984; USFWS 2010).

Geographic or Habitat Restraints or Barriers

Larvae: San Bruno elfin are limited to the sufficient ranges of stonecrop (Sedum spathulifolium). Some patches of stonecrop can be too small to support viable colonies of the San Bruno elfin (USFWS 2010).

Adult: Urban area, stonecrop (Sedum spathulifolium) (host plant): San Bruno Mountain and Milagros Ridge are surrounded by urban areas; limited to the sufficient range of stonecrop. Some patches of stonecrop can be too small to support viable colonies of the San Bruno elfin (USFWS 2010).

Spatial Arrangements of the Population

Larvae: Clumped according to resources.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: Narrow

Adult: Narrow; populations of the San Bruno elfin butterfly correspond closely to patches of the larval host plant, which range from a hundred square m to several hectares in extent (USFWS 2010).

Tolerance Ranges/Thresholds

Larvae: Low; has very specialized habitat requirements (USFWS 2010).

Adult: Low; has very specialized habitat requirements (USFWS 2010).

Site Fidelity

Larvae: High

Adult: High

Habitat Narrative

Larvae: The San Bruno elfin is a habitat specialist and is found where the limited habitat types and conditions occur. It has high site fidelity and typically occurs in coastal grassland and low scrub of north-facing slopes in the fog belt, where the larval host plant grows. San Bruno elfin larvae populations are clumped and are completely dependent on the presence of the larval host plant stonecrop (Sedum spathulifolium) for a food resource. They spend their entire larval stage on the stonecrop plant. Some patches of stonecrop can be too small to support viable colonies of the species (USFWS 2010).

Adult: The San Bruno elfin butterfly is found in coastal grasslands and coastal chaparral, on steep north-facing slopes, and in the fog-belt of the mountains near San Francisco Bay. It loosely follows the narrow, fragmented distribution of its larval host plant, stonecrop (Sedum spathulifolium). The species occurs on steep-slopes and achieves an elevation of 213 m (700 ft.) at Milagra ridge, at 548 m (1,800 ft.) elevation in the Montara Mountains on Peak Mountain, and on a steep, southeast-facing slope on Whiting Ridge (USFWS 2010). The San Bruno elfin butterfly has very low tolerance and very specialized habitat requirements, and needs stonecrop in its environment for all reproductive activities. The habitat for San Bruno elfin is limited to sufficient stonecrop patches; in addition to San Bruno Mountain being surrounded by urban areas, Milagra Ridge is also surrounded by an urbanized area (USFWS 1984; USFWS 2010). The distribution and dynamics of the San Bruno elfin are influenced by larval host plant health and abundance, nectar source availability, topography, size of available habitat and its degree of isolation from other habitat, and weather (USFWS 2010). Populations of the San Bruno elfin butterfly correspond closely to patches of the larval host plant, which range from a hundred square m to several hectares in extent (USFWS 2010).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Larvae: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Larvae: No

Adult: No

Dispersal/Migration Narrative

Larvae: See Adult life stage.

Adult: All current known populations of the San Bruno elfin are restricted to San Mateo County, California. Several populations are known from San Bruno Mountain, Milagra Ridge, the San Francisco Peninsula Watershed, and Montara Mountain. Each of these locations supports an array of highly local demographic units. Milagra Ridge is relatively isolated from the San Bruno Mountain and San Francisco Peninsula Watershed populations, and the ability of this butterfly to recolonize the site is questionable (USFWS 1984; USFWS 2010). Adults are highly sedentary, typically moving less than 100 m (328 ft.), with a maximum recorded movement of 800 m (2,625 ft.). Males tend to perch more than females, and therefore are expected to fly shorter distances (USFWS 2010; USFWS 2015).

Additional Life History Information

Adult: Adults are highly sedentary, typically moving less than 100 m (328 ft.), with a maximum recorded movement of 800 m (2,625 ft.) (USFWS 2010; USFWS 2015).

Population Information and Trends

Population Trends:

Stable

Species Trends:

Declining

Number of Populations:

Exists in local discrete populations of ten to several hundred adults: 15 subpopulations on San Bruno Mountain; 10 on Montara; and 4 on Milagra (USFWS 2010). Six to 20 occurrences (NatureServe 2015).

Population Size:

1,000 or more adults may exist in a good year on San Bruno Mountain (USFWS 2010). Population size unknown (NatureServe 2015). During capture-recapture studies conducted in 1977, 1978, and 1979, the total yearly populations were estimated at 1,088 adults, 401 adults, and 726 adults, respectively (USFWS 1984).

Adaptability:

Low

Population Narrative:

All known locations are restricted to San Mateo County, California, where several populations are known from San Bruno Mountain, Milagra Ridge, the San Francisco Peninsula Watershed, and Montara Mountain (USFWS 2010). Each of these locations supports an array of highly local demographic units tied together by occasional adult migration. Populations may have once existed in San Francisco at Twin Peaks and Mount Davidson, but have disappeared due to urbanization. The number of populations of the San Bruno elfin butterfly are unknown, but there are thought to be 6 to 20 populations (NatureServe 2015). One thousand or more adults may exist in about 15 total subpopulations on San Bruno Mountain in a good year. Montara Mountain supports about 10 local populations, and Milagra Ridge supports about four (USFWS 2010).During capture-recapture studies conducted in 1977, 1978, and 1979, the total yearly populations were estimated at 1,088 adults, 401 adults, and 726 adults, respectively. Populations of San Bruno elfin are relatively stable, but may drop to significantly low levels during certain years, resulting in a decrease in genetic variability or heterozygosity and an increased threat of extinction due to stochastic events (NatureServe 2015; USFWS 2010).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Urbanization, public infrastructure, recreation.
Response: Reduction in quality habitat.
Consequence: Reduction in population numbers.
Narrative: Road construction, county park development, and quarrying represented the greatest threat of destruction, modification, or curtailment to the habitat of the San Bruno elfin butterfly. Now, due to the larval host plant's affinity for steep, rocky, north-facing slopes and the fact that much of the remaining habitat is on publicly protected lands, suburban development and habitat fragmentation do not represent as big a threat to the San Bruno elfin butterflies' remaining habitat or range. However, although the threat level is low, colonies in the Montara Mountain area appear to be the most susceptible to suburban development due to the large number of privately held parcels in the area. In addition, San Bruno Mountain is a popular site for hiking, picnicking, and other passive forms of recreation. Therefore, the number of human visitors will increase, with adverse effects on the San Bruno elfin butterflies. The effects of pollution and density-dependent trampling from recreation can threaten the San Bruno elfin butterflies. Above all else, public infrastructure construction and improvement projects probably represent the greatest threat San Bruno elfin butterfly habitat (USFWS 2010).

Stressor: Illegal collection
Exposure: Collection of San Bruno elfin.
Response: Mortality
Consequence: Reduction in population numbers.
Narrative: Illegal collection of the San Bruno elfin is currently considered a threat to population numbers. San Bruno elfin are known to have been illegally collected. Small populations of butterflies are vulnerable to harm from collection of adults, and collectors may not always realize they are depleting the population of butterflies to below a threshold limit for the survival or recovery population. Adult specimens of the San Bruno elfin butterflies are highly valued by private collectors, and an international market exists for illegally collected specimens, as well as other listed and rare butterflies (USFWS 2010).

Stressor: Parasites
Exposure: Parasites attack larvae.
Response: Mortality
Consequence: Reduction in population numbers.
Narrative: Many of the San Bruno elfin butterfly larvae (50 to 80 percent) are parasitized by a tachinid fly (Aplomya theclarum). Although a facultative myrmecophile, parasitism rates might be higher if ants did not tend to larvae (USFWS 2010).

Stressor: Allee effect
Exposure: Asynchronous reproduction.
Response: See narrative.

Consequence: Reduction in population numbers.
Narrative: The San Bruno elfin butterfly is susceptible to the Allee effect caused by asynchronous reproduction. The Allee effect, where population growth rate decreases at low population densities, is increasingly recognized as a significant feature of many species' population dynamics. Reproductive asynchrony, which occurs when individuals are reproductively active at different times within a larger population-level reproductive period, as is the case with the San Bruno elfin, can decrease the number of males a female overlaps with in her lifetime. This in turn decreases the average probability of mating per male/female pair that does overlap, and may leave some females completely isolated. This loss of reproductive potential reduces a population’s growth rate at lower densities (USFWS 2010)

Stressor: Nonnative plants
Exposure: Nonnative plants encroaching on San Bruno elfin habitat.
Response: Loss of stonecrop, the larval host plant.
Consequence: Habitat loss; reduction in population numbers.
Narrative: Nonnative grasses that have invaded California grasslands are a serious threat to the San Bruno elfin butterfly. Invasive species have the ability to become more abundant while outcompeting the native larval food plant and nectar plants. European annual grasses and forbs have displaced native forbs in California native grasslands, and in turn have contributed to the decline of the San Bruno elfin. Some of the exotic grasses and forbs that have invaded grasslands of the San Francisco Bay Area are Italian ryegrass (Lolium multiflorum), slender oats (Avena barbata), ripgut (Bromus diandrus), and red brome (B. madritensis rubens). Thatch produced as a result of the buildup of dead exotic plants may eliminate or prevent native plant species from growing in an area, and invasive species may adversely alter soil chemistry and structure. In addition, native and exotic plant invasion may change the behavior of the San Bruno elfin butterfly by modifying fundamental aspects of grassland habitat. The invasion and dominance of these plants likely changes the structure of the low-lying grassland, which is detrimental to the butterfly, which uses open habitat. These effects may affect or alter reproductive related behaviors such as mate searching, territorial defense, predator avoidance, oviposition, and nectaring. In grasslands dominated by tall grass species, some butterfly species drop their eggs while in flight or after alighting on the ground if the larval food plant is physically obscured or has senesced; as a result, the larvae have to search for their food plant. Although examples have not been found that specifically identify nonnative invasive plants as a threat to the San Bruno elfin butterfly, its dependence on a single host plant to complete its lifecycle makes it susceptible to habitat loss from nonnative invasive species (USFWS 2010).

Stressor: Climate change
Exposure: Climate change.
Response: Mortality, shift in habitat.
Consequence: Loss of habitat; reduction in population numbers; increase in number of predators, parasites, and diseases.
Narrative: Climate change poses a serious threat to the San Bruno elfin butterflies. Global climate change increases the frequency of extreme weather events, such as heat waves, droughts, and storms. Extreme events, in turn, may cause mass mortality of individual San Bruno elfin. As the

global climate warms, terrestrial habitats are moving northward and upward. In the future, though, range contractions are more likely than simple northward or upslope shifts, which will limit the areas where mission blue butterflies can live. Because climate change threatens to disrupt annual weather patterns, it may result in a loss of their habitats and/or an increase in the numbers of their predators, parasites, and diseases (USFWS 2010).

Stressor: Pesticides
Exposure:
Response:
Consequence:
Narrative: Pesticide use (Factor E) poses a potential threat to both species if used in proximity to occupied habitat (e.g. Varela et al. 2008, Service 2009). (USFWS, 2019)

Stressor: Vole herbivory
Exposure:
Response:
Consequence:
Narrative: Vole herbivory (Factor A) threatens the host plants of the mission blue butterfly, with herbivory in some years causing severe declines in available lupine (Arechiga pers. omm. 2018, O'Brien pers. comm. 2018, Wayne pers. comm. 2018). (USFWS, 2019)

Stressor: Population monitoring
Exposure:
Response:
Consequence:
Narrative: Population monitoring may pose a threat to San Bruno elfin butterflies because of the potential for monitors to inadvertently damage habitat and/or host plants (Factor B)(Bennett and Russo 2016a, Arechiga pers. comm. 2018). (USFWS, 2019)

Recovery

Reclassification Criteria:
FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - Sites supporting metapopulations of the San Bruno elfin butterfly across the historic range of the species (see E/1 below), including San Bruno Mountain, Milagra Ridge, and the Montara Mountain region, must be managed to ensure the maintenance of habitat that includes a diversity of nectar plants and the larval host plant Sedum spathulifolium and to control threats. Long-term maintenance of the sites must be financially sustainable. Use of herbicides, mowing, burning, or livestock grazing in management should be implemented with appropriate methods and timing to avoid impacts to the butterfly and its nectar and host plants. (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Sites support metapopulations across the historic range of the species, including San Bruno Mountain, Milagra Ridge, and the Montara Mountain region. San Bruno Mountain must include a minimum of 7 colonies, the Montara Mountain region must include a minimum of 5 colonies (including Peak Mountain and Whiting Ridge), and Milagra Ridge must include a minimum of 2 colonies. The original recovery plan stated as a primary objective that “Secure, self-sustaining colonies of this species are established and/or re-established on Milagra Ridge, Montara Mountain, Peak Mountain, and Whiting Ridge, and colonies on San Bruno Mountain are secure. Numbers of colonies necessary for reclassification of the San Bruno elfin butterfly to threatened are 7 on San Bruno Mountain, 5 on Montara Mountain (including Peak Mountain and Whiting Ridge), and 2 on Milagra Ridge.” Note that SFPW monitoring includes subpopulations along Whiting Ridge and Fifeld Ridge, which were originally lumped with Montara Mountain. Multiple colonies within metapopulations are recommended to ensure redundancy. Each of these metapopulations must contain an average of at least 30 adults with a stable or increasing population trend for a minimum of 10 years. This is the number of adults considered necessary for resiliency in a congener (member of the same genus), the frosted elfin butterfly (Callophrys irus)(Service 2018). A stable or increasing population trend over a 10-year period is recommended for another member of the Lycaenidae family, the Fender’s blue butterfly (Service 2010b), and also among other butterfly families (e.g. Behren’s silverspot butterfly Speyeria zerene behrensii (Service 2015)). (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Habitat patches in sites supporting colonies in E/1 have a stable or increasing areal extent over the same 10-year period of population growth. This criterion helps to protect against scrub encroachment. (USFWS, 2019)

Recovery Priority Number - 9 (USFWS, 2010)

Delisting Criteria:
FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - The metapopulations at San Bruno Mountain, Milagra Ridge, and the Montara Mountain regions must include on average a minimum of 18, 3, and 7 occupied colonies, respectively, with overall stable or increasing population trends over a 20-year period. (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Habitat patches in sites supporting colonies in E/1 have a stable or increasing areal extent over the same 20-year period of population growth. This criterion helps to protect against scrub encroachment. (USFWS, 2019)

Recovery Actions:
- Coordinate among habitat managers and regulatory agencies to establish recommended San Bruno elfin butterfly monitoring protocols. Concern about damage to host plants and habitat should be considered when determining monitoring activities and frequency. (Priority 3) (USFWS, 2019)
- Investigate biology of San Bruno elfin butterflies to guide population estimates. Studies on oviposition rates and larval survival will help determine how to estimate adult populations from larvae monitoring. (Priority 3) (USFWS, 2019)

- Protect in perpetuity San Bruno elfin habitat on properties near Montara Mountain. (USFWS, 2010)
- Create a San Bruno elfin butterfly working group to: a) Develop a consistent monitoring and surveying scheme; b) Coordinate synchronized and scheduled monitoring of all colonies; and c) Map all currently known habitat locations, including size and extent of host plant. (USFWS, 2010) cover.
- Develop measureable recovery criterion, including colony sizes and dynamics necessary for a population to be self-sustaining in perpetuity. (USFWS, 2010)
- Search for new locations in the SFPW. (USFWS, 2010)
- Develop management plans for all habitat locations based on the findings of the working group. (USFWS, 2010)
- Create local captive propagation facility if determined necessary by the working group. (USFWS, 2010)
- Create plan for population augmentation and reintroduction if determined necessary by the working group. (USFWS, 2010)
-

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The following recommendations incorporate those from the previous 5-year review, recovery plan amendment, various monitoring reports, and communication with species experts: 1. Develop an action plan relative to the updated recovery criteria and coordinate with partners regarding implementation. This may involve updating the step-down outline, narrative, and implementation schedule from the Recovery Plan (Service 1984, pp. 46– 62, 67–74) to incorporate amended recovery criteria, and may take the form of a Recovery Implementation Strategy. This document would likely integrate recommendations from this status review; the process would likely reveal additional recommendations. 2. Coordinate among habitat managers and regulatory agencies to establish recommended San Bruno elfin butterfly monitoring protocols. Concern about damage to host plants and habitat should be considered when determining monitoring activities and frequency. 3. Investigate biology of San Bruno elfin butterflies to guide population estimates and monitoring protocols. Studies on oviposition rates and larval survival, or a meta- analysis/review of data from similar species, could help determine how to estimate adult populations from larvae monitoring. Measuring the size of larvae can help in determining their stage of development, assessing if larvae are occupying different parts of the host plant based on their sizes, and analyzing monitoring trends if surveys detect multiple instars. Research on phenology of the species, and host plant use by larvae, could help guide monitoring recommendations. Investigating correlations and trends between climate, host plant stage, and San Bruno elfin butterfly larvae could aid with understanding the role of climate change as a threat to the species, and/or point to adaptive foraging by San Bruno elfin larvae. 4. Coordinate with partners to develop a consistent monitoring protocol to document size and trends in host plant cover. Documenting areal extent of habitat patches is an important step towards being able to assess these data in comparison to recovery criteria. Continue outplantings of stonecrop when appropriate to increase host plant abundance. 5. Search for larvae at additional documented stonecrop occurrences across the range to determine San Bruno elfin butterfly presence. Increased understanding of San Bruno elfin butterfly larvae habitat use, including host plant leaves, can guide searches for additional occupied patches. (USFWS, 2021)

Additional Threshold Information:

-
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SPECIES ACCOUNT: *Cicindela dorsalis dorsalis* (Northeastern beach tiger beetle)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The largest (13-15 mm) of the recognized subspecies, the Northeastern beach tiger beetle is bronze to greenish with extensive maculations that run the length of the elytra. The maculations are wide, cream-colored, and frequently are expanded to cover much of the elytral surface. Abrasion by sand makes elytra of older individuals lighter. Below it is dark bronze to dark green with dense, white hair-like setae covering the sides of the abdomen. The last pair of legs is exceptionally long. The males and females are visibly different in the shape of the thorax (cylindrical in males, trapezoidal in females), and the shape of the elytral tip (rounded in males, broadly notched in females).

Taxonomy

Northeastern beach tiger beetles in the Chesapeake Bay and Massachusetts are currently physically and genetically isolated from each other.

Historical Range

The northernmost extent of its range is Massachusettes (the island of Martha's Vineyard and a translocation site at Monomoy NWR), and its southernmost occurrence remains in southeast Virginia (Plum Tree NWR and Grandview Beach, City of Hampton). It is considered extirpated from Rhode Island, Connecticut, New York (Long Island), and New Jersey. The sites located on the western shoreline of the Chesapeake Bay (both Maryland and Virginia) are in decline or are extirpated. Six of the ten Maryland sites are extirpated, and twelve sites in Virginia have been extirpated.

Current Range

Once abundant along coastal beaches from Massachusetts to New Jersey, and along the Chesapeake Bay in Maryland and Virginia. The Northeastern beach tiger beetle has been extirpated from Connecticut, Rhode Island, and New York. The status of the translocated population at Gateway National Recreation Area, Sandy Hook, New Jersey is uncertain. Only two known populations of this beetle can be found north of the Chesapeake Bay, both in Massachusetts (Martha’s Vineyard and a translocation population at Monomoy National Wildlife Refuge). There is only four sites remaining in Maryland, and the highest number of populated sites are located along sections of beaches found in Virginia's portion of the Chesapeake Bay.

Distinct Population Segments Defined

not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larvae are sedentary ambush predators that live in well-formed burrows from which they extend to capture passing prey. The larvae will move their burrows up the beach to avoid winter storm floods and narrowing of the beach. Larvae are active primarily at night and plug the entrance to their burrow during warm days when the sand surface dries out.

Adult: Adults are active predators that forage on small invertebrates or scavenge on dead fish, crabs, and amphipods.

Reproduction Narrative

Larvae: Depending on the prey base availability, the larvae will transition through three stages in one to two years before they pupate and emerge as adults. The larvae are present year round on the beach, hibernating through the winter.

Adult: Adults are primarily active from June to September, and over winter as larvae. The adults mate and lay eggs from late June through August. Females are thought to lay eggs at night in shallow burrows in the mid to high tide zone on coastal beaches. Burrows are 15-50 cm deep and are found anywhere from just above mean low tide line to the base of the dunes above the beach.

Geographic or Habitat Restraints or Barriers

Larvae: narrow suitable habitat use

Adult: narrow suitable habitat use

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: specialist; special habitat requirements

Adult: specialist; special habitat requirements

Tolerance Ranges/Thresholds

Larvae: unknown

Adult: unknown

Site Fidelity

Larvae: high

Dependency on Other Individuals or Species for Habitat

Larvae: Adult builds initial burrow

Adult: Not applicable

Habitat Narrative

Larvae: Larvae occur over a relatively narrow band (8—12 m) of the upper intertidal to high drift zone, but the zone may be wider in areas of washover or where the upper beach is flat and gets periodically wet from high tides. Many larvae are thus regularly covered during high tide. In response to the rising tide, they plug the burrow mouth with sand, then re—open when water levels drop; recent studies have shown that larvae can survive flooding for 3-6 days. While this intertidal location poses hazards of flooding and increased energy expenditure to maintain burrows, it is the zone where prey is most abundant. Larvae nearer to the water's edge tend to develop faster than those farther back where it is drier and prey items are less numerous (C.B. Knisley pers. obs.).

Adult: Beaches with a length of at least 100 meters, a width of at least 2 m, and an adult population of at least 30, serve as breeding sites. Adult and larval beetles are typically found on highly dynamic beaches with back beach vegetation, and they prefer long, wide beaches that have low human and vehicular activity, fine sand particle size, and a high degree of exposure. They also seem to prefer beaches with slopes that are at least 6.5 degrees. Preliminary work indicates a correlation between the extent of shallow water fronting the beach and the number of tiger beetles present (i.e., the more sand bars, the more beetles).

Dispersal/Migration

Motility/Mobility

Larvae: limited

Adult: mobile

Migratory vs Non-migratory vs Seasonal Movements

Larvae: not migratory

Adult: not migratory

Dispersal

Larvae: limited

Adult: moderate

Immigration/Emigration

Larvae: very unlikely

Adult: possible if suitable sites are within 7 km

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larvae have occasionally been found crawling on the beach, apparently moving to dig new burrows in a more favorable location. In contrast, the larvae of most other species of tiger beetles remain in the same burrow throughout their development. The burrow relocation behavior of C. d. dorsalis is likely a response to variations in tide levels, soil moisture, or sand accretion and erosion patterns. This behavior may allow larvae to select burrow sites with optimal physical conditions and/or greater abundance of food. The degree of tidal flux and storm activity is much greater along Atlantic Coast beaches than within the Chesapeake Bay. The more dynamic coastal beaches, often exposed to direct ocean waves, change in profile and position annually in response to violent winter storms and summer wave conditions. On Martha's Vineyard, the larvae move 20—50 m up the beach to overwinter on higher ground (Nothnagle and Simmons 1990). This migration has apparently evolved as an adaptive behavior to avoid being washed out to sea during winter months.

Adult: Studies have shown that adults can disperse up to 7 kilometers after emergence.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

1 to 20

Population Size:

1000 to 2500 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:
low

Adaptability:
unknown

Population Narrative:
Northeastern beach tiger beetles in the Chesapeake Bay and Massachusettes are currently physically and genetically isolated from each other. The isolated Martha's Vineyard population and Chesapeake Bay populations had very low genetic variability. The NBTB's historical range was from Massachusetts to Virginia. The species is now extirpated from Rhode Island, Connecticut, New York, and New Jersey and found only in the Chesapeake Bay of Maryland and Virginia and two sites in Massachusetts. Table 3 summarizes the current status and threats to the NBTB throughout its range. Except for GRAs 1 (Massachusetts) and 6 (Tangier Sound, MD), surveys document a continued decline in NBTB numbers and occupied sites. The number of occupied sites, in particular those with greater than 500 adults, have continued to decrease in Maryland and Virginia on the western shoreline of the Chesapeake Bay. The number of occupied sites have remained relatively stable on Virginia's eastern shoreline; however, most sites had declining numbers, and there were fewer sites with very large populations (>1,000 adults). With increasing fragmentation of contiguous areas of occupied habitat, smaller population segments will become increasingly separated by unsuitable habitat, leading to greater isolation, reduced gene flow, and eventual extirpation, as observed in Calvert County, MD with just one viable population remaining. Only one of the GRAs, Tangier Sound, MD, meets the recovery criteria. Some occupied sites are permanently protected, owned and managed by state agencies, Federal agencies, or nongovernmental organizations (NGOs) or protected through conservation easements; however, it is likely difficult for these entities to address offsite impacts such as littoral sand drift and SLR. (USFWS, 2019)

Threats and Stressors

Stressor: Recreational use
Exposure:
Response:
Consequence:
Narrative: Recent studies at Flag Ponds, Maryland, have provided specific evidence of negative impacts from various human activities (Knisley and Hill 1989, 1990; Hill and Knisley 1991). Flag Ponds, a recently developed county park, has experienced a dramatic increase in visitor use, from 2,000 to more than 20,000 per year over the past five years. The park has different areas of beach, which vary greatly in the amount of human use. Knisley and Hill found that the total numbers of larvae were significantly lower and percent survival of first and second instars much lower on the beach area where human activity was concentrated (heavy human use was defined as approximately 350 individuals per 800 m section of beach per week during summer). In

contrast, larval recruitment and survival were much higher where visitor use was low. Experiments in which plots were trampled by the researchers several times, resulting in a 30% to 60% reduction of first and second instar larvae, substantiated the visitor use data. Negative effects of foot traffic apparently involve compaction or disruption of burrows or direct injury to larvae. Although few beetles apparently completed development on the public use section, adults that emerged in other sections moved onto the public use beach. Adults occurred on all areas of the beach and their distribution was much less affected by human activity than that of larvae. However, their normal feeding and reproductive activity appeared to be adversely affected by human activity. For example, very few nests (see Adult Behavior) were found on the. public beach at times when they were common on low use beach areas. It should be noted that management of the Flag Ponds county park is responsive to the need of retaining available habitat for the beetles, and the beach system is very dynamic, with sufficient turnover of habitat to accommodate a breeding population of the subspecies over the long term. Wilson (1970) and Nagano (1980) suggested negative impacts to tiger beetles from off—road vehicles. Schultz (1988) documented direct effects of ORV use on Cicindela oregona along stream edge habitat in Arizona. Vehicles may physically compact the beach substrate and/or disrupt thermal and moisture microhabitat gradients that are important for larvae (Schultz 1988). The best evidence of beach vehicle impacts to C. dorsalis comes from a survey on Assateague Island, Maryland (Knisley and Hill 1992). Adults and larvae of C. d. media were absent from a 16-km (10-mi) section of beach that receives heavy ORV use, but present on either side of the ORV zone, both on the north end of the island and to the south in the Virginia section. It is also significant that C. d. media was common on the northern portion of the ORV zone in 1973, but had disappeared by the summer of 1976, after ORV use became heavy (J. Glaser, Maryland Geological Survey, pers. comm.). Surveys of C. d. dorsalis have also indicated an overall pattern of absence from beaches with moderate to heavy ORV use. The Martha's Vineyard site, one of two sites on the Atlantic Coast where the species has survived (Martha's Vineyard) is very inaccessible and has been well protected from visitor use and vehicle use for many years (T. Simmons, The Nature Conservancy, pers. comm). The newly discovered C. d. dorsalis site in Westport, Massachusetts is not used by ORVs, although it receives heavy pedestrian use (S. von Oettingen, U.S. Fish and Wildlife Service, pers. comm.).

Stressor: Beach Erosion
Exposure:
Response:
Consequence:
Narrative: Beach erosion, resulting from natural or anthropogenic beach modifications, may also have serious effects on C. d. dorsalis larval habitat. The northeastern beach tiger beetle typically is not found at sites that have only narrow, eroded beaches. At sites with large populations, few or no larvae are found in areas of narrow beach (1—3 m wide). Larvae seem to be limited to areas where beaches are at least 5 m wide, with some sand above the high tide zone. Adults are also less abundant in these narrow sections, although larvae are more sensitive to erosion and beach impacts than are adults. Erosion at many sites within the Chesapeake Bay is a natural phenomenon resulting from rising sea levels and prevailing currents; this process has been exacerbated by beach development activities, which interfere with the natural beach dynamics

(Ward et al. 1989). Beach stabilization structures such as groins, jetties, and bulkheads, which are designed to reduce erosion, may interrupt and capture sand from longshore movement and build up the beach around the structure, but rob sand from the down-drift shoreline. There are many examples of erosion resulting from shoreline stabilization in the Chesapeake Bay (Ward et al. 1989). One such example is the north section of Flag Ponds, Maryland, where the beach has become severely eroded over the past 10 years since construction of the jetty at Long Beach just to the north (D. Williams, Calvert County Department of Parks, pers. comm). The eroding beach south of the ferry dock at Kiptopeke Beach, Virginia may be another example of this phenomenon. Natural points and spits may have the same effect as manmadefeatures. The effects of beach nourishment and stabilization on C. d. dorsalis are not known, and a study of erosion control structures is being conducted by C.B. Knisley to address several relevant issues. Although the addition of sand may actually maintain habitat in the long term, it is likely that its immediate effects would result in larval mortality. Larvae could be crushed, smothered, or unable to dig out and resume normal activity. Sand deposition could also have indirect negative effects on food (amphipod) availability. Deposition may have less impact if done in winter, when larvae are inactive and tidal action would erode some of the sand before larvae resume activity in the spring. The effects (both short- and long-term) of beach nourishment on the larvae need investigation. Since larvae seem to be very specific in their microhabitat distribution, sand particle size or other physical aspects of the microhabitat, e.g., slope or profile, may be critical.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
1. At least three populations have been established and permanently protected within each of the four designated Geographic Recovery Areas covering the historical range of the subspecies in the Northeast, with each Geographic Recovery Area having one or more sites with large populations (peak count > 500 adults) with sufficient protected habitat for expansion and genetic interchange. 2. At least 26 populations are permanently protected at extant sites distributed among the five Chesapeake Bay GRAs as follows: Calvert County, MD - four large populations; Tangier Sound, MD - two large populations; Eastern Shore of Chesapeake Bay. VA - four large populations, four others; Western Shore of Chesapeake Bay, VA (Rappahannock River north) - three large populations, three others; Western Shore of Chesapeake Bay, VA (Rappahannock River south) - three large populations, three others. 3. Life history parameters (including population genetics and taxonomy), human impacts, and factors causing decline are understood well enough to provide needed protection and management. 4. There exists an established, long-term management program in all states where the species occurs or is reintroduced.

Recovery Actions:
- 1. Monitor known populations and any additional populations that are discovered.
- 2. Determine population and habitat viability.

- 3. Protect viable populations and their habitat.
- 4. Study life history parameters.
- 5. Evaluate human impacts.
- 6. Implement management measures at natural population sites.
- 7. Develop captive rearing techniques and conduct reintroductions.
- 8. Implement educational activities.
- The 1994 recovery plan for the northeastern beach tiger beetle should be revised.
- Develop a survey protocol to ensure consistent monitoring of populations.
- Continue surveys to monitor population and habitat trends to obtain a better understanding of the beetle's status and metapopulation structure. These data will also be needed to assist the Service with project consultations.
- Expand genetic work to further evaluate the four subspecies, and to compare the beetles within the Chesapeake Bay to those in Massachusetts. This information will assist in understanding the metapopulation structure of this species over time.
- Evaluate the potential effects of sea level rise on tiger beetles, and develop appropriate management strategies to address this potential threat.
- Evaluate the geomorpology of the Atlantic Ocean sites using the same parameters used for the Chesapeake Bay sites. This data is needed to evaluate and compare the habitat criteria of the Atlantic sites to those in the Chesapeake Bay.
- Conduct rangewide assessment of available and potential habitat and shoreline alterations/hardening that have occurred to date.
- Implement a prey base study for the larval stage of the beetle. The goal of such a project would be to obtain an understanding of what the larval stage prey base is and whether there are factors that could limit the prey base availability and in turn impact beetle survival and productivity.
- Work with the Corps to improve understanding of shoreline projects that are being implemented on the Chesapeake Bay without proper permits and construction.
- Work with the local governments to ensure that permitting authorities are aware of the beetle and the threats to it from shoreline projects.
- Work with the Corps and shoreline erosion experts to design appropriate shoreline stabilization methods that will not eliminate beetle habitat.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Revise recovery plan - More detailed and new information regarding the species’ threats, habitat, and populations has become available since the recovery plan was written in 1994. A revised recovery plan should take this new information into account. Specific revisions may include: ● Revising population-based recovery criteria so that they incorporate maintenance of metapopulations and connectivity of these sites to allow for movement and dispersal among sites, which may be necessary for persistence of the species and its ability to respond to large-scale events, such as hurricanes and storms, causing significant coastal erosion. The use of GRAs should be evaluated and changed to fit the Service's use of recovery units for species that use a metapopulation strategy. ● Defining or deleting use of “other” sized population. ● Revising recovery criteria to more explicitly address threats and include objective metrics regarding protection and management of the NBTB. Recommendations for specific recovery actions and priority number (1-3, as defined in the NBTB Recovery Plan [Service 1994]): 1. Pursue long-term protection of additional priority sites in the Chesapeake Bay (appendix B). [Priority 1] 2. Develop best management practices for conserving and protecting the NBTB and its habitat and provide to private landowners, NGOs (e.g., conservation easement holders), and local, state, and Federal government entities. [Priority 1] 3. Work with the Corps, state agencies, and shoreline erosion experts to design appropriate structural and nonstructural methods that will increase or maintain NBTB habitat and find opportunities to implement these methods. [Priority 1] 4. Update the population viability analysis to determine minimum viable population size, number of subpopulations, and proximity of sites and to compare management strategies, while taking into account habitat quantity and quality (e.g., habitat models that account for site-specific SLR projections). [Priority 2] 5. Conduct a rangewide assessment of available and potential habitat and shoreline alterations/hardening that have occurred to date. [Priority 2] 6. Evaluate the potential effects of relative SLR on NBTB and its habitat, and develop appropriate management strategies to address this potential threat. [Priority 2] 7. Identify additional priority sites, based on the results of analyses in item numbers 4, 5, and 6, to pursue long-term protection throughout the NBTB's range. [Priority 2] 8. Continue surveys (by staff and/or contract) to monitor population and habitat trends to obtain a better understanding of the NBTB's status and metapopulation structure. These data will also be needed to assist the Service with project consultations. [Priority 2] 9. Reintroduce populations at sites within the NBTB's historical range at beaches that have suitable habitat and long-term protection and are likely to have resiliency in response to SLR. [Priority 2] 10. Work with local governments to ensure that permitting authorities are aware of the NBTB and threats to its habitat from shoreline projects, including effects from shoreline structures on adjacent beaches. [Priority 2] 11. Work with the Corps, state agencies, and shoreline erosion experts to develop models or methods to assess and account for effects from shoreline structures on adjacent beaches. [Priority 2] 12. Convene an ad hoc task force to meet periodically to discuss recovery of the NBTB. [Priority 2] 13. Evaluate previously occupied sites to determine if active management of the habitat could make it suitable (e.g., vegetation removal, change in beach grooming practices, restrictions on 4-wheel drive vehicles). [Priority 3] 14. Develop a cost-effective survey protocol and population estimation method to ensure consistent and accurate monitoring and estimation of populations. [Priority 3] 15. Conduct prey base studies for adult and larval NBTB to assist in identifying suitable habitat and determine factors that could limit prey base availability, which in turn impact NBTB survival and productivity. [Priority 3] 16. Determine preferred sand grain size for NBTB, in particular for female oviposition and larval recruitment, at sites throughout its range. [Priority 3] 17. Complete genetics work to evaluate the four subspecies of C. dorsalis, and to compare the NBTBs within the Chesapeake Bay to those in Massachusetts. This information will assist in understanding the metapopulation structure of this species over time. [Priority 3] 18. Evaluate the geomorphology of the Atlantic Ocean sites using the same parameters used for the Chesapeake Bay sites. These data are needed to evaluate and compare the habitat criteria of the Atlantic sites to those in the Chesapeake Bay. [Priority 3] (USFWS, 2019)

References

Nature Serve. USFWS. 2019. Northeastern Beach Tiger Beetle (Cicindela dorsalis dorsalis) 5-Year Review: Summary and Evaluation. 27 pp.

USFWS. 2019. Northeastern Beach Tiger Beetle (Cicindela dorsalis dorsalis) 5-Year Review: Summary and Evaluation. 27 pp.

SPECIES ACCOUNT: *Cicindela nevadica lincolniana* (Salt Creek Tiger beetle)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/06/2005; Mountain-Prairie Region (R6) (USFWS, 2016a)

Physical Description

The Salt Creek tiger beetle is metallic brown to dark olive green above, with a metallic dark green underside, and measures 1.3 centimeters (cm) (0.5 inch [in]) in total length. It is distinguished from other tiger beetles by its distinctive form and the color pattern on its dorsal and ventral surfaces. The elytra (wing covers) are metallic brown or dark olive green, and the head and pronotum (body segment behind the head) are dark brown (Carter 1989) (USFWS, 2016b).

Taxonomy

The Salt Creek tiger beetle is a member of the family Carabidae, subfamily Cicindelinae, genus Cicindela. Eighty-five species and more than 200 subspecies of tiger beetles in the genus Cicindela are known from the United States (Boyd et al. 1982, Freitag 1999). The Salt Creek tiger beetle was originally described by Casey (1916) as a separate species, C. lincolniana. Willis (1967) identified C. n. lincolniana as a subspecies of C. nevadica which evolved from C. n. knausii (USFWS, 2016b).

Historical Range

The subspecies was once more widespread and likely occupied suitable habitat throughout the Eastern Nebraska Saline Wetland Complex (USFWS, 2016b).

Current Range

The Salt Creek tiger beetle has one of the most restricted ranges of any insect in the United States (Spomer and Higley 1993; Spomer et al. 2004), only occurring along limited segments of Little Salt Creek and adjacent remnant saline wetlands in Lancaster County, Nebraska (USFWS, 2016b).

Critical Habitat Designated

Yes; 5/6/2014.

Legal Description

On May 6, 2014, the U.S. Fish and Wildlife Service (Service) revised the critical habitat designation for the Salt Creek tiger beetle (Cicindela nevadica lincolniana) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 1,110 acres (ac) (449 hectares (ha)) in Lancaster and Saunders Counties, Nebraska, fall within the boundaries of the revised critical habitat designation.

Critical Habitat Designation

Four units are designated as critical habitat for the Salt Creek tiger beetle. The four units are: (1) Little Salt Creek— under the first prong of the Act's definition of critical habitat and (2) Rock Creek, Oak Creek, and Haines Branch—under the second prong of the Act's definition of critical habitat.

Unit 1: Little Salt Creek Unit. This unit consists of 284 ac (115 ha) of barren salt flats and three stream segments on Little Salt Creek in Lancaster County from near its junction with Salt Creek to approximately 7 mi (11 km) upstream. It includes the three existing populations of Salt Creek tiger beetles (Upper Little Salt Creek-North, Arbor Lake, and Little Salt Creek-Roper) present at the time of listing, and an additional site with an extirpated population (Upper Little Salt CreekSouth). The Upper Little Salt Creek population is not considered viable given low populations numbers known from this area. This unit contains the physical or biological features essential to the Salt Creek tiger beetle. Approximately 50 percent of the unit is either owned by entities that will protect or restore saline wetland habitat (see Table 2) or is part of an easement that protects the saline wetland habitat in perpetuity. This portion of the unit is largely protected from future urban development (e.g., commercial and residential development, road construction, and stream channelization) and future agricultural development (e.g., overgrazing and cultivation) by the landowners' or easement holders' participation in the Implementation Plan for the Conservation of Nebraska's Eastern Saline Wetlands and their membership in the Saline Wetlands Conservation Partnership (SWCP). At least two tracts (owned by the City of Lincoln) have been restored (Arbor Lake and Frank Shoemaker Marsh) (Malmstrom 2011 and 2012, entire) and other areas are in the process of being restored or are managed to conserve saline wetlands. However, special management is needed, because without continued special management, historical impacts from development will continue to adversely affect much of the habitat. The remaining 50 percent of the Little Salt Creek Unit that is not currently receiving special management through protection and restoration of saline wetland habitat remains vulnerable to both historical and ongoing impacts from development. The lower reaches of Little Salt Creek are in or near the City of Lincoln and, consequently, are most vulnerable to impacts related to urban development; upper stream reaches are more impacted by agricultural development.

Unit 2: Rock Creek Unit. The unit consists of 526 ac (213 ha) of barren salt flats and a stream segment of Rock Creek from approximately 2 mi (3 km) above its confluence with Salt Creek to approximately 12 mi (19 km) upstream. Most of this stream reach is in Lancaster County, but the northernmost portion is in southern Saunders County. This unit was not occupied at the time of listing; however, one population was present there until 1998. This unit contains the physical or biological features essential to the Salt Creek tiger beetle. It is essential to the conservation of the subspecies because any population established on Rock Creek would provide redundancy, in the event of a natural or manmade disaster on Little Salt Creek. Approximately 29 percent of the unit is either owned by an entity that will protect or restore saline wetland habitat (see Table 2) or is part of an easement that protects the saline wetland habitat in perpetuity. This portion of the unit is largely protected from future urban development (e.g., commercial and residential development, road construction, and stream channelization), but not future agricultural development (e.g., overgrazing and cultivation). Approximately 152 ac (61 ha) of barren salt flats and the stream segment are part of the Jack Sinn WMA (owned by Nebraska Game and Parks

Commission) located in southern Saunders and northern Lancaster Counties. This tract has undergone several projects to restore saline wetlands. However, special management is needed, because without special management through habitat protection and restoration, historical impacts from development will continue to adversely affect much of the habitat. The 71 percent of the Rock Creek Unit that is not currently receiving special management through protection and restoration of saline wetland habitat remains vulnerable to both historical and ongoing impacts from development. This unit is further removed from Lincoln; therefore, it faces fewer threats from urban development (e.g., commercial and residential development, road construction, and stream channelization) and more threats from agricultural development (e.g., overgrazing and cultivation) than the Little Salt Creek Unit.

Unit 3: Oak Creek Unit. The unit consists of 208 ac (84 ha) of barren salt flats and a saline seep complex located within a historic floodplain of Oak Creek. The unit is located along Interstate 80 in the northwest part of Lincoln, near the Municipal airport in Lancaster County. This unit was not occupied at the time of listing; however, one population was present until 1998. This unit contains the physical or biological features essential to the Salt Creek tiger beetle and is essential to the conservation of the subspecies because any population established on Oak Creek would provide redundancy, in the event of a natural or manmade disaster on Little Salt Creek. Approximately 86 percent of the unit is owned by the City of Lincoln and 14 percent by the Nebraska Department of Roads (see Table 2). This unit is largely protected from future urban development (e.g., commercial and residential development, road construction, and stream channelization) and future agricultural development (e.g., overgrazing and cultivation). Barren salt flats including the saline seep complex along Interstate 80 are part of this unit. This tract was once a part of a large saline wetland complex and is the type locality for the Salt Creek tiger beetle. However, a substantial amount of development has resulted in the loss of the once large saline wetland known from the area and special management practices may be needed to restore hydrology and the saline flat and seep habitats once prevalent in the area. This unit is near the City of Lincoln; however, it faces fewer threats from urban development (e.g., commercial and residential development, road construction, and stream channelization) than the Little Salt Creek Unit given the limitations on development that can be done along the Interstate and within the boundaries of the Lincoln Municipal Airport.

Unit 4: Haines Branch Unit. The unit consists of 92 ac (37 ha) of barren salt flats and a 2.8-mile long Haines Branch stream segment. Haines Branch is located on the west side of Lincoln, near Pioneers Park in Lancaster County. This unit was not occupied at the time of listing, but suitable habitat in the form of saline seeps and wetlands are available for the Salt Creek tiger beetle. This unit contains the physical or biological features essential to the Salt Creek tiger beetle and is essential to the conservation of the subspecies because any population established on Haines Branch Creek would provide redundancy, in the event of a natural or human-caused disaster on Little Salt Creek. The entire unit is owned by private entities (see Table 2). This unit is not protected from future urban development (e.g., commercial and residential development, road construction, and stream channelization) or future agricultural development (e.g., overgrazing and cultivation). Special management is needed to restore the hydrology and saline flat and seep habitats for the subspecies.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Lancaster and Saunders Counties, Nebraska. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Salt Creek tiger beetle consist of saline barrens and seeps found within saline wetland habitat in Little Salt, Rock, Oak and Haines Branch Creeks. Two habitat types within suitable wetlands are required by the Salt Creek tiger beetle:

(i) Exposed mudflats associated with saline wetlands or the exposed banks and islands of streams and seeps that contain adequate soil moisture and soil salinity are essential core habitats. These habitats support egg-laying and foraging requirements. The ‘‘Salmo’’ soil series is the only soil type that currently supports occupied habitat; however, ‘‘Saltillo’’ is the other soil series that has adequate soil moisture and salinity and can also provide suitable habitat.

(ii) Vegetated wetlands adjacent to core habitats that provide shade for subspecies thermoregulation, support a source of prey for adults and larval forms of Salt Creek tiger beetles, and protect core habitats.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on June 5, 2014.

The features essential to the conservation of the Salt Creek tiger beetle (exposed, moist, saline areas associated with stream banks, midchannel islands, and mudflats) may require special management considerations or protection to reduce threats. For example, a loss of moist, open habitat necessary for larval foraging, thermoregulation, and other life-history activities resulted in the extinction of another endemic tiger beetle—the Sacramento Valley tiger beetle (Cicindela hirticollis abrupta) (Knisley and Fenster 2005, p. 457). This was the first tiger beetle known to be extirpated. Actions that could ameliorate threats include, but are not limited to: (1) Increased protection of existing habitat through actions such as land acquisition and limiting access; (2) Restoration of potential habitat within saline wetlands and streams through exposure of saline seeps, removal of sediment layers to expose saline soils and seeps, and use of wells to pump saline water over saline soils by Federal, State, and local interested parties; (3) Establishment of multiple populations in the Rock, Oak, and Haines Branch Creeks through captive rearing and translocation of laboratoryreared larvae originating from wild populations; (4) Protection of habitat adjacent to existing and new populations to provide dispersal corridors, support prey populations, and protect wetland functions; and (5) Avoidance of activities such as groundwater depletions, new channelization projects, increased surface water runoff, and residential or road development that could alter soil moisture levels, salinity, open habitat, or low light levels required by the subspecies.

Life History

Feeding Narrative

Adult: Larval tiger beetles ambush prey passing near the burrow entrance. Once it has captured its prey, the larval tiger beetle pulls it into the burrow with the aid of two pairs of hooks on the abdomen. These hooks also function to prevent the larva from being pulled from its burrow by larger prey or predators. Adult Salt Creek tiger beetles prey on other insects on sandbars, mid-stream gravel areas, and salt flats (USFWS, 2015).

Reproduction Narrative

Adult: Female Salt Creek tiger beetles lay approximately 50 eggs at night in the wild (Farrar 2003) (USFWS, 2016b). The Salt Creek tiger beetle is believed to have a two-year life cycle in the wild. Females deposit their eggs on barren salt flats of saline wetlands, along sloping banks of streams in areas where the salt layer is exposed in the soil horizon, or along saline stream edges that are found in close association with water, near a seep. Wild adults are first observed as early as mid-May or as late as mid-June. Their numbers peak about two-weeks after the first individuals appear and begin to feed and mate. Eggs hatch approximately two weeks after being laid by the female. After the eggs hatch, the young larva digs a burrow and uses its head to scoop out soil (USFWS, 2015).

Geographic or Habitat Restraints or Barriers

Adult: successional vegetation (inferred from USFWS, 2016b)

Environmental Specificity

Adult: Very narrow (inferred from USFWS, 2016b)

Habitat Narrative

Adult: The Salt Creek tiger beetle has very specific habitat requirements and occurs in saline wetlands on exposed saline mud flats or along mud banks of streams and seeps that contain salt deposits and are sparsely vegetated (Carter 1989; Spomer and Higley 1993; LaGrange 1997; Nebraska Game and Parks Commission (NGPC) 1999; Spomer et al. 2004). Salt Creek tiger beetles require open, barren salt flat areas for construction of larval burrows, thermoregulation, foraging, and for use as dispersal corridors (Spomer and Higley 1993; Higley 2002, pers. comm.; Spomer 2005, pers. comm.) (USFWS, 2016b). The species also requires vegetated wetlands adjacent to core habitats that provide shade for thermoregulation, support a source of prey for adults and larval forms of Salt Creek tiger beetles, and protect core habitats (USFWS, 2015).

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from USFWS, 2016b)

Dispersal

Adult: Low (inferred from USFWS, 2016b)

Dispersal/Migration Narrative

Adult: Although tiger beetles are mobile and can fly, the lack of suitable habitat and low population numbers have limited recolonization of other suitable habitats on other stream segments (USFWS, 2016b).

Population Information and Trends

Population Trends:

stable-to-decreasing (USFWS, 2022)

Number of Populations:

4 (USFWS, 2016b)

Adaptability:

High (inferred from USFWS, 2015)

Population Narrative:

There are four metapopulations currently extant (USFWS, 2016b). The species is adapted to highly saline conditions and brief periods of flooding (USFWS, 2015). The SCTB has one of the most restricted ranges of any insect in the United States. The subspecies occurs only on mudbanks along segments of the Little Salt Creek and on sparsely-to non-vegetated mudflats and seeps containing salt deposits on riparian saline wetlands located in northern Lancaster County of Nebraska's Eastern Saline Wetlands. Since the last 5-year status review for the subspecies, new information indicates that the size of the Little Salt Creek metapopulation is stable-to-decreasing, with only a single population at Frank Shoemaker Marsh increasing in size (Spomer et al. 2021). The size of the populations in this metapopulation fluctuate annually based on seasonal weather conditions, which dictate the quantity and salinity of saline soils that are available. The Little Salt Creek metapopulation reached an all-time low of 115 adult beetles in 1993 and a high of 777 adult beetles in 2002 (Spomer et al. 2020). Currently, the estimated size of this metapopulation is approximately 275 adults (Nebraska Natural Heritage Program, August 18, 2022, personal communication). Populations of the larger Little Salt Creek metapopulation continue to be augmented with captive propagated adults. Since the last status review, two additional captive facilities are now rearing SCTB larvae. The success of our annual reintroduction efforts is difficult to measure (Spomer et al. 2021). This may be due to the small size of the current SCTB populations along Little Salt Creek, the lack of large contiguous blocks of suitable saline stream and wetland habitat, and the lack of connectivity between the populations. This lack of connectivity may also reduce the subspecies' genetic diversity and limit recolonization rates. To support large-scale reintroduction efforts, the Nebraska Game and Parks Commission (Commission) finalized a reintroduction plan for SCTB on Commission properties (Commission 2018). This plan opened Commission-managed lands to beetle reintroductions and, also increased the amount of suitable habitat available for reintroduction. Additionally, the plan helped establish some connectivity between existing sites potentially allowing for future largescale reintroductions to occur. Since the development of this plan, we have augmented wild populations of SCTBs at Little Salt Creek East Wildlife Management Area and Little Salt Creek Wildlife Management Area. In 2020, the Lower Platte South Natural Resources District allowed reintroductions to occur on their 150-acre saline wetland restoration project, the Marsh Wren Community Wetlands. This restoration project was completed in 2019 and led to significant improvements of saline wetland resources on the site (Lower Platte South Natural Resources District, August 25, 2022, personal communication). To help reduce the potential loss and function of saline wetlands and streams associated with Little Salt Creek, Rock, Oak, and Haines Branch creeks and their floodplains, the Saline Wetland Conservation Partnership continues to purchase private land parcels voluntarily from willing sellers containing saline wetland /or stream habitat. Since the last status review, an estimated 314 acres of land containing saline wetland habitat have been voluntarily acquired (Nebraska Natural Heritage Program, August 19, 2022, personal communication). In addition to conserving the form and function of Nebraska's Eastern Saline Wetland ecosystem, this effort helped support the conservation of the SCTB by creating larger contiguous expanses of suitable saline stream and wetland habitats for the subspecies (USFWS, 2022).

Threats and Stressors

Stressor: Channelization (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Channelization of Salt Creek from Lincoln to Ashland, Nebraska was done to control flooding and protect infrastructure (Farrar and Gersib 1991; Murphy 1992). In the 1950s, a flood control plan was developed and implemented to reduce the frequency of flooding. The flood control plan resulted in the construction of levees and reservoirs and additional channelization of Salt Creek (Murphy 1992). Channelization of Salt Creek encouraged tributary streams (e.g., Little Salt, Oak, Rock, and Haines Branch Creeks) to head-cut, carving deeper into their beds to adjust to the change in stream bed gradient. This resulted in the gradual lowering of the water table and drainage of adjacent saline wetlands that are important to the Salt Creek tiger beetle (Wingfield et al. 1992). The ongoing long-term effects of these past channelization projects continue to cause saline ground water to be intercepted and directed into streams. This has reduced the flow of saline water to surface seeps and caused the loss and degradation of saline wetlands and salt flats used by the Salt Creek tiger beetle (USFWS, 2016b).

Stressor: Development (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Commercial and residential developments pose a significant threat to the saline wetlands of eastern Nebraska as well as plant and animal species that depend upon these habitats (Gilbert and Stutheit 1994; Ratcliffe and Spomer 2002). Most of the remaining habitat is composed of small habitat complexes (i.e., less than 0.04 hectare (0.09 acre)) that are unlikely to provide all of the necessary life history requirements that the Salt Creek tiger beetle needs to survive without restoration. This spatial dispersion also reduces the connectivity between populations, thereby eliminating genetic interchange and the ability to repopulate after

catastrophic events (Murphy et al. 1990; Fahrig and Merriam 1994; Ruggerio et al. 1994; Noss 2002). Freshwater runoff from commercial and residential developments dilutes salinity. Reduced salinity concentrations on barren salt flats and along saline stream edges has encouraged the invasion of vegetation such as cattail (Typha angustifolia) and reed canary grass (Phalaris arundinacea) into habitats previously used by the Salt Creek tiger beetle. The resulting vegetated habitat then becomes unsuitable for use by the Salt Creek tiger beetle because the overstory shades out open, sunny areas required to thermoregulate, forage, and lay eggs (Fritz 2001, pers. comm.) (USFWS, 2016b).

Stressor: Agriculture (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Agricultural practices can threaten Salt Creek tiger beetle habitat, especially in the rural Upper Little Salt Creek-North, Upper Little Salt Creek-South, and Little Salt Creek-Arbor Lake Metapopulations. Livestock are attracted to exposed salt and can destroy or substantially degrade salt barren habitats, used by both adult and larval Salt Creek tiger beetle. Livestock trample these areas, which can destroy larval burrows and the larvae that inhabit them (Spomer et al. 2001). Cattle grazing also can compact soil and modify soil hydrology, gradually drying out a site and making it unsuitable for adults and larvae (which prefer moist, muddy sites with encrusted salt on soil surfaces). For example, the Upper Little Salt Creek-North Metapopulation occurs along a segment of Little Salt Creek that flows through a pasture; this metapopulation was negatively impacted by cattle grazing as a result (Spomer et al. 2004). Cultivation poses a threat to Salt Creek tiger beetle habitats generally through indirect means. Cultivation can increase sediment erosion and result in the introduction of pesticides into adjacent saline wetlands especially in the absence of a grass buffer. Adverse impacts can also occur if winter and spring thaws wash sediment from cultivated land, which can either cover larval burrows with a thick layer of sediment or encourage vegetative encroachment of saline stream edges through sediment accumulation (USFWS, 2016b).

Stressor: Predation and parasitism (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Predators and parasitoids evolved in conjunction with the Salt Creek tiger beetle and would not normally pose a severe threat to the survival of a healthy and viable metapopulation. In light of the subspecies current small population size and limited distribution, predation and parasitism may be a significant source of mortality and be an issue of concern for the subspecies (Higley 2002, pers. comm.). This issue was likely not a meaningful contributor to historical declines. (USFWS, 2016b).

Stressor: Small population size (USFWS, 2016b)
Exposure:
Response:

Consequence:
Narrative: Metapopulations of Salt Creek tiger beetles are isolated, small, and vulnerable to extinction by chance demographic events, disease, inbreeding, or other events such as changing water levels, succession of wetland vegetation, and habitat destruction (Murphy et al. 1990, Ruggerio et al. 1994, Gibbs 1993). Murphy et al. (1990) and Gilpin (1987) recognized a direct association between increased extinction rates of a species and reduced habitat areas, distances between populations, and small population size. The negative effects of habitat fragmentation and loss on the total number of individuals within a population include the loss of genetic diversity (Lacy 1987).(USFWS, 2016b).

Stressor: Pesticides (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Corn, soybean, pasture, and sorghum fields dominate the Little Salt Creek watershed and are potential sources of pesticide exposure. Insecticides have the potential to harm or kill the Salt Creek tiger beetle and/or reduce the availability of its prey. Research on other ground beetles (Carabidae) indicates that pesticide exposure may place adult Salt Creek tiger beetles at risk from decreased survival and reproduction (Mullin et al. 2010; Pisa et al. 2014). Insecticides applied annually to lawns and landscaping in residential and commercial developments near Little Salt Creek also have the potential to enter the creek and impact the Salt Creek tiger beetle and its prey. Salt Creek tiger beetles also may be exposed to pesticides applied to control mosquitoes, grasshoppers, and pests in residential yards and gardens (USFWS, 2016b).

Stressor: Artificial lights (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Artificial lights that have proliferated due to commercial and residential developments along streets and highways in Lincoln, particularly mercury vapor lamps, may also contribute to population losses of the Salt Creek tiger beetle because such lights have been implicated in population losses of nocturnal insects elsewhere (Pyle et al. 1981). Allgeier et al. (2003) found that Salt Creek tiger beetles were attracted to artificial lights in the following order of preference: a) black light; b) mercury vapor; c) incandescent; d) fluorescent; and e) sodium vapor. Because female Salt Creek tiger beetles lay eggs at night, artificial light sources may reduce reproduction (Allgeier et al. 2003) by drawing females away from suitable breeding habitat. Movement away from habitat to lighted areas, such as areas surrounding major transportation routes (e.g., Interstate 80) and associated residential and commercial developments, may increase energy expenditure, reduce reproductive success, and ultimately impact the survival of the two largest metapopulations of Salt Creek tiger beetles near the City of Lincoln (Allgeier et al. 2004) (USFWS, 2016b).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure:

Response:
Consequence:
Narrative: The Act is the primary tool that we use to protect federally listed endangered subspecies like the Salt Creek tiger beetle. Protections conveyed by the Clean Water Act, Nebraska Water Quality Certification, and comprehensive planning efforts described below are helpful but in the absence of federal listing would not contribute to the ultimate goal of recovering the Salt Creek tiger beetle.

Stressor: Climate and weather events
Exposure:
Response:
Consequence:
Narrative: The remaining metapopulations of Salt Creek tiger beetles are highly susceptible to extinction as a result of weather events. Such events may include: a) heavy rain storms and severe flooding that drown and scour larvae away, dilute salinity, and result in sediment deposition; and b) drought, which can dry out seeps and saline wetlands, making them unsuitable as habitat and modify the diversity and abundance of prey. Climate change may also affect the Salt Creek tiger beetle if predictions about loss of wetlands and gradual warming in the Midwest occur. In such an instance, we could reasonably expect to see a loss of saline wetland habitat for the Salt Creek tiger beetle, which could cause potentially significant issues for the subspecies. (USFWS, 2016b)

Recovery

Reclassification Criteria:
1. Establishment of three metapopulations of Salt Creek tiger beetles with populations each numbering between 500 to 1,000 individuals to ensure population viability (USFWS, 2016).

2. Establishment of these three metapopulations in three recovery areas (USFWS, 2016).

3. At a minimum, no net loss of saline wetlands and streams and their associated functions in Rock, Little Salt, Oak, and Haines Branch Creeks and their floodplains since the time of listing (October 2005), with a likely need for restoration and establishment of additional habitat to support recovered populations.(USFWS, 2016).

Recovery Priority Number: 3C

Delisting Criteria:
In addition to the downlisting criterion, the criterion for delisting includes the establishment of three additional metapopulations (for a total of six metapopulations) of Salt Creek tiger beetles. These metapopulations would each number between 500 and 1,000 individuals for a minimum 10-year period to ensure viability. The distribution of these metapopulations would span at least four recovery areas. There should be protective measures in place to ensure the long-term persistence of these sites in the absence of ESA protections. (USFWS, 2016)

Recovery Actions:

- Recovery area protection - Protection of the majority of recovery areas that count towards the demographic criterion above (from Figure 4) through purchase by fee title, perpetual conservation easements, enrollment in WRP, and establishment of buffers. (USFWS, 2016).
- Recovery area protection - Protection of Recovery Areas through Land Use Planning.(USFWS, 2016).
- Recovery Areas Restoration - Conduct saline wetland and stream restoration projects on Rock, Little Salt, Oak, and Haines Branch Creeks and other saline wetland stream complexes in other identified recovery areas shown in Figure 4 for the benefit of the Salt Creek tiger beetle. (USFWS, 2016)
- Recovery Areas Management - Conduct land management activities at saline wetlands and streams at Rock, Little Salt, Oak, and Haines Branch Creeks and other saline wetland stream complexes in other identified recovery areas shown in Figure 4 for the benefit of the Salt Creek tiger beetle. (UWFWS, 2016)
- Research - Conduct research on surface and groundwater roles in saline wetland and stream restoration and management. (USFWS, 2016)
- Research - Conduct research on the appropriate frequency and intensity of prescribed grazing to inform adaptive management of invasive plants at saline wetlands and to investigate the effect of such grazing on surrogate tiger beetle species. (USFWS, 2016)
- Research - Conduct research on potential competition with saline wetland-dependent tiger beetles to determine which habitat management methods most effectively support Salt Creek tiger beetle population increases. (USFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction - Conduct experimental propagation and rearing techniques. (UWFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction - Synchronize wild and captive-reared life cycles. (UWFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction - Determine the best method for reintroducing captive-reared Salt Creek tiger beetles into the wild. (UWFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction -Evaluate survival success of reintroduced larvae and adults. (USFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction - Determine the microhabitat characteristics of larval habitat located at saline stream and wetland habitats. (USFWS, 2016)
- Salt Creek Tiger Beetle Rearing, Propagation, and Reintroduction - Implement large-scale propagation and reintroduction efforts to restore populations of the Salt Creek tiger beetle at identified occupied and unoccupied recovery areas. (USFWS, 2016)
- Metapopulation and Recovery Area Monitoring - Monitor metapopulations and size by conducting annual surveys for the Salt Creek tiger beetle. (USFWS, 2016)
- Metapopulation and Recovery Area Monitoring - Monitor restoration and management actions to restore habitat at recovery areas. (USFWS, 2016)
- Outreach and Education - educate the public about the Salt Creek tiger beetle and its habitat. (USFWS, 2016)
- Outreach and Education - provide instruction and information to the public. (USFWS, 2016)
- Post-delisting Monitoring - develop and implement a post-delisting monitoring plan. (USFWS, 2016)

- Finalize the subspecies' recovery plan (USFWS, 2016b).
- Continue acquisition, restoration, and management of saline wetlands and streams in tributaries to Salt Creek. Conduct further research in rearing, propagation, and reintroduction methods including synchronization of wild and captive-reared life cycles (USFWS, 2016b).
- Conduct experimental reintroductions in low risk habitats such as saline wetlands located adjacent to Little Salt Creek, Rock Creek, Oak Creek, and Haines Branch Creek (USFWS, 2016b).
- Continue metapopulation surveys and habitat monitoring (USFWS, 2016b).
- Conduct further research on interactions between habitat and saline ground and surface waters; apply such research to habitat restoration projects (USFWS, 2016b).
- Conduct research on the appropriate frequency and intensity of using prescribed grazing as a saline wetland management tool (USFWS, 2016b).
- Conduct research on the effect of grazers on a surrogate tiger beetle species (USFWS, 2016b).
- Conduct research on the effectiveness and success of reintroduction efforts (USFWS, 2016b).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: • Continue metapopulation surveys to monitor SCTB abundance and distribution range-wide, especially following reintroductions. • Continue to acquire property containing saline wetlands and streams voluntarily from willing sellers, and to improve and manage habitat on already acquired lands to create large, contiguous expanses of suitable habitat. • Continue to conduct reintroductions in suitable habitats in and along the Little Salt Creek with a goal of establishing a self-sustaining population prior to expanding reintroductions to saline wetland habitats along Rock Creek (e.g. Jack Sinn Wildlife Management Area) or Oak Creek (e.g. Capitol Beach). • Monitor the effectiveness and success of captive propagation and rearing protocols across all facilities to ensure consistency and to keep mortalities of adults and larvae at facilities below the 60 percent maximum mortality rate. Work to develop genetic profiles on captive propagated SCTBs to ensure reproductive fitness (Omaha's Henry Doorly Zoo and Aquarium, August 25, 2022, personal communication). • Provide support to the Little Salt Creek Watershed Plan. • Conduct research on the potential effects of grazing on a surrogate tiger beetle species. • Conduct research on the appropriate frequency and intensity of grazing as a saline wetland management tool (USFWS, 2022).

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SPECIES ACCOUNT: *Cicindela ohlone* (Ohlone tiger beetle)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 3, 2001 (66 FR 50340).

Physical Description

The adult Ohlone tiger beetle is a relatively small beetle, measuring 9.5 to 12.5 millimeters (mm) (0.37 to 0.49 inch [in.]) long. The adults have large, prominent eyes and metallic green elytra (leathery forewings) with small light spots. Their legs are long, slender, and coppery green. Adult tiger beetles are medium-sized elongate beetles; they are characterized by their usually brilliant metallic green, blue, red, and yellow coloration, highlighted by stripes and spots. Alternatively, they can be brown, black, or dull-colored. The larvae are either white, yellowish, or dusky in coloration; they are grub-like and fossorial (subterranean), with a hook-like appendage on the fifth abdominal segment that anchors the larvae inside their burrows (66 FR 50340; USFWS 2009). Ohlone tiger beetle larvae burrows were measured 1.7 to 8.2 mm (0.16 to 0.23 in.) in diameter (Knisley and Arnold 2013).

Taxonomy

The Ohlone tiger beetle (Cicindela ohlone) is a member of the Coleopteran family Cicindelidae (tiger beetles), which includes more than 2,000 species worldwide and more than 100 species in the United States. Specimens of Ohlone tiger beetle were first collected northwest of the City of Santa Cruz, California, in 1987, and were first described in 1993. Both male and female specimens have been collected (USFWS 2009). The Ohlone tiger beetle is distinguished from its closest relatives, purple tiger beetle (Cicindela purpurea), by several morphological characteristics, its separate geographic range, and a different seasonality (Knisley and Arnold 2013). Despite the fact that tiger beetles are a well-studied taxonomic group with a large body of scientific literature, this insect was apparently overlooked because of its localized range, atypical seasonality, and habitat specificity (USFWS 2009; Knisley and Arnold 2013).

Historical Range

The historic range of the Ohlone tiger beetle is not known, because the species was only recently discovered (1987) and no historic specimens or records are available. Based on available information on topography, substrates, soils, and vegetation, it is likely that suitable habitat for the Ohlone tiger beetle was more extensive and continuous prior to the increase in urban development and agriculture. Historically, potentially suitable habitat may have extended from southwestern San Mateo County to southern Santa Cruz County, California. Tiger beetles are widely collected and well-studied, but no historic specimens were found in the extensive collections of the California Academy of Sciences. The Ohlone tiger beetle's specialized habitat and restricted range may account for the absence of collection records prior to 1987. Historically occupied habitat has been estimated at 42.13 hectares (ha)(104 acres [ac.]) (66 FR 50340; USFWS 2009; Knisley and Arnold 2013).

Current Range

An estimate of known, recently occupied grassland and trail habitats is 6.88 ha (17.0 ac.) in Santa Cruz County (Knisley and Arnold 2013). Currently, the extent of potentially suitable (but unoccupied) habitat for the Ohlone tiger beetle is estimated at 81 to 279 ha (200 to 687 ac.) in Santa Cruz County, California (USFWS 2009; Knisley and Arnold 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Ohlone tiger beetle larvae are predatory, living in small, vertical burrows from which they lunge and seize passing invertebrate prey. When a prey item passes near a burrow, the larva grasps the prey with its strong mandibles (mouthparts) and pulls it into the burrow. Once inside the burrow, the larva will feed on the captured prey (66 FR 50340; USFWS 2009).

Adult: Ohlone tiger beetles are day-active, predatory insects that prey on small arthropods. Adults are ferocious, swift, and agile predators that seize small prey with powerful sickle-shaped jaws. Tiger beetles often feed on insect species that are considered injurious to man and crops, and are regarded as beneficial (66 FR 50340; USFWS 2009). Other tiger beetle species are active during spring, summer, or early fall, but the Ohlone tiger beetle is active from late January to early April, mainly on sunny days. Adult active period coincides with the area's rainy season (66 FR 50340; NatureServe 2015).

Reproduction Narrative

Larvae: Larvae have a 1- to 3-year life cycle, with 2 years being the most common. Larvae instar stages are susceptible to fungal infection, parasitism, desiccation, food limitation, and burrow crushing resulting in mortality. After the larva emerges from the egg and becomes hardened, it enlarges the chamber that contained the egg into a tunnel. First instars emerge from eggs and remain in this stadium from late spring until early summer, then progress to second instar, which usually occurs from late spring to early summer. Development to third instar may occur during summer (as early as June in some years) or be delayed until the following March to early April, when they unplug their burrows after winter inactivity. These third instars complete development during the second spring and summer and emerge as new adults in the following year, thus completing a 2-year life cycle (a third year has been observed in few instances). The 1-year cycle could occur as a result of early oviposition and hatching, adequate food, and favorable climatic conditions (Knisley and Arnold 2013). Before pupation, the third instar larva will plug the burrow entrance and dig a chamber for pupation. After pupation, the adult tiger beetle will dig out of the soil and emerge (USFWS 2009).

Adult: Females of many species of Cicindela are extremely specific in choice of soil type for oviposition; Ohlone tiger beetles appear to only use Watsonville loam or Bonnydoon soil series. Adults reproduce shortly after pupation and emergence from their burrows. Emergence occurs from mid-January to mid-May. Adult female Ohlone tiger beetles excavate a hole in the soil and oviposit (lay) a single egg per mating event. Limited laboratory study observed a range of 2 to 62 eggs laid per female over a 4-week period. It is likely they average 40 to 60 eggs in their single season of reproduction. The eggs are left to hatch, and no parental care is provided.Observed sex ratios were 1.6:1 male-to-female for a single population studied. Total lifespan, including larva stages, is 1 to 4 years, with the adult life stage activity period being 1 to 4 months (mean duration of 87 days) following instar stages. Adults have a low survival rate due to exposure to predators; food limitation; cold temperatures, particularly in the earlier portion of the adult season; crushing; and other factors that significantly reduce their survival times (USFWS 2009; Knisley and Arnold 2013).

Geographic or Habitat Restraints or Barriers

Larvae: Geographic extent of Watsonville loam soil series and bare ground (Knisley and Arnold 2013).

Adult: Geographic extent of Watsonville loam soil series, which has been found only in Santa Cruz County (Knisley and Arnold 2013).

Spatial Arrangements of the Population

Larvae: Clumped

Adult: Clumped

Environmental Specificity

Larvae: Narrow/community with key requirements common.

Adult: Narrow/community with key requirements common.

Site Fidelity

Larvae: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: No

Adult: No

Habitat Narrative

Larvae: See Adult life stage narrative.

Adult: Ohlone tiger beetles are found only in coastal terrace prairie grasslands with remnant stands of open native grassland containing purple needlegrass (Stipa pulchra), California oat grass (Danthonia californica), Gairdner's yampa (Perideridia gairdneri), and/or Kellogg's yampa (Perideridia kelloggii). Soils at these level or nearly level sites are shallow, poorly drained, pale clay or sandy clay soils over bedrock of Santa Cruz mudstone, and include Watsonville loam or Bonnydoon soil series and bare ground. These soil series are found only in coastal Santa Cruz County, California. Due to the limited extent of this specific habitat, the populations are clumped in undeveloped areas with this soil series, and site fidelity is high (USFWS 2009; Knisley and Arnold 2013). Adult tiger beetles generally occupy sun-exposed or open areas in their habitat to thermoregulate (control body temperature) or hunt (USFWS 1998).

Dispersal/Migration

Motility/Mobility

Larvae: Low; larvae do not leave their burrow before pupation.

Adult: Low; due to limited extent of undeveloped suitable habitat.

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Adult: Low

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Larvae: Larvae remain in the burrow they hatched in until pupation (USFWS 2009).

Adult: The dispersal capabilities of Ohlone tiger beetles are unknown; however, because the Ohlone tiger beetle belongs to the purpurea group, its dispersal distance is most likely short. Contiguous suitable habitat would be needed for hunting and thermoregulation, as well as oviposition and larval burrows (USFWS 2009).

Additional Life History Information

Adult: The dispersal capabilities of Ohlone tiger beetles are unknown; however, because the Ohlone tiger beetle belongs to the purpurea group, its dispersal distance is most likely short (USFWS 2009).

Population Information and Trends

Population Trends:

Decreasing; decline of more than 70 percent; the original range was never documented, but most potential habitat has been destroyed (NatureServe 2015).

Species Trends:

Short-term trend unknown: greatly reduced in area of occupancy and numbers, but it is unclear whether it is still declining (NatureServe 2015).

Population Growth Rate:

Declining

Number of Populations:

Nine of seventeen occurrences still known to be extant (Knisley and Arnold 2013). These are probably fragments of one original metapopulation (NatureServe 2015).

Population Size:

50 to 1,000 individuals; no known data, but with an area of occupancy of less than 25 ac., there are presumably only a few dozen to a few hundreds of adults produced per generation (NatureServe 2015).

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Low

Additional Population-level Information:

Known populations have been lost or reduced due to the installation of a vineyard, a horse stable, covering dirt trails with gravel, small-scale excavations, invasion of nonnative plant species after cessation of grazing, and changes in plant communities after controlled burns. Disturbance of the substrate, and removal or elimination of vegetation by urban development, kills or injures individuals and precludes others from feeding, sheltering, or reproducing (USFWS 2009; Knisley and Arnold 2013).

Population Narrative:

Ohlone tiger beetle populations are decreasing or being extirpated; the original range of the species was never documented, but most potential habitat has been destroyed and the short-term trends are largely unknown. Nine of seventeen occurrences are still known to be extant (Knisley and Arnold 2013). These are probably fragments of one original metapopulation (NatureServe 2015). The current population size is not known, but based on area of occupancy of less than 25 ac., there are presumably only a few dozen to a few hundreds of adults produced per generation. Most populations have been lost, largely due to habitat loss. Known populations have been lost or reduced due to the installation of a vineyard, a horse stable, covering dirt trails with gravel, small-scale excavations, invasion of nonnative plant species after cessation of grazing, and changes in plant communities after controlled burns. Disturbance of the substrate, and removal or elimination of vegetation by development, kills or injures individuals and precludes others from feeding, sheltering, or reproducing (USFWS 2009; Knisley and Arnold 2013).

Threats and Stressors

Stressor: Loss of habitat
Exposure: Degradation and destruction of habitat by development and agriculture, or modification of habitat by invasive nonnative vegetation (USFWS 2009; Knisley and Arnold 2013).
Response: Reduced growth, more vulnerable to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Loss of habitat is the principal threat to insect species worldwide, because of their close associations with and dependence on specific habitats. The habitat of the Ohlone tiger beetle is threatened with destruction from urban development or agriculture, or with modification by invasive nonnative vegetation across all of the species' occurrences. Disturbance of the substrate, and removal or elimination of vegetation by urban development, kills or injures individuals and precludes others from feeding, sheltering, or reproducing. Most of what is believed to be the historic habitat for this species has been modified or destroyed by urbanization and agriculture (USFWS 2009). Known populations have been lost or reduced due to installation of a vineyard, a horse stable, covering dirt trails with gravel, small-scale excavations, invasion of nonnative plant species after cessation of grazing, and changes in plant communities after controlled burns (Knisley and Arnold 2013). Other activities, such as vehicular traffic, may create soil compaction and rutting, damaging potential oviposition sites (USFWS 2009).

Stressor: Collecting of Ohlone tiger beetle specimens
Exposure: Overutilization for commercial, recreational, scientific, or educational purposes.
Response: Reduced growth, injury, and death.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Tiger beetle specimens are highly sought by amateur collectors, and members of the genus Cicindela may be the subject of more intense collecting and study than any other single insect genus. Removal of even a few females from a small population could reduce the persistence of the population over time. The Ohlone tiger beetle is not likely to be used for general research projects, because it is a rare and limited species. It may be the subject of studies intended to improve understanding of the species' ecology and to improve management strategies for its conservation. Although such studies would directly benefit the recovery of the Ohlone tiger beetle, they may contribute cumulatively to other threats to the species (USFWS 2009).

Stressor: Disease or predation
Exposure: Predators and parasites.

Response: Reduced growth, injury, and increased vulnerability to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: No diseases are known to threaten this species; however, the Ohlone tiger beetle may be affected by any of several predators and parasites known to prey on or parasitize other tiger beetle species. In general, parasites are considered to be more detrimental than predators to populations of tiger beetles. Known tiger beetle parasites include ant-like wasps of the family Typhiidae. These insect parasites are distributed worldwide and specialize on tiger beetle larvae; some species of tiger beetles from Arizona have larval parasitism rates of 20 to 60 percent. Known tiger beetle predators include birds, shrews (Soricidae), raccoons (Procyon lotor), lizards (Lacertilia), toads (Bufonidae), ants (Formicidae), robber flies (Asilidae), and dragonflies (Anisoptera). Although the magnitude of predation and parasitism on the Ohlone tiger beetle is not known, their effect will likely increase as the species continues to decline (USFWS 2009).

Stressor: Recreational activities in Ohlone tiger beetle habitat
Exposure: Some populations occur on open space or in park areas.
Response: Reduced growth, injury, death, and increased vulnerability to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Some of the remaining Ohlone tiger beetle occurrences are located on open space or in park areas that are accessible to the public. Some recreational uses (i.e., off-highway vehicular use or mountain biking) pose a threat to the Ohlone tiger beetle. Beetles use the hard-packed trails for foraging, thermoregulation, and laying their eggs. Population occurrences in recreational areas are at risk for trail use, potentially resulting in crushing or otherwise injuring or killing adult or larval Ohlone tiger beetles. Although controlled recreational uses may help maintain the open spaces on which Ohlone tiger beetles depend, bicycle traffic has been observed to result in the crushing of individuals. In addition, bicycle and foot traffic could potentially collapse larval tunnels and crush the larvae. Ohlone tiger beetles were potentially extirpated from one area, west of the city of Soquel, in part as a result of substantial impacts caused by uncontrolled recreational uses. Children dug out the primary location of Ohlone tiger beetle burrows at the only occurrence in this geographic area to build ramps for jumping bicycles. Ohlone tiger beetles persisted at the site in reduced numbers and in a smaller area until the remaining habitat became unsuitable due to degradation caused by encroachment of nonnative plants (USFWS 2009).

Stressor: Stochasticity
Exposure: Environmental exposure.
Response: Reduced growth and increased vulnerability to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Demographic stochasticity (random variability in survival and/or reproduction) can have a significant impact on viability for populations that are small, have low fecundity, and are short-lived. In small populations, reduced reproduction or die-offs of a certain age-class will have a significant effect on the whole population. Loss of diversity could limit the species’ ability to adapt to environmental changes, and contributes to inbreeding depression (i.e., loss of reproductive fitness and vigor). Environmental stochasticity is the variation in birth and death rates seasonally in response to weather, disease, competition, predation, or other factors external to the population. For example, drought or predation in combination with a low population year

could result in extinction. One site near Scotts Valley experienced widely fluctuating population numbers of Ohlone tiger beetle between 2003 and 2008, apparently driven by variations in precipitation, which resulted in a 79 percent decline in the population from 2003 to 2005. Small or localized populations are particularly susceptible to catastrophic events. Isolated populations of the Ohlone tiger beetle may be more vulnerable to local extinction from random events or environmental catastrophes (USFWS 2009).

Stressor: Pesticides
Exposure: Environmental exposure.
Response: Reduced growth, injury, death, and increased vulnerability to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Pesticides used by local land owners in their home, garden, or agricultural fields could pose a threat to the Ohlone tiger beetle. These pesticides may drift aerially or be transported by water runoff into Ohlone tiger beetle habitat, where they may kill the Ohlone tiger beetle or its prey species. As development increases near or in Ohlone tiger beetle habitat, negative impacts from pesticides may become more frequent.

Recovery

Reclassification Criteria:
Reclassification criteria have not been established for this species.

Delisting Criteria:
Because the Ohlone tiger beetle was not listed when the recovery plan was published, no recovery criteria were established for the species (USFWS 2009).

Recovery Actions:

- A recovery plan has not been prepared for the Ohlone tiger beetle, because it was listed as an endangered species in 2001. The species was included as species of concern in a recovery plan that was published before it was listed, titled “Recovery Plan for Insect and Plant Taxa from the Santa Cruz Mountains in California.” Only a portion of the Ohlone tiger beetle’s range was included in that recovery plan. This species was included with the intent that this plan would form the basis for a formal recovery plan if the species were eventually listed. Because the Ohlone tiger beetle was not listed when the recovery plan was published, no recovery criteria were established for the species (USFWS 2009). However, several recovery actions were identified:
- Protect habitat for Santa Cruz Mountains species on private land through Habitat Conservation Plans and landowner agreements. Because of the extremely limited amount of habitat that exists, recovery cannot be achieved by the management of state and county lands alone (see task 2). Habitat Conservation Planning with local governments, quarry owners, and developers will provide additional protection. The long-term survival of these species will depend to a large extent on the protection that can be achieved on private lands (USFWS 1998).
- Manage habitat for Santa Cruz Mountains species. Management of the seven species included in this recovery plan and the habitats that support them will depend on data

gathered from monitoring, threat analyses, and available conservation measures. Development and implementation of management programs should be specific to the species complex, ecological process, landowner, and particular threats to be managed (USFWS 1998).

- Conduct research on the life history. ecology, and population dynamics of these species, which will contribute to appropriate management strategies. Research is needed to ensure that management actions that are undertaken are appropriate and will contribute to the long-term survival of these species and the habitats on which they depend (USFWS 1998).
- Locate additional habitat/populations within the historic range of the species. The status of any new populations of these species that are discovered in the future should be evaluated, and an assessment made of appropriate management actions. The value to the recovery strategy for these species of any additional habitat that is located should be assessed (USFWS 1998).
- Develop and implement a public outreach program. An educational program should be established for the public, including private landowners whose property supports these taxa or suitable habitat, to encourage conservation and proper management of the taxa. Nongovernmental organizations such as the California Native Plant Society and the Santa Cruz Mountains Biodiversity Task Force should be approached about participating in this effort (USFWS 1998).
- Evaluate progress of recovery effectiveness of management and recovery actions, and revise management plans (USFWS 1998).
- Habitat Conservation Plans with the County of Santa Cruz, City of Santa Cruz, and City of Scotts Valley that minimize loss of habitat from urban development (USFWS 1998),
- Protection of habitat through acquisition or conservation easements on habitat in the cities of Santa Cruz and Scotts Valley (USFWS 1998).
- Conduct research focusing on habitat requirements for long-term survival (USFWS 1998).
- Develop a Recovery Plan for the Ohlone tiger beetle (USFWS 2009).
- Conduct research to determine habitat management practices that can be used by landowners to benefit the Ohlone tiger beetle (USFWS 2009).
- Establish a uniform, range-wide monitoring program for the Ohlone tiger beetle (USFWS 2009).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: • Enhance existing and potential habitat throughout the species range, as necessary, through removal of invasive species, grazing, burning, planting, or other management actions deemed appropriate by the Service. • Investigate and implement a captive propagation program for the species to bolster existing populations and to introduce the species to suitable breeding habitats. • Investigate and implement the translocation of individuals between populations to ensure genetic diversity. • Work with the City of Santa Cruz to develop coastal prairie management plans for City owned properties. • Work with the University of California, Santa Cruz (UCSC) to ensure potential and suitable habitats on UCSC lands are managed for the benefit of the species. (USFWS, 2019)

Additional Threshold Information:

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SPECIES ACCOUNT: *Cicindela puritana* (Puritan tiger beetle)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Cicindela puritana is a medium—sized (males average 11.5 mm and females average 12.4 mm in Calvert County) terrestrial beetle of the family Cicindelidae (Figure 3). This family is closely related to the family Carabidae and is included as a subfamily of Carabidae by some authors. The background coloration of C. puritana is dark bronze—brown to bronze—green with cream—colored markings on the elytral surfaces. The Puritan tiger beetle is brownish-bronze above with a metallic blue underside and measures under 11.5 mm ('/z-inch) in total length. Each elytron (wing cover) is marked with narrow marginal and transverse white bands. It is distinguished from more common, similarly marked tiger beetles by the uneven or minutely broken edges of the middle band (Glaser 1984). (Federal Register, 1990)

Taxonomy

C. puritana was described by G. Horn (1876) and recognized as a separate species by Schaupp (1883—1884). The taxon subsequently was described as a subspecies of, first, C. cuprascens (Leng 1902, Horn 1930), then C. macra (Vaurie 1951). Willis (1967) established separate species status for each of these taxa, using only Connecticut River specimens of C. puritana for his analysis. The range of C. puritana is separated by several hundred miles from the overlapping ranges of C. cuprascens and C. macra. NOTE: A new study of taxonomy has indicated the genus Cicindela should be changed to Ellipsoptera (Bousquet 2012; p.296) and the new name for the Puritan tiger beetle should be Ellipsoptera puritana. However, the current regulation for this species uses the older name. Until the name change is published in the Federal Register we will continue to use the older name of Cicindela puritana throughout this document to be consistent with current regulations. (USFWS, 2019)

Historical Range

The Puritan tiger beetle occurred historically along the Connecticut River in Connecticut, Massachusetts, and New Hampshire, and along the Chesapeake Bay shoreline in Maryland.

Current Range

Only two small Connecticut River populations remain, one in Massachusetts and one in Connecticut. Approximately six localities with more than 500 adults, and approximately 13 smaller populations, occur along the Chesapeake Bay in Calvert County and near the mouth of the Sassafras River in Kent and Cecil Counties, Maryland.

Distinct Population Segments Defined

Not applicable (USFWS, 2019)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Juvenile: The larvae firmly position themselves at the mouths of their burrows by means of abdominal hooks and wait for small invertebrates to pass by. Larvae are active (as evidenced by open burrows) day and night during cool weather in late spring and early fall. Their activity is reduced during hot, sunny weather (C.B. Knisley and J.M. Hill pers. obs.).

Adult: Adults feed actively in the wrack along the shoreline and probably also to some extent on the bluff face. Smaller invertebrates probably comprise the bulk of their diet. Adult C. puritana are active both day and night.

Reproduction Narrative

Juvenile: Puritan tiger beetles typically undergo a two-year larval period before emergence, similar to that of other species in the genus Cicindela. Larvae hatch in late July or August as first instars. This stage lasts 2—4 weeks; larvae then molt and become second instars. Larvae generally over—winter as second instars and become active again (as evidenced by open burrows) the following spring, when they molt to the third instar. Recent observations indicate that the third instar may last another year, but further studies are required to substantiate this finding. Larvae tend to be most active (as evidenced by open burrows) in the fall, with lesser numbers appearing in the spring and summer. Pupation occurs in late spring, and in Maryland adults emerge during mid- to late-June (Hill and Knisley 1991). The timing of adult emergence is 2-3 weeks later in the Connecticut River populations (P. Nothnagle pers. obs.).

Adult: The adult populations peak in late June to early July and begin to decline in late July. Population size then decreases rapidly until the middle of August, when only a few adults remain. A sympatric species, Cicindela repanda, exhibits an opposite seasonality, with adults emerging during the spring and fall, and larval activity occurring mostly during the summer months, although there is some interspecific overlap of both adults and larvae. Adults feed throughout the day, and mating activities are commonly observed during the afternoon. Pairing activity increases in late afternoon and seems to peak in the early evening. Oviposition behavior is unknown.

Geographic or Habitat Restraints or Barriers

Juvenile: Possibly dams, rip-raps, groins

Adult: Possibly dams, rip-raps, groins

Spatial Arrangements of the Population

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Juvenile: Very narrow. Specialist or community with key requirements scarce.

Adult: Very narrow. Specialist or community with key requirements scarce.

Tolerance Ranges/Thresholds

Juvenile: Unknown

Adult: Unknown

Site Fidelity

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Juvenile: Not applicable

Adult: Not applicable

Habitat Narrative

Larvae: Knisley and Fenster (2009) provided evidence that increased vegetation has a negative effect on larval habitat and may explain the decline of populations at some sites, and that soil compaction and grain size were important determinants of larval habitat. (USFWS, 2019)

Juvenile: In Maryland, C. puritana larvae live in deep burrows, which they dig in sandy deposits on non-vegetated portions of the bluff face. They may also burrow at the base of the bluffs in sediment deposits that have eroded from the bluff face. Knisley (1987a) and Hill and Knisley (1991) have found Chesapeake Bay populations to be most abundant where bluffs are long and high, with little or no vegetation, and composed at least in part of yellow or red sandy soil. Wave—producing storms and concomitant erosion of bluffs are necessary to maintain the bare bluff faces required for larval habitat. Larvae will not utilize densely vegetated bluffs; for instance, Hill and Knisley (1991) found that no tiger beetle larvae or adults occupied bluffs stabilized by kudzu at Calvert Beach, Maryland, although both C. puritana and C. repanda were numerous on adjacent natural bluffs. In contrast to these observations in Maryland, Nothnagle (1987, 1989, 1990) found that larvae at the two extant populations on the Connecticut River generally do not use the low bluffs; instead, their burrows are found among scattered herbaceous vegetation at the upper portions of sandy beaches and occasionally near the water's edge. At the lower Connecticut River site, the larvae are thus subject to tidal flooding twice daily. It is not known whether the differences in habitat preference are inherent or have resulted from recent habitat changes. However, recent observation indicates the potential for some flexibility in larval behavior. P. Nothnagle (pers. obs. 1993) noted some C. puritana larval burrows in the vertical portion of a low (5 m) bank at the Cromwell-Portland site, where the beach almost disappears at high tide.

Adult: The Chesapeake Bay contains two metapopulations along its shorelines, one in Calvert County on the western shore of the Bay, the other along the Sassafras River of the eastern shore of the Bay (figures 1 and 2). Each metapopulation consists of subpopulations that are spatially separated from each other but likely have some level of dispersal among them. There is likely no dispersal between the eastern and western shore metapopulations. In MD, the Puritan tiger beetle larvae occupy only naturally eroding cliffs, where they develop in deep horizontal burrows in sandy deposits of nonvegetated portions of the bluff face or at the base of the cliffs. They are most abundant at sites where the bluffs are long and high with little or no vegetation and composed in part of sandy soil. Erosion results in the loss of some larval beetles, but is necessary to maintain the bare bluff faces they require. In New England, only a few small populations remain; these include one metapopulation consisting of four sites near Cromwell, CT and one single site in MA (figure 3). In New England, Puritan tiger beetles occur in the sand and gravel islands of the river where beetle larvae develop in vertical burrows in suitable substrate. (USFWS, 2019)

Dispersal/Migration

Motility/Mobility

Juvenile: Yes

Adult: Yes

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: not migratory

Adult: not migratory

Dispersal

Juvenile: very limited

Adult: moderate

Immigration/Emigration

Juvenile: unlikely

Adult: possible, but there is not a lot of available information

Dependency on Other Individuals or Species for Dispersal

Juvenile: Not applicable

Adult: Not applicable

Dispersal/Migration Narrative

Adult: Little is known about adult dispersal. It is probable that some individuals disperse from their site of emergence, as indicated by mark-recapture studies in Maryland (Knisley and Hill 1989), which showed that adult numbers decline about two weeks after emergence. No recaptures of marked beetles were obtained from other sites, albeit search effort was minimal. Long-distance dispersal ability is suggested by the observation of two unmarked individuals near Annapolis, Maryland on Bodkin Creek and oneindividual at the mouth of the Patapsco River, all in Anne Arundel County (T. Koenig, Randolph-Macon College, pers. obs. 1989). These sites are approximately 30 miles north of the nearest known Calvert County sites, and about 25 miles from known sites near the mouth of the Sassafras River."

Population Information and Trends

Population Trends:

Variable (USFWS, 2019)

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

1 to 20

Population Size:

8000 to 14000 (USFWS, 2019)

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Additional Population-level Information:

Three population viability analyses (PVAs) for the Puritan tiger beetle in the Chesapeake Bay region have been completed (Gowan and Knisley 2005, Gowan and Knisley 2010, and Gowan and Knisley 2016), the latter two since the last 5-year review. These PVAs compare different management scenarios to the baseline condition of all subpopulations continuing at the current population level. They all conclude that maintaining as many subpopulations as possible is important and that we cannot rely on the protected subpopulations alone to maintain the species. The 2010 PVA indicates that the risk of the Calvert County population reaching the low threshold of 100 individuals in 100 years is 0.08 (8 percent) if all subpopulations continue with current abundance. The risk is essentially the same if each of the subpopulations is reduced to 85 percent of the current carrying capacity. But if each of the subpopulations is reduced to 50 percent of the carrying capacity, the risk of reaching this low threshold goes up to 0.14 (14 percent). For the Sassafras River metapopulation these risks were much higher at that time. The risk of the Sassafras River metapopulation reaching the 100 individual threshold is 0.36 (36 percent) if all populations continue at that level but 0.6 (60 percent) if the carrying capacity of each of the subpopulations is reduced by 50 percent. The 2016 PVA results were consistent with the previous PVA results, but also showed that increases in the Sassafras River metapopulation had reduced the extinction risk to some extent for that population even though it was still smaller than the Calvert County metapopulation. Similarly, the decrease in the Calvert County metapopulation had increased the extinction risk for that metapopulation (Gowan and Knisley 2016). Knisley (2011) states that his studies of tiger beetles have found that many populations have existed at low numbers (less than 100, for example) for a long period of time and that many of these populations have recovered from bottlenecks. (USFWS, 2019)

Population Narrative:

A preliminary estimate of 500—1000 adults as a minimum viable population size for this species (Hill and Knisley 1991) is based on estimates in the literature (Mettler and Gregg 1969, Lacy 1987, Thomas 1990) and on preliminary observations of population stability and decline at several sites. However, at present no long—term genetic or demographic information is available to accurately model how many adults on how large an area, and in what proximity to other large or small populations, are needed to sustain long-term population viability. A population viability analysis for the Puritan Tiger beetle concluded that the Chesapeake Bay meta populations face serious risk of extinction. This risk is particularly high for the Sassafras River metapopulation. Even if all its extant subpopulations are protected, the analysis predicts that over the next 100 cohorts, this metapopulation will almost certainly fall below 200 individuals. To put this into perspective, it should be noted that if the total population of metapopulation falls below 500 individuals, the chances of extinction from catastrophic events, Allee effects, and from loss of genetic diversity will be very high. This species has experienced a significant decline, greater than 90% in New England.   From 2019 5-Year Review: Two new subpopulations have been discovered since the 2007 5-year review in the Chesapeake Bay area (figure 1). One new population site was discovered in 2014 by Benedict Pagac of the Entomological Branch of the U.S. Army Public Health Command. The new site was found on the shore of the Severn River in Anne Arundel County, Maryland, approximately 24 miles north of the nearest known site in Calvert County. Mr. Pagac reported observing two to three dozen Puritan tiger beetles at this site on July 11, 2014. On July 16, 2014, the occurrence of Puritan tiger beetles at this site was confirmed by Andy Moser of the Service. Habitat for the species at this site is limited to several hundred feet of shoreline by riprap to the southeast and lack of cliffs to the northwest. Additional beetles were discovered at a second site on the Severn River 2 miles upstream from the first discovery in 2015. The number of beetles counted at these sites has always been small with 23 and 12 counted at Sites 1 and 2 respectively in 2015, but 54 beetles were recorded in

2018 at Site 2 (Knisley 2018). However, they are likely too far away from other sites to be contributing to the Calvert metapopulation. In 2010 there was an additional discovery of beetles at a new location (Rocky Point) located between the Calvert Cliffs Nuclear Power Plant and Calvert Cliffs State Park by Service biologists visiting the shoreline. Counts of this approximately 1-km length of shoreline have continued since that 2010 discovery with a high of 195 beetles counted in 2017 (Knisley 2018). While this location is nearly continuous with subpopulations to the north and south, it adds additional areas of occupied habitat that we did not realize were there previously. (USFWS, 2019) From 2019 5-year review: From 2019 5 - year review: Calvert County Metapopulation: Surveys for Puritan tiger beetles have been conducted since 1989 in Calvert County and this has always been the largest metapopulaton (Knisley 2018). The highest count was in 1998 with 9,801 beetles, but in most years the total counts ranged between 2,000 and 4,000 (figure 4). The total population of beetles is estimated to be twice the number of beetles that are counted (Knisley and Fenster 2009; Part 2), thus most years the population is between 4,000 and 8,000 beetles. It is unclear why the 1998 beetle count was so high. Sassafras River Metapopulation: Surveys for Puritan tiger beetles have been conducted in the Sassafras River metapopulation since 1992 (Knisley 2018), and numbers have ranged dramatically, from lows of less than 1,000 beetles counted to the highest value of 3,479 in 2018 (figure 10). Most years the counts range from 1,000 to 3,000. The population of beetles is estimated to be twice the number counted (Knisley and Fenster 2009; Part 2), thus most years the population is between 2,000 and 6,000 beetles. New England Region: Since the 2007 review, the CT metapopulation had generally been increasing in numbers with total beetle counts reaching 1,631 beetles in 2012 (Saucier 2018). Then numbers decreased, and the most recent 4 years averaged about 500 beetles (figure 17). Poor weather in 2013 precluded most of the surveys that year. (USFWS, 2019)

Threats and Stressors

Stressor: Dams
Exposure:
Response:
Consequence:
Narrative: The species’ decline in New England is associated with the construction of 17 dams on the Connecticut River above Hartford. The network of flood control dams that extends throughout the Connecticut River watershed has resulted in profound changes to the river’s hydrologic cycle: floods are no longer as high, and periods of low flow have been greatly altered by flow scheduling for hydropower, likely reducing the amount of beach habitat available for foraging adult C. puritana and perhaps reducing the amount of bank erosion. Loss of the New Hampshire sites may have been due to inundation above the dam at Bellows Falls, Vermont. Urbanization and bank stabilization probably contributed to loss of populations at Hartford, Connecticut, as well as Chicopee, Springfield, and Longmeadow, Massachusetts. Pollution of the Connecticut River from mill and factory effluent may also have contributed to the species’ decline.

Stressor: Recreational use

Exposure:
Response:
Consequence:
Narrative: There has been an extensive and largely successful effort to clean up the Connecticut River over the past several decades (McCarry 1972); ironically, the river's current designation as Class C water (unfit for swimming) is probably responsible for less direct human impact on the beetle than would otherwise occur (Nothnagle 1991). Nevertheless, certain recreational uses of the river shoreline continue to imperil the two remaining populations as well as potential reintroduction sites. For instance, the three small Massachusetts sites are currently threatened by camping and beach recreation, which occur on larval habitat (Nothnagle 1987, 1990). The three Cromwell, Connecticut sites are often completely flooded, but greater threats are posed by habitat alteration (e.g., nearby residential construction), and off—road vehicle traffic and camping, which may directly destroy larvae.

Stressor: Invasive woody plants
Exposure:
Response:
Consequence:
Narrative: Despite protection efforts, the Massachusetts C. puritana population has been declining steadily since 1988. It has been suggested that the tiger beetle habitat at these sites is being adversely affected by the invasion of woody plants (P. Nothnagle pers. comm. 1992).

Stressor: shoreline development and shoreline stabilization
Exposure:
Response:
Consequence:
Narrative: At the present time, shoreline development and shoreline stabilization are the most serious and least controllable threats to Puritan tiger beetles in Maryland (Bartgis and Maclvor in press). Shoreline stabilization structures, including revetments, offshore breakwaters, and groins, are designed to minimize wave-induced erosion at the base of the bluff such that, over time, the slope of the bluff will decrease, eventually reaching a stable angle of repose. Slopes thus stabilized eventually become vegetated, making them unsuitable for C. puritana larval habitat (Hill and Knisley 1991 and pers. obs.). From 2019 5-year Review: Destruction or degradation of habitat remains the primary threat to the species, especially for the MD population. Since 1997, Calvert County has required a 100- to 300-foot set-back from the cliffs for new home construction; setbacks of 200 feet are used where housing development is already present (https://ecode360.com/29294889Z). However, the demand for shoreline erosion control measures to protect existing homes has greatly increased. Since 2006, six shoreline revetment projects have been built in Calvert County (primarily in the Chesapeake Ranch Estates (Little Cove Point subpopulation) and Scientists Cliffs communities. Two projects have been built on the eastern shore in the Chesapeake Haven Estates community (Grove Point subpopulation) (USFWS 2019, appendix B). Increasing hardening of shorelines that reduce habitat supporting the Puritan tiger beetle has also been documented by the Virginia Institute of Marine Science (VIMS 2006). In addition, some Puritan tiger beetle habitats along the Chesapeake Bay have been reduced in

value, by increased vegetation growing on habitat cliffs and on the shoreline (Knisley 2005a, 2005b, 2017). Increased degradation of suitable habitat is also occurring in MA and CT, primarily as a result of changes in flow regimes, vegetation encroachment, intensive recreational use, and development of the Connecticut River shoreline in these areas. (USFWS, 2019)

Stressor: Changing climate
Exposure:
Response:
Consequence:
Narrative: Changing climate may have an effect on habitat in the Chesapeake Bay area. Studies of Calvert County cliff erosion suggest that slides and sloughing of the cliff face can happen through freeze/thaw cycles that increase with high amounts of rain and soil moisture (Wilcock et al. 1998; Zeissler et al. 2014). If the mid- Atlantic climate becomes wetter, with more precipitation in winter, as suggested by the 2014 National Climate Assessment (https://nca2014.globalchange.gov/report/our-changing-climate/precipitationchange), it is possible that new exposure of suitable habitat will happen more often, regardless of erosion control structures at the base of the cliff. Hurricanes and winter storms can also cause erosion and provide newly exposed cliff faces in either Chesapeake Bay metapopulation. While storms may cause significant temporary reductions in population size, they help maintain beetle habitat over the long term through shoreline and cliff erosional processes. The species' ability to recover from storm events and recolonize newly created habitat requires the continuation of all the subpopulations and maintaining the distribution across the metapopulation. Sea level rise is an emerging threat with the potential to reduce the requisite beach shoreline habitat for this species in the foreseeable future. Sea level is rising 3 to 4 millimeters per year (12 to 16 inches per century) along the MD coast (Nuckols et al. 2010). Along the Connecticut River there is evidence that prolonged periods of high water during flood events and the resulting prolonged inundation of larval habitat may result in reduced beetle populations (Davis 2006, Davis 2013). Similar to the Chesapeake Bay area, the Northeast is predicted to have higher precipitation in the winter, though there is uncertainty how this may influence summer inundation. (https://nca2014.globalchange.gov/report/our-changingclimate/ precipitation-change, figure 2.14). Changes in duration and frequency of summer precipitation could affect the number of flood events and the need for dams to release water. (USFWS, 2019)

Recovery

Reclassification Criteria:
Recovery Priority Number: 5C (The recovery priority number is unchanged because the species continues to be subject to a high degree of threat with a low potential for complete recovery; USFWS, 2019)

Delisting Criteria:
1. A minimum of six large (500 to 1000+ adults) populations and their habitat are protected in perpetuity at current sites along both shores of the Chesapeake Bay. (USFWS, 1993)

2. Sufficient habitat between these populations is protected to support smaller populations, thereby providing an avenue for genetic interchange among large populations and ensuring a stable metapopulation. (USFWS, 1993)

3. A minimum of three metapopulations, at least two of which are large (500 to 1000+ adults), are maintained (at extant sites) or established (= self-maintained for at least 10 years) within the species' historical range along the Connecticut River, and the habitat they occupy is permanently protected. (USFWS, 1993)

There exists an effective long—term program for site—specific management that is based on an adequate understanding of life history parameters, human impacts, factors causing decline, population genetics, and taxonomy. (USFWS, 1993)

Recovery Actions:

- A high priority be given to identifying additional private landowners who are willing to enter into conservation easements for the protection and management of their Chesapeake Bay or Connecticut River shoreline habitats supporting Puritan tiger beetles. (USFWS, 2019)
- The Service and its partners continue to implement management strategies (vegetation management in New England and the Chesapeake Bay and propagation/translocations in New England) using the principles of adaptive management through monitoring and research to improve population levels and habitat quality and quantity for this species at as many locations as feasible. (USFWS, 2019)
- The species recovery group review the recovery criteria in the 1993 recovery plan in light of progress on habitat protection, results of the 2016 PVA, and new information on threats, population numbers, and genetics. (USFWS, 2019)
- The annual counts of Puritan tiger beetle populations be continued to allow further analysis of population trends. (USFWS, 2019)
- The results of the soon to be completed genetic analysis of Puritan tiger beetle populations be used to determine how they may direct recovery in the future. (USFWS, 2019)
- The potential effects of sea level rise on habitat suitability and the long-term viability of each metapopulation be evaluated. (USFWS. 2019)
- The States of Connecticut, Maryland, and Massachusetts list Cicindela puritana as endangered. Their State laws, as well as regulations promulgated under the Endangered Species Act of 1973, prohibit collection or harassment of this species. The Endangered Species Act also obligates Federal agencies to ensure that their actions do not jeopardize the continued existence of listed species, and provides a framework for the species' conservation.
- Since mid-1985, Cicindela puritana studies funded by the U.S. Fish and Wildlife Service, Maryland Natural Heritage Program, Massachusetts Natural Heritage Program, Connecticut Natural Diversity Database, and The Nature Conservancy have been conducted in Maryland, Connecticut, and Massachusetts. These studies have provided initial data on distribution, annual and seasonal abundance, and certain aspects of larval ecology. In 1989, detailed ecological studies were begun at Calvert Beach in Maryland to determine aspects of reproduction, feeding, predation and parasitism, dispersal, competition, habitat relationships, and general behavior of C. puritana.

- To help determine which areas can be managed for maintenance of Puritan tiger beetle populations in the State, the Maryland Natural Heritage Program analyzed land ownership and land use patterns along shoreline habitats occupied by the beetle (Bartgis and MacIvor in press).
- The Maryland Natural Heritage Program, in cooperation with The Nature Conservancy, is pursuing fee acquisition, easements, or management agreements at three of the priority conservation sites. Landowners of smaller but critical tracts have also been contacted by Natural Heritage Program staff. Randle Cliffs is under active consideration for acquisition as a local nature park (Maryland Natural Heritage Program 1992).
- Maryland Natural Heritage Program staff have provided management recommendations for significant Puritan tiger beetle populations to the three counties with populations of these beetles. This information is intended to be included in local land use ordinances as part of the counties' Chesapeake Bay Critical Areas Programs. Protection areas have already been established for some sites in Calvert and Cecil Counties, and several Kent County sites are being proposed. Calvert County has established a Cliff Policy Task Force, one goal of which is to determine which areas are unsuited for development, and, where development will be allowed, to establish appropriate setback distances from the bluffs (D. Brownlee, Calvert County Department of Planning and Zoning, pers. comm. 1993).
- Much of the bluff area at Calvert Cliffs State Park has been fenced of f since 1989 due to dangerous erosion conditions, and this has probably helped in habitat preservation, as evidenced by the fact that the fenced-off areas have the largest C. puritana populations.
- An experimental reintroduction of adult C. puritana to a historical location in South Windsor, Connecticut was attempted in 1993. Of 39 beetles released, only three were seen again. In contrast, eight of 16 beetles in a control group (handled identically but released on their site of capture) were seen again (P. Nothnagle pers. comm. 1993). This corroborates results obtained in similar experiments with Cicindela dorsalis and underscores the need for developing reliable techniques for rearing and introducing larvae, which may adapt to reintroduction sites better than do adults.

References

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USFWS, 2019. Puritan Tiger Beetle (Cicindela puritana), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Chesapeake Bay Field Office, Annapolis, Maryland.

SPECIES ACCOUNT: *Cicindelidia floridana* (Miami tiger beetle)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/04/2016; Southeast Region (R4) (USFWS, 2016)

Physical Description

A small (6.5 - 9.0 millimeters), elongate beetle with an oval shape and bulging eyes. The underside of the abdomen is orange to orange-brown in color. It is uniquely identified by the shiny dark green dorsal surface, sometimes with a bronze cast and, without close examination in the field, may appear black; the pair of green hardened forewings covering the abdomen have reduced white markings consisting only of a small patch. Miami tiger beetle larvae are elongate with a white grub-like body and a dark or metallic head with large mandibles. An enlarged dorsal portion of the fifth abdominal segment, with two pairs of hooks anchor the larvae into its permanent burrow, while the upper portion of the body extends to capture prey (USFWS, 2016b).

Taxonomy

The Miami tiger beetle (Cicindelidia floridana Cartwright) is a described species in the Subfamily Cicindelinae of the Family Carabidae (ground beetles). Previously, tiger beetles were considered a separate family, but are now classified as a subfamily of the family Carabidae on the basis of recent genetic studies and other characters (Bousquet 2012, p. 30). The Miami tiger beetle is in the C. abdominalis group that also includes the eastern pinebarrens tiger beetle (C. abdominalis), scabrous tiger beetle (C. scabrosa), and Highlands tiger beetle (C. highlandensis). New treatments of tiger beetles (Bousquet 2012, p. 30; Pearson et al. 2015, p. 138) have also elevated most of the previous subgenera of tiger beetles to genera, resulting in a change of the genus of the tiger beetles in the C. abdominalis group from Cicindela to Cicindelidia. These genera were originally proposed by Rivalier (1954, entire) and are widely used by European scientists (Wiesner 1992, entire), but are considered subgenera by many American scientists. The return to Rivalier’s system has also been supported by genetic evidence (Pearson et al. 2015, p. 16). (USFWS, 2016a)

Historical Range

The historical range of the Miami tiger beetle is not completely known, and available information is limited based on the single historical observation prior to the species’ rediscovery in 2007. It was initially documented from collections made in 1934 by Frank Young within a very restricted range in the northern end of the Miami Rock Ridge, in a region known as the Northern Biscayne Pinelands. The Northern Biscayne Pinelands, which extend from the city of North Miami south to approximately SW. 216th Street, are characterized by extensive sandy pockets of quartz sand, a feature that is necessary for the Miami tiger beetle (Service 1999, p. 3–162). The type locality (the place where the specimen was found) was likely pine rockland habitat, though the species is now extirpated from the area (Knisley and Hill 1991, pp. 7, 13; Brzoska et al. 2011, p. 2; Knisley 2015a, p. 7). The exact location of the type locality in North Miami was determined by Rob Huber, a tiger beetle researcher who contacted Frank Young in 1972. Young recalled collecting the type specimens while searching for land snails at the northeast corner of Miami Avenue and Gratigny Road (119th Street), North Miami. Huber checked that location the same year and found that a school had been built there. A more thorough search for sandy soil habitats throughout that area found no potential habitat (Knisley and Hill 1991, pp. 7, 11–12). Although the contact with Young did not provide habitat information for the type locality, a 1943 map of habitats in the Miami area showed pine rockland with sandy soils reaching their northern limit in the area of the type locality (Knisley 2015a, p. 27), and Young's paper on land snails made reference to pine rockland habitat (Young 1951, p. 6). Recent maps, however, show that the pine rockland habitat has been mostly developed from this area, and remaining pine rockland habitat is mostly restricted to sites owned by Miami-Dade County in south Miami (Knisley 2015a, p. 7). In summary, it is likely that the Miami tiger beetle historically occurred throughout pine rockland habitat on the Miami Rock Ridge. Given the lack of recorded collection of the species for nearly 70 years, it may have always had a localized distribution (Schultz, 2016, pers. comm.). (USFWS, 2016a)

Current Range

The Miami tiger beetle was thought to be extinct until 2007, when a population was discovered at the Richmond Heights area of south Miami, Florida, known as the Richmond Pine Rocklands (Brzoska et al. 2011, p. 2; Knisley 2011a, p. 26). The Richmond Pine Rocklands is a mixture of publicly and privately owned lands that retain the largest area of contiguous pine rockland habitat within the urbanized areas of Miami-Dade County and outside of the boundaries of Everglades National Park (ENP). Surveys and observations conducted at Long Pine Key in ENP have found no Miami tiger beetles, and habitat conditions are considered unsuitable for the species (Knisley 2015a, p. 42; J. Sadle, 2015, pers. comm.). At this time, the Miami tiger beetle is known to occur in only two separate locations within pine rockland habitat in Miami-Dade County. The Richmond population occurs on four contiguous parcels within the Richmond Pine Rocklands: (1) Zoo Miami Pine Rockland Preserve (Zoo Miami) (293 hectares (ha); 723 acres (ac)), (2) Larry and Penny Thompson Park (121 ha; 300 ac), (3) U.S. Coast Guard property (USCG) (96 ha; 237 ac), and (4) University of Miami's Center for Southeastern Tropical Advanced Remote Sensing property (CSTARS) (31 ha; 76 ac) (see Table 1 in Supporting Documents on http://www.regulations.gov). The second population, which was recently identified (September 2015) is within approximately 5.0 km (3.1 mi) of the Richmond population and separated by urban development (D. Cook, 2015a, pers. comm.). Based on historical records, current occurrences, and habitat needs of the species (see Habitat section, below), the current range of the species is considered to be any pine rockland habitat (natural or disturbed) within the Miami Rock Ridge (Knisley 2015a, p. 7; CBD et al. 2014, pp. 13–16, 31–32). Miami tiger beetles within the four contiguous occupied parcels in the Richmond population are within close proximity to each other. There are apparent connecting patches of habitat and few or no barriers (contiguous and border each other on at least one side) between parcels. Given the contiguous habitat with few barriers to dispersal, frequent adult movement among individuals is likely, and the occupied Richmond parcels probably represent a single population (Knisley 2015a, p. 10). Information regarding Miami tiger beetles at the new location is very limited, but beetles here are within approximately 5.0 km (3.1 mi) of the Richmond population and separated by ample urban development, which likely represents a significant barrier to dispersal, and the Miami tiger beetles at the new location are currently considered a second population. The Richmond population occurs within an approximate 2-square kilometer (km2) (494-ac) block, but currently much of the habitat is overgrown with vegetation, leaving few remaining open patches for the beetle. Survey data documented a decline in the number of open habitat patches, and Knisley (2015a, pp. 9–10) estimated that less than 10 percent of the mostly pine rockland habitat within this area supports the species in its current condition. (USFWS, 2016a)

Critical Habitat Designated

Yes; 6/22/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for the Miami tiger beetle (Cicindelidia floridana) under the Endangered Species Act of 1973 (Act), as amended. In total, approximately 1,869 acres (756 hectares) in MiamiDade County, Florida, fall within the boundaries of the critical habitat designation. This rule extends the Act's protections to the Miami tiger beetle's critical habitat.

Critical Habitat Designation

Critical habitat units are depicted for Miami-Dade County, Florida

Unit 1: Trinity Pineland, MiamiDade County, Florida. (i) Unit 1 consists of approximately 10 acres (ac) (4 hectares (ha)). The unit is located between SW 72nd Street to the north, SW 80th Street to the south, South Dixie Highway to the east, and Palmetto Expressway to the west.

Unit 2: Rockdale Pineland, MiamiDade County, Florida. (i) Unit 2 consists of approximately 39 ac (16 ha). The unit is located directly west of South Dixie Highway, between SW 144th Street to the north and SW 152nd Street to the south.

Unit 3: Deering Estate South Addition, Miami-Dade County, Florida. (i) Unit 3 consists of approximately 16 ac (6 ha). This unit is located just east of Old Cutler Road and south of 168th Street.

Unit 4: Ned Glenn Nature Preserve, Miami-Dade County, Florida. (i) Unit 4 consists of approximately 11 ac (5 ha). The unit is located directly west of SW 87th Avenue, between 184th Street to the north, Old Cutler Road to the south, and Franjo Road to the west.

Unit 5: Deering Estate at Cutler, Miami-Dade County, Florida. (i) Unit 5 consists of approximately 89 ac (36 ha). The unit is located southeast of SW 152nd Street and Old Cutler Road.

Unit 6: Silver Palm Groves Pineland, Miami-Dade County, Florida. (i) Unit 6 consists of approximately 25 ac (10 ha). This unit is located just north of SW 232nd Street, between SW 216th Street to the north, South Dixie Highway to the east, and SW 147th Avenue to the west.

Unit 7: Quail Roost Pineland, Miami-Dade County, Florida. (i) Unit 7 consists of approximately 48 ac (19 ha). This unit is located between SW 200th Street to the north, SW 127th Avenue to the east, SW 216th Street to the south, and SW 147th Avenue to the west.

Unit 8: Eachus Pineland, MiamiDade County, Florida. (i) Unit 8 consists of approximately 17 ac (7 ha). This unit is located between SW 180th Street to the north, SW 137th Avenue to the east, SW 184th Street to the south, and SW 142nd Avenue to the east.

Unit 9: Bill Sadowski Park, Miami-Dade County, Florida. (i) Unit 9 consists of approximately 20 ac (8 ha). This unit is located south of 168th Street, west of Old Cutler Road, north of SW 184th Street, and east of SW 87th Avenue.

Unit 10: Tamiami Pineland Complex Addition, Miami-Dade County, Florida. (i) Unit 10 consists of approximately 21 ac (8 ha). This unit is located south of 128th Street, west of Florida's Turnpike, north of SW 136th Street, and east of SW 127th Avenue.

Unit 11: Pine Shore Pineland Preserve, Miami-Dade County, Florida. (i) Unit 11 consists of approximately 8 ac (3 ha). This unit is located southwest of the Don Shula Expressway, west of SW 107th Avenue, and north of SW 128th Street.

Unit 12: Nixon Smiley Pineland Preserve, Miami-Dade County, Florida. (i) Unit 12 consists of approximately 117 ac (47 ha). This unit is located between SW 120th Street to the north, SW 127th Avenue to the east, SW 128th Street to the south, and SW 137th Avenue to the west.

Unit 13: Boystown Pineland Preserve, Miami-Dade County, Florida. (i) Unit 13 consists of approximately 81 ac (33 ha). This unit is between SW 104th Street to the north, SW 137th Avenue to the east, SW 12th Street to the south, and SW 147th Avenue to the west

Unit 14: Richmond Pine Rocklands, Miami-Dade County, Florida. (i) Unit 14 consists of approximately 1,347 ac (545 ha). This unit is located between SW 152nd Street to the north, SW 117th Avenue to the east, SW 185th Street to the south, and SW 137th Avenue to the west.

Unit 15: Calderon Pineland, Miami-Dade County, Florida. (i) Unit 15 consists of approximately 14 ac (6 ha). This unit is located between SW 184th Street to the south, SW 137th Avenue to the east, SW 200th Street to the south, and SW 147th Avenue to the west.

Unit 16: Porter Pineland Preserve, Miami-Dade County, Florida. (i) Unit 16 consists of approximately 7 ac (3 ha). This unit is located to the south of SW 216th Street, to the west of South Dixie Highway, to the north of SW 232nd Street, and to the east of SW 147th Avenue.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the Miami tiger beetle consist of the following components:

(i) South Florida pine rockland habitat of at least 2.5 acres (1 hectare) in size that is maintained by natural or prescribed fire or other disturbance regimes

(ii) Open sandy areas within or directly adjacent to the south Florida pine rockland habitat described in paragraph (2)(i) of this entry. These areas have little to no vegetation to allow for normal behavior and growth, such as thermoregulation, foraging, egglaying, and larval development, and to facilitate habitat connectivity.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of this species may require special management considerations or protection to reduce the following threats: vegetation encroachment of pine rockland habitat; loss of pine rockland habitat due to development that further fragments or degrades the few remaining pine rockland parcels in Miami-Dade County; climate change and sea level rise; and pesticide exposure. These threats are exacerbated by having only two small populations in a restricted geographic range, making this species particularly susceptible to extinction. For a detailed discussion of threats, see Summary of Factors Affecting the Species in our proposed listing rule (80 FR 79533, December 22, 2015, pp. 79540–79551). Additional information may be found in the final listing rule (81 FR 68985; October 5, 2016). Some of these threats can be addressed by special management considerations or protection while others (e.g., sea level rise, hurricanes, storm surge) are beyond the control of landowners and land managers. However, even when landowners or land managers may not be able to control all the threats directly, they may be able to address the impacts of those threats. Destruction of rock pinelands for economic development has reduced pine rockland habitat on the Miami Rock Ridge outside of the Everglades by over 98 percent, and remaining habitat in this area is highly fragmented. The Miami tiger beetle occurs on a mix of privately and publicly owned lands, only some of which are managed for conservation. Any occurrences of the beetle on private land or nonconservation public land are vulnerable to the effects of habitat degradation if natural disturbance regimes are disrupted because the species requires active management to keep the habitat functional in the absence of such disturbances. Prolonged lack of fire in pine rockland habitat leads to vegetation encroachment into the open or sparsely vegetated sandy areas that are required by the beetle. Further development and degradation of pine rocklands increases fragmentation and decreases the conservation value of the remaining functioning pine rockland habitat. In addition, pine rocklands are expected to be further degraded and fragmented due to anticipated sea level rise, which would fully or partially inundate some pine rocklands within the Miami Rock Ridge and cause increases in the salinity of the water table and soils, resulting in vegetation shifts. Also, portions of the Richmond Pine Rocklands are proposed for commercial development and some existing pine rockland areas are projected to be developed for housing as the human population grows and adjusts to changing sea levels. Pesticides used in and around pine rockland habitat are a potential threat to the Miami tiger beetle through direct exposure to adults and larvae; secondary exposure from insect prey; an overall reduction in availability of adult and larval prey, thus limiting foraging opportunities; or any combination of these factors. Based on Miami-Dade Mosquito Control's implementation of spray buffers around pine rocklands occupied by the Miami tiger beetle, mosquito control pesticides are not considered a current threat for the species. However, if these buffers were to change or Miami tiger beetles were found in habitat without restrictions of pesticide applications, then the threat of exposure would need to be reevaluated. The features essential to the conservation of the Miami tiger beetle (i.e., open or sparsely vegetated areas of pine rockland habitat that are at least 2.5 ac (1.0 ha) in size) may require special management considerations or protection to reduce threats. Actions that could ameliorate threats include, but are not limited to: (1) Restoration and management of existing and potential Miami tiger beetle habitats throughout the Miami Rock Ridge using prescribed fire and control of invasive, nonnative plants; (2) Protection of habitat adjacent to existing and new occurrences of the species to provide dispersal corridors, support the prey base, protect core habitat, and allow for appropriate habitat management; (3) Use of pesticide spray buffers to prevent potential exposure to the species and probable limitation of foraging opportunities

Life History

Feeding Narrative

Adult: As is typical of other tiger beetles, adult Miami tiger beetles are active diurnal predators that use their keen vision to detect movement of small arthropods and run quickly to capture prey with their well-developed jaws (mandibles). Observations by various entomologists indicate small arthropods, especially ants, are the most common prey for tiger beetles. Willis (1967, pp. 196–197) lists over 30 kinds of insects from many families as prey for tiger beetles, and scavenging is also common in some species (Knisley and Schultz 1997, pp. 39, 103). Larvae are sedentary sit-and-wait predators occurring in permanent burrows flush with the ground surface (Essig 1926, p. 372; Essig 1942, p. 532; Pearson 1988, pp. 131–132) (USFWS, 2015).

Reproduction Narrative

Adult: Females oviposit (lay eggs) in open sandy patches (Knisley 2015a, p. 8). Females will often touch the soil with the antennae, bite it, and even dig trial holes, possibly to determine suitable soil characteristics (Willis 1967, p. 194) before placing a single egg into a shallow oviposition burrow (1 to 2 cm (0.39 to 0.79 in)) dug into the soil with the ovipositor. The egg hatches, apparently after sufficient soil wetting, and the first instar larvae digs a burrow at the site of oviposition. Development in tiger beetles includes three larval instars followed by a pupal and adult stage. In most species of tiger beetles, development requires 2 years, but can range from 1 to 4 or more years depending on climate and food availability. Results of monthly surveys at the Zoo Miami parcel in 2009, and additional late summer and fall surveys through 2014, indicated the adult flight period for the Miami tiger beetle ranges from May 15 through October 17 (Knisley 2015a, p. 5). Adults emerging in May and June would mate, oviposit, and produce larvae that could develop and emerge as a second cohort of adults in late July and August as the earlier cohort of adults were dying off. Larvae from these later active adults would develop through fall and winter, emerging as adults the following May (USFWS, 2015).

Geographic or Habitat Restraints or Barriers

Adult: 6.5 - 23.0 ft. elevation, only occurs in pine rockland habitat (USFWS, 2015)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Habitat Narrative

Adult: The environmental specificity is very narrow (NatureServe, 2015). The Miami tiger beetle is found exclusively on the Miami Rock Ridge within the urbanized areas of Miami-Dade County and outside the boundaries of ENP (Knisley 2015a, pp. 6–7). Pine rockland occurs on relatively flat terrain, approximately 2.0–7.0 m (6.5– 23.0 ft.) above sea level with an average elevation of approximately 3.0 m (9.8 ft.) (Service 1999, p. 3–167; FNAI 2010, p. 62). Pine rockland habitat is maintained by regular fire, and is susceptible to other natural disturbances such as hurricanes, frost events, and sea-level rise (SLR) (Ross et al. 1994, p. 144). Fires historically burned on an interval of approximately every 3 to 7 years (FNAI 2010, p. 3), and were typically started by lightning strikes during the frequent summer thunderstorms (FNAI 2010, p. 3). Presently, prescribed fire must be periodically introduced into pine rocklands to sustain community structure, prevent invasion by woody species, maintain high herbaceous diversity (Loope and Dunevitz 1981, pp. 5–6; FNAI 2010, p. 3), and prevent succession to rockland hammock. Adult Miami tiger beetles require patches of open sandy areas within the pine rocklands for behavioral thermoregulation (avoiding or seeking sources of heat to regulate body temperature) so that they can successfully capture small arthropod prey (Knisley 2015a, p. 8). Patches smaller than 2 to 6 m2 (22– 65 ft2) typically had no adults (Knisley 2015a, p. 8) (USFWS, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2015)

Dispersal

Adult: Low (USFWS, 2015)

Dispersal/Migration Narrative

Adult: Based on available information, the Miami tiger beetle appears to have only limited dispersal abilities. Among tiger beetles there is a general trend of decreasing flight distance with decreasing body size (Knisley and Hill 1996, p. 13). The Miami tiger beetle is one of the smallest tiger beetles (less than half an inch in length); it is likely to be a weak flier based on its size and the limited flight distance of the closely related Highlands tiger beetle (usually flying only 5–10 m (16.4–32.8 ft.)) (Knisley and Hill 2013, p. 39) (USFWS, 2015).

Population Information and Trends

Population Trends:

Presumed extinct until rediscovery in 2007 (USFWS, 2015); > 70% decline (NatureServe, 2015)

Species Trends:

Habit patches declining (USFWS, 2015)

Number of Populations:

2 (USFWS, 2023)

Population Size:

250 or less (NatureServe, 2015)

Adaptability:

Low (NatureServe, 2015)

Additional Population-level Information:

The Miami tiger beetle occurs in two populations, Richmond Pine Rocklands and Nixon Smiley Pineland Preserve, that are separated by approximately 5 km (3.1 mi) of urban development that likely represents a barrier to dispersal. These two extant populations are small and at risk of adverse effects from reduced genetic variation, an increased risk of inbreeding depression, and reduced reproductive output (USFWS, 2023).

Population Narrative:

As noted earlier, several studies comparing various methods for estimating adult tiger beetle abundance have found numbers present at a site are typically two to three times higher than that produced by the index count (Knisley and Schultz 1997, p. 15; Knisley 2009, entire; Knisley and Hill 2013, pp. 27, 29). Numbers are underestimated because tiger beetles are elusive, and some may fly off before being detected while others may be obscured by vegetation in some parts of the survey area. Even in refined linear habitats like narrow shorelines where there is no vegetation and high visibility, index counts produce estimates that are two to three times lower than the numbers present (Knisley and Schultz 1997, p. 152). Information on the Richmond population size is limited because survey data are inconsistent, and some sites are difficult to access due to permitting, security, and liability concerns. Of the occupied sites, the most thoroughly surveyed site for adult and larval Miami tiger beetles is the Zoo Miami parcel (over 30 survey dates from 2008 to 2014) (Knisley 2015a, p. 10). Adult beetle surveys at the CSTARS and USCG parcels have been infrequent, and access was not permitted in 2012 through early summer of 2014. In October 2014, access to both the CSTARS and USCG parcels was permitted, and no beetles were observed during October 2014 surveys. As noted earlier, Miami tiger beetles were recently found at Larry and Penny Thompson Park (D. Cook, 2015b, pers. comm.); however, thorough surveys at this location have not been conducted. For details on index counts and larval survey results from the three surveyed parcels (Zoo Miami, USCG, and CSTARS), see Table 2 in Supporting Documents on http:// www.regulations.gov. Raw index counts found adults in four areas (Zoo A, Zoo B, Zoo C, and Zoo D) of the Zoo Miami parcel. Two of these patches (Zoo C and Zoo D) had fewer than 10 adults during several surveys at each location. Zoo A, the more northern site where adults were first discovered, had peak counts of 17 and 22 adults in 2008 and 2009, but declined to 0 and 2 adults in six surveys from 2011 to 2014, despite thorough searches on several dates throughout the peak of the adult flight season (Knisley 2015a, pp. 9–10). Zoo B, located south of Zoo A, had peak counts of 17 and 20 adults from 2008 to 2009, 36 to 42 adults from 2011 to 2012, and 13 and 18 adults in 2014 (Knisley 2015a, pp. 9–10). These surveys at Zoo A and Zoo B also recorded the number of suitable habitat patches (occupied and unoccupied). Surveys between 2008 and 2014 documented a decline in both occupied and unoccupied open habitat patches. Knisley (2015, pp. 9–10) documented a decrease at Zoo A from 7 occupied of 23 patches in 2008, to 1 occupied of 13 patches in 2014. At Zoo B, there was a decrease from 19 occupied of 26 patches in 2008, to 7 occupied of 13 patches in 2014 (Knisley 2015a, pp. 9–10). Knisley (2015a, p. 10) suggested this decline in occupied and unoccupied patches is likely the result of the vegetation that he observed encroaching into the open areas that are required by the beetle. At the CSTARS site, the only survey during peak season was on August 20, 2010, when much of the potential habitat was checked. This survey produced a raw count of 38 adults in 11 scattered habitat patches, with 1 to 9 adults per patch, mostly in the western portion of the site (Knisley 2015a, p. 10). Three surveys at the USCG included only a portion of the potential habitat and produced raw adult counts of two, four, and two adults in three separate patches from 2009, 2010, and 2011, respectively (Knisley 2015a, p. 10). Additional surveys of the CSTARS and the USCG parcels on October 14 to 15, 2014, surveyed areas where adults were found in previous surveys and some new areas; however, no adults were observed. The most likely reasons for the absence of adults were because counts even during the peak of the flight season were low (thus detection would be lower off-peak), and mid-October is recognized as the end of the flight season (Knisley 2014a, p. 2). As was noted for the Zoo Miami sites, habitat patches at the CSTARS and USCG parcels that previously supported adults seemed smaller due to increased vegetation growth, and consequently these patches appeared less suitable for the beetle than in the earlier surveys (Knisley 2015a, p. 10). Surveys of adult numbers over the years, especially the frequent surveys in 2009, did not indicate a bimodal adult activity pattern (two cohorts of adults emerge during their active season) (Knisley 2015a, p. 10). Knisley (2015a, p. 10) suggests that actual numbers of adult Miami tiger beetles could be two to three times higher than indicated by the raw index counts. Several studies comparing methods for estimating population size of several tiger beetle species, including the Highlands tiger beetle, found total numbers present were usually more than two times that indicated by the index counts (Knisley and Hill 2013, pp. 27–28). The underestimates from raw index counts are likely to be comparable or greater for the Miami tiger beetle, because of its small size and occurrence in small open patches where individuals can be obscured by vegetation around the edges, making detection especially difficult (Knisley 2015a, p. 10). Surveys for larvae at the Zoo Miami parcel (Zoos A and B) were conducted for several years during January when lower temperatures would result in a higher level of larval activity and open burrows (Knisley and Hill 2013, p. 38) (see Table 2 in Supporting Documents on http://www.regulations.gov). The January 2010 survey produced a count of 63 larval burrows, including 5 first instars, 36 second instars, and 22 third instars (Knisley 2013, p. 4). All burrows were in the same bare sandy patches where adults were found. In March 2010, a followup survey indicated most second instar larvae had progressed to the third instar (Knisley 2015a, p. 11). Additional surveys to determine larval distribution and relative abundance during January or February in subsequent years detected fewer larvae in section Zoo B: 5 larvae in 2011, 3 larvae in 2012, 3 and 5 larvae in 2013, 3 larvae in 2014, and 15 larvae in 2015 (Knisley 2013, pp. 4–5; Knisley 2015c, p. 1). The reason for this decline in larval numbers (i.e., from 63 in 2010, to 15 or fewer in each survey year from 2011 to 2015) is unknown. Possible explanations are that fewer larvae were present because of reduced recruitment by adults from 2010 to 2014, increased difficulty in detecting larval burrows that were present due to vegetation growth and leaf litter, environmental factors (e.g., temperature, precipitation, predators), or a combination of these factors (Knisley 2015a, pp. 10–11). Larvae, like adults, also require open patches free from vegetation encroachment to complete their development. The January 2015 survey of Zoo B observed vegetation encroachment, as indicated by several of the numbered tags marking larval burrows in open patches in 2010 covered by plant growth and leaf litter (Knisley 2015c, p. 1). No larvae were observed in the January 2015 survey of Zoo A (Knisley 2015c, p. 1). Knisley (2015c, p. 3) reported that the area had been recently burned (mid-November) and low vegetation was absent, resulting in mostly bare ground with extensive pine needle coverage below trees, which made the identification of previous open patches with adults difficult. Surveys for the beetle's presence outside of its currently known occupied range found no Miami tiger beetles at a total of 42 sites (17 pine rockland sites and 25 scrub sites) throughout Miami- Dade, Broward, Palm Beach, and Martin Counties (Knisley 2015a, pp. 9, 41–45). The absence of the Miami tiger beetle from sites north of Miami-Dade was probably because it never ranged beyond pine rockland habitat of Miami- Dade County and into scrub habitats to the north (Knisley 2015a, p. 9). Sites without the Miami tiger beetle in Miami-Dade County mostly had vegetation that was too dense and were lacking the open patches of sandy soil that are needed by adults for oviposition and larval habitat (Knisley 2015a, pp. 9, 41–45). The Miami tiger beetle is considered as one of two tiger beetles in the United States most in danger of extinction (Knisley et al. 2014, p. 93). The viability of the remaining population is unknown, as no population viability analysis is available (B. Knisley, 2015d, pers. comm.). The Florida Fish and Wildlife Conservation Commission (FWC) (2012, p. 89) regarded it as a species of greatest conservation need. The Miami tiger beetle is currently ranked S1 and G1 by the FNAI (2016, p.16), meaning it is critically imperiled globally because of extreme rarity (5 or fewer occurrences, or fewer than 1,000 individuals) or because of extreme vulnerability to extinction due to some natural or manmade factor. In summary, the overall population size of the Miami tiger beetle is exceptionally small and viability is uncertain. Based upon the index count data to date, it appears that the two populations exist in extremely low numbers (Knisley 2015a, pp. 2, 10–11, 24). (USFWS, 2016a)

Threats and Stressors

Stressor: Habitat loss (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: The Miami tiger beetle has experienced substantial destruction, modification, and curtailment of its habitat and range (Brzoska et al. 2011, pp. 5–6; Knisley 2013, pp. 7–8; Knisley 2015a, p. 11). The pine rockland community of south Florida, on which the beetle depends, is critically imperiled globally (FNAI 2013, p. 3). Destruction of the pinelands for economic

development has reduced this habitat by 90 percent on mainland south Florida (O'Brien 1998, p. 208). Outside of ENP, only about 1 percent of the Miami Rock Ridge pinelands have escaped clearing, and much of what is left is in small remnant blocks isolated from other natural areas (Herndon 1998, p. 1). One of the two known populations of the Miami tiger beetle occur within the Richmond Pine Rocklands, on parcels of publicly or privately owned lands that are partially developed yet retain some undeveloped pine Rockland habitat. In the 1940s, the Naval Air Station Richmond was built largely on what is currently the Zoo Miami parcel. Much of the currently occupied Miami tiger beetle habitat on the Zoo Miami parcel was scraped for the creation of runways and blimp hangars (Wirth 2015, entire). The fact that this formerly scraped pine rockland area now provides suitable habitat for the Miami tiger beetle demonstrates the restoration potential of disturbed pine rockland habitat (Possley 2015, entire; Wirth 2015, entire). Any current known or unknown, extant Miami tiger beetle populations or potentially suitable habitat that may occur on private lands or nonconservation public lands, such as elsewhere within the Richmond Pine Rocklands or surrounding pine rocklands, are vulnerable to habitat loss. Miami-Dade County leads the State in gross urban density at 8,343 people per square mile (https://www.bebr.ufl.edu/ population/publications/measuringpopulation-density-counties-florida [accessed May 18, 2016]), and development and human population growth are expected to continue in the future. By 2025, Miami-Dade County is predicted to near or exceed a population size of 3 million people (Rayer and Wang 2016, p. 7). This predicted economic and population growth will further increase demands for land, water, and other resources, which will undoubtedly exacerbate the threats to the survival and recovery of the Miami tiger beetle. Remaining habitat is at risk of additional losses and degradation. Of high and specific concern are proposed development projects within the Richmond Pine Rocklands (CBD et al. 2014, pp. 19–24). In 2013, plans for potential development on portions of the Zoo Miami and USCG parcels were announced in local newspapers (Munzenrieder 2013, entire) and subsequently advertised through other mechanisms (https://www.miamidade.gov/dpmww/Solicitation Details.aspx?Id=Invitation%20To%20 Negotiate%20(ITN) [accessed April 24, 2014]). The proposed development includes the following: Theme park rides; a seasonally opened water park; a 400-room hotel with a Sony Music Theatre performance venue; a 2,900- square meter (30,000-square feet) retail and restaurant village; an entertainment center with movie theaters and bowling; an outdoor area for sports; a landscaped pedestrian and bike path; parking; and a 2.4-km (1.5-mi) transportation link that unifies the project's parts (Dinkova2014a, p. 1). The proposed development will require at least a portion of the USCG parcel, which would occur through purchase or a land swap (Dinkova 2014b, p. 1). The Service notified Miami-Dade County in a December 2, 2014, letter about proposed development concerns with potential impacts to listed, candidate, and imperiled species, including the Miami tiger beetle. Plans for the proposed development on the Zoo Miami and USCG parcels have yet to be finalized, so potential impacts to the Miami tiger beetle and its habitat cannot be fully assessed. However, based upon available information provided to date, it appears that the proposed development will impact suitable or potentially suitable beetle habitat. In July 2014, the Service became aware of another proposed development project on privately owned lands within the Richmond Pine Rocklands. In a July 15, 2014, letter to the proposed developer, the Service named the Miami tiger beetle (along with other federally listed and proposed species and habitats) as occurring within the project footprint, and expressed concern over indirect impacts (e.g., the ability to conduct prescribed fire within the Richmond Pine Rocklands). Based upon applicant plans received in May 2015, the proposed project will contain a variety of commercial, residential, and other development within approximately 56 ha (138 ac) (Ram 2015, p. 4). It is unknown if the Miami tiger beetle occurs on the proposed development site, as only one limited survey has been conducted on a small portion (approximately 1.7 ha (4.3 ac)) of the proposed development area and ore surveys are needed. Based upon available information, it appears that the proposed developments will likely impact suitable or potentially suitable beetle habitat, because roughly 13 ha (33 ac) of the proposed development are planned for intact and degraded pine rocklands (Ram 2015, p. 91). The Service has met with the developers to learn more about their plans and how they will address listed, candidate, and imperiled species issues; negotiations are continuing, and a draft habitat conservation plan has been developed (Ram 2015, entire). Given the species' highly restricted range and uncertain viability, any additional losses are significant. Additional development might further limit the ability to conduct prescribed burns or other beneficial management activities that are necessary to maintain the open areas within pine rockland habitat that are required by the beetle. The pattern of public and private ownership presents an urban wildland interface, which is a known constraint for implementing prescribed fire in similar pine rockland habitats (i.e., at National Key Deer Refuge and in southern Miami-Dade County) (Snyder et al. 2005, p. 2; Service 2009, p. 50; 79 FR 47180, August 12, 2014; 79 FR 52567, September 4, 2014). The Florida Department of Forestry has limited staff in Miami-Dade County, and they have been reluctant to set fires for liability reasons (URS 2007, p. 39) (see ‘‘Land Management,’’ below). In addition to constraints with fire management, runoff from development (e.g., structures, asphalt, concrete) into adjacent pine rockland habitat will likely increase and further alter the habitat quality (Schultz, 2016, pers. comm.). In summary, given the Miami tiger beetle's highly restricted range and uncertain viability, any additional losses of habitat within its current range present substantial threats to its survival and recovery. (USFWS, 2016a)

Stressor: Land management (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Brzoska et al. 2011, pp. 5–6; Knisley 2013, pp. 7–8; Knisley 2015a, p. 2). Historically, lightning-induced fires were a vital component in maintaining native vegetation within the pine rockland ecosystem, as well as for opening patches in the vegetation required by the beetles (Loope and Dunevitz 1981, p. 5; Slocum et al. 2003, p. 93; Snyder et al. 2005, p. 1; Knisley 2011a, pp. 31–32). Open patches in the landscape, which allow for ample sunlight for thermoregulation, are necessary for Miami tiger beetles to perform their normal activities, such as foraging, mating, and oviposition (Knisley 2011a, p. 32). Larvae also require these open patches to complete their development free from vegetation encroachment. Without fire, successional change from tropical pineland to hardwood hammock is rapid, and displacement of native plants by invasive, nonnative plants often occurs, resulting in vegetation overgrowth and litter accumulation in the open, bare, sandy patches that are necessary for the Miami tiger beetle. In the absence of fire, pine rockland will succeed to tropical hardwood hammock in 20 to 30 years, as a thick duff layer accumulates and eventually results in the appearance of organic

rich humic soils rather than organic poor mineral soils (Alexander 1967, p. 863; Wade et al. 1980, p. 92; Loope and Dunevitz 1981, p. 6; Snyder et al. 1990, p. 260). Fire is not only a necessity for maintaining pine rockland habitat, but also for preventing catastrophic loss to surrounding property and life in an urban landscape (URS 2007, p. 38). Studies and management plans have emphasized the necessity of prescribed fire in pine rockland habitat and highlighted it as preferential, compared to the alternatives to prescribed fire (e.g. herbicide application and mechanical treatment) (Snyder et al. 2005, p. 1; URS 2007, p. 39). Miami-Dade County has implemented various conservation measures, such as burning in a mosaic pattern and on a small scale, during prescribed burns, to help conserve the Miami tiger beetles and other imperiled species and their habitats (URS, 2007, p. J. Maguire, 2010, pers. comm.). Miami-Dade County Parks and Recreation staff has burned several of its conservation lands on fire return intervals of approximately 3 to 7 years. However, implementation of the county's prescribed fire program has been hampered by a shortage of resources, logistical difficulties, smoke management, and public concern related to burning next to residential areas (Snyder et al. 2005, p. 2; FNAI 2010, p. 5). Many homes and other developments have been built in a mosaic of pine rockland, so the use of prescribed fire in many places has become complicated because of potential danger to structures and smoke generated from the burns. The risk of liability and limited staff in Miami-Dade County has hindered prescribed fire efforts (URS 2007, p. 39). Nonprofit organizations, such as the Institute for Regional Conservation, have faced similar challenges in conducting prescribed burns, due to difficulties with permitting and obtaining the necessary permissions, as well as hazard insurance limitations (Bradley and Gann 2008, p. 17; G. Gann, 2013, pers. comm.). Few private landowners have the means or desire to implement prescribed fire on their property, and doing so in a fragmented urban environment is logistically difficult and costly (Bradley and Gann 2008, p. 3). Lack of management has resulted in rapid habitat decline on most of the small pine rockland fragments, with the disappearance of federally listed and candidate species where they once occurred (Bradley and Gann 2008, p. 3). Despite efforts to use prescribed fire as a management tool in pine rockland habitat, sites with the Miami tiger beetle are not burned as frequently as needed to maintain suitable beetle habitat. Most of the occupied beetle habitat at Miami- Dade County's Zoo Miami parcel was last burned in January and October of 2007; by 2010, there was noticeable vegetation encroachment into suitable habitat patches (Knisley 2011a, p. 36). The northern portion (Zoo A) of the Zoo Miami site was burned in November 2014 (Knisley 2015c, p. 3). Several occupied locations at the CSTARS parcel were burned in 2010, but four other locations at CSTARS were last burned in 2004 and 2006 (Knisley 2011a, p. 36). No recent burns are believed to have occurred at the USCG parcel (Knisley 2011a, p. 36). The decline in adult numbers at the two primary Zoo Miami patches (A and B) in 2014 surveys, and the few larvae found there in recent years, may be a result of the observed loss of bare open patches (Knisley 2015a, p. 12; Knisley 2015c, pp. 1–3). Surveys of the CSTARS and USCG parcels in 2014 found similar loss of open patches from encroaching vegetation (Knisley 2015a, p. 13). Alternatives to prescribed fire, such as mechanical removal of woody vegetation, are not as ecologically effective as fire. Mechanical treatments do not replicate fire's ability to recycle nutrients to the soil, a process that is critical to many pine rockland species (URS 2007, p. 39). To prevent organic soils from developing, uprooted woody debris requires removal, which adds to the required labor. The use of mechanical equipment can also damage soils and inadvertently include the removal or trampling of other nontarget species or critical habitat (URS 2007, p. 39).

Nonnative plants have significantly affected pine rocklands (Bradley and Gann 1999, pp. 15, 72; Bradley and Gann 2005, numbers not applicable; Bradley and van der Heiden 2013, pp. 12–16). As a result of human activities, at least 277 taxa of nonnative plants have invaded pine rocklands throughout south Florida (Service 1999, p. 3–175). Neyraudia neyraudiana (Burma reed) and Schinus terebinthifolius (Brazilian pepper), which have the ability to rapidly invade open areas, threaten the habitat needs of the Miami tiger beetle (Bradley and Gann 1999, pp. 13, 72). S. terebinthifolius, a nonnative tree, is the most widespread and one of the most invasive species. It forms dense thickets of tangled, woody stems that completely shade out and displace native vegetation (Loflin 1991, p. 19; Langeland and Craddock Burks 1998, p. 54). Acacia auriculiformis (earleaf acacia), Melinis repens (natal grass), Lantana camara (shrub verbena), and Albizia lebbeck (tongue tree) are some of the other nonnative species in pine rocklands. More species of nonnative plants could become problems in the future, such as Lygodium microphyllum (Old World climbing fern), which is a serious threat throughout south Florida. Nonnative, invasive plants compete with native plants for space, light, water, and nutrients, and make habitat conditions unsuitable for the Miami tiger beetle, which responds positively to open conditions. Invasive nonnatives also affect the characteristics of a fire when it does occur. Historically, pine rocklands had an open, low understory where natural fires remained patchy with low temperature intensity. Dense infestations of Neyraudia neyraudiana and Schinus terebinthifolius cause higher fire temperatures and longer burning periods. With the presence of invasive, nonnative species, it is uncertain how fire, even under a managed situation, will affect habitat conditions or Miami tiger beetles. Management of nonnative, invasive plants in pine rocklands in Miami-Dade County is further complicated because the vast majority of pine rocklands are small, fragmented areas bordered by urban development. Fragmentation results in an increased proportion of ‘‘edge’’ habitat, which in turn has a variety of effects, including changes in microclimate and community structure at various distances from the edge (Margules and Pressey 2000, p. 248); altered spatial distribution of fire (greater fire frequency in areas nearer the edge) (Cochrane 2001, pp. 1518– 1519); and increased pressure from nonnative, invasive plants and animals that may out-compete or disturb native plant populations. Additionally, areas ear managed pine rockland that contain nonnative species can act as a seed source of nonnatives, allowing them to continue to invade the surrounding pine rockland (Bradley and Gann 1999, p. 13). (USFWS, 2016a)

Stressor: Collection (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: Rare beetles, butterflies, and moths are highly prized by collectors. Tiger beetles are the subject of more intense collecting and study than any other single beetle group (Pearson 1988, pp. 123–124; Knisley and Hill 1992a, p. 9; Choate 1996, p. 1; Knisley et al. 2014, p. 94). Interest in the genus Cicindela (and Cicindelidia) is reflected in a journal entitled ‘‘Cicindela,’’ which has been published quarterly since 1969 and is exclusively devoted to the genus. Tiger beetle collecting and the sale and trade of specimens have increased in popularity in recent years (Knisley et al.2014, p. 138). Among the professional researchers and many amateurs that collect tiger beetles are individuals that take only small numbers; however, there are also avid collectors

who take as many specimens as possible, often for sale or trade. At present, it is estimated that nationally 50 to 100 individuals collect tiger beetles, and approximately 50 individuals are avid collectors (Knisley 2015b, p. 14). Knowledge of and communication with many of these collectors suggest sale and trading of pecimens has become much more common in recent years. The increased interest in collecting, along with photographing specimens, seems to have been stimulated in part due to the publication of the tiger beetle field guide (Pearson et al. 2006, entire). Collectors are especially interested in the less common forms, and may have little regard for their conservation (Knisley 2015b, p. 14). Recently, there was posting on social media from a tiger beetle collector with images of several rare species, including nine specimens f the Miami tiger beetle that are thought to have been collected at Zoo Miami (Wirth, 2016a, pers. comm.). here is ample evidence of collectors impacting imperiled and endangered butterflies (Gochfeld and Burger 1997, pp. 208–209) and even contributing to extirpations (Duffey 1968, p. 94). For example, the federally endangered Mitchell's satyr (Neonympha mitchellii mitchellii) is believed to have been extirpated from New Jersey due to overcollecting (57 FR 21567, May 20, 1992; Gochfeld and Burger 1997, p. 209). Collection is a serious threat to the Miami tiger beetle due to the species' extreme rarity (a factor that increases demand by collectors) and vulnerability (i.e., uncertain status and viability with just two known populations and few individuals). Collection is especially problematic if adults are taken prior to oviposition or from small, isolated, or poor-quality sites. Because no large, high-quality sites are currently known, any collection can have serious ramifications on the survival of the remaining population(s). The recent description of the species did not disclose the exact locations of occurrence, due to concerns with collection (Brzoska et al. 2011, p. 5); however, it is now believed that occurrences at Zoo Miami, USCG, and CSTARS in the Richmond population are fairly well known, especially in the tiger beetle collecting community (B. Knisley, 2014b, pers. comm.). We have no specific information on the collection pressure for the Miami tiger beetle, but it is expected to be high based upon what has transpired in comparable situations with other federally listed and imperiled tiger beetles and butterflies both nationwide and in Florida. For example, the federally endangered Ohlone tiger beetle (Cicindela ohlone) was collected from its type locality in California after its description in the scientific literature (66 FR 50340, October 3, 2001) (Knisley 2015a, p. 14). Similarly, overcollection of the Highlands tiger beetle may have contributed to the extirpation of that species from its type locality in Florida (Knisley and Hill 1992a, p. 9). An estimated 500 to 1,000 adult Highlands tiger beetles had been collected at this site during a several year period after its initial discovery (Knisley and Hill 1992a, p. 10). Markets currently exist for tiger beetles. Specimens of two Florida tiger beetles, the Highlands tiger beetle, a Federal candidate species, and the scabrous tiger beetle are regularly offered for sale or trade through online insect dealers (The Bugmaniac 2015 and eBay 2015). Considering the recent rediscovery of the Miami tiger beetle and concerns regarding its continued existence, the desirability of this species to private collectors is expected to increase, which may lead to similar markets and increased demand. Another reason it is not possible to assess actual impacts from collection is that known occurrences of the Miami tiger beetle are not regularly monitored. Two known occurrences on the USCG and CSTARS parcels are gated and accessible only by permit, so collection from these sites is unlikely unless authorized by the property owners. However, other occupied and potential habitats at neighboring and surrounding areas are much more accessible. Risk of collection is concerning at any location and is more likely at less secure sites. Collection potential at Zoo Miami and other accessible sites is high, in part because it is not entirely gated and only periodically patrolled (Knisley, 2014b, pers. comm.). Most of the remaining pine rockland habitat outside of ENP in Miami-Dade County is owned by the County or in private ownership and not regularly monitored or patrolled. We consider collection to be a significant threat to the Miami tiger beetle in light of the few known remaining populations, low abundance, and highly restricted range. Even limited collection from the remaining populations could have deleterious effects on reproductive and genetic viability of the species and could contribute to its extinction. Removal of adults early in the flight season or prior to oviposition can be particularly damaging, as it further reduces potential for successful reproduction. A population may be reduced to below sustainable numbers (Allee effect) by removal of females, reducing the probability that new occurrences will be founded. Small and isolated occurrences in poor habitat may be at greatest risk (see Factor E discussion, below) as these might not be able to withstand additional losses. Collectors may be unable to recognize when they are depleting occurrences below the thresholds of survival or recovery (Collins and Morris 1985, pp. 162–165). With regard to scientific research, we do not believe that general techniques used to date have had negative impacts on the species or its habitat. Visual index surveys and netting for identification purposes have been performed during scientific research and conservation efforts with the potential to disturb or injure individuals or damage habitat. Limited collection as part of laboratory rearing studies or taxonomic verification has occurred at some sites, with work authorized by permits. Based on the extreme rarity of the species, various collecting techniques (e.g., pitfall traps, Malaise traps, light traps) for other more general insect research projects should be considered a potential threat. (USFWS, 2016a)

Stressor: Predation and parasitism (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: Potential impacts from predators or parasites to the Miami tiger beetle are unknown. Given the small size of the Miami tiger beetle's two populations, the species is likely vulnerable to predation and parasitism (USFWS, 2016a).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: There are some regulatory mechanisms currently in place to protect the Miami tiger beetle and its habitat on non-Federal lands. However, there are no Federal regulatory protections for the Miami tiger beetle, other than the limited protections afforded for listed species and critical habitat that co-occur with the Miami tiger beetle. While local regulations provide some protection, they are generally not fully effective (e.g., NFC regulations allow development of 20 percent or more of pine rockland habitat) or implemented sufficiently (e.g., unpermitted clearing of pine rockland habitat) to alleviate threats to the Miami tiger beetle and its habitat. The degradation of habitat for the Miami tiger beetle is ongoing despite existing regulatory mechanisms. Based on our analysis of the best available information, we find that existing

regulatory measures, due to a variety of constraints, are inadequate to fully address threats to the species throughout its range. (USFWS, 2016a)

Stressor: Few, Small, Isolated Populations (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: The Miami tiger beetle is vulnerable to extinction due to its severely reduced range, the fact that only two small populations remain, and the species' relative isolation. Demographic stochasticity refers to random variability in survival or reproduction among individuals within a population (Shaffer 1981, p. 131). Demographic stochasticity can have a significant impact on population viability for populations that are small, have low fecundity, and are short-lived. In small populations, reduced reproduction or die-offs of a certain ageclass will have a significant effect on the whole population. Although of only minor consequence to large populations, this randomly occurring variation in individuals becomes an important issue for small populations. Environmental stochasticity is the variation in birth and death rates from one season to the next in response to weather, disease, competition, predation, or other factors external to the population (Shaffer 1981, p. 131). For example, drought or predation, in combination with a low population year, could result in extirpation. The origin of the environmental stochastic event can be natural or human-caused. In general, tiger beetles that have been regularly monitored consistently exhibit extreme fluctuations in population size, often apparently due to climatic or other habitat factors that affect recruitment, population growth, and other population parameters. In 20 or more years of monitoring, most populations of the northeastern beach and puritan tiger beetles (Cicindela puritan) have exhibited 2 to 5 or more fold differences in abundance (Knisley 2012, entire). Annual population estimates of the Coral Pink Sand Dunes tiger beetle (Cicindela albissima) have ranged from fewer than 600 to nearly 3,000 adults over a 22-year period (Gowan and Knisley 2014, p. 124). The Miami tiger beetle has not been monitored as extensively as these species, but in areas where Miami tiger beetles were repeatedly surveyed, researchers found fluctuations that were several fold in numbers (Knisley 2015a, p. 24). While these fluctuations appear to be the norm for populations of tiger beetles (and most insects), the causes and effects are not well known. Among the suggested causes of these population trends are annual rainfall patterns for the Coral Pink Sand Dunes tiger beetle (Knisley and Hill 2001, p. 391; Gowan and Knisley 2014, p. 119), and shoreline erosion from storms for the northeastern beach and puritan tiger beetles (Knisley 2011b, p. 54). As a result of these fluctuations, many tiger beetle populations will experience episodic low numbers (bottlenecks) or even local extinction from genetic decline, the Allee effect, or other factors. Given that the Miami tiger beetle is known from only two remaining populations with few adult individuals, any significant decrease in the population size could easily result in extinction of the species. Dispersal and movement of the Miami tiger beetle is unknown, but is considered to be very limited. A limited mark-recapture study with the closely related Highlands tiger beetle found that adult beetles moved no more than 150 m (490 ft), usually flying only 5–10 m (16–33 ft) at a time (Knisley and Hill 2013). Generally, tiger beetles are known to easily move around, so exchange of individuals among separated sites will commonly occur if there are habitat connections or if the sites are within dispersal range—which is not the case with the population structure of the Miami tiger

beetle. Species in woodland, scrub, or dune habitats also seem to disperse less than water-edge species (Knisley and Hill 1996, p. 13). Among tiger beetles, there is a general trend of decreasing flight distance with decreasing body size (Knisley and Hill 1996, p. 13). The Miami tiger beetle has a small body size. Given these factors, dispersal may be limited for the Miami tiger beetle. Small, isolated population size was listed as one of several of the threats in the petition received to list the Miami tiger beetle (CBD et al. 2014, pp. 17, 30). The effects of low population size on population viability are not known for tiger beetles, but population viability analyses for the northeastern beach, puritan, and Coral Pink Sand Dunes tiger beetles determined that stochasticity, specifically the fluctuations in population size, was the main factor accounting for the high risk of extinction (Gowan and Knisley 2001, entire; 2005, p. 13; Knisley and Gowan 2009, pp. 13–23). The long-term monitoring of northeastern beach and puritan tiger beetles found that, despite the fluctuations, some small populations with fewer than 50 to 100 adults experienced several fold declines, but persisted (Knisley 2015b, p. 20). Several Highlands tiger beetle sites with fewer than 20 to 50 adults were lost over the past 15–20 years, while several others have persisted during that period (Knisley 2015b, p. 20). Losses may have been due to habitat disturbance or low population size effects. Knisley predicts that the Highlands tiger beetle populations (extinct and extant) are isolated from each other with little chance for dispersal between populations and immigration rescues (Knisley, 2015d, pers. comm.). With only two known populations of the Miami tiger beetle, separated by substantial urban development, the potential for immigration rescue is low. (USFWS, 2016a)

Stressor: Pesticides (UWFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: Pesticides used in and around pine rockland habitat are a potential threat to the Miami tiger beetle through direct exposure to adults and larvae, secondary exposure from insect prey, overall reduction in availability of adult and larval prey, or any combination of these factors. The use of pesticides for agriculture and mosquito control presents potential risks to nontarget insects, especially imperiled insects (EPA 2002, p. 32; 2006a, p. 58; 2006b, p. 44). The negative effect of insecticides on several tiger beetle species was suggested by Nagano (1982, p. 34) and Stamatov (1972, p. 78), although impacts from pesticides do not appear to be well studied in tiger beetles. Efforts to control mosquitoes and other insect pests in Florida have increased as human activity and population size have increased. To control mosquito populations, organophosphate (naled) and pyrethroid (permethrin) adulticides are applied by mosquito control districts throughout south Florida, including Miami-Dade County. These compounds have been characterized as being highly toxic to nontarget insects by the U.S. Environmental Protection Agency (2002, p. 32; 2006a, p. 58; 2006b, p. 44). The use of such pesticides (applied using both aerial and ground-based methods) for mosquito control presents a potential risk to the Miami tiger beetle, and this risk may increase with the spread of any mosquito-borne disease, such as the Zika virus, as current guidelines to incorporate no-spray buffers around butterfly critical habitat are not necessarily adhered to if there is a public health concern (Florida Administrative Code 5E–13.036; Service 2015, entire). In order for mosquito control pesticides to be effective, they must make direct contact with mosquitoes. For this to happen, pesticides are applied using

methods to promote drift through the air, so as to increase the potential for contact with their intended target organism. Truck-based permethrin application methods are expected to produce a swath of suspended pesticides approximately 91 m (300 ft) wide (Prentiss 2007, p. 4). The extent of pesticide drift from this swath is dependent on several factors, including wind speed, wind direction, and vegetation density. Hennessey and Habeck (1989, pp. 1–22; 1991, pp. 1–68) and Hennessey et al. (1992, pp. 715–721) illustrated the presence of mosquito spray residues long after application in habitat of the federally endangered Schaus swallowtail butterfly (Heraclides aristodemus ponceanus), as well as the Florida leafwing butterfly (Anaea troglodyte floridalis), Bartram's scrub-hairstreak butterfly, and other imperiled species. Residues of aerially applied naled were found 6 hours after application in a pineland area that was 750 m (2,460 ft) from the target area; residues of fenthion (an adulticide previously used in the Florida Keys) applied via truck were found up to 50 m (160 ft) downwind in a hammock area 15 minutes after application in adjacent target areas (Hennessey et al. 1992, pp. 715–721). More recently, Pierce (2009, pp. 1–17) monitored naled and permethrin deposition following mosquito control application. Permethrin, applied by truck, was found to drift considerable distances from target areas, with residues that persisted for weeks. Permethrin was detected at concentrations lethal to three butterfly species at a distance of approximately 227 m (745 ft) away from targeted truck routes. Naled, applied by plane, was also found to drift into nontarget areas, but was much less persistent, exhibiting a half-life (time for half of the naled applied to chemically break down) of approximately 6 hours. To expand this work, Pierce (2011, pp. 6–11) conducted an additional deposition study in 2010, focusing on permethrin drift from truck spraying, and again documented low but measurable amounts of permethrin in nontarget areas. In 2009, Bargar (2012, p. 3) conducted two field trials that detected significant naled residues at locations within nontarget areas up to 366 m (1,200 ft) from the edge of zones targeted for aerial applications. After this discovery, the Florida Keys Mosquito Control District recalibrated the on-board model (Wingman, which provides flight guidance and flow rates). Naled deposition was reduced in some of the nontarget zones following recalibration (Bargar 2012, p. 3). In addition to mosquito control chemicals entering nontarget areas, the toxic effects of such chemicals to nontarget organisms have also been documented. Lethal effects on nontarget moths and butterflies have been attributed to fenthion and naled in both south Florida and the Florida Keys (Emmel 1991, pp. 12–13; Eliazar and Emmel 1991, pp. 18–19; Eliazar 1992, pp. 29–30). Zhong et al. (2010, pp. 1961–1972) investigated the impact of single aerial applications of naled on the endangered Miami blue butterfly (Cyclargus thomasi bethunebakeri) larvae in the field. Survival of butterfly larvae in the target zone was 73.9 percent, which was significantly lower than in both the drift zone (90.6 percent) and the reference (control) zone (100 percent), indicating that direct exposure to naled poses significant risk to Miami blue butterfly larvae. Fifty percent of the samples in the drift zone also exhibited detectable concentrations, once again exhibiting the potential for mosquito control chemicals to drift into nontarget areas. Bargar (2012, p. 4) observed cholinesterase activity depression, to a level shown to cause mortality in the laboratory, in great southern white (Ascia monuste) and Gulf fritillary butterflies (Agraulis vanillae) exposed to naled in both target and nontarget zones. Based on these studies, it can be concluded that mosquito control activities that involve the use of both aerial and ground-based spraying methods have the potential to deliver pesticides in quantities sufficient to cause adverse effects to nontarget species in both target and nontarget areas. Pesticide drift at a level of concern to nontarget invertebrates (butterflies) has been measured up to approximately 227 m (745 ft) from truck routes (Pierce 2011, pp. 3–5, 7; Rand and Hoang 2010, pp. 14, 23) and 400 m (1,312 ft) from aerial spray zones (Bargar 2012, p. 3). It should be noted that many of the studies referenced above dealt with single application scenarios and examined effects on only one or two butterfly life stages. Under a realistic scenario, the potential exists for exposure to all life stages to occur over multiple applications in a season. In the case of a persistent compound like permethrin, whose residues remain on vegetation for weeks, the potential exists for nontarget species to be exposed to multiple pesticides within a season (e.g., permethrin on vegetation coupled with aerial exposure to naled). Prior to 2015, aerial applications of mosquito control pesticides occurred on a limited basis (approximately two toour aerial applications per year since2010) within some of Miami-Dade County's pine rockland areas. The Miami tiger beetle is not known to occupy any of these aerial spray zone sites, but any unknown occupied sites could have been exposed, either directly or through drift. The Richmond Pine Rocklands region is not directly treated either aerially or by truck (C. Vasquez,2013, pers. comm.), so any potential pesticide exposure in this area would be through drift from spray zones adjacent to the Richmond area. Pesticide drift from aerial spray zones to the two known populations of Miami tiger beetles is unlikely, based on the considerable distance from spray zone boundaries to known occurrences of the beetle (estimated minimum distances range from 2.0–3.0 km (1.2–1.9 mi) from the Richmond population and 434 m(0.3 mi) for the second population). In the past, truck-based applications occurred within 227 m (745 ft) of known occupied Miami tiger beetle habitat, a distance under which pesticide drift at a concentration of concern for nontarget invertebrates had been measured (Pierce2011, pp. 3–5, 7; Rand and Hoang 2010,pp. 14, 23).For the 2015 mosquito season (May through October), Miami-Dade Mosquito Control coordinated with the Service to institute 250-m truck-based and 400-maerial spray buffers around critical habitat for the Bartram's scrub hairstreak butterfly, with the exclusion of pine rocklands in the Navy Wells area, which is not known to be occupied by the Miami tiger beetle. These newly implemented buffers will also reduce exposure to any other imperiled species occurring on pine rockland habitat within Bartram's scrub-hairstreak butterfly critical habitat, such as the Miami tiger beetle. Assuming that the Miami tiger beetle is no more sensitive to pesticide exposure than the tested butterfly species, these spray buffers should avoid adverse impacts to the Miami tiger beetle population. Based on Miami-Dade Mosquito Control's implementation of spray buffers, mosquito control pesticides are not considered a major threat for the Miami tiger beetle at this time. If these buffers were to change or Miami tiger beetles were found to occur on habitat that is not protected by Bartram's scrub-hairstreak butterfly critical habitat, then the threat of pesticide exposure would have to be reevaluated. (USFWS, 2016a)

Stressor: Human disturbance (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: Vehicular activity and recreational use within the known population of the Miami tiger beetle presents minimal impacts to the species. However, future negative impacts to unknown beetle occurrences on lands open to the public are possible and are expected to increase with the projected future population growth. (USFWS, 2016a)

Stressor: Climate change and sea level rise (USFWS, 2016a)
Exposure:
Response:
Consequence:
Narrative: Climatic changes, including sea level rise (SLR), are major threats to Florida, and could impact the Miami tiger beetle and the few remaining parcels of pine rockland habitat left in Miami-Dade County. Various changes in climate may have direct or indirect effects on species. These may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables such as habitat fragmentation (for examples, see Franco et al. 2006; IPCC 2007a, pp. 8–14, 18–19; Forister et al. 2010; Galbraith et al. 2010; Chen et al. 2011). In addition to considering individual species, scientists are evaluating possible climate change related impacts to, and responses of, ecological systems, habitat conditions, and groups of species; these studies include acknowledgement of uncertainty (e.g., Deutsch et al. 2008; Euskirchen et al. 2009; McKechnie and Wolf 2009; Berg et al. 2010; Sinervo et al. 2010; Beaumont et al. 2011; McKelvey et al. 2011; Rogers and Schindler 2011). According to the Florida Climate Center, Florida is by far the most vulnerable State in the United States to hurricanes and tropical storms (http://climatecenter.fsu.edu/topics/tropicalweather). Based on data gathered from 1856 to 2008, Klotzbach and Gray (2009, p. 28) calculated the climatological probabilities for each State being impacted by a hurricane or major hurricane in all years over the 152-year timespan. Of the coastal States analyzed, Florida had the highest climatological probabilities, with a 51 percent probability of a hurricane (Category 1 or 2) and a 21 percent probability of a major hurricane (Category 3 or higher). From 1856 to 2008, Florida actually experienced more major hurricanes than predicted; out of the 109 hurricanes, 36 were major hurricanes. The most recent hurricane to have major impacts to Miami-Dade County was Hurricane Andrew in 1992. While the species persisted after this hurricane, impacts to the population size and distribution from the storm are unknown, because no surveys were conducted until its rediscovery in 2007. Given the few, isolated populations of the Miami tiger beetle within a location prone to storm influences (located approximately 8 km (5 mi) from the coast), the species is at substantial risk from stochastic environmental events such as hurricanes, storm surges, and other extreme weather that can affect recruitment, population growth, and other population parameters. Other processes to be affected by climate change, related to environmental stochasticity, include temperatures, rainfall (amount, seasonal timing, and distribution), and storms (frequency and intensity). The Miami tiger beetle is anticipated to face major risks from coastal squeeze, which occurs when habitat is pressed between rising sea levels and coastal development that prevents landward movement (Scavia et al. 2002, entire; FitzGerald et al. 2008, entire; Defeo et al. 2009, p. 8; LeDee et al. 2010, entire; Menon et al. 2010, entire; Noss 2011, entire). Habitats in coastal areas (i.e., Charlotte, Lee, Collier, Monroe, Miami- Dade Counties) are likely the most vulnerable. Although it is difficult to quantify impacts due to the uncertainties involved, coastal squeeze will likely result in losses in habitat for the beetles as people and development are displaced further inland. (USFWS, 2106a)

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 5C

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- n 2005, the Service funded the Institute for Regional Conservation (IRC) to facilitate restoration and management of privately owned pine rockland habitats in Miami-Dade County. This initiative included prescribed burns, nonnative plant control, light debris removal, hardwood management, reintroduction of pines where needed, and development of management plans. The Pine Rockland Initiative includes 10-year cooperative agreements between participating landowners and the Service/IRC to ensure restored areas will be managed appropriately during that time. Although most of these objectives regarding nonnative plant control, creation of fire breaks, removal of excessive fuel loads, and management plans have been achieved, IRC has not been able to conduct the desired prescribed burns, due to logistical difficulties as discussed above (see ''Land Management''). IRC has recently resolved some of the challenges regarding contractor availability for prescribed burns and the Service has extended IRC's funding period through August 2016. Results from anticipated fire management restoration activities will be available in the fall of 2016 (USFWS, 2015).
- Fairchild Tropical Botanic Garden (FTBG), with the support of various Federal, State, local, and nonprofit organizations, has established the ''Connect to Protect Network.'' The objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping stone gardens and rights-of-way with native pine rockland species, and restoring isolated pine rockland fragments. Although these projects may serve as valuable components toward the conservation of pine rockland species and habitat, they are dependent on continual funding, as well as participation from private landowners, both of which may vary through time (USFWS, 2015).

Conservation Measures and Best Management Practices:
- RECOVERY VISION: The Miami tiger beetle occurs in two populations, Richmond Pine Rocklands and Nixon Smiley Pineland Preserve, that are separated by approximately 5 km (3.1 mi) of urban development that likely represents a barrier to dispersal. These two extant populations are small and at risk of adverse effects from reduced genetic variation, an increased risk of inbreeding depression, and reduced reproductive output. Future viability for the Miami tiger beetle depends on creating and maintaining multiple resilient populations over time. With only two known populations remaining in the highly fragmented remnant pine rocklands of the Northern Biscayne Pinelands, the species is highly susceptible to stochastic events. The conservation vision is to ensure viability of the species by 1) maintaining and increasing, to the extent possible, the known populations at Richmond Pine Rocklands and Nixon Smiley Pineland Preserve and 2) establishing additional populations throughout the range of the Miami tiger beetle at sites other than the current areas of occupancy and that can be restored and/or managed to provide suitable habitat. ON-GOING CONSERVATION

ACTIONS: • Surveys and Monitoring: Ongoing annual season surveys for adult Miami tiger beetles and larval surveys and larval burrow monitoring. • Habitat: Pine rockland management at Miami-Dade County Environmentally Endangered Lands with Miami tiger beetle occupancy (ongoing as funding and staff availability allow). Pine Rockland vegetation management at the U.S. Coast Guard Station, Richmond (2023–2025 Grant funding awarded to the Institute for Regional Conservation) • Outreach/Education: Outreach and education efforts thus far have been opportunistic. A researcher provided a local high school biology class an overview on Miami tiger beetle biology and survey techniques in 2021. The class participated in a brief survey that resulted in no observations. • Regulatory: Habitat Conservation Plan for Coral Reef Commons and coordination with Miami Wilds and Miami-Dade County on their planned activities in the Richmond Pine Rocklands. INTERIM RECOVERY STRATEGY: The primary threats to the Miami tiger beetle include habitat loss, degradation, and fragmentation; inadequate land management which leads to vegetation encroachment; collection; few, small, isolated populations; climate change factors; and pesticides. Recovery efforts should focus on increasing permanent protection and management of occupied habitat, restoring habitat, and implementing a captive propagation and translocation plan. If these efforts are conducted, resiliency and redundancy for this species will increase, furthering the recovery of the species. ACTION PLAN: Interim recovery actions necessary to prevent further declines in the species status include: • Work with partners to secure funding and implement prescribed fire and vegetation management at occupied (Richmond Pine Rocklands and Nixon Smiley Pineland Preserve) and other potentially suitable pine rockland sites for the Miami tiger beetle. • Surveys for additional populations of Miami tiger beetles at all potentially suitable pine rockland sites throughout the Miami Rock Ridge and evaluate sites for suitability in translocation trials. • Develop and implement a captive propagation plan for successful translocations. • Studies on the Miami tiger beetle’s response to vegetation reduction and removal techniques in localized areas. • Studies on the Miami tiger beetle’s life history, dispersal capabilities, habitat requirements, population dynamics, and threats to develop guidance for best management practices and conservation strategies. • Routine monitoring, preferably monthly, of populations sizes and distribution to assess the status and trends of the species. • Complete a species status assessment and recovery plan for the Miami tiger beetle. STAKEHOLDER INVOLVEMENT: During the recovery planning process, input, comment, and review will be sought from multiple stakeholders within Miami-Dade County. These will include local, State, and Federal agencies, industrial, agricultural, and forestry groups, research universities, and conservation organizations (USFWS, 2023).

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SPECIES ACCOUNT: *Cyclargus (=Hemiargus) thomasi bethunebakeri* (Miami Blue Butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Miami blue is a small, brightly colored butterfly approximately 0.8 to 1.1 inches (1.9 to 2.9 centimeters [cm]) in length (Pyle 1981, p. 488) with a forewing length of 0.3 to 0.5 inches (8.0 to 12.5 millimeters) (Minno and Emmel 1993, p. 134). Wings of males are blue above (dorsally), with a narrow black outer border and white fringes; females are bright blue dorsally, with black borders and an orange/red and black eyespot near the anal angle of the hindwing (Comstock and Huntington 1943, p. 98; Minno and Emmel 1993, p. 134). The underside is grayish with darker markings outlined with white and bands of white wedges near the outer margin. The ventral hindwing has two pairs of eyespots, one of which is capped with red; basal and costal spots on the hindwing are black and conspicuous (Minno and Emmel 1993, p. 134). The winter (dry season) form is much lighter blue than the summer (wet season) form and has narrow black borders (Opler and Krizek 1984, p. 112). Seasonal wing pattern variation may be caused by changes in humidity, temperature, or length of day (Pyle 1981, p. 489). Miami blue larvae are bright green with a black head capsule, and pupae vary in color from black to brown (Minno and Emmel 1993, pp. 134–135).

Taxonomy

The Miami blue is similar in appearance to three other sympatric (occupying the same or overlapping geographic areas without interbreeding) butterflies that occur roughly in the same habitats: cassius blue (Leptotes cassius theonus), ceraunus blue (Hemiargus ceraunus antibubastus), and nickerbean blue (Cyclargus ammon). The Miami blue is slightly larger than the ceraunus blue (Minno and Emmel 1993, p. 134), but the ceraunus blue has a different ventral pattern and flies close to the ground in open areas (Minno and Emmel 1994, p. 647). The cassius blue often occurs with the Miami blue, but has dark bars rather than spots on the undersides of the wings (Minno and Emmel 1994, p. 647). The Miami blue can be distinguished from the ceraunus blue and cassius blue by its very broad white ventral submarginal band, the dorsal turquoise color of both sexes, and the orange-capped marginal eyespot on the hind wings (Opler and Krizek 1984, p. 112). The nickerbean blue is also similar to the Miami blue in general appearance but is considerably smaller; it has three black spots across the basal hindwing, while the Miami blue has four (Calhoun et al. 2002, p. 15). The larvae and pupae of the nickerbean blue closely resemble the Miami blue (Calhoun et al. 2002, p. 15).

Historical Range

Overall, the Miami blue has undergone a substantial reduction in its historical range, with an estimated > 99 percent decline in area occupied (Florida Fish and Wildlife Conservation Commission [FWC] 2010, p. 11). In 2009, metapopulations existed at two main locations: BHSP (Bahia Honda State Park) and KWNWR (Key West National Wildlife Refuge), roughly 50 miles (80 km) apart. The metapopulation at BHSP is now possibly extirpated with the last adult documented in July 2010 (A. Edwards, Florida Atlantic University, pers. comm. 2011). It is feasible that additional occurrences exist in the Keys, but these may be ephemeral and low in population number (Saarinen 2009, p. 143).

Current Range

The Miami blue butterfly (Cyclargus thomasi bethunebakeri) is endemic to Florida with additional subspecies occurring in the Bahamas, Puerto Rico, and Hispaniola (Smith et al. 1994, p. 129; Hernandez 2004, p. 100; Saarinen 2009, pp. 18–19, 28). Field guides and other sources differ as to whether C. thomasi bethunebakeri occurs in the Bahamas.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Larvae:</u> Larval host plants include blackbead, nickerbean, balloonvine, and presumably Acacia spp. (Dyar 1900, pp. 448–449, Kimball 1965, p. 49; Lenczewski 1980, p. 47; Pyle 1981, p. 489; Calhoun et al. 2002, p. 18). Gray nickerbean (Caesalpinia bonduc) is widespread and common in coastal south Florida. Following disturbances,it can dominate large areas (K. Bradley, The Institute for Regional Conservation [IRC], pers. comm. 2002). Gray nickerbean has been recorded as far north as Volusia County on the east coast, matching the historical range of the Miami blue, and Levy County on the west coast (J. Calhoun, pers. comm. 2003b). The Miami blue is also reported to use peacock flower (Caesalpinia pulcherrima) (Matteson 1930, pp. 13– 14; Calhoun et al. 2002, p. 18), a widely cultivated exotic that occurs in disturbed uplands and gardens (Gann et al. 2001–2010, p. 1). Rutkowski (1971,p. 137) and Opler and Krizek (1984, p. 113) reported the use of snowberry. Brewer (1982, p. 22) reported the use of cat's paw blackbead (Pithecellobium unguis-cati) on Sanibel Island in Lee County.

<u>Adult:</u> Adult Miami blues have been reported to feed on a wide variety of nectar sources including Spanish needles (Bidens alba), Leavenworth's tickseed (Coreopsis leavenworthi), scorpionstail (Heliotropium angiospermum), turkey tangle fogfruit or capeweed (Lippia nodiflora), buttonsage (Lantana involucrata), snow squarestem (Melanthera nivea [M. aspera]), blackbead, Brazilian pepper (Schinus terebinthifolius), false buttonweed (Spermacoce spp.), and seaside heliotrope (Heliotropium curassavicum) (Pyle 1981, p. 489; Opler and Krizek 1984, p. 113; Minno and Emmel 993, p. 135; Emmel and Daniels 2004, p. 12). Emmel and Daniels (2004, p. 12) reported that the Miami blue uses a variety of flowering plant species in the Boraginaceae, Asteraceae, Fabaceae, Polygonaceae, and Verbenaceae families for nectar. Cannon et al. (2010, p. 851) found the butterfly uses nine plant species as nectar sources within KWNWR, including: Blackbead, snow squarestem, coastal searocket (Cakile lanceolata), black

torch (Erithalis fruticosa), yellow joyweed (Alternanthera flavescens), bay cedar (Suriana maritime), sea lavender (Argusia gnaphalodes), seaside heliotrope, and sea purslane (Sesuvium portulacastrum). Nectar sources must be near potential host plants since the butterflies are sedentary and may not travel between patches of host and nectar sources (Emmel and Daniels 2004, p. 13). This may help explain the absence of theMiami blue from areas in which host plants are abundant and nectar sources are limited (J. Calhoun, pers. comm. 2003b). Emmel and Daniels (2004, p. 13) argued that it is potentially critical that sufficient available adult nectar sourcesbe directly adjacent to host patches and also important that a range of potential nectar sources be available in the event one plant species goes out of flower or is adversely impacted by environmental factors. Cannon et al. (2010, p. 851) suggested that the growth stage ofblackbead, coupled with abundant nectar from herbaceous plants, likely influenced Miami blue abundance; the highest counts occurred when blackbead was flowering profusely andproducing new leaves.

Reproduction Narrative

Adult: Like all butterflies, the Miami blue undergoes complete metamorphosis, with four life stages (egg, caterpillar or larva, pupa or chrysalis, and adult). The generation time is approximately 30–40 days (Carroll and Loye 2006, p. 19; Saarinen 2009, p. 22, 76). Although a single Miami blue female can lay 300 eggs, high mortality may occur in the immature larval stages prior toadulthood (T. Emmel, University of Florida [UF], pers. comm. 2002). Reported host plants are blackbead (Pithecellobium spp.), nickerbean (Caesalpinia spp.), balloonvine (Cardiospermum spp.), and presumably Acacia spp. (Kimball 1965, p. 49; Lenczewski 1980, p. 47; Pyle 1981, p. 489; Opler and Krizek 1984, p. 113; Minno and Emmel 1993, p. 134; Calhoun et al. 2002, p. 18; Cannon et al. 2010, p. 851). In addition, Rutkowski (1971, p. 137) observed a female laying one egg just above the lateral bud on snowberry (Chiococca alba). Eggs are laid singly near the base of young pods or just above the lateral buds of balloonvine and the flowers of leguminous trees (Opler and Krizek 1984, p. 113; Minno and Emmel 1993, p. 134); flower buds and young tender leaves of legumes are preferred (Minno and Minno 2009, p. 78; M. Minno, pers. comm. 2010). On nickerbean (Caesalpinia spp.), females lay eggs on developing shoots, foliage, and flower buds (Saarinen 2009, p. 22). Oviposition occurs throughout the day with females often seeking terminal growth close to the ground (< 3.3 feet [< 1 meter]) or in locations sheltered from the wind (Emmel and Daniels 2004, p. 13). Eggs are generally laid singly, but may be clustered on developing leaves, shoot tips, and flower buds (Saarinen 2009, p. 22). After several days of development, larvae chew out of eggs and develop through four instar stages, with total larval development time lasting 3 to 4 weeks, depending upon temperature and humidity (Saarinen 2009, p. 22). Fourth instar larvae pupate in sheltered or inconspicuous areas, often underneath leaf whorls or bracts (Saarinen 2009, p. 22). Adult butterflies eclose (emerge) after 5 to 8 days, depending on temperature and humidity (Saarinen 2009, p. 22). On blackbead plants, females lay eggs on flower buds and emerging leaves(Cannon et al. 2010, p. 851). Oviposition on, or larval consumption of, mature blackbead leaves was not observed (Cannon et al. 2010, p. 851). Thus, Cannon et al. (2010, p. 851) suggest that abundance may be limited by the availability of young blackbead leaves and buds for egg-laying, even if abundant suitable nectar sources (see Habitat) are available year-round.On balloonvine, females lay single eggs near fruit (capsules) (Carroll and Loye 2006, p. 18). Newly hatched larvae chew distinctive holes through the outer walls of the capsules to access seeds (Minno and Emmel 1993, p. 134). After consuming seeds within the natal capsule, larvae must crawl to a sequence of two or three balloons before growing large enough to pupate. Attending ants follow through the same holes (see Interspecific relationships below). Miami blues were also observed to commonly pupate within mature capsules (sometimes with ants in attendance within the capsule) (Carroll and Loye 2006, p. 20). The Miami blue has been described as having multiple, overlapping broods year-round (Pyle 1981, p. 489). Adults can be found every month of the year (Opler and Krizek 1984, pp. 112–113; Minno and Emmel 1993, p. 135; 1994, p. 647; Emmel and Daniels 2004, p. 9; Saarinen 2009, p. 22). Opler and Krizek (1984, pp. 112–113) indicated one long winter generation from December to April, during which time the adults are probably in reproductive diapause (a period in which growth, development, and physiological activity is suspended or diminished); a succession of shortergenerations was thought to occur from May through November, the exact number of which is unknown. Glassberg et al. (2000, p. 79) described the Miami blue as having occurred all year, with three or more broods. Researchers have noted a marked decrease of adults from December to early February at BHSP, indicative of a short diapause (Emmel and Daniels 2003, p. 3; 2004, p. 9). Saarinen also noted that the life cycle at BHSP slowed in winter months and suspected a slight diapause (E.V. Saarinen and J.C. Daniels, unpub. data, as cited in Saarinen 2009, p. 22). Conversely, Minno (pers. comm. 2010) notes that there have been records ofadults in December and January and suggests that this tropical butterfly may not have a winter diapause, but rather, emergence may be delayed by cold temperatures in some years. Salvato and Salvato (2007, p. 163) and Cannon et al.(2010, pp. 849–850) also reported numerous adults at BHSP and KWNWR, respectively, during winter months. Information on adult lifespan is limited. Adults may live a maximum of 9 days, but most adults live only a few days (J. Daniels, UF, pers. comm. 2003a, 2003b). In general, adult butterflies survive less than a week in the wild; there are approximately 8–10 generations per year (Saarinen et al. 2009a, p. 31). Generations are not completely discrete due to the variance in development time of all life stages (Saarinen et al. 2009a, p. 31).

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: moderate

Adult: moderate

Site Fidelity

Larvae: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: blackbead, nickerbean, balloonvine, and presumably Acacia spp

Adult: Spanish needles (Bidens alba), Leavenworth's tickseed (Coreopsis leavenworthi), scorpionstail (Heliotropium angiospermum), turkey tangle fogfruit or capeweed (Lippia nodiflora), buttonsage (Lantana involucrata), snow squarestem (Melanthera nivea [M. aspera]), blackbead, Brazilian pepper (Schinus terebinthifolius), false buttonweed (Spermacoce spp.), and seaside heliotrope (Heliotropium curassavicum)

Habitat Narrative

Adult: The Miami blue is a coastal butterfly reported to occur in openings and around the edges of hardwood hammocks (forest habitats characterized by broad-leaved evergreens), and inother communities adjacent to the coast that are prone to frequent natural disturbances (e.g., coastal berm hammocks, dunes, and scrub) (Opler and Krizek 1984, p. 112; Minno andEmmel 1994, p. 647; Emmel and Daniels 2004, p. 12). It also uses tropical pinelands (Minno and Emmel 1993, p. 134) and open sunny areas along trails (Pyle 1981, p. 489). In the Keys, it wasmost abundant near disturbed hammocks where weedy flowers provided nectar (Minno and Emmel 1994, p. 647). It also occurred in pine rocklands (fire-dependent slash pinecommunity with palms and a grassy understory) on Big Pine Key (Minno and Emmel 1993, p. 134; Calhoun et al. 2002, p. 18) and elsewhere in Monroe and Miami-Dade Counties. In Miami-Dade County, it occurred locally inland, sometimes in abundance (M. Minno, pers. comm. 2010). Within KWNWR, all occupied areas had coastal strands and dunes fronted by beaches (Cannon et al. 2007, p. 13; Cannon et al. 2010, p. 851).

Dispersal/Migration

Motility/Mobility

Larvae: very limited

Adult: mobile

Migratory vs Non-migratory vs Seasonal Movements

Larvae: not migratory

Adult: not migratory

Dispersal

Larvae: very low

Adult: moderate

Immigration/Emigration

Larvae: no

Adult: unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: Adult Miami blues are nonmigratory and appear to be very sedentary (Emmel and Daniels 2004, p. 6). Based on mark recapture work conducted in 2002– 2003, recaptured adults (N = 39) moved an average of 6.53 +/¥ 11.68 feet (2.0 +/¥ 3.6 meters), four individuals moved between 25 and 50 feet (7.6 and 15.2 meters), and only three individuals moved more than 50 feet (15.2 meters) over a few days (Emmel and Daniels 2004, pp. 6, 32–38). Few individuals were found to move between the lower and upper walkway locations of the south end colony sites at BHSP(approximately 100 feet [30.5 meters]); no movement between any of the smaller individual, isolated colony sites was recorded (Emmel and Daniels 2004, p. 6). However, Saarinen (2009, pp. 73, 78–79) found that genetic exchange between colonies occurred at BHSP and noted that small habitat patches may be crucial in providing links between subpopulations in an area. The frequency of dispersal between islands is also not known (Cannon et al. 2010, p. 852). Due to the distance between the Marquesas and Boca Grande (i.e., about 7 miles [11 km]) and the species' limited dispersal capabilities, it is possible that two (or more) distinct metapopulations exist within KWNWR (J. Daniels, pers. comm. 2010b).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

2 populations (USFWS, 2024)

Population Size:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Prior to its apparent extirpation, the metapopulation at BHSP was monitored regularly from 2002 to 2009 (Emmel and Daniels 2009, p. 4). Pollard transects atthe south-end colony site (largest) yielded annual peak counts of approximately 175, 84, 112, and 132, from 2002 to 2005 (prior to hurricanes), and 82, 81, 120, and 38, from 2006 to 2009 (Emmel and Daniels 2009, p. 4). From October 2002 to September 2003, abundance estimates using markrelease-recapture (Schnabel method) ranged from a low of 19.7 in February 2003 to a high of 114.5 in June 2003 (Emmel and Daniels 2004, p. 9). Counts ranged from 6 to 100 adults during surveys by the NABA conducted from February 2004 to January 2005 (NABA 2005, unpub. data). Monthly (2003 to2006) or bimonthly (2007) monitoring by Salvato (pers. comm. 2011c) at the south-end colony produced annual average counts of 129, 58, 46, 6, and 8, respectively, from 2003 to 2007. Salvato (pers. comm. 2011c) observed 21, 10, and 0 Miami blues from 2008 to 2010, respectively, based on limited surveys. In general, early (dry) season numbers were low in most years and were attributed to a persistent south Florida drought (Emmel and Daniels 2009, p. 4). Abundance trends indicated that there was a marked decrease in the number of individuals during the winter months (November to February) (Emmel and Daniels 2004, p. 9; 2009, p. 4). Higher abundances during the summer wet season may relate to production of a large quantity of new terminal growth on the larval host plants (nickerbean) and availability of nectar sources from spring rainfall (Emmel and Daniels 2004, pp. 9–11). Two populations (USFWS, 2024)

Threats and Stressors

Stressor: Habitat loss
Exposure:
Response:
Consequence:
Narrative: Acute habitat fragmentation has apparently severely diminished the butterfly's ability to repopulate formerly inhabited sites or to successfully locate host plants in new areas (Calhoun et al. 2002, p. 18). Although larval host plants remain locally common, the disappearance of core populations and extent of habitat fragmentation may now prevent the subspecies from colonizing few areas (J. Calhoun, pers. comm.2003b). The Miami blue is sedentary and not known to travel far from pockets of larval host plants and adult nectar sources (J. Calhoun, pers. comm. 2003b; Emmel and Daniels 2004, p. 6, 13). The presence of adult nectar sources proximal to larval host plants is critical to the Miami blue and may help explain its absence from areas that contain high larval host plant abundance but few nectar sources (J. Calhoun, pers. comm. 2003b; Emmel and Daniels 2004, p. 13).

Stressor: Improper land management practices
Exposure:
Response:

Consequence:
Narrative: Land management practices that remove larval host plants and nectar sources can be a threat to the Miami blue. Maintenance, including pruning of host vegetation along trails and roadsides, use of herbicides, and impacts from other projects could lead to direct mortality in occupied habitats (Emmel and Daniels 2004, p. 14). Lack of prescribed fire on public lands may have adversely affected the Miami blue through time, but impacts are unclear. In summary, a variety of land management practices on public lands (e.g., removal of host plants, mowing of nectar sources, and lack of prescribed fires) may have adversely affected the Miami blue and its habitat historically and continues to do so currently.

Stressor: Small, isolated populations
Exposure:
Response:
Consequence:
Narrative: Due to the few metapopulations, small population size, restricted range, and remoteness of occupied habitat, we believe that collection is a significant threat to the subspecies and could potentially occur at any time. Even limited collection from the small population in KWNWR (or other populations, if discovered) could have deleterious effects on reproductive and genetic viability and thus could contribute to its extinction. The Miami blue is vulnerable to extinction due to its severely reduced range, small population size, metapopulation structure, few remaining populations, and relative isolation. In general, isolation, whether caused by geographic distance, ecological factors, or reproductive strategy, will likely prevent the influx of new genetic material and can result in low diversity, which may impact viability and fecundity (Chesser 1983, pp. 66–77).

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Overutilization for commercial, recreational, scientific, or educational purposes is a threat to the Miami blue. Collection is a significant threat to the subspecies. Based on our analysis of the best available information, we have no reason to believe that its vulnerability to collection and risks associated with scientific or conservation efforts will change in the foreseeable future.

Stressor: Disease and predation
Exposure:
Response:
Consequence:
Narrative: Studies suggest that various stressors (e.g., baculovirus, fire ants) have the potential to negatively impact the Miami blue, but we do not have evidence of their impacts to wild populations. The Miami blue may have some mechanisms to potentially deter predators and parasitoids, but these are not well understood. Disease and predation have the potential to impact the Miami blue's continued survival, given its few remaining populations, low abundance, and limited range. Based on our analysis of the best available information, we do not believe that

disease or predation is a significant threat to its overall status at this time. However, given its small population size, disease and predation have the potential to impact the subspecies now or in the foreseeable future.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Despite these existing regulatory mechanisms, the Miami blue continues to decline due to the effects of habitat loss (see Factor A) and a wide array of other factors. We find that regulatory measures have been insufficient to significantly reduce or remove the threats to the Miami blueand, therefore, that the inadequacy of existing regulatory mechanisms is a threat to the subspecies throughout all of its range. Based on our analysis of the best available information, we have no reason to believe that the aforementioned regulations, which currently do not offer adequate protection to the Miami blue, will be improved in the foreseeable future.

Stressor: Invasive iguana
Exposure:
Response:
Consequence:
Narrative: The exotic green iguana (Iguana iguana) is a severe threat to the Miami blue (75 FR 69258; Daniels 2009, p. 5;FWC 2010, pp. 6, 13; Olle 2010, pp. 4, 14). Effects of herbivory to the host plant (nickerbean) at BHSP were evident by late 2008 and early 2009 (Emmel and Daniels 2009, p. 4; Daniels 2009, p. 5; P. Hughes, pers. comm. 2009; P. Cannon, pers. comm. 2009; A. Edwards, pers. comm. 2009). In addition to damage, iguanas likely consume eggs and pupae when opportunistically feeding (P. Hughes, pers. comm. 2009; Daniels 2009, p. 5; FWC 2010, p. 13), especially since the butterfly uses the same terminal growth of host plants. Displacement of native plants including host plants by invasive exotic species, a common problem throughout south Florida, also possibly contributed to habitat loss of the Miami blue.

Stressor: Pesticide
Exposure:
Response:
Consequence:
Narrative: Although substantial progress has been made in reducing impacts, the potential effects of mosquito control applications and drift residues remain a threat to the Miami blue.

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Environmental factors have likely impacted the Miami blue and its habitat within its historical range. A hard freeze in the late 1980s likely contributed to the Miami blue's decline (L. Koehn, pers. comm. 2002) presumably due to loss of larval host plants in south Florida.

Prolonged cold temperatures in January 2010 and December 2010 through January 2011 may have also impacted the remaining metapopulations in the Keys. Unseasonably cold temperatures during winter 2010 (in combination with impacts from iguanas) resulted in a substantial loss of nickerbean and nectar sources at BHSP. This reduction, albeit temporary, may have severely impacted an already depressed Miami blue population on the island. Similarly, extended dry conditions and drought can affect the availability of host plants and nectar sources and affect butterfly populations (Emmel and Daniels 2004, pp. 13–14, 17). Depressed numbers of the Miami blue at BHSP in 2008 were attributed to severe drought (Emmel and Daniels 2009, p. 4). The Keys are regularly threatened by tropical storms and hurricanes. No area of the Keys is more than 20 feet (6.1 m) above sea level (and many areas are only a few feet (meters) in elevation). These tropical systems have affected the Miami blue and its habitat.

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Not available

Recovery Actions:

- No information
- Study gene flow and genetic diversity within contemporary populations

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES Recovery Activities In conjunction with the recommended actions in the recovery plan outline (Service 2012b), we suggest the following recovery activities: • Maintain high quality patches of beachside scrub where nickerbean and other host plants are abundant and where the butterfly could survive, including at Hobe Sound and Merritt Island National Wildlife Refuges, among others. o Continue to monitor high quality sites, especially after large disturbances to ensure their continued suitability. • Implement removal of invasive green iguanas that consume and destroy host plants specifically in Key West National Wildlife Refuge and at reintroduction sites. • Continue captive colony efforts at the McGuire Center and Florida Keys, including as needed and determined to be appropriate or feasible: o Collect individuals periodically to enrich captive colony genetic diversity. o Conduct releases of captively reared butterflies with subsequent surveys to determine establishment. Monitoring / Research Activities • Continue to survey areas with potential extant populations. • Conduct surveys in Northern Cuba and the Bahamas (sites without prior collection) to collect individuals. o Using molecular techniques, determine if any individuals found abroad belong to the same taxon as the Miami blue butterfly. • Using surrogate species, identify potential diseases or parasitoids that may be negatively impacting the Miami blue butterfly. • Using surrogate species, identify impacts of herbicides and pesticides commonly used near suitable Miami blue habitat. • Continue to search for possible future reintroduction sites where sea level rise and other threats are minimal (e.g., peninsular Florida). • Further research into the history of the butterfly using a broader array of genes, and across a longer time frame. o Examine the genetic structure of populations over time to determine the occurrence and impact of any bottlenecking events (USFWS, 2024).

References

2012 USFWS. Endangered and Threatened Wildlife and Plants Listing of the Miami Blue Butterfly as Endangered Throughout Its Range. FR 77(67) 20948, April 6, 2012, Final Rule.

USFWS. 2024. Miami Blue Butterfly (Cyclargus thomasi bethunebakeri) 5-Year Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Vero Beach, Florida. 12 pp.

USFWS. 2024. Miami Blue Butterfly (Cyclargus thomasi bethunebakeri) 5-Year Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Vero Beach, Florida. 12 pp.

SPECIES ACCOUNT: *Desmocerus californicus dimorphus* (Valley elderberry longhorn beetle)

Species Taxonomic and Listing Information

Commonly-used Acronym: VELB

Listing Status: Threatened; August 8, 1980 (45 FR 52803).

Physical Description

The valley elderberry longhorn beetle (Desmocerus californicus dimorphus) is a medium-sized red and dark green (to red and black) insect, approximately 2 centimeters (cm) (0.8 inch [in.]) long. Females are larger than males and resemble males except that the elytra (first pair of wings) do not fully cover the abdomen when viewed from above. Males possess longer, more robust antennae than females (USFWS 1984).

Taxonomy

Two subspecies have been described: the California elderberry longhorn beetle (D. c. californicus), which lives along the coast and in the Coast Ranges from San Diego to Mendocino County; and the valley elderberry longhorn beetles (D. c. dimorphus), which is endemic to the Central Valley. The two subspecies can be identified with certainty only by adult male coloration, where males of the D. c. dimorphus have predominantly red elytra with four dark spots, whereas males of the common, California elderberry longhorn beetle have dark metallic green to black elytra with a red border. The ranges of the two subspecies overlap along the eastern edge of the Coast Range. Adult males with atypical color patterns (i.e., resembling that of D. c. californicus) have been observed in Colusa, Yolo, Placer, Sacramento, San Joaquin, Mariposa, Merced, Fresno, Kern, and Tulare counties, although it is unclear whether these were intergrades or D. c. californicus (79 FR 55874; USFWS 2006).

Historical Range

Although the entire historical distribution of the valley elderberry longhorn beetle is unknown, extensive destruction of riparian forests of the Central Valley during the past 150 years strongly suggests that the beetle's range has decreased and become greatly fragmented. Museum records indicate that the beetle has been collected in four central California counties: Merced, Sacramento, Solano, and Yolo (USFWS 1984).

Current Range

When the valley elderberry longhorn beetle was listed in 1980, it was known from 10 occurrence records at three locations: the Merced River (Merced County), the American River (Sacramento County), and Putah Creek (Yolo County) of the Central Valley of California. There are approximately 190 records of the animal (largely based on exit holes) in the Central Valley. Although records exist for Kern County, no specimens or observations of living beetles exist the support the assertion that the species is found there (USFWS 2006).

Critical Habitat Designated

Yes; 8/8/1980.

Legal Description

On August 8, 1980, the Service designated critical habitat for the valley elderberry longhorn beetle (Desmocerus californicus dimorphus) under the Endangered Species Act of 1973, as amended (45 FR 52803 - 52807).

Critical Habitat Designation

Critical habitat for D. c. dimorphus is designated in Sacramento county, California.

(1) Sacramento Zone. An area in the city of Sacramento enclosed on the north by the Route 160 Freeway, on the west and southwest by the Western Pacific railroad tracks, and on the east by Commerce Circle and its extension southward to the railroad tracks.

(2) American River Parkway Zone. An area of the American River Parkway on the south bank of the American River, bounded on the north by latitude 30”37’30”N, on the west and southwest by Elmanto Drive from its junction with Ambassador Drive to its extension to Jatitute 38”37’30”N, and on the south and east by Ambassador Drive and its extension north to latitude 38’37’30”N. Goethe Park, and that portion of the American River Parkway northeast of Goethe Park, west of the Jedediah Smith Memorial Bicycle Trail, and north to a line extended eastward from Palm Drive.

Primary Constituent Elements/Physical or Biological Features

Not available

Special Management Considerations or Protections

Section 4(f)(4) of the Act requires, to the maximum extent practicable, that any final regulation specifiying Critical Habitat be accompanied by a brief description and evaluation of those activities which, in the opinion of the Director, may adversely modify such habitat if undertaken, or may be impacted by such designation. Such activities are identified below for the valley elderberry longhorn beetle. (1) Modification of riparian habitats by river channelization. (2) Construction of buildings, roads, bridges, or parking lots, directly eliminating the beetle’s host plant, elderberry (Sumbucus sp.). (3) Human disturbance, such as vandalism or fire, resulting from increased recreational use, which adversely affects the beetle.

Life History

Feeding Narrative

Adult: The valley elderberry longhorn beetle is an herbivorous specialist that feeds almost exclusively on blue elderberry (Sambucus cerulea) throughout all stages of its life. Adults feed on the foliage and perhaps flowers (and nectar) of the host plant, which are present from March through early June. Larva feed on the pith, and emergence of the adult beetle from the pith of the host is synchronized with the host plant bloom period. The species’ food resources are limited in distribution. Adults are active from March until June, while larvae are active year-round. California elderberry longhorn beetle (D. c. californicus) may compete with Valley elderberry longhorn beetle, because they can share food sources and their ranges can overlap. The species may also be preyed upon by insectivorous birds, lizards, European earwigs (Forficula auricularia), and Argentine ants (Linepithema humile). The species is entirely dependent on blue elderberry for feeding, and requires the riparian moist woodlands in which the plant grows. To serve as habitat, the shrubs apparently must have stems 2.5 cm (1 in.) or greater in diameter at ground level, so that larva may bore into them (79 FR 55874; USFWS 1984; USFWS 2006).

Reproduction Narrative

Adult: The valley elderberry longhorn beetle reproduces through oviparity, with females laying eggs on leaves of the host plant. Females lay eggs singly; the number of eggs are varied, ranging from 8 to 110 in a laboratory setting. In one study, a total of 136 larvae (and an additional 44 eggs that did not hatch) were produced by one captive female valley elderberry longhorn beetle. Hatching success has been estimated at 50 to 67 percent of eggs laid, but survival rates of larvae are unknown. Females lay eggs on elderberry leaves and at the junction of leaf stalks and main stems, with all eggs laid on new growth at the outer tips of elderberry branches. Based on observations of females along the Kings River, females laid eggs at locations on the elderberry branch where the probing ovipositor (i.e., the female's egg-laying organ) could be inserted. In a laboratory setting, the majority of eggs laid were attached to leaves and stems of foliage (provided as food), with a preference for leaf petiole-stem junctions, leaf veins, and other areas containing crevices and depressions. Eggs are approximately 2.3 to 3.0 mm (0.09 to 0.12 in.) long and reddish-brown in color, with longitudinal ridges. Eggs are initially white to bright yellow, then darken to brownish white and reddish (79 FR 55874; USFWS 1984; USFWS 2006).Individuals are very dependent on their host plant, blue elderberry (Sambucus spp.). The first instars larvae bore to the center of elderberry stems, where they develop and feed on the pith. Prior to forming their pupae, the elderberry wood boring larvae chew through the bark and then plug the holes with wood shavings. The larvae crawl back to their pupal chamber, which they pack with grass. In the pupal chamber, the larvae metamorphose into their pupae and then into adults, whereupon they emerge between mid-March and mid-June (peak late April to mid-May) and breed. The short adult life stage, including breeding, coincides with the bloom period of the elderberry. The species needs woodland habitat suitable for growing blue elderberry plants for reproduction. Oviposition occurs on stems with diameters greater than about 2.5 cm (1 in.). The larval stage reportedly often takes 2 years inside the host plant; however, a 1-year cycle has been observed in a laboratory setting. Adults live from a few days to a few weeks after emergence, and die within 3 months (79 FR 55874; USFWS 1984; USFWS 2006).

Geographic or Habitat Restraints or Barriers

Adult: Restricted to the Central Valley of California, and bounded by the Cascade Range, Sierra Nevada, Tehachapi Mountains, and coastal ranges and San Francisco Bay (79 FR 55874).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Requires the host blue elderberry plant for larval and adult life stages (79 FR 55874).

Habitat Narrative

Adult: The valley elderberry longhorn beetle is a habitat specialist and spends almost its entire life history on the sole host plant, blue elderberry. The species is dependent on the blue elderberry plant for larval and adult life stages. Blue elderberries are an important component of riparian ecosystems in California. Within the range of the species, habitats range from lowland riparian forest to foothill oak woodlands, with elevation ranges from 18.3 to 689 m (60 to 2,260 ft.). It has occasionally been found with these plants in more upland habitats, including scrubland and chaparral habitats. The range of the species is bounded by the Cascade Range to the north, Sierra Nevadas to the east, Tehachapi Mountains to the south, and coastal ranges and San Francisco Bay to the west (79 FR 55874; NatureServe 2015).Historically, the riparian forests in the Central Valley consisted of several canopy layers with a dense undergrowth, and included Fremont cottonwood (Populus fremontii), California sycamore (Platanus racemosa), willows (Salix sp.), valley oak (Quercus lobata), box elder (Acer negundo var. californicum), Oregon ash (Fraxinus latifolia), and several species of vines (e.g., California grape [Vitis californica] and poison oak [Toxicodendron diversilobum]). These plant communities encompass several remaining natural and semi-natural floristic vegetation alliances and associations in the Great Valley Ecoregion of California. Elderberry shrubs have been found most frequently in mixed plant communities, and in several types of habitat, including nonriparian locations, as both an understory and overstory plant, with valley elderberry longhorn beetle adults and exit holes created by the valley elderberry longhorn beetle found most commonly in riparian woodlands and savannas. The species uses moist valley oak woodlands suitable for blue elderberry plants. Shrub characteristics and other environmental factors appear to have an influence on use by the valley elderberry longhorn beetle in some recent studies, with more exit holes in shrubs in riparian than nonriparian scrub habitat types (USFWS 1984; 79 FR 55874).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: The valley elderberry longhorn beetle has very limited dispersal; it usually stays on or near the host plant for the duration of its life. Dispersal distance of an adult valley elderberry longhorn beetle from its emergent site is estimated to be 50 m (164 ft.) or less (USFWS 1984; 79 FR 55874).

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: The valley elderberry longhorn beetle requires elderberry species (USFWS 1984).

Dispersal/Migration Narrative

Adult: The valley elderberry longhorn beetle is a nonmigratory species with low mobility, usually staying on or near the host blue elderberry plant throughout its entire life. The dispersal distance of an adult valley elderberry longhorn beetle from its emergent site is estimated to be 50 m (164 ft.) or less. The species requires habitats such as woodlands and riparian areas that can contain elderberry species for dispersal. It is thought to occasionally disperse several kilometers/miles, but generally stays among the elderberry habitats. Male adult valley elderberry longhorn beetles appear more active than female adults, and males were observed taking short flights both within elderberry shrubs and to another shrub (USFWS 1984; USFWS 2006; 79 FR 55874).

Additional Life History Information

Adult: The valley elderberry longhorn beetle is thought to occasionally disperse several kilometers/miles, but generally stays among the elderberry habitats. Male adult valley elderberry longhorn beetles appear more active than female adults, and males were observed taking short flights both within elderberry shrubs and to another shrub (USFWS 2006; 79 FR 55874).

Population Information and Trends

Population Trends:

Long-term trend: decline of greater than 50 percent (NatureServe 2015). The overall trend of valley elderberry longhorn beetle occupancy was moderately downward when comparing the 1991 and 1997 survey data (79 FR 55874).

Species Trends:

There has been an overall decline of approximately 90 percent since the 1800s (79 FR 55874).

Number of Populations:

Occupancy of the valley elderberry longhorn beetle within the presumed historical range over the past 16 years has occurred in approximately 18 hydrologic units and 36 geographical locations in the Central Valley (79 FR 55874).

Population Size:

No true estimates have been made due to the cryptic nature of the species (79 FR 55874).

Adaptability:

Low

Additional Population-level Information:

An integrative approach of all three spatial frameworks (patch, gradient, and hierarchical) best defined a population structure for the valley elderberry longhorn beetle. This population structure can be characterized as patchy-dynamic, with regional distributions made up of local aggregations of populations. These localized populations are defined by both broad-scale or continuous factors associated with elderberry shrubs (e.g., shrub age or densities), and environmental variables associated with riparian ecosystems (e.g., elevation, associated trees) that themselves have patch, gradient, and hierarchical structures (79 FR 55874).

Population Narrative:

Occupancy of the valley elderberry longhorn beetle within the presumed historical range over the past 16 years has occurred in approximately 18 hydrologic units and 36 geographical locations in the Central Valley. The overall trend of valley elderberry longhorn beetle occupancy was moderately downward when comparing the 1991 and 1997 survey data. The species trend is an overall decline of approximately 90 percent since the 1800s (79 FR 55874).With regard to population size, no true estimates have been made due to the cryptic nature of the species. Based on a spatial analysis of valley elderberry longhorn beetle populations in the Central Valley, Talley concluded that the several-hundred-meter distances observed between local aggregations of the species supports a limited migration distance for this species. An integrative approach to all three spatial frameworks (patch, gradient, and hierarchical) best defined a population structure for the valley elderberry longhorn beetle. This population structure can be characterized as patchy-dynamic, with regional distributions made up of local aggregations of populations. These localized populations are defined by both broad-scale or continuous factors associated with elderberry shrubs (e.g., shrub age or densities) and environmental variables associated with riparian ecosystems (e.g., elevation, associated trees) that themselves have patch, gradient, and hierarchical structures (79 FR 55874).

Threats and Stressors

Stressor: Agricultural and urban development
Exposure: Loss of habitat to development.
Response: Lack of elderberry plants for individuals to inhabit.
Consequence: Population decline and extirpation.
Narrative: A significant amount of riparian vegetation (of which a portion contained elderberry shrubs) has been converted to agriculture and urban development since the mid-1800s. Agricultural development has probably reached close to its maximum extent in the Central Valley. However, conversion of agricultural lands into urban development continues at a significant rate,

and as a consequence continues to affect beetle habitat by eliminating elderberries along irrigation channels and hedgerows, eliminating the buffering effect, and precluding the potential to restore riparian forest vegetation (79 FR 55874).

Stressor: Levees and flood protection
Exposure: Loss of habitat to development of levees.
Response: Individuals lose habitat that sustains host elderberry plants.
Consequence: Population decline and extirpation.
Narrative: The flood protection system in California's Central Valley includes about 2,575 kilometers (km) (1,600 miles [mi.]) of federal project levees, 1,931 km (1,200 mi.) of designated floodways, 26 project channels covering several thousand hectares (acres), and 56 other major flood protection works. Projects that may have impacted, or could impact, valley elderberry longhorn beetle habitat include: levee construction; bank protection; channelization; facility improvements or ongoing maintenance activities, including clearing and snagging; construction of bypasses; and construction of ancillary features (such as overflow weirs and outfall gates). Some of these projects or facilities predate federal authorization, and either meet or are modified to meet (through current or future activities) federal standards. Many predate listing, although some facilities have been constructed since listing, and additional projects are proposed for imminent construction (79 FR 55874). Levee vegetation management actions are expected to continue to impact elderberry shrubs within the range of the valley elderberry longhorn beetle. Threats related to removal of elderberry vegetation may be reduced in the future in some locations in the Central Valley, based on revisions to the U.S. Army Corps of Engineers' vegetation management policies, as outlined in the 2014 Water Resources Reform and Development Act. Long-term impacts of levee vegetation management actions may be offset with implementation of mitigation (e.g., establishment of mitigation sites or restrictions on pruning); however, the success of mitigation sites in establishing occupancy of the valley elderberry longhorn beetle has not been fully evaluated, so its success is currently indeterminable ((79 FR 55874).

Stressor: Climate change
Exposure: Dramatic change in climate over a short period of time.
Response: Loss of host plant.
Consequence: Population decline and extirpation.
Narrative: Average temperatures have been rising in the Central Valley of California, and this trend will likely continue because of climate change. Climate change may also affect precipitation and the severity, duration, or periodicity of drought. However, there is a great deal of uncertainty as to the rate at which the average temperature may increase, and the effect of climate change on both precipitation and drought. In addition to the uncertainty associated with how the overall climate of the Central Valley may change, the impact of climate change on the valley elderberry longhorn beetle will depend on a complex array of other factors, including how the subspecies and its habitat respond to climate change. One of the elderberry species on which the beetle depends is well adapted to warm temperatures, and extends its range into southern California and northern Mexico. Information is unavailable that would allow for a meaningful prediction of whether potential changes in temperature and precipitation patterns would significantly affect elderberry growth, or whether such changes may cause shifts in the timing of elderberry

flowering relative to beetle emergence, or affect the relationship of these two species in any other way (79 FR 55874).

Stressor: Invasive plants
Exposure: Invasive plants outcompeting native plant species.
Response: Invasive plants have the potential to displace native plants in riparian communities, altering habitats.
Consequence: Habitat loss.
Narrative: Invasive nonnative plants may be impacting the species through modification or loss of habitat due to competition for space and resources with its host plant, but additional information is needed to evaluate the magnitude of this threat. The natural plant communities of the Central Valley have been altered by removal of native trees, as described above; and by the rapid spread of invasive plants following the influx of immigrants and livestock into the area during the gold rush era. As an example, the replacement of native plants, particularly in grassland communities, by nonnative annual grasses was nearly complete by 1880 (79 FR 55874).

Stressor: Predation
Exposure: Nonnative Argentine ant (Linepithema humile), European earwig (Forficula auricularia), birds, and lizards.
Response: Individuals are consumed by predators.
Consequence: Population decline.
Narrative: The invasive, nonnative Argentine ant (Linepithema humile) has been identified as a potential threat to the valley elderberry longhorn beetle. This ant is both an aggressive competitor with, and predator on, several species of native fauna; it is spreading throughout California riparian areas and displacing assemblages of native arthropods. Although additional studies are needed to better characterize the level of predation threat to the valley elderberry longhorn beetle from Argentine ants, the best available data indicate that this invasive species is a predation threat to the valley elderberry longhorn beetle, and is likely to expand to additional areas within the range of the valley elderberry longhorn beetle in the foreseeable future (79 FR 55874).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: Potential mismanagement of species.
Consequence: Population decline and extirpation.
Narrative: State and federal laws provide some degree of protection for riparian vegetation and valley elderberry longhorn beetles. The beetle may benefit from local impact minimization or mitigation plans for special-status species that have been developed as part of city or county general plans. Conversely, other types of local zoning or changes in open space designations in the future could affect the beetle. Although regulatory mechanisms are in place and provide some protection to the valley elderberry longhorn beetle and its habitat, absent the protections of the Endangered Species Act, other regulatory mechanisms would not provide adequate protection from the threats currently acting on the species (79 FR 55874).

Stressor: Pesticides
Exposure: Use of pesticides in elderberry habitat.
Response: Individuals and their host plant can be killed by chemicals.
Consequence: Population decline.
Narrative: Many pesticides are commonly used in the valley elderberry longhorn beetle's range. These pesticides include insecticides (most of which are broad-spectrum and likely toxic to the beetle) and herbicides (which may harm or kill its elderberry host plants). In 1997, the California Department of Pesticide Regulation listed 239 pesticide active ingredients applied in proximity to locations of the beetle. Four of the five counties (Fresno, Kern, Tulare, and Madera) that have the greatest pesticide use in California are in the San Joaquin Valley, where approximately 33 percent of beetle occurrences are documented. Many pesticide applications likely coincide with the period when adult beetles are active, and when the beetle eggs and early larval stages occur. These are considered the life stages at which the beetle is most vulnerable to pesticide effects, because they occur on the outside of elderberry stems. The pesticides, although not applied directly to beetle habitat, may indirectly affect the beetle or its habitat if pesticides drift from nearby locations (79 FR 55874).

Recovery

Reclassification Criteria:
Reclassification criteria for the valley elderberry longhorn beetle have not been established.

Delisting Criteria:
Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - A/1 - Sufficient suitable habitat patches within each management unit (Table 1) should be protected (i.e., voluntary land acquisitions, conservation easements, or other similar mechanisms). Suitable habitat for the Valley elderberry longhorn beetle is a riparian community with a mix of young and mature elderberry shrubs as well as signs of natural elderberry recruitment in the form of new saplings or young shoots from established elderberry shrubs. Each HUC8 subbasin within the management unit should contain at least five patches of quality habitat (see A/4) that are 656 – 2,625 feet (200 – 800 meters) long. HUC8 subbasins that are small or where only a small portion of the subbasin is in the management area should contain at least one patch of quality habitat that meets the criteria in A/3 that is 656 – 2,625 feet (200 – 800 meters) long. Small subbasins are those that cover less than 100,000 acres within the management unit. There are 9 subbasins that meet this definition. (USFWS, 2019)

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - A/2 - Valley elderberry longhorn beetles should be present in at least three suitable habitat patches (from A/1) within each HUC8 subbasin. Currently 45% of the HUC8 subbasins meet this criterion (Table 1). Because Valley elderberry longhorn beetle populations can show a pattern of short-term colonization and extinction (Collinge et al. 2001), three locations were considered the minimum need to maintain redundant populations of beetles are present in each watershed. (USFWS, 2019)

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - A/3 - Protected, clusters of suitable habitat patches within HUC8 subbasins (see A/1) should be no more than 12.4 mi (20 km) from the nearest adjacent protected suitable habitat patch along the same river system or major drainage. This distance was chosen based on the results of Collinge et al. (2001) which suggested that the Valley elderberry longhorn beetle population exhibits classic metapopulation dynamics at scales of less than 12.4mi (20km). (USFWS, 2019)

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - A/4 - Within the areas of protected suitable habitat, there should be a diversity of elderberry life stages and signs of natural recruitment. (USFWS, 2019)

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - A/5 - All areas of protected suitable habitat need to have comprehensive management plans that maintain habitat values for the Valley elderberry longhorn beetle and address potential threats such as Argentine ants, invasive plants, pesticide and herbicide use, as well as provide for habitat maintenance and enhancement. Implementation of habitat management plans is expected to also ameliorate threats described such as altered fire regime, vandalism and changes in environmental conditions resulting from climate change. (USFWS, 2019)

Factor C: Disease or Predation - C/1 - It is believed that Argentine ants may predate Valley elderberry longhorn beetle eggs (Huxel 2000). To delist the beetle, Argentine ants should be eliminated or controlled at sites specifically designated for recovery of the Valley elderberry longhorn beetle. A control or eradication program for Argentine ants should be implemented at each bank or other conservation area that has been established to support recovery of the Valley elderberry beetle. Control is considered achieved when the population of Argentine ants on a site is not appreciably affecting Valley elderberry longhorn beetle recruitment. (USFWS, 2019)

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence - E/1 - Water flows are sufficient to promote healthy elderberry and riparian habitats at all sites identified in A/1. Healthy habitats are those that have a diverse native plant community and show recruitment and multiple age classes of elderberry shrubs. (USFWS, 2019)

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence - E/2 - At least two of the locations in A/2 show long-term population viability. For the purpose of recovery, long-term is defined as at least 10 years. The 10-year time frame is long enough to account for short-term colonization and extinction (Collinge et al. 2001) and encompasses years with average, above-average, and below-average rainfall conditions. The populations must demonstrate the ability to survive both precipitation extremes. (USFWS, 2019)

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence - E/3 - In order to maintain resiliency, the populations identified in A/2 should have 2-3 recent exit holes/1,076.4ft2 (100m2) of elderberry habitat. Density information is based on Talley (2005) from areas along Putah Creek and the American River with known long-term persistent populations. (USFWS, 2019)

Recovery Actions:

- Priority 1: An action that must be taken to prevent extinction or to prevent a species from declining irreversibly. Acquire, enhance, restore, and protect suitable habitat for the Valley elderberry longhorn beetle. This action involves land acquisition, habitat management, and site improvements. (USFWS, 2019)
- Priority 1: An action that must be taken to prevent extinction or to prevent a species from declining irreversibly. Develop management and monitoring plans for protected riparian areas that consider the threats and needs of the Valley elderberry longhorn beetle. Plans should include status and demographic monitoring, non-native predator control, habitat enhancement, and other needed activities that may increase the resilience of the Valley elderberry longhorn beetle. (USFWS, 2019)
- Priority 3: All other actions necessary to provide for full recovery of the species. Complete studies that focus on: habitat patch size, elderberry density, and connectivity that influence the viability of individual Valley elderberry beetle populations; influences on demography and reproductive rates of the Valley elderberry longhorn beetle; and factors that influence or limit adult dispersal. (USFWS, 2019)
- Priority 3: All other actions necessary to provide for full recovery of the species. Include Valley elderberry longhorn beetle conservation as a component of state and local programs to protect riparian habitat. (USFWS, 2019)
- Priority 2: An action that must be taken to prevent a significant decline of the species population/habitat quality or some other significant negative impact short of extinction. Conduct surveys for the Valley elderberry longhorn beetle in each HUC8 subbasin to monitor and assess the health of known populations and to locate new populations. (USFWS, 2019)
- The U.S. Fish and Wildlife Service (USFWS) has prepared conservation guidelines for federal and nonfederal project applicants needing incidental take authorization. These guidelines establish measures to avoid and minimize adverse effects on the valley elderberry longhorn beetle. In addition, survey monitoring procedures are provided, designed to avoid any adverse effects to the species (USFWS 1999). Specifically, the guidelines include:
- Avoidance. Complete avoidance (i.e., no adverse effects) may be assumed when a 100-ft. (or wider) buffer is established and maintained around elderberry plants containing stems measuring 2.5 cm (1.0 in.) or greater in diameter at ground level. Firebreaks may not be included in the buffer zone. In buffer areas, construction-related disturbance should be minimized, and any damaged area should be promptly restored following construction. USFWS must be consulted before any disturbances in the buffer area are considered. In addition, USFWS must be provided with a map identifying the avoidance area, and written details describing avoidance measures (USFWS 1999).
- Protective Measures. 1. Fence and flag all areas to be avoided during construction activities. In areas where encroachment on the 100-ft. buffer has been approved by USFWS, provide a minimum setback of at least 20 ft. from the dripline of each elderberry plant. 2. Brief contractors on the need to avoid damaging the elderberry plants and the possible penalties for not complying with these requirements. 3. Erect signs every 50 ft. along the edge of the avoidance area with the following information: "This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment." The signs should be clearly readable from a distance of 20 ft., and

must be maintained for the duration of construction. 4. Instruct work crews regarding the status of the beetle and the need to protect its elderberry host plant (USFWS 1999).

- Restoration and Maintenance. 1. Restore any damage done to the buffer area (area within 100 ft. of elderberry plants) during construction. Provide erosion control and revegetate with appropriate native plants. 2. Buffer areas must continue to be protected after construction from adverse effects of the project. Measures such as fencing, signs, weeding, and trash removal are usually appropriate. 3. No insecticides, herbicides, fertilizers, or other chemicals that might harm the beetle or its host plant should be used in the buffer areas, or within 100 ft. of any elderberry plant with one or more stems measuring 1.0 in. or greater in diameter at ground level. 4. The applicant must provide a written description of how the buffer areas are to be restored, protected, and maintained after construction is completed. 5. Mowing of grasses/ground cover may occur from July through April to reduce fire hazard. No mowing should occur within 5 ft. of elderberry plant stems. Mowing must be done in a manner that avoids damaging plants (e.g., stripping away bark through careless use of mowing/trimming equipment) (USFWS 1999).
- Transplant Elderberry Plants that Cannot Be Avoided. Elderberry plants must be transplanted if they cannot be avoided by the proposed project. All elderberry plants with one or more stems measuring 1.0 in. or greater in diameter at ground level must be transplanted to a conservation area (see below). At USFWS' discretion, a plant that is unlikely to survive transplantation because of poor condition or location, or a plant that would be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, the minimization ratios may be increased to offset the additional habitat loss. Trimming of elderberry plants (e.g., pruning along roadways, bicycle paths, or trails) with one or more stems 1.0 in. or greater in diameter at ground level, may result in take of beetles. Therefore, trimming is subject to appropriate minimization measures. 1. Monitor. A qualified biologist (monitor) must be on site for the duration of the transplanting of the elderberry plants to ensure that no unauthorized take of the valley elderberry longhorn beetle occurs. If unauthorized take occurs, the monitor must have the authority to stop work until corrective measures have been completed. The monitor must immediately report any unauthorized take of the beetle or its habitat to USFWS and to the California Department of Fish and Wildlife (CDFW). 2. Timing. Transplant elderberry plants when the plants are dormant—approximately November through the first 2 weeks in February—after they have lost their leaves. Transplanting during the nongrowing season will reduce shock to the plant and increase transplantation success. 3. Transplanting Procedure. a. Cut the plant back 3 to 6 ft. from the ground or to 50 percent of its height (whichever is taller) by removing branches and stems above this height. The trunk and all stems measuring 1.0 in. or greater in diameter at ground level should be replanted. Any leaves remaining on the plant should be removed. b. Excavate a hole of adequate size to receive the transplant. c. Excavate the plant using a Vemeer spade, backhoe, front end loader, or other suitable equipment, taking as much of the root ball as possible, and replant immediately at the conservation area. Move the plant only by the root ball. If the plant is to be moved and transplanted off site, secure the root ball with wire and wrap it with burlap. Dampen the burlap with water, as necessary, to keep the root ball wet. Do not let the roots dry out. Care should be taken to ensure that the soil is not dislodged from around the roots of the transplant. If the site receiving the transplant does not have adequate soil moisture, pre-wet the soil a day or two before transplantation. d. The planting area must be at least 1,800 square feet (sq. ft.) for each elderberry transplant. The root ball should be planted so that its top is level with the existing ground. Compact the soil sufficiently so that settlement

does not occur. As many as five additional elderberry plantings (cuttings or seedlings) and up to five associated native species plantings (see below) may also be planted in the 1,800-sq.-ft. area with the transplant. The transplant and each new planting should have its own watering basin measuring at least 3 ft. in diameter. Watering basins should have a continuous berm measuring approximately 8 in. wide at the base and 6 in. high. e. Saturate the soil with water. Do not use fertilizers or other supplements or paint the tips of stems with pruning substances, because the effects of these compounds on the beetle are unknown. f. Monitor to ascertain whether additional watering is necessary. If the soil is sandy and well-drained, plants may need to be watered weekly or twice monthly. If the soil is clayey and poorly drained, it may not be necessary to water after the initial saturation. However, most transplants require watering through the first summer. A drip watering system and timer is ideal. However, in situations where this is not possible, a water truck or other apparatus may be used (USFWS 1999).

- Plant Additional Seedlings or Cuttings. Each elderberry stem measuring 2.5 cm (1.0 in.) or greater in diameter at ground level that is adversely affected (i.e., transplanted or destroyed) must be replaced, in the conservation area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). Stock of either seedlings or cuttings should be obtained from local sources. Cuttings may be obtained from the plants to be transplanted if the project site is in the vicinity of the conservation area. If USFWS determines that the elderberry plants on the proposed project site are unsuitable candidates for transplanting, USFWS may allow the applicant to plant seedlings or cuttings at higher ratios for each elderberry plant that cannot be transplanted (USFWS 1999).
- Plant-Associated Native Species. Studies have found that the beetle is more abundant in dense native plant communities with a mature overstory and a mixed understory. Therefore, a mix of native plants associated with the elderberry plants at the project site or similar sites will be planted at ratios ranging from 1:1 to 2:1 [native tree/plant species to each elderberry seedling or cutting. These native plantings must be monitored with the same survival criteria used for the elderberry seedlings. Stock of saplings, cuttings, and seedlings should be obtained from local sources. If the parent stock is obtained from a distance greater than 1 mi. from the conservation area, approval by USFWS of the native plant donor sites must be obtained prior to initiation of the revegetation work. Planting or seeding the conservation area with native herbaceous species is encouraged. Establishing native grasses and forbs may discourage unwanted nonnative species from becoming established or persisting at the conservation area. Only stock from local sources should be used (USFWS 1999).
- Conservation Area – Provide Habitat for the Beetle in Perpetuity. The conservation area is distinct from the avoidance area (though the two may adjoin), and serves to receive and protect the transplanted elderberry plants and the elderberry and other native plantings. USFWS may accept proposals for offsite conservation areas where appropriate. 1. Size. The conservation area must provide at least 1,800 sq. ft. for each transplanted elderberry plant. As many as 10 conservation plantings (i.e., elderberry cuttings or seedlings and/or associated native plants) may be planted in the 1,800-sq.-ft. area with each transplanted elderberry. An additional 1,800 sq. ft. shall be provided for every additional 10 conservation plants. Each planting should have its own watering basin measuring approximately 3 ft. in diameter. Watering basins should be constructed with a continuous berm measuring approximately 8 in. wide at the base and 6 in. high. The planting density specified above is primarily for riparian forest habitats or other habitats with naturally dense cover. If the conservation area is an open habitat (i.e., elderberry savanna or oak woodland), more area may be needed for the required plantings. Contact USFWS for assistance if the above

planting recommendations are not appropriate for the proposed conservation area. No area to be maintained as a firebreak may be counted as conservation area. Like the avoidance area, the conservation area should connect with adjacent habitat wherever possible, to prevent isolation of beetle populations. Depending on adjacent land use, a buffer area may also be needed between the conservation area and the adjacent lands. For example, herbicides and pesticides are often used on orchards or vineyards. These chemicals may drift or run off onto the conservation area if an adequate buffer area is not provided. 2. Long-Term Protection. The conservation area must be protected in perpetuity as habitat for the valley elderberry longhorn beetle. A conservation easement or deed restrictions to protect the conservation area must be arranged. Conservation areas may be transferred to a resource agency or appropriate private organization for long-term management. USFWS must be provided with a map and written details identifying the conservation area; and the applicant must receive approval from USFWS that the conservation area is acceptable prior to initiating the conservation program. A true, recorded copy of the deed transfer, conservation easement, or deed restrictions protecting the conservation area in perpetuity must be provided to USFWS before project implementation. Adequate funds must be provided to ensure that the conservation area is managed in perpetuity. The applicant must dedicate an endowment fund for this purpose, and designate the party or entity that will be responsible for long-term management of the conservation area. USFWS must be provided with written documentation that funding and management of the conservation area (items 3 through 8 above) will be provided in perpetuity. 3. Weed Control. Weeds and other plants that are not native to the conservation area must be removed at least once a year, or at the discretion of USFWS and the CDFW. Mechanical means should be used; herbicides are prohibited unless approved by USFWS. 4. Pesticide and Toxicant Control. Measures must be taken to ensure that no pesticides, herbicides, fertilizers, or other chemical agents enter the conservation area. No spraying of these agents must be done within 100 ft. of the area, or if, in the opinion of biologists or law enforcement personnel from USFWS or the CDFW, they have the potential to drift, flow, or be washed into the area. 5. Litter Control. No dumping of trash or other material may occur in the conservation area. Any trash or other foreign material found deposited in the conservation area must be removed within 10 working days of discovery. 6. Fencing. Permanent fencing must be placed completely around the conservation area to prevent unauthorized entry by off-road vehicles, equestrians, and other parties that might damage or destroy the habitat of the beetle, unless approved by USFWS. The applicant must receive written approval from USFWS that the fencing is acceptable prior to initiation of the conservation program. The fence must be maintained in perpetuity, and must be repaired/replaced within 10 working days if it is found to be damaged. Some conservation areas may be made available to the public for appropriate recreational and educational opportunities with written approval from USFWS. In these cases, appropriate fencing and signs informing the public of the beetle’s threatened status and its natural history and ecology should be used and maintained in perpetuity. 7. Signs. A minimum of two prominent signs must be placed and maintained in perpetuity at the conservation area, unless otherwise approved by USFWS. The signs should note that the site is habitat of the federally threatened valley elderberry longhorn beetle and, if appropriate, include information on the beetle's natural history and ecology. The signs must be approved by USFWS. The signs must be repaired or replaced within 10 working days if they are found to be damaged or destroyed (USFWS 1999).

- Monitoring. The population of valley elderberry longhorn beetles, the general condition of the conservation area, and the condition of the elderberry and associated native plantings in the conservation area must be monitored over a period of either 10 consecutive years or for 7 years over a 15-year period. The applicant may elect either 10 years of monitoring, with surveys and reports every year; or 15 years of monitoring, with surveys and reports on years 1, 2, 3, 5, 7, 10, and 15. The conservation plan provided by the applicant must state which monitoring schedule will be followed. No change in monitoring schedule will be accepted after the project is initiated. If conservation planting is done in stages (i.e., not all planting is implemented in the same time period), each stage of conservation planting will have a different start date for the required monitoring time. Surveys. In any survey year, a minimum of two site visits between February 14 and June 30 of each year must be made by a qualified biologist. Surveys must include: 1. A population census of the adult beetles, including the number of beetles observed, their condition, behavior, and their precise locations. Visual counts must be used; mark-recapture or other methods involving handling or harassment must not be used. 2. A census of beetle exit holes in elderberry stems, noting their precise locations and estimated ages. 3. An evaluation of the elderberry plants and associated native plants on the site, and on the conservation area, if disjunct, including the number of plants, their size, and condition. 4. An evaluation of the adequacy of the fencing, signs, and weed control efforts in the avoidance and conservation areas. 5. A general assessment of the habitat, including any real or potential threats to the beetle and its host plants, such as erosion, fire, excessive grazing, off-road vehicle use, vandalism, or excessive weed growth. Reports. A written report, presenting and analyzing the data from the project monitoring, must be prepared by a qualified biologist in each of the years in which a monitoring survey is required. Copies of the report must be submitted by December 31 of the same year to USFWS (Chief of Endangered Species, Sacramento Fish and Wildlife Office), and the Department of Fish and Game (Supervisor, Environmental Services, Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814; and Staff Zoologist, California Natural Diversity Data Base, Department of Fish and Game, 1220 S Street, Sacramento, California 95814). The report must explicitly address the status and progress of the transplanted and planted elderberry and associated native plants and trees, as well as any failings of the conservation plan and the steps taken to correct them. Any observations of beetles or fresh exit holes must be noted. Copies of original field notes, raw data, and photographs of the conservation area must be included with the report. A vicinity map of the site and maps showing where the individual adult beetles and exit holes were observed must be included. For the elderberry and associated native plants, the survival rate, condition, and size of the plants must be analyzed. Real and likely future threats must be addressed, along with suggested remedies and preventative measures (e.g. limiting public access, or more frequent removal of invasive nonnative vegetation). A copy of each monitoring report, along with the original field notes, photographs, correspondence, and all other pertinent material, should be deposited at the California Academy of Sciences (Librarian, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118) by December 31 of the year that monitoring is done and the report is prepared. USFWS' Sacramento Fish and Wildlife Office should be provided with a copy of the receipt from the Academy library acknowledging receipt of the material, or the library catalog number assigned to it. Access. Biologists and law enforcement personnel from the CDFW and USFWS must be given complete access to the project site to monitor transplanting activities. Personnel from both these agencies must be given complete access to the project and the conservation area to monitor the beetle and its habitat in perpetuity (USFWS 1999).

- Success Criteria. A minimum survival rate of at least 60 percent of the elderberry plants and 60 percent of the associated native plants must be maintained throughout the monitoring period. Within 1 year of discovery that survival has dropped below 60 percent, the applicant must replace failed plantings to bring survival above this level. USFWS will make any determination as to the applicant's replacement responsibilities arising from circumstances beyond its control, such as plants damaged or killed as a result of severe flooding or vandalism (USFWS 1999).

Additional Threshold Information:

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References

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USFWS (U.S. Fish and Wildlife Service). 1984. Recovery Plan for the Valley Elderberry longhorn beetle. U.S. Fish and Wildlife Service. Portland, Oregon. 70 pp. June 28. Available online at: http://ecos.fws.gov/docs/recovery_plan/840628.pdf. Date accessed: April 12, 2016

USFWS (U.S. Fish and Wildlife Service). 2006. Valley Elderberry longhorn beetle (Desmocerus californicus dimorphus) 5-Year Review, Summary and Evaluation. U.S. Fish and Wildlife Service. Sacramento Fish and Wildlife Office, Sacramento, California. 30 pp. September. Available online at: http://ecos.fws.gov/docs/five_year_review/doc779.pdf. Date accessed: April 12, 2016.

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USFWS (U.S. Fish and Wildlife Service). 1999. Conservation Guidelines for the Valley Elderberry Longhorn Beetle. Sacramento Fish and Wildlife Service. July 9. Available online at: http://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/Documents/velb_conservation.pdf. Date accessed: April, 21, 2016.

SPECIES ACCOUNT: *Dinacoma caseyi* (Casey's June Beetle)

Species Taxonomic and Listing Information

Listing Status: Endangered; September 22, 2011 (76 FR 58954).

Physical Description

Casey’s June beetle (Dinacoma caseyi) measures 1.4 to 1.8 centimeters (cm) (0.55 to 0.71 inch [in.]) long. It is dusty brown or whitish in color, with brown and cream longitudinal stripes on the elytra (wing covers and back). The females are flightless and display an accentuated sexual dimorphism, characterized by an enlarged abdomen, reduced legs and antennae, and metathoracic (the hindmost of the three divisions of the thorax of an insect, bearing the third pair of legs and the second pair of wings) wing reduction and venation (74 FR 32857).

Taxonomy

Casey's June beetle belongs to the scarab family (Scarabidae). The genus Dinacoma includes two described species, D. caseyi and D. marginata. A researcher and taxonomic expert experienced with the genus Dinacoma stated, ‘‘Dinacoma caseyi is a distinct species morphologically and comprises its own species group—the caseyi complex—the other [species group] being the marginata complex, which includes the bulk/remainder of the genus.’’ Casey's June beetle was first collected in Palm Springs, California, in 1916, and was later described based on male specimens (71 FR 44960).

Historical Range

Alluvial fans and river wash areas in Palm Springs, and similar habitats south to the City of Indian Wells. The majority of the historic collections are from Palm Springs. Other early records identify "Palm Desert," "Indian Wells," and "Palm Canyon," all from the western Coachella Valley east of the San Jacinto Mountains. The possible historic range is somewhere around Chino Canyon floodplains (or at most northwest to the Snow Creek drainage), south to around Indian Wells (Riverside County, California) (USFWS 2013).

Current Range

The current known range is limited to southern portions of Palm Springs in Riverside County, California; the species is generally associated with Palm Canyon Wash. Based on male movement potential and occupied habitat distribution, it has been determined that there is likely only one remaining population in Palm Springs (USFWS 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/22/2011.

Legal Description

On September 22, 2011, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Casey's June beetle (Dinacoma caseyi) under the Endangered Species Act of 1973, as amended (76 FR 58954 - 58998), The critical habitat includes approximately 587 acres (237 hectares) of land for the species in Riverside County, California.

Critical Habitat Designation

One unit is designated as critical habitat for Casey's June beetle. The approximate area of designated critical habitat for Casey's June beetle totals 587 ac (237 ha), including 152 ac (62 ha) of tribal allotment and fee land, 141 ac (57 ha) of local government land, and approximately 301 ac (122 ha) of private and quasi-public (flood control and water conservation district) land.

Palm Springs Unit The unit consists of 587 ac (237 ha) and is located in Riverside County, California, and extends from the confluence of Andreas Canyon Wash with Palm Canyon Wash northward along the toe of slope northeastward (downstream) along Palm Canyon Wash, crossing East Palm Canyon Drive to south and east of Gene Autry Trail. The unit includes Palm Canyon Wash and contiguous suitable soils from the entrance of Indian Canyons north to Calle Arriba, and one area south of and adjacent to East Palm Canyon Drive (SR 111) west of Gene Autry Trail. The entire critical habitat unit is considered occupied by Casey's June beetle and contains the physical or biological features essential to the conservation of the species, including alluvial soils of the CdC, RA, ChC (if mapped as completely surrounded by CdC and RA soils), MaB, and CpA soil series at or below 620 ft (189 m) in elevation, associated with washes and alluvial fans deposited on 0 to 9 percent slopes (PCE 1), and predominantly native desert vegetation (PCE 2). Habitat in the unit is threatened by development, soil disturbance, fragmentation, effects of stream channelization, and effects of climate change. Specifically, urban expansion, in-fill development, and recreational activities continue to result in the loss and degradation of habitat. Therefore, the features essential to the conservation of the species in this unit require special management considerations or protection to minimize impacts resulting from these threats. Approximately 25 percent of this unit (152 ac (62 ha)) is on Agua Caliente Band of Cahuilla Indians reservation land. As described above (see Factor D), the Tribe informed us in an October 28, 2008, letter that they removed Casey's June beetle from the list of species addressed in the draft Tribal HCP; however, they indicated they will ''continue to informally coordinate with the Service regarding this species where it occurs on the Reservation.'' The Tribe stated they are deferring to the Service to allow ''the Service to take the lead in addressing how to effectively conserve and protect this species'' (ACBCI 2008, p. 1). We continue to work with the Agua Caliente Band of Cahuilla Indians to encourage management of Casey's June beetle habitat. We determined that at this time it is appropriate to exclude 11 ac (4 ha) tribal trust reservation lands (i.e., non-fee and non-allotted lands) from the critical habitat unit.

Primary Constituent Elements/Physical or Biological Features

The critical habitat unit is designated for Riverside County in California. Within this area, the primary constituent elements of critical habitat for Casey's June beetle are the habitat components that provide:

(i) Soils of the Carsitas (CdC) gravelly sand and Riverwash (RA) series, or inclusions of Carsitas cobbly sand (ChC) series soils, or inclusions of Myoma fine sands (MaB) or Coachella fine sands (CpA) within CdC soils, at or below 620 ft (189 m) in elevation, associated with washes and alluvial fans deposited on 0 to 9 percent slopes to provide space for population growth and reproduction, moisture, and food sources; and

(ii) Predominantly native desert vegetation, to provide shelter from traffic-related mortality and food for the species.

Special Management Considerations or Protections

Critical habitat does not include lands covered by manmade structures, such as buildings, aqueducts, airports, and roads, existing on the effective date of this rule and not containing one or more of the primary constituent elements.

Special management of the physical or biological features is required in these areas to reduce threats to habitat. Major threats to Casey's June beetle habitat include: (1) Habitat disturbance; (2) habitat loss and fragmentation associated with development (such as grading, building roads and other infrastructure, and constructing commercial and residential structures); and (3) recreational activities (for example, ORV use and equestrian activities). Because Casey's June beetle is now restricted to a relatively small area compared to its known historical range, and habitat loss and fragmentation are threats to the long-term viability of Casey's June beetle, special management considerations or protection of the PCEs are needed to address development or urban expansion impacts. Urban expansion should be avoided within or adjacent to Casey's June beetle habitat and linkage corridors between habitat patches should be provided to address the protection necessary for this species at this time. Preserving habitat and corridors linking habitat patches have been shown, in general, to be vital for the conservation of many species, and it stands to reason this is true for a species such as Casey's June beetle that has flightless females.

Life History

Feeding Narrative

Larvae: The food source for Casey's June beetle larvae while underground has not been studied, but other June beetle species are known to feed below ground on organic matter or detritus and associated decay organisms. Emergence holes have not been associated with any particular species or type of plant. It is assumed that Casey's June beetle larvae do not require any particular species of host plants for feeding. However, native plant species are likely an important habitat component, because native plant species are an integral component of the ecosystem in which Casey's June beetle evolved (76 FR 58954). In addition, areas with higher soil moisture are associated with higher densities of vegetation and microorganisms, such as fungi and bacteria, believed to provide a more diverse food source for beetle larvae (74 FR 32857).

Adult: Adult Casey's June beetles have not been observed feeding underground and have not been associated with any particular species or type of plant. Therefore, specific feeding information for the Casey's June beetle is not known. It is assumed that Casey's June beetles do not require any particular species of host plants for feeding. However, native plant species are likely an important habitat component, because native plant species are an integral component of the ecosystem in which Casey's June beetle evolved (76 FR 58954). Although Casey's June beetle distribution is not likely correlated with the distribution of a specific plant host, proximity of observed emergence holes to Sonoran (Coloradan) Desert scrub plants indicate that these plants may be important as a direct or indirect food source (74 FR 32857). Additionally, co-occurring annual plants and grasses using these desert scrubs as nurse plants or refugia contribute to surface litter and likely provide an additional food source as radiculum (plant rootlets) (74 FR 32857).

Reproduction Narrative

Larvae: See adult narrative.

Adult: Little is conclusively known about the Casey's June beetle and its life history. Based on surveys conducted to assess the species' presence, both male and female Casey's June beetles emerge from underground burrows sometime between late March and early June, with abundance peaks generally occurring in April and May. During the active flight season, adults emerge from the ground and males begin flying near dusk. Males are reported to fly back and forth or crawl on the ground where a female beetle has been detected. After emergence, females (who are flightless) remain on the ground and release pheromones to attract flying males. After mating, females return to their burrows or dig a new burrow and deposit eggs (76 FR 58954; Noss et al. 2001; USFWS 2013).Breeding success depends on males' ability to detect pheromones and to maneuver to remain in contact with the pheromone plume. The southern Palm Springs area is surrounded by mountain and ridges that protect the area from the frequent high winds of the Coachella Valley, thus providing conditions that are conducive to successful male flight, pheromone detection, and tracking. Minimally disturbed suitable habitat is also essential to Casey's June beetle. The adults burrow in alluvial soils (not too rocky or compacted), in particular those of Carsitas Series (CdC), to lay eggs. The larval stages are known to live out their life stage in alluvial soil as well (76 FR 58954; USFWS 2013).

Geographic or Habitat Restraints or Barriers

Larvae: Same as adult.

Adult: Casey's June beetle has primarily been found on Carsitas series (CdC) and Riverwash (RA) soils, and also some Carsitas cobbly sand (ChC) soils. These soil series are associated with alluvial fans, rather than areas of Aeolian or windblown sand deposits. Its burrowing habit would suggest that the Casey's June beetle needs soils that are not too rocky or compacted and difficult to burrow into (USFWS 2013; 71 FR 44960).

Spatial Arrangements of the Population

Larvae: Same as adult.

Adult: Clumped

Environmental Specificity

Larvae: Same as adult.

Adult: Narrow/specialist.

Site Fidelity

Larvae: Same as adult.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: None

Adult: None

Habitat Narrative

Larvae: The Palm Springs area has slightly higher precipitation than surrounding areas in the eastern Coachella Valley, due to its proximity to the base of the San Jacinto and Santa Rosa mountains. This precipitation keeps the underlying soil damp, which is important for Casey's June beetles because they, like many other subterranean scarab beetles, prefer the interface between surface soil and damp subsoil. The depth of the damp soil is generally between 10 cm (3.94 in]) and 20 cm (7.87 in.), and averages 22 to 26 degrees °C (72 to 78 degrees °F). This depth coincides with the depth at which larvae are usually found (5 cm [1.97 in.] to 20 cm [7.87 in.]). Individual scrub plant architecture has developed for maximum capture of precipitation, channeling water along stems to the central root system. Moisture in the soil layer prevents desiccation of larvae and eggs, and maintains a constant temperature. Additionally, areas with higher soil moisture are associated with a higher density of vegetation and microorganisms, such as fungi and bacteria, believed to provide a more diverse food source for beetle larvae (74 FR 32857). The Sonoran Desert scrub plant community endemic to the Palm Canyon Wash and adjacent terraces also serves to maintain habitat consistency. The Carsitas series soils have a water table located from 0.6 to 1.9 m (2 to 6 ft.) deep. Shrubs are important in water and nutrient cycling in desert ecosystems. Desert shrubs have deeper root systems that bring water from lower levels up to higher levels, cycle nutrients through the soil, and mediate diurnal temperature variations. Midday temperatures are lower near the center of desert scrub patches than in areas outside the canopy. The combination of moisture cycling, diurnal temperature variation, and seasonal climate change may provide beetle larvae with a gradient of micro-environments to inhabit in the subsoil through the year, thereby allowing them to maintain optimal body temperature and humidity levels. Therefore, the precipitation of the Palm Canyon area, and its influence on the local plant community, may be a unique factor critical for Casey's June beetle (74 FR 32857).

Adult: Knowledge of Casey's June beetle habitat characteristics is primarily based on correlation of known, mapped environmental features with species occupancy. Therefore, described habitat characteristics include soils type, slope aspect, elevation, vegetation type, and hydrologic information (USFWS 2013). Historically, Casey's June beetle was associated with native Sonoran (Coloradan) Desert vegetation, desert alluvial fans, and bajadas (compound alluvial fans) at the base of the San Jacinto Mountains (USFWS 2013). These areas include sandy dry washes with ephemeral flow, and dry upland areas associated with soil deposition from extreme flood events. Casey's June beetle has primarily been found on Carsitas series (CdC; gravelly sand on 0 to 9 percent slopes) and Riverwash (RA) soils, and also some Carsitas cobbly sand (ChC) soils. These soil series are associated with alluvial fans, rather than areas of Aeolian or windblown sand deposits. Its burrowing habit would suggest that the Casey's June beetle needs soils that are not too rocky or compacted and difficult to burrow into (USFWS 2013; 71 FR 44960).Experts have hypothesized that upland habitats provide core refugia from which the species recolonizes wash habitat after intense flood scouring events (approximately every 10 years), and are required for long-term survival of the species (USFWS 2013).Designated critical habitat consists of two PCEs: (1) Soils of the Carsitas (CdC) gravelly sand and Riverwash (RA) series, or inclusions of Carsitas cobbly sand (ChC) series soils, or inclusions of Myoma fine sands (MaB) or Coachella fine sands (CpA) within CdC soils, at or below 189 m (620 ft.) in elevation, associated with washes and alluvial fans deposited on 0 to 9 percent slopes to provide space for population growth and reproduction, moisture, and food sources; and (2) Predominantly native desert vegetation, to provide both shelter from traffic-related mortality and food for the species (76 FR 58954).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low to moderate; males can fly (with reasonable potential for movement throughout all suitable habitat areas); females are flightless (74 FR 32857).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Larvae: The larval life-stage of Casey's June beetle has not been well studied. This life stage lives in underground burrows, and has low motility and no ability to disperse (USFWS 2013).

Adult: It is unlikely that this species would disperse widely, because the flightless females cannot emigrate to isolated habitat areas where a new sub-population could be established. A related species that also has flightless females recorded the movement of male dispersal to be 281 m (923 ft.). It is unknown how far females can disperse over land, and they are restricted geographically to a relatively small area. Because they fly, it can be assumed males are primarily responsible for genetic mixing within the one known extant population (and historically among populations) (76 FR 58954).However, their dispersal is likely less than 305 m (1,000 ft.), and restricted geographically to a relatively small area (74 FR 32857). Soils that are modified, compacted, or too isolated for females to recolonize by crawling are not likely to support persistent occupancy. We do not know if females disperse at all; reported observations of females are limited to presence, and emergence to mate followed by re-entering the soil within minutes of mating (76 FR 58954; USFWS 2013).Because male Casey's June beetles cannot repopulate an area by themselves, and females are flightless, habitat fragmentation and isolation are significant threats to gene flow in this species. Therefore, connectivity of suitable habitats that provides for dispersal over multiple generations is essential to the conservation of the species (76 FR 58954).

Additional Life History Information

Larvae: The larval life-stage of Casey's June beetle has not been well studied. This life stage lives in underground burrows, and has low motility and no ability to disperse (USFWS 2013).

Adult: A related species that also has flightless females recorded the movement of male dispersal to be 281 m (923 ft.). It is unknown how far females can disperse over land, and they are restricted geographically to a relatively small area. Because they fly, it can be assumed males are primarily responsible for genetic mixing within the one known extant population (and historically among populations). Because male Casey's June beetles cannot repopulate an area by themselves, and females are flightless, habitat fragmentation and isolation are significant threats to gene flow in this species. Therefore, connectivity of suitable habitats that provides for dispersal over multiple generations is essential to the conservation of the species (76 FR 58954).

Population Information and Trends

Population Trends:

Short-term: decline of 10 to 30 percent; long-term: decline of 30 to 50 percent (NatureServe 2015).

Species Trends:

Short-term: decline of 10 to 30 percent; long-term: decline of 30 to 50 percent (NatureServe 2015).

Population Growth Rate:

Declining. Short-term trend: decline of 10 to 30 percent; long-term trend: decline of 30 to 50 percent (NatureServe 2015).

Number of Populations:

There is likely only one remaining population, in Palm Springs, California (USFWS 2013). There are between and one and five occurrences of the species (NatureServe 2015).

Population Size:

Unknown (NatureServe 2015)

Adaptability:

Low

Additional Population-level Information:

This species is a narrow endemic, known to occur only in the Coachella Valley where it meets the boundary of the San Jacinto Mountains, in an area of approximately 242 hectares (ha) (600 acres [ac.]) (74 FR 32857; NatureServe 2015).

Population Narrative:

This species is a narrow endemic, known to occur only in the Coachella Valley where it meets the boundary of the San Jacinto Mountains in an area of approximately 242 ha (600 ac.) (74 FR 32857; NatureServe 2015). Based on male movement potential and occupied habitat distribution, it is likely that there is only one remaining population, which in in decline (USFWS 2013).Most records are from the edge of the Coachella Valley desert floor where it meets the boundary of the San Jacinto Mountains. Recent records are from a few locations on the Agua Caliente Indian Reservation at the mouth of Palm Canyon, and from private land in the Smoke Tree Ranch residential community (NatureServe 2015). The species is currently restricted to an area of southern Palm Springs north of Acanto Way, east of South Palm Canyon Drive, south of State Route 111, and west of Palm Canyon Wash; and includes portions of the Agua Caliente Tribal Reservation. Recently, several hundred Casey's June beetle males were collected at light traps in Palm Canyon Wash in the vicinity of the Smoke Tree Ranch development (74 FR 32857; NatureServe 2015).

Threats and Stressors

Stressor: Destruction, modification, and fragmentation of habitat
Exposure: Commercial and residential development.
Response: Injury, mortality, reduced growth, habitat removal and degradation, and alteration of hydrology.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Commercial and residential development are the greatest threats to habitat in the upland CdC soils that are believed to support Casey’s June beetle. General location descriptions from early collection records were used to determine the historical range of Casey’s June beetle. Soils data from this analysis were used to estimate that 97 percent of the historical range of Casey’s June beetle has been converted to residential and commercial development. Although habitat fragmentation and loss due to development has slowed since 2005, the wash and associated occupied habitat areas are subject to flood control activities such as sand removal and

levy and detention basin construction. We anticipate additional upland habitat for the beetle may be impacted or lost in the near future due to requirements for flood control operations to maintain health and safety. These activities may impact conservation of Casey's June beetle into the future (USFWS 2013).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Commercial and residential development.
Response: Injury, mortality, reduced growth, habitat removal and degradation, and alteration of hydrology.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Existing regulatory mechanisms were not preventing continued habitat modification and fragmentation prior to listing. There are no regulatory mechanisms that address the management or conservation of habitat for Casey's June beetle. Occupied areas are better protected under Section 9 of the Endangered Species Act now that the species has been listed, and areas designated as critical habitat are better protected from impacts due to actions authorized, funded, or carried out by federal agencies. However, other habitats important to recovery are still vulnerable to development and habitat modification. Recovery of this species will depend on the protection and management of occupied and formerly occupied habitats that are not currently conserved (USFWS 2013).

Stressor: Natural or manmade factors
Exposure: Commercial, recreational, and residential development; catastrophic flood events; loss of individuals due to foot, vehicle, and horse traffic and other soil-disturbing activities; lights attracting male beetles away from habitat.
Response: Injury, mortality, reduced growth, habitat removal and degradation, and alteration of hydrology.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Natural or manmade factors, such as catastrophic flood events; loss of individuals due to foot, vehicle, and horse traffic and other soil-disturbing activities; and loss of individuals due to attraction to swimming pools and light sources. Lights attract male beetles away from habitat and females, resulting in wasted energy; males are frequently trapped and die in lights that have broken covers, or die in swimming pools. Any additional development in or adjacent to Casey's June beetle habitat will likely increase traffic into occupied areas, and include external lighting and swimming pools. Impacts from these threats may result in additional losses, and will continue to adversely affect the existing population (USFWS 2013).In addition to a restricted range and small population size, Casey's June beetle has limited dispersal capabilities. These conditions likely increase the degree of threat due to chance events, such as extreme floods or drought (USFWS 2013).

Stressor: Climate change
Exposure: Stochastic climate events.
Response: Injury, mortality, reduced growth, habitat removal and degradation, and alteration of hydrology.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.

Narrative: Climate change is likely to reduce Casey's June beetle population density by increasing severe scouring flood events, and decreasing soil moisture levels. Increased winter runoff and severe scouring flood events in Palm Canyon Wash are anticipated due to increasing frequency and severity of extreme storm events, causing more concentrated rainfall (and consequently less moisture absorption by the soil). Decreased total rainfall, increased evapotranspiration due to increased temperatures, and increased winter runoff may all decrease soil moisture levels (USFWS 2013).

Recovery

Reclassification Criteria:
Reclassification criteria have not been established for this species.

Delisting Criteria:
Delisting criteria have not been established for this species.

Recovery Actions:

- The goal of the initial phase of recovery is to arrest and reverse the general population decline, and to protect the available suitable habitat and range occupied by Casey's June beetle. These are recommended actions to occur in the interim between completion of the recovery outline and the recovery plan. These immediate actions will inform future research, restoration, threat abatement, and other conservation actions (USFWS 2013):
- Continue to coordinate with local partners and stakeholders to: (1) gather existing historical hydrologic data (frequency and severity of flash floods); (2) identify existing areas with suitable habitat for Casey's June beetle; and (3) identify future information needs related to Casey's June beetle biology (USFWS 2013).
- Ensure persistence of individuals in occupied upland habitat designated as critical habitat within 0.4 kilometer (0.25 mile) of and contiguous with Palm Canyon Wash, and the designated critical habitat area ("Matthew Place") adjacent to State Route 111, through conservation easements, management, and cooperative planning, with landowners, partners, and stakeholders (USFWS 2013).
- Design a range-wide monitoring scheme and begin its implementation throughout the current population distribution (USFWS 2013).
- Coordinate with local partners and land managers to educate the public on the impacts that recreational activities have on active adult beetles during the mating season (USFWS 2013).
- Initiate activities to abate threats related to unauthorized off-highway vehicle use in Palm Canyon Wash (USFWS 2013).
- Although this list of actions will likely change during the recovery planning process as we learn more about the species, we recommend the following actions as a more comprehensive list, using all available methods to lead to the conservation of Casey's June beetle. Specific actions that should be undertaken to meet the primary objectives are outlined below (USFWS 2013).
- a. Survey and monitor range-wide to accurately document populations, occupied habitat, and local threats • Develop a range-wide population monitoring or survey protocol that will lead to a better understanding of life history strategies, such as patterns of dispersal, growth, reproduction, and recruitment. • Conduct range-wide population monitoring of currently

occupied watersheds. • Conduct range-wide monitoring and assessment of potentially occupied habitat within the historical range. • Monitor habitat to identify locations in or adjacent to currently occupied areas where habitat suitability can be improved (for example, by decreasing soil compaction and increasing summer soil moisture levels) (USFWS 2013).

- b. Protect all suitable habitats in Palm Springs within the current estimated population distribution. Ensure persistence of existing population through conservation easements, management in perpetuity, and cooperative planning with landowners, partners, and stakeholders (USFWS 2013).
- c. Conduct research designed to inform management actions that would ameliorate or reduce current threats. • Develop a better understanding of the species' habitat requirements and environmental tolerances by documenting habitat conditions in currently occupied habitat, such as soil moisture, soil texture/compaction, water table depth, ground cover types, percent root volume per unit volume of soil, spring wind velocities correlated with adult mating activity, and the geographic distribution and frequency of such winds during the beetle's flight season. • Monitor the amount and velocity (intensity) of water flow during peak flood events, and the frequency of these events to determine whether flood events result in mortality of subterranean Casey's June beetles in Palm Canyon Wash. • Characterize habitat conditions that may provide suitable food resources (i.e., investigating diet through examination of larval gut contents). • Investigate the impacts of suburban development on Casey's June beetle occupancy and persistence at Smoke Tree Ranch. Investigative approaches include determination of onsite environmental correlations, follow-up experimentation, and comparison with other occupied sites. • Determine whether predation by ravens or crows is a threat to Casey's June beetle. Investigate whether Casey's June beetles are being consumed; and if so, quantify the number of individuals consumed through documentation of foraging by flocks in occupied habitat during the flight season, and examination of bird gut contents (USFWS 2013).
- d. Expand the current distribution by restoring and maintaining historically occupied habitat patches in Palm Springs (for example, restore former habitat in the Tahquitz Creek area). • Determine whether reintroduction and population augmentation are necessary; and if so, develop a comprehensive plan to facilitate this process. • Develop a comprehensive plan for acquiring suitable sites and establishing additional populations. • Assess and prioritize areas that can be restored and made suitable for reintroduction of Casey's June beetle. • Develop habitat restoration and creation techniques. • Investigate techniques to translocate Casey's June beetles (USFWS 2013).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The recommended actions listed below are to be completed over the next 5 years. Successful implementation of these actions will reduce threats to Casey's June beetle and provide information to better understand the biological and physical factors limiting the population growth and distribution. We recognize that conservation of this taxon will require cooperation and coordination with partners (Tribes, Federal, State, and local agencies) to minimize impacts from current threats, aid future restoration, and maximize effectiveness of limited funding. 1. Protect the existing population, occupied habitat, and suitable habitat through acquisition, conservation easements, management in perpetuity and cooperative planning with stakeholders. 2. Continue to monitor and document potential threats where Casey's June beetle occurs. 3. Develop a comprehensive re-introduction and restoration plan including identifying current sites suitable for reintroduction, prioritize areas for restoration, develop habitat restoration and creation techniques, and investigate techniques to translocate Casey’s June beetle. 4. Expand the current distribution within unoccupied areas of Tahquitz Creek and Palm Canyon Wash by restoring areas that are currently dominated by grass and ornamental vegetation. 5. Work with local partners to develop a rearing program to support future reintroductions. 6. Coordinate with local partners and land managers to educate the public on the impacts of recreational activities on beetles during the mating season. 7. Initiate activities to abate threats related to unauthorized off-highway vehicle use in Palm Canyon Wash. 8. Continue research to further our understanding of life history strategies such as dispersal, growth, reproduction, and recruitment. 9. Develop research to better characterize the effects of flood events on the beetle. 10. Investigate larval food sources to help characterize potential habitat. 11. Investigate the magnitude and sources of predation by birds. 12. Continue to coordinate with the District to develop a long-term plan for sediment removal in Palm Canyon Wash that minimizes the number of beetle individuals removed from the wash and maximizes the amount of larval food sources (detritus and organic material) in the wash system. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Drosophila digressa* (Hawaiian picture-wing fly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/29/2013; Pacific Region (Region 1) (USFWS, 2016)

Physical Description

Drosophila digressa is small, with adults ranging in size from 4.0 to 5.0 mm in length. Adults are brownish yellow in color and have yellow-colored legs and hyaline (shinyclear) wings with prominent brown spots. (USFWS, 2013)

Historical Range

Historically, D. digressa was known from six sites on the Island of Hawaii: Moanuiahea pit crater on Hualalai, Papa in South Kona, Manuka Forest Reserve, Kipuka 9 along Saddle Road, Bird Park in Hawaii Volcanoes National Park, and Olaa Forest Reserve (Montgomery, 1975; Magnacca, 2006, pers. comm.; HBMP, 2010d; Magnacca, 2011b, in litt.; Kaneshiro, 2013, in litt.). (USFWS, 2013)

Current Range

Currently, D. digressa is known from only two locations, one population in the Manuka NAR within the Manuka Forest Reserve, in the lowland mesic and montane mesic ecosystems, and a second population in the Olaa Forest Reserve in the montane wet ecosystem (Magnacca, 2011b, in litt.). (USFWS, 2013)

Critical Habitat Designated

No; 4/3/2024.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for 12 federally endangered species on the island of Hawaiʻi under the Endangered Species Act of 1973 (Act), as amended. In total, approximately 119,326 acres (48,289 hectares) on the island of Hawaiʻi, in the State of Hawaii, fall within the boundaries of the critical habitat designation. This rule extends the Act's protections to these species' designated critical habitats.

Critical Habitat Designation

Critical habitat units are depicted for Hawaii County, Hawaii,

Drosophila digressa—Unit 1; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 1 consists of 15,714 ac (6,359 ha) of wet forest ecosystem from Ookala to Maulua Nui on the northeastern slope of Maunakea. Lands within this unit include approximately 4,098 ac (1,658 ha) in Federal ownership, 10,644 ac (4,308 ha) in State ownership, and 972 ac (394 ha) in private or other ownership. Federal lands within this unit are within the Hakalau Forest National Wildlife Refuge Hakalau Forest Unit. State lands within this unit are part of the Hilo Forest Reserve Humuula, Laupahoehoe, and Piha Sections; the Laupahoehoe Natural Area Reserve; and the Manowaialee Forest Reserve.

Drosophila digressa—Unit 2; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 2 consists of 31,998 ac (12,949 ha) of wet forest ecosystem from Olaa to Upper Waiakea on the eastern slope of Mauna Loa and partially on the northern slope of Kilauea Volcano. Lands within this unit include approximately 7,875 ac (3,187 ha) in Federal ownership, 23,897 ac (9,671 ha) in State ownership, and 226 ac (91 ha) in private or other ownership. Federal lands in this unit are within Hawaii Volcanoes National Park. State lands in this unit are part of the Hilo Forest Reserve Kukuau Section, Olaa Forest Reserve Mountain View Section, Upper Waia¯kea Forest Reserve, Waia¯kea Forest Reserve, Puu Makaala Natural Area Reserve, and Waiakea 1942 Lava Flow Natural Area Reserve.

Drosophila digressa—Unit 3; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 3 consists of 8,781 ac (3,554 ha) of wet and mesic forest ecosystems at Kahuku on the southern slopes of Mauna Loa. Lands within this unit include approximately 8,773 ac (3,550 ha) in Federal ownership and 8 ac (3 ha) in State ownership. Federal lands within this unit are within Hawaii Volcanoes National Park. State-owned lands in this unit are part of the Ka'u¯ Forest Reserve.

Drosophila digressa—Unit 4; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 4 consists of 167 ac (67 ha) of mesic forest ecosystem at Manuka on the southern slopes of Mauna Loa. Lands within this unit are entirely in State ownership and are part of the Manuka Natural Area Reserve.

Drosophila digressa—Unit 5; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 5 consists of 3,412 ac (1,381 ha) of wet forest ecosystem from Kipahoehoe to Honomalino on the southwestern slopes of Mauna Loa. Lands within this unit include approximately 411 ac (166 ha) in State ownership and 3,001 ac (1,214 ha) in private or other ownership. Stateowned lands in this unit are part of the Kipahoehoe Natural Area Reserve and South Kona Forest Reserve KapuaManuka¯ Section. Some private lands are owned by The Nature Conservancy, within the Kona Hema Preserve.

Drosophila digressa—Unit 6; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 6 consists of 224 ac (91 ha) of wet forest ecosystem from Milolii to Honomalino on the southwestern slopes of Mauna Loa. Lands within this unit are entirely in State ownership and are part of the South Kona Forest Reserve KapuaManuka Section.

Drosophila digressa—Unit 7; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 7 consists of 1,346 ac (545 ha) of wet forest ecosystem from Kukuiopae to Olelomoana on the southwestern slopes of Mauna Loa. Lands within this unit include approximately 1,179 ac (477 ha) in State ownership and 167 ac (68 ha) in private or other ownership. Stateowned lands in this unit are part of the South Kona Forest Reserve Kukuiopae Section

Drosophila digressa—Unit 8; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 8 consists of 661 ac (267 ha) of wet forest ecosystem in Kaohe on the southwestern slopes of Mauna Loa.

Lands within this unit include approximately 352 ac (142 ha) in State ownership and 309 ac (125 ha) in private or other ownership. State-owned lands in this unit are part of the South Kona Forest Reserve, Kaohe Section and Kukuiopae Section

Drosophila digressa—Unit 9; Hawaii County, Hawaii. (i) Drosophila digressa—Unit 9 consists of 1,906 ac (771 ha) of wet forest ecosystem in Hookena on the southwestern slopes of Mauna Loa. Lands within this unit include 1,906 ac (771 ha) of Federal land within Hakalau Forest National Wildlife Refuge Kona Forest Unit and less than 1 ac (less than 1 ha) of land that is privately owned or has other ownership.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of Drosophila digressa consist of the following components:

(i) In units 1, 2, 5, 6, 7, 8, and 9, the physical or biological features essential to the conservation of Drosophila digressa are the features of the wet forest ecosystem and consist of: (A) Elevation of less than 7,218 feet (ft) (2,200 meters (m)). (B) Annual precipitation that is greater than 98 inches (in) (250 centimeters (cm)). (C) Substrate of very weathered soils to rocky substrate, basaltic lava, undeveloped soils, or developed soils. (D) Canopy contains one or more of the following native plant genera: Acacia, Antidesma, Cheirodendron, Ilex, Melicope, Metrosideros, Myrsine, Pittosporum, Psychotria. (E) Subcanopy contains one or more of the following native plant genera: Cibotium, Clermontia, Coprosma, Cyanea, Freycinetia, Hydrangea, Vaccinium. (F) Understory contains one or more of the following native plant genera: Adenophorus, Cibotium, Cyrtandra, Dicranopteris, Huperzia, Peperomia, Stenogyne.

(ii) In unit 3, the physical or biological features essential to the conservation of Drosophila digressa are the features of both the wet forest ecosystem and the mesic forest ecosystem and consist of the physical and biological features described in paragraphs (2)(i)(A) through (F) and (2)(iii)(A) through (F) of this entry. (iii) In unit 4, the physical or biological features essential to the conservation of Drosophila digressa are the features of the mesic forest ecosystem and consist of: (A) Elevation of less than 6,562 ft (2,000 m). (B) Annual precipitation of 39 to 150 in (100 to 380 cm). (C) Substrate of rocky, shallow, organic muck soils; rocky talus soils; shallow soils over weathered rock; deep soils over soft weathered rock; or gravelly alluvium. (D) Canopy contains one or more of the following native plant genera: Acacia, Antidesma, Charpentiera, Chrysodracon, Metrosideros, Myrsine, Nestegis, Pisonia, Santalum. (E) Subcanopy contains one or more of the following native plant genera: Coprosma, Freycinetia, Leptecophylla, Myoporum, Pipturus, Rubus, Sadleria, Sophora. (F) Understory contains one or more of the following native plant genera: Ctenitis, Doodia, Dryopteris, Pelea, Sadleria.

Life History

Feeding Narrative

Larvae: Drosophila digressa relies on the decaying stems of Charpentiera spp. and Pisonia spp. as a larval substrate (Magnacca et al., 2008; Magnacca 2013, in litt.). (USFWS, 2013)

Adult: The adult flies are generalist microbivores (microbe eating) and feed upon a variety of decomposing plant material. (USFWS, 2013)

Reproduction Narrative

Adult: Breeding generally occurs year-round, but egg laying and larval development increase following the rainy season as the availability of decaying matter, which the flies feed on, increases in response to the heavy rains (K. Kaneshiro, in litt., 2005b). In general, Drosophila lay between 50 and 200 eggs in a single clutch. Eggs develop into adults in about a month, and adults generally become sexually mature one month later. Adults generally live for one to two months. (USFWS, 2006a)

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2013)

Environmental Specificity

Adult: Very high/specialist with limited plant hosts (USFWS, 2013)

Site Fidelity

Adult: Very high (USFWS, 2013)

Dependency on Other Individuals or Species for Habitat

Larvae: Host plants: Charpentiera spp. and Pisonia spp. (USFWS, 2013)

Adult: Closely associated with Charpentiera spp. and Pisonia spp. (USFWS, 2013)

Habitat Narrative

Larvae: Drosophila digressa occurs in elevations ranging from approximately 2,000 to 4,500 feet, in the lowland mesic, montane mesic, and montane wet ecosystems of the island of Hawaii (Magnacca 2011a, pers. comm.). (USFWS, 2013)

Adult: Drosophila digressa occurs in elevations ranging from approximately 2,000 to 4,500 feet, in the lowland mesic, montane mesic, and montane wet ecosystems of the island of Hawaii (Magnacca 2011a, pers. comm.). Within these systems, D. digressa is closely associated with Charpentiera spp. and Pisonia spp., the larval host plants. (USFWS, 2013)

Dispersal/Migration

Motility/Mobility

Larvae: Limited to host plant (USFWS, 2006a)

Dispersal/Migration Narrative

Larvae: Eggs are laid on the host plant and larvae complete development in the decaying tissue before dropping to the soil to pupate (Montgomery, 1975; Spieth, 1986). (USFWS, 2013)

Population Information and Trends

Population Trends:

Declining (inferred from NatureServe, 2015)

Species Trends:

Declining (NatureServe, 2015)

Number of Populations:

5 (USFWS, 2020)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Adaptability:

Very low (USFWS, 2013)

Population Narrative:

For all occurrences between 1971 and 1986, the most collected at any one time was less than twenty specimens. (NatureServe, 2015) Currently, D. digressa is known from only two locations. The number of individuals at each of these locations is unknown (Magnacca 2011b, in. litt.). (USFWS, 2013). Hawaii picture-wing fly, Drosophila digressa is an endangered endemic species found only on the island of Hawaiʻi. The species is known from the mesic forest and montane wet forest habitats where rainfall occurs between 79 to 118 inches (200 to 300 cm) per year and humidity needs are met (Hardy and Kaneshiro 1968 p. 182; Montgomery 1975, p. 93). This picture-wing fly, historically known from five locations, is most recently known only from two locations, ʻŌlaʻa Small Tract of Hawaiʻi Volcanoes National Park (2009) and Manukā Natural Area Reserve (2010). Both of these populations occur in fenced areas, but neither of these locations are managed specifically for the needs of Drosophila digressa. Though adult D. digressa are generalist microbivores, feeding on decaying plant material, the species depends on decaying stems of Charpentiera spp., and Pisonia spp. as a host for oviposition and larval development. The loss or decrease in host plant resources and degradation or loss of habitat capable of meeting the humidity needs of the fly and decay cycle of the plant host threaten the existence of D. digressa. In addition, this picture-wing fly is threatened by predation from wasps and ants, and completion for resources from tipulid flies. The lengthy and conspicuous lekking and courtship behaviors of the picture-wing fly and its relatively large size, leave the species vulnerable to predation by yellow-jacket wasps. Other nonnative wasps may indiscriminately sting the larvae of Drosophila digressa resulting in its mortality. Because D. digressa larvae feed on decaying stems and bark and pupate in the soil, the larvae and pupae are vulnerable to predation by ants. In addition, competition for limited larval substrate with tipulid flies can exhaust food resources, which affects both the probability of D. digressa larval survival and the body size of adults. This can result in reduced adult fitness, fecundity, and lifespan of D. digressa. In summary, the primary factors that pose serious and ongoing threats to the species, its plant hosts, and its habitat range include the following: habitat degradation and destruction, nonnative ungulates and plants, drought, fire, predation, inadequate regulatory mechanisms to address nonnative species, natural disasters, limited numbers of populations and individuals, competition, potential environmental changes, and the interaction of these threats. A recovery plan is expected to be completed in 2021. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat degradation/ungulates (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Feral pig browsing alters the essential microclimate in Drosophila digressa habitat by opening up the canopy, leading to increased desiccation of soil and host plants (Charpentiera spp. and Pisonia ssp.), which disrupts the host plants' life cycle and decay processes, resulting in disruption of the picture-wing fly's life cycle, particularly oviposition and larvae substrate (Magnacca et al., 2008). Goats, cattle, and mouflon also cause habitat damage. In addition, the larval host plants are highly vulnerable to the impacts of introduced alien plants. (USFWS, 2013)

Stressor: Non-native plants (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Nonnative plants pose a serious and ongoing threats to D. digressa by destroying and modifying habitat. They can adversely impact microhabitat by modifying the availability of light and nutrient cycling processes, and by altering soil-water regimes. They can also alter fire regimes affecting native plant habitat, leading to incursions of fire-tolerant nonnative plant species into native habitat. (USFWS, 2013)

Stressor: Predation and competition (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Western yellow-jacket wasps have been observed feeding upon recently captured adult Hawaiian Drosophila (Kaneshiro and Kaneshiro, 1995). In addition, native picture-wing flies, including D. digressa may be particularly vulnerable to predation by wasps due to their lekking behavior and conspicuous courtship displays that can last for several minutes (Kaneshiro 2006, pers. comm.). These wasps are also believed to feed upon picture-wing fly larvae within their host plants (Carson, 1986). In addition, non-native ants are believed to prey upon picture-wing flies. Competition from tipulid larvae for D. digressa host plants is also a threat. (USFWS, 2013)

Stressor: Stochastic events (USFWS, 2013)
Exposure:
Response:

Consequence:
Narrative: Because of their very limited numbers, D. digressa are threatened by such events as hurricanes and drought. Drought has been observed as a factor for host plants, and hurricanes have the potential to significantly and adversely alter the habitat. (USFWS, 2013)

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Global climate change can increase temperatures, decrease precipitation, and increase storm intensities, sea-level rise, and coastal inundation. Consequential impact on D. digressa are related to changes in microclimatic conditions due to direct physiological stress, the loss or alteration of habitat, or changes in disturbance regimes (e.g., droughts, fire, storms, and hurricanes). (USFWS, 2013)

Recovery

Reclassification Criteria:
Not available.

Recovery priority numbers are assigned to species or subspecies based on the degree of threat, the potential for recovery, and their taxonomic status (i.e., full species vs. subspecies) and range from 1C (highest, “C” indicating the potential for conflict with human economic activities) to 18 (lowest) (USFWS 1983a, 1983b). All of the 15 species have a high degree of threat to their habitat and continued existence (Table 2). These threats are ongoing and include habitat loss and degradation by invasive nonnative plant species, feral ungulates, predation or herbivory by nonnative invertebrates and vertebrates, diseases, climate change, and the stochastic and demographic consequences associated with a low number of individuals and populations. Pittosporum hawaiiense and Pritchardia lanigera are assigned a recovery priority number of 2 based on a high degree of threat, a high potential for recovery because their threats are well understood and can be alleviated, and because of their status as full species. Bidens micrantha ssp. ctenophylla is assigned a recovery priority number of 3, based on a high degree of threat, a high potential for recovery because its threats are understood and can be alleviated, and because of its status as a subspecies. Cyanea marksii, Cyanea tritomantha, Cyrtandra nanawaleensis, Cyrtandra wagneri, Drosophila digressa, Phyllostegia floribunda, Platydesma remyi, Schiedea hawaiiensis, Stenogyne cranwelliae, and Vetericaris chaceorum are assigned a recovery priority number of 5, based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being well understood while others are difficult to mitigate, and because of their status as a species. Bidens hillebrandiana ssp. hillebrandiana and Schiedea diffusa ssp. macraei are assigned a recovery priority number of 6, based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being well understood while others are difficult to mitigate, and because of their status as subspecies (USFWS, 2019).

Delisting Criteria:
Not available.

Recovery Actions:

- No recovery information is available for the Hawaiian Picture-Wing Fly (USFWS, 2016)
- Not available.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop measureable downlisting and delisting criteria for the recovery of Drosophila digressa. • Conduct surveys for extant populations throughout the range of Drosophila digressa • Monitor and assess abundance of individuals and growth trend of populations. • Establish a captive rearing program for Drosophila digressa. • Identify and prepare suitable habitats for translocation of picture-wing flies. • Outplant populations of Drosophila digressa host plants in suitable habitats that can support the plant host and picture-wing fly. • Increase numbers of populations and individuals in suitable habitat through translocation to build resilient populations with redundancy and representation. • Develop and implement fire management plans for all populations of Drosophila digressa and its habitat. • Construct and maintain fenced exclosures to protect Charpentiera spp. and Pisonia spp. host plants of Drosophila digressa from the negative impacts of feral ungulates. • Control invasive, nonnative plant species that compete with Charpentiera spp. and Pisonia spp. in Drosophila digressa habitats. • Implement effective control methods for nonnative wasps at all Drosophila digressa and host plant populations in habitats suitable for the picture-wing fly. • Implement effective control methods for ants at all Drosophila digressa and host plant populations in habitats suitable for the picture-wing fly. • Implement effective control methods for tipulids at all Drosophila digressa and host plant populations in habitats suitable for the picture-wing fly. • Control any new threats to Drosophila digressa before they become widespread. • Develop fine-scale climate models to identify future suitable habitat based on existing and historical distributions and determine potential future climate conditions. • Identify, develop, and support alliances and partnerships to plan and implement Drosophila digressa habitat restoration and management to benefit and recover the species. (USFWS, 2020)

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SPECIES ACCOUNT: *Drosophila heteroneura* ((Unnamed) pomace fly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 5/9/2006; Pacific Region (Region 1) (USFWS, 2016)

Physical Description

Drosophila heteroneura is about 5.7 mm in length with wings approximately 7 mm long (Kaneshiro and Kaneshiro 1995). It has very large spots on the bases of the wings and the males have a broad head with the eyes situated laterally, giving them a hammerhead appearance. The face is yellow. The thorax is predominantly yellow with several black streaks and markings on top. The legs are yellow except for slight tinges of brown. The wings are transparent with ornate markings. The abdomen is shiny black with a large yellow spot on the top of each segment. (USFWS, 2012)

Historical Range

Historically, this species was known to be relatively widely distributed on the island of Hawaii between 915 to 1,830 meters (3,000 and 6,000 feet) above sea level. Drosophila heteroneura has been recorded from 24 localities on four of the island's five volcanoes (Hualalai, Mauna Kea, Mauna Loa, and Kilauea) in five different mesic to wet montane environments (K. Kaneshiro, in litt., 2005). (USFWS, 2012)

Current Range

Drosophila heteroneura has been observed since 2000 only in and near the South Kona Forest Reserve and the Kona Unit of the Hakalau Forest National Wildlife Refuge (D. Foote, U.S. Geological Survey, in litt., 2005). The most current observations have been at Kukuiopae in the South Kona Forest Reserve. (USFWS, 2012). Extant on Island of Hawaii (USFWS, 2021). Drosophila heteroneura, in the family Drosophilidae, is a picture-wing fly endemic mesic and wet montane habitats on the island of Hawaiʻi. Historically, the species was known from 24 sites on four of the islandʻs five volcanoes (Hualālai, Kīlauea, Mauna Kea, Mauna Loa). Currently the species is known from the mesic montane habitat in the Kukuiopaʻe and Kaʻohe area of the South Kona Forest Reserve. (USFWS, 2020). Distribution: Hawaiʻi (extant) (USFWS, 2022)

Critical Habitat Designated

Yes; 12/4/2008.

Legal Description

On December 4, 2008, the U.S. Fish and Wildlife Service designated critical habitat for Drosophila heteroneura under the Endangered Species Act, as amended (73 FR 73795 - 73895).

Critical Habitat Designation

Critical habitat is designated for D. heteroneura in Kau Forest, Hawaii County, island of Hawaii, Hawaii; Kona Refuge, Hawaii County, island of Hawaii, Hawaii; Lower Kahuku, Hawaii County, island of Hawaii, Hawaii; Pit Crater, Hawaii County, island of Hawaii, Hawaii; and Waihaka Gulch, Hawaii County, island of Hawaii, Hawaii.

Unit 1—Kau Forest consists of 125 ac (51 ha) of montane, wet, ohia forest, and is located on the southern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 5,215–5,510 ft (1,590–1,680 m), this unit is owned by the State of Hawaii, and is largely managed as part of a State forest reserve. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 8), this unit was occupied by D. heteroneura at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Cheirodendron trigynum, Clermontia sp., and Delissea parviflora, the larval stage host plants associated with this species.

Unit 2— Kona Refuge consists of 3,604 ac (1,459 ha) of montane, mesic, closed koa and ohia forest, and is located on the western flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 2,980–5,755 (910–1,755 m), this unit is owned by the Service, and is managed as part of the Kona Unit of the Hakalau Forest National Wildlife Refuge. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 8), this unit was occupied by D. heteroneura at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Cheirodendron trigynum, Clermontia sp., and Delissea parviflora, the larval stage host plants associated with this species.

Unit 3— Lower Kahuku consists of 687 ac (278 ha) of montane, mesic to wet, ohia forest, and is located on the southern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 3,705–4,685 ft (1,130–1,430 m), this unit is owned and managed by the National Park Service (NPS), Hawaii Volcanoes National Park. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 8), this unit was occupied by D. heteroneura at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Cheirodendron trigynum, Clermontia sp., and Delissea parviflora, the larval stage host plants associated with this species.

Unit 4—Pit Crater consists of 46 ac (18 ha) of montane, mesic, open ohia forest with mixed grass species, and is located on the western flank of Hualalai and south of the Kaupulehu lava flow on the island of Hawaii. Ranging in elevation between 3,835–4,525 ft (1,170–1,380 m), this unit is privately owned and managed. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 8), this unit was occupied by D. heteroneura at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Cheirodendron trigynum, Clermontia sp., and Delissea parviflora, the larval stage host plants associated with this species.

Unit 5— Waihaka Gulch consists of 120 ac (49 ha) of montane, wet, koa and ohia forest, and is located on the southern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 4,065– 4,390 ft (1,240–1,340 m), this unit is owned by the State of Hawaii, and is largely managed as part of a State forest reserve. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 8), this unit was occupied by D. heteroneura at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Cheirodendron trigynum, Clermontia sp., and Delissea parviflora, the larval stage host plants associated with this species.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for County of Hawaii, island of Hawaii, Hawaii. The primary constituent elements of critical habitat for Drosophila heteroneura are:

(i) Mesic to wet, montane, ohia and koa forest between the elevations of 2,908–5,755 ft (908–1,754 m); and

(ii) The larval host plants Cheirodendron trigynum ssp. trigynum, Clermontia clermontioides, C. clermontioides ssp. rockiana, C. hawaiiensis, C. kohalae, C. lindseyana, C. montis-loa, C. parviflora, C. peleana, C. pyrularia, and Delissea parviflora, which exhibit one or more life stages (from seedlings to senescent individuals).

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, and roads) and the land on which they are located existing within the legal boundaries on the effective date of this rule.

Nonnative plants and animals pose the greatest threats to the 12 picture-wing flies. In order to counter the ongoing degradation and loss of habitat caused by feral ungulates and invasive nonnative plants, active management or control of nonnative species is necessary for the conservation of all populations of the 12 picture-wing flies (Kaneshiro and Kaneshiro 1995, pp. 37– 38). Without active management or control, native habitat containing the features that are essential for the conservation of the 12 picture-wing flies will continue to be degraded or destroyed. In addition, habitat degradation and destruction as a result of wildfire, competition with nonnative insects, and predation by nonnative insects, such as the western yellow-jacket wasp (Vespula pensylvanica), may significantly threaten many of the populations of the 12 picture-wing flies. Active management is necessary to control these threats, as well. The threats to the physical and biological features in the areas designated as critical habitat for the 12 picture-wing flies that may require special management considerations or protection include feral ungulates, rats, invasive nonnative plants, and yellowjacket wasps. In addition, the units in dry or mesic habitats may also require special management to address wildfire and ants.

Life History

Feeding Narrative

Larvae: Drosophila heteroneura larvae primarily feed on the decomposing bark and stems of Clermontia sp. (family Campanulaceae), including C. clermontioides, and Delissea sp. (family Campanulaceae), but it is also known to feed within decomposing portions of Cheirodendron sp. (family Araliaceae) in open mesic and wet forest habitat (Kaneshiro and Kaneshiro 1995). They face competition for this resource with non-native tipulid fly larvae. (USFWS, 2012)

Adult: The adult flies feed on a variety of decomposing plant matter. During drier seasons or during times of drought, it is expected that available adult and larval stage food material in the form of decaying plant matter may decrease (K. Kaneshiro, 2005b). (USFWS, 2006c)

Reproduction Narrative

Adult: Breeding generally occurs year-round, but egg laying and larval development increase following the rainy season as the availability of decaying matter, which the flies feed on, increases in response to the heavy rains (K. Kaneshiro, in litt., 2005b). In general, Drosophila lay between 50 and 200 eggs in a single clutch. Eggs develop into adults in about a month, and adults generally become sexually mature one month later. Adults generally live for one to two months. (USFWS, 2006a)

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2006a)

Environmental Specificity

Adult: Very high/specialist with limited plant hosts (USFWS, 2006a)

Site Fidelity

Adult: Very high (USFWS, 2006a)

Dependency on Other Individuals or Species for Habitat

Larvae: Host plants: Clermontia sp., Delissea sp., and occasionally Cheirodendron sp. (USFWS, 2006a)

Adult: Closely associated with larval hosts: Cheirodendron bark, Clermontia bark, and Delissea stem (Montgomery, 1975). (NatureServe, 2015)

Habitat Narrative

Larvae: The habitat of Drosophila heteroneura is mesic to wet, montane, ohia and koa forests between the elevations of 2980 and 5755 feet, where the larval stage host plants in the genera Cheirodendron (one species), Clermontia (eight species), and Delissea (one species) occur. (USFWS, 2012)

Adult: The habitat of Drosophila heteroneura is mesic to wet, montane, ohia and koa forests between the elevations of 2980 and 5755 feet, where the larval stage host plants in the genera

Cheirodendron (one species), Clermontia (eight species), and Delissea (one species) occur. (USFWS, 2012)

Dispersal/Migration

Motility/Mobility

Larvae: Limited to host plant (USFWS, 2006a)

Dispersal/Migration Narrative

Larvae: Eggs are laid on the host plant and remain deep in the substrate of the plant until they emerge and pupate in the ground. (USFWS, 2006a)

Population Information and Trends

Population Trends:

Probably declining (inferred from USFWS, 2012)

Species Trends:

Clearly declining (USFWS, 2012)

Number of Populations:

≥1 (USFWS, 2022)

Population Size:

Unknown (USFWS, 2022)

Adaptability:

Very low (USFWS, 2012)

Population Narrative:

Based on the relatively extensive survey data, the population decline of D. heteroneura has been demonstrated clearly. For example, D. heteroneura was recorded 760 times during surveys between 1975 and 1979. In the early 1980s, the first disappearance of a D. heteroneura population was recorded from the Olaa Forest site in Hawaii Volcanoes National Park (Carson 1986; Foote and Carson 1995). Subsequently, the absence of the species was noted in several other locations in southern and western parts of the island where D. heteroneura had previously been relatively common. By the late 1980s, D. heteroneura was believed to be extinct until an extremely small population was discovered on private land at Hualalai Volcano in 1993. The species was not observed again until 1998 when Foote (2000) recorded six specimens. At this Kona site, over 134 individuals have been observed from 1999-2001 (D. Foote, U.S. Geological Survey, in litt., 2005). Over a three year period from 2009-2011, 23 individuals have been observed at Kukuiopae (4600 ft elevation) in the South Kona Forest Reserve (K. Magnacca in litt. 2012a). Additional surveys in historical and under-surveyed areas are needed to better estimate the demographics of D. heteroneura. (USFWS, 2012). No new information on the distribution of

Drosophila heteroneura has been received since the last 5-year review. Based on relatively extensive survey data from 1965 to 1999, the population of D. heteroneura has clearly declined (Kaneshiro 2005 in litt., entire). The species was recorded 760 times during surveys between 1975 and 1979. In the early 1980s, the first disappearance of a D. heteroneura population was recorded from the ʻŌlaʻa Forest in Hawaii Volcanoes National Park (Carson 1986, entire; Foote and Carson 1995, entire). Subsequently, the absence of the species was noted at several other locations in southern and western parts of the island where D. heteroneura had previously been relatively common. By the late 1980s, D. heteroneura was believed to be extinct until an extremely small population was discovered on private land at Hualālai Volcano in 1993. The species was not observed again until 1998 when eight individuals were observed (Kaneshiro 2005 in litt., entire). In 1999, a D. heteroneura population was recorded at the National Wildife Refuge South Kona Hakalau Forest unit. At this South Kona site, over 134 individuals were observed from 1999-2001 (Foote 2005 in litt., entire). The most recent observations of the species were on the South Kona Forest Reserve at Kukuiopaʻe and Kaʻohe area (Magnacca 2012 in litt, entire). In 2009, at an elevation of about 4,600 feet (ft) (1,400 meters [m])), five D. heteroneura females and five males were observed on a bait sponge. In 2010, at the same location, five females and four males were observed. The last observation of this population was made in 2011, when three females were observed at the 4,900 ft (1,1495 m) elevation (Magnacca 2012 in litt., entire). Currently, the species appears to be limited to the South Kona area (Magnacca 2019 in litt., entire). • The current population size or distribution of Drosophila heteroneura throughout its historic range is unknown. The species is believed to be extant in South Kona (Magnacca 2019 in litt., entire). It is possible the species survives in undocumented, isolated populations at other locations that have mesic to wet, montane habitats with suitable host plants (Clermontia spp., Cheirondendron sp., or Delissea sp.). Most of the historic areas have not been surveyed in the last 20 years. (USFWS, 2020). Number of populations: ≥1. Number of individuals: unknown (USFWS, 2022).

Threats and Stressors

Stressor: Feral ungulates (USFWS, 2006a)
Exposure:
Response:
Consequence:
Narrative: Feral pigs and goats have dramatically altered the native vegetation (Kaneshiro and Kaneshiro 1995; D. Foote, pers. comm., 2005; Science Panel 2005). These feral ungulates destroy host plant seedlings and habitat by the trampling action of their hooves and through the spread of seeds of nonnative plants (Cuddihy and Stone 1995; D. Foote, pers. comm., 2005). Cattle and goats also contribute to erosion on some steeper slopes where D. heteroneura host plants occur. (USFWS, 2006a)

Stressor: Herbivory (USFWS, 2006a)
Exposure:
Response:
Consequence:

Narrative: Goats, pigs, and rats directly feed upon the host plants of D. heteroneura (USFWS, 2006a)

Stressor: Fire (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The invasion of wildfire-adapted alien plants, facilitated by ungulate disturbance, has contributed to wildfire frequency. This change in wildfire regime has reduced the amount of forest cover for native species (Hughes et al. 1991; Blackmore and Vitousek 2000) and resulted in an intensification of fire threat and feral ungulate disturbance in the remaining native forest areas. Habitat damaged or destroyed by wildfire is more likely to be revegetated by nonnative plants that cannot be used as host plants by these picture-wing flies. (USFWS, 2012)

Stressor: Invasive plants (USFWS, 2006a)
Exposure:
Response:
Consequence:
Narrative: The invasion of several nonnative plants, particularly Psidium cattleianum, Rubus ellipticus, Passiflora mollissima, and Pennisetum setaceum, contributes to the degradation of picture-wing host plant habitat on the island of Hawaii (Kaneshiro and Kaneshiro 1995; Wagner et al. 1999; Science Panel 2005). (USFWS, 2006a)

Stressor: Predation and competition (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Picture-wing flies face predation threats by non-native ants, yellowjackets, tipulids, other insects, and lizards. Wasps may be the most serious predator. Ants will prey on the pupal stage. Larval tipulids compete with larval D. heteroneura for food. (USFWS, 2012)

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The effects of climate change on picture-wing flies and host-plant range will likely be significant. Life cycle characteristics such as length of larval period and adult longevity are highly dependent on temperature and other environmental factors affected by climate change. In general, stage length and longevity decrease with temperature increase. (USFWS, 2012)

Recovery

Reclassification Criteria:
Recovery Priority Number = 5 (USFWS, 2022)

Island-based geographic units, critical habitat units, and populations per geographic unit required for downlisting of Drosophila heteroneura. Island-based Geographic Unit= Hawaii. Critical Habitat Unit= 5 units totaling 4,582 ac (855 ha). Minimum Populations Per Geographic Unit for Downlisting=5 (USFWS, 2022).

Delisting Criteria:
Viable populations will persist on protected and managed habitat throughout most of the species' historical range on their islands of origin. (USFWS, 2006b)

Threats, primarily habitat loss and degradation and predation by nonnative insect species, will be sufficiently abated to ensure the high probability of survival for each listed species of Hawaiian picture-wing fly for at least 100 years. (USFWS, 2006b)

Island-based geographic units, critical habitat units, and populations per geographic unit required for delisting of Drosophila heteroneura. Island-based Geographic Unit= Hawaii. Critical Habitat Unit= 5 units totaling 4,582 ac (855 ha). Minimum Populations Per Geographic Unit for Delisting=10 (USFWS, 2022).

Recovery Actions:
- Protect habitat and control threats. (USFWS, 2006b)
- Expand existing wild Drosophila host plant populations as necessary. (USFWS, 2006b)
- Conduct additional research essential to recover the 12 Hawaiian picture-wing flies. (USFWS, 2006b)
- Develop and implement a detailed monitoring plan for each species
- Investigate need for and feasibility of picture-wing translocations into unoccupied historical habitat. (USFWS, 2006b)
- Develop and initiate a public information program for the 12 picture-wing flies. (USFWS, 2006b)
- Develop downlisting and delisting criteria as necessary to validate recovery objectives. (USFWS, 2006b)
- Develop and implement a Recovery Plan. (USFWS, 2012)
- Protect Drosophila heteroneura and Cheirodendron, Clermontia and Delissea spp., the larvae hosts of Drosophila heteroneura, from habitat destruction and control fire, rat, nonnative insect, and ungulate threats. (USFWS, 2012)
- Eliminate or manage nonnative Psidium cattleianum, Rubus ellipticus, Passiflora mollissima, and Pennisetum setaceum plants and other invasive plants that compete with larvae host plants and increase wildfire risk. (USFWS, 2012)
- Survey and document predatory threats. (USFWS, 2012)
- Develop and implement a systematic Drosophila heteroneura survey and monitoring plan that includes historic habitats and other suitable habitats. (USFWS, 2012)
- Evaluate the need to re-establish or supplement larvae host plants and wild picture-wing fly populations within their historical range. (USFWS, 2012)

Conservation Measures and Best Management Practices:

- New Management Actions: • In 2008, five units totaling 4,582 acres (ac) (855 hectares [ha]), of critical habitat was designated for Drosophila heteroneura (USFWS 2008, entire). Critical habitat Unit 1, located in the Kaʻu Forest, consists of 125 ac (51 ha) of wet montane ʻōhiʻa forest, and is located on the southern slope of Mauna Loa. Ranging in elevation between 5,215–5,510 ft (1,590–1,680 m), this unit is owned by the State of Hawaiʻi, and is largely managed as part of a State Forest Reserve. General actions to manage rapid ʻōhiʻa death and prevent ungulate damage to host plants have benefitted Clermontia spp. and subsequently, D. heteroneura if present. • Critical habitat Unit 2, located on the National Wildlife Refuge, South Kona Section, consists of 3,604 ac (1,459 ha) of montane, mesic, closed koa and ʻōhiʻa forest, and is located on the western slope of Mauna Loa on the island of Hawaiʻi. Ranging in elevation between 2,980–5,755 ft (910–1,755 m), this unit is owned by the Service, and is managed as part of the Kona Unit of the Hakalau Forest National Wildlife Refuge. General actions to manage rapid ʻōhiʻa death and prevent ungulate damage benefit Drosophila heteroneura, if present, and its Clemontia spp. hosts. • Critical habitat Unit 3, located within the lower Kahuku section of Hawaiʻi Volcanoes National Park, consists of 687 ac (278 ha) of montane, mesic to wet, ʻōhiʻa forest, and is located on the southern slope of Mauna Loa. Ranging in elevation between 3,705–4,685 ft (1,130–1,430 m). Hawaiʻi Volcanoes National Park is completing an environmental assessment for restoration work planned in the Kahuku section of the park. The restoration efforts include constructing boundary fences and removing feral ungulates, invasive plant control, and reforestation with native plants. Clermontia lindseyana, Clermontia clermontioides, Clermonita hawaiensis, and Clermontia montis-loa, hosts of Drosophila heteroneura, are present in this section and are expected to benefit from the restoration actions. Drosophila heteroneura is historically known from these park lands, but no recent (in the last ≈20 years) surveys have been conducted specifically for the picture-wing fly species. The planned restoration actions in the lowland mesic Kahuku section are expected to improve the condition of the mesic forest that may house undocumented, isolated populations or future reestablishment of D. heteroneura populations. • Large populations of Clermontia sp. a host of Drosophila heteroneura, have reestablished on the northeastern slopes of Mauna Loa near Puʻu Makaʻala and Kulani in the wet montane ʻōhiʻa forest since ungulate fencing was installed (Magnacca 2019 in litt., entire). The host plants occur as understory vegetation beneath the canopy of ʻōhiʻa and koa trees. Historically, D. heteroneura is known from the the northeastern slopes of Mauna Loa, though no recent surveys for the picture-wing fly have been conducted in this area. The presence of large populations of host plants provides an important resource for reestablishment of D. heteroneura. (USFWS, 2020).

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SPECIES ACCOUNT: *Drosophila mulli* ((Unnamed) pomace fly)

Species Taxonomic and Listing Information

Listing Status: Threatened; 05/09/2006; Pacific Region (R1) (USFWS, 2016)

Physical Description

Drosophila mulli has a head that is yellow on the front and covered with light, silvery grey fuzz. The face of the male is characteristically white, while that of the female is brown. The top of the thorax is brownish yellow and lacks conspicuous markings or stripes. The legs are predominantly yellow, and the front legs of males bear three distinct rows of long, curled hairs. The wings are two and one-half times longer than wide, with distinct brown markings at the base and the tip. The length of the body is 4.3-5.0 mm, and the wings are 4.3-4.8 mm long (Kaneshiro and Kaneshiro 1995). (USFWS, 2006a)

Historical Range

Drosophila mulli is restricted to the island of Hawaii and is historically known from three locations between 2,150 and 4,000 feet above sea level: the Olaa Forest Reserve at approximately 3,200 feet, Upper Waiakea Forest Reserve, and along Stainback Highway at approximately 4,000 feet elevation. (USFWS, 2012)

Current Range

The last record for Drosophila mulli was in the Olaa Forest Reserve near Volcanoes National Park on the island of Hawaii. No observations have been reported since 2001. (USFWS, 2012). Extant on Island of Hawaii (USFWS, 2021). Distribution: Hawaiʻi (extant) (USFWS, 2022)

Critical Habitat Designated

Yes; 12/4/2008.

Legal Description

On December 4, 2008, the U.S. Fish and Wildlife Service designated critical habitat for Drosophila mulli under the Endangered Species Act, as amended (73 FR 73795 - 73895).

Critical Habitat Designation

Critical habitat for D. mulli is designated in Olaa Forest, Hawaii County, island of Hawaii, Hawaii; Stainback Forest, Hawaii County, island of Hawaii, Hawaii; and Waiakea Forest, Hawaii County, island of Hawaii, Hawaii.

Unit 1—Olaa Forest consists of 244 ac (99 ha) of montane, wet, ohia forest and is located to the northeast of Kilauea Caldera on the southeastern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 3,120–3,300 ft (950– 1,005 m), this unit is owned by the State of Hawaii and is largely managed as part of a State forest reserve. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 10), this unit was occupied by D. mulli at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Pritchardia beccariana, the larval stage host plant associated with this species.

Unit 2—Stainback Forest consists of 76 ac (31 ha) of montane, wet, ohia forest, and is located to the northeast of Kilauea Caldera on the southeastern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 1,955–2,165 ft (595– 660 m), this unit is owned by the State of Hawaii and is largely managed as part of a State forest reserve. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 10), this unit was occupied by D. mulli at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Pritchardia beccariana, the larval stage host plant associated with this species.

Unit 3—Waiakea Forest consists of 373 ac (151 ha) of montane, wet, ohia forest, and is located to the northeast of Kilauea Caldera on the southeastern flank of Mauna Loa on the island of Hawaii. Ranging in elevation between 3,130–3,585 ft (955– 1,095 m), this unit is owned by the State of Hawaii and is largely managed as part of a State forest reserve. According to the most recent survey data (K. Kaneshiro, in litt. 2005a, p. 10), this unit was occupied by D. mulli at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of Pritchardia beccariana, the larval stage host plant associated with this species.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for County of Hawaii, island of Hawaii, Hawaii. The primary constituent elements of critical habitat for Drosophila mulli are:

(i) Wet, montane, ohia forest between the elevations of 1,955–3,250 ft (596– 1,093 m); and

(ii) The larval host plant Pritchardia beccariana, which exhibits one or more life stages (from seedlings to senescent individuals).

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, and roads) and the land on which they are located existing within the legal boundaries on the effective date of this rule.

Nonnative plants and animals pose the greatest threats to the 12 picture-wing flies. In order to counter the ongoing degradation and loss of habitat caused by feral ungulates and invasive nonnative plants, active management or control of nonnative species is necessary for the conservation of all populations of the 12 picture-wing flies (Kaneshiro and Kaneshiro 1995, pp. 37– 38). Without active management or control, native habitat containing the features that are essential for the conservation of the 12 picture-wing flies will continue to be degraded or destroyed. In addition, habitat degradation and destruction as a result of wildfire, competition with nonnative insects, and predation by nonnative insects, such as the western yellow-jacket wasp (Vespula pensylvanica), may significantly threaten many of the populations of the 12 picture-wing flies. Active management is necessary to control these threats, as well. The threats to the physical and biological features in the areas designated as critical habitat for the 12 picture-wing flies that may require special management considerations or protection include feral ungulates, rats, invasive nonnative plants, and yellowjacket wasps. In addition, the units in dry or mesic habitats may also require special management to address wildfire and ants.

Life History

Feeding Narrative

Larvae: Drosophila mulli has been found only in association with the palm tree Pritchardia beccariana, but the exact larval feeding site on this host plant remains unknown because attempts to rear D. mulli from decaying parts of P. beccariana have thus far been unsuccessful (Science Panel 2005). (USFWS, 2012)

Adult: The adult flies feed on a variety of decomposing plant matter. During drier seasons or during times of drought, it is expected that available adult and larval stage food material in the form of decaying plant matter may decrease (K. Kaneshiro, 2005b). (USFWS, 2006c)

Reproduction Narrative

Adult: Breeding generally occurs year-round, but egg laying and larval development increase following the rainy season as the availability of decaying matter, which the flies feed on, increases in response to the heavy rains (K. Kaneshiro, in litt., 2005b). In general, Drosophila lay between 50 and 200 eggs in a single clutch. Eggs develop into adults in about a month, and adults generally become sexually mature one month later. Adults generally live for one to two months. (USFWS, 2006a)

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2006a)

Environmental Specificity

Adult: Very high/specialist with limited plant host (USFWS, 2006a)

Site Fidelity

Larvae: Very high (USFWS, 2012)

Adult: Very high (USFWS, 2006a)

Dependency on Other Individuals or Species for Habitat

Larvae: Presumably the fan palm, Pritchardia beccariana is the host plant (USFWS, 2012)

Adult: Fan palm, Pritchardia beccariana (USFWS, 2012)

Habitat Narrative

Larvae: Drosophila mulli habitat consists of fan palms, Pritchardia beccariana, which is presumably the larval host plant, in wet, montane, ohia forest between the elevations of 1,955–4000 feet on the island of Hawaii. (USFWS, 2012)

Adult: Drosophila mulli habitat consists of fan palms, Pritchardia beccariana, in wet, montane, ohia forest between the elevations of 1,955–4000 feet on the island of Hawaii. (USFWS, 2012)

Dispersal/Migration

Motility/Mobility

Larvae: Limited to host plant (USFWS, 2006a)

Dispersal/Migration Narrative

Larvae: Eggs are laid on the host plant and remain deep in the substrate of the plant until they emerge and pupate in the ground. (USFWS, 2006a) Where the larvae specifically develop within the fan palm is unknown. (USFWS, 2012)

Population Information and Trends

Population Trends:

Declining (USFWS, 2012)

Species Trends:

Declining (inferred from USFWS, 2012)

Number of Populations:

≥3 (USFWS, 2022)

Population Size:

Unknown (USFWS, 2022)

Adaptability:

Very low (USFWS, 2012)

Population Narrative:

The site where the species was discovered was surveyed at least 62 times between years 1965 and 2001, with fewer than ten individuals observed on four different dates. The last recorded observation at this site occurred in 2001 (K. Kaneshiro, in litt., 2005). The other two sites were discovered in 1999 and 2000, and no individuals have been recorded there since that time, although surveys have been limited. The last D. mulli observation anywhere was in 2001. (USFWS, 2012) . The current population size and distribution of D. mulli throughout its historically known range are unknown. (USFWS, 2021b).

Threats and Stressors

Stressor: Feral ungulates (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Feral pigs and goats have dramatically altered the native vegetation (Kaneshiro and Kaneshiro 1995; D. Foote, pers. comm., 2005; Science Panel 2005). These feral ungulates destroy host plant seedlings and habitat by the trampling action of their hooves and through the spread of seeds of nonnative plants (Cuddihy and Stone 1995; D. Foote, pers. comm., 2005). Feral ungulates also contribute to watershed erosion and inhibit Pritchardia regeneration. (USFWS, 2012)

Stressor: Herbivory (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Rats directly feed upon the seeds, bark and flowers of the host plant, Pritchardia beccariana. Some non-native scoloytid beetles bore into the fruit of P. beccariana causing the fruit to drop before maturation and thus inhibiting regeneration of the host plant. (USFWS, 2012)

Stressor: Invasive plants (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The invasion of several nonnative plants, particularly Psidium cattleianum, Rubus ellipticus, and Pennisetum setaceum, contributes to the degradation of picture-wing host plant habitat on the island of Hawaii by physically excluding native plants, while Passiflora mollissima is a vine that can overload tree species and shade areas below. (USFWS, 2012)

Stressor: Predation and competition (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Picture-wing flies face predation threats by non-native ants, yellowjackets, tipulids, other insects, and lizards. Wasps may be the most serious predator. Ants will prey on the pupal stage. (USFWS, 2012)

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence:

Narrative: The effects of climate change on picture-wing flies and host-plant range will likely be significant. Life cycle characteristics such as length of larval period and adult longevity are highly dependent on temperature and other environmental factors affected by climate change. In general, stage length and longevity decrease with temperature increase. (USFWS, 2012)

Stressor: Yellow jackets, picture flies, ants (USFWS, 2021b)
Exposure:
Response:
Consequence:
Narrative: Multiple insect species are listed as threats to this species (USFWS, 2021b)

Recovery

Reclassification Criteria:
Recovery Priority Number = 5 (USFWS, 2022)

Island-based geographic units, critical habitat units, and populations per geographic unit required for downlisting of Drosophila mulli. Island-based Geographic Unit= Hawaii. Critical Habitat Unit= 3 units totaling 693 ac (281 ha). Minimum Populations Per Geographic Unit for Downlisting=5 (USFWS, 2022).

Delisting Criteria:
Viable populations will persist on protected and managed habitat throughout most of the species' historical range on their islands of origin. (USFWS, 2006b)

Threats, primarily habitat loss and degradation and predation by nonnative insect species, will be sufficiently abated to ensure the high probability of survival for each listed species of Hawaiian picture-wing fly for at least 100 years. (USFWS, 2006b)

Island-based geographic units, critical habitat units, and populations per geographic unit required for delisting of Drosophila mulli. Island-based Geographic Unit= Hawaii. Critical Habitat Unit= 3 units totaling 693 ac (281 ha). Minimum Populations Per Geographic Unit for Delisting=10 (USFWS, 2022).

Recovery Actions:
- Protect habitat and control threats. (USFWS, 2006b)
- Expand existing wild Drosophila host plant populations as necessary. (USFWS, 2006b)
- Conduct additional research essential to recover the 12 Hawaiian picture-wing flies. (USFWS, 2006b)
- Develop and implement a detailed monitoring plan for each species
- Investigate need for and feasibility of picture-wing translocations into unoccupied historical habitat. (USFWS, 2006b)
- Develop and initiate a public information program for the 12 picture-wing flies. (USFWS, 2006b)

- Develop downlisting and delisting criteria as necessary to validate recovery objectives. (USFWS, 2006b)
- Conduct surveys for Drosophila mulli. (USFWS, 2012)
- Develop and implement a Recovery Plan. (USFWS, 2012)
- Protect Drosophila mulli and Pritchardia beccariana habitat and control fire, rat, nonnative insects, and ungulate threats. (USFWS, 2012)
- Eliminate or manage nonnative scolytid beetles and other nonnative insects that reduce host plant regeneration and fitness for Drosophila mulli. (USFWS, 2012)
- Survey and document predatory threats. (USFWS, 2012)
- Develop and implement a systematic Drosophila mulli survey and monitoring plan that includes historic habitats and other suitable habitats. (USFWS, 2012)
- Conduct research to confirm larval stage host plants and evaluate larval resource competition or predation. (USFWS, 2012)
- Evaluate the need to re-establish or supplement Pritchardia beccariana and wild picture-wing fly populations within their historical range. (USFWS, 2012)

Conservation Measures and Best Management Practices:

- New Management Actions: Drosophila mulli is known from Hawaii Volcanoes National Park, but may be present because of the Park's contiguous forests. Rat Control Experiments. Pig Fencing (USFWS, 2021b).

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SPECIES ACCOUNT: *Elaphrus viridis* (Delta green ground beetle)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened; August 8, 1980 (45 FR 52807).

Physical Description

The delta green ground beetle (Elaphrus viridis) is approximately 0.6 centimeter (0.25 inch) long. It is typically brilliant metallic green and bronze. There are two slightly different color forms. Most adults are metallic green with bronze spots on the elytra (first pair of wings). Some adults lack the spots and are nearly uniform metallic green. Larvae of the delta green ground beetle are seldom seen due to their small size, and perhaps also because they hide under dense vegetation or in cracks in the ground. It is also difficult to differentiate them from other ground beetle larvae in the field (USFWS 2015).

Taxonomy

Although beetles of the genus Elaphrus superficially resemble tiger beetles (Cicindelidae), they belong to the ground beetle family Carabidae. The larvae are generally similar to other carabid larvae, and have hardened exterior surfaces with a metallic sheen. Adult delta green ground beetles can easily be distinguished from related species by their brilliant metallic colors, which are unique among California Elaphrus, and by the lack of outlined pits on the elytra. In addition, the delta green ground beetle is the only known California Elaphrus species whose adults are active during the winter (USFWS 2005). Since listing of the species in 1980, the tribe, genera, and subgenera of the taxonomic tribe Elaphrini have been redefined based on characters of adults and larvae. However, the delta green ground beetle (E. viridis) remains unchanged as one of 34 species of Elaphrus (USFWS 2009).

Historical Range

The historical distribution of the delta green ground beetle is unknown. The range of this vernal pool-associated species in California's Central Valley has been reduced and fragmented by human activities, and this species may have inhabited a much larger range than it does now. Significant losses of Central Valley wetlands and the lack of comprehensive insect surveys in California over the past century, in addition to the delta green ground beetle's cryptic coloration and its habit of hiding in vegetation or cracks in mud, make it difficult to estimate the former historical range of this species (USFWS 2005; USFWS 2009).

Current Range

To date, the delta green ground beetle has only been found in the greater Jepson Prairie area in south-central Solano County, California (USFWS 2005).

Critical Habitat Designated

Yes; 8/8/1980.

Legal Description

On August 8, 1980, the Service determined the delta green ground beetle (Elaphrus viridus) to be a threatened species and designated critical habitat under the Endangered Species Act of 1973, as amended (45 FR 52807 - 52810).

Critical Habitat Designation

Critical habitat for E. viridus is designated in Solano County, California: T5N R1E West 1/2 Sec. 12, Southwest 1/4 Sec. 13, southeast 1/4 Sec. 14, northeast 1/4 Sec. 23, northwest 1/4 Sec. 24.

Primary Constituent Elements/Physical or Biological Features

Known constituent elements essential to the continued existence of the delta green ground beetle are:

the vernal pools with their surrounding vegetation, and the land areas which surround and drain into these pools.

Special Management Considerations or Protections

Section 4(f)(4) of the Act requires, to the maximum extent practicable, that any final regulation specifying Critical Habitat be accompanied by a brief description and evaluation of those activities which, in the opinion of the Director, may adversely modify such habitat if undertaken, or may be impacted by such designation. Such activities are identified below for the delta green ground beetle: 1. Agricultural practices threaten this, species. Bulldozing and plowing near one of the vernal pools where the beetle has been collected may have eliminated it at this site. 2. Phase II of the North Bay Aqueduct and wastewater disposal for the city of Vacaville could adversely affect the Critical Habitat of the beetle if the needs of this species are not considered. There is Federal involvement with both of these projects. The agencies planning these activities are aware of the presence-of the delta green ground beetle and the federally Endangered Orcutt’s grass in the area, and are considering possible impacts of their proposed actions on these species. As noted above, the Service anticipates little, if any, conflict based on current proposals and planning for these projects. 3. Oil or natural gas exploration and exploitation, if conducted without regard for the ecosystem represented in the Critical Habitat, could adversely affect the area. The Service has no information indicating that Critical Habitat designation will prevent these activities within or adjacent to the Critical Habitat.

Life History

Feeding Narrative

Larvae: The larvae of the delta green ground beetle are predators that have been observed feeding on terrestrial larvae of chironomid midges, and beetle larvae of undetermined species (USFWS 2005).

Adult: Both larvae and adults of the delta green ground beetle are generalized predators, able to eat many different kinds of prey. Springtails (subclass Collembola) are an important food source.

Terrestrial larvae of chironomid midges (family Chironomidae) may also be a food source for both larvae and adults. When springtails are scarce, adult midges are apparently important prey items, and the beetles catch ones that happen to crash-land nearby. Delta green ground beetles have also been observed feeding on a few other beetle larvae of undetermined species. Key resources needed for feeding include vernal pools and their surrounding vegetation, and the presence of springtails, their primary food source. Active during the daytime, they are most active on sunny, nonwindy days, when the temperature is 16 to 21 °C (62 to 70 °F), continuing to moving until after sunset. There are seven stages in the life cycle: egg, three larval instars, pre-pupa, pupa, and adult. In the laboratory, each stage prior to the adult takes about 5 to 7 days, for a total development time of about 35 to 45 days (USFWS 2005).

Reproduction Narrative

Larvae: See Adult life stage.

Adult: The delta green ground beetle begins to reproduce at approximately 35 to 45 days. The breeding season lasts from February until mid-May. The clutch size is two to four eggs, and there is one reproductive event per year. The lifespan of the delta ground green beetle is approximately 9 to 12 months (NatureServe 2015; USFWS 2005). Males actively search through the vegetation for females, who hide in the plant cover or run away from the males. Males chase the females when they see one moving nearby, and mounting occurs almost immediately upon contact. Copulations last an average of 1 minute and 43 seconds. The copulation is terminated when the female tries to either shake the male off or move away from him. The male then chases the female until she manages to elude him in the vegetation (NatureServe 2015).

Spatial Arrangements of the Population

Larvae: Clumped

Adult: Clumped

Environmental Specificity

Larvae: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Moderate

Site Fidelity

Larvae: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: The presence of springtails (Collembola), the most important prey source for the delta green ground beetle, is a required habitat trait (USFWS 2009).

Habitat Narrative

Larvae: Delta ground green beetles rely on dense vegetation and cracks in the ground for survival. As the available habitat becomes dry, delta green ground beetle larvae crawl into cracks in the soil in preparation for pupation (USFWS 2005).

Adult: The species' preferred habitat is not well understood. Some entomologists believe that the species prefers more open habitats in the grassland-playa pool matrix where the beetle is frequently found, such as edges of pools, trails, roads, and ditches. However, this may be because denser cover hinders observation of the beetles elsewhere. Adults may also occur in the surrounding grasslands (USFWS 2015). This species is dependent on the presence of vernal pools, vernal lakes, and surrounding vegetation, as well as the land areas which surround and drain into these pools (45 FR 52807). Delta green ground beetles are most often found along the margins of vernal pools within 1.5 m (5 ft.) of the water, in areas where the sandy mud substrate slopes gently into the water, and where there is very low-growing vegetation providing 25 to 100 percent cover (NatureServe 2015). The habitat characteristics most strongly associated with the beetle's presence include Navarretia cover (a genus of vernal pool plants), Downingia cover (a genus of vernal pool plants), soil type, and cracks in the soil. Cracks in the soil are believed to be used as dry season refugia for larvae and diapausing pupae (USFWS 2009). The beetle appears to be primarily associated with Pescadero Clay (which forms the clay base to vernal pools and lakes), the Solano-Pescadero Complex, Solano Loam, and the Pescadero Clay Loam soil types (USFWS 2009). Upland habitat is also known to be frequented by the beetles, which have been found hundreds of meters from the nearest shoreline, but only during the wet season. The delta ground green beetle is also dependent on the presence of springtails (Collembola), the most important prey source for the species (USFWS 2009).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Low

Adult: Limited. May occur only within a very restricted season, time of day, or set of environmental conditions. No large migratory movements of the delta green ground beetle are known (USFWS 2009).

Immigration/Emigration

Larvae: No

Adult: Unlikely

Dispersal/Migration Narrative

Larvae: See Adult life stage.

Adult: Delta green ground beetles are nonmigratory, and capable of limited dispersal with moderate mobility. Although no research has determined the extent or success of delta green ground beetle dispersal, it is possible that adult delta green ground beetles may be good fliers. The delta green ground beetle has also been observed swimming on top of the water in Olcott Lake and moving through standing water in smaller pools that required short swimming bouts between emergent plants. Dispersal may occur only within a very restricted season, time of day, or set of environmental conditions. Three observations of flights have been observed, all of which imply short distances (15 m [50 ft.]) and low elevations (under 2 m [7 ft.]). No large migratory movements of the delta green ground beetle are known (USFWS 2009).

Additional Life History Information

Adult: Although no research has determined the extent or success of delta green ground beetle dispersal, it is possible that adult delta green ground beetles may be good fliers. The delta green ground beetle has also been observed swimming on top of the water in Olcott Lake and moving through standing water in smaller pools that required short swimming bouts between emergent plants (USFWS 2005).

Population Information and Trends

Population Trends:

Unknown (USFWS 2005; USFWS 2009)

Species Trends:

Unknown (USFWS 2009). Numbers of delta green ground beetles appear somewhat lower than in previous years, although such a trend has not been statistically validated (USFWS 2005).

Number of Populations:

There are six extant populations: Jepson Prairie Preserve, western Wilcox Ranch, eastern Wilcox Ranch, Ranch Site, Campbell Ranch, and an unnamed site in the vicinity of the Jepson Prairie (USFWS 2005; USFWS 2009).

Population Size:

Unknown (USFWS 2009). A range-wide survey conducted in 2007 counted 42 adult beetles, but statistical estimates of population size are not possible (USFWS 2009).

Resistance to Disease:

No disease or vector for disease has been observed or documented for the beetle (USFWS 2009).

Adaptability:

Low

Additional Population-level Information:

Statistical estimates of population sizes have not been possible, due to the limited number of individual beetles found at any one location. Population size remains unknown, due to the difficulty in surveying for this cryptic beetle, its little-known biology and ecology, and other abiotic and biotic factors (USFWS 2009).

Population Narrative:

There are six extant populations of delta green ground beetle, all of which occur in the vicinity of the Jepson Prairie Preserve (including the Campbell Ranch Conservation Bank, Wilcox Ranch, and Burke Ranch) (USFWS 2005; USFWS 2009). Statistical estimates of population sizes for the delta green ground beetle have not been possible, due to the limited number of individual beetles that have been found at any one location. The population size remains unknown, due to the difficulty in surveying for this cryptic beetle, its little-known biology and ecology, and other abiotic and biotic factors. Additionally, population monitoring surveys to date do not provide adequate information to reveal trends in the distributions of the beetle (USFWS 2009). Recently, numbers of delta green ground beetles appear somewhat lower than in previous years, although such a trend has not been statistically validated (USFWS 2005).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Agricultural conversion.
Response: Habitat destruction.
Consequence: Decrease in populations; and mortality and injury.
Narrative: When the delta green ground beetle was listed in 1980, the elimination of vernal pools by agricultural conversion and the plowing and leveling of land in and around the vernal pools caused damage to this species (USFWS 2009).

Stressor: Site-specific habitat threats
Exposure: Possible expansion of the runway at Travis Air Force Base (AFB), maintenance and monitoring activities associated with the high-powered transmission lines, proposed widening of Highway 12, and increased vehicle traffic at the Jepson Prairie Preserve (USFWS 2009).
Response: Habitat destruction.
Consequence: Decrease in populations; and mortality and injury.

Narrative: Currently, there are several site-specific threats that can be classified as relating to the present or threatened destruction, modification, or curtailment of the range of this species. Nearly 54 percent of available habitat is protected by preserves, conservation or mitigation banks, or conservation easements. Threats which may lead to the loss or degradation of habitat include the possible expansion of the Travis AFB runway, maintenance of electrical power lines crossing Olcott Lake, widening highway 12, and the increased traffic into the Jepson Prairie area, which may introduce undesirable invasive plant and animal species (USFWS 2009).

Stressor: Introduction of nonnative insect species
Exposure: Argentine ant (Iridomymes humilis) and the European earwig (Forficula auricularia).
Response: Competition for the beetle's prey base of Collembola.
Consequence: Predation and population reduction.
Narrative: No disease or vector for disease has been observed or documented for the beetle. Predation on the beetle in excessive numbers has not been observed or documented. The introduction of nonnative insect species such as the Argentine ant and the European earwig, a known predator of small insects, may present the possibility of competition for the beetle's prey base of Collembola (USFWS 2009).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Existing regulatory mechanisms.
Response: Other laws have limited ability to protect the species.
Consequence: Remains vulnerable to threats in its habitat.
Narrative: The Endangered Species Act (ESA) is the primary federal law that provides protection for this species since its listing as endangered in 1980. Other federal and state regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under ESA. Therefore, other laws and regulations have limited ability to protect the species in the absence of ESA (USFWS 2009).

Stressor: Nonnative plants
Exposure: Nonnative plants.
Response: Interferes with feeding behavior of the beetle and suppresses the availability of its invertebrate prey, the springtail.
Consequence: Habitat loss and population reduction.
Narrative: Since listing, the proliferation and dominance of nonnative plants in the Jepson Prairies Preserve has been identified as a serious threat to the beetle. Grasses and forbs that produce a heavy build-up of thatch when they die cover preferred habitat of the beetle. This altered habitat interferes with the feeding behavior of the beetle and suppresses the availability of its invertebrate prey, the springtail. The regional management plan for the Greater Jepson Ecological Ecosystem contains the revised management policies for controlling invasive plants in the ecosystem, which are expected to benefit the beetle and its habitat (USFWS 2009).

Stressor: Wastewater sludge applications
Exposure: Application of sludge from wastewater treatment plants.

Response: Growth of higher, thicker vegetation; and water quality degradation.
Consequence: Habitat loss and decreased support of existing populations.
Narrative: Application of sludge from wastewater treatment plants as a soil amendment or fertilizer in grasslands in Solano County was approved by Solano County, and if applied to areas adjacent to vernal pools (for example, around Jepson Prairie Preserve) could promote the growth of vegetation. Higher and thicker vegetation in the critical habitat of the delta green ground beetle will adversely affect its feeding regime, even with the designation of setbacks from vernal pools where the sludge is not applied. Water quality of the pools may also be affected by runoff, particularly the unintentional accumulation of additional nutrients into runoff that drains into the vernal pools (USFWS 2009).

Stressor: Climate change
Exposure: Climate change may cause a warming trend in the mountains of western North America.
Response: A warming trend could decrease snowpack, hasten spring runoff, and reduce summer stream flows.
Consequence: Habitat loss and impacts to populations.
Narrative: Impacts to the delta green ground beetle under predicted future climate change are unclear. A trend of warming in the mountains of western North America is expected to decrease snowpack, hasten spring runoff, and reduce summer stream flows. Increased summer heat may increase the frequency and intensity of wildfires. Although the specific effects of climate change on the delta green ground beetle are unknown, the effects of increased winter flooding and drought conditions in the spring and summer have the potential to adversely affect this species (USFWS 2009).

Recovery

Reclassification Criteria:
The delta green ground beetle is listed as a threatened species. No reclassification or uplisting criteria have been established for the species.

Delisting Criteria:
Accomplish habitat protection that promotes vernal pool ecosystem function sufficient to contribute to population viability of the species, including: a. Suitable vernal pool habitat in each prioritized core area for the species is protected. The delisting criterion for the species requires that 95 percent of the range-wide suitable habitat in core areas zone 1 be protected. b. Species occurrences distributed across the species' geographic and genetic range are protected. Protection of extreme edges of populations protects the genetic differences that occur there. The criterion specifies that 100 percent of the delta green ground beetle occurrences be protected. c. Reintroduction and introductions must be carried out and meet success criteria. Additional populations must be discovered or established through reintroduction to or colonization of restored habitat to delist. d. Protection of additional occurrences identified through future site assessments, GIS and other analyses, and status surveys that are determined essential to recovery. Any newly found occurrences may count toward recovery goals if the

occurrences are permanently protected as described in the Recovery Plan. e. Habitat protection results in protection of hydrology essential to vernal pool ecosystem function, and monitoring indicates that hydrology that contributes to population viability has been maintained through at least one multi-year period that includes above-average, average, and below-average local rainfall as defined above, a multi-year drought, and a minimum of 5 years of post-drought monitoring (USFWS 2005).

Adaptive Habitat Management and Monitoring, including: a. Habitat management and monitoring plans that facilitate maintenance of vernal pool ecosystem function and population viability have been developed and implemented for all habitat protected, as previously discussed above. b. Mechanisms are in place to provide for management in perpetuity, and long-term monitoring of items presented above, as previously discussed (funding, personnel, etc.). c. Monitoring indicates that ecosystem function has been maintained in the areas protected under items presented above for at least one multi-year period that includes above-average, average, and below-average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring (USFWS 2005).

Status surveys, including a. Status surveys, 5-year status reviews, and population monitoring show populations in each vernal pool region where the species occur are viable (e.g., evidence of reproduction and recruitment) and have been maintained (stable or increasing) for at least one multi-year period that includes above-average, average, and below-average local rainfall, a multi-year drought, and a minimum of 5 years of post-drought monitoring. b. Status surveys, status reviews, and habitat monitoring show that threats identified during and since the listing process have been ameliorated or eliminated. Site-specific threats identified through standardized site assessments and habitat management planning also must be ameliorated or eliminated (USFWS 2005).

Research, including: a. Research actions necessary for recovery and conservation of the covered species have been identified (these are research actions that have not been specifically identified in the recovery actions, but for which a process to develop them has been identified). Research actions (both specifically identified in the recovery actions and determined through the process) on species biology and ecology, habitat management and restoration, and methods to eliminate or ameliorate threats have been completed and incorporated into habitat protection, habitat management and monitoring, and species monitoring plans, and refinement of recovery criteria and actions. b. Research on genetic structure has been completed (for species where necessary—for reintroduction and introduction, and seed banking), and results incorporated into habitat protection plans to ensure that in and among population, genetic variation is fully representative by populations protected. c. Research necessary to determine appropriate parameters to measure population viability for each species has been completed (USFWS 2005).

Participation and outreach, including: a. Recovery Implementation Team is established and functioning to oversee range-wide recovery efforts. b. Vernal pool regional working groups are established and functioning to oversee regional recovery efforts. c. Participation plans for each vernal pool region have been completed and implemented. d. Vernal pool regional working groups have developed and implemented outreach and incentive programs that develop partnerships contributing to achieving recovery criteria (USFWS 2005).

All known beetle occurrences and 95 percent of suitable beetle habitat in the Jepson Prairie core area are protected in perpetuity (USFWS, 2021)

Management and monitoring plans that facilitate maintenance of vernal pool ecosystem function and promote population viability. (USFWS, 2021)

Conduct status surveys and monitoring to show where populations are viable. (USFWS, 2021)

Research the biology and ecology of the delta green ground beetle. (USFWS, 2021)

Establish a recovery implementation team to oversee the implementation of recovery actions.(USFWS, 2021)

Recovery Actions:

- Protect vernal pool habitat in the largest blocks possible from loss, fragmentation, degradation, and incompatible uses (USFWS 2005).
- Manage, restore, and monitor vernal pool habitat to promote the recovery of listed species and the long-term conservation of the species (USFWS 2005).
- Conduct range-wide status surveys and status reviews for all species addressed in this recovery plan to determine species status and progress toward achieving recovery of listed species and long-term conservation of species (USFWS 2005).
- Conduct research and use results to refine recovery actions and criteria, and guide overall recovery and long-term conservation efforts (USFWS 2005).
- Develop and implement participation programs (USFWS 2005).
- Continue to protect and manage suitable vernal pool and upland habitat for the delta green ground beetle (USFWS 2009).
- Continue to acquire property with suitable habitat for the delta green ground beetle (USFWS 2009).
- Start captive breeding research with programs that may lead to reintroductions of the delta green ground beetle into unoccupied suitable habitat (USFWS 2009).
- Conduct research on life history traits of the delta green ground beetle (USFWS 2009).
-

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Here we propose several habitat conservation and ecological research recommendations which will aid in the recovery and conservation of the delta green ground beetle. Some of these recommendations have already been discussed in the previous 5-year review (Service 2009) and remain valid. 1. Continue to protect and manage suitable vernal pool and upland habitat for the delta green ground beetle. Management practices should be implemented at all locations where suitable beetle habitat exists in order to reduce the proliferation of invasive and non-native plants. The density and height of these invasive plants significantly disrupt the beetle’s feeding regime. Appropriate management practices are outlined in the Greater Jepson Prairie Ecosystem Regional Management Plan (Witham 2006), and include grazing, and prescribed burns during the dry summer months when the beetles are not on the ground surface. 2. Research and adaptively manage the grazing regime within each parcel to benefit delta green ground beetle. The timing and intensity of grazing required to benefit the beetle can differ on adjacent properties depending on conditions; therefore, the appropriate grazing regimes should be studied for each grazing parcel and then actively adapted as needed. Specifically, the timing and amount of rain can result in increased vegetative growth that requires additional grazing pressure for a short period of time, but could become detrimental if that pressure is applied for too long. Actively managing the grazing regime based on real-time information would greatly benefit the species. 3. Establish a delta green ground beetle recovery implementation team. The team would serve to coordinate and facilitate survey efforts and prioritize other recovery actions and implementation. By conducting organized discussions with relevant parties, coordination in conservation efforts will be increased. 4. Provide alternative water sources for livestock. Because playa and vernal pools are attractive to livestock as a source of water, additional water sources should be provided to livestock within actively grazed pastures. Increased livestock pressure within these pools can result in pot holing along the shoreline and increased nutrient input from waste, and providing additional sources of water will discourage livestock from using the playa and vernal pools as drinking water. 5. Continue to acquire property with suitable habitat for the delta green ground beetle. Acquisitions of vernal pool habitat through mechanisms such as conservation banks and cooperative agreements will ultimately benefit the beetle. These properties should also have adequate management plans. 6. Start captive breeding research with programs that may lead to reintroductions of the delta green ground beetle into unoccupied suitable habitat. Successful development of captive breeding protocols and their implementation will ensure that sufficient numbers of individuals will be available to colonize new suitable habitat. Continuing surveys for undiscovered occurrences and suitable habitat will locate those areas best suited for reintroductions. Monitoring existing occurrences will help determine trends in distributions, and possibly population sizes, and should provide guidance for efforts on reintroductions. 7. Conduct research on life history traits of the delta green ground beetle. Research on the life history and developmental stages of the beetle as outlined in the Recovery Plan is necessary for success in captive breeding and reintroductions, and for effectively managing existing occurrences. Research priorities include: • Sources and rates of mortality for adults, pupae, larvae, and eggs; • Productivity; • Dispersal; • Preferred habitat conditions for larvae and adults; • Preferred sites for oviposition; • Activity cycles, both daily and annual; and • Timing of life-cycle stages. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Euchloe ausonides insulanus* (Island marble butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Island marble butterflies have a wingspan of approximately 1.75 inches (in) (4.5 centimeters (cm)) (Pyle 2002, p. 142) and are differentiated from other subspecies of the large marble butterfly by their larger size and the expanded marbling pattern of yellow and green on the underside of the hindwings and forewings (Guppy and Shepard 2001, p. 159). Immature stages of the island marble butterfly have distinctly different coloration and markings from Euchloe ausonides; specifically, the third and fourth larval instars (instars are the larval stages between molting events) have a white spiracular stripe (a stripe that runs along the side of a caterpillar) subtended (bordered below) by a yellow-green subspiracular stripe and a green-yellow ventral area, which is different from the stripe colors and patterns described for E. ausonides (James and Nunnallee 2011, pp. 102– 103; Lambert 2011, p. 15). The island marble butterfly is also behaviorally distinct; large marble butterflies pupate (enter the final stage of larval development before transforming into a butterfly) directly on their larval host plants, whereas the island marble butterflies leave their host plants to find a suitable pupation site up to 13 feet (ft) (4 meters (m)) away from their larval host plants (Lambert 2011, p. 19) (USFWS, 2020).

Taxonomy

The island marble butterfly (Euchloe ausonides insulanus) is a subspecies of the large marble butterfly (E. ausonides) in the Pieridae family, subfamily Pierinae, which primarily consists of yellow and white butterflies. The island marble butterfly was formally described in 2001, by Guppy and Shepard (p. 160) based on 14 specimens collected between 1859 and 1908 on or near Vancouver Island, British Columbia, Canada, and is geographically isolated from all other E. ausonides subspecies (USFWS, 2020).

Historical Range

The island marble butterfly was historically known from just two areas along the southeastern coast of Vancouver Island, British Columbia, Canada, based on 14 museum records: The Greater Victoria area at the southern end of Vancouver Island; and near Nanaimo and on adjacent Gabriola Island, approximately 56 miles (mi) (90 kilometers (km)) north of Victoria (USFWS, 2020).

Current Range

After 90 years without a documented occurrence, the island marble butterfly was rediscovered in 1998 on San Juan Island, San Juan County, Washington, at least 9 mi (15 km) east of Victoria across the Haro Strait. Subsequent surveys in suitable habitat across southeastern Vancouver Island and the Gulf Islands in Canada (see COSEWIC 2010, p. 5), as well as the San Juan Islands and six adjacent counties in the United States (Whatcom, Skagit, Snohomish, Jefferson, Clallam, and Island Counties), revealed only two other occupied areas. One of these occupied areas was centered on San Juan Island and the other on Lopez Island, which is separated from San Juan Island by just over 0.5 mi (1 km) at its closest point. These occupied areas were eventually determined to comprise five populations, as described in detail in our 2006 12-month finding (71 FR 66292; November 14, 2006). Since 2006, the number and distribution of populations has declined. Four of the five populations that once spanned San Juan and Lopez Islands have not been detected in recent years, and the species is now observed only in a single area centered on American Camp, a part of San Juan Island National Historical Park that is managed by the National Park Service (NPS). The island marble butterfly has also been sighted using the lands adjoining or near American Camp; there were observations of island marble butterflies flying beyond the boundaries of these adjoining lands in 2015 and 2017 (Potter 2015a, in litt.; Lambert 2018, in litt.). No current records exist of any life history stage of the island marble butterfly except at or near American Camp at San Juan Island National Historical Park. Therefore, we consider only American Camp and the immediately adjacent areas to be occupied at the time of this final listing (USFWS, 2020).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 6/4/2020.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the island marble butterfly (Euchloe ausonides insulanus) and designate critical habitat. In total, approximately 812 acres (329 hectares) on the south end of San Juan Island, San Juan County, Washington, fall within the boundaries of the critical habitat designation (USFWS, 2020).

Critical Habitat Designation

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the island marble butterfly (Euchloe ausonides insulanus) and designate critical habitat. In total, approximately 812 acres (329 hectares) on the south end of San Juan Island, San Juan County, Washington, fall within the boundaries of the critical habitat designation (USFWS, 2020).

Primary Constituent Elements/Physical or Biological Features

Island Marble Butterfly (Euchloe ausonides insulanus) (1) The critical habitat unit is depicted for San Juan County, Washington, on the map below. (2) Within the critical habitat area on San Juan Island, Washington, the physical or biological features essential to the conservation of the island marble butterfly consist of the following components: (i) Open, primarily treeless areas with short-statured forb- and grass-dominated vegetation that include diverse topographic features such as ridgelines, hills, and bluffs for patrolling, dispersal corridors between habitat patches, and some south-facing terrain. Areas must be large enough to allow for the development of patchy-population dynamics, allowing for multiple small populations to establish within the area. (ii) Low- to medium-density larval host plants, with both flower buds and blooms on them between the months of May through July, for egg-laying and larval development. Larval host plants may be any of the following: Brassica rapa, Sisymbrium altissimum, or Lepidium virginicum. (iii) Adult nectar resources in flower and short-statured, white-flowering plants in bloom used for mate-finding, which may include, but are not limited to, Abronia latifolia (yellow sand verbena), Achillea millefolium (yarrow), Amsinckia menziesii (small-flowered fiddleneck), Cakile edentula (American sea rocket), Cerastium arvense (field chickweed), Erodium cicutarium (common stork's bill), Geranium molle (dovefoot geranium), Hypochaeris radicata (hairy cat's ear), Lomatium utriculatum (common lomatium), Lupinus littoralis (seashore lupine), Myosotis discolor (common forget-menot), Ranunculus californicus (California buttercup), Rubus ursinus (trailing blackberry), Taraxacum officinale (dandelion), Toxicoscordion venenosum (death camas, formerly known as Zigadenus venenosus), and Triteleia grandiflora (Howell's brodiaea, formerly Brodiaea howellii). (iv) Areas of undisturbed vegetation surrounding larval host plants sufficient to provide secure sites for diapause and pupation. The vegetation surrounding larval host plants must be left standing for a sufficient period of time for the island marble butterfly to complete its life cycle. (3) Critical habitat includes road shoulders and road margins, but does not include other manmade structures (such as buildings, aqueducts, runways, paved portions of roads, and other paved areas) and the land on which they are located existing within the legal boundaries on June 4, 2020. (4) Critical habitat map unit. Data layers defining the map were created using 2015 National Agriculture Imagery Program (NAIP) digital imagery in ArcGIS, version 10.4 (Environmental Systems Research Institute, Inc.), a computer geographic information system program. The map in this entry, as modified by any accompanying regulatory text, establishes the boundaries of the critical habitat designation. The coordinates or plot points or both on which the map is based are available to the public at the Service's internet site at https:// www.fws.gov/wafwo/, at http:// www.regulations.gov at Docket No. FWS–R1–ES–2016–0145, and at the field office responsible for this designation. You may obtain field office location information by contacting one of the Service regional offices, the addresses of which are listed at 50 CFR 2.2. (5) Island marble butterfly critical habitat, San Juan County, Washington. (i) Island marble butterfly critical habitat consists of 812 acres (ac) (329 hectares (ha)) on San Juan Island in San Juan County, Washington, and is composed of lands in Federal (742 ac (301 ha)), State (37 ac (15 ha)), State/ County joint (1 ac (0.4 ha)), County (30 ac (12 ha)), and private (2 ac (0.8 ha)) ownership. The critical habitat designated on private parcels along Eagle Cove only includes the area of steep coastal bluff between the marine shoreline and the upland edge at the top of the bluff; it does not include areas landward of the top of the bluff, which are typically mowed and maintained as yard. (USFWS, 2020).

Life History

Feeding Narrative

Adult: Adults primarily nectar (forage) on their larval host plants (Potter 2015e, pers. comm.), but use a variety of other nectar plants including: • Abronia latifolia (yellow sand verbena), • Achillea millefolium (yarrow), • Amsinckia menziesii (smallflowered fiddleneck), • Cakile edentula (American sea rocket), • Cerastium arvense (field chickweed), • Erodium cicutarium (common stork's bill), • Geranium molle (dovefoot geranium), • Hypochaeris radicata (hairy cat's ear), • Lomatium utriculatum (common lomatium), • Lupinus littoralis (seashore lupine), • Myosotis discolor (common forgetme-not), • Ranunculus californicus (California buttercup), • Rubus ursinus (trailing blackberry), • Taraxacum officinale (dandelion), • Toxicoscordion venenosum (death camas, formerly known as Zigadenus venenosus), and • Triteleia grandiflora (Howell's brodiaea, formerly Brodiaea howellii) (Miskelly 2004, p. 33; Pyle 2004, pp. 23–26, 33; Miskelly and Potter 2005, p. 6; Lambert 2011, p. 120; Vernon and Weaver 2012, Appendix 12; Lambert 2015a, p. 2, Lambert 2015b, in litt.). Of these additional nectar resources, island marble butterflies are most frequently observed feeding on yellow sand verbena, small-flowered fiddleneck, and field chickweed (Potter 2015e, pers. comm.). Adults primarily use lowstatured, white flowering plants such as field chickweed as mating sites (Lambert 2014b, p. 17) (FR Vol. 83, No. 71).

Reproduction Narrative

Adult: The island marble butterfly life cycle comprises four distinct developmental phases: Egg, larva, chrysalis, and butterfly. Development from egg to chrysalis takes approximately 38 days and includes five instars (phases of larval development between molts) (Lambert 2011, p. 7). Female island marble butterflies produce a single brood per year, and prefer to lay their eggs individually on the unopened terminal flower buds of their larval host plants (Lambert 2011, pp. 9, 48, 51). Gravid female butterflies appear to select plants with many tightly grouped flower buds over host plants with fewer buds, and they tend to avoid laying eggs on inflorescences (flower heads) where other island marble butterflies already have deposited eggs (Lambert 2011, p. 51). However, the number of eggs laid on a single host plant has been observed to vary with the density and distribution of host plants and may also be affected by host plant robustness as well as the age of the individual female butterfly (Parker and Courtney 1984, entire; Lambert 2011, pp. 9, 53, 54) (FR Vol. 83, No. 71).

Spatial Arrangements of the Population

Adult: Colonies (NatureServe, 2015)

Environmental Specificity

Adult: Moderate. Generalist or community with some key requirements. (NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Adult: The island marble butterfly has three known host plants, all in the mustard family (Brassicaceae). One is native, Lepidium virginicum var. menziesii (Menzies' pepperweed), and two are nonnative: Brassica rapa (no agreedupon common name, but sometimes called field mustard; hereafter referred to as field mustard (FR Vol. 83, No. 71).

Habitat Narrative

Adult: The island marble butterfly has three known host plants, all in the mustard family (Brassicaceae). One is native, Lepidium virginicum var. menziesii (Menzies' pepperweed), and two are nonnative: Brassica rapa (no agreedupon common name, but sometimes called field mustard; hereafter referred to as field mustard for the purposes of this document) (ITIS 2015b, entire), and Sisymbrium altissimum L. (tumble mustard) (Miskelly 2004, pp. 33, 38; Lambert 2011, p. 2). All three larval host plants occur in open grass- and forb-dominated vegetation systems, but each species is most robust in one of three specific habitat types: Menzies' pepperweed at the edge of low-lying coastal lagoon habitat; field mustard in upland prairie habitat, disturbed fields, and disturbed soils, including soil piles from construction; and tumble mustard in sand dune habitat (Miskelly 2004, p. 33; Lambert 2011, pp. 24, 121–123). While each larval host plant can occur in the other habitat types, female island marble butterflies select specific host plants in each of the three habitat types referenced above, likely because certain host plants are more robust in each habitat type during the flight season (Miskelly 2004, p. 33; Lambert 2011, pp. 24, 41, 50, 54–57, 121–123). Adults primarily nectar (forage) on their larval host plants (Potter 2015e, pers. comm.), but use a variety of other nectar plants including: • Abronia latifolia (yellow sand verbena), • Achillea millefolium (yarrow), • Amsinckia menziesii (smallflowered fiddleneck), • Cakile edentula (American sea rocket), • Cerastium arvense (field chickweed), • Erodium cicutarium (common stork's bill), • Geranium molle (dovefoot geranium), • Hypochaeris radicata (hairy cat's ear), • Lomatium utriculatum (common lomatium), • Lupinus littoralis (seashore lupine), • Myosotis discolor (common forgetme-not), • Ranunculus californicus (California buttercup), • Rubus ursinus (trailing blackberry), • Taraxacum officinale (dandelion), • Toxicoscordion venenosum (death camas, formerly known as Zigadenus venenosus), and • Triteleia grandiflora (Howell's brodiaea, formerly Brodiaea howellii) (Miskelly 2004, p. 33; Pyle 2004, pp. 23–26, 33; Miskelly and Potter 2005, p. 6; Lambert 2011, p. 120; Vernon and Weaver 2012, Appendix 12; Lambert 2015a, p. 2, Lambert 2015b, in litt.). Of these additional nectar resources, island marble butterflies are most frequently observed feeding on yellow sand verbena, small-flowered fiddleneck, and field chickweed (Potter 2015e, pers. comm.). Adults primarily use lowstatured, white flowering plants such as field chickweed as mating sites (Lambert 2014b, p. 17) (FR Vol. 83, No. 71).

Dispersal/Migration

Dispersal

Adult: Low to intermediate dispersal capacity (USFWS, 2020).

Dispersal/Migration Narrative

Adult: The flight season for this butterfly is remarkably long, from sometime in April into June in many or even all years, while individuals rarely live more than two weeks (average about nine days). (NatureServe, 2015). Island marble butterflies exhibit strong site fidelity and low dispersal capacity and, when considered on the whole, exist as a group of spatially separated populations that interact when individual members move from one occupied location to another (Miskelly and Potter 2009, p. 14; Lambert 2011, p. 147). For the island marble butterfly, a population is defined as a group of occupied sites close enough for routine genetic exchange between individuals. Thus, occupied areas separated by distances greater than 3 mi (4.8 km) with no intervening suitable habitat and a low likelihood of genetic exchange are considered to be separate populations (Miskelly and Potter 2009, p. 12). Five potential populations of island marble butterflies were identified and described in detail in the 2006 12-month finding (71 FR 66292, November 14, 2006, p. 66294): American Camp and vicinity, San Juan Valley, Northwest

San Juan Island, Central Lopez Island, and West Central Lopez Island. As described previously, only the population at American Camp has been detected since 2012 (FR Vol. 83, No. 71). Island marble butterflies generally exhibit weak site fidelity and low to intermediate dispersal capacity. When considered rangewide, the island marble butterfly exists as a group of spatially separated populations that interact when individual members move from one occupied location to another (Miskelly and Potter 2009, p. 14; Lambert 2011, p. 147). For the island marble butterfly, a population is defined as a group of occupied sites close enough for routine genetic exchange between individuals. Thus, occupied areas separated by distances greater than 3 mi (4.8 km) with no intervening suitable habitat and a low likelihood of genetic exchange are considered to be separate populations (Miskelly and Potter 2009, p. 12). Five potential populations of island marble butterflies were identified and described in detail in the 2006 12-month finding (71 FR 66292, November 14, 2006, p. 66294): American Camp and vicinity, San Juan Valley, Northwest San Juan Island, Central Lopez Island, and West Central Lopez Island. As described previously, only the population at American Camp has been detected since 2012 (USFWS, 2020).

Population Information and Trends

Population Trends:

Long-term trends suggest declines of 50-90%, whereas short-term trends indicate declines of 10-30% (NatureServe, 2015)

Number of Populations:

1 (USFWS, 2020)

Population Size:

1,000-2,000 (NatureServe, 2015)

Population Narrative:

Long-term population trends suggest declines of 50-90%, whereas short-term trends indicate declines of 10-30%. There are at least two occurrences, probably slightly more. There is one precarious population on Lopez Island off Washington but colonies on San Juan Island might or might not be all referable to a single occurrence. Black and Foltz (2009) regard only one occurrence as viable, but even this one is probably of marginal quality if one allows for fluctuation, with at most a few hundred adults in years for which there are data, also disturbances and apparently very low inter-site dispersal (Peterson, 2010) etc. However, it is possible some of the others support larger populations than surveys have detected. Black and Foltz (2009, attachment 5) state that the total population size is less than 2000 adults which seems to be clearly correct. Nevertheless, from review of the 2010 report and some others, it appears very unlikely that the known sites produced more than 1000 adults in any of the years with recent observations. (NatureServe, 2015) Since the species was discovered in the San Juan Islands in 1998, the species’ range has contracted from five populations on two islands (San Juan and Lopez) to a single population, at American Camp on San Juan Island, today. The causes of these extirpations are not well understood, but likely include habitat loss outside American Camp from a combination of sources. Within the single remaining population at American Camp, the number of sites where island marble butterflies are detected during surveys declined from 25 in 2007, to 4 in 2015. Encounter rates for adult butterflies calculated from survey data have declined each year, from almost 2 per 100 meters in 2004, to about 0.3 per 100 meters in 2015. The slight increase in this rate in 2016, to 0.6 per 100 meters, does not reverse the overall trend of decline. Captive rearing and release of the island marble butterfly shows promise for bolstering the remaining population of the species. However, the potential for this species to recolonize areas within its historical range is uncertain due to ongoing, pervasive habitat degradation that results from herbivory by deer and other animals on larval host plants, from plant succession and invasion by nonnative plants that render habitat unsuitable for larval host plants, and potentially from cultivation and other land uses. The widespread occurrence of native (spiders) and nonnative (wasps) predators of eggs and larvae is also an ongoing threat that may hamper or prevent potential recolonizations. Furthermore, the source for any recolonizations consists of a single, small population already vulnerable to these threats and to stochastic sources of mortality, such as severe storms and other climate anomalies (USFWS, 2020).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: Habitat loss for the island marble butterfly is extensive and ongoing, and has resulted in the extirpation of the island marble butterfly from much of its former range due, in large part, to: (1) Development; (2) road maintenance activities; (3) agricultural practices; and (4) herbivory by black-tailed deer and livestock (USFWS, 2016).

Stressor: Predation (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: Direct predation by spiders (on larvae and adults) and wasps (on larvae) accounts for a significant proportion of mortality for the island marble butterfly where grazers are excluded. Where grazers cannot be excluded, incidental predation by browsing black-tailed deer accounts for a high proportion of mortality for eggs and larvae of the island marble butterfly, as deer preferentially eat the flowering heads of the larval host plants where the island marble butterflies lay their eggs (USFWS, 2016).

Stressor: Small populations (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The last known population of the island marble butterfly is centered on American Camp, a unit of the San Juan Island National Historical Park that is managed by the National Park

Service. Given that the very small population at American Camp is likely the only remaining population of the subspecies, we conclude that small population size makes it particularly vulnerable to a number of likely stochastic events that remove individuals from the population or decrease its reproductive success. We further find that the increased frequency and strength of storm surges associated with climate change is a threat to the island marble butterfly (USFWS, 2016).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
Downlisting Criterion 1 At least four core OCs have been established or identified within the range of the island marble butterfly. These must include a minimum of two core OCs on San Juan Island, a minimum of one core OC on Lopez Island, and one additional core OC that may be on either of those islands or elsewhere within the species’ range (USFWS, 2023).

Downlisting Criterion 2 Within the four core OCs in Downlisting Criterion 1, population resiliency is demonstrated by the amount of suitable habitat occupied by the island marble butterfly remaining stable or increasing in at least 9 years over a monitoring period of 9 to 12 years (USFWS, 2023).

Downlisting Criterion 3 Sufficient suitable habitat is conserved and managed with long-term management commitments to achieve Downlisting Criteria 1 and 2. This includes conservation of large, open treeless areas with diverse topographic features, suitable habitat representing the diversity of habitat types used by this species (coastal lagoons/shoreline, grassland/prairie and sand dune), and stepping-stone habitat connecting them (USFWS, 2023).

Delisting Criteria:
Delisting Criterion 1 At least six core OCs have been established or identified within the range of the island marble butterfly, with a minimum of three core OCs on San Juan Island, a minimum of two core OCs on Lopez Island, and one additional core OC that may be on either of those islands or elsewhere within the species' range (USFWS, 2023).

Delisting Criterion 2 Within the six core OCs in Delisting Criterion 1, continuing population resiliency after meeting downlisting criteria is indicated by the total amount of suitable habitat occupied by the island marble butterfly remaining stable or increasing in at least 9 years over a monitoring period of 9 to 12 years without population augmentation (USFWS, 2023).

Delisting Criterion 3 Sufficient suitable habitat is conserved and managed with long-term management commitments to achieve Delisting Criteria 1 and 2. This includes conservation of large, open treeless areas with diverse topographic features, suitable habitat representing the diversity of habitats used by this species (coastal lagoons/shoreline, grassland/prairie and sand dune), and stepping-stone habitat connecting them (USFWS, 2023).

Recovery Actions:
- 1. Protect the island marble butterfly and its habitat at American Camp by reducing herbivory on host plants and incidental predation on butterflies, enhancing suitable habitat, and controlling invasive plants (USFWS, 2023).
- 2. Establish and expand suitable habitat for the island marble butterfly across its range representing the diversity of habitat types used by this species (coastal lagoons/shoreline, grassland/prairie and sand dune) (USFWS, 2023).
- 3. On sites with long-term conservation commitments, conserve and manage suitable habitat for the island marble butterfly by maintaining disturbance regimes and reducing herbivory on host plants and incidental predation on butterflies (USFWS, 2023).
- 4. In areas of suitable habitat within the species range, identify or establish (through captive rearing, augmentation, reintroduction, and/or dispersal) three to five additional core OCs to increase the species' resiliency, representation, and redundancy (USFWS, 2023).
- 5. Actively and adaptively manage dispersal corridors and stepping-stone habitat to improve connectivity among core OCs (USFWS, 2023).
- 6. Conduct research on life history, management techniques, and the effects of climate change on the species and habitat to guide conservation efforts for the island marble butterfly (USFWS, 2023).
- 7. Monitor the species range-wide, track trends over time, and assess threats (USFWS, 2023).
- 8. Coordinate and collaborate with partners to conserve the island marble butterfly throughout its range (USFWS, 2023).

Conservation Measures and Best Management Practices:

- The key components to recovering the island marble butterfly include the following: • Stabilizing the last known population; • Protecting, enhancing, and expanding key habitat sources where the last known population persists; • Protecting host plant patches and pupation sites from human-caused disturbance; • Reducing the primary threats to island marble butterflies and their habitats by reducing host plant herbivory from deer, European rabbits, and brown garden snails in and near the occupied area; • Encouraging the use of all three known host plant species to reduce the risk of a host plant-specific catastrophic event; • Developing and evaluating habitat establishment and maintenance methods; • Increasing and protecting habitat patches across the former known range; • Developing a short-term island marble butterfly translocation strategy to allow salvage of potentially “lost” eggs and larvae in years when they are unlikely to survive due to a lack of suitable host plants around the American Camp Unit of San Juan National Historical Park; • Developing a strategy for learning from translocation efforts as time and funding allow; • Maintaining and expanding the captive propagation program, including the development of an additional captive propagation facility, as habitat is expanded and secured; • Increasing the number and distribution of populations across the known historical range; • Coordinating and collaborating with Federal, state, county, and municipal organizations, and private land managers and landowners; • Continuing to develop local support for and involvement in the conservation of this species; and • Proactively and collaboratively addressing important administrative processes (e.g., National Environmental Policy Act [NEPA], Section 106 of the National Historic Preservation Act, public engagement, etc.) associated with land management activities (USFWS, 2020a)

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SPECIES ACCOUNT: *Euphilotes enoptes smithi* (Smith's blue butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 1, 1976 (41 FR 22041).

Physical Description

The Smith's blue butterfly (Euphilotes enoptes smithi) is about 2.5 centimeters (1 inch) across the wings. Males are blue on dorsal side of the wings and females are brown and with a red-orange band across the hind wings. Underneath, the wings are white to gray, with black dots on both sexes. On the hind-wings there is a red-orange band along the outer edge of the wing (Black and Vaughan 2005).

Taxonomy

The Smith's blue butterfly was originally described as Philotes enoptes smithi in 1954. In 1975, several genera of butterflies were realigned; Smith's blue butterfly was moved into the genus Shijimiaeoides and in 1976 was listed under the Endangered Species Act as Shijimiaeoides enoptes smithi. In 1977, several genera of butterflies were realigned again; Smith's blue butterfly was placed into the genus Euphilotes, resulting in its current scientific name, Euphilotes enoptes smithi. Smith's blue butterfly is considered to be a single subspecies. In 1998, scientists proposed a new subspecies and taxonomic split for the Smith's butterfly based on host plant preference, difference in flight periods, and minor difference in wing coloration. However, the U.S. Fish and Wildlife Service (USFWS) does not currently recognize this split, because not enough analyses are available (USFWS 2006; Black and Vaughan 2005). Intergrades between the Smith's blue butterfly and Tilden's blue butterflies (E. e. tildeni) have been observed in inland Santa Cruz County and possibly in the Carmel Valley of Monterey County (USFWS 2006).

Historical Range

Historically, Smith's blue butterflies were found within an approximately 129-kilometer (80-mile) strip along the California coast, including dune habitats along Monterey Bay, from the Salinas River south to the City of Monterey and along the coast of Monterey and northern San Luis Obispo Counties, from the Carmel River area south to San Carpoforo Creek. At the time of listing, Smith's blue butterflies were known primarily from coastal dune habitats along Monterey Bay, plus a few localities on the Big Sur coast. Subsequent to listing, surveys have located Smith's blue butterflies over a wider range (USFWS 2006; Black and Vaughan 2005).

Current Range

Currently, the Smith’s blue occurs in scattered colonies along approximately 93 mi (150 km) of California’s Central Coast from Monterey County to San Luis Obispo County. The range of the Smith’s blue is larger than was known at the time of listing, primarily due to the discovery of additional occupied habitat along the coast of Monterey County south of the Monterey Peninsula and extending into northern San Luis Obispo County. The current distribution includes two separate metapopulations separated by development around the City of Monterey (Figure 2). The majority of observation data comes from locations directly adjacent to roads from the

California Natural Diversity Database (CDFW 2019). These points are the "collections localities" depicted in Figure 2. These points do not necessarily reflect all known localities for Smith's blue butterflies. For example, the Salinas River National Wildlife Refuge is one of the best surveyed areas for the species and no points on the Refuge are currently included in the California Natural Diversity Database.(USFWS, 2020)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Smith's blue butterfly larva are herbivores, and the caterpillars only feed on the host buckwheat plant on which they are born (either coast buckwheat [Eriogonum latifolium] or seacliff buckwheat [E. parvifolium]) (USFWS 2006).

Adult: Adult Smith's blue butterflies are nectarivores and specialist feeders. Like the larva, the adults feed on the host buckwheat plant (coast buckwheat [Eriogonum latifolium] or seacliff buckwheat [E. parvifolium]). Unlike the larva, adults can also feed on naked buckwheat (E. nudum) (USFWS 2006).

Reproduction Narrative

Larvae: Larvae hatch 4 to 8 days after females lay the eggs. Larvae mature in approximately 1 month. Smith's blue butterflies overwinter as pupae for approximately 10 months and emerge as adults the following flight season. The larvae's entire life stage takes place on one of two host buckwheat plants, on which they feed, and where they grow and pupate. The larvae host plants are coast buckwheat (Eriogonum latifolium) and seacliff buckwheat (E. parvifolium) (USFWS 2006; Black and Vaughan 2005). Parasitism (from the Tachinidae family) of larvae has been observed as a substantial source of mortality in Smith's blue butterflies (USFWS 2006). However, ants protect the larvae from parasites, spiders, and wasps, and in return feed on a sugary substance that the caterpillar produces (Black and Vaughan 2005).

Adult: The flight season, or breeding season, for Smith's blue butterflies occurs from mid-June to early September, which is synchronized with the peak flowering period of buckwheats (Eriogonum sp.). The emergence of individual Smith's blue butterflies is staggered over the long summer flight period. Females lay an average of 32 eggs, but it has ranged from 5 to 67. Smith's blue butterflies are univoltine, which means only one generation reaches sexual maturity per year. Females can breed after emerging from their pupal cases (approximately 10 months after transitioning from larvae to pupae). Females oviposit eggs in flower heads of the larvae host plant. The larvae host plants, coast buckwheat (Eriogonum latifolium) and seacliff buckwheat (E. parvifolium), are required for all reproductive activities (USFWS 1984; USFWS 2006).

Geographic or Habitat Restraints or Barriers

Larvae: Habitat degradation reduces the subspecies distribution, and reduces and fragments the amount of available habitat, especially in the northern part of the range (USFWS 2006).

Adult: Habitat degradation reduces the subspecies distribution, and reduces and fragments the amount of available habitat, especially in the northern part of the range (USFWS 2006).

Spatial Arrangements of the Population

Larvae: Clumped according to resources.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Two buckwheat species: coast buckwheat (Eriogonum latifolium) and/or seacliff buckwheat (E. parvifolium).

Adult: Two buckwheat species: coast buckwheat (Eriogonum latifolium) and/or seacliff buckwheat (E. parvifolium).

Habitat Narrative

Larvae: See Adult life stage.

Adult: Smith's blue butterflies are found in coastal sand dunes, cliff faces, and chaparral along the central California coast. Areas where the Smith’s blue butterfly are found must contain seacliffs and the larvae host plants. All life stages are dependent on the coast buckwheat (Eriogonum latifolium) and/or seacliff buckwheat (E. parvifolium) host plants. Adults feed on the nectar and deposit eggs on the flowers. Larva eat, grow, and pupate on the host plants. Smith's blue butterflies spend their lifetime within 61 m (200 ft.) of the larvae host plants from which they emerged. Habitat degradation reduces the subspecies distribution. Habitat degradation reduces and fragments the amount of available habitat, especially in the northern part of the range.Smith's blue butterflies in the northern part of the range along Monterey Bay are significant in that they occupy approximately 15 percent of the range and use different habitat relative to those in the southern portion of the range. Those in the northern part of the range use dune habitat, while those in the southern range use chaparral, scrub, and grassland habitat (USFWS 2006; Black and Vaughan 2005).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Larvae: No

Adult: Emigrate

Dependency on Other Individuals or Species for Dispersal

Larvae: No

Adult: No

Dispersal/Migration Narrative

Larvae: See Adult life stage.

Adult: Smith's blue butterflies are very sedentary and move at most 61 m (200 ft.) from the hatching site, with most moving only 30 m (98 ft.) (NatureServe 2015; Black and Vaughan 2005). Average home ranges for both sexes are relatively small. Larger home ranges have been observed at Marina State Beach, with 0.9 to 3.4 hectares (ha) (2.2 to 8.3 acres [ac.]) for males and 1.2 to 3.1 ha (3.2 to 7.7 ac.) for females. Due to habitat fragmentation, the distance that dispersing adults must travel to reach the nearest buckwheat stand has likely increased in many areas. The low vagility of adults, coupled with fragmentation of suitable habitat, reduces the probabilities of colonization events and migrator exchange between populations (USFWS 2006).

Additional Life History Information

Larvae: See Adult life stage.

Population Information and Trends

Population Trends:

Stable/declining; short-term on a decline of less than 30 percent or stable; long-term population decline between 50 to 90 percent (NatureServe 2015).

Representation:

The two metapopulations encompass the north-south and east-west gradients within the limited distribution of the subspecies and both ecological settings, likely encompassing the breadth of genetic and ecological diversity within and among populations. Though Smith's blues are able to utilize two species of buckwheat as host plants (both of which were historically very common in the environment) in a reasonably wide range of habitats (from sand dunes to cliffside chaparral), the subspecies is unable to adapt to conversion of the habitat to nonnative, invasive vegetation due to its niche specificity. Because of its reliance on buckwheat, the nonnative, invasive vegetation must be managed in order for the Smith's blues to have sufficient habitat. Given the host-plant specificity, the subspecies has always had some level of limitation on its adaptive capacity. Habitat loss and degradation has reduced the potential for already limited adaptive capacity, which comprises representation for the subspecies. (USFWS, 2020)

Redundancy:

Redundancy will always be limited for local, endemic species with a naturally limited range. The subspecies is comprised of two metapopulations and the northern metapopulation is particularly small and restricted. Range contraction appears to have occurred due to habitat loss at the center of the range in the area of the Monterey Peninsula. However, the size of the Smith's blue's range is considerably larger than it was known to be at the time of listing due to the discovery of numerous new occupied sites found throughout the southern metapopulation. Currently, there are thought to be multiple populations throughout much of the known range of the subspecies, which inhabit a reasonably wide range of habitats (from sand dunes to cliffside chaparral). Metapopulations throughout the two habitat types provides some level of redundancy in each metapopulation in the face of potential catastrophic events, such as wildfire or catastrophic drought. But, overall redundancy in this species is low given the limited range and evidence of potential differentiation between the two metapopulations (USFWS, 2020)

Number of Populations:

2 metapopulations (USFWS, 2020)

Adaptability:

Low

Population Narrative:

In the short-term, the Smith's blue butterfly population has been declining less than 30 percent or remaining stable. In the long-term trend, the decline of the Smith's blue butterfly population has been 50 to 90 percent (NatureServe 2015). There are no longer-term population studies of Smith's blue butterfly that would yield information on the population trends. Between 1977 and 1979, population estimates at the northern Fort Ord Site (2.3 ha [5.7 ac.]) ranged from 3,081 to 5,201 individuals. In 1978, the population at the southern Fort Ord Site (4.8 ha [11.9 ac.]) was estimated to be 2,753 individuals. In 1986, the estimated population at the Marina State Beach site (15.2 ha [37.6 ac.]) was 4,511 individuals (USFWS 2006).Small and localized populations are particularly susceptible to catastrophic events. Extirpation of localized populations of Smith's blue butterflies due to stochastic events may adversely affect the subspecies as a whole. Throughout the range of the Smith's blue butterfly, the distance that dispersing adults must travel to reach the nearest buckwheat stand has likely increased in many areas due to habitat fragmentation, making it less likely that patches of habitat will be recolonized after local extirpations. The low viability of adults, coupled with fragmentation of suitable habitat, reduces the probabilities of colonization events and migratory exchange between populations (USFWS 2006). The occupied range of the Smith's blue is significantly larger than was known at the time the subspecies was listed, and numerous new occupied sites have been found throughout the southern part of its range. At the time of listing, the Smith's blue was thought to inhabit only the coastal sand dunes that extend from the mouth of the Salinas River south to Del Rey Creek in northern Monterey County. The 1984 Recovery Plan noted that since the Smith's blue was listed, extensive surveys had located the butterfly in more abundance and more diverse habitats, including the Carmel Valley and the coastal Big Sur area to the south. Smith's blue is currently thought to occur in scattered colonies in the inland and coastal sand dunes, serpentine grasslands, and cliffside chaparral communities in Monterey and San Luis Obispo Counties in two metapopulations. These two metapopulations are now likely isolated from one another, with one inhabiting the dunes along Monterey Bay and one in the Carmel Valley south into Big Sur, separated by development around the City of Monterey. The northern metapopulation is approximately 23 square miles (mi2 ; 60 square kilometers [km2]). The southern metapopulation is estimated in two parts: the Carmel Valley, which includes the more inland habitat, is approximately 69 mi2 (179 km2), and the Big Sur coastal habitat is approximately 108 mi2 (280 km2). Buckwheat host plants, coastal habitats with appropriate disturbance regimes for maintenance of buckwheat host plants, and habitat connectivity are needed across the range for long-term viability. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat destruction
Exposure: Recreation, development.
Response: Reduced quality habitat.
Consequence: Reduction in population numbers.
Narrative: The decline of the Smith's blue butterfly across its range is attributed to degradation and loss of habitat as a result of urban development, recreational activities, sand mining, and military activities. All of these threats, except for military activities, are ongoing in occupied Smith's blue butterfly habitat. Loss of habitat for the Smith's blue butterfly in the coastal dunes north of the Monterey Peninsula has been particularly significant. More than 50 percent of the dunes in the Seaside-Marina complex have been destroyed or significantly altered. Highway 1

also bisects the dune system, and may present a dispersal barrier for Smith's blue butterflies. Some of the habitat for Smith's blue butterfly south of the Monterey Peninsula is privately owned and could be (and has been) proposed for development. Recreation activities and trail maintenance results in damage to individual buckwheat plants in some areas, and may cause erosion (USFWS 2006).

Stressor: Nonnative species
Exposure: Introduction of nonnative species.
Response: Reduction of host plants.
Consequence: Reduction in habitat and population numbers.
Narrative: As a result of urban development, the introduction of invasive, nonnative plants has increased. Aggressive, disturbance-oriented, invasive species such as kikuyi grass (Pennisetum clandestinum), pampas grass (Cortaderia jubata), Cape ivy (Delaireria odorata), and French broom (Genista monspessulana) are found throughout the range of the Smith's blue butterfly on sites otherwise suitable for buckwheat. In sand dunes along Monterey Bay, nonnative iceplant (Carpobrotus spp.) and beach grass (Ammophila spp.) have covered hundreds of acers of habitat formerly suitable for Smith's blue butterfly. The establishment of invasive, nonnative plants has resulted in a gradual reduction in the abundance of host plants, and continues to threaten habitat for Smith's blue butterfly (USFWS 2006).

Stressor: Parasitism
Exposure: Parasites
Response: See narrative.
Consequence: Mortality
Narrative: Heavy parasitism of Smith's blue butterfly larvae has been observed. However, it is unknown how widespread such parasitism is or how it affects Smith's blue butterflies at the population level (USFWS 2006).

Stressor: wildfire (USFWS, 2020a)
Exposure:
Response:
Consequence:
Narrative: Since the 2006 5-year review, several large fires have burned many thousands of acres of Smith's blue butterfly habitat in the southern metapopulation, including the 2008 Basin Complex fire, 2016 Soberanes Fire, and 2020 Dolan Fire. Smaller wildfires can create disturbances that favor establishment of the host buckwheats, while large, high-intensity fires are more likely to damage soils and destroy seed banks to the detriment of native plant communities. Due to a lack of monitoring data, the effects of these fires on Smith's blue butterflies or their host buckwheats are unavailable. However, a large area of potential habitat has been burned and mortality of the species and removal of some habitat likely resulted. Given the 2020 Dolan Fire, we recommend taking this opportunity to monitor Smith's blue butterflies and their habitat use in this area to better understand the impacts of large-scale wildfire on the species and buckwheat host plants. (USFWS, 2020a)

Stressor: Climate Change (USFWS, 2020a)
Exposure:
Response:
Consequence:
Narrative: According to California's 4th Climate Change Assessment from 2018, average annual maximum temperatures in Monterey County are expected to increase between 3.5 and 5 degrees Fahrenheit based on Representative Concentration Pathway (RCP) 4.5 and 8.5. Climate projections also show an increase in extreme dry events and that drought conditions will increase. Increased drought is expected to lead to an increase in the intensity and size of wildfires, especially in grasslands and shrublands of California's coast and foothills. Warmer and dryer conditions and increased wildfire are also expected to lead to a reduction in shrub dominated habitats in the California Coast Ranges, including the scrub and chaparral habitats of the Smith's blue butterfly, favoring increased spread of invasive, nonnative vegetation. (USFWS, 2020a)

Recovery

Reclassification Criteria:
The 1984 recovery plan includes identifies 18 sites identified for protection in the recovery plan; three are north of the currently accepted range and one was likely misidentified, because it is at a higher elevation than any other occupied site and has no suitable habitat (USFWS 2006). The 2006 Smith's Blue Butterfly 5-Year Review recommends reclassification of the species to Threatened, and preparation of a revised recovery plan that updates the species delisting criteria (USFWS 2006). The 18 sites and the associated reclassification criteria identified in the 1984 recovery plan include:

Eighteen sites or colonies for reclassification and delisting criteria: Marina State Beach site, Salinas River National Wildlife Refuge site, Naval Post-Graduate School site, Ford Ord Military Reservation site, Crystal Springs Reservoir site, Santa Cruz Aggregate Quarry site, Big Creek Preserve site, Burns Creek site, Vasquez Knob site, Cone Peak Road site, Phillips Petroleum site, Sand City site, City of Marina sites, Lone Star Olympia Quarry site, Partington Canyon site, Point Gorda site, Dolan Creek site, Kirk Creek site.

As an interim measure, the Smith's blue butterfly will qualify for reclassification from endangered to threatened when either of the following conditions have been met (USFWS 1984):

The Smith's blue butterfly colonies at 18 sites have been made secure. For the purposes of reclassification from endangered to threatened, a colony will be considered secure when a viable, self-sustaining population has been maintained at the site for a period of 5 consecutive years and no foreseeable threats to the future survival of the colony exist (USFWS 1984).

An equivalent number of Smith's blue butterfly colonies have been made secure at comparable alternative sites to ensure the continued existence of E. e. smithi. The determination that a colony is secure and is comparable to one of the ones listed above is to be based on the following criteria (USFWS 1984).

1. Status surveys are conducted that indicate that the alternative colony is comparable in size and distribution to the colony listed above.

2. Status surveys are conducted that indicate that the alternative colony has, relative to one of the colonies listed above, comparable opportunities for genetic exchange with other Smith's blue butterfly colonies.

3. Genetic studies are performed that indicate that there are no taxonomic differences between the alternative colony and the colony listed above; and

4. Status surveys are conducted to document that a viable, self-sustaining population has been maintained at the alternative site for a period of 10 consecutive years, and that no foreseeable threats to the future survival of the colony exist.

Delisting Criteria:
The 1984 recovery plan includes identifies 18 sites identified for protection in the recovery plan; three are north of the currently accepted range and one was likely misidentified, because it is at a higher elevation than any other occupied site and has no suitable habitat (USFWS 2006). The 2006 Smith's Blue Butterfly 5-Year Review recommends preparation of a revised recovery plan that updates the species delisting criteria (USFWS 2006). The 18 sites and the associated delisting criteria identified in the 1984 recovery plan include:

Eighteen sites or colonies for delisting criteria: Marina State Beach site, Salinas River National Wildlife Refuge site, Naval Post-Graduate School site, Ford Ord Military Reservation site, Crystal Springs Reservoir site, Santa Cruz Aggregate Quarry site, Big Creek Preserve site, Burns Creek site, Vasquez Knob site, Cone Peak Road site, Phillips Petroleum site, Sand City site, City of Marina sites (2), Lone Star Olympia Quarry site, Partington Canyon site, Point Gorda site, Dolan Creek site, Kirk Creek site.

The Smith's blue butterfly colonies at the 18 sites have been made secure. A colony will be considered secure when viable, self-sustaining populations have been maintained for a period of 10 consecutive years and no foreseeable threats to the future survival of the colony exist. If, after 10 consecutive years, these sites appear to be permanently projected, and the butterfly colonies that occupy these sites no longer appear to be threatened, then the Smith's blue butterfly would qualify for delisting (USFWS 1984).

An equivalent number of Smith's blue butterfly colonies have been made secure at comparable alternative sites to ensure the continued existence of E. e. smithi (USFWS 1984). The determination that a colony is secure and is comparable to one of the ones listed above is to be based on the following criteria:

1. Status surveys are conducted that indicate that the alternative colony is comparable in size and distribution to the colony listed above.

2. Status surveys are conducted that indicate that the alternative colony has, relative to one of the colonies listed above, comparable opportunities for genetic exchange with other Smith's blue butterfly colonies.

3. Genetic studies are performed that indicate there are no taxonomic differences between the alternative colony and the colony listed above; and

4. Status surveys are conducted to document that a viable, self-sustaining population has been maintained at the alternative site for a period of 10 consecutive years, and that no foreseeable threats to the future survival of the colony exist.

Recovery Actions:

- The 1984 recovery plan includes "recovery objectives," which are similar to the recovery criteria in more recent USFWS recovery plans (for other species). However, due to changes in USFWS knowledge of the subspecies' range and the threats that it faces, the objectives are largely obsolete. The range is larger and shifted to the south relative to what was known in 1984, and several of the localities identified for protection in the recovery plan do not have suitable habitat or are outside the currently accepted range. Of the 18 sites identified for protection in the recovery plan, three are north of the currently accepted range and one was likely misidentified, because it is at a higher elevation than any other occupied site and has no suitable habitat (USFWS 2006). Based on the 2006 Smith's Blue Butterfly 5-Year Review, the USFWS recommended that the recovery plan be updated to reflect the current knowledge of the subspecies' range and threats, and stresses the importance of habitat restoration and connectivity (USFWS 2006). Recovery actions identified in the 1984 Smith's Blue Butterfly Recovery Plan include:
- Preserve publically owned habitat sites (USFWS, 1984).
- Increase law enforcement activity (USFWS 1984).
- Control off-road vehicle use of habitat (USFWS 1984).
- Revegetate due areas (USFWS 1984).
- Control foot traffic (USFWS 1984).
- Remove exotic plants and replace with native plants (USFWS 1984).
- Provide for caretakers at dune sites (USFWS 1984).
- Secure known habitat sites (USFWS 1984).
- Develop restoration techniques for native vegetation (USFWS 1984).
- Determine ecological needs of the Smith's blue butterfly (USFWS 1984).
- Determine ecotype status of butterfly populations (USFWS 1984).
- Monitor and coordinate agency compliance with the recovery plan (USFWS 1984).
- Coordinate agency recovery efforts (USFWS 1984).
- Develop public awareness through meetings, signs, tours, etc. (USFWS 1984).
- Preparation of a revised recovery plan that reflects the current knowledge of the subspecies' range and threats, and stresses the importance of habitat restoration and connectivity. Updated delisting criteria should be included in the revised recovery plan (USFWS 2006).

- Evaluation of the overall effect of nonnative species and collaboration with partners to implement nonnative species removal, as appropriate, throughout the range of the Smith's blue butterfly (USFWS 2006).
- Further surveys to quantify habitat and determine occupancy throughout the subspecies' range (USFWS 2006).
- A study of the effects of livestock grazing on Smith's blue butterflies and their habitat (USFWS 2006).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Conduct surveys to quantify habitat and determine occupancy and population trends throughout the range of Smith’s blue butterfly. 2. Evaluate the short and long-term effects of large-scale wildfire on Smith’s blue butterflies and their host plants. 3. Implement long-term restoration, monitoring, and adaptive management at priority sites throughout the range to reduce the Smith’s blue buttefly’s risk from invasive, nonnative vegetation and overstabilization. 4. Conduct genetic analysis to identify subspecies limits. 5. Revise the recovery plan to reflect current knowledge of the subspecies’ range and threats, and to stress the importance of habitat restoration and connectivity; update recovery criteria. (USFWS, 2020a)

Additional Threshold Information:

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SPECIES ACCOUNT: *Euphydryas editha bayensis* (Bay checkerspot butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened; September 18, 1987 (52 FR 35366).

Physical Description

Bay checkerspot butterfly (Euphydryas editha bayensis) (bay checkerspot) is a medium-sized butterfly in the brush-footed butterfly family (Nymphalidae). It has a wing span of a little more than 5 centimeters (cm) (2 inches [in.]). The dorsal surfaces of the wings have black bands along all the veins on the surfaces, contrasting sharply with bright red, yellow and white spots. The black basal coloration gives a more decidedly checkered appearance than in other subspecies (52 FR 35366; USFWS 2009; Xerces 2005).

Taxonomy

The bay checkerspot was described by Sternitsky in 1937 and is recognized as a subspecies of Euphydryas editha on the basis of its physical characteristics. The bay checkerspot differs from LuEsther's checkerspot (Euphydryas editha luestherae) by being darker, and by lacking a relatively uninterrupted red band demarcating the outer wing third. The bay checkerspot is not as dark and has brighter red and yellow colors than the island checkerspot (Euphydryas editha insularis) (of the Channel Islands and nearby mainland of southern California). The black banding on the forewings of the bay checkerspot gives a more checkered appearance than in other subspecies, such as the smaller Quino checkerspot (Euphydryas editha quino) of southern California, or the montane subspecies (e.g., the Mono checkerspot, Euphydryas editha monoensis) (USFWS 1998). In practice, the locality, habitat, and general species characteristics as a whole may serve to identify this subspecies (NatureServe 2015). The current distribution of Euphydryas butterflies is in small discrete populations, and the genetic distinction of many of these butterfly populations may have been different as recently as 300 butterfly generations ago. Well-resolved phylogenies for many butterfly species do not exist despite their well-studied biology. The majority of genetic studies on the bay checkerspot butterfly occurred in the 1970s and 1980s, prior to the advent of more advanced molecular techniques, although studies published in 1990 suggest that various subspecies were recently interconnected (as early as the last ice age, approximately 8,000 to 10,000 years ago) and that gene frequency distributions are more reflective of historical gene flow rather than current gene flow (USFWS 2009).

Historical Range

Historically, the bay checkerspot butterfly occurred at six core locations associated with native grasslands with serpentine soils and/or outcrops in the eastern, western, and southern parts of San Francisco Bay, California. The northern extent of the species range was Twin Peaks in San Francisco, the eastern extent being Mount Diablo in Contra Costa County, and the southern range extending approximately to Hollister. Over the entire historic range of the bay checkerspot, the total area of known suitable serpentine habitats does not exceed 5,000 hectares (ha) (12,000 acres [ac.]), and may have been more widely distributed prior to the introduction of invasive Eurasian grasses and weeds in the 1700s (USFWS 1998; USFWS 2009).

Current Range

The current range of the bay checkerspot butterfly is reduced to one core area: all known extant populations exist within a 14.5-kilometer (km) (9-mile [mi.]) radius of Coyote Ridge in Santa Clara County, California (more specifically, Edgewood Park in San Mateo County, along the eastern ridgeline stretching from San Jose south to Morgan Hill). The currently occupied habitat for the bay checkerspot butterfly is highly fragmented and isolated. Since listing, the number of sites with extant bay checkerspot butterfly populations has decreased considerably, and there are no populations in Alameda, Contra Costa, San Mateo, or San Francisco counties (USFWS 2009, Page 5).

Critical Habitat Designated

Yes; 8/26/2008.

Legal Description

On August 26, 2008, the U.S. Fish and Wildlife Service (Service) designated revised critical habitat for the Bay checkerspot butterfly (Euphydryas editha bayensis) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 18,293 acres (ac) (7,403 hectares (ha)) fall within the boundaries of the revised critical habitat designation for the Bay checkerspot butterfly. The revision to critical habitat is located in San Mateo and Santa Clara Counties, California. The final revised designation therefore constitutes a reduction of 1,453 ac (588 ha) from our 19,746 ac (7,990 ha) proposed revised designation of critical habitat for the Bay checkerspot butterfly published on August 22, 2007.

Critical Habitat Designation

13 units are designated as critical habitat for the Bay checkerspot butterfly. These units, which generally correspond to those units in the 2007 proposed revised designation, when finalized, would entirely replace the current critical habitat designation for the Bay checkerspot butterfly at 50 CFR 17.95(i).

Unit 1: San Bruno Mountain. Unit 1 consists of 775 ac (314 ha) in San Mateo County. The unit is primarily within San Bruno Mountain State and County Park, and is entirely within the boundaries of the San Bruno Mountain Area Habitat Conservation Plan. This unit was occupied at the time of listing and contains all the features essential for the conservation of the subspecies; however, the Bay checkerspot butterfly has not been observed in this unit since a wildfire in 1986 and is currently unoccupied. Unit 1 represents the most northerly part of the subspecies' range on the San Francisco peninsula. Unit 1 is necessary as a supporting element of the San Mateo metapopulation because it represents the largest area of contiguous native grassland habitat that can support the Bay checkerspot butterfly's host and nectar plants within San Mateo County. This unit currently supports populations of the federally endangered Callippe silverspot butterfly (Speyeria callippe callippe), endangered San Bruno elfin butterfly (Callophrys mossii bayensis), and endangered Mission blue butterfly (Icaricia icarioides missionensis), which share some of the habitat requirements as the Bay checkerspot butterfly (such as native grasslands). The majority of this unit, approximately 577 ac (234 ha), is within the boundaries of the San Bruno Mountain State and County Park, while the rest of the unit is privately owned (198 ac (80 ha)). The distance between Unit 1 and the most proximate unit, Unit 2, is greater than the published dispersal distance of the Bay checkerspot butterfly; however, numerous small patches of intervening grasslands may serve as additional stepping stones to potentially allow for movement between these two units. These patches of grassland habitat are not designated as critical habitat because the Service has no information regarding the presence of sufficient PCEs within these areas.

Unit 2: Pulgas Ridge. Unit 2 consists of 179 ac (72 ha) in San Mateo County. The unit is located north of the intersection of Interstate 280 and Highway 92, east of Crystal Springs Reservoir. This unit was occupied at the time of listing and contains all the features essential for the conservation of the subspecies. Since listing, Bay checkerspot butterflies in this unit have been extirpated, and the unit is currently unoccupied. However, the Bay checkerspot butterfly formerly inhabited this unit, and the unit still contains all the PCEs. The land within this unit is owned by San Francisco Public Utilities Commission (SFPUC) and is part of the Peninsula watershed and not subject to development. This unit provides habitat for the subspecies, especially in years with particularly favorable weather conditions that support expanding populations of Bay checkerspot butterflies; represents a stepping stone location to nearby units; and secures the metapopulation dynamics of the subspecies by providing adjacent or dispersal habitat for the subspecies. According to the Peninsula watershed management plan (SFPUC 2002, pp. 2-11), portions of the watershed currently support populations of the endangered San Bruno elfin butterfly and the endangered Mission blue butterfly that share similar habitat requirements as the Bay checkerspot butterfly (including native grasslands). In addition, according to the environmental impact statement for the Peninsula watershed management plan (SFPD 2001, p. XLB- 7), portions of the watershed have a high probability of supporting the Bay checkerspot butterfly and are designated as serpentine grassland habitat.

Unit 3: Edgewood Park. Unit 3 consists of 409 ac (166 ha) in San Mateo County. This unit is comprised primarily of the Edgewood Park and Natural Preserve, a San Mateo County park located east of the junction of Edgewood Road and Interstate 280. A portion of the unit, approximately 141 ac (57 ha), is owned by the San Francisco Public Utilities Commission and is part of the Peninsula watershed. This unit was occupied at the time of listing, is currently occupied, and contains all the features essential to the conservation of the subspecies. Until recently, this unit supported the main population of Bay checkerspot butterflies within the San Mateo metapopulation. However, the subspecies was last observed here in 2002, after a steady decline beginning in the late 1990s. Larval Bay checkerspot butterflies were reintroduced to this unit in early 2007. The population of Bay checkerspot butterflies within this unit has been described as the only core population in San Mateo County, and without Bay checkerspot butterflies in this unit, the subspecies in San Mateo County is unlikely to persist, which would leave only the one metapopulation in Santa Clara County and the loss of Unit 3 would constitute a significant range reduction for the subspecies.

Unit 4: Jasper Ridge. Unit 4 consists of 329 ac (133 ha) in San Mateo County. The unit is entirely contained within Stanford University's Jasper Ridge Biological Preserve. The unit is 4 mi (7 km) southeast of Unit 3 and 23 mi (37 km) west-northwest of Unit 5, and represents the closest connection to the Santa Clara County metapopulation. This unit was occupied at the time of listing and contains all the features essential to the conservation of the subspecies. Dozens of published scientific papers about the Jasper Ridge population of the Bay checkerspot butterfly exist. The population was almost extirpated by prolonged drought in the late 1970s and again in the late 1980s. The unit was occupied at the time of listing; however the last known observation of the Bay checkerspot butterfly in this unit was in 1997. The unit is currently unoccupied. The unit is managed as a biological preserve by Stanford University, and suitable habitat, containing all the PCEs, continues to be present. Unit 4 is the closest unit in San Mateo County to populations of the Bay checkerspot butterfly in Santa Clara County. While currently not known to be occupied, metapopulation dynamics may allow for natural recolonization to occur by Bay checkerspot butterflies from the Edgewood Park Unit (Unit 3). The Jasper Ridge Unit is the closest suitable habitat with sufficient PCEs to the recently reintroduced Edgewood Park population and is necessary to support and maintain the Edgewood Park population, which in turn supports the metapopulation dynamics of the Bay checkerspot butterfly in San Mateo County.

Unit 5: Metcalf. Unit 5 consists of 4,503 ac (1,822 ha) in Santa Clara County. The unit encompasses Units 10, 11, and 12 as identified in the 2001 designation and is the northern half of Unit 5 as identified in the 2007 proposed revised designation. The unit comprises the northern half of the ridgeline currently referred to as Coyote Ridge (although in the past has been referenced as Morgan Hill, Kirby Canyon, and the East Hills), the majority of which is in private ownership, although approximately 110 ac (45 ha) are owned by Santa Clara County Parks for off-road vehicle recreation. To the north the unit is bordered by Yerba Buena Road near its intersection with U.S. Highway 101 and Metcalf Road to the south. The unit was occupied at the time of listing, contains all the features essential to the conservation of the subspecies, and represents the northern portion of the only remaining core population of the Bay checkerspot butterfly. Other units in Santa Clara County depend on the core population as a source for recolonization. The unit represents the second largest, most contiguous, and highest quality habitat containing the second largest population of Bay checkerspot butterflies. Researchers historically referred to the Bay checkerspot butterflies within this unit as three populations, Metcalf, San Felipe, and Silver Creek Hills, and our 2001 designation identified them as separate units. However, according to Launer (2008, p. 4), there are likely multiple subpopulations or populations within each of the historically studied populations, and the four names only represent the centers of historic study areas. The Metcalf population supported an estimated 400,000 individuals in 2004, but has suffered a significant decline down to an estimated 45,000 individuals in 2006 (Weiss 2006, p. 1). The Metcalf population is within the limits of the City of San Jose and is located on private land. The San Felipe population is also located on private lands and within the limits of the City of San Jose. The Service is unaware of any recent surveys of the San Felipe population; however, the population was estimated at 100,000 individuals in 1999 (Weiss 2006, p. 1). The Silver Creek Hills population is the last of the three populations within this unit. The population was considered relatively large, with approximately 115,000 individuals in 1993 (Weiss 2006, p. 1). This population was significantly affected by the development of a residential area and associated golf course (Ranch on Silver Creek) in the late 1990s. As a result of formal consultation on the Ranch on Silver Creek, approximately 473 ac (191 ha) owned by William Lyon Homes were preserved under a conservation easement and are being managed for the Bay checkerspot butterfly. Approximately 40 adults were observed at the Silver Creek Preserve in 2006 (WRA 2006, p. i).

Unit 6: Tulare Hill. Unit 6 consists of 348 ac (141 ha) in Santa Clara County. The unit is located in the middle of the Santa Clara Valley, south of San Jose, and west of the crossing of Metcalf Road and Monterey Highway. The unit was occupied by the Bay checkerspot butterfly at the time of listing and is noted as one of the locations occupied in Harrison et al. (1988, p. 362). The unit is currently occupied, contains all the features essential to the conservation of the subspecies, and is essential to the conservation of the subspecies because it acts as a population center and because it provides a dispersal corridor across Coyote Valley. This unit is the closest suitable intervening habitat between the Coyote Ridge core population and most of the other populations in Santa Clara County, primarily those on the western side of Coyote Valley. Hundreds of butterflies have been observed on the southern half of the unit from 2001-2006 (Weiss 2006, p. 1). The highest numbers of individuals were 2,000 to 3,000 post diapause larvae in 2002, but the population has declined significantly, and that decline is believed to be due to lack of grazing over much of the unit (CH2M Hill 2008, p. 8-8). We have determined that the long-term viability of the Bay checkerspot butterfly in Santa Clara County depends on the presence of corridors for dispersal of adults between Coyote Ridge and the other units in Santa Clara County. Tulare Hill is an ideal location for such a corridor because of the narrowness of the valley at this location, the limited amount of development currently present, the presence of high elevations on the hill that may attract butterflies over the highways and developed areas, and the presence of suitable habitat on Tulare Hill itself. Migrant butterflies from either Santa Teresa Hills or Coyote Ridge may settle on Tulare Hill, contributing individuals to the population within this unit, and adults from Tulare Hill may migrate to the adjacent habitat areas. Locally owned lands within this unit include parts of Coyote Creek Park, Metcalf Park, and Santa Teresa County Park totaling approximately 14 ac (5 ha). Roughly half of Tulare Hill itself is within the limits of the City of San Jose; the remainder is on private lands in unincorporated Santa Clara County. Approximately 114 ac (46 ha) of the unit is currently protected under a conservation easement and is managed for the Bay checkerspot butterfly by the Land Trust for Santa Clara County. The unit is bisected by transmission lines from Pacific Gas & Electric (PG&E), and the operations and maintenance of these lines are the subject of a Safe Harbor Agreement and Habitat Conservation Agreement for the Bay checkerspot butterfly.

Unit 7: Santa Teresa Hills. Unit 7 consists of 3,278 ac (1,327 ha) in Santa Clara County. The unit lies north of Bailey Avenue, McKean Road, and Almaden Road; south of developed areas of the city of Santa Clara; and west of Santa Teresa Boulevard. The unit abuts Unit 6. This unit was occupied at the time of listing, although that was not specifically mentioned in the listing rule. An unspecified number of Bay checkerspot butterflies were observed in this unit in 1988 (CNDDB 2006, p. 26). The unit is currently occupied (Arnold 2007, p. 1; H.T Harvey and Associates 1998, p. 11), and contains the physical and biological features essential to the conservation of the subspecies. Further, it includes the largest block of undeveloped habitat containing all the PCEs west of U.S.

Route 101 in Santa Clara County. In addition, due to the prevailing winds, Unit 7 may experience less air pollution (i.e., nitrogen and ammonia deposition) than the units on the east side of Coyote Valley. Approximately 425 ac (172 ha) within the unit is owned by Santa Clara County Department of Parks and Recreation with the remainder of the unit consisting of private land.

Unit 8: Calero Reservoir. Unit 8 consists of 1,543 ac (624 ha) in Santa Clara County. The unit is south of McKean Road and east of the town of New Almaden, Almaden Road, and Alamitos Creek. This unit was occupied at the time of listing (CNDDB 2006, p. 26), is currently occupied, and contains all the features essential for the conservation of the subspecies. The unit is less than 0.5 mi (0.8 km) south of Unit 7 and 1 mi (1.6 km) east of Unit 9. It is also 3.3 mi (5.3 km) southwest of the core population in Unit 5, and this distance is well within the dispersal capabilities of the subspecies; therefore, Unit 8 is an important component of the species' Santa Clara County metapopulation. The unit is comprised of over 1,400 ac (567 ha) of mapped serpentine soils on public land. The majority of the unit is within the Calero County Park and managed by Santa Clara County Department of Parks and Recreation. The remainder is owned and managed by the Santa Clara Valley Water District.

Unit 9: Kalana Hills. Unit 9 consists of two separate subunits: Subunit 9A (170 ac (69 ha)) and Subunit 9B (56 ac (22 ha)), totaling 226 ac (91 ha) in Santa Clara County. The two subunits are located on the southwest side of the Santa Clara Valley between Laguna Avenue and San Bruno Avenue and are entirely on private land. Both subunit 9A and 9B were occupied by the Bay checkerspot butterfly at the time of listing and are noted as one of the locations occupied in Harrison et al. (1988, p. 362). Adults were again observed during the last survey of the unit in 1997 (CNDDB 2006, p. 23). The two subunits include four hilltop serpentine outcrops, which contain all the features essential for the conservation of the species, and some intervening grassland. The intervening grassland does not contain the larval host plants or serpentine or similar soils, but does contain PCEs 1, 3, and 4 and connects the four serpentine outcrops. Unit 5 lies about 2.1 mi (3.2 km) to the northeast, Unit 7 is 1 mi (1.6 km) to the northwest, Unit 8 is 1 mi (1.6 km) to the west, and Unit 10 about 2.2 mi (3.5 km) to the southeast. The essential physical and biological features in Unit 9 assist in maintaining the metapopulation dynamics of the subspecies by providing habitat for the subspecies within dispersal distance of adjacent or nearby critical habitat units. Because of its proximity to several other large population centers for the Bay checkerspot butterfly, we expect the Kalana Hills subunits to be regularly occupied by the subspecies and assist in maintaining the metapopulation dynamics for the subspecies. If, as is possible given the Bay checkerspot butterfly's large population swings, the butterfly's population in these subunits were to become extirpated, the subunits are likely to be repopulated by Bay checkerspot butterflies immigrating from adjacent sites. These subunits act as a ''stepping stone'' to adjacent or nearby units. A portion of the largest and northernmost serpentine outcrop within subunit 9A is within the limits of the City of San Jose; the remainder of the subunit is in unincorporated Santa Clara County. Subunit 9A's northeast boundaries are bordered by the proposed Coyote Valley Specific Plan.

Unit 10: Hale. Unit 10 consists of 507 ac (205 ha) in Santa Clara County. The unit is northwest of the City of Morgan Hill, east of Willow Springs Road, and south of Hale Avenue. The unit name

‘‘Hale’’ was changed from ‘‘Morgan Hill’’ in our 2007 proposed revised designation based on comments from peer reviews. This unit was occupied in the late 1980s and is described in the CNDDB as an ‘‘active site’’ (CNDDB 2006) for the subspecies. The unit was occupied at the time of listing and is noted as one of the locations occupied in Harrison et al. (1988, p. 362). Adult butterflies were observed in the unit in 1997 (CNDDB 2006). Unit 10 is essential to the conservation of the subspecies because it has large areas of serpentine soils and grassland with a variety of slope exposures, contains all the PCEs, and serves as a ‘‘stepping stone’’ between the southernmost occurrences of the subspecies (Unit 12) and the populations to the north. The unit is 1.5 mi (2.4 km) southwest of Unit 5 and 2.2 mi (3.5 km) southeast of Unit 9, provides dispersal habitat from adjacent critical habitat units, and provides habitat during years with particularly favorable weather conditions that support expanding populations of the Bay checkerspot butterfly. This unit is comprised mostly of private property, a portion of which is within the limits of the City of Morgan Hill and the rest in unincorporated Santa Clara County.

Unit 11: Bear Ranch. Unit 11 consists of 283 ac (114 ha) in Santa Clara County. The unit is adjacent to Coyote Reservoir and is entirely contained within the Coyote Lake– Harvey Bear Ranch County Park. The Bay checkerspot butterfly was known to occur within this unit in the mid-1970s, but was considered extirpated in the listing rule; however, Bay checkerspot butterflies were observed in this unit in 1994, 1997, and 1999 (CNDDB 2006, p. 15; Launer 2000, p. 1). This unit is currently occupied and is the most southern occurrence of the Bay checkerspot butterfly on the east side of Coyote Valley. Although we are unable to determine from the available data that Unit 11 was occupied by the species at the time of listing, we have determined that this area is essential for the conservation of the subspecies because it assists in maintaining the metapopulation dynamics of the subspecies by providing adjacent or nearby habitat for Bay checkerspot butterflies to disperse to or to use as foraging or resting habitat during longer dispersal events. The unit contains all the features essential for the conservation of the species. This unit is underlined by both serpentine and serpentine-like soils. There are two patches of serpentine soils separated north–south by intermittent woody vegetation; these patches are surrounded by grasslands underlined by serpentine-like soils that provide adequate dispersal corridors between the two patches.

Unit 12: San Martin. Unit 12 consists of 467 ac (189 ha) in Santa Clara County. The unit is located in the western foothills of the Santa Clara Valley. This unit was occupied at the time of listing, is currently occupied, and contains all the features essential for the conservation of the subspecies. The unit has extensive areas of serpentine soils interspersed with grasslands that have PCEs 1, 3, 4, and 5. These areas are important for dispersal between higher quality habitats within the unit that contain all the necessary features essential for conservation of the subspecies. The unit lies entirely on private lands in unincorporated Santa Clara County, about 4 mi (6.4 km) west-southwest of Unit 11, 4 mi (6.4 km) southeast of Unit 10, and 6 mi (9.6 km) south of Unit 5’s core area. This unit is the southernmost occurrence of the Bay checkerspot butterfly. The adjacent Cordevalle Golf Club has purchased approximately 298 ac (121 ha) of property within the unit, has developed a management plan for the property, and is currently working to establish a conservation easement for preservation as open space. A portion of the proposed open space, approximately 42.3 ac (17.1 ha), will be managed to benefit serpentine species including the Bay checkerspot butterfly. The remainder of the unit is privately owned.

Unit 13: Kirby. Unit 13 consists of 5,446 ac (2,204 ha) in Santa Clara County. The unit encompasses Unit 8 identified in the 2001 designation and is the southern half of Unit 5 as identified in the 2007 revised proposed rule. The unit comprises the southern half of the ridgeline currently referred to as Coyote Ridge (but as noted above has been referred to by a variety of names in the past), the majority of which is in private ownership. To the north the unit is bordered by Metcalf Road, to the southwest by U.S. Highway 101, and Metcalf Road to the south. The unit was occupied at the time of listing, contains all the features essential to the conservation of the subspecies, and represents the southern portion of the only remaining core population of the Bay checkerspot butterfly (Unit 5 contains the northern portion of the core population). Other units in Santa Clara County depend on the core population as a source for recolonization. The unit represents the largest, most contiguous, and highest quality habitat containing the largest population of Bay checkerspot butterflies. The Kirby population is the southernmost of the four historically studied populations and has consistently had the largest numbers of Bay checkerspot butterflies. The Kirby area had an estimated 700,000 individuals in 2004, 100,000 individuals in 2005 (Weiss 2006, p. 1), and 40,000 in 2007 (CH2M Hill p. 8-8). Although still under private ownership, approximately 291 ac (118 ha) of the Kirby area is under some form of protection or management for special status species, including the Bay checkerspot butterfly. In addition, a 250-ac (101-ha) butterfly preserve is being managed by Waste Management Incorporated (WMI) as compensation for adverse effects to the Bay checkerspot butterfly in association with its landfill. However, the protection afforded the butterfly preserve is not permanent, and the land the preserve is on is not owned by WMI. Approximately 90 ac (37 ha) is owned by the Santa Clara Department of Parks and Recreation.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for San Mateo and Santa Clara Counties, California. The primary constituent elements of critical habitat for the Bay checkerspot butterfly are the habitat components that provide:

(i) The presence of annual or perennial grasslands with little to no overstory that provide north–south and east–west slopes with a tilt of more than 7 degrees for larval host plant survival during periods of atypical weather (for example, drought). Common grassland species include wild oats (Avena fatua), soft chess (Bromus hordeaceus), California oatgrass (Danthonia californica), purple needlegrass (Nassella pulchra), and Idaho fescue (Festuca idahoensis); less abundant in these grasslands are annual and perennial forbs such as filaree (Erodium botrys), true clovers (Trifolium sp.), dwarf plantain (Plantago erecta), and turkey mullein (Croton setigerus). These species, with the exception of dwarf plantain, are not required by the Bay checkerspot butterfly, but merely are provided here as an example of species commonly found in California grasslands.

(ii) The presence of the primary larval host plant, dwarf plantain (Plantago erecta), and at least one of the secondary host plants, purple owl's-clover (Castilleja densiflora) or exserted paintbrush (Castilleja exserta), are required for reproduction, feeding, and larval development.

(iii) The presence of adult nectar sources for feeding. Common nectar sources include desertparsley (Lomatium spp.), California goldfields (Lasthenia californica), tidy-tips (Layia platyglossa), sea muilla (Muilla maritima), scytheleaf onion (Allium falcifolium), false babystars (Linanthus androsaceus), and intermediate fiddleneck (Amsinckia intermedia).

(iv) Soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar soils (Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that provide areas with fewer aggressive, nonnative plant species for larval host plant and adult nectar plant survival and reproduction.

(v) The presence of stable holes and cracks in the soil, and surface rock outcrops that provide shelter for the larval stage of the Bay checkerspot butterfly during summer diapause.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing on the effective date of this rule and not containing one or more of the primary constituent elements.

Threats to those features identifed as the PCEs laid out in the appropriate quantity and spatial arrangement for conservation of the Bay checkerspot butterfly that may require special management considerations or protection include habitat loss and fragmentation, invasion of exotic plants, nitrogen deposition (including NOx and ammonia), pesticide application (including drift), illegal collecting, fire, overgrazing, and gopher control.

Life History

Feeding Narrative

Egg: Larvae of the bay checkerspot butterfly feed exclusively on the spring growth vegetation of the primary larval host plant, dwarf plantain (Plantago erecta), and the secondary larval host plants, purple owl's-clover (Castilleja densiflora) and the exserted paintbrush (Castilleja exserta), and have no known competitors for food (66 FR 21450; Murphy and Weiss 1988). Newly hatched larvae form webs and feed gregariously until the oviposition plant is defoliated or senesces (plant tissue death following completion of seed production in annual life cycle) (Murphy and Weiss 1988). Larvae begin feeding as soon as they hatch, and continue until they have grown sufficiently to reach their fourth instar (development phase) and enter diapause (a state of dormancy). During the dry summer season, larval host plants senesce. Dwarf plantain senesces earlier than secondary host plants; larvae then disperse to these species, which remain edible later in the season (Xerces 2005). Larvae that do not have adequate resources to attain sufficient growth are not able to enter diapause prior to host plant senescence starve. The delayed senescence of plants on cool, moist slopes allows larvae survive later into the summer (USFWS 2009). Host plants on drier slopes and aspects may senesce up to a month prior to those on the coolest slopes (Murphy and Weiss 1988). It has been noted that larvae preferentially feed on their larval host plants when those plants occur in area serpentine soils (even when host plants occur in contiguous, nonserpentine habitats), but will feed on host plants grown in laboratory conditions using nonserpentine soils (USFWS 2009). Larvae have high bioenergetic requirements initially; provided adequate food, larvae may reach the fourth instar and may enter diapause within 2 weeks after hatching. However, larvae also experience periods of low bioenergetic requirements as they enter diapause in summer. Post-diapause, they feed through winter and spring and have moderate bioenergetic requirements as they attain sufficient mass to pupate; in total, spending nearly an entire year after their initial pre-diapause growth to reach pupation into an adult butterfly (USFWS 2009).

Adult: Adults are nectarivores who use native plants, including but not limited to California goldfields (Lasthenia californica), coastal tidytips (Layia platyglossa), sickle leaf onion (Allium falcifolium), sea muilla (Muilla maritima), and lomatium (Lomatium sp.), as nectar sources (66 FR 21450; Murphy and Weiss 1988; NatureServe 2015). Its nectar sources are limited in distribution to grassland habitats found on serpentine soils. Adults have high bioenergetic requirements because they require nectar sources to be in bloom as they feed, disperse, and reproduce in the span of their 1- to 3-week long flight period (USFWS 2009).Abundant nectar sources contribute to increased adult longevity and improved adult condition (females produce more and larger egg masses). However, females are capable of producing eggs without food (i.e., in dry years when flowers produce less nectar or in areas where there are no mature nectar plants) (USFWS 2009).

Reproduction Narrative

Egg: Eggs hatch into larvae approximately 2 weeks after they are laid (between March and May); the larvae feed for another 2 weeks until they reach their fourth instar (larval development stage/molt), at which time they are able to enter summer diapause. Larvae break diapause and resume feeding with the onset of the rainy season and host plant germination, generally between November through January. Post-diapause larvae then feed until reaching sufficient mass to pupate. Pupation occurs from late January to early April. Larger, heavier eggs produced by females with greater access to nectar sources result in an increased likelihood of larval survival, with larvae's ability to enter diapause dependent on size. Slow-developing larvae may not reach diapause before the larval host plants senesce. Pre-diapause larvae experience mortality rates upward of 95 percent, and pupal mortality rates of 26 to 89 percent have been observed (USFWS 2009).

Adult: Bay checkerspot butterflies are an oviparous, univoltine (one generation reaches sexual maturity per year) species whose typical lifespan is 1 year; however, some larvae may be capable of diapausing more than once for several years (66 FR 21450). Males may mate multiple times; females typically only mate once, laying one to five egg masses of five to 350 eggs each (USFWS 2009; Xerces 2005). Adult flight season and breeding is weather-dependent, but generally occurs for 4 to 6 weeks, from late February to early May, depending on the weather. Females that eclose (emerge as adults from pupae) early in the flight season will contribute more eggs, because nectar availability can be limited later in the flight season. However, females are capable of producing eggs without food (i.e., in dry years when flowers produce less nectar or in areas where there are no mature nectar plants). The average reported lifetime egg production was 401 to 805 eggs, with average lifetime egg production being 426 by females without food (USFWS

2009). Females oviposit (lay their eggs) on larval host plants; primarily on dwarf plantain (Plantago erecta), and may use secondary species in drier conditions, typically owl's clover (Castilleja sp.) (USFWS 2009; Xerces 2005). Adults live an average lifespan of 10 days, with a maximum observed lifespan of 3 weeks (USFWS 2009). Increased nectar intake results in a longer adult life span and improved adult condition (female egg production increases significantly in terms of size and quantity with increased nutrient intake). Longer adult survival (influenced by available nectar sources for females) is important during wet years for females that lay eggs on cool slopes, because larvae from these eggs develop more slowly (USFWS 2009). The exposures of slopes on which pupation takes place affect the length of the pupal stage, with warm slopes advancing adult eclosion and cool slopes retarding it (Murphy and Weiss 1988).

Geographic or Habitat Restraints or Barriers

Egg: Irregular surfaces in grassland habitats constrain larval movements; the smaller the larvae, the greater the effects on dispersal (Murphy and Weiss 1988).

Adult: Qualitative observations suggest that bay checkerspots move readily over suitable grassland habitat, but are more reluctant to cross scrub, woodland, or other unsuitable habitat. Roads, especially those traveled more heavily and at higher speeds, present a risk of death or injury to dispersing butterflies (66 FR 21450).

Spatial Arrangements of the Population

Egg: Clumped according to resources.

Adult: Clumped according to resources.

Environmental Specificity

Egg: See Adult life stage.

Adult: High

Tolerance Ranges/Thresholds

Egg: Low to moderate; early host plant senescence can result in high larval mortalities; however, some larvae may enter additional diapause periods if conditions are unfavorable (USFWS 2009). Larval and pupal development are suppressed on cool overcast days (Murphy and Weiss 1988).

Adult: Low; the bay checkerspot’s life cycle is closely tied to host plant biology. Host plants germinate anytime from early October to late December, and senesce (dry up and die) from early April to mid-May (66 FR 21450). Adult flight is suppressed on cool overcast days, regardless of the amount of rain that falls on a specific site (Murphy and Weiss 1988).

Site Fidelity

Egg: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Egg: Larval host plants growing on serpentine soils (USFWS 2009).

Adult: Native plant nectar sources; larval host plants growing on serpentine soils for egg-laying (USFWS 2009).

Habitat Narrative

Egg: See Adult life history.

Adult: The species is restricted to serpentine grassland habitat, in areas around the San Francisco Bay with soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar nonserpentine soils (such as Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that support at least two of the subspecies’ larval host plants, although the range of all the host plants is greater than that of the bay checkerspot butterfly. Serpentine or serpentine-like soils are characterized as shallow, nutrient-poor (typically lacking in nitrogen, phosphorous, and calcium), containing high magnesium (and other heavy metals), and having low water-holding capacity. Poor nutrient availability of serpentine soils creates essentially isolated patches where native grassland vegetation is capable of persisting in a landscape that is otherwise dominated by nonnative and invasive plant species. Elevation does not appear to be an important physical habitat characteristic (USFWS 2009).The subspecies' life cycle is closely tied to its host plant biology. Host plants germinate anytime from early October to late December, and senesce (dry up and die) from early April to mid-May (66 FR 21450). Larvae require areas with topographic diversity (warm southern and western slopes as well as cool northern and eastern slopes) that provide a variety of microhabitats, allowing resiliency of populations through consecutive years and a variety of climactic conditions. Some slopes become unfavorable, depending on annual weather conditions and time of year. Varying topography is important to provide the microclimate conditions necessary to ensure that some larvae (including those in diapause) survive varying climate conditions, because pre-diapause larval mortality is the most significant factor influencing population size (USFWS 2009). Key areas are those where cool slopes directly abut warm slopes over a scale of 1 to 30 m (3 to 100 ft.). Such proximity allows post-diapause larvae to disperse readily from cool to warm microclimates, and thus to advance development rates. Narrow ridgelines and “V'-shaped gullies create the most abrupt interfaces, often on a scale of less than 10 m (33 ft.). The rounded shapes of most Californian coastal foothills create more gradual transitions over longer distances, especially near hilltops, in hollows, and in saddle areas. Spring rainfall through March and April determines host plant senescence, which is cued by soil moisture (Murphy and Weiss 1988). Additionally, larvae require soil with cracks and crevices or rocks under which larvae may shelter for periods of diapause (USFWS 2009).The bay checkerspot butterfly exhibits low tolerance ranges and thresholds in terms of several factors, both biotic (habitat with low density of nonnative, invasive plant species and presence of appropriate combinations of larval host plants and nectar resources, regulated by suitable levels of vertebrate grazing) and abiotic (heterogeneity of microclimate in relatively small areas, suitable weather regimes), that largely regulate its population. The stringent requirements of topographic diversity and rainfall mean that large habitat size by itself does not guarantee population persistence (Murphy and Weiss 1988). Qualitative observations suggest that bay checkerspot butterfly adults move readily over suitable grassland habitat, but are more reluctant to cross scrub, woodland, or other unsuitable habitat. Roads, especially those traveled more heavily and at higher speeds, present a risk of death or injury to dispersing butterflies (66 FR 21450). Larval and pupal development, and adult flight, are suppressed on cool overcast days, regardless of the amount of rain that falls on a specific site (Murphy and Weiss 1988).

Dispersal/Migration

Motility/Mobility

Egg: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Egg: Nonmigratory

Adult: Nonmigratory

Dispersal

Egg: Low

Adult: Low

Immigration/Emigration

Egg: No

Adult: Immigrates/emigrates.

Dependency on Other Individuals or Species for Dispersal

Adult: Yes/host plant. When females fail to encounter preferred host plants, the likelihood of emigration to other suitable habitat patches increases (66 FR 21450). Studies have indicated that the absence of adult butterflies in an area may contribute to deterring potential migrants from establishing in unoccupied habitat patches. Natural reestablishment of populations in disrupted habitat island systems where patches are highly isolated is therefore probably infrequent (Murphy and Weiss 1988).

Dispersal/Migration Narrative

Egg: Larvae are nonmigratory and do not immigrate/emigrate; they may not move beyond the slope or even the host plant on which they hatched if adequate food is available. Pre-diapausal larvae may disperse for limited distances to find additional host plants to continue their growth, though the earlier these larvae move the slower their overall growth. Post-diapause, small larvae may be constrained by their size and limited ability to transverse irregular grassland surfaces, though large post-diapause larvae may move more than 10 m (33 ft.) per day in search of food sources. Post-diapause larvae often disperse dozens of meters (hundreds of feet) in search of pupation sites (Murphy and Weiss 1988).

Adult: Bay checkerspot butterfly are a nonmigratory species that may immigrate/emigrate in a given metapopulation. Adults are relatively sedentary; flight behavior likely suited the continuous historical distribution of suitable habitat, which likely existed in central California prior to the invasion of Eurasian grasses and weeds (Murphy and Weiss 1988). Females have a higher rate of emigration than males; when females fail to encounter preferred host plants, the likelihood of emigration to other suitable habitat patches increases (66 FR 21450, USFWS 2009). Studies have indicated that the absence of adult butterflies in an area may contribute to deterring potential migrants from establishing in unoccupied habitat patches. Patches of habitat, whether of high or marginal quality, can serve as “stepping stones” for regional metapopulations. These patches can facilitate gene flow between small populations, and can provide routes for individuals to colonize surrounding habitats that have been subject to local extinction (66 FR 21450). Natural reestablishment of populations in disrupted habitat island systems where patches are highly isolated is therefore probably infrequent (Murphy and Weiss 1988).Adult dispersal by the bay checkerspot is typically less than 150 m (490 ft.) between recaptures. In one study of the Santa Clara County bay checkerspot metapopulation, no colonizations of unoccupied habitat patches farther than 4.5 km (2.8 mi.) from the source population were detected over a 10-year period (66 FR 21450). Mark and recapture studies have observed adult movements to decline dramatically, down to 5 percent between 200 and 300 m (656 and 984 ft.), and as low as 1.7 percent at 488 m (1,600 ft.). Extended movements, between 3.2 and 7.5 km (2 and 4.7 mi.), have been observed in the field; these distances being the basis for the hypothesis that habitats greater than 8 km (5 mi.) from source populations are unlikely to ever sustain populations of the species. This hypothesis is based on the presence or absence of adults in Santa Clara County in apparently suitable habitat and their relative distance from Coyote Ridge. Studies have not been conducted to predict adult bay checkerspot upper limits of dispersal (USFWS 2009).

Additional Life History Information

Adult: Studies have not been conducted to predict bay checkerspot upper limits of dispersal. Females have a higher rate of emigration than males (66 FR 21450; USFWS 2009).

Population Information and Trends

Population Trends:

Declining (USFWS 2009)

Species Trends:

Declining (USFWS 2009)

Population Growth Rate:

Rapidly declining.

Number of Populations:

The Coyote Ridge core population has historically been referred to as four separate populations (Silver Creek Hills, San Felipe, Metcalf, and Kirby Canyon), because it exhibits metapopulation dynamics and exists in one central, near-contiguous location (USFWS 2009).

Population Size:

From 1992 to 2007, as few as 20,000 to as many as 700,000 estimated post-diapause larvae and zero to thousands of adults were observed (USFWS 2009).

Minimum Viable Population Size:

According to the delisting criteria, populations of 8,000 adult butterflies or populations of at least 20,000 post-diapause larvae are considered to be healthy; however, no minimum population size has been presented (USFWS 1998; USFWS 2009).

Resistance to Disease:

Moderate; at the time of the listing, parasitism by three species of parasitoids was not a major threat factor for this subspecies. Mold and viruses may contribute to pupal mortality in areas of high vegetation density (USFWS 2009).

Adaptability:

Low

Additional Population-level Information:

In spring 2007, an effort was made to reintroduce the bay checkerspot butterfly to Edgewood Park (San Mateo County) by relocating approximately 1,000 post-diapause larvae collected from Coyote Ridge. However, the reintroduction appears not to have been successful; no larvae and only one adult butterfly were observed at Edgewood Park in 2008 (USFWS 2009).

Population Narrative:

The bay checkerspot butterfly is patchily distributed in one population: Coyote Ridge. The Coyote Ridge core population has historically been referred to as four separate populations (Silver Creek Hills, San Felipe, Metcalf, and Kirby Canyon), because it exhibits metapopulation dynamics (a group of spatially separated populations that can occasionally exchange dispersing individuals, and may undergo interdependent extirpation and recolonization) and exists in one central, near-contiguous location. All satellite populations of bay checkerspot butterfly exist within a 14.5 km (9-mi.) radius of Coyote Ridge, but are not well studied and are considered to be part of the core population. Fluctuation in the number of populations and the number of individuals in a population varies dramatically from one year to the next, based on the population dynamics and life history of the bay checkerspot butterfly.Population trends are primarily available for the four historical populations of Coyote Ridge; they exhibit an overall declining trend, with population growth considered to be rapidly declining. Counts and estimates of post-diapause larvae and adults have varied significantly in studies conducted from 1992 to 2007, with areas studied reporting as few as 20,000 to as many as 700,000 estimated post-diapause larvae and zero to thousands of adults observed (USFWS 2009). According to the delisting criteria, populations of 8,000 adult butterflies or of at least 20,000 post-diapause larvae are considered to be healthy; however, no minimum population size has been presented (USFWS 1998; USFWS 2009). In spring 2007, an effort was made to reintroduce the bay checkerspot butterfly to Edgewood Park (San Mateo County) by relocating approximately 1,000 post-diapause larvae collected from Coyote Ridge. However, the reintroduction appears not to have been successful; no larvae and only one adult butterfly were observed at Edgewood Park in 2008 (USFWS 2009). Historically, four large serpentine outcrops probably supported core populations, but at the time of listing there were only two areas thought to support persistent populations: Edgewood Park (San Mateo County) and along the eastern ridgeline in Santa Clara County stretching from San Jose south to Morgan Hill (here on referred to as Coyote Ridge) (Diversity Database 2020; Service 1987, p. 35376). Serpentine habitat that may have once supported core populations but were extirpated before listing include a large outcrop in San Leandro in San Mateo County and an outcrop in San Mateo, northeast of Crystal Springs Reservoir. The species distribution has reduced since the time of listing, with restrictions noted in the Recovery Plan (Service 1998, p. II.177–II.180), when critical habitat was revised (Service 2008, p. 50422), and in the last status review (Service 2009, pp. 5–6). The current distribution remains similar to that described in Service (2009, p. 5), with the exception that several reintroductions have occurred. Outside of the reintroductions, only one core area is still occupied (Coyote Ridge), and all known extant occurrences of the Bay checkerspot butterfly are within a 9-mile radius of Coyote Ridge in Santa Clara County. Since 2009, Bay checkerspot butterfly reintroductions or translocations have occurred or continued in Santa Clara County at Tulare Hill and in San Mateo County at Edgewood Natural Preserve (hereafter Edgewood) and San Bruno Mountain, as discussed below in Translocations and Reintroductions. The Edgewood and Tulare Hill reintroductions thus far have limited success, leaning towards unsuccessful, while the San Bruno Mountain reintroduction has the potential for success. However, because the reintroductions at San Bruno Mountain are still relatively recent and are ongoing, it is still uncertain whether this population will be self-sustaining (USFWS, 2022).

Threats and Stressors

Stressor: Nonnative, invasive plant species
Exposure: Nonnative, invasive plants establish in butterfly habitat.
Response: Competition and crowding of host plant habitat, and increased nitrogen deposition.
Consequence: Reduction or elimination of population; and increased dispersal distances, resulting in lowered genetic exchange and fitness.
Narrative: Nonnative, invasive annual grasses that have dominated native grassland habitat in California since European settlement have displaced numerous native species; now, due to increased soil nitrogen deposition, additional nonnative invasive species are able to colonize the otherwise nutrient-poor, native serpentine bunchgrass communities. Continued spread of nonnative vegetation threatens to degrade and eliminate areas that are occupied by the bay checkerspot butterfly, by reducing or eliminating both larval and adult host plants as well as increasing the distance of unsuitable habitat between extant occurrences of the butterfly. Management of conserved lands under the Santa Clara Valley Habitat Conservation Plan/Natural

Community Conservation Plan (HCP/NCCP) will include grazing and invasive species management programs to minimize the impacts of nitrogen deposition. The HCP/NCCP will also include an adaptive management plan that will allow for adjustments to grazing and invasive species programs to account for changes in these threats (such as new invasive species, or increased/decreased nitrogen deposition) (USFWS 2009).

Stressor: Development
Exposure: Butterfly habitat is lost to development.
Response: Reduced available habitat.
Consequence: Habitat loss or fragmentation; and increased distances between extant populations, reducing the likelihood of recolonization.
Narrative: At the time of listing, habitat loss from urban development (e.g., road construction and subdivisions) was noted as a threat to the bay checkerspot butterfly. The threat from development still exists, but is not as significant as it was historically, because a number of historical butterfly locations are currently under some form of protection (i.e., all historical occurrences in San Mateo County). Much of the remaining occupied habitat in Santa Clara County is expected to be preserved and managed for the bay checkerspot butterfly and other serpentine species under the Santa Clara Valley HCP/NCCP. A relatively small amount of habitat in Santa Clara County will be lost to development under the HCP/NCCP, but the U.S. Fish and Wildlife Service (USFWS) is not aware of any specific plans for development that would fragment the remaining populations in Santa Clara County. In addition, completion of the Santa Clara Valley HCP/NCCP is expected to protect and manage several thousand ac. of bay checkerspot butterfly habitat, including areas on Coyote Ridge. An ongoing threat is the reduced likelihood that individuals from core populations could recolonize extirpated sites as the distance between extant populations increases due to loss of populations resulting from habitat modification, including the development and conversion of native grasslands to nonnative annual grasslands (USFWS 2009).

Stressor: Vegetation management
Exposure: Butterfly habitat is overgrazed, or grazing is removed entirely.
Response: Nonnative, annual grasses crowd out native forbs, including host plants.
Consequence: Reduction or elimination of suitable habitat, and decreased population.
Narrative: Overgrazing has previously been identified by USFWS as a threat; however, a more common threat today is lack of grazing or undergrazing. Grazing is frequently used as a management tool to reduce standing biomass of nonnative vegetation; however, overgrazing can be a potential threat if grazing densities are not appropriately managed. Studies have found that areas fenced to prevent or remove grazing resulted in an increased nonnative annual grasses and a crowding out of native forbs, including those essential to the bay checkerspot butterfly. Forbs were shown to persist in areas that included limited grazing, and one study reported ambient grazing (one cow and calf per 4 ha [10 ac.]) to be most beneficial over other nonnative plant reduction methods. The USFWS considers limited, appropriately managed amounts of grazing to be beneficial to bay checkerspot butterfly habitat (USFWS 2009).

Stressor: Gopher control

Exposure: Removal of gophers (Thomomys bottae) reduces the herbivorous control of grasses, allowing them to proliferate.
Response: Larval host plants exhibit shorter growing seasons as a result of crowding from unchecked growth of grasses that inhibit small forb persistence.
Consequence: Delays in larval maturation, and reduced reproductive capacity and fitness.
Narrative: It has been hypothesized that soil disturbance or tilling by gophers (Thomomys bottae) may limit the growth of grasses, similar to the result of grazers reducing the standing grass biomass in a system, which allowed the persistence of small forbs. Larval host plants that stay green longer into the dry season may allow more pre-diapause larvae to reach their fourth instar and enter diapause. However, gopher control measures are not widely implemented in areas currently occupied by bay checkerspot butterfly, and the threat potential is low (USFWS 2009).

Stressor: Illegal collection for private or scientific purposes
Exposure: Capture of bay checkerspot butterfly adults.
Response: Direct mortality or wing-wear.
Consequence: Increased chances of extinction or depletion of colonies below survival/recovery thresholds.
Narrative: Adult specimens of rare butterflies, such as the bay checkerspot, are highly valued by private collectors; an international market exists for illegally collected specimens of the species, as well as other listed and rare butterflies. Butterflies in small populations are vulnerable to harm from collection of adult butterflies. A population may be reduced to below sustainable numbers by removal of females, thereby reducing the probability that new populations will be founded. Collectors pose a threat because they may be unable to recognize when they are depleting colonies below the threshold of survival or recovery. Although USFWS is not aware of recent instances of illegal collection, illegal collection is still considered a threat to bay checkerspot butterfly populations because of the small size of many of the remaining populations. Increased foot traffic and certain sampling techniques for scientific purposes may have increased studied populations' risk of extinction as much as 15 percent; however, the effects of a mark-and-recapture study on the bay checkerspot butterfly on Jasper Ridge were found to not significantly increase observable wing-wear, given that handling was conducted by experienced researchers (USFWS 2009).

Stressor: Inadequate regulatory mechanisms
Exposure: Limited protections for take of bay checkerspot butterfly or its habitat.
Response: Direct mortality or destruction/degradation of extant habitat.
Consequence: Reduction in suitable habitat, and reduced population and overall fitness.
Narrative: The Endangered Species Act (ESA) is the primary federal law that provides protection for this species since its listing as threatened in 1987. Other federal or state regulatory mechanisms provide some discretionary protections for the butterfly; however, other laws and regulations have limited ability to protect the bay checkerspot butterfly in the absence of the ESA (USFWS 2009).

Stressor: Pesticide use
Exposure: Application of insecticides and herbicides in or adjacent to butterfly populations.

Response: Potential adverse effects or mortality from larval or adult exposure to pesticides.
Consequence: Unknown
Narrative: Pesticides (which include both insecticides and herbicides) are known to affect a wide range of organisms, and some target butterflies (Lepidoptera) in particular. However; USFWS does not have specific information regarding the use of individual pesticides or their possible adverse effects on the bay checkerspot butterfly beyond a general understanding that pesticides are harmful to a variety of species, including butterflies; therefore, USFWS considers them to be a current threat to the bay checkerspot butterfly. A variety of pesticides are used within the range of the bay checkerspot butterfly, but USFWS does not have specific information regarding pesticide use in occupied habitat (USFWS 2009).

Stressor: Wildfire
Exposure: Wildfire burns uncontrollably in butterfly habitat.
Response: Individuals are harmed or habitat is destroyed during the burn.
Consequence: Direct mortality, population decline, and reduced carrying capacity of habitat.
Narrative: Wildfire may pose a greater risk now than at listing, due to small population size and the current narrow distribution of the butterfly. No bay checkerspot butterflies were observed on San Bruno Mountain after a wildfire burned portions of the mountain in 1986. However, only about 50 adult bay checkerspot butterflies were observed on the mountain in 1984, so their subsequent disappearance may not have been solely related to the fire (over-collection and drought likely contributed to the extirpation at this site). Wildfires can burn large tracts of grassland habitats, and the only remaining core population is on Coyote Ridge in primarily contiguous grassland. A large wildfire at this location could eliminate or result in substantial declines in the core population. Although wildfire poses a significant threat, prescribed fire can be an effective management tool in restoring native grassland ecosystems. The use of fire as a management regime in serpentine grasslands has not been well studied; however, use of prescribed burns may be an effective management tool depending on timing, intensity, and size of the area burned. A wildfire on the northwestern portion of Tulare Hill in 2004 resulted in higher densities of both larval host and adult nectar plants; however, population surveys have not been conducted on that portion of Tulare Hill (USFWS 2009).

Stressor: Small population size
Exposure: Any combination of threats or stressors on a population, including extreme/unusual weather, invasive species, or habitat loss.
Response: Fewer individuals in a population results in greater vulnerability to harmful changes/events.
Consequence: Reduced fitness and resiliency in the face of stochastic events; and local population extirpation.
Narrative: The population size of the bay checkerspot butterfly is heavily dependent on the survival of pre-diapause larvae, which in turn is tied to the timing of host plant senescence (conditional or planned aging or death of plant tissues), which is tied to the annual variation in precipitation and temperature as well as slope aspect (i.e., solar exposure). Populations that are reduced to a small size are less resilient to extreme weather, and are prone to local extirpation. Given the metapopulation dynamic of the bay checkerspot butterfly, population fluctuations,

local extirpations, and recolonization are normal occurrences for the subspecies. However, small population size combined with the species' metapopulation dynamics, climate change, nitrogen deposition, development, and habitat fragmentation is likely a significant threat.

Stressor: Climate change
Exposure: Variability in timing, quantity, and frequency of precipitation, in addition to fluctuation/anomalous seasonal temperatures.
Response: Alteration to host plant life cycle, adult butterfly flight period, and egg hatching.
Consequence: Increased mortality of larvae, population decline, and local population extirpation.
Narrative: The bay checkerspot butterfly is very susceptible to climate change, because the butterfly's development (and mortality) is tied to its host plant's development, which in turn is temperature- and rainfall-dependent. The threat from extreme weather (i.e., periods of prolonged drought or excessive rain) has been expanded to include anthropogenic climate change. Several populations of bay checkerspot butterflies were known to disappear following the droughts in the 1960s, 1970s, and 1980s. Small population size of locations makes them more vulnerable and lowers their ability to withstand changes in climate regime. Changes to precipitation (rainfall) and temperature could shift the development of the butterfly to be out of sync with its host plants. For instance, with periods of drought with warmer, drier climates driving flight periods to occur earlier, and seasonal rains occurring too late, larvae could hatch into habitat exhibiting insufficient food, and this mistiming would lead to increased larval mortality (USFWS 2009).

Recovery

Reclassification Criteria:
Reclassification/uplisting criteria have not been established for this subspecies. The bay checkerspot butterfly is currently listed as threatened, and was recommended for uplisting to endangered status in the most recent 5-year review (USFWS 2009).

Recovery Priority Number: 3C

Delisting Criteria:
The bay checkerspot butterfly will be recommended for delisting with the completion of the following criteria, addressing all four of the listing factors noted in the final rule to list the subspecies (USFWS 1998; USFWS 2009):

Core population – Adult populations of at least 8,000 butterflies, or populations of at least 20,000 post-diapause larvae, in 12 of 15 consecutive years, at each of the following areas (in the Coyote Ridge core population): Kirby, Metcalf, San Felipe, Silver Creek Hills, Santa Teresa Hills, and Edgewood Park. Total population across all core areas should be at least 100,000 adults or 300,000 post-diapause larvae in each of the 12 years, with no recent severe decline (USFWS 1998; USFWS 2009). The Coyote Ridge core population has historically been referred to as four separate populations (Silver Creek Hills, San Felipe, Metcalf, and Kirby Canyon), but what constitutes a population has not been defined, and Coyote Ridge may comprised many populations (USFWS 2009).

Satellite populations – Adult populations of at least 1,000 butterflies, or populations of at least 3,000 post-diapause larvae, in 10 of 15 consecutive years, at each of at least nine distinct areas: three in San Mateo County, five in Santa Clara County, and one in Contra Costa County. Adult populations of at least 300 butterflies, or populations of at least 1,000 post-diapause larvae, in 8 of 15 consecutive years, at each of at least 18 additional distinct areas: 5 in San Mateo County, 10 in Santa Clara County, 1 in Alameda County, and 2 in Contra Costa County. To be “distinct,” populations should be separated by at least 1 km (3,000 ft.) of unsuitable, unrestorable habitat. Note: this criterion is no longer considered valid, given that satellite populations in Alameda and Contra Costa counties are unlikely to be established naturally, due to the distance between them and extant populations being several times greater than the known dispersal capabilities of the bay checkerspot butterfly (USFWS 1998; USFWS 2009).

Protection and management of habitat – Permanent protection of adequate primary (core population), secondary (moderate-sized satellite), and tertiary habitat (small-sized satellite) to support long-term persistence of the metapopulations detailed under criteria 1 and 2 above. For satellite populations, because of their natural tendency to wink in and out of existence at various sites, this will mean protecting more habitat areas than the minimum 9 moderate-sized and 18 small-sized populations. It is estimated that nearly all known suitable habitats in San Mateo, central and western Santa Clara, western Alameda, and Contra Costa counties will be needed to support an adequate constellation of bay checkerspot butterfly satellite populations. Appropriate adaptive management in perpetuity of the bay checkerspot butterfly’s native ecosystem should be guaranteed in all protected habitat, including secure funding for ongoing management (USFWS 1998). Note: this criterion is only considered partially valid. Protecting habitat from development alone has proven insufficient to maintain populations of bay checkerspot; in the absence of appropriate grazing regimes, larval host plants have been outcompeted by nonnative invasive grasses, resulting in extirpation from most historical areas (USFWS 2009).

Investigation and removal of existing or reasonably foreseeable threats to bay checkerspot butterfly populations and habitat (USFWS 1998).

Recovery Actions:

- Develop and implement cooperative programs and participation plans (USFWS 1998).
- Protect and secure existing populations (USFWS 1998).
- Manage habitat (USFWS 1998).
- Survey historic locations and other potential habitat where species covered in the plan may occur. Incorporate any new or rediscovered populations into all aspects of recovery planning (USFWS 1998).
- Conduct necessary biological research, and use results to guide recovery/conservation efforts (USFWS 1998).
- Undertake artificial enhancement, repatriation, or introduction efforts, where necessary (USFWS 1998).

- Periodically review the status of species of concern (USFWS 1998).
- Many of the recovery tasks identified in the Recovery Plan focus on securing and protecting serpentine habitats. All historical bay checkerspot butterfly populations in San Mateo County are now extirpated despite the majority of these sites being protected from development. Protection of historical and existing sites alone appears to be insufficient to recover the butterfly. Management of many of the San Mateo sites is lacking, and may have contributed to the loss of the butterfly in these areas. The development and implementation of appropriate management actions at multiple sites (Recovery task 3.1) may be the most important step in protecting the bay checkerspot butterfly. Once historical sites have management plans that are being implemented and habitat quality improves (i.e., through the establishment of grazing), initiation of introductions (Recovery task 6.2) should proceed to establish core and satellite populations outside of Santa Clara County. A third important task should be the establishment of artificial rearing techniques (Recovery task 5.41). Multiple reintroductions to the same site are likely to be necessary to establish populations. Establishment of artificial rearing techniques for this subspecies, including captive populations, would allow multiple reintroductions of the butterfly without depleting the only remaining core population (USFWS 2009).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Many of the recovery tasks identified in the Recovery Plan focus on securing and protecting serpentine habitats. However, protection of habitat alone may be insufficient to recover the butterfly (e.g., all historical Bay checkerspot butterfly populations in San Mateo County, with the exception of the San Bruno Mountain and Edgewood reintroduction sites, are now extirpated despite the majority of these sites being protected from development). The following recommendations incorporate those from the previous 5-year review, Recovery Plan, and communication with species experts. In addition to continuing habitat protection efforts, many of these recommendations focus on reducing or eliminating threats on protected lands: 1) Create a Bay checkerspot butterfly or Bay Area butterfly Recovery Implementation Team. Bringing together a team including species experts with representatives from partner and regulatory agencies is likely to be beneficial towards advancing recovery objectives, and would aid in coordination related to the recommendations suggested below. 2) Continue to protect and manage habitat for the Bay checkerspot butterfly. The Santa Clara Valley Habitat Agency (the implementing entity for the Santa Clara Valley Habitat Plan) should continue efforts to try to acquire and preserve habitat within the Coyote Ridge population. 3) Continue to develop and implement appropriate management actions. Research comparing efficacy of management techniques in addition to grazing, or correlations between different grazing regimes and Bay checkerspot butterfly population and habitat response, may be useful. Pilot treatments for goatgrass control methods should be considered, and the potential to expand or improve available habitat at Edgewood should be investigated. 4) Follow best practices for conservation translocations. Translocations of at-risk butterflies are discussed in Daniels et al. (2018, entire), and were developed and tested based on the International Union for Conservation of Nature's Guidelines for Reintroductions and Other Conservation Translocations (IUCN 2013, entire). Current translocation methods should be adapted to more closely align with these guidelines. 5) Assess monitoring methods, ability to reproduce results, and efficiency for small populations. Larval surveys at the Silver Creek Preserve and Kirby Slope Preserve (both within the Coyote Ridge core population) were discontinued after 2008 because no larvae were detected by biologists at that site from 2005 through 2008 despite adult presence during surveys (WRA 2010, p. 6; WRA 2019, p. 3), and accuracy of extrapolating low numbers of larvae at other sites is unclear. For example, larval surveys at Tulare Hill had 0 observations in 2019 and 2 larvae in 2020, for a population estimate in the low hundreds (Kent and Niederer 2020, p. 2). 6) Conduct research or analyze available data related to climate change effects on Bay checkerspot butterfly and their habitat. The suitability of historical sites such as Tulare Hill and Edgewood has come into question based on reintroduction attempts, with rising spring temperatures pointed to as potentially linked to declining populations at those sites. Potential areas for research range from correlative studies including long-term monitoring datasets and both exogenous and endogenous factors, to more experimental studies. 7) Revisit the recovery strategy for the species. New information suggests that the Recovery Plan vision that all known suitable habitats in San Mateo, central and western Santa Clara, western Alameda, and Contra Costa Counties are needed to support an adequate constellation of Bay checkerspot butterfly satellite populations may not be a feasible path to recovery and alternative approaches that result in long-term viability should be considered. A more thorough analysis of population resiliency and species' level representation and redundancy would be useful in reassessing the recovery strategy for the species. Available long-term datasets can be leveraged to analyze potential causes and effects of population trends. Potential future reintroductions to historical sites should be evaluated using lessons learned from the three reintroduction sites so far. 8) Consider controlled propagation or headstarting Bay checkerspot butterflies at a captive breeding facility. Although the Coyote Ridge source population seems robust to removal of larvae for translocations to additional locations (Weiss pers. comm. 2021), controlled propagation or headstarting may be considered as an alternative. The Quino checkerspot butterfly (Euphydryas editha quino) population augmentation project (described in Strahm 2018, entire) could serve as a useful model (USFWS, 2022).

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SPECIES ACCOUNT: *Euphydryas editha quino (=E. e. wrighti)* (Quino checkerspot butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 1/16/1997 (62 FR 2313).

Physical Description

The adult Quino checkerspot butterfly (Euphydryas editha quino) has a wingspan of approximately 4 centimeters (cm) (1.5 inches [in.]) (USFWS 2009). The dorsal (top) sides of the wings have a red, black, and cream-colored checkered pattern; the ventral (bottom) sides are dominated by a checkered red and cream pattern. The abdomen of the Quino checkerspot butterfly has red stripes across the top. The Quino differs from other checkerspot butterflies (Euphydryas editha) in a variety of characteristics, including size, wing coloration, and larval and pupal phenotypes (USFWS 2009). After their second molt, Quino checkerspot butterfly larvae can be recognized by the characteristic dark-black coloration and row of eight to nine orange tubercles (fleshy/hairy extensions) on their back. Before their first molt, larvae have a predominantly yellow coloration, and before their second molt they are grey with black markings. Pupae are mottled black on a pale blue-gray background, and are extremely cryptic (USFWS 2003). Three other co-occurring butterfly species look similar: the chalcedon or variable checkerspot (Euphydryas chalcedona), Gabb's checkerspot (Chlosyne gabbi), and Wright's checkerspot (Thessalia leonira wrighti). Chalcedon checkerspot butterfly adults are darker and often larger than Quino checkerspot butterflies, and have white abdominal stripes and spots instead of red stripes. Male and female Gabb’s checkerspot butterfly adults have a more orange appearance than Quino checkerspot butterflies, but female coloration is of higher contrast and may closely resemble Quino checkerspot butterflies. Gabb’s checkerspot butterflies can be differentiated from Quino checkerspot butterflies by silver-white spots on their underwings, the lack of red abdominal stripes, and a scalloped forewing margin (USFWS 2003).

Taxonomy

The Quino checkerspot butterfly is a member of the family Nymphalidae (brush-footed butterflies) and the subfamily Melitaeinae (checkerspots and fritillaries), and one of at least 21 subspecies in this species, which differ in minor maculation characters and sometimes food plant (NatureServe 2015). The taxon now commonly called the Quino checkerspot butterfly has undergone several nomenclatural changes. It was originally described as Melitaea quino and then reduced to a subspecies of Euphydryas chalcedona. At the same time, Euphydryas editha wrighti was described from a checkerspot butterfly specimen collected in San Diego. After reexamining these descriptions and specimens, it was concluded that the Quino checkerspot should be associated with E. editha, not E. chalcedona, and that it was synonymous with E. editha wrighti. Because E. editha wrighti is a junior synonym for the Quino checkerspot, E. editha quino is now the accepted scientific name (USFWS 2009).

Historical Range

The Quino checkerspot butterfly's historical range included much of nonmontane southern California: southwestern Ventura, southwestern San Bernardino, Los Angeles, Western Riverside, and San Diego counties. More than 75 percent of the Quino checkerspot butterfly's historical range has been lost, including more than 90 percent of its coastal mesa and bluff distribution. At listing, Quino checkerspot butterfly populations were reduced in number and size from historical conditions by more than 95 percent range-wide (USFWS 2009).

Current Range

The current range of the subspecies includes multiple areas in southern Riverside County, south into Mexico. All extant populations in the United States are said to occur in southwestern Riverside and north-central San Diego counties. At least one population is known to exist in Mexico, in Sierra Juarez near Tecate (USFWS 2009). The populations occur in north Riverside County (Harford Springs, Canyon Lake, Lake Mathews, Warm Spring Creek, Warm Springs Creek North, Winchester, Domenigoni Valley, and Skinner/Johnson), south Riverside County (Pauba Valley, Black Hills, Vail Lake, Sage, Brown Canyon, San Ignacio, Rocky Ridge, Wilson Valley, Butterfield/Radec, Billy Goat Mountain, Aguanga, Dameron Valley, and Oak Grove), south Riverside and north San Diego counties (Southwest Cahuilla, Tule Peak, Silverado, Spring Canyon, Cahuilla Creek, Bautista Road, Pine Meadow, and Lookout Mountain), southwest San Diego County (San Vicente Reservoir, Alpine, West Otay Mesa, Otay Valley, West Otay Mountain, Otay Lakes/Rancho Jamul, Proctor Valley, Jamul, Hidden Valley, Rancho San Diego, Los Montañas, Honey Springs, Dulzura, Marron Valley, Barrett Junction, and Tecate), southeast San Diego (Jacumba Peak), southeast San Diego, and Baja California (Otay Mountain in Baja California) (USFWS 2003).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/15/2002.

Legal Description

On June 17, 2009, the U.S. Fish and Wildlife Service (Service)designated final revised critical habitat for the Quino checkerspot butterfly (Euphydryas editha quino) under the Endangered Species Act of 1973, as amended (Act). Approximately 62,125 acres (ac) (25,141 hectares (ha)) of habitat in San Diego and Riverside Counties, California, are being designated as critical habitat for the Quino checkerspot butterfly. This final revised designation constitutes a reduction of approximately 109,479 ac (44,299 ha) from the 2002 designation of critical habitat for the Quino checkerspot butterfly.

Critical Habitat Designation

Approximately 62,125 ac (25,141 ha) are designated as critical habitat for the Quino checkerspot butterfly within 9 units, identified as Units 2 through 10 (proposed critical habitat Unit 1 is excluded in its entirety.

Unit 2: Skinner/Johnson. Unit 2 consists of approximately 5,444 ac (2,203 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta, Antirrhinum coulterianum, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 39, 41; Service GIS database). Unit 2 is located in Riverside County, north of the City of Temecula, in the vicinity of Lake Skinner. This unit includes land associated with the Skinner/Johnson Core Occurrence Complex as described in the Recovery Plan (Service 2003a, p. 79). The physical and biological features found in Unit 2 may require special management considerations or protection to minimize impacts from maintenance and recreational activities, invasion by nonnative plants, fire, enhanced soil nitrogen, and climate change.

Unit 3: Sage. Unit 3 consists of approximately 123 ac (50 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 41, 43; Service GIS database). Unit 3 is located in Riverside County, northeast of Temecula, in the vicinity of the community of Sage. This unit includes land associated with the Sage Core and San Ignacio Non-core Occurrence Complexes described in the Recovery Plan (Service 2003a, p. 79). New occurrence information indicates the San Ignacio Non-core Occurrence Complex should be considered part of the Sage Core Occurrence Complex (see ''Background'' and ''Criteria Used To Identify Critical Habitat'' sections above). The physical and biological features found in Unit 3 may require special management considerations or protection to minimize impacts from recreational activities, trash dumping, invasion by nonnative plants, fire, enhanced soil nitrogen, and climate change.

Unit 4: Wilson Valley. Unit 4 consists of approximately 463 ac (187 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta, P. patagonica, Antirrhinum coulterianum, Collinsia concolor, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 41, 43; Pratt 2008b pp. 1–2; 2008e, p. 1; Service GIS database). Unit 4 is located in Riverside County, north of SR 79, east of Oak Mountain and the City of Temecula in the vicinity of Wilson Valley. This unit includes land associated with the Wilson Valley Core Occurrence Complex described in the Recovery Plan (Service 2003a, p. 79). The physical and biological features found in Unit 4 may require special management considerations or protection to minimize impacts from recreational activities, trash dumping, invasion by nonnative plants, fire, enhanced soil nitrogen, and climate change.

Unit 5: Vail Lake/Oak Mountain. Unit 5 consists of approximately 1,788 ac (724 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 41, 43; Service GIS database). Unit 5 is located in Riverside County, north and south of SR 79, and east of Temecula within the vicinity of Oak Mountain and Vail Lake. This unit includes land associated with the Vail Lake Core Occurrence Complex and Butterfield/Radec Non-core Occurrence Complex described in the Recovery Plan (Service 2003a, p. 79). New occurrence information indicates the Butterfield/ Radec Non-core Occurrence Complex should be considered part of the Vail Lake Core Occurrence Complex (see the proposed revised critical habitat rule, 73 FR 3328; January 17, 2008). The physical and biological features found in Unit 5 may require special management considerations or protection to minimize impacts from recreational activities, trash dumping, invasion by nonnative plants, fire, enhanced soil nitrogen, and climate change.

Unit 6: Tule Peak. Unit 6 consists of approximately 326 ac (132 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago patagonica, Antirrhinum coulterianum, Collinsia concolor, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open, woody canopy scrublands; and hilltops (Service 2003a, pp. 44–47; Service GIS satellite imagery; Pratt 2008a, p. 1; 2008b, p. 1; 2008c, p. 1; 2008d, p. 1; 2008e, p. 1). Unit 6 is located in Riverside County, south of SR 371 and the community of Anza, in the vicinity of Tule Peak Road and the southern boundary of the Cahuilla Band of Indians' lands. This unit includes land associated with the Tule Peak/ Silverado Core Occurrence Complex (see ''Background'' section above). The physical and biological features found in Unit 6 may require special management considerations or protection to minimize impacts from recreational activities, primarily unauthorized off-road vehicle activity (Service 2003b, p. 79), trash dumping, invasion by nonnative plants, fire, and climate change.

Unit 7: Bautista. Unit 7 consists of approximately 13,880 ac (5,617 ha) of habitat that was not within the geographical area occupied by the subspecies at the time of listing (although this area falls within the historical range of the species). Currently this unit contains habitat that may be unoccupied by individuals in a given year, but lands within this unit are considered occupied at the population level. This unit contains the Bautista Road Core, Pine Meadow Noncore, Lookout Mountain Non-core and Horse Creek Non-core Occurrence Complexes (see ''Background'' and ''Criteria Used To Identify Critical Habitat'' sections above). As further discussed in the ''Criteria Used To Identify Critical Habitat'' section, we determined habitat connectivity to higher elevation occurrence complexes is essential for the conservation of the subspecies, and, therefore, that the area in Unit 7 is essential for the conservation of the subspecies. Additionally, this unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago patagonica, Antirrhinum coulterianum, Collinsia concolor, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woodycanopy scrublands; and hilltops (Service 2003a, pp. 44–47; Service GIS database; Anderson 2008, pp. 1–5). Unit 7 is located in Riverside County north of SR 371 and the community of Anza.

Unit 8: Otay. Unit 8 consists of approximately 34,941 ac (14,140 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all of the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 50, 51; Service GIS database). Unit 8 is located in San Diego County, from the Mexican border to north of SR 94 in the vicinity of Otay Mountain and Otay Lakes. This unit includes land associated with the Otay Mountain Core Occurrence Complex (see ''Background'' and ''Summary of Changes From Previously Designated and Proposed Revised Critical Habitat'' sections above). The physical and biological features found in Unit 8 may require special management considerations or protection to minimize impacts from loss and fragmentation of habitat and landscape connectivity due to development, maintenance and recreational activities, trash dumping, invasion by nonnative plants, fire, enhanced soil nitrogen, and climate change.

Unit 9: La Posta–Campo. Unit 9 consists of approximately 2,647 ac (1,071 ha) of habitat that was not within the geographical area occupied by the subspecies at the time of listing. However, this unit is currently occupied and contains the La Posta/Campo Core Occurrence Complex (see ''Status and Distribution of Populations in San Diego County'' section of the proposed rule published January 17, 2008 (73 FR 3328), and ''Criteria Used To Identify Critical Habitat'' section above). We determined that the area supporting the La Posta/ Campo Core Occurrence Complex is essential for the conservation of the subspecies because it is likely to contain a resilient core population including one or more subpopulations that are a source of immigrants to other habitat (see ''Background'' and ''Criteria Used To Identify Critical Habitat'' sections above). Additionally, this unit contains all the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Antirrhinum coulterianum, Collinsia concolor, Cordylanthus rigidus, and Castilleja exserta host plants; nectar sources; open woody-canopy scrublands; and hilltops (Bureau of Indian Affairs 1992, p. C–5; Allen and Kurnow 2005, pp. 10, 13–16; Dicus 2005a, p.1; PSBS 2005a, p. 18; 2005b, p. 26; O'Conner 2006, pp. 1–4, Science Applications International Corporation 2006 pp. 33, 34, 37; Alfaro and Alfaro 2007, pp. 6–8; Service GIS database).

Unit 10: Jacumba. Unit 10 consists of approximately 2,514 ac (1,017 ha) of habitat that was occupied by the subspecies at the time of listing and is currently occupied. This unit contains all the features essential to the conservation of the subspecies (PCEs 1, 2, and 3), including the following: Plantago erecta and P. patagonica host plants; nectar sources; open woody-canopy scrublands; and hilltops (Service 2003a, pp. 52, 54; Service GIS database). Unit 10 is located in San Diego County south of Interstate 8 and north of the community of Jacumba. This unit includes land associated with the Jacumba Core Occurrence Complex (see ''Background'' and ''Criteria Used To Identify Critical Habitat'' sections above). The physical and biological features found in Unit 10 may require special management considerations or protection to minimize impacts from loss and fragmentation of habitat and landscape connectivity due to development, recreational activities, trash dumping, invasion by nonnative plants, fire, and climate change.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Riverside and San Diego Counties, California. The primary constituent elements of critical habitat for the Quino checkerspot butterfly are:

(i) Open areas within scrublands at least 21.5 square feet (ft2) (2 square meters (m)) in size that: (A) Contain no woody canopy cover; and (B) Contain one or more of the host plants Plantago erecta, Plantago patagonica, Antirrhinum coulterianum, or Collinsia concolor used for Quino checkerspot butterfly growth, reproduction, and feeding; or (C) Contain one or more of the host plants Cordylanthus rigidus or Castilleja exserta that are within 328 ft (100 m) of the host plants listed in paragraph (2)(i)(B) above; or (D) Contain flowering plants with a corolla tube less than or equal to 0.43 in (11 mm) used for Quino checkerspot butterfly feeding;

(ii) Open scrubland areas and vegetation within 656 ft (200 m) of the open canopy areas (described in paragraph (2)(i) of this entry) used for movement and basking; and

(iii) Hilltops or ridges within scrublands, containing an open, woodycanopy area at least 21.5 ft2 (2 m2) in size used for Quino checkerspot butterfly mating (hilltopping behavior) and are contiguous with (but not otherwise included in) open areas and natural vegetation described in paragraphs (2)(i) and (ii) above.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule.

Management needs and actions recommended in the Recovery Plan that may be required to protect and maintain the PCEs for the Quino checkerspot butterfly include: (1) Reestablishment and maintenance of habitat and landscape connectivity within and between populations (Service 2003a, pp. 57, 96–101); (2) habitat restoration and control of invasive nonnative species (Service 2003, pp. 58, 96–101, 146–159); (3) monitoring of ongoing habitat loss and nonnative plant invasion (Service 2003a, p. 106); (4) phased replacement of grazing with nonnative invasive plant control (Service 2003, pp. 60, 101–102); (5) carefully controlled burn experiments to assess effectiveness for control of nonnative plant invasion and protection of PCEs from wildfire destruction (Service 2003, p. 61); (6) reduction of local nitrogen emissions from sources such as hightraffic roads (Service 2003a, p. 62); (7) management of off-road vehicle activity (Service 2003a, pp. 59, 146– 159), including outreach and partnerships with local off-road vehicle clubs and organizations (Service 2003a, p. 105); (8) reduction of trash dumping in habitat (Service 2003a, p. 109); and (9) prudent design of managed habitats to include landscape connectivity (suitable habitat connectivity) and ecological connectivity (connectivity of wildlands that may not currently include habitat) (Service 2003a, pp. 65, 96).

Life History

Feeding Narrative

Larvae: Quino checkerspot butterflies are herbivores and rely completely on the host plants, including dwarf plantain (Plantago erecta), Patagonian plantain (Plantago patagonica), white snapdragon (Anterrhinum coulterianum), or Chinese houses (Collinsia concolor) for feeding (USFWS 2009). The host plants face competition from nonnative species for survival (USFWS 2003). In open, woody canopy communities, larvae seek microclimates with high solar exposure for basking, to speed their growth rate (USFWS 2009). Older pre-diapause larvae usually wander independently in search of food, and may switch to feeding on a different species of host plant. All known species of host plant may serve as primary or secondary host plants, depending on location and environmental conditions (USFWS 2003; USFWS 2009).

Adult: Quino checkerspot butterflies are nectarivores and require the presence of one of the host plants, including dwarf plantain (Plantago erecta), Patagonian plantain (Plantago patagonica), white snapdragon (Anterrhinum coulterianum), or Chinese houses (Collinsia concolor) in their environment for feeding (USFWS 2003). Adult Quino checkerspot butterflies have a short tongue, approximately 11 millimeters (mm) (0.43 in.) long, and typically cannot feed on flowers that have deep corolla tubes or flowers evolved to be opened by bees. Therefore, flowers with a corolla tube greater than 11 mm (0.43 in.) are less likely to be used as nectar sources. In addition, nectar sources greater than 200 meters (m) (656 feet [ft.]) from larval host plants are not likely used by the Quino checkerspot butterfly (USFWS 2009).Quino are ectothermic (cold-blooded) and therefore require an external heat source to increase their metabolic rate to levels needed for normal growth and behavior. Like most butterflies, adult Quino frequently bask and remain in sunny areas to increase their body temperature to the level required for normal active behavior (USFWS 2009). Flight is not possible below about 16°C (60°F).

Reproduction Narrative

Larvae: The Quino checkerspot butterfly life cycle includes four distinct life stages: egg, larva (caterpillar), pupa (chrysalis), and adult, with the larval stage divided into five to seven instars (periods between molts, or shedding skin). Larvae may remain in diapause (summer dormancy) for multiple years or re-enter diapause several times, prior to maturation. (USFWS 2009) Eggs typically hatch in 10 to 14 days. During larval development, the host plants age, eventually drying out and becoming inedible (senescence). At the time of host plant senescence, if larvae are old enough and have accumulated sufficient reserves, they are able to enter diapause. While in diapause, larvae are much less sensitive to climatic extremes and can tolerate temperatures from above 49 degrees Celsius (°C) (120 degrees Fahrenheit [°F]) to below freezing. Return to diapause may also occur under conditions when plants are unusually dry or developmentally advanced, because poor host plant conditions can result in high larval mortality. Larvae appear to have a narrow window of time during which diapause may be re-entered. Last instar larvae do not appear to be able to re-enter diapause, and repeated diapause has only rarely been observed in next-to-last instar larvae. There is probably also a significant mortality risk during diapause, so the likelihood of successful development and reproduction must be lower than the probability of surviving a second season of diapause for repeated diapause to have a fitness benefit. (USFWS 2003) Sufficient rainfall, usually during November or December, apparently causes larvae to break diapause. Records of rare late second flight seasons following unusual summer rains indicate that the Quino checkerspot butterfly does not require winter chilling to break diapause, and may not diapause at all under some circumstances. Because of variable weather during winter and early spring, the time between diapause termination and pupation can range from 2 weeks, if conditions are warm and sunny, to 2 or 3 months, if cold, rainy conditions prevail (USFWS 2003). In addition to the host plants identified, egg clusters and pre-diapause larval clusters have also been documented in the field on thread-leaved bird's beak

(Cordylanthus rigidus) and purple owl's-clover (Castilleja exserta). However, these species are rarely used, and are not believed to support breeding alone (USFWS 2003).

Adult: There is one generation of adult Quino checkerspot butterfly per year. Adult butterflies will only deposit eggs on larval host plants. Quino checkerspot butterfly oviposition (i.e., egg deposition) has been documented on erect or dwarf plantain (Plantago erecta), Patagonian plantain (Plantago patagonica), and white snapdragon (Anterrhinum coulterianum). In 2008, oviposition and larval development were recorded for the first time on a new species of host plant, Chinese houses (Collinsia concolor). The two most important factors affecting the suitability of host plants (i.e., dwarf plantain, Patagonian plantain, white snapdragon, or Chinese houses) for Quino checkerspot butterfly oviposition are exposure to solar radiation and phenology (timing of the plant's development). Adult female butterflies are adept at selecting those plants that receive adequate sunshine and will remain edible the longest. Egg clusters and pre-diapause larval clusters have also been documented in the field on thread-leaved bird's beak (Cordylanthus rigidus) and purple owl's-clover (Castilleja exserta) (USFWS 2003). However, these species are rarely used, and are not believed to support breeding alone (USFWS 2003).Females are less likely to deposit eggs on host plants that are shaded by other plants, and instead deposit eggs on plants located in full sun, preferably surrounded by bare ground or sparse, low vegetation (USFWS 2009).The flight period (coincident with breeding period) begins in late January to early March and continues as late as early May, depending on weather conditions. If sufficient rain falls in late summer or early fall, a rare second generation of reduced numbers may occur. Females lay egg clusters, two times a day for their entire lifetime (10 to 14 days). Egg clusters are typically 20 to 150 eggs, only a small fraction of which are likely to survive to maturity. Destruction of eggs by predators and physical disturbance can be substantial (USFWS 2003).

Geographic or Habitat Restraints or Barriers

Larvae: Same as adult.

Adult: Unsuitable habitat; shaded areas and closed-canopy vegetation limit the distribution (USFWS 2003).

Spatial Arrangements of the Population

Larvae: Same as adult.

Adult: Clumped

Environmental Specificity

Larvae: Same as adult.

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Larvae: Same as adult.

Adult: Low

Site Fidelity

Larvae: Same as adult.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Same as adult.

Habitat Narrative

Larvae: See Adult narrative.

Adult: Habitat for the Quino checkerspot butterfly includes shrublands classified as coastal sage scrub, open chaparral, juniper woodland, and native grasslands. These areas are characterized by patchy shrub or small tree landscapes with openings of several m (tens of ft.) between woody plants, or a landscape of open swales alternating with dense patches of shrubs. The species will frequently alight on vegetation or other substrates to mate or bask, and require open areas with high solar exposure to facilitate breeding and movement. Habitat destruction has limited available habitat. In addition, shaded areas and closed-canopy vegetation limit the distribution of the Quino checkerspot butterfly (USFWS 2009).If air temperature is cool, clear skies and bright sunshine may provide enough thermal power for flight, but flight is not possible below about 16°C (60°F). In warmer air temperatures, flight may still be possible with scattered clouds or light overcast conditions, but has not been observed in very cloudy, overcast, or foggy weather. Adults remain hidden (often roosting in bushes or trees) during fog, drizzle, or rain, and usually avoid flying in windy conditions (sustained winds greater than 24 kilometers (km) [15 miles (mi.)] per hour) (USFWS 2003).The habitats at Harford Springs, Canyon Lake, and Lake Mathews in northwest Riverside County typically support abundant dwarf plantain on exposed soil patches. It is not possible to determine habitat suitability based on standing host plant densities. Densities of dwarf plantain required for larval development have been estimated; however, it is not always possible to determine typical host plant densities, because germinating host plants may be entirely consumed by larvae, or seeds may not germinate and larvae may return to in diapause when precipitation levels are below-average. These principles apply to all host plant species to some extent; therefore, host plants detected in habitat appearing otherwise suitable should be considered an indicator of habitat suitability (USFWS 2003).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Low

Adult: When quality host plants are in short supply, adult Quino checkerspot butterflies respond by dispersing (USFWS 2003).

Immigration/Emigration

Larvae: No

Adult: Immigrates/emigrates.

Dispersal/Migration Narrative

Larvae: Newly hatched pre-diapause larvae cannot move more than a few cm (couple of in.) during the first two instars, restricting their development during this stage to the individual host plant where the eggs were deposited (USFWS 2009). Older pre-diapause larvae usually wander independently in search of food, and may switch to feeding on a different species of host plant (USFWS 2009). Quino checkerspot larvae rely completely on one of the host plants (i.e., dwarf plantain, Patagonian plantain, white snapdragon, or Chinese houses) (USFWS 2003).

Adult: Quino checkerspot butterflies have moderate motility and rely on one of the host plants (i.e., erect or dwarf plantain, Patagonian plantain, white snapdragon, or Chinese houses) to be present for dispersal. If air temperature is cool, clear skies and bright sunshine may provide enough thermal power for flight, but flight is not possible below about 16°C (60°F). They are a nonmigratory species of butterfly, and appear to exhibit sedentary behavior during the majority of their adult life in most seasons; nectar sources greater than 200 m (656 ft.) from larval host plants are not likely used by the Quino checkerspot butterfly (USFWS 2009).The female checkerspot butterflies have been found to be more likely to emigrate than males (USFWS 2003). When female butterflies of the Edith's checkerspot (E. editha) species fail to encounter preferred host plants, the likelihood of emigration to other suitable habitat patches increases. In addition, older adults appear to have a greater tendency to disperse as host plant suitability and female egg loads decline (USFWS 2003). Dispersal tendency also increases when densities are low and dry conditions reduce the number and suitability of host plants for depositing eggs (oviposition) (USFWS 2003). It is difficult for higher elevation populations to recolonize lower elevation habitats, because host plant and other aspects of breeding habitat suitability decline earlier at lower elevations with the approach of drier summer weather (USFWS 2009).Establishment of local populations in distant habitat patches may be achieved in a single season through dispersal of individual butterflies, or over several seasons through “stepping-stone” habitat patch establishment events (USFWS 2003). Dispersal and recolonization events were high during the 1990s and 2000s, but abundance peaked during the 2000s (USFWS 2009). Long-distance movements by individuals are not common, but may be sufficient to allow for infrequent between-patch exchanges of up to 6 km (3.7 mi.) (USFWS 2003). Quino checkerspot butterflies have been observed flying several hundred m (couple hundred ft.) from the nearest larval host plant micro-patch to nectar sources (USFWS 2003).

Population Information and Trends

Population Trends:

Short-term: stable; long-term: decline of 90 percent (NatureServe 2015).

Species Trends:

Declining

Number of Populations:

37 extant occurrence complexes, 26 presumed extant (USFWS, 2023)

Population Size:

1,000 to 100,000 (NatureServe 2015).

Resistance to Disease:

Unknown (USFWS 2009)

Adaptability:

Low

Additional Population-level Information:

Available population size Information is inadequate. An important consideration is that a robust population can produce zero adults in particularly unfavorable climatic conditions, because larvae can probably remain in diapause through more than one season when food plant availability or quality is poor, feeding briefly and then re-entering diapause for at least another season (NatureServe 2015).

Population Narrative:

In 1997, it was predicted that Quino checkerspot butterfly would be the “passenger pigeon butterfly” – a once common, widespread species crashing to extinction over a few decades (USFWS 2009). The recent population trend of the Quino checkerspot butterfly is stable; however, the species has experienced a long-term decline of 90 percent (NatureServe 2015). The Quino checkerspot butterfly is a climate-sensitive, “eruptive” species that periodically experiences order-of-magnitude increases in abundance every 5 to 20 years, then drops back to much lower abundance over time (USFWS 2009).Based on population distribution estimates, there may have been as many as 37 extant populations at the time of listing; there are currently 33, with 10 categorized as “core” (USFWS 2009). Distribution studies over multiple years are required to quantify Quino population distributions based on recorded subspecies locations. Therefore, the U.S. Fish and Wildlife Service (USFWS) discusses Quino population locations in terms of “occurrence complexes” (best estimators of approximate population location and population membership). Some occurrence complexes are identified as “core.” These occurrence complexes are considered likely centers of population density based on characteristics including geographic size, number of reported individuals, documented reproduction, and repeated observations. Population distributions documented post-listing consist of six core and 15 noncore extant distributions, six noncore distributions of unknown status, and four noncore distributions extirpated post-listing.Among these populations there is inadequate information to estimate the total population size. In general, the population size is believed to be somewhere between 1,000 and 100,000 individuals. An important consideration is that a robust population can produce zero adults in particularly unfavorable climatic conditions, because larvae can probably remain in diapause through more than one season when food plant availability or quality is poor, feeding briefly then re-entering diapause for at least another season (NatureServe 2015).Stochastic events are a threat that can severely reduce population abundance. Although natural catastrophic events existed under historical environmental conditions and were likely to temporarily impact resilient populations, increased frequency and intensity of stochastic events due to climate change has made the Quino checkerspot butterfly population more vulnerable. Small population size also increases the species' vulnerability to stochastic events, makes it more difficult for individuals to find mates, and may result in inbreeding. The extirpation of Quino from Orange County is an example of permanent regional-scale loss of populations due to a combination of human impacts and natural (from a historical/evolutionary perspective) fluctuations in abundance (USFWS 2009). Populations that are geographically closest to each other are genetically closest to each other (USFWS 2003). There are a variety of status changes to Quino occurrence complexes since the last review. There are 18 newly documented occurrence complexes; the status improved for 20 occurrences (documented occupancy, decreased uncertainty, and/or size expansion); worsened for 27 (increased uncertainty or extirpation); and 15 had no change in status (Table 1). These are slightly different categories (Extirpated, Possibly extirpated, Presumed extant, Extant) than we used in the last 5-year review (Extirpated, Unknown, Extant; Service 2009 p. 42). Table 1 indicates how the status changed in terms of improved or worsened status using the definitions above. Although the apparent positive changes (38 newly documented or improved status) outnumber the negative (27 extirpated or worsened status), this information must be assessed in the context of metapopulation dynamics. While occurrence complex extirpations are likely permanent without intervention, all occurrence complex polygons (Figures 1 and 2), represent a historical metapopulation footprint; expanded polygons represent historically occupied habitat and can also include habitat that has been developed or is unoccupied. Due to the ephemeral nature of Quino subpopulations, no habitat patches should be considered permanently occupied, which is why occurrence complexes represent population-scale shifting occupancy areas used by adults over a period of years to decades (Service 2003, p. 24). We did not quantify temporary or permanent decreases in occupancy of occurrence complexes, or reduced habitat suitability, only increases in occurrence complex polygon size. For example, habitat patches in significant portions of some extant core occurrence complexes, such as Skinner/Johnson, have been permanently lost (Service 2009, Figures 1 and 2; Cornelisse 2020, p. 17). There are a total of 37 extant occurrence complexes, 26 presumed extant, 12 extirpated, and 5 possibly extirpated. There are also 10 new occurrence complexes recorded since 2009; 4 were previously recorded but not analyzed/listed in the last 5-year status review (Table 1) (USFWS, 2023).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Human activities, fragmentation, and recreation.
Response: Reduction in habitat.
Consequence: Reduction in population size.
Narrative: At the time of listing, the Quino checkerspot butterfly was imperiled primarily because habitat was being damaged, fragmented, and destroyed by human activities. Urban development, grazing, and invasion of nonnative plants were the predominant threats at that time. These threats included loss and fragmentation of habitat and landscape connectivity, invasion by nonnative plants, off-road vehicle activity, grazing, enhanced soil nitrogen, and increased atmospheric carbon dioxide concentration. Little has changed with regard to the magnitude and immediacy of these threats since publication of the Recovery Plan. Loss and modification of Quino checkerspot butterfly habitat continues to be a primary threat to the subspecies, especially in areas where urbanization is expected to expand.

Stressor: Recreational activities
Exposure: Off-road vehicle use, and proximity to human populations.
Response: Compaction of soil, destruction of host plants, and increased erosion and fire frequency.
Consequence: Reduction in host plants, and reduction in quality habitat.
Narrative: Frequent off-road vehicle use compacts soil, destroys host plants, increases erosion and fire frequency, creates trails that are conduits of nonnative plant invasion, and in occupied habitat causes direct mortality of Quino checkerspot butterflies. Increased human population densities proximal to occupied Quino habitat increase the rate of disturbance due to recreational activities such as off-road vehicle activity. Recreational disturbance is frequently observed in monitored, occupied habitat where larvae are observed on host plants (USFWS 2009).

Stressor: Nonnative species
Exposure: Land conversion, agricultural areas, residential areas, and animal grazing.
Response: Reduced abundance and suitability of host plants, and increased dominance of nonnative plants, rates of invasion, and habitat fragmentation.
Consequence: Reduction in host plants, and direct mortality.
Narrative: Conversion from native vegetation to nonnative annual grassland is the greatest threat to conserved habitat. Increased dominance of nonnative plant species reduces the abundance (by competition) and suitability (by shading) of Quino checkerspot butterfly host plants. Females are less likely to deposit eggs on host plants that are shaded by other plants, and instead deposit eggs on plants located in full sun, preferably surrounded by bare ground or sparse, low vegetation. Habitat fragmentation exacerbates vegetation type conversion because ground disturbance and edge effects in fragments with large edge-to-area ratios experience higher rates of invasion.Nitrogen deposition also influences nonnative plant invasion by increasing soil fertility,

because invasive species are often better competitors for soil nutrients than native plant species. Soils in urbanized and agricultural regions are often fertilized by excess nitrogen generated by human activities, and this threat continues to increase in magnitude as human population densities increase. Soils in the most polluted regions near Riverside, California, have more than 80 parts per million (weight) extractable nitrogen, which is more than four times the typical concentration detected in natural, unpolluted soils.Grazing by cattle and sheep also increases initial rates of invasion by nonnative plants by disturbing the soil, and causes direct mortality of Quino checkerspot butterfly. However, once grazing is removed, the rate of nonnative plant invasion increases (USFWS 2009).

Stressor: Overutilization
Exposure: Collection of Quino checkerspot butterflies.
Response: See narrative.
Consequence: Unknown
Narrative: At the time of listing, over-collection was considered a potential threat to Quino checkerspot butterfly because of specimen value to collectors. The impact of overutilization for any purpose is not known at this time (USFWS 2009).

Stressor: Lack of regulatory mechanism
Exposure: Lack of listing in Mexico.
Response: No protection for species or habitats.
Consequence: Reduction in population size.
Narrative: There are no existing regulatory mechanisms that protect the Quino or its habitat in Mexico. The Quino is not listed under the Mexican equivalent of the Endangered Species Act (Norma Official Mexicana NOM-059) (USFWS 2009).

Stressor: Stochastic events
Exposure: Random events, small population size.
Response:
Consequence: Reduction in populations and abundance, and inbreeding.
Narrative: Droughts, wildfires, and floods can severely reduce population abundance of Quino checkerspot butterflies. Although natural catastrophic events existed under historical environmental conditions and were likely to temporarily impact resilient populations, increased frequency and intensity of stochastic events due to climate change has made the Quino checkerspot butterfly population more vulnerable. Small population size also increases the vulnerability of the species to stochastic events, makes it more difficult for individuals to find mates, and may result in inbreeding (USFWS 2009).

Stressor: Climate change
Exposure: Change in climate.
Response: Reduced growth rate and increased extirpation rates, increased diapause death, and butterfly-host asynchrony.
Consequence: Mortality, reduction in population, and extirpations.

Narrative: Studies demonstrate a correlation of population distribution and phenology changes with climate changes for many other butterfly and insect species in California and around the world. Metapopulation viability analyses of other endangered nymphalid butterfly species also indicate that current climate trends pose a major threat to butterfly metapopulations by reducing butterfly growth rates and increasing subpopulation extirpation rates. The ongoing and predicted climate change trends likely contribute to increased pre-diapause larval death due to early host plant aging at the southern range edge (in Mexico) and at lower elevations in the United States. Field studies have documented population crashes and extirpations in several butterfly species, including Edith's checkerspot, as a direct result of butterfly-host asynchrony (USFWS 2009).

Stressor: Illegal Marijuana Growing (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: "The Anza [Quino] populations are still here, although they have suffered drastically from a variety of things. One of the major problems is caused by local marijuana growing. Pesticides, herbicides, fertilizers, etc. put into the habitat where Quino occur have taken their toll upon local populations. Converting land use for marijuana growing on even Federal lands set aside in part for Quino such as with the Beauty Mountain Wilderness seems to have caused drastic reductions in populations. Less than 10 years back I could walk local drainages and literally see hundreds of Quino, now I can walk the same drainages and consider myself lucky to see one." (USFWS, 2023).

Recovery

Reclassification Criteria:
According to the 5-year review, the recovery criteria are still applicable, but some criteria require updating. The Quino Recovery Plan (USFWS 2003) did not have threat-based recovery criteria (USFWS 2009). The Quino checkerspot butterfly could be downlisted to threatened when the following criteria are met:

Permanently protect the habitat within occurrence complexes (estimated occupied areas based on habitat within 1 km [0.6 mi.] of recent butterfly occurrences), in a configuration designed to support resilient populations. One or more occurrence complexes may belong to a single greater population distribution, or an occurrence complex may contain more than one whole or partial population distribution. When population distributions are determined, they will replace the occurrence complex as the protected unit. There are currently 46 described occurrence complexes (USFWS 2009).

Conduct research, including determining the current short-term and potential long-term distributions of populations and associated habitat; and preliminary modeling of metapopulation dynamics for core occurrence complexes (USFWS 2009).

Permanently provide for and implement management of occurrence complexes (or population distributions when delineated) to restore or enhance habitat quality and population resilience (USFWS 2009).

The protected, managed (conserved) population segments in core occurrence complexes (or population distributions when delineated) must demonstrate evidence of resilience. Evidence of resilience is demonstrated if a decrease in the number of occupied habitat patches over a 10- to 20-year period in an occurrence complex (or population distribution when delineated) is followed by increases of equal or greater magnitude. Monitoring must be initiated in the third of 3 years of favorable climate (total annual January and February precipitation within one standard error of the average total for those months over the past 30 years, based on local or proxy climate data). Populations that do not demonstrate resilience after 20 years should be augmented and monitoring reinitiated (USFWS 2009).

One additional population should be documented or introduced in the Lake Mathews population site (formerly occupied, not known to be currently occupied) in the Northwest Riverside Recovery Unit. At least one of the extant populations outside of current recovery units (e.g. the San Vicente Reservoir occurrence complex) must meet resilience specifications above, unless an additional population is established or documented within 10 km (6 mi.) of the ocean (a more stable marine climate influence should minimize susceptibility to drought and reduce probability of extirpation) (USFWS 2009).

Establish and maintain a captive propagation program for purposes of maintenance of representative refugia populations, research, and reintroduction and augmentation of wild populations, as appropriate (USFWS 2009).

Initiate and implement a cooperative outreach program targeting areas where Quino checkerspot butterfly populations are concentrated in western Riverside and southern San Diego counties (USFWS 2009).

ADDITIONAL AND AMENDED RECOVERY ACTIONS The goals of this recovery plan remain: (1) protecting habitat supporting known current population distributions (occurrence complexes) and connectivity among them; (2) maintaining or creating resilient populations; and (3) conducting research necessary to achieve recovery criteria. Recommendations made in the recovery action narrative required to achieve these goals (Service 2003, pp. 96–113) and meet the amended criteria should be generally the same, except with respect to site specificity (updated occurrence complexes as described in criteria, illustrated in Figures 1– 3, and listed in Table 1). Specific sites where actions are applicable should be clear in the recovery criteria. Below are new actions: 1) Seek funding for acquisition of habitat from willing sellers in areas described in delisting criteria (Priority 1). 2) In the South Riverside/North San Diego Recovery Unit, in the vicinity of the community of Anza, determine areas that would best provide ecological connectivity among core occurrence complexes that do not include Tribal lands (Cahuilla Band of Indians). Work with State, Federal, and local government agencies to conserve these areas, and to conserve habitat outside of Tribal lands (Ramona Band of Cahuilla, Santa

Rosa Band of Cahuilla Indians) associated with the Bautista Road core, and Table Mountain Truck Trail and Lookout Mountain non-core occurrence complexes. Work with Tribal partners to plan for voluntary ecological connectivity and habitat conservation as appropriate (Priority 1). 3) Determine areas that would best provide ecological connectivity in southern San Diego County among core occurrence complexes that do not include Tribal lands (Barona Band of Mission Indians, Viejas Band of Kumeyaay Indians, Sycuan Band of the Kumeyaay Nation). Work with State, Federal, and local government agencies to conserve these areas. Secure remaining ecological connectivity in non-Tribal land bottleneck north of the Barona Band of Mission Indians' reservation (vicinity of San Vicente Road). Work with Tribal partners to determine recovery value and Tribal conservation status of ecological connectivity within the Capitan Grande Reservation. Work with Tribal partners to plan for voluntary ecological connectivity conservation as appropriate (Priority 1). 4) In Southeast San Diego County, in the vicinity of the communities of Campo and La Posta, determine areas that would best provide ecological connectivity among core occurrence complexes. Work with State, Federal, and local government agencies to conserve these areas. Work with Tribal partners to plan for voluntary ecological connectivity and habitat conservation as appropriate (Priority 2). (USFWS, 2019)

Delisting Criteria:

Delisting Recovery Criteria Delisting criteria apply to all occurrences referred to in the criteria below and identified in Table 1. The Quino Checkerspot butterfly will be considered for delisting when downlisting criteria are met and: 1. Reproduction is documented at least 4 years after reintroduction or last augmentation for the populations established in the Northwest Riverside Recovery Unit and in the footprint of the Warm Springs Creek Core Occurrence complex. 2. A total of 15 core occurrence complexes (not including the former Harford Springs or Warm Springs Creek core occurrence complexes) are conserved (protected and managed) in perpetuity, support resilient populations or metapopulations, and are ecologically connected via conserved lands to other core occurrence complexes (this includes ecological connectivity among the northern and southern portions of the range). 3. Adequate (80 percent or greater of known) non-core occurrence complexes are conserved, as defined by the following: a. The 40 non-core occurrence complexes within existing ecological connectivity areas among core occurrence complexes (Table 1, Figures 2 and 3) support populations that demonstrate reproduction in the field for at least 4 years prior to delisting. b. In addition to those non-core occurrence complexes that contribute to ecological connectivity, non-core occurrence complexes with high-elevation montane influence (above 4000 ft (1219 m) in elevation) are conserved and managed with reproduction in the field at least 4 years prior to delisting. c. Occurrence complexes and areas of occurrence complex distribution with marine influence (Coastal Terraces and Coastal Hills California Ecological Subregions; Figure 4) are conserved and have landscape connectivity to habitat occupied by a resilient population. 4. A management plan is implemented for populations specified in delisting criteria 2 and 3 that effectively manages and ameliorates impacts from nonnative plants, enhanced nitrogen deposition effects, and increasing atmospheric carbon dioxide effects (Threat Factor A). 5. A management plan is implemented to effectively manage and ameliorate impacts from Off-road vehicle activity and grazing to the populations specified in criteria 2 and 3 (Threat Factors A and E). 6. The risk of permanent population extirpation due to wildfire and climate change (Factor E) is minimized across the species range by protection and management of populations specified in delisting criterion 2 and 3 (USFWS, 2019).

Recovery Actions:

- Protect (via acquisition, conservation easement, or other means) habitat patches and dispersal areas within and between mapped occurrence complexes, and provide ongoing management to enhance habitat and maintain or create resilient populations (USFWS 2003).
- Continue yearly reviews and monitoring as needed as part of adaptive management, until there is evidence that populations associated with core occurrences are resilient (USFWS 2003).
- Assess and augment lowest density populations as needed to help establish resilience (USFWS 2003).
- Establish and maintain a captive propagation program (USFWS 2003).
- Initiate and implement an outreach program to inform the public about the biology of the Quino checkerspot butterfly and the ecological significance of its decline (an indicator of ecosystem decline) (USFWS 2003).
- Conduct biological research needed to refine recovery criteria and guide conservation efforts (USFWS 2003).
- Document or reintroduce populations in the Lake Mathews Population Site in the Northwest Riverside Recovery Unit (USFWS 2003).
- Reduce firearm use and unauthorized trash dumping in habitat areas (USFWS 2003).
- Continue coordination with the Cahuilla Band of Indians (USFWS 2003).
- Survey for habitat and undocumented populations in undeveloped areas outside of recovery units (USFWS 2003).
- Survey areas not recommended for survey that fall within the latest recommended survey area map (USFWS 2003).
- Enter into dialogue with Baja California, Mexico, nongovernmental organizations and local governments (USFWS 2003).
- Work with partners to help protect habitat in the vicinity of the community of Anza, in particular that associated with the new observations west and east of the Tule Peak critical habitat unit and private land in the Bautista critical habitat unit. Prudent design of reserves should include landscape connectivity to other habitat patches and ecological connectivity (habitat patches linked by dispersal areas) to accommodate range shift due to climate change. This action helps meet recovery criterion 1 by reducing or eliminating loss and modification of Quino habitat, by eliminating the threat of urban development and other land use changes (USFWS 2009).
- Identify partners to conduct potential research to aid in management and conservation of Quino: a. Research the effects of common herbicides on immature life stages for use in restoring/managing occupied habitat. b. Determine primary and secondary host plant species used in the Campo core habitat-based population distribution. c. Determine whether larvae are using beard tongues (Penstamon sp.) as a secondary host plant in the field. This action helps meet recovery criterion 2 by providing information needed to determine what habitat requires protection and how to restore modified habitat, which will ultimately contribute to reduced Quino habitat loss and modification (USFWS 2009).
- Conduct an experimental reintroduction at Irvine Ranch Preserve using current captive stock (owned by the Irvine Ranch Conservancy) in Orange County at the northern end of the Santa Ana Mountains. This action helps meet recovery criterion 5 by reducing the threat of

population extirpation due to restricted range, localized distribution, and small population size (USFWS 2009).

- Conduct surveys to determine the extent of new population discovered in 2009 on California Department of Fish and Wildlife preserve lands (Cañade de San Vicente) in Ramona, and evaluate its status. This action is required to meet recovery criteria 1 and 3, which help reduce or eliminate loss and modification of Quino habitat by eliminating the threat of urban development and other land use changes (USFWS 2009).
- Work with partners to help conserve the Quino checkerspot butterfly. Identify opportunities to continue conservation and initiation of formal monitoring of all core habitat-based population distributions (including Warm Springs, Sage, and Bautista Road in Riverside County, and all San Diego County). Currently, the Riverside Conservation Authority monitors reference sites in all other core habitat-based population distributions in Riverside County. Other current monitoring is informal and occurs on select conserved lands that may not reflect population status (e.g., in the Warm Springs occurrence complex by Center for Natural Lands Management), or as USFWS staff or volunteers are available. This action helps reduce loss and modification of Quino habitat by eliminating the threat of urban development and other land use changes, and is required to demonstrate successful reduction of all threats and subspecies recovery. This action will help meet recovery criteria 1 and 4 (USFWS 2009).
- Consider updating the Recovery Plan and recovery units. Revision should include a new recovery unit in central San Diego County that captures the San Vicente, Cañade de San Vicente, and Mission Trails Park habitat-based population distributions, and one in northern Orange County that captures suitable habitat for reintroduction. This action will help achieve subspecies recovery (downlisting or delisting) (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS These actions focus on protecting remaining habitat, re-introducing Quino to formerly occupied areas, and avoiding future habitat loss, which has always been the primary threat to Quino. Based on our synthesis of new information in this 5-year review, recommendations for future actions are listed below. 1. Proactively enhance larval host plant patches within known occupied habitat patches to increase population density/abundance. 2. Conserve remaining occupied habitat patches and increase connectivity among protected habitat patches to increase species in situ resistance and resilience to climate change by improving the health of populations, species, and ecosystems connectivity. a. Initiate studies in Riverside and San Diego counties to assess accuracy of preserve planning to retain/improve connectivity. b. Work with partners to identify opportunities for conservation or preservation of private lands occupied by Quino within core occurrence complexes. Support land acquisition to meet Habitat Conservation Plan goals in San Diego and Riverside counties. Work with local, State, and Federal partners to identify and leverage funding (i.e., section 6) to acquire Quino habitat. 3. Continue translocation efforts and monitoring to expand the current distribution through augmentations and reintroductions. a. Continue to implement San Diego National Wildlife Refuge Quino Checkerspot Butterfly Reinforcement Project with an emphasis on monitoring of the release sites for the next 5 years to determine if larvae persist at those habitat patches. b. Investigate and initiate reintroduction to unoccupied suitable isolated coastal habitat patches. c. Investigate and initiate reintroduction to the unoccupied suitable habitat patch and in the Center for Natural Lands Management Warm Springs Creek core occurrence complex preserve (#11; S018 Warm Springs/OBED). 4. Partners and land managers work to provide focused conservation buffer areas for current preserves and other protected areas. a. Increased vigilance and threat detection through increased patrolling, installation/monitoring of wildlife cameras. b. Nurture enhanced partnerships and coordination including with local police and fire departments. c. Work with local law enforcement on private and public lands to reduce impacts of marijuana cultivation in occupied habitat (USFWS, 2023).

Additional Threshold Information:

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SPECIES ACCOUNT: *Euphydryas editha taylori* (Taylor's (=whulge) Checkerspot)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Region (R1) (USFWS, 2016)

Physical Description

A medium-sized (4-5 cm. wingspan) orange, black, and white butterfly in the family Nymphalidae. (NatureServe, 2015)

Historical Range

The Taylor's checkerspot butterfly was historically known to occur in British Columbia, Washington, and Oregon, and its current distribution represents a reduction from over 80 locations rangewide to 14 sites in 2013. Historically, the Taylor's checkerspot butterfly was likely distributed throughout grassland habitat found on prairies, balds, grassland bluffs, and grassland openings within a forested matrix on south Vancouver Island, the northern Olympic Peninsula, the south Puget Sound prairies, and the Willamette Valley (USFWS, 2016).

Current Range

Known from the Puget Trough/Willamette Valley/Georgia Basin, from west central Oregon, through Washington, to southern Vancouver Island in Canada (NatureServe, 2015). Nearly all localities for the Taylor's checkerspot butterfly in British Columbia have been lost; the only location currently known from British Columbia was discovered in 2005 (COSEWIC 2011, p. iv). In Oregon, the number of locations occupied by Taylor's checkerspot butterflies has declined from 13 to 2 (Ross 2011, in litt., p. 1). In Washington State, 43 historical locales were documented for the Taylor's checkerspot butterfly. In 2013, there were 11 documented locations for the Taylor's checkerspot butterflies in Washington, with only one of the localities consistently harboring more than 1,000 individuals, and the majority of known sites have daily counts of fewer than 100 individual butterflies (USFWS, 2016).

Critical Habitat Designated

Yes; 10/3/2013.

Legal Description

On October 3, 2013, the U.S. Fish and Wildlife Service designated critical habitat for the Taylor's checkerspot butterfly (Euphydryas editha taylori) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 1,941 acres (786 hectares) in Island, Clallam, and Thurston Counties in Washington, and in Benton County in Oregon, fall within the boundaries of the critical habitat designation for Taylor's checkerspot butterfly.

Critical Habitat Designation

Three units are designated as critical habitat based on sufficient elements of physical or biological features being present to support life-history processes for the Taylor's checkerspot butterfly.

These 3 units are further divided into 11 subunits. These units are are: Unit 1, South Sound—1,143 ac (462 ha) in Washington State (545 ac (220 ha) of County ownership, 420 ac (170 ha) of private ownership, and 178 ac (72 ha) of lands owned by a Port, local municipality, or nonprofit conservation organization); Unit 2, Strait of Juan de Fuca—779 ac (315 ha) in Washington State (160 ac (65 ha) of Federal ownership, 188 ac (76 ha) of State ownership, 201 ac (81) of private ownership, and 229 ac (93 ha) of land owned by a Port, local municipality, or nonprofit organization); and Unit 4–D, Willamette Valley—20 ac (8 ha) of privately owned lands in Oregon.

Unit 1: South Sound. The South Sound Unit consists of 1,143 acres (462 ha) of land designated for the Taylor's checkerspot butterflies in five subunits. This unit is found entirely in Thurston County, Washington. Subunit Descriptions 1–A Rocky Prairie—(Thurston County, Washington). The Rocky Prairie critical habitat subunit is composed of two disjunct habitat patches comprising a total of 43 ac (17 ha). The first patch is a linear strip of prairie under private ownership. It is approximately 15 ac (6 ha) in size and bounded on the north by residential homes, on the east by the Burlington Northern railroad line, the south by forest (approximately 443 ft (135 m) north of where the Burlington Northern rail line intersects Old Hwy 99), and on the west by the Washington Department of Natural Resources Rocky Prairie Natural Area Preserve (NAP). The second prairie patch of this subunit is 29 ac (12 ha) of property owned by a conservation organization known as Wolf Haven International. It is located southeast of the Burlington Northern habitat patch. Wolf Haven is bounded on the north by Offut Lake Road, and bounded by a service road in all but the extreme northeastern corner of the property. The landscape on the east, west, and south boundaries of the prairie at Wolf Haven is delineated by mixed Garry oak and conifer forest (east), or conifer forest (west and south). Both habitat patches within this subunit are unoccupied at the time of listing. This subunit is within a matrix of historically occupied patches from which Taylor's checkerspot butterfly has been completely extirpated. We have determined this subunit is essential for the conservation of the Taylor's checkerspot butterfly because it has the potential for restoration of the physical or biological features sufficient to enable the reintroduction of Taylor's checkerspot butterfly. In addition, although currently unoccupied, this area presently provides many of the essential features to support long-term conservation and recovery of the Taylor's checkerspot butterfly. The subunit is composed of grasslands and includes oak woodland margins, and some transitional, colonization (first growth) Douglas-fir forest within the greater prairie landscape. Several PCEs, including landscape heterogeneity and diverse and abundant larval and adult plants resources, are present. 1–B Tenalquot Prairie—(Thurston County, Washington). The Tenalquot Prairie subunit is a privately owned conservation area of approximately 135 ac (55 ha) in size and part of the larger, historically contiguous Tenalquot Prairie, the majority of which occurs on JBLM. The northern boundary of this subunit is a fenceline boundary, which separates South Weir prairie on JBLM from the adjacent private land. The western boundary of this subunit is a large pasture clearly delineated by a fence line, and it is bordered on the southeast by Military Road. This subunit is unoccupied at the time of listing. We have determined this subunit is essential for the conservation of the Taylor's checkerspot butterfly because it would provide for the reintroduction and reestablishment of Taylor's checkerspot butterfly. Although currently unoccupied, this area presently provides many of the physical or biological features necessary to support the long-term conservation and recovery of Taylor's checkerspot butterfly and has the potential to serve as metapopulation center within a larger prairie landscape context (~2,000 ac (810 ha) in the south region of Thurston County. The physical or biological features present at this site include landscape heterogeneity, bare ground for basking, and diverse and abundant larval and adult plant resources. This subunit is periodically managed using prescribed burning as well as with mechanical methods to remove Scot's broom (Cytisus scoparius) and to sustain early seral conditions. 1–C Glacial Heritage—(Thurston County, Washington). Glacial Heritage is a large, County-owned property managed with conservation, research, and education as its primary objectives. The property consists of more than 1,200 acres, with approximately 545 ac (220 ha) designated as critical habitat. The northwestern boundary is an abandoned railroad line, and to the direct north are rural residential properties; the eastern boundary of the preserve is the Black River, and the southern boundary is owned by two private landowners: one is a large industrial tree farm where conifer seedlings are grown, and the other is dominated by pasture grown for haying. The southern border is clearly defined by the land use change along the fenceline. This subunit is occupied at the time of listing, and provides the essential physical or biological features for the Taylor's checkerspot butterfly, including diverse topography, abundant and diverse larval and adult nectar plant resources, a water course, and areas of bare ground for basking due to ongoing, active management. Threats to the physical or biological features that are essential to the conservation of this species and may warrant special management considerations or protections include, but are not limited to, the inadvertent short-term negative impacts of restoration activities, such as burning, mowing, and the use of herbicides; control of native and nonnative invasive woody species such as Scot's broom and Douglas fir (Pseudotsuga menziesii), as well as control of invasive Mediterranean grasses; habitat modifications brought on by succession of vegetation from the lack of disturbance, at a small and large scale; disease affecting larval host plants; and the effects of climate change. Special management considerations may be required to provide protection to larval and adult food resources by reducing human disturbance during the flight season, and when eggs and early instar larvae are present. 1–D Rock Prairie—(Thurston County, Washington). We are designating approximately 244 ac (99 ha) of critical habitat on the northern portion of Rock Prairie, a large, privately owned property in south Thurston County. The subunit has diverse landscape features with mounded prairie, old field pasture, oak woodland, and conifer forest. The northern boundary is delineated by dense conifer forests, the southern border is State Highway 99 (referred to as old 99), the western boundary is clearly delineated by rural residential lots, and the eastern border is the urban growth boundary for the town of Tenino, Washington. This subunit is unoccupied at the time of listing. This historically occupied subunit is essential for the conservation of the Taylor's checkerspot butterfly as it presently provides many of the features necessary to support long-term conservation and recovery of the Taylor's checkerspot butterfly. These include diverse topography with swales and terraces, abundant and diverse larval and adult food resources, and a location close to a water course formed by Scatter Creek. 1–E Bald Hill—(Thurston County, Washington). The Bald Hill subunit is a collection of balds (shallow-soil areas without typical conifer vegetation) and former clearcut areas that have not regenerated and now maintain features of open habitat that produce larval and adult food resources that can be utilized by the Taylor's checkerspot butterfly. All independent, isolated habitat patches are surrounded by conifer forests on all sides. Some patches are bordered by WDNR roads, and others are bordered by private roads used for fire control and to access the forested property. The Bald Hill subunit comprises a total of 176 ac (71 ha) (rounded up). The western habitat patch of this subunit is approximately 110 ac (45 ha), and the eastern patch is approximately 65 ac (26 ha); both are unoccupied at the time of listing. The Taylor's checkerspot butterfly was recently extirpated from this historically occupied subunit. We have determined it is essential for the conservation of the Taylor's checkerspot butterfly because it has the potential to provide for the reintroduction and reestablishment of Taylor's checkerspot butterfly and to support recovery of the subspecies. This area presently contains many of the features to support longterm conservation and recovery of the Taylor's checkerspot butterfly, including a diverse topography of balds, steep slopes, canyons, oak glades, a rich diversity of larval and adult food resources, and patches of bare soil for basking and resting. This particular critical habitat subunit is unique in that it provides the only bald habitat for Taylor's checkerspot butterfly at low elevation within Thurston County.

Unit 2: Strait of Juan de Fuca. The Strait of Juan de Fuca Unit is composed of 779 acres (315 ha) made up of balds, former clearcuts, coastal bluffs, coastal back dunes, and prairie in five subunits located in Clallam County and Island County, Washington. Subunit descriptions 2–A Deception Pass State Park— (Island County, Washington). Deception Pass State Park is owned and managed by Washington State Parks. The subunit contains approximately 149 ac (60 ha) of designated critical habitat found along low-lying beaches (coastal dunes) and on balds along high, south-facing slopes within the park. These areas include the shoreline along Bowman Bay, Bowman Hill and Beach, Reservation Head, Pass Island, Goose Rock, and West Beach, all within the park. Deception Pass State Park is divided by Highway State 20, and bordered by the portion of Puget Sound that forms Deception Pass to the north, and to the south by private rural residential properties. This park was historically occupied by Taylor's checkerspot butterfly, but at this time the subunit is unoccupied. We have determined this subunit is essential for the conservation of the subspecies because it has the potential for reintroduction and reestablishment of the Taylor's checkerspot butterfly to support recovery. In addition, although currently unoccupied, this area presently provides many of the features to support a reintroduced population of Taylor's checkerspot butterfly, including diverse topography with balds and beaches, abundant larval and adult food resources, areas of bare soil for basking of larvae and adults, and water sources made up of saltwater along the western shoreline and a freshwater wetland. 2–B Central Whidbey— (Island County, Washington). This subunit is located on Whidbey Island in Washington, and comprises a total of 229 ac (92 ha), and includes Ebey's Landing (~87 ac (35 ha)), the NaasAdmiralty Inlet Conservation Area (~8 ac (3 ha)), and the former Smith Prairie (~134 ac (54 ha)). The Central Whidbey subunit is made up of two distinct patches: one is located along the centralwest coast on coastal bluffs of the island (Ebey), and the second (Smith Prairie) is located on relatively flat prairie located centrally-north on the island. The coastal area is bordered by Puget Sound to the west, and rural residential property and farmland to the east. The Smith Prairie is surrounded by rural residential properties on all sides; Parker Road runs along the western border of the property, and Morse Road is found along the south boundary. This subunit was historically occupied but is currently unoccupied. We have determined this subunit is essential for the conservation of the subspecies because it has the potential for reintroduction and reestablishment of Taylor's checkerspot butterfly to support recovery. In addition, although currently unoccupied, this area presently provides many of the features to support a reintroduced population of Taylor's checkerspot butterfly, including diverse topography with coastal bluffs and beaches, abundant larval and adult food resources, areas of bare soil, and water sources made up of a freshwater wetland, and saltwater along the western shoreline. 2–C Elwha—(Clallam County, Washington). The Elwha critical habitat subunit is composed of private lands in Clallam County made up of balds, and former clear cut areas within a landscape of conifer forests. The subunit polygons adjoin occupied patches owned and managed by the WDNR, one is owned and managed by a nongovernmental conservation organization, the Center for Natural Lands Management, and the other small parcel is owned by a private timber company. These two patches are found primarily on the south slope of Dan Kelly Ridge, and they are separated by essential habitat owned by WDNR that has been excluded due to an HCP providing for species-specific habitat management. The habitat patches at both locations are bounded by conifer forests. The balds at each of these locations are presently occupied by the Taylor’s checkerspot butterfly, which has been observed flying up and down the steep slopes and onto private lands. Both of these locations contain essential physical or biological features, including topographic heterogeneity, abundant and diverse larval and adult food resources, and bare soil for basking and resting. Puddles on the road provide a water source during the adult flight season. Threats to the physical or biological features that are essential to the conservation of this species and may warrant special management considerations or protections include, but are not limited to, development; the inadvertent short-term negative impacts of restoration activities, such as control of native and nonnative, invasive, woody species such as Scot’s broom, snowberry (Symphoricarpos albus), and Douglas fir; the use of herbicides; habitat modifications brought on by succession of vegetation from lack of disturbance, at a small and large scale; disease affecting larval host plants; and the effects of climate change. The physical or biological features essential to the conservation of the species may require special management considerations or protection to sustain the open conditions that are needed to manage for and sustain the larval and adult food resources. Special management considerations may be required to provide protection to larval and adult food resources by reducing human disturbance during the flight season, and when eggs and early instar larvae are present. 2–D Sequim—(Clallam County, Washington). Sequim is a private property estate and farm of low-lying stabilized dune habitat of approximately 151 ac (61 ha). The subunit includes stabilized dunes and beach habitat adjacent to the Strait of Juan de Fuca; it is approximately 20 ft (6 m) above sea level. The landowner has been working cooperatively with the WDFW to manage their property for multiple uses, including the conservation of Taylor’s checkerspot butterfly. The subunit is occupied at the time of listing. The Sequim subunit contains several essential physical or biological features, including landscape heterogeneity with fore and back dune areas and terraces; rich and abundant larval and adult food resources; a marsh; and bare soil for basking and resting. Threats to the physical or biological features that are essential to the conservation of this species and may warrant special management considerations or protections include, but are not limited to, development; the inadvertent short-term negative impacts of restoration activities; habitat modifications brought on by succession of vegetation from lack of disturbance, at a small and large scale; disease affecting larval host plants; and the effects of climate change. The physical or biological features essential to the conservation of the species may require special management considerations or protection to sustain the open conditions that are needed to manage for and sustain the larval and adult food resources. Special management considerations may be required to provide protection to larval and adult food resources by reducing human disturbance during the flight season, and when eggs and early instar larvae are present. 2–E Dungeness—(Clallam County, Washington). The Dungeness subunit is found entirely on U.S. Forest Service (USFS) land on the northeast Olympic Peninsula. This subunit comprises a total of 160 ac (65 ha) and is composed of bald habitat, and former clearcuts that function similarly to balds. The three occupied areas within this subunit and are known as Bear Mountain (low elevation), 3 O'Clock Ridge (middle elevation) (which is composed of two habitat patches), and the upper Dungeness (highest elevation). These locations on USFS lands are the highest elevations known to be occupied by Taylor's checkerspot butterflies. The Bear Mountain location is entirely surrounded by conifer forests and originated as a small harvest unit that functions similar to a bald. 3 O'Clock ridge is bounded by the upper Dungeness Road on the northwest boundary, Cougar Creek to the northeast, Bungalow creek to the southwest, and conifer forests to the southeast of the occupied unit. Upper Dungeness is bounded by an unnamed creek to the northeast and Mueller Creek to the southwest, and by conifer forests to the southeast of the occupied unit. All habitat patches within this subunit are presently occupied by the Taylor's checkerspot butterfly. The subunit contains several essential physical or biological features, including landscape heterogeneity, abundant larval and adult food resources, nearby streams, and plentiful areas of bare ground for basking and resting. Early restoration work conducted by USFS has included tree harvesting and removal, which has resulted in the expansion of larval and adult food resources in this habitat. Threats to the physical or biological features that are essential to the conservation of this species and may warrant special management considerations or protections include, but are not limited to, the inadvertent short-term negative impacts of restoration activities and control of native and nonnative, woody species; the use of herbicides that my impact larval and adult nectar resources; habitat modification brought on by succession of vegetation from lack of disturbance, at a small and large scale; disease affecting larval host plants; and the effects of climate change. The physical or biological features essential to the conservation of the species may require special management considerations or protection to sustain the open conditions that are needed to manage for and sustain the larval and adult food resources. Special management considerations may be required to provide protection to larval and adult food resources by reducing human disturbance during the flight season, and when eggs and early instar larvae are present.

Unit 4: Willamette Valley. Unit 4, located in the Willamette Valley, is the only critical habitat unit that includes critical habitat for both the streaked horned lark and Taylor's checkerspot butterfly. Unit 4 includes four subunits in the State of Oregon; three for the streaked horned lark (4–A, 4–B, and 4–C; described below), and a single subunit (4–D) for the Taylor's checkerspot butterfly in Benton County. Unit 4–D Fitton Green-Cardwell Hill— (Benton County, Oregon). Fitton GreenCardwell Hill is located in the eastern foothills of the Coastal Range on the western edge of the Willamette Valley. The habitat is composed of multiple small natural openings of approximately 3 ac (1 ha) in size within a conifer-oak forest landscape. These habitat patches collectively comprise the 20 ac (8 ha) that constitute Subunit 4–D. The northern patch of this subunit is a BPA right-of-way that passes through a large occupied patch of county-owned habitat that provides conservation benefit to the Taylor's checkerspot butterfly through the Benton County Prairie Species HCP. This subunit is currently occupied by the Taylor's checkerspot butterfly. This subunit contains several of the essential physical or biological features for the Taylor's checkerspot butterfly, including native perennial bunchgrass plant communities with abundant larval and adult food resources, landscape heterogeneity, and bare soil for basking and resting. Threats to the physical or biological features that are essential to the conservation of this species and may warrant special management considerations or protections include, but are not limited to, the inadvertent short-term negative impacts of restoration activities such as control of native and nonnative, invasive, woody species and invasive Mediterranean grasses through mechanical means and with herbicide; habitat modification due to succession of vegetation in the absence of disturbance, at a small and large scale; impacts of disease on larval food plants; and climate change. The physical or biological features essential to the conservation of Taylor's checkerspot butterfly may require special management considerations or protection to sustain short-statured vegetation structure and to reduce human disturbance during the flight season or when eggs and early instar larvae are present. The physical or biological features of this site may be particularly vulnerable to the effects of recreational use, such as trampling of vegetation.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are desingated for Island, Clallam, and Thurston Counties in Washington, and in Benton County in Oregon. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Taylor's checkerspot butterfly consist of four components:

(i) Patches of early seral, shortstatured, perennial bunchgrass plant communities composed of native grass and forb species in a diverse topographic landscape ranging in size from less than 1 ac up to 100 ac (0.4 to 40 ha) with little or no overstory forest vegetation that have areas of bare soil for basking that contain: (A) In Washington and Oregon, common bunchgrass species found on northwest grasslands include Festuca roemeri (Roemer's fescue), Danthonia californica (California oat grass), Koeleria cristata (prairie Junegrass), Elymus glaucus (blue wild rye), Agrostis scabra (rough bentgrass), and on cooler, high-elevation sites typical of coastal bluffs and balds, Festuca rubra (red fescue). (B) On moist grasslands found near the coast and in the Willamette Valley, there may be Bromus sitchensis (Sitka brome) and Deschampsia cespitosa (tufted hairgrass) in the mix of prairie grasses. Less abundant forbs found on the grasslands include, but are not limited to, Trifolium spp. (true clovers), narrow-leaved plantain (Plantago lanceolata), harsh paintbrush (Castilleja hispida), Puget balsamroot (Balsamorhiza deltoidea), woolly sunshine (Eriophyllum lanatum), nineleaved desert parsley (Lomatium triternatum), fine-leaved desert parsley (Lomatium utriculatum), common camas (Camassia quamash), showy fleabane (Erigeron speciosus), Canada thistle (Cirsium arvense), common yarrow (Achillea millefolium), prairie lupine (Lupinus lepidus), and sicklekeeled lupine (Lupinus albicaulis).

(ii) Primary larval host plants (narrow-leaved plantain and harsh paintbrush) and at least one of the secondary annual larval host plants (blue-eyed Mary (Collinsia parviflora), sea blush (Plectritis congesta), or dwarf owl-clover (Triphysaria pusilla) or one of several species of speedwell (marsh speedwell (Veronica scutella), American speedwell (V. beccabunga var. americana), or thymeleaf speedwell (V. serpyllifolia).

(iii) Adult nectar sources for feeding that include several species found as part of the native (and one nonnative) species mix on northwest grasslands, including: narrow-leaved plantain; harsh paintbrush; Puget balsam root; woolly sunshine; nine-leaved desert parsley; fine-leaved desert parsley or spring gold; common camas; showy fleabane; Canada thistle; common yarrow; prairie lupine; sickle-keeled lupine; and wild strawberry (Fragaria virginiana).

(iv) Aquatic features such as wetlands, springs, seeps, streams, ponds, lakes, and puddles that provide moisture during periods of drought, particularly late in the spring and early summer. These features can be permanent, seasonal, or ephemeral.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, railroad tracks, and other paved areas) and the land on which they are located existing within the legal boundaries on November 4, 2013.

Threats to the physical or biological features that are essential to the conservation of this species and that may warrant special management considerations or protection include, but are not limited to: (1) Loss of habitat from conversion to other uses; (2) control of nonnative, invasive species; (3) development; (4) construction and maintenance of roads and utility corridors; and (5) habitat modifications brought on by succession of vegetation from the lack of disturbance, both small and large scale. These threats also have the potential to affect the PCEs if they are conducted within or adjacent to designated units. Restoration and maintenance of occupied Taylor's checkerspot butterfly sites will require active management to plan, restore, enhance, and manage habitat using an approach that resets the vegetation composition and structure to an early seral stage. Management actions that produce suitable conditions for Taylor's checkerspot butterflies and reset the ecological clock to early seral conditions favored by the butterfly include prescribed fires, mechanical harvesting of trees, activities such as hand planting or mechanical planting of grasses and forbs, and the judicious use of herbicides for nonnative, invasive species control.

Life History

Feeding Narrative

Larvae: For most butterfly species, larvae feed on plants within a single family (Scott 1986, p. 64). Some butterfly species are highly specialized and feed on only a single plant species or a few closely related species. Female Taylor's checkerspot butterflies and their larvae use plants that contain defensive chemicals known as iridoid glycosides, which have been recognized to influence the selection of oviposition sites by adult nymphalid butterflies (butterflies in the family Nymphalidae) (Murphy et al. 2004, p. 22; Page et al. 2009, p. 2), and function as a feeding stimulant for some checkerspot larvae (Kuussaari et al. 2004, p. 147). As maturing larvae feed, they accumulate these defensive chemical compounds from their larval host plants into their bodies. According to the work of Bowers (1981, pp. 373–374), this accumulation appears to deter predation. These larval host plants include members of the Broomrape family (Orobanchaceae), such as Castilleja (paintbrushes) and Orthocarpus, which is now known as Triphysaria (owl's clover), and native and nonnative Plantago species, which are members of the Plantain family (Plantaginaceae) (Pyle 2002, p. 311). Taylor's checkerspot butterfly larvae have been confirmed feeding on Plantago lanceolata (narrow-leaf plantain) and P. maritima (sea plantain) in British Columbia (Guppy and Shepard 2001, p. 311), narrow-leaf plantain and Castilleja hispida (harsh paintbrush) in Washington (Char and Boersma 1995, p. 29; Pyle 2002, p. 311; Severns and Grosboll 2011, p. 4), and exclusively on narrow-leaf plantain in Oregon (Dornfeld 1980, p. 73; Severns and Warren 2008, p. 476). In 2012, the Taylor's checkerspot butterfly was documented preferentially ovipositing on the threatened Castilleja levisecta (golden paintbrush) in studies conducted in Washington, and in 2013, Castilleja levisecta was subsequently observed being utilized as a larval host plant in both Washington and Oregon (Kaye 2013, Aubrey 2013, in litt). The recent rediscovery in 2005 of Taylor's checkerspot butterflies in Canada led to the observation that additional food plants (Veronica serpyllifolia (thymeleaf speedwell) and V. beccabunga ssp. americana (American speedwell)) were being used by Taylor's checkerspot butterfly larvae (Page et al. 2009, p. 2). Oviposition choices made by females determine which individual plant and which plant species prediapause larvae will feed upon. It is important to distinguish between pre- and post-diapause host plants when considering Taylor's checkerspot conservation because oviposition has only been observed to occur on two plant species in Oregon and Washington (P. lanceolata and C. hispida), whereas post-diapause larvae have been documented to eat C. hispida, P. lanceolata, Plectritis congesta (sea blush), Collinsia parviflora (small-flowered blue-eyed Mary), Triphysaria pusilla (dwarf owl-clover), and Symphoricarpos albus (snowberry) (Severns and Grosboll 2011, p. 71). Other larval host plants documented in Washington include Collinsia grandiflora (large-flowered blue-eyed Mary) and Orthocarpus attenuatus (narrow-leaved owl-clover) (Stinson 2005, p. 88) (USFWS, 2016).

Adult: Adult butterflies do not grow, but feeding is required to maintain activity and egg development. In general, adult butterflies are less specialized in their use of food plants than larvae, and can meet their needs in the general vicinity of the larval food plants. Total egg production in checkerspots is affected by the availability of nectar sources and can double when nectar is plentiful (Murphy 1983, p. 261). Taylor's checkerspots may be somewhat specialized on certain nectar sources, and the number of nectar sources is limited during their spring flight period. Adult nectar sources for feeding include several species found as part of the native (and one nonnative) species mix on northwest grasslands, including, but not limited to: Balsamorhiza deltoidea (Puget balsam root); Eriophyllum lanatum (Oregon sunshine); Lomatium utriclatum (fine-leaved desert parsley or spring gold); Lomatium triternatum (Nineleaf biscuitroot); Camassia quamash (common camas); Cerastium arvense (field chickweed); and wild strawberry (Fragaria virginiana) (Stinson 2005, p. 91) (USFWS, 2016).

Reproduction Narrative

Adult: The Taylor's checkerspot butterfly is univoltine (producing a single generation per year) and is nonmigratory. All butterflies have four stages of development (egg, larvae, pupae, and adult). Taylor's checkerspot butterflies emerge as adults in the spring, typically flying in May, although depending on local site and climatic conditions, the flight period may begin in mid-April (Stinson 2005, p. 79) and extends into June, as in Oregon, where the flight season has been documented as lasting up to 43 days (Ross 2008, p. 3). The life-span of individual adult butterflies is usually brief, lasting only 4 to 14 days (Cushman et al 1994, p. 196). During the flight period adult butterflies patrol their habitat for mates, nectar sources and host plants.

Adult checkerspot butterflies are non-migratory, rarely dispersing from their natal habitats (Singer and Hanski 2004, pp. 184-185). Males seek females for mating, and once mated, the females seek larval host plants on which to lay eggs (oviposit). Female E. editha generally only mate once and may lay up to 1,200 eggs in clusters of 20 to 350 directly onto larval host plants (James and Nunnallee 2011, p. 286). Captive Taylor's checkerspot typically produce 100-400 eggs depending on body condition of the female (Linders and Lewis 2013, pp. 12-14). Eggs hatch after 13 to 15 days (Murphy et al 2004, p. 25). In E. editha, newly hatched caterpillars live colonially in a loose silk web during early development. The web is thought to deter generalist predators and parasitoids (Kuusaari et al. 2004, p. 139) (USFWS, 2016).

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 2016)

Environmental Specificity

Adult: Narrow. Specialist or community with key requirements common. (Natureserve, 2015)

Habitat Narrative

Adult: Dry prairies or prairie-like native grassland in Puget Sount, Willamette portions of range, maritime meadows within Garry oak ecosystems in Canada (NatureServe, 2015). Taylor's checkerspot butterfly requires open grassland habitat dominated by short-statured grasses, with abundant forbs to serve as larval host plants and nectar sources. These habitats are found on prairies, shallow-soil balds (Chappell 2006, p. 1), grassland bluffs, and grassy openings within a forested matrix on south Vancouver Island, British Columbia; the north Olympic Peninsula; south Puget Sound, Washington; and the Willamette Valley, Oregon. Occupied habitats range in elevation from near sea-level to over 3,200 ft in elevation, and occupied grassland patches range in size from less than 1 acre up to 100-plus acres (0.4 to 40 ha). In British Columbia, Canada, Taylor's checkerspot butterflies were historically known to occupy coastal grassland habitat on south Vancouver Island and the nearby Gulf Islands, not forests that were converted to early successional conditions by clear-cutting. The recently discovered population on Denman Island in Canada, discovered in May 2005, occupies an area that had been clear-cut harvested, and is now dominated by grass and forb vegetation, but is changing rapidly and requires management to maintain early seral conditions. In Washington, Taylor's checkerspot butterflies inhabit glacial outwash prairies in the south Puget Sound region. Northwest prairies were formerly more common, larger, and interconnected, and supported a greater distribution and abundance of Taylor's checkerspot butterflies than prairie habitat does today. On the north Olympic Peninsula they use shallow-soil balds dominated by prairie forbs and bunchgrasses within a forested landscape, as well as roadsides, former clear-cut areas within a forested matrix, and a coastal stabilized dune site near the Strait of Juan de Fuca (Stinson 2005, pp. 93–96). The two Oregon sites are on grassland hills in the Willamette Valley within a forested matrix (Ross 2008, p. 1; Benton County 2010, Appendix N, p. 5). The total area and quality of habitat for the Taylor's checkerspot butterfly has rapidly declined over the past century due to development, conversion, successional changes to grassland habitat, and the spread of nonnative invasive plants (USFWS, 2016).

Dispersal/Migration

Motility/Mobility

Adult: High (USFWS, 2016)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2016)

Dispersal

Adult: Low (USFWS, 2016)

Immigration/Emigration

Adult: Unlikely (USFWS, 2016)

Dispersal/Migration Narrative

Adult: Adult checkerspot butterflies are non-migratory, rarely dispersing from their natal habitats (Singer and Hanski 2004, pp. 184-185) (USFWS, 2016).

Population Information and Trends

Population Trends:

Unknown (USFWS, 2016)

Number of Populations:

Currently there are 14 population complexes that may be extant (USFWS, 2024)

Population Size:

250 - 2500 individuals per population (NatureServe, 2015)

Additional Population-level Information:

Currently there are 14 population complexes that may be extant, although none are currently considered to be resilient, and three of the 14 are likely nearing extirpation. Monitoring of the Graysmarsh site detected two adults in both 2023 and 2024, zero adults were detected at the Graywolf site in 2023, and there have been no detections since 2019 at Training Area 7S on JBLM. Partners are working to refine surveying and monitoring methods to ensure that resiliency of populations can be effectively measured and tracked over time. Translocations, including reintroductions, augmentations, and assisted colonization facilitated by the captive rearing programs, continue to help sustain resiliency in existing population complexes and are integral to increasing the resiliency and number of population complexes over time. The Service and partners also continue working to restore and conserve habitat, and to ensure commitments for ongoing protection and management for the benefit of the species and prairie habitats (USFWS, 2024).

Population Narrative:

Checkerspot butterfly populations can fluctuate widely from year to year primarily due to the complex interactions of host plant phenology, annual weather conditions, and local topography (McLaughlin et al., 2002, p. 538, Hellmann et al., 2004, p. 41). Some Taylor's checkerspot butterfly populations in Washington have exhibited boom years with several thousand individuals and then declined dramatically with only 100 or so butterflies remaining the following year (Stinson 2005, p. 85). Long-term monitoring of checkerspot populations has revealed that population dynamics in E. editha are driven by both density-dependent factors (e.g., host plant availability) and density-independent factors (e.g., weather and topography) and that the response of local butterfly populations to the same weather conditions is highly variable depending on site topography and habitat conditions (McLaughlin et al., 2002, p. 538). Local topography is important, as minor variations in aspect and moisture directly influence development of larvae and pupae, as well as host plant development (Hellmann et al. 2004, p. 47). Female checkerspots lay a large number of eggs, which represents a great potential for population growth, but in most populations and in most years, nearly all larvae die before reaching the adult stage due to the effects of weather and the availability and quality of host plants (Hellman et al 2004, p. 41). Population dynamics for the Taylor's checkerspot have not been studied, but probably have similarities to that of the bay checkerspot (E.e. bayensis). Bay checkerspot populations fluctuate widely in size from year to year, often due to pre-diapause mortality rates that can be in excess of 90 percent (Kuussaari et al. 2004, p. 149). Egg to adult survival in Taylor's checkerspot populations is unknown, but may be similar to that of bay checkerspots which is estimated to be 1 to 5 percent per year (Moore 1989, p. 1735). Population survival for checkerspots depends on the production of large numbers of larvae, so that some larvae survive to maturity. Drought affects populations by reducing the period of host plant availability, while extended periods of rain reduces reproduction, egg survival, and larval growth (Hellmann et al. 2004, p. 44). Pre-diapause mortality strongly affects adult abundance in the subsequent year (McLaughlin et al., 2002, p. 538). Climate and topography also affect growth of post-diapause larvae in the winter, when aspect-determined contrasts in solar exposure are greatest and weather patterns strongly influence post-diapause larval development (McLaughlin et al., 2002, p. 539). The availability and quality of larval host plants is an important factor affecting larval survival. Larval survival can vary depending on the host plant species used, presumably due to the relative nutritional value of the host plant species (Moore 1989, p. 1735). Populations with more than one potential host plant species available for use may be more likely to persist during adverse conditions (Hanski et al 2004, p. 270). Larvae are able to disperse between host plants and may shift use from one host species to another depending on the availability and senescence of host plant species (Hellmann et al. 2004, p. 43). Larval mortality from starvation can also occur due to competition when large numbers of larvae defoliate the available host plants (Kuussaari et al. 2004, p. 149). Predation and parasitism can be important sources of mortality in some butterfly species. However, there is no evidence that predation or parasitism is a significant source of larval mortality in E. editha (Kuussaari et al. 2004, p. 149). Metapopulations A metapopulation is a set of local populations that are connected over time by migration of individuals through dispersal and colonization (Nieminen et al. 2004, p. 64). Taylor's checkerspot butterfly most likely exhibited and persisted as a series of metapopulations composed of large and small local populations that interacted within a larger landscape context, with periodic extinction and colonization events. Most checkerspots are relatively sedentary and only a small percentage of individuals migrate to another habitat patch in any given year (Singer and Hanski 2004, p. 184). Colonization of empty patches may not occur in most years, but can occur in response to either very high or very low densities of butterflies within a habitat patch (Singer and Hanski 2004, pp. 189-190). Where there are other suitable habitat patches within dispersal distance, a vacant patch may become occupied, or genetic exchange between closely situated local populations may occur. In E. editha, metapopulation dynamics are largely dependant on a few larger populations that act as sources of migrants to colonize habitat patches in the surrounding landscape (Hellman et al. 2004, p. 59). Not all habitat patches are occupied simultaneously, but in order for a metapopulation to persist over time, there is a balance between local extinctions and recolonizations. The conservation of butterfly species requires the protection of minimum viable metapopulations that include key source populations as well as smaller populations that allow the re-colonization of vacant patches to continue (Murphy and Weiss 1988, p. 183, Harrison 1989, p. 1242). Population modeling for other checkerspot species indicate a theoretical threshold of 15-20 well-connected habitat patches are necessary for long-term survival of a metapopulation (Hanski et al. 1996, pp. 539, Baguette and Schickzelle 2003, p. 410). It is important to recognize that the total abundance and number of sites occupied by Taylor’s checkerspot has been steadily declining over time. Habitat loss due to development, invasive plants, and natural succession has increased the isolation between occupied sites. The recent losses of multiple local populations due to stochastic extirpations has resulted in the loss of entire metapopulations (e.g., Bald Hills and south Puget Prairies in the vicinity of Rochester/Tenino, WA). The remaining extant populations of Taylor’s checkerspot represent a relict distribution that is well below minimum habitat thresholds for long-term persistence. Management intervention is required to maintain and restore occupied habitat, and reintroduction efforts are needed to re-establish occupancy in habitats where metapopulations have been lost to local extinctions (Schultz et al. 2011, p. 374). Without metapopulation structure, the Taylor’s checkerspot butterfly will likely continue to decline and may become extirpated at several of the locations where it currently is found (78 FR 61461). Extinction Risk and Minimum Viable Populations Most checkerspots live in small local populations. Small populations are influenced by several types of stochastic processes which can be grouped into environmental, demographic, and genetic processes (Whalberg et al 2004, p. 222). Checkerspots are highly vulnerable to perturbations in weather patterns, and populations can decline dramatically after years of extreme weather (hot and dry or cold and wet) because these extremes reduce reproductive success and larval survival (Hellmann et al. 2004, p. 51). Demographic factors can also lead to population declines due to competition for host plants at sites with high densities of larvae (Kuussarri et al 2004, p. 159), or genetic factors associated with inbreeding depression in very small populations (Nieminen et al. 2001, p. 243). Stochastic extirpations are often related to patch size and isolation (Thomas et al. 1992, p. 563, Hanski et al. 1995, p. 25), and habitat-driven extinctions are often due to successional changes causing the habitat to become unsuitable (Thomas 1994, p. 373). The extirpations of local E.e. bayensis populations have ultimately been traced to successive years of adverse weather coupled with isolation and habitat loss in the surrounding area that precluded colonization from adjacent populations (Hellmann et al 2004, p. 58). The population monitoring data for the bay checkerspot demonstrate that even sites that consistently support populations of 1,000 to 10,000 butterflies can decline rapidly to extirpation within a matter of a few years due to environmental stochasticity (McLaughlin et al. 2002, p. 542). The total abundance and number of sites occupied by E.e. taylori has declined steadily over the past several decades, with observed local extirpations at multiple sites documented from the mid 1990's to present (Stinson 2005, pp. 93-96). Habitat loss, habitat degradation, and loss of metapopulation structure has reduced local populations of Taylor's checkerspot to such low levels that they have become highly vulnerable to local extirpation. Population dynamics for Taylor's checkerspot have not been modelled, and basic information concerning the size of and trend of extant populations is generally not available. The limited information available suggests that most extant local populations likely consist of less than 1,000 individuals in most years, indicating the remaining Taylor's checkerspot populations are at high risk for stochastic extirpation. Estimates of minimum viable population size for Taylor's checkerspot have not been developed, but are likely comparable to other sedantary butterfly species, which indicate that in order for metapopulations to persist over the long-term (greater than 100 years), each metapopulation should consist of 10 to 20 well connected habitat patches, supporting minimum metapopulations of 1,000's of butterflies (Hanski et al 1996, p. 539; Bergman and Kindvall 2004, p. 57, Schiktzelle 2005, p. 578). Most of the remaining Taylor's checkerspot populations do not currently meet these theoretical criteria for metapopulation viability (USFWS, 2016).

Threats and Stressors

Stressor: Habitat Loss and Fragmentation Associated with Land Conversion (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The primary long-term threat to the Taylor's checkerspot butterfly is the loss, conversion, and degradation of habitat, particularly as a consequence of agricultural and urban development, successional changes to grassland habitat, and the spread of invasive plants. Prairies, which historically covered over 145,000 acres (60,000 ha) of the south Puget Sound region, have largely been lost over the past 150 years (Crawford and Hall 1997, p. 11). The primary causes of prairie habitat loss in the region are attributed to the conversion of prairie habitat to urban development and agricultural uses (over 60 percent of losses), and succession to Douglas-fir forest (32 percent) (Crawford and Hall 1997, p. 11). Today approximately 8 percent of the original prairies in the south Puget Sound area remain, but only about 3 percent contain native prairie vegetation (Crawford and Hall 1997, p.11). In the remaining prairies, many of the native bunchgrass communities have been replaced by nonnative pasture grasses (Rogers 2000, p. 41). In the Willamette Valley, Oregon, native grassland has been reduced from the most common vegetation type to scattered parcels intermingled with rural residential development and farmland; it is estimated that less than 1 percent of the native grassland and savanna remains in Oregon (Altman et al. 2001, p. 261). Native prairies and grasslands have been severely reduced throughout the range of the Taylor's checkerspot butterfly as a result of human activity due to conversion of habitat to residential and commercial development and agriculture. Prairie habitat continues to be lost, particularly to residential development (Stinson 2005, p. 70) by removal of native vegetation and the excavation and grading of surfaces and conversion to non-habitat (buildings, pavement, other infrastructure). Residential development is associated with

increased infrastructure such as new road construction, which is one of the primary causes of landscape fragmentation (Watts et al. 2007, p. 736). Activities that accompany low-density development are correlated with decreased levels of biodiversity, mortality to wildlife, and facilitated introduction of nonnative, invasive species (Trombulak and Frissell 2000, entire; Watts et al. 2007, p. 736). Four historical locales for Taylor's checkerspot butterflies in the south Puget Sound region were lost to development or conversion. Dupont, Spanaway, and Lakewood were all converted to urban areas, and Joint Base Lewis McChord (JBLM) Training Area 7S became a gravel pit (Stinson 2005, pp. 93–96). The decline in native grassland habitats is exemplified by the reduction in the distribution of the Taylor's checkerspot butterfly from 43 historic populations to 11 populations in Washington, from 13 historic populations to 2 populations in Oregon, and from 24 historic populations to 1 population known from Canada (78 FR 61480). Most sites with extant populations of Taylor's checkerspot butterfly are protected from further development through either state, Federal, or local conservation ownership, but habitats at many of these sites are further degraded by invasive species and competing uses such as recreation or military training (Schultz et al. 2011, p. 370). As prairie habitat has been lost to urban development and agricultural conversion, the resulting fragmentation of remnant prairie habitat has led to a significant reduction in total prairie area, patch size and potential connectivity between habitat patches. Because of this, sites where Taylor's checkerspot have been locally extirpated are unlikely to be re-colonized given their isolation from any source population (Schultz et al., 2011, p. 371). The historic metapopulation dynamics that linked various local populations of the Taylors checkerspot butterfly have been lost due to the fragmentation and isolation of remnant prairie patches, leaving the subspecies at high risk of extirpation due to habitat factors, weather extremes, increased mortality due to human impacts, and inbreeding (Stinson 2005, p. 100) (USFWS, 2016).

Stressor: Loss of Ecological Disturbance Processes, Invasive Species, and Succession (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of individuals/loss of habitat
Narrative: The suppression and loss of natural and anthropogenic disturbance regimes, such as fire, across vast portions of the landscape has resulted in altered vegetation structure in the prairies and meadows and has facilitated invasion by nonnative grasses and woody vegetation, rendering habitat unusable for Taylor's checkerspot butterflies. Historically, the prairies and meadows of the south Puget Sound region of Washington and western Oregon are thought to have been actively maintained by the native peoples of the region, who lived there for at least 10,000 years before the arrival of Euro-American settlers (Boyd 1986, entire; Christy and Alverson 2011, p. 93). Frequent burning reduced the encroachment and spread of shrubs and trees (Boyd 1986, entire; Chappell and Kagan 2001, p. 42; Storm and Shebitz 2006, p. 264), favoring open grasslands with a rich variety of native plants and animals. The basic ecological processes that maintain prairies or meadows have disappeared from, or have been altered on, all but a few protected and managed sites. At JBLM, approximately 39 percent (over 16,200 acres [6560 ha]) of the original prairie habitat has transitioned to Douglas-fir forest, and only a fraction of the original prairie habitat remains as small, isolated prairies (Tveten 1997, p. 124, Foster and Shaff

2003, p. 283). Fires on the prairie create a mosaic of vegetation conditions, which serve to maintain native prairie forbs like Camassia quamash (common camas), Achillea millefolium (yarrow), and Lomatium spp. (desert parsley or biscuit root), which are adult nectar foods for the Taylor's checkerspot butterfly. Stands of native perennial grasses (Festuca idahoensis ssp. roemeri (Roemer's fescue)) are also well adapted to regular fires and produce habitat favorable to the Taylor's checkerspot butterfly. In some prairie patches, fires will reset succession back to bare ground, creating early successional vegetation conditions suitable for Taylor's checkerspot butterflies (Pearson and Altman 2005, p. 13). The historical fire return frequency on prairies has been estimated to be 3 to 5 years (Foster 2005, p. 8). The result of fire suppression has been the invasion of the prairies and oak woodlands by native and nonnative plant species (Dunn and Ewing 1997, p. v; Tveten and Fonda 1999, p. 146), notably woody plants such as the native Douglas-fir (Pseudotsuga menziesii) and the nonnative Scot's broom, and nonnative grasses such as Arrhenatherum elatius (tall oatgrass) in Washington and Brachypodium sylvaticum (false brome) in the Willamette Valley of Oregon. This increase in woody vegetation and nonnative plant species has resulted in less available prairie habitat overall, and habitat that is avoided by Taylor's checkerspot butterflies (Tveten and Fonda 1999, p. 155). Where controlled burns or direct tree removal are not used as a management tool, this encroachment will continue to cause the loss of open grassland habitats for the Taylor's checkerspot butterfly. Unintentional fires ignited by military training burns patches of prairie grasses and forbs on JBLM on an annual basis. These light ground fires create a mosaic of conditions within the grassland, maintaining a low vegetative structure of native and nonnative plant composition, and patches of bare soil. On sites where regular fires occur, such as on JBLM, there is a high complement of native plants and fewer invasive species, and a higher percentage of bare soil. These types of fires promote the maintenance of the native, short-statured vegetation communities (Severns and Warren 2008, p. 476) favored by the Taylor's checkerspot butterflies for larval and nectar food resources. Fire management to maintain or restore native vegetation is essential to maintaining suitable habitat for the Taylor's checkerspot butterfly, but requires careful planning and implementation because prescribed fire can destroy larvae, eggs, or adult butterflies when occupied habitats are burned. Bald habitat at National Forest and Washington State Department of Natural Resources sites where Taylor's checkerspot butterflies are found were created due to shallow soil conditions or they may have been formerly forested and recently harvested, which resulted in early seral vegetation conditions suitable for Taylor's checkerspot. On bald habitat that was formerly forested, these areas appear to have been colonized by the Taylor's checkerspot butterfly shortly after they were cleared. At the time the trees were harvested from each of these balds they were replanted with conifers. The establishment and growth of the conifers, and the establishment and expansion of Acer macrophyllum (bigleaf maple), Holodiscus discolor (oceanspray), and other shrubs has resulted in shaded habitat that has replaced habitat occupied by the Taylor's checkerspot butterfly. Management of these balds should focus on removing shade-forming trees and shrubs coupled with active management to revegetate native forbs. Sites that currently have Taylor's checkerspot butterflies present will quickly become unsuitable if trees and shrubs are not removed and if the sites are not managed specifically for the long-term conservation of the Taylor's checkerspot butterfly or the maintenance of bald habitat. This is the case for several balds recently occupied by the Taylor's checkerspot butterfly but no longer supporting the subspecies, including Bald Hills NAP in Thurston County of south Puget Sound, and Highway 112 and Striped Peak in Clallam County, on the north Olympic Peninsula (USFWS, 2016).

Stressor: Military Training and Associated Activities (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of individuals/loss of habitat
Narrative: JBLM contains the largest patches of remnant prairie habitat remaining in the south Puget Sound region (Stinson 2005, p. 11), and also contains the only remaining native population of Taylor's checkerspot butterfly on Puget prairie habitat. Frequent, low-intensity fires on the 91st Division Prairie on JBLM have maintained large areas of relatively high-quality prairie habitat (Stinson 2005, p. 12), and active prairie restoration and habitat maintenance programs on JBLM have facilitated recent reintroduction efforts both on and off JBLM. However, ongoing military training activities on JBLM has resulted in direct mortality of Taylor's checkerspot butterflies and the destruction of Taylor's checkerspot butterfly habitat through road construction, land conversion, and other developments. Off-road vehicle use, training with explosives, and soldier foot traffic in occupied habitat can kill butterfly eggs, larvae, and adults, and destroy larval host plants. These actions disrupt intact prairie plant communities by disturbing the vegetation and exposing soils, directly introducing invasive plant seeds carried in on tires or boots, and accelerating the rate of establishment of invasive grasses or other nonnative plants. Several Department of Defense policies and an Integrated Natural Resources Management Plans (INRMP) are in place on JBLM to provide conservation measures to reduce the impacts of training activities to habitat occupied by Taylor's checkerspot. JBLM's INRMP includes provisions that will promote protection and conservation practices to support the Taylor's checkerspot butterfly, and to prevent further population declines associated with habitat loss or inappropriate management on JBLM properties. Despite these conservation measures, military training continues to have significant, habitat-altering impacts on the Taylor's checkerspot butterfly. All training areas on JBLM that are currently occupied by Taylor's checkerspot butterflies experience regular training, including mounted vehicle training and infantry training, with foot soldiers directly impacting the area where the subspecies is found. The U.S. Fish and Wildlife Service has worked closely with the Department of Defense to develop protection areas within the primary habitat for the Taylor's checkerspot butterfly on JBLM. These include areas where no vehicles are permitted on occupied habitat, where vehicles will remain on roads only, and where foot traffic is allowed. These conservation measures are important for reducing the impacts of the training activities, but these activities are likely to continue to harm individuals because not all areas on JBLM that are occupied by Taylor's checkerspot butterfly are protected by existing policy or the INRMP (USFWS, 2016).

Stressor: Habitat Management and Restoration (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The ongoing threat of habitat loss and degradation associated with succession and the presence of nonnative invasive plants requires active management of prairie and grassland

habitat in order for the Taylor's checkerspot butterfly to persist. Restoration activities are recognized as necessary and beneficial for the long-term persistence of the subspecies, but restoration activities must be carefully planned and implemented to minimize impacts to extant populations (Schultz et al. 2011, p. 375). On occupied sites, Taylor's checkerspot butterflies are present throughout the year in some life cycle form. Restoration activities (application of herbicides, use of restoration equipment, and prescribed fire) can result in trampling, crushing, and destruction of Taylor's checkerspot butterfly eggs, larvae, and adults, and the destruction of larval host plants. Mowing to reduce the cover and competition from woody species, if done at the wrong time of year, can crush larval host plants and nectar plants used by adult butterflies on a site or even crush and kill larvae. Mowing activities should be timed to coincide with the diapause period for the subspecies, and mowing should be relatively high above the soil level to avoid any larvae that may not have burrowed into the soil. Restoration actions to improve Taylors' checkerspot butterfly habitat or increase the number of checkerspots on specific prairie patches is likely to have short-term adverse impacts to individuals. However, with careful planning and implementation, impacts to local populatons can be minimized and allow for successful reintroduction efforts or the expansion of occupied habitats (USFWS, 2016).

Stressor: Pesticides and Herbicides (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of individuals/loss of habitat
Narrative: In the south Puget Sound region, currently occupied Taylor's checkerspot butterfly sites are found in a matrix of rural agricultural lands and low-density development. In this context, herbicide and insecticide use may have direct effects on nontarget plants (butterfly larval and nectar hosts) and butterflies (Stark et al. 2012, p. 23). Herbicides are commonly used to manage rare butterfly habitat and control invasive nonnative plants in south Puget Sound prairies (Schultz et al. 2011, p. 373). Herbicide use can affect butterflies by damaging or destroying larval or adult food sources, or through the direct ingestion of a toxic substance, resulting in reduced larval survival and increased rates of development from larvae to adult, as well as decreased wing area in some species of butterflies (Russell and Schultz 2010, p. 53). These studies indicate that the direct application of herbicide onto eggs, larvae, and larval host plants can result in reduced rates of larva-to-adult survival in some butterfly species, emphasizing the need for careful management using selective applications in habitats occupied by Taylor's checkerspot butterflies. Aerial applications of pesticide also pose a potential threat to Taylor's checkerspot. The lepidopteran-specific insecticide, Bacillus thurengensis var. kurstaki (Btk) has been aerially applied to control Asian gypsy moth (Lymantria dispar) in the Puget Sound region and likely contributed to the extirpation of three historical locales for Taylor's checkerspot butterflies in Pierce County, Washington, in 1992 (Vaughan and Black 2002, p. 13). Although grasslands are not targeted for Btk applications, drift from aerial applications can be lethal to non-target butterflies up to 1.8 miles (3 km) away from the target area (Whaley et al. 1998, p.539). Severns (2002) sampled butterfly diversity, richness, and abundance (density) for two years following a Btk application at Schwarz Park in Lane County, Oregon. Diversity, richness, and density were found to be significantly reduced for 2 years following spraying of Btk (Severns 2002, p. 168). Species like Taylor's checkerspot butterflies, which have a single brood per year, are active in the spring and

their larvae are active during the spray application period. For nontarget lepidoptera, the early instar stages of larvae are the most susceptible stage (Wagner and Miller 1995, p. 21). A widespread application of Btk could have substantial impact on a local butterfly population if the pesticide were sprayed in an area where the habitat is exposed to the pesticide from direct application or through aerial drift (USFWS, 2016).

Stressor: Recreation and Off-Road Vehicles (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of individuals/loss of habitat
Narrative: Recreational foot traffic may be a threat to the Taylor's checkerspot butterfly, as trampling will crush larvae if they are present underfoot. The incidence of trampling is limited to the few locations where Taylor's checkerspot butterflies and recreation overlap. For example, foot traffic is relatively common at Scatter Creek Wildlife Area in Washington, where plants and butterfly habitat have been trampled by horses during specialized dog competitions in which dogs are followed by observers on horseback (Stinson 2005, p. 6), and by foot traffic using the trail system to access the meadows of Beazell Memorial Forest (Park) in Oregon. Recreation by JBLM personnel and local individuals occurs on and near the 13th Division Prairie. Trampling by humans and horses, as well as people walking dogs on the 13th Division Prairie, is likely to crush some larvae, as well as the larval and nectar prairie plant communities that are restored and managed for in this area. Larvae have potentially been crushed on Dan Kelly Ridge, on the north Olympic Peninsula by vehicles that access the site to maintain a cell tower on the ridge. Also, recreational off-road vehicle (ORV) traffic on Dan Kelly Ridge, and on Eden Valley, has damaged larval host plants. The ORV damage on Dan Kelly Ridge occurs despite efforts by Washington State Department of Natural Resources to block access into the upper portions of the road system through gating of the main road. Based on our review, we conclude that ground-disturbing recreational activities are a threat to the Taylor's checkerspot butterfly and where the population is depressed may constitute a serious threat to the long-term conservation of the subspecies (USFWS, 2016).

Stressor: Low Genetic Diversity, Small or Isolated Populations, and Low Reproductive Success (USFWS, 2016)
Exposure:
Response:
Consequence: Extinction
Narrative: There are a number of studies that demonstrate that habitat patch size, local population size, and proximity to adjacent populations have important implications for the long-term persistence of butterfly populations with limited dispersal capabilities (e.g., Thomas and Jones, 1993, p. 472; Hanski et al. 1995, p. 618; Saccheri et al. 1998, p. 492; Maes et al. 2004, pp. 234-235). Studies that examined butterfly population dynamics generally define "small" populations as having fewer than 500 adults and "very small" as having fewer than 100 adults at peak emergence (e.g., Maes et al. 2004, p. 232; Davies et al. 2005, p. 192). Essentially all populations of the Taylor's Checkerspot butterfly except two are currently classified as small or very small populations. Extremely small butterfly populations (e.g. fewer than 20 individuals)

are not only highly vulnerable to environmental factors such as adverse weather conditions (Schtickzelle et al. 2005, p. 578), but such small populations are also at increased risk of extinction due to genetic effects associated with inbreeding (Saccheri et al. 1998, p. 491; Nieminen et al. 2001, p. 243). Inbreeding in small populations of the Glanville fritillary butterfly (Melitaea cinxia) resulted in reduced egg hatching rates, larval survival, and adult longevity (Nieminen et al. 2001, p. 243). Although the genetic diversity and population structure of the Taylor's checkerspot butterfly is unknown, a loss of genetic diversity may have occurred as a result of geographic isolation and fragmentation of habitat patches across the distribution of the existing populations. Dispersal of individuals between local populations directly affects the genetic composition of populations and possibly the abundance of individuals in a population (Hellmann et al. 2004, p. 59). For other subspecies of Edith's checkerspot and their closely related European relative Melitaea, small populations led to a high rate of inbreeding (Boggs and Nieminen 2004, p. 98). Due to the Taylor's checkerspot small population size and fragmented distribution, we conclude that the negative factors associated with small populations, as well as the potential historical loss of genetic diversity, may contribute to further population declines for the Taylor's checkerspot butterfly (USFWS, 2016).

Stressor: Climate Change (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat/extinction
Narrative: Over the next century, climate change at global and regional scales is predicted to result in changes in butterfly species distributions and altered life histories (McLaughlin et al. 2002, p. 6074, Hill et al. 2002, p. 2163, Singer and Parmesan 2010, p. 3161). Rare butterflies, including the Taylor's checkerspot, may be vulnerable to climate change, as their populations are often fragmented due to habitat losses that restrict the species' ability to adapt to changing environmental conditions (Schultz et al. 2011, p. 375). In the Pacific Northwest, mean annual temperatures rose 0.8 °C (1.5 °F) in the 20th century and are expected to continue to warm from 0.1 °C to 0.6 °C (0.2 °F to 1.0 °F) per decade (Mote and Salathe 2010, p.29). Global climate models project an increase of 1 to 2 percent in annual average precipitation, with some models predicting wetter autumns and winters with drier summers (Mote and Salathe 2010, p.29). Regional models of potential climate changes are much more variable, but the models generally indicate a warming trend in mean annual temperature, reduced snowpack, and increased frequency of extreme weather events (Salathe et al. 2010, pp. 72-73). Downscaled regional climate models, such as those presented by www.climatewizard.org have tremendous variation in projections for annual changes in temperature or precipitation depending upon the climate model or scenario. Averaged values across large areas generally indicate a general warming trend in mean annual temperature consistent with the climate projections reported by Salathe and others (2010, pp. 72-73). Because the Taylor's checkerspot butterfly occupies a relatively small area of specialized habitat, it may be vulnerable to climatic changes that could decrease suitable habitat or alter food plant seasonal growth patterns (phenology). The relationship between climate change and survival for the Euphydryas editha complex is driven more by the indirect effects of the interaction between seasonal growth patterns of host plants and the life cycle of the checkerspot butterfly than by the direct effects of temperature and precipitation (Guppy and

Fischer 2001, p. 11; Parmesan 2007, p. 1868; Singer and Parmesan 2010, p. 3170). Predicting seasonal growth patterns of butterfly host plants is complicated, because these patterns are likely more sensitive to moisture than temperature (Cushman et al 1992, pp. 197–198; Bale et al. 2002, p. 11), which is predicted to be highly variable and uncertain in the Pacific Northwest (Mote and Salathé 2010, p. 31). Climate models for the Georgia Basin—Puget Sound Trough—Willamette Valley Ecoregion consistently predict a deviation from the historical monthly average precipitation, with the months of January through April projected to show an increase in precipitation across the region, while June through September are predicted to be much drier than the historical average (Climatewizard 2012). It is likely that the overlap of seasonal growth patterns between primary larval host plants and the Taylor's checkerspot butterfly will display some level of stochasticity due to climatic shifts in precipitation and increased frequency of extreme weather events. For the Edith's checkerspot (E. editha), Parmesan (2007, p. 1869) reported that a lifecycle mismatch can cause a shortening of the time window available for larval feeding, causing the death of those individuals unable to complete their larval development within the shortened period, citing a study by Singer (1972, p. 75). In that study, Singer documented routine mortality of greater than 98 percent in the field due to phenological mismatches between larval development and senescence of their annual host plant Plantago erecta (California plantain). When mismatches such as these form the 'starting point,' insects may be highly vulnerable to small changes in synchrony with their hosts (Parmesan 2007, p. 1869). The interplay between host plant distribution, larval and adult butterfly dispersal, and female choice of where to lay eggs will ultimately determine the population response to climate change (Singer and Parmesan 2010, p. 3164). However, determining the long-term responses to climate change from even well-studied butterflies in the genus Euphydryas is difficult, given their ability to switch to alternative larval food plants in some instances (Singer and Thomas 1996, pp. S33–34; Hellmann 2002, p. 933; Singer et al. 1992, pp. 17–18). Attempts to analyze the interplay between climate and host plant growth patterns using predictive models or general State-wide assessments and to relate these to the Taylor's checkerspot butterfly are equally complicated (Murphy and Weiss 1992, p. 8). Despite the potential for future climate change in Western Washington, we have not identified, nor are we aware of any data on an appropriate scale to evaluate the effects of climate change to habitat or population trends for the Taylor's checkerspot butterfly. However, we recognize that weather events and climatic factors strongly influence the reproduction and larval survival rates for the Taylor's checkerspot, and these effects are most profound in species with small, isolated populations such as the Taylor's checkerspot (USFWS, 2016).

Stressor: Stochastic Weather Events (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of populations
Narrative: Adverse weather (freezing temperatures, heavy rain events, or prolonged drought) can extirpate local butterfly populations by killing adults, larvae, or larval food plants (Guppy and Shephard 2001, p. 59). Even large populations of butterflies (greater than 5,000 individuals) can rapidly decline in response to successive seasons of unfavorable weather conditions during reproduction and larval development (Ehrlich et al. 1980, pp. 102-103). Poor weather conditions,

such as cool temperatures and rainy weather, reduce the number of days in the flight period for several early spring flying butterflies, including the Taylor's checkerspot butterfly. A shorter flight season reduces the number of opportunities for oviposition (egg laying) for female butterflies, thus affecting the emergence of adult butterflies in the future. Butterflies, including the Taylor's checkerspot butterfly, may experience increased mortality or reduced fecundity if the timing of plant development does not match the timing of larval or adult butterfly development (Peterson 1997, p. 167), and large fluctuations in population sizes have been observed based on local weather patterns (Hellmann et al. 2004, p. 45). During 2010 and 2011, the emergence of Taylor's checkerspot butterfly adults was approximately 3 weeks later than "normal" due to wet and cool spring weather. In addition, it has been reported that both drought and deluge may interrupt the insect-plant interaction, resulting in decreased populations (Hellmann et al. 2004, p. 45). The effects of drought have been shown to negatively affect populations of Edith checkerspot butterflies in California (Hellmann et al. 2004, p. 45). Because the historical numbers and distribution of the Taylor's checkerspot butterfly has been reduced to a handful of relict populations, the subspecies is particularly vulnerable to the effects of adverse weather events, particulary when compounded with other ongoing threats associated with habitat loss and degradation associated with succession and invasive plants (USFWS, 2016).

Recovery

Recovery Actions:

- The imperiled status of the Taylor's checkerspot butterfly has led to a number of habitat restoration actions and reintroduction efforts. The Washington Department of Fish and Wildlife in cooperation with the Oregon Zoo and others have an ongoing captive rearing program to support reintroduction of Taylor's checkerspot butterflies at south Puget prairie sites that have been managed for butterfly habitat (Linders 2011, p. 383). Sites targeted for reintroduction include areas that historically supported Taylor's checkerspot butterfly. Reintroductions of captive-reared postdiapause larvae and adult butterflies have resulted in the tentative establishment of three Taylor's checkerspot populations since 2007 (Table 1, above), while efforts at fourth site (JBLM-Pacemaker) have been discontinued, and very few butterflies were seen at this site in 2013 (Linders & Lewis 2013, p. 45). Habitat restoration efforts to manage invasive species and restore native forb and grass communities is ongoing at most sites currently occupied by the Taylor's checkerspot butterfly (e.g., Linders & Lewis 2013, Hayes 2011, Ross 2008). In 2007, JBLM, started an Army Compatible Use Buffer (ACUB) initiative that includes support for interagency butterfly habitat management on several Puget prairie sites (Fimbel et al 2011, p. 379). Habitat restoration using prescribed fire, herbicide applications, followed by seeding and planting of native grasses and forbs have proven to be successful methods for restoring degraded prairie habitats (Fimbel et al 2011, p. 379). Removal of small trees and shrubs within natural balds and occupied clearcut areas on the Olympic Peninsula has been undertaken to slow the rate of natural succession occurring there, as these sites are undergoing rapid transition from grass to forested habitat (Hayes 2011, p. 10). Habitat restoration and maintenance is an ongoing conservation need at all sites currently occupied by Taylor's checkerspot butterfly, as native plant communities have largely been replaced by non-native grasses and invasive shrubs (USFWS, 2016).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS In addition to the actions and activities specified within the Taylor's checkerspot butterfly draft recovery plan and recovery implementation strategy (Service 2022a; 2022b), these actions will help address knowledge gaps and facilitate recovery: • Perform research to determine the genetic structure within and among populations of Taylor's checkerspot butterfly. • Identify and evaluate additional locations and necessary restoration actions to establish population complexes in the North Salish Sea and Wilamette Valley recovery regions. • Perform experiments to understand the relative importance of different host plant species for larval development. • Develop and implement a monitoring strategy across the range of Taylor's checkerspot that will reflect progress towards recovery goals (USFWS, 2024).

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SPECIES ACCOUNT: *Euproserpinus euterpe* (Kern primrose sphinx moth)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened; April 8, 1980 (45 FR 24088).

Physical Description

The Kern primrose sphinx moth (Euproserpinus euterpe) is a moderate-sized moth with a wingspan of 7.5 centimeters (3 inches [in.]) (Xerces 2005). It has a streamlined yet stout body and elongate forewings which are oblique at the outer margins. The adult Kern primrose sphinx moth is distinctly marked by a broad and contrasting white band on the abdomen, convex costal margins of the hindwing and forewing, and white scaling on the dorsal surface of the antenna. Eggs are approximately 1 millimeter in size (0.04 in.) and light green in color. The colorful larvae are without hair or spines, and the dorsal part of the eighth abdominal segment contains a horn or spur (USFWS 2007). Early instar larvae are green with dark-brown to black heads, legs, lateral spiracles shields, and blunt anal horns. Fourth and fifth instar larvae have red to dark-red heads, green to red rust green bodies accented with black areas around spiracles, anal shields, and anal horns. The legs are green and the prolegs (appendages that are not true legs) are red in these mature larvae. Adult males are similar in appearance to adult females, though slightly smaller in size (Xerces 2005).

Taxonomy

The Kern primrose sphinx moth is one of three distinct species in the genus Euproserpinus; the other two species are Prairie sphinx moth (E. wiesti) and Phaeton primrose sphinx moth (E. phaeton). The Prairie sphinx moth is also a rare species with only a few known colonies. Of the three species, Phaeton primrose sphinx moth is the most commonly observed and until recently was the only member of the genus whose biology was known. The adults and immature stages of Kern primrose sphinx moth are quite different from those of its closest relatives and preclude generalization from information available about its congeners. The Phaeton primrose sphinx moth also occurs in Kern County; however, there is no evidence to indicate that it and the Kern primrose sphinx moth occur sympatrically (USFWS 1984). Recent genetic studies support the morphological evidence that Euproserpinus taken from the Carrizo Plain and the Walker Basin are the same species, which is Kern primrose sphinx moth (USFWS 2007).

Historical Range

At the time of listing, the only known colony of Kern primrose sphinx moth was in the extreme northwestern portion of Walker Basin, Kern County, California, primarily on 4,000 square meters (m2) (43,056 square feet [sq. ft.]) of a sandy wash. The area where this species is known to occur is described in the recovery plan as 6.1 hectares (ha) (15 acres [ac.]). Kern primrose sphinx moth may have been primarily confined to the Walker Basin even at the time of its original type specimen collection in 1888 (45 FR 24088; USFWS 1984; USFWS 2007).

Current Range

At the time of listing, the Kern primrose sphinx moth was known only from the northwest portion of the Walker Basin in Kern County, primarily on 4,000 square meters (43,053 square feet) of a sandy wash (45 FR 24088; Service 1980). Prior to the last 5-year review, the known species' distribution expanded to include six populations at the Carrizo Plain National Monument in San Luis Obispo County and five populations in the Cuyama Valley in Santa Barbara and Ventura Counties (Jump et al. 2006). Since the last 5-year review, periodic surveys continue to be completed by Bureau of Land Management and species experts with 10(a)(1)(A) recovery permits. In 2015, two new occurrence locations were found within the Carrizo Plain population (BLM 2016) and the latest survey completed in 2019 found an overall average flight season with moths continuing to be observed in known locations (BLM 2020). An artificial pheromone lure that attracts Kern primrose 2 sphinx moth has been created and tested in the field (Osborne 2011), and the lure has since been used as a survey tool to develop a better understanding of species occupation throughout their range (BLM 2016; BLM 2019). The surveys that have been completed since the previous 5-year review do not alter our understanding of the species' current distribution. Although surveys usually occur annually to determine species presence and local abundance, population estimates or trends have not been determined. (USFWS, 2020)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: The larvae feed exclusively on the vegetation of evening primrose (Camissonia sp.) (USFWS 2015). On Carrizo Plain, larvae have been found feeding on field primrose (Camissonia campestris), while larvae at Walker Basin are reported to feed on Camissonia contorta epilobioides, which is thought to be derived from a field primrose and sandysoil suncup (Camissonia strigulosa) cross. Other closely related sphingids use more than one species of Onagraceae as larval hosts, so multiple hosts may be expected for Kern primrose sphinx moth as well (Jump et al. 2006).

Adult: Adult Kern primrose sphinx moths feed on nectar of filaree (Erodium cicutarium), goldfields (Lasthenia chrysostoma), baby blue-eyes (Nemophila menziesii), and miniature lupine (Lupinus bicolor) (NatureServe 2015). On Carrizo Plain, larvae have been found feeding on Camissonia campestris, while larvae at Walker Basin are reported to feed on Camissonia contorta epilobioides, which is thought to be derived from a Camissonia campestris and Camissonia strigulosa cross. Other closely related sphingids use more than one species of Onagraceae as larval hosts, so multiple hosts may be expected for the Kern primrose sphinx moth as well (Jump et al. 2006). Most nectaring occurs in the morning at flowers of filaree and baby blue-eyes. By afternoon, the nectar may be exhausted or wind speed too high for insect flight (USFWS 1984).

Reproduction Narrative

Larvae: Larvae emerge from the eggs in a minimum of 11 days after oviposition, and begin feeding exclusively on evening primrose. There are five larval instars before pupation occurs in May. Pupae are known to diapause (delay metamorphosis to adult form) underground for multiple years during drought periods (USFWS 1984; USFWS 2015). At the time of listing, the nonnative, invasive, low-growing weedy plant, filaree (Erodium sp.), was thought to negatively impact the Kern primrose sphinx moth at the Walker Basin because it was noted that female moths oviposit on nonhost plants and other objects. Subsequent observations revealed that the first instar (growth period between molts in larval insects) larvae is actually capable of making forays from nonhost plants across open ground to find host plants if the individual host plants are of adequate density. This means that Kern primrose sphinx moth oviposition on filaree does not necessarily lead to death of the hatching larvae (USFWS 2015).

Adult: Adults emerge and fly from late February to early April. The flight season of this species was observed to occur earlier in the year at Carrizo Plain (late January through late February) than at Walker Basin (mid-March through early April). This difference is attributed to the seasonally warmer than average temperatures prior to the flight season during this survey event. However, it is believed that the Carrizo Plain, being at a lower elevation, will normally have an earlier flight season than the Walker Basin, owing to the higher temperatures earlier in the year (USFWS 2007). Moths emerge from the pupae in the morning, and expand their wings and begin to fly by mid-morning. Mating usually occurs prior to noon, and ovipositing females are generally observed between late morning and early afternoon. Females fly low to the ground and deposit one or two eggs on the underside of the evening primrose (Camissonia sp.) and filaree (Erodium cicutarium) leaves (USFWS 1984; USFWS 2015).

Spatial Arrangements of the Population

Larvae: See adult life history.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: See adult life history.

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Larvae: See adult life history.

Adult: Moderate

Site Fidelity

Larvae: See adult life history.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Larvae require the presence of evening primrose (Camissonia sp.), their sole food source (USFWS 1984).

Adult: Adults feed on the nectar of several species of flowers, including filaree (Erodium cicutarium), baby blue-eyes (Nemophila menziesii), rabbit brush (Chrysothamnus nauseosus), gold fields (Lasthenia chrysostoma), and brome grass (Bromus arenarius) (USFWS 1984).

Habitat Narrative

Larvae: Larvae require the presence of evening primrose (Camissonia sp.), their sole food source (USFWS 1984).

Adult: The Kern primrose sphinx moth occurs in sandy washes consisting of coarse to fine-textured, decomposed granite soil, and dominant vegetation that includes filaree (Erodium cicutarium), baby blue-eyes (Nemophila menziesii), rabbit brush (Chrysothamnus nauseosus), gold fields (Lasthenia chrysostoma), and brome grass (Bromus arenarius). Essential to the survival of the Kern primrose sphinx moth larvae is the presence of its primary food, evening primrose (Camissonia sp.) (USFWS 1984). The essential habitat elements at the Carrizo Plain and the Cuyama Valley include sandy washes with open soil for morning basking, young alluvial sandy soils that support the food plant, field primrose (Camissonia campestris), soils that are loose enough to allow larvae to burrow and construct shallow pupal chambers, and sufficiently dense stands of primrose (Camissonia sp.) that allow Kern primrose sphinx moth larvae to travel from stand to stand as they consume their host plants. The Kern primrose sphinx moth populations at Walker Basin and those at the Carrizo Plain and in the Cuyama Valley use different host plant species (Jump et al. 2006). The ecological integrity of the community is variable; one occurrence is in fairly natural desert scrub, the other in a primarily agricultural area. Some of the habitat has been disked, and some roads and development are within the population areas (NatureServe 2015). Topography, especially slope-specific insolation, is known to influence both host plant growth and post-diapause larval growth for some butterfly species, and may be one factor in Kern primrose sphinx moth occurrences in certain washes (USFWS 2007).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory (NatureServe 2015)

Adult: Nonmigratory (NatureServe 2015)

Dispersal

Larvae: Low

Adult: Low

Immigration/Emigration

Adult: Possibly; one hypothesis is that younger washes are necessary to provide appropriate soil conditions for the species, while older formations support consolidated soils and too few food plants. Consistent with this habitat characteristic is the theory that the species is adapted to colonization of new habitats over the course of decades (Jump et al. 2006).

Dependency on Other Individuals or Species for Dispersal

Larvae: Yes; sufficiently dense stands of primrose (Camissonia sp.) that allow Kern primrose sphinx moth larvae to travel from stand to stand as they consume their host plants (Jump et al. 2006).

Adult: Abundant supplies of nectar plants (USFWS 2007).

Dispersal/Migration Narrative

Larvae: Kern primrose sphinx moth larvae require young alluvial sandy soils that support the food plant field primrose (Camissonia campestris), soils that are loose enough to allow larvae to burrow and construct shallow pupal chambers, and stands of field primrose that are sufficiently dense to allow Kern primrose sphinx moth larvae to travel from stand to stand as they consume their host plants (USFWS 2007).

Adult: The Kern primrose sphinx moth has fairly low mobility and is nonmigratory. The species requires abundant supplies of nectar plants for dispersal (USFWS 2007). One hypothesis is that younger washes are necessary to provide appropriate soil conditions for the species, while older formations support consolidated soils and too few food plants. Consistent with this habitat characteristic is the theory that the species is adapted to colonization of new habitats over the course of decades (Jump et al. 2006). Female Kern primrose sphinx moths fly slower and are easier to capture, which may have led to a serious depletion of females at Walker Basin prior to listing, when large numbers of Kern primrose sphinx moths were captured by collectors (USFWS 1984).

Additional Life History Information

Adult: Female Kern primrose sphinx moths fly slower and are easier to capture, which may have led to a serious depletion of females at Walker Basin prior to listing, when large numbers of Kern primrose sphinx moths were captured by collectors (USFWS 1984).

Population Information and Trends

Population Trends:

Unknown: due to a complex life history, it is difficult to establish long-term trends. Eleven new populations have been discovered since listing (USFWS 2007). Population trends range from a decline of less than 30 percent to relatively stable (NatureServe 2015).

Species Trends:

Unknown: due to a complex life history, it is difficult to establish long-term trends (USFWS 2007). Population trends range from a decline of less than 30 percent to relatively stable (NatureServe 2015).

Number of Populations:

Twelve: one population in the northwestern portion of Walker Basin, five populations in the Cuyama Valley, and six populations in Carrizo Plain (USFWS 2007).

Population Size:

Fifty to 2,500 individuals (NatureServe 2015).

Adaptability:

Low

Additional Population-level Information:

Although population surveys have been continuous and ongoing, it is difficult to establish long-term trends from these population data. Adult populations of Kern primrose sphinx moth vary significantly in size from year to year, and the phenology of pupation and metamorphosis of the Kern primrose sphinx moth is not yet well known. Because pupae may spend several years in diapause, buried in loose soil, population abundances will most likely be underestimated (USFWS 2007).

Population Narrative:

The Kern primrose sphinx moth has probably experienced a very large decline over recent centuries, but there are too few historic records to provide an adequate analysis (NatureServe 2015). At the time of listing, the Kern primrose sphinx moth was known from only the northwestern portion of the Walker Basin, primarily on 4,000 m2 (43,053 sq. ft.) of a sandy wash. Since that time, 11 new populations have been discovered. Currently, there are 12 known populations: one population in the northwestern portion of Walker Basin, five populations in the Cuyama Valley, and six populations in Carrizo Plain. The distance between the Walker Basin and the Carrizo Plain populations is approximately 120 kilometers (75 miles) as the moth flies, yet no additional colonies of Kern primrose sphinx moth have been found between these two locations (USFWS 2007). The total number of individuals is estimated to range between 50 and 2,500 (NatureServe 2015). Although population surveys have been continuous and ongoing, it is difficult to establish long-term trends from these population data (USFWS 2007). The population and species level trends are estimated to range from relatively stable to a decline of less than 30 percent (NatureServe 2015). The adult populations of Kern primrose sphinx moth vary significantly in size from year to year, and the phenology of pupation and metamorphosis of the Kern primrose sphinx moth is not yet well known. Because pupae may spend several years in diapause, buried in loose soil, population abundances will most likely be underestimated (USFWS 2007).

Threats and Stressors

Stressor: Agricultural land use practices
Exposure: Sheep grazing, disking, and herbicide and pesticide use.
Response: May damage the soil, cause erosion, or directly destroy Kern primrose sphinx moth eggs, larvae, pupae, or adult moths, as well as nectar and host plants.
Consequence: Habitat degradation and loss, possible reduction in population size.
Narrative: Various agricultural practices, including sheep grazing, disking, and herbicide and pesticide use exist throughout the known range of the Kern primrose sphinx moth. These practices can damage the habitat by means of trampling, destruction of the cryptogamic crusts, alteration of the native plant community, erosion, and direct exposure to herbicides and pesticides. Potential consequences include habitat degradation and/or loss of habitat, and reduction in population size (USFWS 2007).

Stressor: Development
Exposure: Residential development in the Walker Basin.
Response: Damage to the habitat.
Consequence: Loss of habitat and population loss; injury; and mortality.
Narrative: Presently, a 486-ha (1,202-ac.) parcel in the Walker Basin has been targeted for subdivision into small agricultural ranches. The parcel is known to have suitable habitat for Kern primrose sphinx moth, including stands of evening primrose (Camissonia sp.), is near known populations of the Kern primrose sphinx moth, and may be occupied by Kern primrose sphinx moths as well. Potential development in the Walker Basin for agricultural purposes could cause habitat damage and/or loss, or could reduce the size of the populations in the Walker Basin (USFWS 2007).

Stressor: Illegal collection, over-collection
Exposure: Commercial collection.
Response: Removal of females.
Consequence: Population reductions and Allee effect.
Narrative: At the time of listing, collectors had removed a significant number of moths. The majority of these were females, which fly more slowly and are therefore more easily caught. Illegal collection for commercial purposes remains a threat for this moth. This is primarily because small populations of moths and butterflies are vulnerable to harm from collection of adults. A population may be reduced below sustainable numbers (Allee effect) by removal of females, thus reducing the probability that new colonies will be founded. The Kern primrose sphinx moth is particularly affected by loss of females to collection because females fly slower and often land for oviposition. Collectors may not always realize they may be depleting colonies of butterflies or moths to below threshold limits for the survival or recovery of the colony. Poachers may also use various methods to escape detection or to evade prosecution. An illegal market exists for rare

insect species, and private collectors are willing to pay substantial sums for valued specimens of listed species (USFWS 2007).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Habitat remains unprotected. No state or local protections afforded to the species.
Response: Populations on private land remain unprotected; only indirect measures may be implemented, such as educating landowners on what activities are damaging to Kern primrose sphinx moth, and placing barricades to discourage trespassing on private property.
Consequence: Damage to or loss of habitat, and reduction of population size.
Narrative: Much of the known habitat and large areas of suitable habitat for the Kern primrose sphinx moth are on private lands and remain unprotected. Currently, no land at Walker Basin has been acquired to protect the known population of Kern primrose sphinx moth existing there, and the population at the Carrizo Plain exists on both public and private land. Only indirect measures can be taken to protect Kern primrose sphinx moth on these private properties, such as educating landowners on what activities are damaging to Kern primrose sphinx moth, and placing barricades to discourage trespassing on private properties near public lands.The Lacey Act: The Kern primrose sphinx moth is also protected by the Lacey Act, as amended in 16 United States Code 3371. The Lacey Act makes unlawful the import, export, or transport of any wild animals, whether alive or dead; and further makes unlawful the selling, receiving, acquisition, or purchasing of any wild animal, alive or dead. The designation of wild animal includes parts, products, eggs, or offspring.State and Local Protections: The Kern primrose sphinx moth is not specifically protected under any state or local law. The California Endangered Species Act does not provide protection to insects (Sections 2062, 2067, and 2068, California Fish and Game Code) (USFWS 2007).

Stressor: Succession on alluvial fans
Exposure: Succession
Response: Decrease of evening primrose.
Consequence: Decreased support of populations.
Narrative: Evening primrose (Camissonia spp.) grows abundantly in disturbed sandy washes. As the sandy nature of the soil is lost over time due to succession, the abundance and density of evening primrose is decreased and appears to be unable to support Kern primrose sphinx moth populations (USFWS 2007).

Stressor: Roadkill of basking moths
Exposure: Vehicles at the Walker Basin.
Response: Road mortality.
Consequence: Loss of individuals in the Walker Basin population.
Narrative: Adult Kern primrose sphinx moths bask on open, bare, sandy ground. Moths at the Walker Basin have been run over by vehicles while basking (USFWS 2007).

Stressor: Off-road vehicle use
Exposure: Off road vehicle use.

Response: Destruction of host plant and the cryptogamic crusts, and mortality of the early stages of the Kern primrose sphinx moth.
Consequence: Habitat damage/destruction, reduction of population; and mortality.
Narrative: Off-road vehicles in suitable habitat on private and Bureau of Land Management lands in the Carrizo Plain and the Cuyama Valley will destroy the evening primrose host plant and the cryptogamic crusts, and kill the early stages of the Kern primrose sphinx moth. In the Cuyama Valley, the use of unimproved roads occurs in three of the washes inhabited by populations of Kern primrose sphinx moths (USFWS 2007).

Recovery

Reclassification Criteria:
Reclassification/uplisting criteria have not been established for this species.

Delisting Criteria:
Protect the only known colony of the Kern primrose sphinx moth, and establish three more secure colonies in the Walker Basin, with a combined total of 2,023 ha (5,000 ac.) that are secured by easement, long-term agreement, or other protective strategy. Each of these colonies should be maintained without threat from agricultural conversion, pesticides, disease or collection for a period of 10 consecutive years before delisting should be considered (USFWS 1984; USFWS 2007). Since the Recovery Plan was written, several other populations have been discovered, so this information needs to be updated (USFWS 2007).

Conduct ecological and life history studies of the Kern primrose sphinx moth before establishing new colonies (USFWS 1984; USFWS 2007).

Recovery Actions:
- Use laws and regulations to protect Kern primrose sphinx moth (USFWS 1984).
- Protect and enhance existing Kern primrose sphinx moth populations (USFWS 1984).
- Establish additional colonies of Kern primrose sphinx moth in the Walker Basin (USFWS 1984).
- Inform the public about Kern primrose sphinx moth and its habitat (USFWS 1984).
- Revise the Kern primrose sphinx moth recovery plan. The 1984 recovery plan does not adequately address the current threats to the Kern primrose sphinx moth and no longer conforms to the best available scientific information. A new recovery plan should be based on the findings summarized in Jump et al. (2006). The most important new findings include an expanded population distribution of Kern primrose sphinx moth and the capability of Kern primrose sphinx moth larvae to traverse small distances to find proper host plants (USFWS 2007).
- Protect known Kern primrose sphinx moth populations at Carrizo Plain National Monument and at Cuyama Valley (USFWS 2007).
- Survey suitable habitat for undiscovered Kern primrose sphinx moth populations (USFWS 2007).
- Acquire Kern primrose sphinx moth habitat at Walker Basin and provide protection for Kern primrose sphinx moth (USFWS 2007).

- Continue life history, ecology, and genetic studies of Kern primrose sphinx moth (USFWS 2007).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The following recommendations were included in the previous 5-year review and remain valid: 1. Protect known Kern primrose sphinx moth populations at Carrizo Plain National Monument and at Cuyama Valley: Although area has been conserved in the Carrizo Plain since the last status review, known populations that exist at the Carrizo Plain and Cuyama Valley still exist on both private and public land. The public land is managed by BLM (Carrizo Plain) and the U.S. Forest Service (Cuyama Valley). Although measures have been taken to protect these populations through signs and fencing, there exists no means to protect the remaining suitable habitat from being trampled by sheep grazing on private land or from destruction by unauthorized OHV use (A. Kuritsubo in litt. 2006; K. Sharum in litt. 2006). Possible protective actions for the Kern primrose sphinx moth on private properties need to be discussed and, if appropriate, implemented. 2. Acquire Kern primrose sphinx moth habitat at Walker Basin and provide protection for Kern primrose sphinx moth: Protection of known populations of the Kern primrose sphinx moth at the Walker Basin is vital for maintaining a third location for the species. Property acquisition should follow after clear indications of sphinx moth presence results from thorough surveys. Once acquired, the property needs to be protected from trespassing and from any practices adverse to the Kern primrose sphinx moth life history. 3. Survey suitable habitat for undiscovered Kern primrose sphinx moth populations: Suitable habitat for the Kern primrose sphinx moth exists in and around the Carrizo Plain, Cuyama Valley, and Walker Basin that has not yet been extensively surveyed for the presence of the Kern primrose sphinx moth. These areas should be surveyed coinciding with the Kern primrose sphinx moth flight period to determine presence/absence as a minimum. 4. Continue life history, ecology, and genetic studies of Kern primrose sphinx moth: Jump et al. (2006) provided a comprehensive report of the current knowledge of Kern primrose sphinx moth life history. Future research should build upon the current understanding of species life history and ecology as well as provide a better understanding of pupal development and survival. 5. Revise the Kern primrose sphinx moth recovery plan: The 1984 recovery plan does not adequately address the current threats to the Kern primrose sphinx moth and no longer conforms to the best available scientific information. A new recovery plan should be based on the findings summarized in the previous and current 5-year reviews. The most important new findings include an expanded population distribution of Kern primrose sphinx moth and the capability of Kern primrose sphinx moth larvae to traverse small distances to find proper host plants. (USFWS, 2020)

Additional Threshold Information:

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SPECIES ACCOUNT: *Heraclides aristodemus ponceanus* (Schaus swallowtail butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2015)

Physical Description

The Schaus swallowtail butterfly is a large blackish-brown swallowtail butterfly with contrasting markings that are mostly dull yellow (Klots 1951, Pyle 1981, Opler and Krizek 1984). Wingspan is 8.6 to 9.5 centimeters (3.4 to 3.7 inches) (Klots 1951, Pyle 1981). The species is endemic to south Florida and the Florida Keys. Historically, it occurred in hardwood hammocks from south Miami to Lower Matecumbe Key, Florida. As a result of urban development and pesticide spraying, only about 12 isolated colonies of this butterfly remain. The stronghold of the population resides on several islands in Biscayne National Park and north Key Largo, in areas protected from development.

Taxonomy

One of four subspecies, the others being P. a. bjordalae (Bahamas), P. a. aristodemus (Hispaniola), and P. a. temenes (Cayman Islands and Cuba). Some workers do not accept Ponceanus as a valid taxon, but most published sources do. (NatureServe, 2015)

Current Range

The present distribution of the Schaus swallowtail butterfly is limited to tropical hardwood hammocks in portions of Miami-Dade and Monroe Counties. The largest remaining populations of the Schaus swallowtail occur on southern Elliott Key in Biscayne National Park and associated smaller islands and south to Key Largo, particularly Crocodile Lake National Wildlife Refuge and Key Largo Hammock State Botanical Site (Minno and Emmel 1993, Glassberg et al. 2000). Although Schaus swallowtail butterflies were sighted on Lignumvitae Key in 1973 (Covell 1976), Big Pine Key in 1966 (Service 1982), and Upper Matecumbe Key in 1986 (Emmel 1986a), regular sightings of this species are uncommon south of Key Largo (Emmel and Daniels 2002). The last known mainland specimen was collected at Coconut Grove in May 1924 (Service 1982, Emmel and Daniels 2002), however following re-introduction efforts in 1995 and 1997 the Schaus swallowtail has been observed within the Deering Estate in southeastern Miami-Dade County (Emmel and Daniels 2002; M. Salvato, Service, personal observations, 2004). Emmel and Daniels (2005) reported periods of peak Schaus abundance often occurred following or during normal rains years. Available evidence suggests population abundance in BNP rebounded after Hurricane Andrew, in normal rain years, to numbers approaching those observed there in the mid-1980s (Emmel 1995). Numbers subsequently declined during drought conditions. During May and June 2004 the Schaus swallowtail was observed not only on Elliott Key, but at several locations on northern Key Largo (Salvato, Service, personal observations, 2004). Although, abundant in 2004, numbers of the Schaus swallowtail were considerably lower during the 2005 flight season, likely the result inadequate spring rains needed to encourage emergence of the species (Salvato, Service, personal observations, 2005). The influence of persistent drought in southern Florida during the past decade may help to explain ongoing declines in Schaus swallowtail populations (Salvato, personal communication 2012). Higher levels of spring precipitation in recent years (2012 to 2015) resulted in exceptional habitat conditions (increased new hostplant growth) and likely contributed to increased abundance of Schaus' swallowtails (Daniels 2014). Captive propagation efforts for the Schaus swallowtail butterfly began in May 1992, and the first pupae were released at several sites in the Deering Estate and the northern keys during the butterfly's flight seasons in 1995-1997. These initial captive releases did result in a sustained increase in numbers of the Schaus swallowtail at the release sites. Beginning in 2012 UF, the Service, NPS, and other partners reinitiated captive rearing efforts for the Schaus' swallowtail, with reintroduction activities occurring within BNP and northern Key Largo in 2014 and 2015.

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Nectaring activity usually occurs on blossoms of cheese shrub (Morinda royoc), blue porterweed (Stachytarpheta jamaicensis), sea grape (Coccoloba uvifera), wild sage (Lantana involucrata), wild coffee (Psychotria nervosa), or guava (Psidium guajava) along the margins of these hammocks. However, up to 30 different wild plant species may be exploited (Emmel 1988, 1995a). This species rarely feeds in areas open to direct sunlight (Service 1982, Rutkowski 1971).

Reproduction Narrative

Adult: The Schaus swallowtail butterfly normally produces a single annual brood (or generation) that occurs primarily in late spring (Minno and Emmel 1993). Most sightings have been recorded between mid-April and mid-July although a second much smaller brood has occasionally been noted in August (Brown 1976, Minno and Emmel 1993, Smith et al. 1994). Eggs are laid on torchwood (Amyris elemifera) and wild lime (Zanthoxylum fagara), and take 3 to 5 days to hatch (Grimshawe 1940, Rutkowski 1971, Brown 1973, Loftus and Kushlan 1984). Torchwood is the primary food source for caterpillars (Minno and Emmel 1993, Smith et al. 1994). Pupal mortality rates are high and most likely result from bird predation (Emmel 1995b). The Schaus swallowtail may remain in the chrysalis stage for 1 or 2 years (Grimshawe 1940). The annual emergence and flight season of the Schaus swallowtail butterfly appears to be triggered by rainfall (Smith et al. 1994, Emmel and Daniels 2002). Adults are diurnal and short lived, with survival rates in the wild averaging 3.3 days for males and 3.6 days for females (Emmel 1988, 1995b). They remain almost entirely within the tropical hardwood hammock habitat, although individuals are known to travel between islands (Brown 1973, Emmel 1986a). The males prefer trails and hammock edges while the females more often fly within the hammock, occasionally venturing out to feed on flowers but typically staying within the hammocks proper (Rutkowski 1971).

Habitat Narrative

Adult: – Habitat suitable for Schaus swallowtail butterfly occurs at relatively high elevation of 3.0 to 4.6 meters (9.8 to 15 feet) above sea level, away from tidal waters, and has a mature overstory of trees such as gumbo-limbo (Bursera simaruba), pigeon plum (Coccoloba diversifolia), black ironwood (Krugiodendron ferreum), West Indian mahogany (Swietenia mahagoni), and wild tamarind (Lysiloma latisiliquum) (Covell 1976). These plants grow on a substrate of Key Largo limestone, which characterizes the Upper Keys

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal/Migration Narrative

Adult: Not migratory but adults are dispersive and even fly between islands over a km apart. (NatureServe, 2015)

Population Information and Trends

Population Narrative:

Although population numbers of the Schaus swallowtail butterfly fluctuate year to year, there was a general decline in range and numbers between 1924 and 1981. The Schaus swallowtail butterfly has been considered rare on north Key Largo since the mid-1970s. Suitable habitat remaining for this species is estimated as 43 percent in Biscayne NP and 17 percent for north Key Largo. The decline has been attributed primarily to habitat destruction. North Key Largo contains one of the last remaining protected areas of tropical hardwood hammock habitat. The majority of the Schaus swallowtail butterfly population is found on Adams, Elliott, Old Rhodes, Swan, and Totten Keys within Biscayne National Park. Monitoring was initiated in 1984, when only 70 adults were detected range-wide. Between 1985 and 1990, the Elliott Key population fluctuated between 600 to 1,000 adults annually, with smaller populations of at least 50 to 100 individuals on each of the other Keys. Although Hurricane Andrew temporarily reduced the Biscayne National Park population in 1992 to 58 identified individuals, the population rebounded to over 600 in 1994 and was presumed stable (Emmel 1995a). In response to reduced numbers following Hurricane Andrew, captive propagation efforts for the Schaus swallowtail butterfly began in May 1992, and the first pupae were released at several sites in the northern keys, as well as the Charles Deering Estate (Miami-Dade County, Coral Gables, Florida) during the butterfly's flight seasons in 1995-1997. Including reintroduced individuals, range-wide population numbers for Schaus swallowtail during this period were estimated to be 1,200 to 1,400. None of the colonies re-established during reintroduction efforts remain extant (Emmel and Daniels 2005, Daniels and Minno 2012). Elliott Key, within BNP, contains the largest extant Schaus swallowtail population. Abundance (mark-recapture) estimates for 1999 through 2003 were 212, 253, 115, 264, and 255, respectively. The range-wide population in 2003 was estimated to be approximately 360 to 400 adults, including the 255 on Elliott Key. In 2004, the point estimate for the Elliott Key population was approximately 300 to 350 individuals (Emmel and Daniels 2005, Daniels and Minno 2012). For almost a decade the only Schaus swallowtail butterfly data collected came from seasonal North American Butterfly Association (NABA) butterfly counts. These NABA counts were conducted annually from 2003 to 2012, excluding 2009, for Elliott Key and Key Largo. On Elliott Key, the number of Schaus swallowtails observed (during mid-May) ranged from 0 (2012) to 28 (2003). On Key Largo, the number of Schaus swallowtails observed (during late May-early June) ranged from between zero (several years) and eight (2004) individuals. A single Schaus swallowtail was photographed at the Charles Deering Estate on May 31, 2006 (Service 2008). The individual likely represented a vagrant from BNP. The Florida Fish and Wildlife Conservation Commission (FWC) led a Schaus swallowtail survey during May and June 2011 and recorded only 41 individuals, 35 within BNP and 6 on northern Key Largo. The Service funded UF to continue monitoring Schaus swallowtail activity during the 2012-2013 flight seasons. In 2012, only four individuals were encountered range-wide (Daniels and Minno 2012). Subsequent monitoring has encountered 32 and 413 adult Schaus swallowtails, range-wide, for 2013 and 2014, respectively (Daniels 2014). In addition to monitoring efforts, UF has reinstated captive rearing and release of Schaus' swallowtail adults and larvae being released within BNP and northern Key Largo in in 2014 (over 350 individuals released) and 2015 (approximately 470 individuals released) (Daniels 2014, Daniels, pers. comm. 2015).

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: Intense habitat destruction, hurricanes, droughts, and probably widespread aerial application of extremely toxic biocides such as Baytex and Dibrome for mosquito control have severely impacted this species, from about the 1940s to 1980s and it is now much reduced in numbers and area of occupancy in Florida. Minno and Emmel (1993) suggest north Key Largo is merely frequently colonized by females from Biscayne NP that basically waste eggs there. A change in mosquito control practices from malathion to Baytex and Dibrome in the early 1970s probably hastened the decline since then. Biocide applications for mosquito control continue in some places (as of 1993) despite Federal Listing. Although there was concern as far back as Klots (1951), there is little or no evidence of any real impact from collecting in the past and this now seems unlikely unless populations were smaller in the past than now. Collecting this species now in the USA would be a violation of federal law punishable by at least substantial fines, and poaching on a scale sufficient to pose a threat to a population that fluctuates from several hundred to over a thousand would be unlikely to go unnoticed for long. There is disagreement now as to how much impact mosquito spraying has had but several Lepidopterists at the time thought this was a major impact. Malathion was found to be less toxic to Lepidoptera than most other mosquito control chemicals (Salvato, 2001[J. Lepid. Soc.]) so a shift from this to other biocides is a plausible explanation if the decline did coincide in time and place with such a change. (NatureServe, 2015)

Recovery

Delisting Criteria:

We are providing recovery criteria for the Schaus' recovery plan (USFWS 1999), which will supersede (replace) the existing criteria. The below recovery criteria describes a recovered species, or a species that should be considered for removal from the List of Endangered and Threatened Wildlife (50 CFR 17). 1. The two (2) existing populations maintain a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A and E). 2. A network of five (5) new populations are either discovered or reintroduced in Monroe County that exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes. 3. One (1) new population is either discovered or reintroduced in Miami-Dade County that exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes. 4. Eight (8) populations (criteria 1,2,3) are on protected lands and managed such that these populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes. (addresses Factor A, B, C, D, and E) 5. Threats have been reduced or eliminated to the degree that the subspecies will remain viable for the foreseeable future. (addresses Factor A, B, C, D, and E) (USFWS, 2018)

[1] The two (2) existing populations maintain a stable or increasing trend, evidenced by natural recruitment and multiple age classes; [2] A network of five (5) new populations are either discovered or reintroduced in Monroe County that exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes; [3] One (1) new population is either discovered or reintroduced in Miami-Dade County that exhibits a stable or increasing trend, evidenced by natural recruitment and multiple age classes; [4] Eight (8) populations (criteria 1,2,3) are on protected lands and managed such that these populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes; and [5] Threats have been reduced or eliminated to the degree that the subspecies will remain viable for the foreseeable future. (USFWS, 2021)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Assess the current and projected impact of nonnative ants (twig ants, fire ants) and respond accordingly. • Identify and target select conservation areas within the historical range of Schaus' for hardwood hammock restoration efforts in order to increase the subspecies' current distribution. • Evaluate the basis of Schaus' population fluctuations and consider environmental, stochastic, and habitat-associated influences as possible drivers. • Determine whether additional nonnative predators and parasitoids have become established, and whether predators and parasitoids in general are a limiting factor in either occupied and potentially occupied areas. • Assess the current distribution and abundance of larval hostplants, particularly torchwood. • Assess the ecological characteristics, such as time since disturbance, that affect abundance and distribution of Schaus' and its larval hostplants and adult nectar sources. • Based on assessments of hostplant abundance and distribution, estimate if and where host plants are a limiting resource, use these assessments along with a consideration of financial resource potentials to determine an optimal response and guide actions, and implement actions accordingly. • Continue to conduct habitat restoration activities within hardwood hammocks on northern Key Largo and BNP, including planting native vegetation such as torchwood. • Continue to conduct annual rangewide monitoring of Schaus' populations during the spring and fall flight seasons to determine distribution and abundance throughout the range. • Continue to work with partners to develop and implement measures that limit or prohibit mosquito control pesticide drift on protected State, Federal, and other conservation lands and seek cooperative ways to reduce application of broad spectrum mosquito control pesticides within hardwood hammocks on private lands. • Develop potential adaptation strategies to moderate or delay the effects of sea level rise on Schaus'. For example, increase connectivity where sea level rise is likely to cause fragmentation. (USFWS, 2021)

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SPECIES ACCOUNT: *Hesperia dacotae* (Dakota Skipper)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Small to medium-sized butterfly with a wingspan of 2.4–3.2 centimeters (cm) (0.9–1.3 inches (in)) and hooked antennae (Royer and Marrone 1992a, p. 3). Like other Hesperiidae species, Dakota skippers have a faster and more powerful flight than most butterflies because of a thick, well-muscled thorax (Scott 1986, p. 415). Adult Dakota skippers have variable markings. The dorsal surface of adult male wings ranges in color from tawny orange to brown and has a prominent mark on the forewing; the ventral surface is dusty yellow-orange (Royer and Marrone 1992a, p. 3). The dorsal surface of adult females is darker brown with diffused tawny orange spots and a few diffused white spots restricted to the margin of the forewing; the ventral surfaces are dusty gray-brown with a faint white spotband across the middle of the wing (Royer and Marrone 1992a, p. 3). Dakota skipper pupae are reddish-brown, and the larvae are light brown with a black collar and dark brown head (McCabe 1981, p. 181).

Taxonomy

Family Hesperiidae; Adult Dakota skippers may be confused with the Ottoe skipper (H. ottoe), which is somewhat larger with slightly longer wings (Royer and Marrone 1992a, p. 3).

Historical Range

The historical distribution of Dakota skippers may never be precisely known because ‘‘much of tallgrass prairie was extirpated prior to extensive ecological study’’ (Steinauer and Collins 1994, p. 42), such as butterfly surveys. Britten and Glasford’s (2002, pp. 363, 372) genetic analyses support the presumption that this species formerly had a relatively continuous distribution; the small genetic divergence (genetic distance) among seven sites in Minnesota and South Dakota indicate that populations there were once connected. Dakota skipper dispersal is very limited due in part to its short adult life span and single annual flight. Therefore, the species’ extirpation from a site is likely permanent unless it is within about 1 km (0.62 mi) of a site that generates a sufficient number of emigrants or is artificially reintroduced to a site. The Dakota skipper’s range once comprised native prairie in five States and Canada, extending from Illinois to Saskatchewan.

Current Range

The Dakota skipper currently occurs in Minnesota, North Dakota, South Dakota, Manitoba, and Saskatchewan.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 10/1/2015.

Legal Description

On October 1, 2015, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the Dakota skipper (Hesperia dacotae) under the Endangered Species Act (Act). In total, approximately 19,903 acres (8,054 hectares) in Chippewa, Clay, Kittson, Lincoln, Murray, Norman, Pipestone, Polk, Pope, and Swift Counties, Minnesota; McHenry, McKenzie, Ransom, Richland, and Rolette Counties, North Dakota; and Brookings, Day, Deuel, Grant, Marshall, and Roberts Counties, South Dakota, fall within the boundaries of the critical habitat designation for Dakota skipper.

Critical Habitat Designation

The critical habitat designation for Hesperia dacotae includes 38 units in Chippewa, Clay, Kittson, Lincoln, Murray, Norman, Pipestone, Polk, Pope, and Swift Counties in Minnesota; McHenry, McKenzie, Ransom, Richland, and Rolette Counties in North Dakota; and Brookings, Day, Deuel, Grant, Marshall, and Roberts Counties in South Dakota. The units are (1) DS Minnesota Units 1–14; (2) DS North Dakota Units 1–3, 5–9, and 11–13; and (3) DS South Dakota Units 1–8, 15–18, and 22.

Unit descriptions not available.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Dakota skipper consist of three components:

(i) Primary Constituent Element 1— Wet-mesic tallgrass or mixed-grass remnant untilled prairie that occurs on near-shore glacial lake soil deposits or high-quality dry-mesic remnant untilled prairie on rolling terrain consisting of gravelly glacial moraine soil deposits, containing: (A) A predominance of native grasses and native flowering forbs; (B) Glacial soils that provide the soil surface or near surface (between soil surface and 2 cm depth) micro-climate conditions conducive to Dakota skipper larval survival and native-prairie vegetation; (C) If present, trees or large shrub cover of less than 5 percent of area in dry prairies and less than 25 percent in wet-mesic prairies; and (D) If present, nonnative invasive plant species occurring in less than 5 percent of area.

(ii) Primary Constituent Element 2— Native grasses and native flowering forbs for larval and adult food and shelter, specifically: (A) At least one of the following native grasses to provide food and shelter sources during Dakota skipper larval stages: prairie dropseed (Sporobolus heterolepis) or little bluestem (Schizachyrium scoparium); and (B) One or more of the following forbs in bloom to provide nectar and water sources during the Dakota skipper flight period: purple coneflower (Echinacea angustifolia), bluebell bellflower (Campanula rotundifolia), white prairie clover (Dalea candida), upright prairie coneflower (Ratibida columnifera), fleabane (Erigeron spp.), blanketflower (Gaillardia spp.), black-eyed Susan (Rudbeckia hirta), yellow sundrops (Calylophus serrulatus), prairie milkvetch (Astragalus adsurgens), or common gaillardia (Gaillardia aristata) .

(iii) Primary Constituent Element 3— Dispersal grassland habitat that is within 1 km (0.6 mi) of native highquality remnant prairie (as defined in Primary Constituent Element 1) that connects high-quality wet-mesic to dry tallgrass prairies or moist meadow habitats. Dispersal grassland habitat consists of undeveloped open areas dominated by perennial grassland with limited or no barriers to dispersal including tree or shrub cover less than 25 percent of the area and no row crops such as corn, beans, potatoes, or sunflowers.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 2, 2015.

The greatest, overarching threats to the Dakota skipper and Poweshiek skipperling are habitat curtailment, destruction, and fragmentation. The aforementioned activities will require special management consideration not only for the direct effects of the activities on the species and their habitat, but also for their indirect effects and how they are cumulatively and individually increasing habitat curtailment, destruction, and fragmentation. Based on our analysis of threats to Dakota skipper and Poweshiek skipperling, special management activities that could ameliorate these threats include, but are not limited to, habitat maintenance or restoration activities that occur at an intensity, duration, spatial arrangement, or timing that is not detrimental to the species. These activities include, but are not limited to, the following: Late-season haying (after the adult flight period), brush or tree removal, prescribed low intensity rotational grazing, invasive species control, habitat preservation, and prescribed fire.

Life History

Feeding Narrative

Larvae: Dakota skipper larvae feed on several native grass species; little bluestem (Schizachyrium scoparium) is a frequent food source of the larvae (Dana 1991, p. 17; Royer and Marrone 1992a, p. 25), although they have been found on Dichanthelium spp., and other native grasses (Royer and Marrone 1992a, p. 25). When presented with no other choice, Dakota skipper larvae may feed on a variety of native and nonnative grasses (e.g., Kentucky bluegrass (Poa pratensis)) at least until diapause (Dana 1991, p. 17). The timing of growth and development of grasses relative to the larval period of Dakota skippers are likely important in determining the suitability of grass species as larval host plants. Large leaf blades, leaf hairs, and the distance from larval ground shelters to palatable leaf parts preclude the value of big bluestem and Indian grass as larval food plants, particularly at younger larval stages (Dana 1991, p. 46). In captivity, Dakota skipper larvae ate big bluestem (Andropogon gerardii), at older larval stages, and prairie dropseed (Sporobolus heterolepis) (Runquist 2014, pers. comm.). Captive larvae also fed on smooth brome (Bromus inermis) (Dana 1991, p 17), but this was not tested in a natural setting and the structural features of this grass would hinder or prevent larval survival (Dana 2013, pers. comm.). The larvae emerge from their shelters at night to forage (McCabe 1979, p. 6; McCabe 1981, p. 181; Royer and Marrone 1992a, p. 25) and appear to clip blades of grass and bring them back to their shelters to consume (Dana 2012a, pers. comm.).

Adult: Nectar and water sources for adult Dakota skippers vary regionally and include purple coneflower (Echinacea angustifolia), blanketflower (Gaillardia aristata), black-eyed Susan (Rudbeckia hirta), purple locoweed (Oxytropis lambertii), bluebell bellflower (Campanula rotundifolia), prairie milkvetch (Astragalus adsurgens) (syn. A. laxmannii), and yellow sundrops (Calylophus serrulatus) (Dana 1991; McCabe and Post 1977, pp. 36–38; Royer and Marrone 1992a, p. 21; Rigney 2013a, p. 142). Plant species likely vary in their value as nectar sources due to the amount of nectar available during the adult flight period (Dana 1991, p.48). Nectar source preferences are typically indicated as the relative proportion of plants selected for nectaring among all the available species in a particular area. Swengel and Swengel (1999, pp. 280–281) observed nectaring at 25 plant species, however, most of the nectaring was at purple coneflower and blanketflower. In Manitoba, nectar sources include: White sweetclover (Melilotus alba), purple prairie clover (Petalostemon purpureus), yellow evening-primrose (Oenothera biennis), palespike lobelia (Lobelia spicata), fiddleleaf hawksbeard (Crepis runcinata), and upland white aster (Solidago ptarmicoides) (Rigney 2013a, pp. 4, 57). In addition to nutrition, the nectar of flowering forbs provides water for Dakota skipper, which is necessary to avoid desiccation during flight activity (Dana 1991, p. 47; Dana 2013, pers. comm.). The flight of the adult female typically extends beyond that of males (Dana 2014, pers. comm.; Dana 1991, pp. 1,15; Rigney 2013a, p. 138); therefore the two sexes can visit the same nectar plant species at different rates (e.g., if the flowering period is more coincident with either the male or the female flight period).
Larvae feed on grasses. (USFWS, 2018)

Reproduction Narrative

Larvae: Dakota skippers overwinter as larvae and complete one generation per year. Dakota skipper eggs hatch after incubating for 7–20 days; therefore, hatching is likely completed before the end of July. Recent research at the Minnesota Zoo demonstrated that, under controlled conditions in the laboratory, Dakota skippers eggs hatched after 11 to 16 days, and the majority of the caterpillars hatched on the 13th and 14th days (Runquist 2014, pers. comm.). After hatching, Dakota skipper larvae crawl to the bases of grass plants where they form shelters at or below the ground surface with silk, fastened together with plant tissue (Dana 1991, p. 16).

Adult: Dakota skippers lay eggs on broadleaf plants (McCabe 1981, p. 180) and grasses (Dana 1991, p. 17), although larvae feed only on grasses. Potential lifetime fecundity is between 180 and 250 eggs per female Dakota skipper; realized fecundity depends upon longevity (Dana 1991, p. 26). Female Dakota skippers lay eggs daily in diminishing numbers as they age (Dana 1991, pp. 25–26). Dana (1991, p. 32) estimated the potential adult life span of Dakota skipper to be 3 weeks and the average life span (or residence on site before death or emigration) to be 3 to 10 days on one Minnesota prairie (USFWS, 2014). Adults are dependent on Native grass species, Native flowering forbs and a water source for reproduction. The habitat structure must be mid-height grasses; If present, trees or large shrub cover less than 5% and 25% of area in dry and wet mesic prairies, respectively. Note: Mid-height grasses provide perches for males, which need unobstructed flight path from perches to chase rivals, search for mates (USFWS, 2018).

Spatial Arrangements of the Population

Larvae: Clumped according to suitable microhabitat characteristics

Adult: Clumped according to suitable microhabitat characteristics

Environmental Specificity

Larvae: specialist; requires host plant

Adult: specialist; requires host plant

Tolerance Ranges/Thresholds

Larvae: Low tolerance; Hypersensitive to fires

Adult: Low tolerance; Hypersensitive to fires

Site Fidelity

Larvae: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: native prairie species

Adult: native prairie species

Habitat Narrative

Egg: Eggs are dependent on Native grasses, broadleaf plants and dry-mesic habitat for sheltering. Habitat must not be subject to intense herbivory or fire when eggs are present (USFWS, 2018).

Larvae: Larvae and Pupa are dependent on Native grass species and a soil surface (0-2cm) microclimate for feeding and sheltering. Note: Little bluestem (S. scoparium) is frequent larval food source. Temperature and relative humidity near soil surface may be important for larval survival (USFWS, 2018).

Adult: Dakota skippers are obligate residents of undisturbed (remnant, untilled) high quality prairie, ranging from wet-mesic tallgrass prairie to dry-mesic mixedgrass prairie (Royer and Marrone 1992a, pp. 8, 21). High-quality prairie contains a high diversity of native plant species, including flowering herbaceous plants (forbs). Royer and Marrone (1992a, p. 21) categorized Dakota skipper habitat into two main types that were once intermixed on a landscape scale, but are now mostly segregated. The first, referred to as ‘‘Type A’’ by Royer et al. (2008, pp. 14–16), is low wet-mesic prairie that occurs on near-shore glacial lake deposits. Type A Dakota skipper habitat is dominated by bluestem grasses, with three other plant species almost always present and blooming during Dakota skipper’s flight period: Wood lily (Lilium philadelphicum), bluebell bellflower, and mountain deathcamas (smooth camas; Zigadenus elegans) (McCabe 1981, p.

190). This habitat type has a high water table and is subject to intermittent flooding in the spring, but provides ‘‘sufficient relief to provide segments of non-inundated habitat during the spring larval growth period within any single season’’ (Royer et al. 2008, p. 15). Common forbs in bloom during the late season in Type A habitat include Rocky Mountain blazing star (Liatris ligulistylis), Canada goldenrod (Solidago canadensis), strict blue-eyed grass (Sisyrinchium montanum), common goldstar (Hypoxis hirsuta), and black-eyed Susan (Lenz 1999, p. 6). Type A habitats also contain small patches of dry-mesic prairie inhabited by Dakota skippers. Common forb species in these dry-mesic areas include stiff sunflower (Helianthus pauciflorus Nutt. ssp. pauciflorus) and candle anenome (Anemone cylindrica), although purple coneflower was rare in these habitats (Lenz 1999, pp. 6–11). The second Dakota skipper habitat type, referred to as ‘‘Type B’’ by Royer et al. (2008, p. 14), occurs on rolling terrain over gravelly glacial moraine deposits and is dominated by bluestems and needle grasses (Heterostipa spp.).As with Type A habitat, bluebell bellflower and wood lily are also present in Type B habitats, but Type B habitats also support more extensive stands of purple coneflower, upright prairie coneflower, and common gaillardia (Royer and Marrone 1992a, p. 22). Both Type A and Type B prairies may contain slightly depressional (low topographical areas that allow for the collection of surface water) wetlands with extensive flat areas and slightly convex hummocks, which are dryer than the wet areas (Lenz 1999, pp. 4, 8). Two key factors, soils unsuitable for agriculture and steep topography, have allowed remnant native-prairie habitats inhabited by Dakota skippers to persist(Royer and Marrone 1992a, p. 22). McCabe (1979, pp. 17–18; 1981, p. 192) and Royer et al. (2008, p. 16) have linked the historical distribution ofDakota skippers to surface geological features and soils that are glacial in origin and, possibly, regional precipitation-evaporation ratios.Soil types typical of Dakota skipper sites were described as sandy loams, loamy sand, or loams (Lord 1988 in Royer et al. 2008, pp. 3, 10). Additional edaphic(soil) features, such as soil moisture, compaction, surface temperature, pH, and humidity, may be contributing factors in larval survival and, thus, important limiting factors for Dakota skipper populations (Royer et al. 2008, p. 2). For example, edaphic parameters measured in sites throughout the range of Dakota skipper and occupied by the species included a bulk density (an indicator of soil compaction) that ranged from 0.9g/cm3 to 1.3 g/cm3 and mean soil pH that ranged from 6.3 to 6.7 with high micro-scale variation (variation on a small scale) (Royer et al. 2008, p. 10). Soil texture ranged from 4 to 12 percent clay, 53 to 74 percent sand, and 14 to 39 percent silt (Royer et al. 2008, p. 12). Seasonal soil temperatures, measured at three depths (20, 40, and 60 cm (8, 16, and 24 in))were the same at all depths within a site; occupied Minnesota sites generally had higher soil temperatures at all depths than occupied sites in NorthDakota or South Dakota (Royer et al. 2008, p. 11). Royer did not measure these parameters in unoccupied sites. Rigney (2013a, pp. 108–109) measured edaphic features at 8 sites in Manitoba occupied by the species and broadly characterized the soil compaction (at 10 cm) as 570 to 990 kPA, bulk density ranging from 0.75 to 1.30 kg/L, mean soil surface air temperature at 18 °C during Julian weeks 28–39 (continuous count of weeks since the beginning of the calendar year), and mean relative humidity at 85 percent during the same time period. Soils were classified as clay loams and sandy loams, with generally low to moderate compaction (<1375 kPA) and bulk densities, which is indicative of little or no compacting forces from cattle grazing, tilling, or agricultural vehicles (Rigney 2013a, pp. 104, 119). Royer (2008, pp. 2, 16) hypothesized that Dakota skipper larvae are particularly vulnerable to desiccation (drying out) during dry summer monthsand require ‘‘vertical water distribution'' (movement of shallow groundwater to the soil surface) in the soils or wet low areas to provide relief from highsummer temperatures. Humidity may also be essential for larval survival during winter months since the larvae cannot take in water during that timeand depend on humid air to minimize water loss through respiration (Dana 2013, pers. comm.). Royer (2008, pp. 14–15) measured microclimalogicallevels (climate in a small space, such as at or near the soil surface) within ''primary larval nesting zones'' (0 to 2 cm (0 to 0.8 inches) above the soilsurface) throughout the range of Dakota skippers, and found an acceptable rangewide seasonal (summer) mean temperature range of 18 to 21 °C (64 to70 °F), rangewide seasonal mean dew point ranging from 14 to 17 °C (57 to 63 °F), and rangewide seasonal mean relative humidity between 73 and 85percent. Royer (2008) only examined occupied areas for these parameters; therefore, the statistical and biological significance of these edaphic variablescannot be determined from his study. After hatching, Dakota skipper larvae crawl to the bases of grass plants where they form shelters at or below the ground surface with silk, fastened together with plant tissue (Dana 1991, p. 16). They construct 2–3 successively larger shelters as they grow (Dana 1991, p. 16). Dakota skippers have six or seven larval stages (instars) (Dana 1991, pp. 14–15) and overwinter (diapause) in ground-level or subsurface shelters during either the fourth or fifth instar (McCabe 1979, p. 6; McCabe 1981, pp. 180, 189; Dana 1991, p. 15; Royer and Marrone 1992a, pp. 25–26). In the spring, larvae resume feeding and undergo two additional molts before they pupate. During the last two instars, larvae shift from buried shelters to horizontal shelters at the soil surface (Dana 1991, p. 16).

Dispersal/Migration

Motility/Mobility

Larvae: Extremely low. Adult more mobile.

Adult: Low; 3.5

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Non-migratory.

Adult: Flight period that may occur from the middle of June through the end of July

Dispersal

Larvae: A lot less than a km

Adult: 1 km

Immigration/Emigration

Larvae: Does not migrate or emmigrate

Adult: Not likely; Butterflies capable of dispersing approximately 1 km. Sites are isolated, not likely that butterflies are migrating to new sites.

Dependency on Other Individuals or Species for Dispersal

Larvae: Not applicable

Adult: Not applicable

Dispersal/Migration Narrative

Larvae: Dakota skipper are not known to disperse widely; the species was evaluated among 291 butterfly species in Canada as having relatively low mobility. Experts estimated Dakota skipper to have a mean mobility of 3.5 (standard deviation = 0.7) on a scale of 0 (sedentary) to 10 (highly mobile) (Burke et al. 2011, p. 2279; Fitzsimmons 2012, pers. comm.). Dakota skippers may be incapable of moving greater than 1 kilometer (km) (0.6 miles (mi)) between patches of prairie habitat separated by structurally similar habitats (e.g., crop fields, grassdominated fields or pasture, but not necessarily native prairie) (Cochrane and Delphey 2002, p. 6). Royer and Marrone (1992a, p. 25) concluded that Dakota skippers are not inclined to disperse, although they did not describe individual ranges or dispersal distances. McCabe (1979, p. 9; 1981, p. 186) found that concentrated activity areas for Dakota skippers shift annually in response to local nectar sources and disturbance. In a mark–recapture study, average adult movements of Dakota skipper were less than 300 meters (m) (984 feet (ft)) over 3–7 days; marked adults crossed less than 200 m (656 ft) of unsuitable habitat between two prairie patches and moved along ridges more frequently than across valleys (Dana 1991, pp. 38–40). Dana (1997, p. 5) later observed reduced movement rates across a small valley dominated by exotic grasses compared with movements in adjacent widespread prairie habitat. Roads and crop fields were suspected as impediments for movement among prairie patches along two sites of the main valley (Dana 1997, p. 5), although movements beyond the study area were beyond the scope of the 1997 mark–recapture study (Dana 2013, pers. comm.). Skadsen (1999, p. 2) reported possible movement of Dakota skippers in 1998 from a known population at least 800 m (2625 ft) away to a site with an unusually heavy growth of purple coneflower; he had not found Dakota skippers in three previous years when coneflower production was sparse. The two sites were connected by native vegetation of varying quality, interspersed by a few asphalt and gravel roads (Skadsen 2001, pers. comm.). In summary, the best information we have suggests that dispersal of Dakota skipper is very limited due in part to its short adult life span and single annual flight. Therefore, the species' extirpation from a site is likely permanent unless it is within about 1 km (0.6 mi) of a site that generates a sufficient number of emigrants or is artificially reintroduced to a site; however, the capability to propagate the Dakota skipper is currently lacking.

Adult: Dakota skippers are univoltine (having a single flight per year), with an adult flight period that may occur from the middle of June through the end of July (McCabe 1979, p. 6; McCabe 1981, p. 180; Dana 1991, p. 1; Royer and Marrone 1992a, p. 26; Skadsen 1997, p. 3; Swengel and Swengel 1999, p. 282). The actual flight period varies somewhat across the range of each species and can also vary significantly from year to year (e.g., Rigney 2013a, p. 138), depending on temperature patterns (Bink and Bik 2009, Koda and Nakamura 2012). Females emerge slightly later than males (Dana 1991, p. 15, Rigney 2013a, p. 138), and the observed sex ratio of Dakota skippers was roughly equal during peak flight periods (Dana 1991, p. 15; Swengel and Swengel 1999, pp. 274, 283). The Dakota skipper flight period in a locality lasts 2 to 4 weeks, and mating occurs throughout this period (Braker 1985, p. 46; McCabe and Post 1977, pp. 36–38; McCabe 1979, p. 6; McCabe 1981, p. 180; Dana 1991, p. 15; Swengel and Swengel 1999, p. 282; Rigney 2013a, p. 138). Adult male Dakota skippers exhibit perching behavior (perch on tall plants to search for females), but occasionally appear to patrol in search of mating opportunities (Royer and Marrone 1992a, p. 25).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

Dakota skipper resiliency is defined by the ability of populations to persist despite environmental stochasticity and transient disturbances and primarily relies upon the health of its populations, quality of the habitats inhabited by the species, and distribution of populations across heterogeneous conditions. The health of Dakota skipper populations has declined markedly over time due to: (1) a reduction in the extent of habitat; (2) fragmentation and isolation of the remaining habitat patches; and, (3) stress on the remaining populations caused by invasive species and incompatible land management practices, including neglect. These factors have allowed habitat conditions to deteriorate, have resulted in mortality that is unsustainable, and have minimized the likelihood that vacant habitat patches will be recolonized. Now the species is threatened by continued extirpation of sub- and metapopulations due to both stressors and stochastic factors. Given the present state conditions, only 42% of the remaining populations have a probability of persistence of greater than 0.5 and 14% have a probability of persistence greater than 0.90. Dakota skipper habitat was once widespread and as a result, populations likely ebbed and flowed across the landscape in response to transient factors. These factors may have included locally intense grazing by bison, fire, cool springs, hot and dry summers, and flooding. The species was likely resilient to these factors due to: 1) its abundance and pervasiveness in habitats around areas where it was temporarily eliminated; 2) the ability of plant species important to the Dakota skipper to rebound soon after intense disturbances; 3) heterogeneous habitats that provided refugia from unfavorable weather conditions and some disturbances; and the broad distribution of populations east to west and south to north, likely fostered population synchrony (USFWS, 2018).

Representation:

Dakota skipper representation is influenced by the breadth of adaptive diversity possessed by Dakota skipper and by maintaining the evolutionary processes (i.e., gene flow and natural selection) that drive adaptation. Assuming the delineated ACUs represent unique sources of adaptive diversity, Dakota skipper may have reduced ability to adapt to novel changes (e.g., diseases, predators, climate, etc.) in its environment. The complete loss of the species from broad areas in the southern and easternmost portion of the species range--from ACU 221 and from the south and eastern part of ACU 251B--suggests that a substantial amount of the Dakota skipper's adaptive capacity has already been lost. The isolation of the species into fragments of its historical habitat may have further eroded adaptive capacity that developed at smaller scales within ACUs. More importantly, the current fragmented landscape has greatly impeded gene flow between populations and thereby impairing adaptation (USFWS, 2018).

Redundancy:

Dakota skipper redundancy is influenced primarily by the distribution of populations across spatially heterogeneous environments that would allow the species to persist in the event of a large scale drought. We do not know how many populations of the Dakota skipper occurred historically, but we may infer from the geographic dispersion of the species' records coupled with available genetic information (Britten and Glasford 2002) that populations were widespread and contiguous over broad areas. The spatial dispersion of the species likely contributed to its persistence in the face of extreme and widespread drought, like that which occurred in the 1930s. Current redundancy of the Dakota skipper is reduced greatly compared to historical conditions, due to wide scale habitat destruction and other factors that have isolated and extirpated populations. Conversion of prairie for agriculture and urbanization completely eliminated the species from broad geographic areas that comprised the eastern and southern portions of its range, including one entire ACU. Additional habitat conversion, incompatible management practices, and other stressors have further eroded the species redundancy by reducing the number of populations and the geographic area inhabited by the species. Despite the marked reduction in the Dakota skipper's historical abundance and distribution, the species' viability benefits today from the variety of ecological settings in which it has survived and the geographic extent of its distribution. The frequency and intensity of droughts likely vary across the many different ecological settings and landscapes that the species still inhabits. Thus, it seems that the species' current widespread distribution provides some buffer against rangewide-scale catastrophic drought. Similarly, the broad distribution likely provides buffer against rangewide-scale pesticide applications events. We have not yet, however, quantitatively assessed the past, current, and future vulnerability of Dakota skipper populations to these types of catastrophes. Nor have we fully assessed the implications of climate change (USFWS, 2018).

Population Growth Rate:

unknown

Number of Populations:

83 sites (USFWS, 2014). 75 metapopulations consisting of 157 subpopulations persist across 5 states (USFWS, 2018). 67 subpopulations at the time of this review (2018) (USFWS, 2019). The capacity for Dakota skipper populations to grow is limited by the quantity and quality of the habitat and by connectivity among habitat patches. The minimum extent of habitat that is sufficient to support a healthy local population is unknown, but discrete populations have been recorded in prairie remnant patches as small as one acre. Populations in patches this small likely rely heavily on the existence of populations in nearby patches to ensure their long-term persistence (USFWS, 2019). As of 2018, we estimate there are 76 metapopulations consisting of 150 distinct subpopulations that persist (67 Present and 83 Unknown status subpopulations)

across 3 states and 2 Canadian provinces (USFWS, Unpublished geodatabase). Using the methodology in the SSA and accounting for new populations, approximately 56 subpopulations have become extirpated since the time of listing, with the majority of subpopulations lost occurring in Minnesota. Many of the sites that became extirpated, however, were small and isolated populations where a low likelihood of persistence was anticipated based on poor habitat quality. While the number of known Dakota skipper subpopulations is in decline, new subpopulations have been discovered in areas not previously surveyed at the far western edge of its range. A total of 36 new subpopulations have been found, 34 in North Dakota and 2 in South Dakota (Table 2), and the full extent of similar habitat in these areas have not been fully surveyed (USFWS, 2019).

Population Size:

unknown

Minimum Viable Population Size:

unknown

Adaptability:

low

Population Narrative:

Once found in native prairies in five States and two Canadian provinces, the Dakota skipper and its habitat have undergone dramatic declines; the species is now limited to native prairie remnants in three States and two Canadian provinces. 67 subpopulations at the time of this review (2018) (USFWS, 2019)

Threats and Stressors

Stressor: Habitat Destruction and conversion of habitat
Exposure: No shelter or food source
Response: Starve; Cannot reproduce
Consequence:
Narrative: Conversion of prairie for agriculture may have been the most influential factor in the decline of the Dakota skipper since Euro-American settlement, but the impacts of such conversion on extant populations is not well known. By 1994, tallgrass prairie had declined by 99.9 percent in Illinois, Iowa, Indiana, North Dakota, Wisconsin, and Manitoba; and by 99.6 percent in Minnesota; and 85 percent in South Dakota (Samson and Knof 1994, p. 419). Conversion for agriculture on lands suitable for such purposes is a current, ongoing stressor of high level of impact to the Dakota skipper populations in areas where such lands still remain. Advances in technology may also increase the potential of conversions in areas that are currently unsuitable for agriculture. Prairie conversion has had a devastating impact on the distribution and abundance of the Dakota skipper historically and, if the rate of prairie conversion increases, it could further exacerbate the threat to the Dakota skipper posed by habitat fragmentation. Conversion of native prairie to cropland and non-agricultural land uses, such as energy

development, gravel mining, transportation, and housing, and the degradation of remnant prairie, have reduced the historical abundance and distribution of the Dakota skipper and pose continuing threats to the species' persistence. Prairie conversion is the act of replacing native prairie plants with non-native grasses or legumes for hay or pasture, crops, or other developments. This conversion increased dramatically in the U.S. with the invention of the steel plow, making it easier to cut through heavy sod grasses. The historical loss of tallgrass prairie over the range of the Dakota skipper varies from about 85% in South Dakota to nearly 100% in Iowa, Minnesota, and North Dakota (Samson and Knopf 1994). Similarly, though not as drastic, about 60% of mixed grass prairies in South and North Dakota and Montana have been converted to cropland (Higgins et al. 2002). Following the rapid and extensive conversion of native prairie that began in the 1800s, conversion of remnant native grasslands continues today and threatens to further deplete Dakota skipper habitat. It is unclear how much is converted annually due to differences in the geographic area or time period studied. Earlier studies estimate an annual conversion rate of 0.004% in the Missouri Coteau region of central North Dakota and north-central South Dakota, from 1989-2003 (Stephens et al. 2008) and 1% in the Northern Great Plains from 1997-2007 (Classen et al. 2011). Conversion rates documented in more recent studies reflect the increase in corn prices that occurred in 2007. Wright and Wimberly (2013) estimated the annual rate of conversion in the Western Corn Belt was between 1%-5.4% and Gage et al. (2016) reported a 2% annual loss from 2009-2015 in the Great Plains. Although corn prices have decreased in recent years, conversion most likely will continue at a significant rate due to ethanol fuel standards, crop insurance subsidies or other governmental disaster or loan programs, as well as technological advances in equipment, seed, and herbicides (Classen et al. 2011, Wright 2015, Higgins et al. 2002). The region with the greatest grassland conversion currently occurring is the area covered by the Prairie Habitat Joint Venture, which covers portions of the Canadian provinces of Manitoba, Saskatchewan, and Alberta (Gage et al. 2016). From 2011-2015, cumulative losses in this region alone totaled 16.44% with an average of over 4% per year. This area contains important Dakota skipper populations in southeastern Saskatchewan and southwestern Manitoba. Similarly, the Prairie Pothole Joint Venture region3, which contains all the remaining Dakota skipper populations in the United States, is experiencing sustained grassland conversion. During the same period (2011-2015), more than 10% of this region's grasslands had been converted to cropland with an average annual loss of 2.7% (Gage et al. 2016). The proportion of these grasslands that were Dakota skipper habitat is unknown. Dakota skippers inhabit only high quality native prairies; when converted they are essentially lost as habitat for the species, even if they are later replanted to grassland. This has been documented by looking at the survey data over time and from expert observation at prairie sites bordered by a completely re-established prairie. (USFWS, 2018) Prairie conversion, a market driven factor that may continue into the future at current rates, appears to be the greatest within portions of the Canadian provinces of Manitoba, Saskatchewan, and Alberta (16.44% loss in the region between 2011-2015). Similarly, the Prairie Pothole Joint Venture region, which includes the remaining U.S. populations of Dakota skipper, have had a 10% loss of grasslands during that same 5-year period (Gage et al. 2016, as cited in USFWS 2018, p. 50). (USFWS, 2019)

Stressor: Energy development
Exposure: Spills; Road, facility, and other infrastructure construction

Response: Mortality; Reproductive problems; Destroys habitat; Introduces invasive vegetation that outcompetes food source leads to starvation
Consequence:
Narrative: Energy development (oil, gas, and wind) and associated roads and facilities result in the loss or fragmentation of suitable prairie habitat (Reuber 2011, pers. comm.). Major areas of recent oil and gas development, such as that occurring in the Bakken formation, overlaps with parts of the Dakota skipper's range in North Dakota. Catastrophic events, such as oil and brine spills, could cause direct mortality of Dakota skipper larvae that are in shelters at or below the soil surface. Such spills may also cause the loss of larval host and nectar plants in the spill path. Additional plants may be lost during spill response, particularly if the response involves burning. Wind energy turbines and associated infrastructure (e.g., maintenance roads) are likely stressors to Dakota skipper populations, particularly on private land in South Dakota (Skadsen 2002, p. 39; Skadsen 2003, p. 47; Skadsen 2012d, pers. comm.). Similar to oil and gas development, wind development would destroy native-prairie habitat in the footprint of the structure, add access roads and other infrastructure that may further fragment prairies, and could be catalysts for the spread of invasive species. Further, it is unknown if the noise and flicker effects associated with wind turbines may impact Dakota skipper populations beyond direct impacts from the turbines and/or infrastructure. Additional conversion and fragmentation of native prairie may result from the ongoing development of wind energy in the Dakota skipper range. There are currently seventeen wind farms located in the eastern half of South Dakota with 34 more proposed (SDWEA 2015). Although wind towers probably do not cause direct mortality (e.g. through collision) of butterflies (Grealey and Stephenson 2007), the area affected by the development of a wind energy farm can be significant. For example, a 200+ turbine proposed wind farm in Clark County South Dakota would be spread across 43,000 acres of land (C. Mueller, U.S. Fish and Wildlife Service, Waubay National Wildlife Refuge, pers. comm. 2017). Not all the area will be directly affected, but development of pads, access roads, and collection lines will occur in grasslands, some of which are native prairie. This will not only result in a direct loss of native prairie, but it will also increase grassland fragmentation and can exacerbate the invasion of nonnative species (Jones et al. 2015). In the Draft Environmental Assessment of the Crocker Wind Farm, a desktop review of appropriate Dakota skipper habitat identified 65 potential areas for surveys. Ground based assessments found 34 sites with suitable habitat. These 34 sites were surveyed from 29 June to 13 July 2017 for presence of Dakota skippers and Poweshiek skipperlings with negative results for either species (Crocker Wind Farm, LLC 2018). The Peckham Ranch metapopulation is within 6.5 miles of the Crocker Wind Farm and currently six SD metapopulations occur within the boundaries of proposed wind farms and three more are within 5 miles, including Scarlet Fawn and Oak Island/Wike metapopulations. North Dakota, South Dakota and Minnesota all occur in high wind areas (USDOE 2018) and will likely continue to develop wind energy resources. (USFWS, 2018) The scale of habitat impacts from gas and oil development may have been understated in the listing decision, particularly in the western portion of the range where new populations have been discovered (USFWS 2018, pp. 49-50). Since listing, proposed construction for pipelines and oil well pads resulted in the discovery of 9 new Dakota skipper metapopulations made up of 27 subpopulations; in some cases, suitable habitat has been impacted (USFWS 2019, Unpublished geodatabase). (USFWS, 2019)

Stressor: Flooding/Hydrology
Exposure: Destroy food source and habitat; Introduce invasives; Increase predation
Response: Mortality (drown, larvae desicate, starve)
Consequence:
Narrative: Flooding is a stressor to Dakota skippers at sites where too much of the species' habitat is flooded or where patches are flooded too frequently. Dakota skippers must either survive flooding events in numbers sufficient to rebuild populations after the flood or recolonize the area from nearby areas that had not flooded. In addition, the return interval of floods must be infrequent enough to allow for recovery of the populations between floods. Changes in hydrology resulting from wetland draining and development may permanently alter the plant community and, therefore, pose a threat to Dakota skipper due to loss of larval food and nectar sources. The Dakota skipper are presumed extirpated from several sites due to flooding or draining. Fluctuating water levels are a current stressor to populations across both species' ranges. Loss of habitat or direct mortality due to fluctuating water levels, such as permanent flooding or wetland draining, is a current stressor to populations in at least 14 Dakota skipper sites with present or unknown status. Interrupted groundwater flow-through fens can reduce water levels and facilitate woody vegetation establishment and growth (Michigan Natural Features Inventory 2012, p. 4). Agricultural and residential drains and wells can lower the groundwater table, thereby reducing the supply of calcareous seepage, which is an essential underlying component of prairie fen hydrology (Michigan Natural Features Inventory 2012, p. 4). Furthermore, nutrient additions associated with drain fields can contribute to invasive species encroachment. For instance, if groundwater flow to prairie wetlands is severed, fen habitats may convert from native grasses and flowering forbs to habitats dominated by invasive species or woody vegetation (Fiedler and Landis 2012, p. 51, Michigan Natural Features Inventory 2012, p. 4).

Stressor: Invasive species
Exposure: Destroy food source and habitat; alter hydrology
Response: Mortality
Consequence:
Narrative: Dakota skippers typically occur at sites embedded in agricultural or developed landscapes, which make them more susceptible to nonnative or woody plant invasion. Nonnative species including leafy spurge, Kentucky bluegrass, alfalfa, glossy buckthorn, smooth brome, purple loosestrife (Lythrum salicaria), Canada thistle (Cirsium arvense), reed canary grass, and others, have invaded Dakota skipper habitat throughout their ranges (Orwig 1997, pp. 4, 8; Michigan Natural Features Inventory 2011, unpubl. data; Skadsen 2002, p. 52; Royer and Royer 2012b, pp. 15–16, 22–23). Once these plants invade a site, they replace or reduce the coverage of native forbs and grasses used by adults and larvae of both butterflies. Thus, a prevalence of these grasses reduces food availability for the larvae. The stressor from nonnative invasive herbaceous species is compounded by the encroachment of woody species into native-prairie habitat. Invasion of tallgrass prairie and prairie fens by woody vegetation such as glossy buckthorn reduces light availability, total plant cover, and the coverage of grasses and sedges (Fiedler and Landis 2012, pp. 44, 50–51). This in turn reduces the availability of both nectar and larval host plants for Dakota skippers. If groundwater flow to prairie wetlands is disrupted (e.g., by

development) or intercepted (e.g., digging a pond in adjacent uplands or installing wells for irrigation or drinking water), it can quickly convert to shrubs or other invasive species (Fiedler and Landis 2012, p. 51; Michigan Natural Features Inventory 2012, p. 4). When prairie is converted to shrubland, forest, or semi-forested habitat types and facilitates invasion of adjacent native prairie by exotic, cool-season grasses, such as smooth brome. Moreover, the trees and shrubs provide perches for birds that may prey on the butterflies (Royer and Marrone 1992b, p. 15; 1992a, p. 25). Other new potential threats have been identified through research, such as a slower growth rate for Dakota skippers forced to feed on sub-optimum larval food plants such as invasive Kentucky bluegrass and smooth brome. If developing larvae are unable to find suitable high quality food sources in the wild, they will likely have reduced fitness and survivorship (Runquist et. al 2017, pp. 4-8). (USFWS, 2019)

Stressor: Fire
Exposure: Burns caterpillar or butterflies; Temporily removes shelter, food, and breeding areas.
Response: Mortality
Consequence:
Narrative: Dakota skipper populations existed historically in a vast ecosystem maintained in part by fire. Due to the great extent of tallgrass prairie in the past, fire and other intense disturbances (e.g., locally intensive bison grazing) likely affected only a small proportion of the habitat each year, allowing for recolonization from unaffected areas during the subsequent flight period (Swengel 1998, p. 83). Fire can improve Dakota skipper habitat (e.g., by helping to control woody vegetation encroachment), but it may also kill most or all of the individuals in the burned units and alter entire remnant prairie patches, if not properly managed (e.g., depends on the timing, intensity, etc.). Accidental wildfires also may burn entire prairie tracts (Dana 1997, p. 15). Intentional fires, without careful planning, may also have significant adverse effects on populations of Dakota skippers, especially after repeated events (McCabe 1981, pp. 190–191; Dana 1991, pp. 41– 45, 54–55; Swengel 1998, p. 83; Orwig and Schlicht 1999, pp. 6, 8). The effects of fire on prairie butterfly populations are difficult to ascertain (Dana 2008, p. 18), but the apparent hypersensitivity of Dakota skippers indicates that it is a stressor to both species in habitats burned too frequently or too broadly. The Dakota skipper is not known to disperse widely (Swengel 1996, p. 81; Burke et al. 2011, p. 2279); therefore, in order to reap the benefits of fire to habitat quality, Dakota skippers must either survive in numbers sufficient to rebuild populations after the fire or recolonize the area from a nearby unburned area. In addition, the return interval of fires needs to be infrequent enough to allow for recovery of the populations between burns. Therefore, fire is a stressor to Dakota skippers at any site where too little of the species' habitat is left unburned or where patches are burned too frequently. When all or large portions of prairie remnants are burned, many or all prairie butterflies may be eliminated at once. Complete extirpation of a population, however, may not occur after a single burn event (Panzer 2002, p. 1306), and the extent of effects would vary depending on time of year and fuel load. As the spring progresses, the vulnerability of Dakota skippers to fire increases as larvae shift from buried shelters to horizontal shelters at the soil surface (Dana 1991, p. 16).

Stressor: Grazing

Exposure: Trampled; Alters adult behavior; Destroys habitat; Destroys food source; Introduces invasives; Increases predation; Larvae desicate
Response: Mortality; Reproductive problems; Destroys habitat; Introduces invasive vegetation that outcompetes food source leads to starvation
Consequence:
Narrative: Grazing may maintain habitat for the Dakota skipper, but as with any management practice, appropriate timing, frequency, and intensity are important. The level of impact of grazing on Dakota skipper populations also depends on the type of habitat that is being grazed. In addition, grazing may be a valuable tool for controlling smooth brome invasion and maintaining native diversity in prairies, especially where circumstances make the use of fire difficult or undesirable (Service 2006, p. 2; Smart et al. 2013, pp. 685–686). Conversely, grazing may stimulate brome growth and reduce native plant diversity. Bison (Bison bison) grazed at least some Dakota skipper habitats historically (McCabe 1981, p. 190; Bragg 1995, p. 68; Schlicht and Orwig 1998, pp. 4, 8; Trager et al. 2004, pp. 237–238), but cattle (Bos taurus) are now the principal grazing ungulate in both species' ranges. Bison and cattle both feed primarily on grass, but have some dissimilar effects on prairie habitats (Damhoureyeh and Hartnett 1997, pp. 1721–1725; Matlack et al. 2001, pp. 366–367). Cattle consume proportionally more grass and grasslike plants than bison, whereas bison consume more browse and forbs (flowering herbaceous plants) (Damhoureyeh and Hartnett 1997, p. 1719). Grasslands grazed by bison may also have greater plant species richness and spatial heterogeneity than those grazed by cattle (Towne et al. 2005, pp. 1553–1555). Both species remove forage for larvae (palatable grass tissue) and adults (nectar-bearing plant parts), change vegetation structure, trample larvae, and alter larval microhabitats. Grazing reduces Dakota skipper numbers in direct proportion to its intensity, due to the reduction in flowers that provide nectar and perhaps by influencing adult behavior (Dana 1997, p. 4). Proximity of nearby populations or contiguous habitat may alleviate some of the negative impacts of grazing. Grazing also causes direct mortality of larvae due to trampling and altering larval microhabitats (Royer et al. 2008, pp. 10–15). Grazing can compact soils in wet-mesic prairie inhabited by Dakota skippers and Poweshiek skipperlings, altering vertical water movement in the soil, which may lead to larval desiccation (Royer et al. 2008, p. 16) and may inhibit subsurface shelter construction, potentially increasing larval vulnerability to predators, parasites, and other environmental stressors (Dana 2013, pers. comm.). Cattle may also kill larvae by trampling them (McCabe 1981, p. 189).

Stressor: Haying and Mowing
Exposure: Removes food source; crush or smash butterflies/caterpillars
Response: Mortality; Emigration
Consequence:
Narrative: Haying (mowing grasslands and removing the cuttings) may maintain habitat for the Dakota skipper, but as with any management practice, appropriate timing, frequency, and intensity are important. Haying generally maintains prairie vegetation structure, but it may favor expansion of invasive species such as Kentucky bluegrass. If done during the adult flight period, haying may kill the adult butterflies or cause them to emigrate, and if done before or during the adult flight period, it may reduce nectar availability (McCabe 1979, pp. 19–20; McCabe 1981, p. 190; Dana 1983, p. 33; Royer and Marrone 1992a, p. 28; Royer and Marrone 1992b. p. 14;

Swengel 1996, p. 79; Webster 2003, p. 10). In summary, haying is a current and ongoing stressor of moderate to high level of impacts to Dakota skippers at the few sites where the site is normally hayed before August and where annual haying is reducing availability of larval food and adult nectar plants. However, fall haying is beneficial to both species, specifically if it is conducted after the flight period (after August 1), no more than every other year, and there is no indication that native plant species diversity is declining due to timing or frequency of haying. Haying is a current stressor at a small number of sites for both species.

Stressor: Lack of Management/Disturbance
Exposure: Increases invasive vegation; Reduces available shelters and food sources
Response: Mortality; reproductive problems
Consequence:
Narrative: Prairies that lack periodic disturbance become unsuitable for Dakota skippers due to expansion of woody plant species (secondary succession), litter accumulation, reduced densities of adult nectar and larval food plants, or invasion by nonnative plant species (e.g., smooth brome) (McCabe 1981, p. 191; Dana 1983, p. 33; Dana 1997, p. 5; Higgins et al. 2000, p. 21; Skadsen 2003, p. 52).

Stressor: Size/Isolation
Exposure: Extirpated sites remain extirpated; Inbreeding; Unadaptable
Response: Mortality; Extirpation
Consequence:
Narrative: Small, isolated populations face a current and ongoing stressor of moderate to high severity. The stressor has a high impact to populations when isolation is combined with small habitat fragments or small populations; for example, where the population is too small to supplement nearby populations without adverse genetic consequences to the source population. Isolated populations occur throughout the entire range; about 40 percent (64–69 of 171 sites) of Dakota skipper sites with present or unknown occupancy. The small populations are subject to erosion of genetic variability leading to inbreeding, which lowers the ability of the species to adapt to environmental change.

Stressor: Herbicide and/or Pesticide Use
Exposure:
Response: Mortality or kills food source/shelter; Reproductive issues
Consequence:
Narrative: Neonicotinyl pesticides, such as the imidacloprid compound, for example, are a commonly used seed dressing that spreads to nectar and pollen of flowering crops (Whitehorn 2012, p. 1). The use of neonicotinoids on agricultural crops has dramatically increased in the last ten years and they are now the most widely used group of insecticides in the world (Jeschke et al. 2011, pp. 2897–2898; Main et al. 2014, p. 2; Goulson 2013, pp. 1–2). Neonicotinoids persist in the environment (Goulson 2013, p. 1) and are thought to accumulate in the soil from repeated applications over time (Hopwood et al. 2013, p. 4). Insects can be exposed through multiple routes— neonicotinoids are used in seed dressings, foliar spray, soil irrigation water, soil drench, granular in pastures, tree injections, and topical applications to pets. Similarly, soybean aphid

spraying occurs during the adult flight period, is widespread, and applied aerially—this spray can drift to nearby Dakota skipper habitat. A study has recently begun, investigating the levels of neonicotinoids, aphid pesticides, and other insecticides that may be present at several skipper sites in Minnesota and South Dakota. Insecticides used in the gypsy moth suppression programs sometimes include Foray, a formulation of the bacterial insecticide Bacillus thuringiensis kurstakii, which is lethal to butterfly larvae (e.g., Karner blue butterfly) (Carnes 2011, p. 1). Some efforts to manage woody encroachment and invasive species, such as herbicide use, can be a stressor to both Dakota skipper populations. Invasive species management is a current and ongoing stressor of low to high impact to populations, depending on the intensity and extent of the use, types of techniques, and the compounding effects that may occur from varying management. Medium- to high-level impacts of herbicide or pesticide use to Dakota skipper populations have been documented in North and South Dakota. This stressor has a high impact to populations when it is combined with other stressors, such as management, that reduces or eliminates nectar food sources, or small habitat fragments that are isolated from other source populations that may replenish individuals killed by pesticides. Herbicide and pesticide use may have direct or indirect effects on Dakota skipper. Although such activities occur, there is no evidence that these activities alone have significant impacts on either species, since their effects are often localized. However, these factors may have a cumulative effect on the Dakota skipper when added to habitat curtailment and destruction because dramatic population declines have occurred i. Invasive species and woody vegetation management helps to maintain prairie habitats and can also be beneficial to populations of both species, for example, when concentrated on affected areas through spot spraying. Ivermectin, a widely used and persistent veterinary pharmaceutical used to treat cattle, is a chemical of emerging concern to the Dakota skipper. Ivermectin is an anthelmintic (drugs that are used to treat infections with parasitic worms) that is spread to prairie environments via the dung of grazing cattle (Lange et al. 2009, p. 2238). Lange et al. (2009, pp. 2234, 2238) found that skipper butterflies are particularly vulnerable to ivermectin, due to their low dispersive capacities and habitat preferences for soil. While the loss of suitable Dakota skipper habitat is unknown, the decrease of grasslands increases fragmentation and the potential for pesticide drift and exacerbates the spread of invasive species into natural habitats. (USFWS, 2019)

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change may currently or into the future pose a threat to the Dakota Skipper. Although experts believe climate change effects could—currently or over time--influence Dakota skipper survival or reproductive success, data are lacking. Given that climate, along with fire and herbivory, were major drivers in maintaining the native plant cover prior to Euro-American settlement (Anderson 2006), we explored the effects of climate change via changes to habitat. Specifically, we evaluated how length of growing season and annual precipitation are predicted to change over time (1950-2100) under two IPCC Representative Concentration Pathways (RCP) scenarios, RCP 4.5 and RCP 8.5 (USFWS, 2018). We are just starting to understand the complexity of the influences of climate change on the Dakota skipper. One of the likely effects of climate

change that is emerging is the lengthening of the growing season, which allows invasive species, such as Kentucky bluegrass and smooth brome, to get a stronger foothold on remaining prairie remnants (USFWS 2018, p. 51). As mentioned above, these sub-optimum food plants have been shown to affect Dakota skipper development. Climate change factors such as these are subjects we need to explore more in the recovery stage to better understand the potential effects on the species, especially with regards to invasive species and prairie quality. In addition, under a RCP8.5 climate model analyzed in the SSA, increased annual precipitation across the range of Dakota skipper is projected and could result in increased woody encroachment leading to the continued degradation of native prairie ecosystems, if not managed (USFWS 2018, pp. 52-53). (USFWS, 2019)

Stressor: Catastrophic Drought
Exposure:
Response:
Consequence:
Narrative: Drought is a natural ecosystem process of prairies, and prairie-dependent species are generally very drought tolerant. Through expert input, we defined catastrophic drought as a Palmer Drought Severity Index of -4.0 or lower, persisting for one year or more (i.e., one full generation). The primary effects of this level and extent of drought include direct mortality through larval desiccation, as well indirect mortality (e.g., starvation) resulting from impacts to larval plant food resources. Extreme drought would cause above-ground plant tissues to desiccate, resulting in lower quality and availability of larval food and water resources (R. Dana, Minnesota Dept. of Natural Resources, pers. comm. 2016; R. Westwood, University of Winnipeg, pers. comm. 2016). Larvae are most susceptible to drought mortality during late summer and winter (R. Royer, retired, Minot State University, pers. comm. 2016). Adults in captivity require the provision of a water source, such as freshly cut flowers or misting of cages (R. Dana, Minnesota Dept. of Natural Resources, pers comm., 2017; E. Runquist, Minnesota Zoo, pers comm. 2017), indicating that severe droughts during mid-summer (i.e., the flight period) could result in direct adult mortality. The negative effects of drought would be particularly strong in dry prairies (Royer et al. 2008 referred to these as Type B Habitats), though a catastrophic drought could cause metapopulation collapse in any prairie type. A milder or shorter-lived drought may have any one of the above effects (e.g., reduced larval food quality) without leading to population collapse. The species experts agreed that the duration and extent of the drought would need to be extreme in order to cause extirpation of this prairiedependent (i.e., drought tolerant) species (USFWS, 2018).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Criterion 1: A minimum of 50 healthy populations spread throughout the range with at least 5 healthy populations in each of the 4 conservation units (USFWS, 2021)

Criterion 2: Each healthy population considered under Criterion 1 has a management plan in place that promotes healthy populations considering ongoing threats for the foreseeable future. (USFWS, 2021)

Recovery Actions:

- Supportive Factors: Supportive factors specifically focused on the Dakota skipper are few. In 2014, the Dakota skipper was listed as Threatened under the ESA. In Canada, Dakota skipper is listed as threatened on the SARA List of Wildlife Species at Risk. States that recognize Dakota skipper in their State Wildlife Action Plans as Endangered, Threatened or Greatest Conservation Need include Minnesota, North Dakota, South Dakota, and Iowa. The Dakota skipper was listed in 2014 and thus is protected under the ESA; federal agencies are required under section 7(a)(2) of the ESA to consult with the Service and ensure their activities (including those they conduct themselves as well as those they may fund, authorize or permit) do not jeopardize the continued existence of the species. The conservation focus in the section 7(a)(2) consultation process is often limited to avoidance and minimization of impacts of activities subject to federal purview, not necessarily on actions to broadly improve the status of the species. However, most of the extant Dakota skipper populations are located on private land (about 70%); about 13% are on State or county owned land, and about 17% are on Federal or Tribal lands in the U.S. and over 90% of the populations are located on private land in Canada. Most conservation for Dakota skipper will take place on private lands; conservation actions by Non-governmental organizations, County and State governments, and private landowners are occurring, but not in a coordinated manner. We anticipate recovery of the species will be predicated on a comprehensive, coordinated strategy that we will be designing together with our Federal, Tribal, State and local partners. Below we describe some of the ongoing conservation efforts. Maintenance of High Quality Habitats: Recovery of the Dakota skipper will be closely tied to the extent and condition of its native grassland habitat. The species is endemic to North American tallgrass and mixed grass prairie and does not inhabit non-native grasslands, weedy roadsides, tame hayland, or other habitats that are not remnant native prairie. In addition, Dakota skippers have not been recorded in reconstructed prairie, e.g., former cropland that has been replanted to native prairie. Therefore, Dakota skipper needs native prairie habitats that are diverse in flowering herbaceous plants and native grasses. Land management actions that affect Dakota skipper habitat will also play a critical role in the species' survival. Haying, grazing, and fire are essential management tools to maintain native prairie and the essential features of the Dakota skipper's grassland habitats. In the absence of grazing, fire, or haying, Dakota skipper habitat is likely to become too brushy or wooded to support the species (e.g., Rigney 2013, p. 151) or can succumb to invasion by cool season exotic grasses, especially Kentucky bluegrass and smooth brome. Increasingly, conservation land managers are considering Dakota skipper and other invertebrates in setting their management regimes (timing, intensity and duration of the management practices). 56 Research and Captive Rearing: The captive rearing program at Minnesota Zoo is now capable of producing significant numbers of the Dakota skipper ex situ, such that reintroduction of the species is feasible. The Minnesota Zoo, U.S. Fish and Wildlife Service and its partner agencies have finalized a plan to guide ex situ management of the species. Under that plan, ex situ management would be used to facilitate important research, but also to produce animals for reintroduction. In May 2017, a formal plan for the reintroduction of Dakota skipper at Hole-in-the-Mountain Prairie was prepared and the first year of introduction was conducted during the 2017 flight season. There were 196 individuals released at Hole-in-the-Mountain Prairie and 111 were observed post-release. Mating, oviposition in the wild, and egg viability have all been confirmed and two additional years of Dakota skipper release are planned at this site followed by extensive monitoring to determine if the population is self-supporting (Runquist and Nordmeyer 2018). Perpetual Protection of Dakota Skipper Habitats: Acquisition of perpetually protected lands throughout the Dakota skipper's range has been ongoing for many decades. Grasslands are protected both through fee title and easements, by many agencies and organizations. In recent years, native prairie protection and management has become a high priority for many of those agencies. For example, several conservation agencies in Minnesota are committed to a unified, 25-year statewide prairie conservation plan, which includes goals for perpetual protection of over 850,000 acres of grasslands in targeted landscapes (Minnesota Prairie Plan Working Group 2011). Although the condition of these protected grasslands is not fully known, it is likely that at least some of these conservation lands and easements include good to high quality native prairie and could provide habitat for Dakota skippers. At the least, these acres may provide areas for dispersal and connectivity between populations (USFWS, 2018).

- A. Habitat Conservation Conserving sufficient quality and quantity of habitat (threshold for "sufficient" will be further explored in the RIS) from destruction or degradation through various mechanisms, including short-term conservation programs (for example, U.S. Fish and Wildlife Service Partners for Fish and Wildlife agreements, U.S. Dept. of Agriculture-Natural Resources Conservation Service's (NRCS) Conservation Reserve Program, U.S. Fish and Wildlife Service Safe Harbor agreements); incentivizing other conservation programs (for example, include ranking criteria under the NRCS Environmental Quality Incentives Program actions that promote Dakota skipper persistence); and land acquisition (for example, fee title, conservation easements). In many cases, active habitat management will be necessary to ensure habitat suitability (see below for additional information on habitat management actions). Estimated cost: $5,200,000 (USFWS, 2021)
- B. Habitat Management and Restoration Implement actions to maintain and restore sufficient quality and quantity of habitat rangewide by: ▯ Collaboratively planning and prioritizing management actions. ▯ Implementing habitat management such as targeted or compatible grazing, fire, or haying regimes. ▯ Developing habitat management plans that include contingencies for threats and catastrophes. ▯ Restoring or enhancing habitat within priority areas (to be identified in the recovery implementation strategies). ▯ Conducting habitat reconstruction to provide buffer from threats, act as potential dispersal corridors, and to set the stage for full habitat suitability if research determines that Dakota skippers will respond positively to reconstruction efforts. ▯ Working with partners to identify or develop voluntary programs for private landowners to enhance, restore, and reconstruct Dakota skipper habitat on their property. Estimated cost: $10,750,000 (USFWS, 2021)
- C. Population Management Develop and implement population management strategies that ameliorate stressors. This may include conservation propagation methods such as augmentation or enhancement in areas where populations exist, but may need to be increased to improve their health; reintroduction or translocations to areas where populations are extirpated and where the number of populations needs to be increased; or insurance populations to maintain genetic diversity in case of catastrophic loss in the wild. Estimated cost: $8,530,000 (USFWS, 2021)
- D. Population and Habitat Surveys and Monitoring Conduct standardized population and habitat surveys and monitoring rangewide. This entails developing standardized protocols,

monitoring at extant sites, conducting surveys at potential new and historical sites, and data sharing among partners. Estimated cost: $3,750,000 (USFWS, 2021)

- E. Education and Outreach Develop and foster partnerships to support the conservation of the Dakota skipper, while seeking to understand stakeholders' interests. Work with our partners to improve awareness of the Dakota skipper and its habitat. Also, provide technical assistance to private landowners, land managers, and other parties to conserve the species and its prairie habitat, while allowing for continued operation and management on the ground. Estimated cost: $600,000 (USFWS, 2021)
- F. Research Conduct critical research needed for improved conservation of the Dakota skipper across all populations. Priority research includes: Understanding key aspects of Dakota skipper life history, including: 1) minimum effective population size (Ne); 2) the structure and functioning of populations, including the importance of gene flow between populations; 3) dispersal ability and behavior; 4) larval life history and specific habitat needs of both immature and adult stages, and 5) the sensitivity of population numbers to environmental stochasticity. Understanding the effects of non-native species on habitat quality, and the species' response to varying levels of habitat quality and quantity. Understanding key sources of mortality, which may include pesticides, pathogens, drought conditions, and unsuitable management practices. Identifying and delineating the underlying variation in adaptive diversity Understanding the effects of climate change on Dakota skipper life stages Understanding sources, exposure, and impacts of pesticides. Understanding Dakota skipper use of and viability in reconstructed and restored prairies Developing CU-level and population-level viability analyses Estimated cost: $4,100,000 (USFWS, 2021)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The results of our 2018 SSA indicate that Dakota skipper viability continues to decline at a low to moderate rate from historical conditions. Both near-term and long-term efforts are required to achieve recovery and will be addressed in the Recovery Plan. Several recommendations designed to halt this downward trajectory and ultimately reverse it, so that the Dakota skipper can recover and persist into the future, are provided below. Near-term Recovery Actions: ● Conduct standardized population and habitat monitoring ● Implement actions to maintain and restore sufficient quality and quantity of habitat by: ○ Implementing habitat management such as targeted/compatible grazing, fire, and haying regimes ○ Developing habitat management plans that include contingencies for threats and catastrophes ○ Conducting habitat restoration/enhancement within priority areas ● Continue conservation propagation methods such as augmentation/enhancement, reintroduction, insurance populations, and translocation ● Protect sufficient quality and quantity of habitat from destruction through various mechanisms, including short-term conservation programs, incentivizing other conservation programs, and land acquisition ● Work with our partners to improve awareness of the Dakota skipper and its habitat needs Long-term Recovery Actions: ● Conduct habitat reconstruction to provide buffer from threats, act as potential dispersal corridors, and to set the stage for full habitat suitability if research determines that Dakota skippers will respond positively to reconstruction efforts Research Needs: ● Understand key aspects of Dakota skipper life history, including: ○ minimum effective population size, Ne ○ the structure and functioning of populations, including the importance of gene flow between populations ○ dispersal ability and behavior ○ larval life history and specific habitat needs of both immature and adult stages ○ the sensitivity of population numbers to environmental stochasticity ● Understand the effects of non-native species on habitat quality, and the species' response to varying levels of habitat quality and quantity ● Understand key sources of mortality, which may include natural enemies, pesticides, drought conditions, and management practices ● Understand Dakota skipper use of and viability in reconstructed prairies ● Understand the effects of climate change on Dakota skipper life stages (USFWS, 2019).

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SPECIES ACCOUNT: *Heterelmis comalensis* (Comal Springs riffle beetle)

Species Taxonomic and Listing Information

Listing Status: endangered

Physical Description

The Comal Springs riffle beetle is a small, aquatic beetle known from Comal Springs and San Marcos Springs. Adult Comal Springs riffle beetles are about 2 millimeters (mm) (1/8 inch (in)) long, with females slightly larger than males. Unlike the other two organisms listed here, the Comal Springs riffle beetle is not a subterranean species. It occurs in the gravel substrate and shallow riffles in spring runs. Some riffle beetle species can fly (Brown 1987), but the hind wings of H. comalensis are short and almost certainly non-functional, making the species incapable of this mode of dispersal (Bosse et al. 1988).

Taxonomy

The closest relative of H. comalensis appears to be H. glabra, a species that occurs region (Bosse et al. 1988).

Historical Range

The Comal Springs riffle beetle is known from Comal Springs and San Marcos Springs (Hays County). Nothing is known about whether this species may have historically ranged in other springs that are now dry almost all the time, such as San Pedro Springs and San Antonio Springs.

Current Range

The Comal Springs riffle beetle is known from Comal Springs and San Marcos Springs (Hays County).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 10/23/2013.

Legal Description

On October 23, 2013, the U.S. Fish and Wildlife Service (Service), revised the critical habitat for the Comal Springs riffle beetle (Heterelmis comalensis) under the Endangered Species Act of 1973, as amended (78 FR 63100 - 63127).

Critical Habitat Designation

Critical habitat for H. comalensis is designated in Units 1 and 4.

Unit 1: Comal Springs Unit. The purpose of this unit is to independently support a population of Comal Springs dryopid beetle, Comal Springs riffle beetle, and Peck's cave amphipod in a functioning spring system with associated streams and underground spaces immediately inside of or adjacent to springs, seeps, and upwellings that provide suitable water quality, supply, and detritus (decomposed plant material). Unit 1 contains Comal Springs and consists of 124 ac (50 ha) of subsurface critical habitat for the Comal Springs dryopid beetle and the Peck's cave amphipod (Tables 2 and 4). Unit 1 also contains 38 ac (15 ha) of surface habitat for these two species and the Comal Springs riffle beetle (Table 3). This unit was occupied at the time of listing and is still occupied by the Comal Springs dryopid beetle, Comal Springs riffle beetle, and Peck's cave amphipod (Table 1). Portions of the Comal Springs Unit are owned by the State of Texas, City of New Braunfels, and private landowners in southern Comal County, Texas. A large portion of the unit is operated as a city park (Landa Park) with private residences and landscaped yards along the edge of the lower part of the unit. The surface water and bottom of Landa Lake are State-owned. The City of New Braunfels owns approximately 40 percent of the land surface adjacent to the lake, and private landowners own approximately 60 percent. This nearly L-shaped lake is surrounded by the City of New Braunfels. The spring system primarily occurs as a series of spring outlets that lie along the west shore of Landa Lake and within the lake itself. Practically all of the spring outlets and spring runs associated with Comal Springs occur within the upper part of the lake above the confluence of Spring Run No. 1 to the lake. This unit contains all of the essential physical and biological features for these species. The physical or biological features in this unit require special management or protection because of the potential for depletion of spring flow from water withdrawals, hazardous materials spills from a variety of sources in the watershed, pesticide use throughout the watershed, excavation and construction surrounding the springs and in the watershed, stormwater pollutants in the watershed, and invasive species impacts on the surface habitat.

Unit 4: San Marcos Springs. The purpose of this unit is to independently support a population of Comal Springs riffle beetle in a functioning spring system with associated streams that provide suitable water quality, supply, and detritus (decomposed plant material). Unit 4 contains San Marcos Springs and consists of 16 ac (6 ha) of surface critical habitat for the Comal Springs riffle beetle (Table 3). This unit was occupied at the time of listing and is still occupied by the Comal Springs riffle beetle (Table 1). This unit is located on State-owned lands in the City of San Marcos, Hays County, Texas. This unit contains all of the essential physical and biological features for this species. The physical or biological features in this unit require special management or protection because of the potential for depletion of spring flow from water withdrawals, hazardous materials spills from a variety of sources in the watershed, pesticide use throughout the watershed, excavation and construction surrounding the springs and in the watershed, stormwater pollutants in the watershed, and invasive species impacts on the surface habitat.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for this species in Comal and Hays Counties, Texas. Within these areas, the primary constituent elements of the physical or biological features essential to the Comal Springs riffle beetle consist of these components:

(i) Springs, associated streams, and underground spaces immediately inside of or adjacent to springs, seeps, and upwellings that include: (A) High-quality water with no or minimal pollutant levels of soaps, detergents, heavy metals, pesticides, fertilizer nutrients, petroleum hydrocarbons, and semivolatile compounds such as industrial cleaning agents; and (B) Hydrologic regimes similar to the historical pattern of the specific sites, with continuous surface flow from the spring sites and in the subterranean aquifer;

(ii) Spring system water temperatures that range from approximately 68 to 75 °F (20 to 24 °C); and

(iii) Food supply that includes, but is not limited to, detritus (decomposed materials), leaf litter, living plant material, algae, fungi, bacteria, other microorganisms, and decaying roots.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing on the surface within the legal boundaries on November 22, 2013.

For the Comal Springs riffle beetle, threats to adequate water quantity and quality (PCEs 1 and 2) include alterations to the natural flow regimes affecting the aquifer recharge system and its associated springs, streams, and riparian areas. Threats to water quantity and quality include water withdrawals, impoundment, and diversions; hazardous material spills; stormwater drainage pollutants including soaps, detergents, pharmaceuticals, heavy metals, fertilizer nutrients, petroleum hydrocarbons, and semivolatile compounds such as industrial cleaning agents; pesticides and herbicides associated with pathogenic organisms or invasive species; invasive species altering the surface habitat; excavation and construction surrounding the springs and in the watershed; and climate change. All of these threats are known to be ongoing at various levels in and around the Edwards Aquifer ecosystem. Examples of special management actions that would ameliorate these threats include: (1) Maintenance of sustainable groundwater use and subsurface flows; (2) use of adequate buffers for water quality protection; (3) selection of appropriate pesticides and herbicides; and (4) implementation of integrated pest management plans to manage existing invasive species as well as prevent the introduction of additional invasive species.

Life History

Feeding Narrative

Adult: This species is a detritivore.

Reproduction Narrative

Adult: There is not any available reproduction information for this species.

Spatial Arrangements of the Population

Adult: clumped according to suitable habitat

Tolerance Ranges/Thresholds

Adult: low

Site Fidelity

Adult: high

Habitat Narrative

Adult: Larvae have been collected with adults in the gravel substrate of the spring headwaters and not on submerged wood as is typical of most Heterelmis species (Brown and Barr 1988). Usual water depth in occupied habitat is 2 to 10 centimeters (cm)(1 to 4 in) although the beetle may also occur in slightly deeper areas within the spring runs. The Comal Springs riffle beetle is not a subterranean species. It occurs in the gravel substrate and shallow riffles in spring runs.

Dispersal/Migration

Motility/Mobility

Adult: limited

Migratory vs Non-migratory vs Seasonal Movements

Adult: Not migratory

Dispersal

Adult: Very limited

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: Some riffle beetle species can fly (Brown 1987), but the hind wings of H. comalensis are short and almost certainly non-functional, making the species incapable of this mode of dispersal (Bosse et al. 1988).

Population Information and Trends

Population Trends:

unknown

Species Trends:

unknown

Population Growth Rate:

unknown

Number of Populations:

2

Population Size:

50 - 2500 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Populations are reported to reach their greatest densities from February to April (Bosse et al. 1988).

Threats and Stressors

Stressor: Human water use and removal from aquifer
Exposure:
Response:
Consequence:
Narrative: The main threat to the habitat of this speices is a reduction or loss of water of adequate quantity and quality, due primarily to human withdrawal of water from the San Antonio segment of the Edwards (Balcones Fault Zone) Aquifer and other activities. Total withdrawal from the San Antonio region of the Edwards Aquifer has been increasing since at least 1934. There is an integral connection between the water in the aquifer west of the springs and the water serving as habitat for these species. Water in the Edwards Aquifer flows from west to east or northeast and withdrawal or contamination of water in the western part of the aquifer can have a direct effect on the quantity and quality of water flowing toward the springs and at the spring openings. The Panel also stated that in the year 2000, if pumping continues to grow at historical rates and a drought occurs, Comal Springs would go dry for a number of years (Technical Advisory Panel 1990).

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: Other possible effects of reduced spring flow exist. These include changes in the chemical composition of the water in the aquifer and at the springs, a decrease in current velocity and corresponding increase in siltation, and an increase in temperature and temperature fluctuations in the aquatic habitat (McKinney and Watkins 1993). Another threat to the habitat of these species is the potential for groundwater contamination. Pollutants of concern include, but

are not limited to, those associated with human sewage (particularly septic tanks), leaking underground storage tanks, animal/feedlot waste, agricultural chemicals (especially insecticides, herbicides, and fertilizers) and urban runoff (including pesticides, fertilizers, and detergents). Pipeline, highway, and railway transportation of hydrocarbons and other potentially harmful materials in the Edwards Aquifer recharge zone and its watershed, with the attendant possibility of accidents, present a particular risk to water quality in Comal and San Marcos Springs. Comal and San Marcos Springs are both located in urbanized areas. Hueco Springs is located alongside River Road, which is heavily traveled for recreation on the Guadalupe River, and may be susceptible to road runoff and spills related to traffic. Of the counties containing portions of the San Antonio segment of the Edwards Aquifer, the potential for acute, catastrophic contamination of the aquifer is greatest in Bexar, Hays, and Comal counties because of the greater level of urbanization compared to the western counties. Although spill or contamination events that could affect water quality do happen to the west of Bexar County, dilution and the time required for the water to reach the springs may lessen the threat from that area. As aquifer levels decrease, however, dilution of contaminants moving through the aquifer may also decrease. The TWC reported that in 1988 within the San Antonio segment of the Edwards Aquifer, Bexar, Hays, and Comal counties had the greatest number of land-based oil and chemical spills in central Texas that affected surface and/or groundwater with 28, 6, and 4 spills, respectively (TWC 1989). As of July, 1988, Bexar County had between 26 and 50 confirmed leaking underground storage tanks, Hays County had between 6 and 10, and Comal County had between 2 and 5 (TWC 1989) putting them among the top 5 counties in central Texas for confirmed underground storage tank leaks. The TWC estimates that, on average, every leaking underground storage tank will leak about 500 gallons per year of contaminants before the leak is detected. These tanks are considered one of the most significant sources of groundwater contamination in the state (TWC 1989). The TWC (1989), using the assessment tool DRASTIC (Aller, et al. 1987), classified aquifers statewide according to their pollution potential. The Edwards Aquifer (Balcones Fault Zone—Austin and San Antonio Regions) was ranked among the highest in pollution potential of all major Texas aquifers.
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Recovery

Reclassification Criteria:
Not available; species not included in SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1996

Delisting Criteria:
Not available; species not included in SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1997

Recovery Actions:

- 1. Assure sufficient water levels in the Edwards aquifer and flows in Comal and San Marcos Springs to maintain habitat for all life stages of the five listed species and integrity of the ecosystem upon which they depend.
- 2. Protect water quality.

- 3. Establish and maintain populations for all five listed species in their historic habitats.
- 4. Conduct biological studies necessary for successful monitoring, management, and restoration.
- 5. Encourage partnerships with landowners and agencies to develop and implement conservation strategies.
- 6. Develop and implement a regional Aquifer Management Plan.
- 7. Develop and implement local management and restoration plans to address multiple threats.
- 8. Promote public information and education.

References

Final Listing Rule

Final critical habitat designation

Nature Serve

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

Revised Critical Habitat for the Comal Springs Dryopid Beetle, Comal Springs Riffle Beetle, and Peck's Cave Amphipod. Final rule. 78 FR 63100 - 63127 (October 23, 2013).

Final listing rule

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1996

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1997

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1998

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1999

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SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 2003

SPECIES ACCOUNT: *Hypolimnas octocula mariannensis* (Mariana eight-spot butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Mariana eight-spot butterfly (Hypolimnas octocula marianensis) is endemic to the islands of Guam and Saipan in the Mariana archipelago. Like most nymphalid butterflies, orange and black are the two primary colors exhibited by this subspecies. The males are smaller than the females by at least a third or more in size. Males are predominantly black with an orange stripe running vertically on each wing. The stripe on the hindwings exhibits small black dots in a vertical row. Overall, the females appear more orange in color than the males, and black bands across the apical (top) margins of both pair of wings are exhibited. Along the inner margin of these black bands, large white spots are exhibited across the entire length of the wings (Swezey 1942). The caterpillar larva of this species is black in color with red-colored spikes and a black head. It can be differentiated by its black-colored head and red spines from similar appearing caterpillars including Hypolimnas bolina, H. anomala, and Pipturus spp. (Schreiner and Nafus 1996, p. 10; Schreiner and Nafus 1997, p. 26).

Taxonomy

This subspecies was originally described by Butler and is recognized as a distinct taxon (Swezey 1942). Swezey (1942) is the most recent and accepted taxonomy for this species.

Historical Range

The Mariana eight-spot butterfly is historically known from limestone karst forest habitat on Saipan and Guam.

Current Range

The most extensive and thorough historical surveys for the Mariana eight-spot butterfly occurred in 1995 on Guam, Rota, and Saipan (Schreiner and Nafus 1996, p. 2). On Saipan, several areas including the base below Suicide Cliff and Kalebrera Cave were discovered to support healthy populations of the host plant, Procris pedunculata, but no Mariana eight-spot butterflies were seen and the researchers believed the species may have been extirpated on Saipan (Schreiner and Nafus 1996, p. 2; Schreiner and Nafus 1997, p. 26). Distribution: Guam, Saipan (USFWS, 2020b).

Distinct Population Segments Defined

Not Applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: The larvae of this butterfly feed on two native plants, Procris pedunculata (the original recorded host plant) and Elatostema calcareum (also discovered to be a host during surveys in 1995) (Schreiner and Nafus, 1996, p. 1).

Reproduction Narrative

Adult: There is not much information regarding the reproduction of this species.

Geographic or Habitat Restraints or Barriers

Larvae: Restricted to karst limestone

Adult: Restricted to karst limestone

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Environmental Specificity

Larvae: specialist

Tolerance Ranges/Thresholds

Larvae: unknown

Adult: unknown

Dependency on Other Individuals or Species for Habitat

Larvae: Procris pedunculata and Elatostema calcareum

Adult: Procris pedunculata and Elatostema calcareum

Habitat Narrative

Larvae: Both of these forest herbs (Family Urticaceae) grow only on karst limestone (Schreiner and Nafus 1996, p. 1; Rubinoff, in litt. 2013, p. 1). The overall status, including range, number of populations, and population density, of these two plants currently remains relatively unknown. Neither host plant species is known to be common in their range and both are believed to be susceptible to feral ungulate grazing based upon anecdotal observations indicating that they only occur in the extremely rugged limestone karst terrain found on portions of Guam and the CNMI and believed to be avoided by most ungulates (Rubinoff, in litt. 2013, p. 1). During surveys for the Mariana eight-spot butterfly and its host plants in 2011 and 2013, researchers generally found some evidence of the butterflies on host plants including eggs and empty pupal cases.

Adult: When adult butterflies were observed, they were always in proximity to the host plants (Rubinoff, in litt. 2011, pp. 1-2; 2013, p. 1).

Dispersal/Migration

Motility/Mobility

Larvae: low

Adult: moderate

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Adult: non-migratory

Dispersal

Larvae: low

Adult: likely low because of habitat fragmentation

Immigration/Emigration

Larvae: likely low because of habitat fragmentation

Adult: likely low because of habitat fragmentation

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: There is not much information regarding the dispersal of this species.

Population Information and Trends

Population Trends:

declining

Species Trends:

declining

Population Growth Rate:

unknown

Number of Populations:

6-10 (USFWS, 2023)

Population Size:

Unknown (USFWS, 2023)

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

No quantitative estimates are given for the subspecies as a whole; however, Schreiner and Nafus (1996, p. 2) noted about their surveys that the most butterflies observed in one day was six individuals. During the same surveys, the researchers noted that one or more life stage of the Mariana eight-spot butterfly were present in most host plant populations sites. While they generally observed eggs to be rare, a total of 71 eggs were counted during one survey at the Mangilao population site and 30 eggs at the Tweeds Cave population site (Schreiner and Nafus 1996, p. 2). The Mariana eight-spot butterfly is a butterfly in the Nymphalidae family that is known solely from the islands of Guam and Saipan, in the forest ecosystem (Schreiner and Nafus 1996, p. 2; Schreiner and Nafus 1997, p. 26). The larvae of this butterfly feed on two native plants, Procris pedunculata (no common name) and Elatostema calcareum (Schreiner and Nafus, 1996, p. 1). The Mariana eight-spot butterfly is now found in only six populations on the island of Guam. This butterfly is dependent upon two relatively rare host plant species, both of which are susceptible to the effects of ungulate grazing. The Mariana eight-spot butterfly is vulnerable to the impacts of continued habitat loss and destruction from agriculture, urban development, nonnative animals and plants, and typhoons. We anticipate the effects of climate change will further exacerbate many of these threats in the future. Herbivory of its host plants by nonnative animals, combined with direct predation by ants and parasitic wasps, contribute to the decline of the Mariana eight-spot butterfly. Low numbers of individuals and populations in a contracted range, along with a low reproductive rate magnify the threats to viability. Existing regulatory mechanisms and conservation efforts do not adequately address these threats, which are likely to continue into the future. Given the extent of threats, declining numbers of individuals and populations, and lack of management of these threats, this species best fits the definition of endangered. A draft recovery plan is expected to be completed in 2021. (USFWS, 2021). Number of Known Populations: 6-10. Number of Individuals in the Wild in the Marianas: Unknown (USFWS, 2023)

Threats and Stressors

Stressor: Invasive species

Exposure:

Response:
Consequence:
Narrative: Numerous nonnative insect predators and parasitoids of Lepidoptera have become established, purposefully or adventitiously, in the Mariana Islands, including on Guam and Saipan. Some of these insects have been documented to attack and significantly impact certain species of native butterflies (Peterson 1957; Schreiner and Nafus 1986; Nafus 1989, 1992, 1993a, b, c). Schreiner and Nafus (1996, pp. 2-5) found that egg predation by ants and egg parasitism killed the majority of Mariana eight-spot butterflies studied for a year on Guam. In the one year study, Schreiner and Nafus (1996, pp. 2-5) documented parasitism of eggs of the Mariana eight-spot butterfly by two native parasitoid wasps, Telenomus sp. (no common name) and Ooencyrtus sp. (no common name), on Guam. These wasps are tiny and likely hitch-hiked with adult female butterflies in order to access freshly laid eggs, as has been observed in related species (Woelke 2008). The wasps lay their own eggs within the butterfly eggs, thus preventing caterpillar development. Nafus (1993a) found ants to be major predators of the eggs and larvae of the common eggfly (Hypolimnas bolina), a closely related butterfly species. The most commonly observed ants were dwarf pedicel ants (Tapinoma minutum), tropical fire ants (Solenopsis geminata), white-footed ants (Technomyrmex albipes), and bi-colored trailing ants (Monomorium floricola). Many ant species are known to prey on all immature stages of Lepidoptera and can completely exterminate populations (Zimmerman 1958). In the same one year study noted above, Schreiner and Nafus (1996, p. 3) found predation by nonnative ants to be one of the primary causes of mortality (>90 percent) in the Mariana eight-spot butterfly.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The Mariana eight-spot butterfly currently receives no protection under the federal Endangered Species Act (16 U.S.C. §1531-1544) or the CNMI Endangered Species List (Public Law 2-51 CMC 5108b). It does receive protection under the Guam Endangered Species Act (5GCA § 63205(c)).

Stressor: Population Isolation/Fragmentation
Exposure:
Response:
Consequence:
Narrative: The Mariana eight-spot butterfly apparently persists in extremely low numbers on Guam. This circumstance makes it vulnerable to extinction due to a variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Small populations are also demographically vulnerable to extinction caused by random fluctuations in population size and sex ratio and to catastrophes such as typhoons (Lande 1988).

Recovery

Reclassification Criteria:
not applicable

Recovery Priority Number: 6

Delisting Criteria:
not applicable

Recovery Actions:

- Develop and implement monitoring surveys for the Mariana eight-spot butterfly
- Develop and implement monitoring surveys to better understand the status of the two host plant species
- confirming whether the host plants are susceptible to feral ungulates including pigs and deer, and if so, developing and implementing control to protect the host plants
- Conduct parasite control
- Conduct ant control
- In 2009, field information sheets were provided with color pictures and descriptions of the Mariana eight-spot butterfly and its host plants to over 20 professional staff currently working in the field on the islands of Rota, Tinian, and Saipan. The sheets request that pictures, GPS points and field notes be provided to the FWS in an effort to obtain information on this species (Hawley, FWS, in litt. 2009). A survey led by the FWS was conducted on the island of Tinian, CNMI from June through October, 2008, to determine the presence or absence of two butterfly species, the Mariana wandering butterfly and the Mariana eight-spot butterfly. While Tinian is not known to be part of either species historical range, the likelihood of introduced pests arriving on Tinian due to an increase in sea and air transports to this island is a concern for a suite of native butterfly species, including the Mariana eight-spot butterfly. Additionally, any reduction of host plant sites for either butterfly species may be of conservation concern if translocation to Tinian is considered in future recovery or enhancement plans. While several Elatostema calcareum host plant population sites were identified and monitored in limestone karst forest habitat on Tinian, no life stages of the Mariana eight-spot butterfly were observed (Hawley 2009). Surveys on Guam insect biodiversity are currently underway (Aguon, in litt. 2009). In addition, a survey for the butterfly in Pagat was conducted between July 15 and July 24, 2009. While the survey was only able to confirm the presence of one adult male, they did fine eggs, larvae, one viable chrysalis, and three empty chrysalides of Hypolimnas spp. Unfortunately, immature life stages are difficult to distinguish and therefore unless reared to adult form cannot be confirmed (Campora and Lee 2009, pp. 3-5). In 2011, the FWS contracted with Dr. Dan Rubinoff, a University of Hawaii lepidopterist, to conduct surveys for both the Mariana wandering butterfly and the Mariana eight-spot butterfly on Guam and Saipan. These surveys were completed in in July, 2011, and the results along with a 2013 survey done for the U.S. Navy are discussed above (see Current Range and Distribution).
- Threat and Recovery Potential: Subspecies with a high degree of threat and low recovery potential. (USFWS, 2020b)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop and finalize a Draft Recovery Plan that included the Mariana eight-spot butterfly. • Initiate control of habitat-modifying threats, such as ungulates, ants, wasps, and invasive nonnative plants, within the highest priority management units. • Assess or confirm the distribution, current status, and potential future distribution of existing habitats and determine the most intact sites for management. Make use of landscape modeling, spatial analysis, remote sensing technology, and existing survey data to better understand species distributions and priority areas for targeting future surveys. • Conduct systematic, island-wide surveys for additional populations. • Protect all remaining extant populations by controlling species-specific threats. • Prevent the influx of new invasive species into recovery areas. Increase the efforts of the Guam Invasive Species Advisory Committee and Micronesia Regional Invasive Species Council and improve border security. • Prioritize research that will provide information and tools that will aid in ameliorating known threats and limiting factors of the species and habitats. • Secure propagules for captive propagation for genetic storage and reintroduction. • Increase outreach efforts and coordination with Territorial agencies, private landowners, and the military regarding habitat conservation. • Promote opportunities to assist in the recovery of these species through habitat conservation plans, safe harbor agreements, Federal action agency Section 7(a)(1) and 7(a)(2) consultation obligations under the ESA, and through various conservation partnerships funded by Territorial and Federal agencies and private organizations. (USFWS, 2021)

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2013. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

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SPECIES ACCOUNT: *Icaricia icarioides fenderi* (Fender's blue butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Region (R1) (USFWS, 2016); Proposed downlisting including a proposed 4D; Pacific Region (posted in the FR in July 2021)

Physical Description

The Fender's blue butterfly belongs to the group of blue butterflies in the family Lycaenidae. The Fender's blue butterfly is one of about a dozen subspecies of Boisduval's blue butterfly (Icaricia icarioides) found only in western North America. Fender's blue butterfly is small, with a wingspan of approximately 25 mm (1 inch). The upper wings of the males are brilliant blue in color and the borders and basal areas are black. The upper wings of the females are completely brown. The undersides of the wings of both sexes are creamish tan with black spots surrounded by a fine white border or halo. The dark spots on the underwings of male butterflies are small. In contrast, the dark spots on the underwings of the pembina blue butterfly (Icaricia icariodes pembina) are surrounded with wide white haloes, and the underside of the hindwings of Boisduval's blue butterfly (Icaricia icariodes) is very pale whitish gray with broad haloes around the black spots (Schultz et al. 2003) (USFWS, 2016).

Taxonomy

Family: Lycaenidae; Subfamily: Polyommatinae; Genus: Icaricia; Species: icarioides; Subspecies: fenderi

Historical Range

The historic distribution of Fender's blue butterfly is not precisely known due to the limited information collected on this species prior to its description in 1931. Although the type specimen for this butterfly was collected in 1929, few collections were made between the time of the subspecies' discovery and Macy's last observation of the butterfly on May 23, 1937, in Benton County, Oregon (Hammond and Wilson 1992). Uncertainty regarding the butterfly's host plant caused researchers to focus their survey efforts on common lupine species known to occur in the vicinity of Macy's collections. Fifty years passed before the Fender's blue butterfly was found again (USFWS, 2016)

Current Range

As of 2018, there are a total of 15 known Fender's blue butterfly metapopulations and 6 independent groups distributed across the known historical range of the species in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties (Figure 3.3; Table 3.3 in the SSA, 2020). Of those metapopulations, six are located in the Salem Recovery Zone, five are in the Corvallis Recovery Zone, and four are in the Eugene Recovery Zone. The six independent groups are known as Bond Butte, Dallas, McCaleb Road, McTimmonds Valley, Mill Creek, and Tanager.

Distinct Population Segments Defined

N/A

Critical Habitat Designated

Yes; 10/6/2006.

Legal Description

On October 31, 2006, the U.S. Fish and Wildlife Service (Service)designated critical habitat for the Fender's blue butterfly (Icaricia icarioides fenderi), pursuant to the Endangered Species Act of 1973, as amended (Act). Approximately 3,010 acres (ac) (1,218 hectares (ha)) for Fender's blue butterfly in Benton, Lane, Polk, and Yamhill Counties, Oregon.

Critical Habitat Designation

13 units are desingated as critical habitat for the Fender's blue butterfly.

Unit 1 for Fender's blue butterfly (Units FBB–1A and 1B). Units FBB–1A and 1B encompass approximately 6.2 ac (2.5 ha) and 14.1 ac (5.7 ha), respectively, of private land occurring within northern Yamhill County and within the Oak Ridge habitat network. The Oak Ridge butterfly population is supported by three separate habitat patches, and the population has been monitored annually since 1993 (Hammond 2004, pp. 1, 3). The population has become much larger over the last 3 years, with an estimated 259 butterflies in 2004 (Hammond 2004, pp. 3, 34). FBB–1A represents the northernmost known occupied habitat patch in the current range of Fender's blue butterfly, and occurs along both the east and west sides of Oak Creek Road. FBB–1B is located approximately 0.7 miles (1.1 km) south of FBB–1A along both the east and west sides of Oak Creek Road, near the junction with Fairdale Road. The prairie habitat within FBB–1A and FBB–1B contains the PCEs essential to the conservation of this core population. In recent years the Oak Ridge butterfly metapopulation has been evenly distributed among the three lupine patches. However, 10 years of monitoring reports for this population indicate that the number of individuals supported by each habitat patch has increased and decreased annually, with one habitat patch disproportionately supporting the population each year. The population fluctuations documented at these sites are attributed to roadside maintenance and presence of invasive species (Hammond 2002, pp. 3, 4; Hammond 2004, pp. 5, 33). The overall population has remained relatively stable, likely because its distribution among the three habitat patches provides opportunity for recolonization of impacted habitat patches (Hammond 2004, pp. 4–5). The prairie habitat within and between FBB–1A and 1B should be managed to allow for growth and expansion of this relatively small population in order to achieve and maintain the population. Unit 1 for Fender's blue butterfly contains habitat features that are essential to the continued persistence of the species' core population throughout its range. Establishing stepping-stone habitat between FBB–1A and 1B will contribute to a more connected functioning metapopulation. However, at this time we do not have enough information to identify additional potential habitat for population expansion that may be necessary to meet delisting criteria. The habitat identified in FBB–1A and 1B has the features essential to the conservation of Fender's blue butterfly; has one of the largest remaining Fender's blue butterfly metapopulations; supports the butterfly's primary host plant, Lupinus sulphureus ssp. kincaidii; occurs at the northernmost extent of the species' range (Hammond 2004, p. 5); and is surrounded by prairie habitat available for population expansion.

Unit 2 for Fender's blue butterfly (Unit FBB–2). Unit FBB–2 consists of approximately 51 ac (20.6 ha) of private lands within southern Yamhill County. The Gopher Valley butterfly population has been monitored annually since 1995 (Hammond 2004, p. 7), and has remained stable with a relatively low number of individuals consistently being reported (compared to other stable populations) (Hammond 2004, p. 35). The Lupinus sulphureus ssp. kincaidii habitat supporting this population occurs in two habitat patches scattered along the east and west sides of Gopher Valley Road. The largest distance separating lupine patches is approximately 0.12 miles (0.2 km). This population is threatened by the limited availability of nectar sources, presence of invasive species, and roadside maintenance activities. With proper management of the prairie habitat surrounding the population located within the FBB–2 unit boundary, the habitat provides opportunities for population growth and expansion of both Fender's blue butterfly and Lupinus sulphureus ssp. kincaidii. Unit FBB–2 provides ease of Fender's blue butterfly movement between lupine habitat patches, and to all the features essential to the conservation of the species. Given the increased size of the lupine patch at the Deer Creek Park site (Hammond 2005, p. 8), this area will substantially contribute to the conservation of the Fender's blue butterfly. The habitat in FBB–2 has the features essential to the conservation of Fender's blue butterfly; one of the largest remaining Fender's blue butterfly populations in this portion of the butterfly's range; supports one of Fender's blue butterfly's primary host plants; provides the foundation for the existence of the species in this portion of its range; and has surrounding prairie habitat available for population expansion. In addition, Hammond (2005, pp. 8, 9) identified an expanding L. sulphureus ssp. kincaidii population at Deer Creek Park that now supports Fender's blue butterfly, increasing the size and long-term viability of this metapopulation.

Unit 3 for Fender's blue butterfly (Unit FBB–3). Unit FBB–3 encompasses approximately 3.6 ac (1.5 ha) of primarily State-owned lands within northern Polk County. The Mill Creek butterfly population has been monitored annually since 1993 (Hammond 1993, pp. 18, 24; Hammond 2004, pp. 9, 10) and the overall number of individuals has increased over the past 3 years (Hammond 2004, p. 10). The lupine habitat supporting this population occurs in two patches scattered along the northeast and southwest sides of Highway 22, near the intersection with Mill Creek Road. The Oregon Department of Transportation (ODOT) owns most of the habitat supporting this population. Hammond (2004, p. 10) documented the threats to this unit as largely the presence of invasive grasses and shrubs that have overgrown the habitat, suppressing the lupine and Erigeron decumbens var. decumbens populations occupying this prairie remnant. Habitat management activities implemented by ODOT in 2000 resulted in a large growth flush of Lupinus sulphureus ssp. kincaidii and an increased number of Fender's blue butterflies. This demonstrates that appropriate management of this site can provide for population growth and expansion. The habitat in unit FBB–3 supports the butterfly's primary host plant; the Fender's blue butterfly population size has been increasing over the last few years.

Unit 4 for Fender's blue butterfly (Units FBB–4A and 4B). Units FBB–4A and 4B encompass approximately 748.4 ac (302.9 ha) and 416.1 ac (168.4 ha), respectively, of private and Federal land occurring within northern Polk County. Units FBB–4A and 4B are located adjacent to Highway 22 approximately 5.5 miles (8.8 km) northeast of the City of Dallas. An estimated 64 percent of the habitat encompassed within Unit FBB–4 occurs within the boundaries of the Service's Baskett Slough National Wildlife Refuge (Refuge) and approximately 36 percent of the prairie habitat occurs on adjacent private lands. Refuge biologists have documented the occurrence of the PCEs throughout the habitat within FBB–4A and 4B and also the Fender's blue butterfly's utilization of these areas (USFWS 2005, Smith, in litt.a, pp. 2, 3). Many of the populations occurring in FBB–4A have been monitored annually since 1993 (Hammond 2004, p. 17), and the populations occupy ten separate patches of Lupinus arbustus which are scattered across the unit. Between 1993 and 2001, habitat conditions steadily declined in many areas due to encroachment of grasses and brush in the upland prairie habitat (Hammond 2004, p. 18). Such habitat conditions adversely impacted not only the Fender's blue butterfly but also the population of Erigeron decumbens var. decumbens supported within FBB–4A. Recent survey results indicate that this metapopulation increased dramatically in size during 2003–2004 (Hammond 2004, p. 18). The total population size was estimated at 223 individuals in 2001 and approximately 1,368 individuals in 2004. Unit FBB–4B is located approximately 0.12 miles (0.2 km) from FBB–4A with predominately agricultural lands occurring between the areas supporting this metapopulation. Unit FBB–4 (FBB– 4A and 4B) supports the largest known Fender's blue butterfly metapopulation and the largest contiguous occupied prairie patch in the range of the species. This relatively large, contiguous prairie habitat is one of a few occupied remnants occurring on valley hillsides; most remaining populations occur on the valley floor. The open nature of the lands occurring between FBB–4A and 4B increases the potential for individuals to successfully disperse among habitat patches. The habitat in this unit has the features essential to the conservation of the species; it supports the largest known metapopulation, consists of several connected populations and provides an abundance of nectaring and dispersal habitat that allows for population growth and expansion.

Unit 5 for Fender's blue butterfly (Unit FBB–5). Unit FBB–5 consists of approximately 12.3 ac (5 ha) of private lands within the central portion of Polk County. Unit FBB–5 is located near the junction of Highway 223 and Oakdale Avenue and largely falls within the City of Dallas' urban-growth boundary. Although Hammond (Hammond and Wilson 1993, pp. 10, 15; 2004, pp. 10, 12) has estimated the size of the Dallas population since 1991 (Hammond 1996, p. 13), he documents that he has been unable to access the site for over seven years and has been limited to visuallyobstructed roadside observations. The Fender's blue butterfly needs special management in this unit because the population is threatened by the limited availability of food plants, presence of invasive species, and the impacts associated with the encroachment of urban development. Hammond (2004, p. 12) has documented the removal of several acres of Fender's blue butterfly habitat adjacent to this unit over the last ten years for residential development. Appropriate management of the prairie habitat within FBB–5 should provide opportunity for population growth and expansion population. Unit FBB–5 provides the habitat containing the features essential for the continued persistence of this core population.

Unit 6 for Fender's blue butterfly (Units FBB–6A and 6B). Units FBB–6A and 6B encompass approximately 2.4 ac (1 ha) and 15.9 ac (6.4 ha), respectively, of private lands occurring within southern Polk County. Unit FBB–6A is located along McCaleb Road near Cooper Creek and Unit FBB– 6B is approximately 0.8 mile (1.4 km) south of FBB–6A along Monmouth Highway. Several

Fender’s blue butterfly populations historically occurring south of Dallas, Oregon, have been extirpated over the last decade (Hammond 2004, p. 12, 13). The habitat encompassed within FBB–6 (FBB–6A and 6B) supports the core butterfly population occurring at the southern end of the Dallas/Polk County functioning network and has been monitored annually since 1994 (Hammond 2005, p. 16). Reintroductions of Lupinus sulphureus ssp. kincaidii or augmentations may be necessary at extirpated sites to provide steppingstone habitat between FBB–5 and FBB–6. Unit FBB–6 provides the habitat containing the features essential to the persistence of this core population, as evidenced by an increasing butterfly population size over the last few years; it is one of the largest remaining Fender’s blue butterfly populations in this portion of its range and it is one of two core, isolated populations providing the ‘‘backbone’’ of the Dallas/Polk County functioning network. The larval host plant found in FBB– 6B is Lupinus albicaulis, and based on roadside observations, Hammond (2004, p. 12) estimates several hundred butterflies occupy this habitat. Since L. albicaulis is a short-lived perennial, Hammond (2004, p. 12) documents that without periodic disturbance this butterfly population may disappear more quickly than populations using L. sulphureus ssp. kincaidii and L. arbustus as a host plant. However, L. albicaulis is the primary host plant for Puget blue butterfly (Icaricia icarioides blackmorei) and appears to serve the Puget blue quite well (Schultz, in litt.b, 2005). Additionally, another roadside population (McTimmonds Valley) of Polk County Fender’s blue butterfly supported by L. albicaulis (Hammond 2002, p. 15) has remained stable for over a decade (Hammond 2004, pp. 13, 14). FBB–6A supports a roadside population of Lupinus sulphureus ssp. kincaidii and is located between FBB– 6B and a Fender’s blue butterfly site where, in spite of surveys, individuals have not been seen for 2 years. FBB–6A provides stepping-stone habitat for Fender’s blue butterfly.

Units 7, 8, and 9 for Fender’s blue butterfly (Units FBB–7, FBB–8, and FBB–9). Units FBB–7, FBB–8, and FBB–9 collectively represent the areas of habitat containing the features essential to the conservation of the Fender’s blue butterfly populations in northern Benton County. This area is located in the central region of the species’ range and consists of two large and one medium-sized populations that are isolated from one another. The availability of habitat in each of these units provides opportunity for population growth and expansion, with appropriate stepping-stone habitat conditions available for facilitating movement within units. Each of these units has features that are essential to the conservation of the species because there is surrounding prairie habitat available for metapopulation expansion, and the units collectively support three of the largest remaining Fender’s blue butterfly populations in this portion of the species’ range. Additionally, these populations are located in relatively close proximity to one another, thus increasing the potential for interaction between populations. Stepping-stone habitat between FBB–7, FBB–8, and FBB–9 will likely be necessary for these currently isolated populations to function as a larger metapopulation. The habitat included within each of these units provides the foundation for longterm persistence of each respective isolated population.

Unit 7 for Fender’s blue butterfly (Unit FBB–7). Unit FBB–7 consists of approximately 11.5 ac (4.6 ha) of private and State lands within Benton County. The habitat in this unit, uniquely located in a meadow surrounded by forested land, supports the second largest known Fender’s blue butterfly population and occurs in McDonald Forest located off Oak Creek Road. Approximately 15 percent of the habitat supporting the PCEs within FBB–7 occurs on Oregon State University lands and the remaining 85 percent occurs on private lands. This Fender's blue butterfly population has been monitored annually since 1993 (Hammond 2004, pp. 26–27) and recent studies indicate that this population has the highest chance of long-term persistence based on population trend data (Schultz et al. 2003, pp. 67–68). This population of Fender's blue butterfly is threatened by the encroachment of invasive grasses and succession to forest, especially in narrow areas of the meadow where tree encroachment could block-off portions of the habitat and isolate portions of the populations (Hammond 2004, p. 27). Although a management plan has not been completed for this unit, the landowner is interested in maintaining the prairie habitat for the butterfly. In cooperation with Oregon State University scientists, the landowner is studying appropriate management techniques for controlling invasive Brachypodium sylvaticum (false brome). Unit FBB–7 provides a diverse composition of high quality habitat utilized by all life stages of the Fender's blue butterfly.

Unit 8 for Fender's blue butterfly (Unit FBB–8). Unit FBB–8 encompasses approximately 716.7 ac (290 ha) of private lands within Benton County. This unit is located in Wren, Oregon, between Kings Valley Highway, Cardwell Hill Road and Blakesly Creek Road, approximately 2 miles (3.2 km) southwest of Unit FBB–7. Several of the Fender's blue butterfly populations occupying this unit have been surveyed regularly since 1991 (Hammond and Wilson 1993, p 10, 22; Hammond 1997, p. 6; Hammond 1999, p. 20; Hammond 2001, p. 22; Hammond 2003, pp. 22, 23; Hammond 2004, pp. 23–25; Hammond 2005, p. 26). A new Fender's blue butterfly population has been documented using a large population of Lupinus sulphureus ssp. kincaidii located between two of the regularly monitored populations of Fender's blue butterfly (Hammond 2004, p. 23). The powerline right-of-way that runs across Unit FBB– 8 appears to play a significant role in Fender's blue butterfly dispersal between the L. sulphureus ssp. kincaidii populations scattered across this large contiguous high quality prairie (USFWS 2004a, 2004c). The relatively ''pristine'' (Hammond 2004, p. 23), large prairie habitat included within Unit FBB–8 contains the features essential for all life stages of this Fender's blue butterfly metapopulation.

Unit 9 for Fender's blue butterfly (Unit FBB–9). Unit FBB–9 consists of approximately 48.5 ac (19.6 ha) of private lands located north of Philomath. The habitat occurs primarily to the south of West Hills Road and to the west of 19th Street. The Greenbelt Land Trust recently obtained a conservation easement for 51 percent of the prairie habitat supporting this population. Adult Fender's blue butterfly individuals have been observed using the nectaring habitat in this remnant prairie and many of the Lupinus sulphureus ssp. kincaidii populations scattered throughout the unit. The Fender's blue butterfly population utilizing the eastern portion of this site has been monitored annually since 1999 (Hammond 2005, p. 34), with the first observation of individuals occurring in 1992 (Hammond and Wilson 1993, pp. 10, 21). Threats to this site include encroachment of invasive species, trees and shrubs, and a small portion of the Unit FBB–9 is located along West Hills Road and impacted by roadside maintenance activities. Unit FBB–9 provides the habitat features essential for all life stages of this butterfly population, and is one of the core populations.

Units 10, 11, and 12 for Fender's blue butterfly (Unit FBB–10, FBB–11, and FBB–12). Units FBB–10, FBB–11, and FBB–12 support the core populations of the species in the southern portion of their range. Collectively, these units provide the foundation for the West Eugene habitat network. This area supports three core populations that are mostly isolated from one another (greater than 0.93 miles (1.5 km) from the nearest occupied lupine patch) with steppingstone populations located between core populations. The availability of habitat within each of these units provides opportunity for population growth and expansion, as well as areas appropriate for stepping-stone habitat that will facilitate ease of movement within units. Each of these units provide habitat with features essential to the conservation of the species; they collectively support two of the largest remaining Fender's blue butterfly metapopulations (FBB–10 and FBB–12); the two metapopulations are located in relatively close proximity to one another providing a unique opportunity to reestablish a larger connected set of populations that functions as a viable metapopulation; the butterfly populations are all supported by Lupinus sulphureus ssp. kincaidii; and there is surrounding prairie habitat available for population expansion. Stepping-stone habitat in FBB–11 is necessary to provide connectivity among core butterfly populations to ensure the long-term persistence of this metapopulation.

Unit 10 for Fender's blue butterfly (Units FBB–10A, 10B, 10C, 10D, and 10E). Unit FBB–10A–E encompass approximately 487.4 ac (197.2 ha) of prairie habitat in Lane County, Oregon. The prairie habitat included within FBB–10A–E occurs on BLM and Corps land (63 percent), private lands (33 percent), and County lands (4 percent). Unit FBB–10A, 10B, and 10C collectively support two core metapopulations of Fender's blue butterfly and Lupinus sulphureus ssp. kincaidii that have been surveyed annually since 1993 (Severns 2004, p. 2; Fitzpatrick 2005, p. 2). Within FBB–10A, 84 percent of the area occurs on Corps property located near Shore Lane, NE Fern Ridge Reservoir. The populations occupying FBB–10A require tall-oat grass (Arrhenatherum elatius) management because this invasive grass now covers 100 percent of the habitat supporting all six populations (Severns 2004, p. 1). Nevertheless, the 2004 population surveys reported the largest number of butterflies ever observed at the site; the population size more than doubled between 2003 and 2004. The Army Corp of Engineers has reestablished populations of Lupinus sulphureus ssp. kincaidii between Fender's blue butterfly populations located within this unit to provide butterfly stepping-stone habitat and increase connectivity. In 2001, a small patch of L. sulphureus ssp. kincaidii was planted on the side of a spoil mound, on the south side of the Amazon Canal. The Fender's blue butterfly was documented using this lupine patch during the 2004 field season. This demonstrates that the recommended stepping-stone reserve design (Schultz 1998, p. 291) will allow for successful dispersal between core populations occurring on Corps lands in FBB–10A and on BLM lands in FBB– 10C (Severns 2004, p. 1). The steppingstone habitat is important to establishing a viable, connected Fender's blue butterfly metapopulation (McIntire et al. in review, pp. 1–47; Severns 2004, p. 1). Portions of the habitat occurring on BLM land within FBB–10C are severely threatened by the closed canopy cover of Rubus armeniacus that has overtaken large areas of the site (Kaye 2004). Fender's blue butterfly populations supported by the habitat within FBB– 10B would benefit from adult nectar source augmentations (Severns 2004, p. 1). Habitat management will be necessary to increase the size and connectivity of butterfly populations by restoring additional stepping-stone habitat patches that enhance the connection between the core populations occupying FBB–10A and FBB–10C (McIntire et al. in review, pp. 1–47). Units FBB–10D and 10E provide essential features for the conservation of the species and stepping-stone habitat to populations occurring in Units FBB–11 and FBB–12 (McIntire et al. in review, pp.

1–47). Unit FBB–10A–E provides the habitat containing the features essential for two butterfly populations. This unit includes one of the most extensive contiguous prairie remnants, which increases the potential for connectivity between these two core populations. This prairie remnant provides the foundation for reestablishing a large functioning metapopulation within the West Eugene Habitat Network.

Unit 11 for Fender's blue butterfly (Units FBB–11A, 11B, 11C, 11D, 11E, 11F, 11G, 11H, and 11I). Unit FBB–11A consists of 15.5 ac (6.3 ha) of privately owned land. FBB–11B includes approximately 14 ac (5.7 ha) of primarily BLM land (94 percent) with 6 percent occurring on private lands. FBB–11C encompasses approximately 22 ac (9 ha) with 94 percent occurring on BLM land and 6 percent on private lands. FBB–11D encompasses approximately 29.3 ac (11.9 ha) with 68 percent on federally owned lands and 32 percent on private lands. FBB–11E consists of approximately 4.4 ac (1.8 ha) of land entirely owned by Lane County. FBB–11F encompasses approximately 28.8 ac (11.6 ha) with 80 percent on federally owned lands, 9 percent on state owned lands and 11 percent on private lands. FBB–11G encompasses approximately 4.6 ac (1.9 ha) with 67 percent on Federal lands and 33 percent on private lands. FBB–11H consists of approximately 58.6 ac (23.7 ha) with 97 percent on Federal lands, less than 2 percent on private lands, and less than 1 percent on county lands. FBB–11I encompasses approximately 51.5 ac (20.8 ha) with 75 percent occurring on Federal lands and 25 percent on private lands. Most of the lupine populations scattered across the prairie habitat within this unit are relatively small, but the habitat supporting them is important to the long-term viability of a larger functioning Fender's blue butterfly metapopulation in this southern portion of the species range (McIntire et al. in review, pp. 1–47). The area included within this unit provides needed stepping-stone habitat between the BLM/Army Corp of Engineers metapopulation to the northwest and The Nature Conservancy (TNC) metapopulations to the southeast (McIntire et al. in review, pp. 1–47). Local land managers recently surveyed this area to identify habitat patches suitable for reestablishing Lupinus sulphureus ssp. kincaidii populations as stepping-stones for the Fender's blue butterfly (McIntire et al. in review, pp. 1–47). The areas identified occur within this unit boundary will need to be enhanced to increase the size and connectivity of butterfly populations by restoring patches between core metapopulations within FBB–10 and FBB–12 (McIntire et al. in review, pp. 1–47). Unit FBB–11 (FBB–11A, 11B, 11C, 11D, 11E, 11F, 11G, 11H, and 11I) provides the features essential for all life stages of this butterfly population because it includes habitat to reestablish connectivity between two of the largest remaining metapopulations, and it increases viability of all populations in this portion of the species' range. The habitat included within FBB–11 is important for reestablishing connectivity between existing metapopulations and providing for a large functioning metapopulation (McIntire et al. in review, pp. 1–47).

Unit 12 for Fender's blue butterfly (Units FBB–12A and 12B). Units FBB–12A and 12B encompasses approximately 114.4 ac (46.3 ha) near the intersection of Bailey Hill Road and Bertelson Road, with the majority of this land occurring on TNC property. The Lupinus sulphureus ssp. kincaidii and Fender's blue butterfly populations are scattered across the 508 ac (206 ha) of remnant prairie known as the Willow Creek Natural Area (Fitzpatrick 2005, pp. 2, 27). FBB–12A and 12B function as a metapopulation and collectively represent the third largest Fender's blue butterfly metapopulation across the range of the species. The populations occurring within this unit have been monitored annually since 1993 (Fitzpatrick 2005, p. 2). The habitat within FBB–12A and 12B is threatened by exotic vegetation and succession to woody vegetation. To ensure a viable, connected metapopulation in west Eugene, the area within this unit should be enhanced to provide opportunity for population growth and expansion (McIntire et al. in review, pp. 1–47). Unit FBB–12 (FBB– 12A and 12B) provides habitat features essential to the conservation of the species; it includes some of the highest quality remaining upland prairie, and supports the largest core metapopulation in this portion of the species range.

Unit 13 for Fender’s blue butterfly (Unit FBB–13): Unit FBB–13 encompasses approximately 132.5 ac (53.6 ha) of private land that supports several patches of primarily Lupinus arbustus scattered across the remnant prairie. The Fender’s blue butterfly population occupying this unit has been monitored since 1993 (Fitzpatrick 2005, p. 7). This habitat supports one of the largest remaining butterfly populations and the highest diversity of native plants documented for Fender’s blue butterfly habitat (Hammond 1994, p. 45). This butterfly population occurs on a valley hillside and is supported by habitat that appears to be stable climax grassland which is very different than the populations growing on the valley floor (Hammond and Wilson 1993, p. 45; Hammond 1994, p. 45). Hammond and Wilson (1993, p. 45) indicate this population should be regarded as a distinct ecological segregate that should be preserved as a unique population. The size, quality and its unique ecological conditions make this unit important to the conservation of the species.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Benton, Lane, Polk, and Yamhill Counties, Oregon. The primary constituent elements of critical habitat for Fender’s blue butterfly are the habitat components that provide:

(i) Early seral upland prairie, wet prairie, or oak savanna habitat with a mosaic of low-growing grasses and forbs, an absence of dense canopy vegetation, and undisturbed subsoils;

(ii) Larval host-plants Lupinus sulphureus ssp. kincaidii, L. arbustus, or L. albicaulis;

(iii) Adult nectar sources, such as:Allium acuminatum (tapertip onion), Allium amplectens (narrowleaf onion), Calochortus tolmiei (Tolmie’s mariposa lilly), Camassia quamash (small camas), Cryptantha intermedia (clearwater cryptantha), Eriophyllum lanatum (wooly sunflower), Geranium oreganum (Oregon geranium), Iris tenax (toughleaf iris), Linum angustifolium (pale flax), Linum perenne (blue flax), Sidalcea campestris (Meadow checkermallow), Sidalcea virgata (rose checker-mallow), Vicia cracca (bird vetch), V. sativa (common vetch), and V. hirsute (tiny vetch);

undeveloped open areas with the physical characteristics appropriate for supporting the short-stature prairie oak savanna plant community (well-drained soils), within ~1.2 miles (~2 km) of natal lupine patches.

Special Management Considerations or Protections

Critical habitat does not include man-made structures (such as buildings, aqueducts, airports, roads, and other paved areas, and the land on which such structures are located) existing on the effective date of this rule and not containing one or more of the primary constituent elements.

Without active management or natural disturbance, many populations may be lost to habitat succession (Wilson 1998a, p. 15, 1998b, p. 13; Wilson et al. 2003, p. 80) as trees and shrubs grow and outcompete early seral plants and shade or crowd out important early seral species such as Fender’s blue butterfly nectar sources. The Fender’s blue butterfly is at risk of inbreeding depression and site extirpation across its range because populations are small and isolated from one another (Jackson 1996, p. 6; Schultz et al. 2003, p. 62, Severns 2003a, p. 222, 2003b, p. 334). This species will benefit from reestablishing prairie plant patches in proximity to core populations.

Life History

Feeding Narrative

Larvae: Larvae feed exclusively on certain lupine, mainly LUPINUS SULPHUREUS var. KINCAIDI occasionally L. LAXIFLORUS and ALBICAULIS.; Food Habits: Herbivore (Immature), Nectarivore (Adult)One brood adults from the end of April into June. Larvae feed in early summer and again in early spring. It is possible that larvae may sometimes extend diapause over more than one winter.; (NatureServe, 2015). Kincaid’s lupine is the larval host plant at most known Fender’s blue butterfly population sites. At two sites, Coburg Ridge and Baskett Butte, the butterfly feeds primarily on longspur lupine, although small amounts of Kincaid’s lupine is present (Schultz et al. 2003). Sickle-keeled lupine is used by the butterfly where it occurs in poorer quality habitats (Schultz et al. 2003). It is interesting to note that Fender’s blue butterfly has not been found to use broadleaf lupine (Lupinus latifolius), a plant commonly used as a food source by other subspecies of Icaricia icarioides, even though it occurs in habitats occupied by the butterfly (Schultz et al. 2003) (USFWS, 2016).

Adult: Larvae feed exclusively on certain lupine, mainly LUPINUS SULPHUREUS var. KINCAIDI occasionally L. LAXIFLORUS and ALBICAULIS.; Food Habits: Herbivore (Immature), Nectarivore (Adult)One brood adults from the end of April into June. Larvae feed in early summer and again in early spring. It is possible that larvae may sometimes extend diapause over more than one winter.; (NatureServe, 2015). Kincaid’s lupine is the larval host plant at most known Fender’s blue butterfly population sites. At two sites, Coburg Ridge and Baskett Butte, the butterfly feeds primarily on longspur lupine, although small amounts of Kincaid’s lupine is present (Schultz et al. 2003). Sickle-keeled lupine is used by the butterfly where it occurs in poorer quality habitats (Schultz et al. 2003). It is interesting to note that Fender’s blue butterfly has not been found to use broadleaf lupine (Lupinus latifolius), a plant commonly used as a food source by other subspecies of Icaricia icarioides, even though it occurs in habitats occupied by the butterfly (Schultz et al. 2003) (USFWS, 2016). Habitat requirements for Fender’s blue butterfly include lupine host plants (Kincaid’s lupine, longspur lupine, and sickle-keeled lupine) for larval food and oviposition sites and wildflowers for adult nectar food sources. Documented native nectar sources include species such as: narrowleaved onion (Allium amplectens), Tolmie star-tulip (Calochortus tolmiei), rose checker-mallow (Sidalcea malviflora ssp. virgata), common woolly sunflower (Eriophyllum lanatum), and Oregon geranium (Geranium oreganum) (Wilson et al. 1997, York 2002, Schultz et al. 2003). Non-native vetches and other flowers are also frequently used as nectar sources, although they are considered inferior to the native nectar sources (Schultz et al. 2003) (USFWS, 2016).

Reproduction Narrative

Adult: Adult Fender's blue butterfly live approximately 7-14 days and are estimated to travel approximately 2 km (1.2 miles) over their life span (Schultz 1998). Although only limited observations have been made of the early life stages of the butterfly, the life cycle of the species likely is similar to other subspecies of Icaricia icarioides (Hammond and Wilson 1993). The life cycle of Fender's blue butterfly may be completed in one year. An adult female butterfly may lay approximately 350 eggs over her 10-15 day lifespan, of which perhaps fewer than two will survive to adulthood (Schultz 1998, Schultz et al. 2003). Females lay their eggs on Kincaid's lupine (Lupinus sulphureus ssp. kincaidii), longspur lupine, (Lupinus arbustus) or sickle-keeled lupine (Lupinus albicaulis), which are the larval food plants, during May and June (Ballmer and Pratt 1988). Newly hatched larvae feed for a short time, reaching their second instar in the early summer, at which point they enter an extended diapause. Diapausing larvae remain in the leaf litter at or near the base of the host plant through the fall and winter when the lupine plant senesces. Larvae become active again in March or April of the following year. Some larvae may be able to extend diapause for more than one season depending upon the individual and environmental conditions. Once diapause is broken, the larvae feed and grow through three to four additional instars, enter their pupa stage, and after about two weeks emerge as adult butterflies in May and June (Schultz et al. 2003) (USFWS, 2016).

Geographic or Habitat Restraints or Barriers

Egg: Willamette Valley in Oregon (SSA, 2020)

Larvae: Willamette Valley in Oregon (SSA, 2020)

Juvenile: Willamette Valley in Oregon (SSA, 2020)

Adult: Willamette Valley in Oregon (SSA, 2020)

Habitat Narrative

Adult: Fender's blue butterfly populations occur on upland prairies characterized by native fescue spp. (bunch grasses). The association of Fender's blue butterfly with upland prairie is mostly a result of its dependence on lupine host plants, although the butterfly also uses wet prairies for nectaring and dispersal habitat. Known sites occupied by the Fender's blue butterfly are predominantly located on the western side of the Willamette Valley, within 33 km (21 miles) of the Willamette River. Habitat requirements for Fender's blue butterfly include lupine host plants (Kincaid's lupine, longspur lupine, and sickle-keeled lupine) for larval food and oviposition sites and wildflowers for adult nectar food sources. Documented native nectar sources include species such as: narrowleaved onion (Allium amplectens), Tolmie star-tulip (Calochortus tolmiei), rose checker-mallow (Sidalcea malviflora ssp. virgata), common woolly sunflower (Eriophyllum lanatum), and Oregon geranium (Geranium oreganum) (Wilson et al. 1997, York 2002, Schultz et al. 2003). Non-native vetches and other flowers are also frequently used as nectar sources, although they are considered inferior to the native nectar sources (Schultz et al. 2003). Therefore, larger prairie patches, with on-going management to improve and maintain habitat quality, are necessary to support a viable Fender's blue butterfly populations. Kincaid's lupine is the larval host plant at most known Fender's blue butterfly population sites. At two sites, Coburg Ridge and Baskett Butte, the butterfly feeds primarily on longspur lupine, although small amounts of Kincaid's lupine is present (Schultz et al. 2003). Sickle-keeled lupine is used by the butterfly where it occurs in poorer quality habitats (Schultz et al. 2003). It is interesting to note that Fender's blue butterfly has not been found to use broadleaf lupine (Lupinus latifolius), a plant commonly used as a food source by other subspecies of Icaricia icarioides, even though it occurs in habitats occupied by the butterfly (Schultz et al. 2003) (USFWS, 2016).

Dispersal/Migration

Motility/Mobility

Adult: High (USFWS, 2016)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2016)

Dispersal

Adult: Low (USFWS, 2016); maximum dispersal distance is 3.2 km (2 mi; Severns 2004)

Immigration/Emigration

Adult: Little

Dispersal/Migration Narrative

Adult: Fender's blue butterfly is believed to have limited dispersal ability, potentially remaining within 2 km (1.2 miles) of their natal lupine patch (Schultz 1998). The maximum dispersal distance reported for the Fender's blue butterfly is 3.2 km (2 mi; Severns 2004). Habitat fragmentation makes dispersal of this magnitude less likely to occur so recovery strategies focus on establishing "functioning networks" to ensure connectivity between habitat patches (USFWS 2010). A study at the main area of Willow Creek in Lane County, showed 95% of adult Fender's blue butterfly are found within 10 m (33 feet) of large lupine patches (Schultz 1998) (USFWS, 2016).

Population Information and Trends

Population Trends:

Unknown (USFWS, 2020)

Resiliency:

Metapopulation Resiliency: For Fender's blue butterfly, resiliency is the ability to sustain metapopulations in the face of stochastic events. Examples of stochastic events that have the potential to affect Fender's blue butterfly include fire, drought, or unseasonably cold or wet weather, especially during the adult flight period. To evaluate resiliency, we created a core conceptual model of resource needs in Chapter 2. There, we identified lupine plants; nectar plants; and open prairie or oak savannah habitat as the most important habitat requirements to sustain individuals and metapopulations of Fender's blue butterfly. We also identified abundance and connectivity as important demographic factors influencing the ability of a metapopulation to grow and persist over time. Thus, greater abundance and greater connectivity within a metapopulation mean greater resiliency of Fender's blue butterfly metapopulations. As summarized earlier in Table 2.4, we determined that for a metapopulation of Fender's blue butterfly to be resilient, the requisite resource needs are an abundance of lupine host plants and nectar plants within prairie patches at least 6 ha (15 ac) in size, with habitat heterogeneity and minimal amounts of invasive plants and woody vegetation. In terms of abundance, a resilient metapopulation would support a minimum of 200 butterflies each year for at least 10 consecutive years. Connectivity would be achieved by ensuring that butterflies are distributed in multiple groups or subpopulations across lupine patches that are within easy dispersal distance of one another and free from barriers to movement, ideally within 0.5 to 1.0 km (0.3 to 0.6 mi) of one another. (USFWS, 2020)

Representation:

Representation is the maintenance of genetic or ecological diversity within a species in order to retain its adaptive capacity, or the ability to adapt to change over time. In the case of Fender's blue butterfly, we do not have any information available specific to the genetic composition or diversity of the species. In addition, there is little indication of significant differences between groups or metapopulations in terms of ecological settings occupied across the range of the species. Most of the ecological settings occupied by Fender's blue butterfly are relatively similar in terms of the habitat type, although there are some elevational differences as shown in areas like West Eugene and Coburg Hills, as well as some variety in terms of metapopulations occupying drier, upland prairie sites as opposed to some metapopulations that are found in wetter prairie types. Lacking any specific information about genetic or ecological diversity within the species, we can only attempt to maintain the capacity of Fender's blue butterfly to adapt to future environmental change by preserving the full suite of geographic and habitat representation available through retaining metapopulations throughout its full range. Historically, metapopulations of Fender's blue butterfly were likely distributed in a more continuous distribution across the prairies and oak savannahs of the Willamette Valley. Anthropogenic changes to the valley since European settlement, however, have resulted in extensive losses of prairie habitats and permanent alterations of the environment to the extent that it is not feasible to contemplate the re-establishment of metapopulations that are connected across the range of the species. Realistically, and as acknowledged by the Recovery Plan, the best possible outcome for Fender's blue butterfly in today's Willamette Valley is the attainment of resilient metapopulations distributed across the historical range of the species, as evidenced by multiple metapopulations occurring within each of the three recovery zones, but without the expectation that all of these metapopulations will be capable of interacting with one another. The establishment of numerous “stepping stone” habitats between existing metapopulations may possibly help to address this connectivity issue in the future, at least between those metapopulations where distances make movements between them potentially feasible. In addition, representation across the range could be increased by establishing metapopulations on the eastern side of the Willamette Valley (east of I-5) and conducting habitat restoration in the northern and the higher elevation edges of the range for heterogeneity. For example, habitat along Wild Iris Ridge just southeast of Willow Creek has potential to connect from low elevation to high elevation to provide an altitudinal gradient. As mentioned in Chapter 5, the Service is in the process of developing an individual-based spatial model that will integrate such considerations into a population viability assessment for Fender’s blue butterfly with the intent of further refining the current recovery criteria for the species. (USFWS, 2020)

Redundancy:

Fender’s blue butterfly needs to have multiple resilient metapopulations distributed throughout its range to provide for redundancy. The more metapopulations, and the broader their distribution across the historical range of the species, the greater the redundancy (and representation) for the species, with concomitant gains in relative viability. Redundancy increases the likelihood of a species surviving rare but catastrophic events, such as a widespread climatic event or the introduction of a serious pathogen. Having multiple resilient metapopulations spread out across a broad geographic area reduces the risk that all or a large portion of the species’ range will be negatively affected by a catastrophic natural or anthropogenic event at a given point in time. Ideally, to maintain both redundancy and representation, resilient metapopulations of Fender’s blue butterfly would be distributed across the historical range of the species, as indicated by the occurrence of multiple metapopulations distributed across each of the three recovery zones established for the species. (USFWS, 2020)

Number of Populations:

15 metapopulations (USFWS, 2020)

Population Size:

~13,700 (USFWS, 2020)

Population Narrative:

While we do not know the precise historical abundance or distribution of Fender’s blue butterfly, there were approximately 3,391 individuals on 32 sites at the time of listing in 2000. Those numbers have grown across all three recovery zones as a result of metapopulation expansion, metapopulation discovery, and metapopulation creation. There are currently 15 known Fender’s blue butterfly metapopulations distributed throughout the Willamette Valley in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties. There are 137 total sites containing approximately 13,700 Fender’s blue butterfly that occur over a broad range of land ownerships with varying degrees of land protection and management on an area totaling approximately 344 ha (825 ac)(Table ES-I). (USFWS, 2020)

Threats and Stressors

Stressor: Habitat loss (USFWS, 2016)/ Habitat fragmentation (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Habitat loss, encroachment of shrubs and trees into prairie habitats due to fire suppression, fragmentation, invasion by non-native plants, and elimination of natural disturbance regimes all threaten the survival of Fender's blue butterfly. Few populations occur on protected lands. Most occur on private lands which are not managed to maintain native prairie habitats. These populations are at high risk of loss to development or continuing habitat degradation (USFWS 2000) (USFWS, 2016). Habitat fragmentation has isolated some Fender's blue butterfly populations to such an extent that butterfly movement among suitable habitat patches may now occur only rarely. This reduction in movement is not expected to maintain the population over time (Schultz 1998). The rarity of host lupine patches and fragmentation of habitat are thought to be the major ecological factors limiting reproduction, dispersal, and subsequent colonization of new habitat (Hammond and Wilson 1993, Hammond 1994, Schultz 1997, Schultz and Dlugosch 1999). Extirpation of remaining small populations as a result of localized events and/or probable low genetic diversity associated with small populations is expected (Schultz and Hammond 2003) (USFWS, 2016).

Stressor: Non-native plants (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The prairies of western Oregon and southwestern Washington have been overtaken by non-native plants that shade-out or crowd-out important native species. Fast growing non-native shrubs Himalayan blackberry (Rubus armeniacus) and Scotch broom (Cytisus scoparius), non-native grasses such as tall oatgrass (Arrhenatherum elatius), and non-native forb, such as meadow knapweed (Centaurea debeauxii), can virtually take over the prairies, inhibiting the growth of the lupine host plants and native nectar sources (Hammond 1996, Schultz et al. 2003). When these highly invasive non-native plants become dominant, they can effectively preclude Fender's blue butterfly from using the native plant species the butterfly needs to survive and reproduce (Hammond 1996). In the absence of a regular disturbance regime, succession of native trees and shrubs also threaten to alter prairie habitats. Common native species found to encroach on undisturbed prairies include Douglas-fir (Pseudotsuga menziesii), Oregon white oak (Quercus garryana), Oregon ash (Fraxinus latifolia), Douglas' hawthorn (Crataegus douglasii) and Pacific poison oak (Toxicodendron diversilobum) (USFWS, 2016).

Stressor: Climate Change (SSA, 2020)
Exposure:
Response:
Consequence: Impacts to resources and habitat

Narrative: Climate models predict warmer and wetter winters along with hotter and drier summers, which may increase the likelihood of drought. These changes could alter prairie plant composition, structure, or timing of plant life cycles. If so, Fender's blue butterflies would be negatively impacted by the loss of nectar species availability and potential increases in nonnative plants, making it difficult to locate host lupine species (SSA, 2020)

Stressor: Insecticides and herbicides (SSA, 2020)
Exposure:
Response:
Consequence: Impacts to the population
Narrative: Can directly kill eggs, larvae, and adult butterflies during application of the chemicals to vegetation and sublethal effects may indirectly kill all life stages (SSA, 2020)

Recovery

Recovery Actions:

- Biologists from Federal and state agencies and private conservation organizations are engaged in active research and monitoring programs to improve the status of Fender's blue butterfly. Recent research has focused on population viability analyses (Schultz and Hammond 2003), metapopulation dynamics and the effects of habitat fragmentation (Schultz 1998), population response to habitat restoration (Wilson and Clark 1997, Kaye and Cramer 2003, Schultz et al. 2003), and developing protocols for captive rearing. Recent studies have shown that Fender's blue butterfly populations respond positively to habitat restoration. Mowing, burning and mechanical removal of weeds have all resulted in increasing butterfly populations. At two sites in the West Eugene Wetlands, The Nature Conservancy's (TNC's) Willow Creek Natural Area and the BLM's Fir Butte site), both adults and larval Fender's blue butterflies have increased in number following mowing to reduce the stature of herbaceous non-native vegetation, although the response to habitat restoration is often complicated by other confounding factors, such as weather fluctuations (Schultz and Dlugosch 1999, Fitzpatrick 2005). Wilson and Clark (1997) conducted a study on the effects of fire and mowing on Fender's blue butterfly and its native upland prairie at Baskett Slough National Wildlife Refuge in the Willamette Valley. Although fire killed all larvae in burned patches, female butterflies from the nearby unburned source patch were able to colonize the entire burned area, including lupine patches that were 107 m (350 feet) from the unburned source plants. They found that Fender's blue butterfly eggs were 10-14 times more abundant in plots that were mowed or burned compared to undisturbed, control plots. Woody plants were reduced 45% with burning and 66% with mowing. Fender's blue butterfly population trends have been correlated with lupine vigor. High leaf growth appears to produce larger butterfly populations. At the USACE's Fern Ridge Reservoir, the Fender's blue butterfly population has increased dramatically since fall mowing of lupine patches has been implemented. The abundance of Fender's blue butterfly eggs was found to be correlated with the abundance of Kincaid's lupine leaves at a number of study sites (Kaye and Cramer 2003); egg abundance increased substantially at sites which had been treated to control non-native weeds (Schultz et al. 2003). Fender's blue butterfly populations occur on public lands or lands that are managed by a conservation organization at the Service's Baskett Slough National Wildlife Refuge, the USACE's Fern Ridge Reservoir, the BLM's West

Eugene Wetlands, TNC's Willow Creek Preserve and Coburg Ridge easement, and on a small portion of Oregon State University's Butterfly Meadows in the McDonald State Forest. All of these parcels have some level of management for native prairie habitat values. The Partners for Fish and Wildlife Program works with private landowners to restore wildlife habitats. Native prairie restoration and Fender's blue butterfly recovery are key focus areas of the program in the Willamette Valley (USFWS, 2016).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: Continue to pursue and maintain management agreements to ensure continuation of management for prairie conditions. Improve availability of lupine host plants and seed for restoration. Research the causative factors that differentiate resilient and poor-quality population networks of Fender's blue butterfly. Research methods for management and eradication of tall oatgrass. Consider a proposed rule to downlist Fender's blue butterfly from endangered to threatened. Revise recovery criteria, as appropriate. (USFWS, 2019)
- Conservation Measures: Conservation measures are ongoing efforts that offset influences on Fender's blue butterfly viability. These actions are performed by Federal, State and County agencies; non-governmental organizations (NGO) such as TNC; and private landowners. Collectively, the agencies and organizations that manage lands have acquired conservation easements and conducted 63 management actions to benefit prairie habitat and the Fender's blue butterfly. Various types of agreements are also in place with private landowners to perform voluntary conservation actions on their land. Many agencies are working collaboratively on habitat restoration such as at Baskett East, where sites are enrolled in the PFW program and actively managed under interagency agreements between the Service, TNC and Natural Resources Conservation Service (NRCS). Below we summarize some of the conservation efforts occurring across the range of the Fender's blue butterfly and beneficial results of these efforts. Habitat Management Native prairie habitat restoration and management is occurring on public lands or lands that are managed by a conservation organization at the following locations: Baskett Slough NWR and surrounding areas, Finley NWR, Fern Ridge Reservoir, West Eugene Wetlands, Willow Creek Preserve, Yamhill Oaks Preserve, Coburg Ridge, Lupine Meadows, Hagg Lake, a small portion of the McDonald State Forest, and some Benton County public lands. Upland prairie sites that do, or that could, support Fender's blue butterflies and Kincaid's lupine generally require routine treatment to remove woody vegetation and invasive plants in order to maintain and enhance the native plant community and open prairie conditions. Manual and mechanical plant removal methods, prescribed fire, and herbicides have been successful at reducing woody vegetation in some areas. For example, TNC successfully removed Himalayan blackberry and young conifers that were encroaching into lupine patches (Hammond 2008, p. 10). While woody vegetation has been reduced, tall invasive grasses are more challenging to eliminate and there are no known methods to completely eradicate any of the invasive plant species, and control requires continuous maintenance over time. Fender's blue butterfly responds positively to habitat restoration and management as demonstrated in oviposition rates, adult butterflies numbers, larvae numbers, and egg numbers. For example, even with lower lupine density, oviposition in restored prairie frequently exceeded oviposition in existing prairie habitat within 5 years post-restoration (Carleton and Schultz 2013, p. 517). Numbers of Fender's blue butterflies increased in habitat restoration sites using mowing, burning and mechanical removal of invasive vegetation. At two sites in the West Eugene Wetlands (TNC's Willow Creek Natural Area and the BLM's Fir Butte site), both adult and larval Fender's blue butterflies have increased in number following mowing to lower the stature of herbaceous nonnative vegetation (Fitzpatrick 2005, p. 17; Kaye and Benfield 2005, pp. 24- 25). At Fern Ridge Reservoir, Fender's blue butterfly counts have increased since fall mowing of lupine patches has been implemented (U.S. Army Corps of Engineers

2006, p. 4). At Baskett Slough NWR, a study on the effects of fire and mowing found that Fender's blue butterfly eggs were 10 to 14 times more abundant in plots that were previously burned or mowed compared to undisturbed, control plots, and that woody plants were reduced 45 percent with burning and 66 percent with mowing (Wilson and Clark 1997, pp. 23-24). The same trend for egg numbers was observed at Bailey Hill (Fitzpatrick 2005, p. 16; Fitzpatrick 2006, p. 22). Although fire killed all larvae in burned patches, fecundity was higher in burned areas for two years following the burn in one study and overwinter larval survivorship was higher the year after the burn (Warchola et al 2018, pp. 804-805). Another study also showed that all larvae were killed, however, female Fender's blue butterflies from the nearby unburned source patch were able to colonize the entire burned area the following year, including lupine patches that were 107 m (350 ft) from the unburned source plants (Wilson and Clark 1997, p. 10). A study that modeled the effect of prescribed burning found that the best long-term population growth could be achieved by burning one-third of the habitat of a Fender's blue butterfly population each year (Schultz and Crone 1998, p. 244) and targeted burning, ideally of one-quarter of the habitat each year, led to much higher population growth rates than wildfire (Warchola et al 2018, p. 806). 4.5.2 Habitat Protection Approximately 96 percent of the Willamette Valley ecoregion is in private ownership (Oregon Department of Fish and Wildlife 2006, p. 235) and the majority (53 percent) of designated critical habitat for Fender's blue butterfly is on private lands (USFWS 2006, p. 63883). Thus, the conservation and recovery of Fender's blue butterfly, Kincaid's lupine, and the suite of native species associated with them will rely in large part on the voluntary actions of many willing nonFederal landowners to conserve, enhance, restore, reconnect and actively manage native prairie habitats that support these species (USFWS 2010, entire). NGOs have actively pursued conservation easements and acquisition of properties throughout the Willamette Valley. Some specific examples include the 2005 acquisition and establishment of the Lupine Meadows Preserve by GLT and the 2008 acquisition and establishment of the of Yamhill Oaks Preserve by TNC. More information on conservation measures performed by NGOs specific to each metapopulation of Fender's blue butterfly can be found in Appendix C: Metapopulation Descriptions under Current Conditions. The Service provides several voluntary options for working with private landowners and nonFederal property owners. As mentioned in the descriptions of current metapopulations in Chapter 3, many sites across the range have PFW agreements, SHAs, or HCPs. SHAs are voluntary agreements involving private or other non-Federal property owners whose actions contribute to the recovery of species listed as threatened or endangered under the ESA. In exchange for actions that contribute to the recovery of listed species on non-Federal lands, participating property owners receive formal assurances from the Service that if they fulfill the conditions of the SHA, the Service will not require any additional or different management activities by the participants without their consent. The Service administers and implements a programmatic SHA for the benefit of Fender's blue butterfly, which encourages non-Federal landowners to undertake proactive conservation and restoration actions in Benton, Lane, Linn, Marion, Polk, Washington, and Yamhill Counties of Oregon (USFWS 2008, entire). The programmatic SHA provides eligible landowners with a streamlined process for obtaining assurances that certain actions taken to benefit the Fender's blue butterfly will not result in additional regulatory obligations under the ESA. Under the programmatic SHA, the Service has 19 properties with site-specific plans and Certificates of Inclusion covering approximately 567 ha (1,400 ac) as of February 2019. Another 10 agreements are in the process of being developed, which will cover approximately 405 ha (1,000 ac). Of those lands with completed SHAs, six properties contain Kincaid's lupine and may contain Fender's blue butterflies and eight properties are actively managing habitat to support Kincaid's lupine in the future. 65 Three HCPs designed to minimize and mitigate effects to the Fender's blue butterfly have been developed: the 2011 Benton County HCP, the 2014 Yamhill County Road ROWs HCP, and the 2017 ODOTHCP. Conservation measures to avoid, minimize, or compensate for adverse effects under the Benton County HCP for the next 50 years include: acquiring properties with existing populations of Fender’s blue butterfly and prairie habitat from willing sellers; designating Prairie Conservation Areas on over 500 acres of public lands or lands under conservation easement to be managed specifically for prairie species; implementing best management practices for Fender’s blue butterfly in the Prairie Conservation Areas and other covered lands owned by Benton County and the cooperators; augmenting and/or enhancing populations of Fender’s blue butterfly; and implementing a Prairie Conservation Strategy to facilitate effective and voluntary conservation actions by public and willing private landowners in Benton County. The Yamhill County Road ROWs HCP addresses county road routine and necessary maintenance activities over the next 30 years. The county, in cooperation with the Service, surveyed the road ROW for Fender’s blue butterflies and designated 11 km (7 mi) of road fragments as Special Maintenance Zones that receive special protection and management for butterflies under the HCP. An additional 12 km (7 mi) of Special Maintenance Zones were designated to protect seven Kincaid’s lupine sites that are not currently used by Fender’s blue butterflies. The ODOT HCP is a statewide plan addressing routine maintenance of State roads over the next 25 years. ODOT may conduct routine maintenance from the edge of pavement to the ROW boundary on all highway ROWs statewide except for those locations outside of the operational roadway (identified as areas of the ROW necessary to maintain safe operation of the highway) where Fender’s blue butterflies occur. Mitigation for these impacts to Fender’s blue butterflies include protection of butterflies and their habitats in areas where normal required maintenance activities will not impact them.(USFWS, 2020)

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SPECIES ACCOUNT: *Icaricia icarioides missionensis* (Mission blue butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 1, 1976 (41 FR 22041).

Physical Description

The mission blue butterfly is a small butterfly with a wingspan of 2.5 to 3.6 centimeters (1 to 1.4 inches). In males, the upper surface of the wings is iridescent blue, with a black border fringed with white hair-like scales. In females, the upper surface of the wings is dark brown, marked with blue basal areas, with a margin similar to the male. In both sexes, the ventral surfaces of the wings are pale grey with two rows of irregular white-ringed black spots (USFWS 2010).

Taxonomy

The holotype (a single specimen by which a new species is described) mission blue butterfly (Icaricia icarioides missionensis) was described from Twin Peaks, San Francisco County, California. This taxon appears to be a phenotypic intermediate between the darkly marked “inland” populations referred to as pardalis blue butterfly (I. i. pardalis) and populations on the immediate coast, which sport extremely pale ventral wing surfaces and are referred to as Pheres blue (I. i. pheres). Hybridization zones may occur between the closely related mission blue butterfly and the pardalis blue butterfly. The pardalis and mission blue butterfly subspecies have been differentiated from one another by phenotypic characteristics. On the pardalis blue butterfly, the outermost (sub marginal) row of dark spots on the ventral hindwing tend to be somewhat arrowhead shaped and pointed toward the base; while on the mission blue butterfly, the sub marginal spots are less prominent and usually much smaller (USFWS 2010).

Historical Range

Mission blue butterflies historically occurred on hill tops and ridges throughout much of northern San Mateo County northward and up the San Francisco Peninsula to southern Marin County (USFWS 1984).

Current Range

The largest population of mission blue butterflies is found on the San Bruno Mountains, in northern San Mateo County, California. The next largest population is found on Fort Baker and in the Marin Headlands in Marin County, California. Based on the lack of sightings of the adults during the normal flight season since 2004, the mission blue butterfly is either on the verge of being extirpated from Twin Peaks or already extirpated. A chain of smaller populations of mission blue butterflies is found in the San Francisco Peninsula Watershed, extending along Sweeney Ridge and ending at Milagra Ridge (USFWS 1984; USFWS 2010).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Mission blue butterfly larva are herbivores, and the caterpillars only eat silver lupine (Lupinus albifrons), manycolored lupine (L. variicolor), and/or summer lupine (L. formosus) (USFWS 2010).

Adult: Adult mission blue butterflies are nectarivores. Adults feed on a variety of nectar flowers such as hairy false golden aster (Heterotheca villosa), bluedicks (Dichelostemma capitatum), and seaside buckwheat (Eriogonum latifolium) but do not tend to wander far from the areas containing the larval host plant (USFWS 2010).

Reproduction Narrative

Larvae: Caterpillars emerge from eggs 4 to 10 days after the eggs are laid. The mature larvae are reddish-purple or green with three purple or inconspicuous diagonal white lines on each body segment, and the body is covered with short white hairs. The first and second instar larvae feed on the mesophyll of the lupine food plant. About 3 weeks after the larvae emerge, the second instar larvae begin an obligate diapause (dormancy); most diapause in the leaf litter at the base of the food plants. The following spring, the larvae break diapause and resume feeding. Cessation of diapause varies widely, even among sibling larvae. Mission blue butterflies go through three or four instar before pupation. All reproductive activities are carried out among patches of the three known larval host plants: silver lupine (Lupinus albifrons), manycolored lupine (L. variicolor), and summer lupine (L. formosus) (USFWS 2010).

Adult: Females may be mated with less than 24 hours after emergence from chrysalis. Males fly or perch on elevated host plant stalks and fly out to encounter any passing objects, and eventually contact receptive females. Mating occurs on from late morning to late afternoon and lasts anywhere between one to several hours. Females oviposit throughout the flight season/breeding season and lay eggs singly at the rate of several dozen a day on leaves, stems, flowers, and seed pods of the host plants. The majority of deposited eggs has been observed on new growth, particularly the upper surface of leaflets, hatching in about 4 to 10 days. Mission blue butterflies are univoltine (one generation reaches sexual maturity each year). Male mission blue butterflies live 7 days and females live 8 days. All reproductive activities are carried out among patches of the three known larval host plants: silver lupine (Lupinus albifrons), manycolored lupine (L. variicolor), and summer lupine (L. formosus) (USFWS 2010; Xerces 2005).

Geographic or Habitat Restraints or Barriers

Larvae: See Adult life stage.

Adult: The property of the San Bruno Mountains is bordered by urbanized areas: South San Francisco, Brisbane, Colma, and Daly City. The removal of nectar-providing flowering plants and larval host plants also limits habitat for the mission blue butterfly (USFWS 2010).

Spatial Arrangements of the Population

Larvae: Clumped according to resources.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Larvae: High

Adult: High

Habitat Narrative

Larvae: See Adult life stage.

Adult: Typical habitat for the mission blue butterfly consists of coastal scrubland and grassland vegetation that contains at least one of three larval host plants: silver lupine (Lupinus albifrons), manycolored lupine (L. variicolor), and summer lupine (L. formosus). Larvae rely solely on the host plants, but adults feed on other flowering nectar plants found in the habitat. The coastal prairie grasslands where mission blue butterflies are found are climax communities. That is, maintenance and regeneration of the plants characteristic of these ecosystems are dependent on irregular perturbation processes that preclude normal succession. The lupine host plants are dependent on natural disturbance processes—such as rockslides, mudslides, and fires—to establish their seedling (USFWS 2010). San Bruno Mountain has a maximum elevation of 401 m (1,314 ft.). The mountain is characterized by steep canyons and rocky outcrops. Twin Peaks is hilly and rocky and a prominent landmark in the San Francisco. The mission blue butterfly colony at Fort Baker is along the cliffs near the northern end of the Golden Gate Bridge (USFWS 1984).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Somewhat mobile.

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Larvae: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Larvae: No

Adult: No

Dispersal/Migration Narrative

Larvae: See Adult life stage.

Adult: Adult mission blue butterflies can travel up to 2,500 m (8,200 ft.) at San Bruno Mountain, although most travel less than 600 m (1,968 ft.). A mission blue butterfly metapopulation is found in the southern portion of its range in San Mateo County. This metapopulation is a chain of distinct colonies that extends north from the San Francisco Peninsula Watershed, along Sweeney Ridge, and ends at Milagra Ridge. Although not documented, it is highly probable there is gene flow between these colonies. However, many of the mission blue butterfly positions are surrounded by urbanization, which may impede gene flow, immigration, emigration, and recolonization (USFWS 2010).

Additional Life History Information

Adult: Adult butterflies can travel up to 2,500 m (8,200 ft.) at San Bruno Mountain, although most travel less than 600 m (1,968 ft.). What appears to be a mission blue butterfly metapopulation is found in the southern portion of its range in San Mateo County. This metapopulation is a chain of distinct colonies that extends north from the San Francisco Peninsula Watershed, along Sweeney Ridge, and ends at Milagra Ridge. Although not documented, it is highly probable there is gene flow between these colonies (USFWS 2010).

Population Information and Trends

Population Trends:

Short term: relatively stable (less than a 10 percent change). Long term: decline of more than 50 percent (NatureServe 2015).

Species Trends:

Declining

Number of Populations:

Three (San Bruno Mountain, Twin Peaks, and Fort Baker); however, several additional colonies have been located in San Mateo and Marin counties (USFWS 2010); 1 to 15 (NatureServe 2015).

Population Size:

10,000 to 100,000 (NatureServe 2015).

Resistance to Disease:

Disease affects the larval host plants of the mission blue butterfly (USFWS 2010).

Adaptability:

Low

Additional Population-level Information:

Populations of the mission blue butterfly may drop to significantly low levels during certain years, resulting in a decrease in genetic variability or heterozygosity and an increased threat of extinction due to stochastic events (USFWS 2010).

Population Narrative:

The current population of mission blue butterflies is between 10,000 and 100,000 butterflies. The short-term population trend is relatively stable, but the long-term trend has been on a decline of 50 percent. At the time of listing in 1976, only two locations with population of mission blue butterflies were known; Twin Peaks in San Francisco and San Bruno Mountain. By the time the recovery plan was published in 1984, a population in the Marin Headlands at Fort Baker in Marin County was included. Since then, several additional colonies have been located in San Mateo and Marin counties. Although disease does not affect the butterfly itself, it can kill the larval host plant, resulting in fewer habitats for the mission blue butterflies. Populations of the mission blue butterfly may drop to significantly low levels during certain years, resulting in a decrease in genetic variability or heterozygosity and an increased threat of extinction due to stochastic events (NatureServe 2015; USFWS 2010).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Urbanization, public infrastructure.
Response: Reduced habitat.
Consequence: Reduction in population numbers.

Narrative: Present or threatened destruction, modification, or curtailment of the habitat or range of the mission blue and San Bruno elfin butterflies due to private development projects no longer pose as serious of a threat to the species as they did at the time of listing. However, public infrastructure development projects remain a significant threat. For example, the San Francisco Peninsula Watershed is managed to provide water, sewage, and power services to 1.6 million customers; utility improvement and repair projects in the watershed are likely and may conflict with the mission blue butterfly and habitat. In addition, as of June 2009, 7.9 hectares (19.64 acres) of habitat that is allowed to be developed under the San Bruno Mountain HCP remains undeveloped (USFWS 2010).

Stressor: Disease
Exposure: Unknown fungal pathogen.
Response: Fewer lupine host plants.
Consequence: Reduction in population numbers.
Narrative: The outbreak of an unknown fungal pathogen that infected lupine host plants during the El Niño year of 1998 at Milagra Ridge and Twin Peaks represents a threat to the mission blue butterfly throughout its range. Although many of the lupine host plant patches have reestablished themselves at Milagra Ridge, and the mission blue butterfly population has been reestablished along with them, the fungus remains present in the soil. The potential spread and outbreaks of this pathogen poses a greater threat to small and isolated populations of the mission blue butterfly (USFWS 2010).

Stressor: Illegal take
Exposure: Collection of mission blue butterflies.
Response: Mortality
Consequence: Reduction in population numbers.
Narrative: Illegal take of the mission blue butterflies is considered a threat to mission blue butterfly populations. Mission blue butterflies are known to have been illegally collected. Collectors may not always realize if they are depleting the population of butterflies to below a threshold limit for the survival or recovery population. Adult specimens of mission blue butterflies are highly valued by private collectors; an international market exists for illegally collected mission blue butterfly specimens, as well as other listed and rare butterflies (USFWS 2010).

Stressor: Small population size
Exposure: Reduction in population numbers.
Response: Decrease in genetic variability or heterozygosity.
Consequence: Reduction in population numbers.
Narrative: Population numbers of the mission blue butterfly have been drastically reduced. The populations that do persist are on islands of habitat surrounded by a sea of urbanization, which may impede gene flow, immigration, emigration, and recolonization. In addition, populations may drop to significantly low levels during certain years, resulting in a decrease in genetic variability or heterozygosity and an increased threat of extinction due to stochastic events. Another possible effect of reduced population densities and fragmentation on the mission blue is the Allee effect

(where population growth rate decreases at low population densities), which is caused by asynchronous reproduction and is increasingly recognized as a significant feature of the mission blue population dynamics (USFWS 2010).

Stressor: Nonnative plants
Exposure: Invasion of nonnative plants.
Response: Outcompetes lupines.
Consequence: Reduction in population numbers.
Narrative: Nonnative grasses that have invaded California grasslands are a serious threat to the mission blue butterfly. Invasive species have the ability to become more abundant while outcompeting the native larval food plant and nectar plants. European annual grasses and forbs have displaced native forbs in California native grasslands, and in turn have contributed to the decline of the mission blue butterfly. Some of the exotic grasses and forbs that have invaded grasslands of the San Francisco Bay Area are Italian ryegrass (Lolium multiflorum), slender oats (Avena barbata), ripgut (Bromus diandrus), and red brome (B. madritensis rubens). Thatch produced as a result of the buildup of dead exotic plants may eliminate or prevent native plant species from growing in an area, and invasive species may adversely alter soil chemistry and structure. Although many exotic forbs are used by mission blue butterfly as nectar sources, they outcompete and replace native nectar plants and larval food plants. The invasion of nonnative plants remains one of the most serious present-day threats to the mission blue butterfly (USFWS 2010).

Stressor: Lack of fire regime
Exposure: Suppressing fire.
Response: Shift in habitat type.
Consequence: Reduction in population numbers.
Narrative: Studies have found that prescribed burning in late spring reduces nonnative annual plant seed production and the resulting size of the seed bank; and increases perennial grass seedling establishment due to litter removal and lowered competition. However, when the natural fire regime is altered, as in the case of San Bruno Mountain, highly fire-adapted plant communities can become vulnerable to competition from exotic invasive plants. There is a chance that San Bruno Mountain will revert to coastal scrub in the absence of a disturbance mechanism, such as fire, and grazing. Fire can have unforeseen, adverse consequences if mismanaged. In addition, the level of urbanization around San Bruno Mountain creates a conflict between using fire to manage chaparral and the air quality issues the smoke creates for adjacent communities (USFWS 2010).

Stressor: Climate change
Exposure: Climate change.
Response: Mortality, shift of habitat.
Consequence: Reduction in population numbers.
Narrative: Climate change poses a serious threat to the mission blue butterflies. Global climate change increases the frequency of extreme weather events, such as heat waves, droughts, and storms. Extreme events, in turn, may cause mass mortality of individual mission blue butterflies.

As the global climate warms, terrestrial habitats are moving northward and upward. In the future, though, range contractions are more likely than simple northward or upslope shifts, which will limit the areas where mission blue butterflies can live. Because climate change threatens to disrupt annual weather patterns, it may result in a loss of their habitats and/or an increase in the number of their predators, parasites, and diseases (USFWS 2010).

Stressor: Pesticides
Exposure:
Response:
Consequence:
Narrative: Pesticide use (Factor E) poses a potential threat to both species if used in proximity to occupied habitat (e.g. Varela et al. 2008, Service 2009). (USFWS, 2019)

Stressor: Vole herbivory
Exposure:
Response:
Consequence:
Narrative: Vole herbivory (Factor A) threatens the host plants of the mission blue butterfly, with herbivory in some years causing severe declines in available lupine (Arechiga pers. comm. 2018, O'Brien pers. comm. 2018, Wayne pers. comm. 2018).

Stressor: Population monitoring
Exposure:
Response:
Consequence:
Narrative: Population monitoring may pose a threat to San Bruno elfin butterflies because of the potential for monitors to inadvertently damage habitat and/or host plants (Factor B)(Bennett and Russo 2016a, Arechiga pers. comm. 2018). (UWFWS, 2019)

Recovery

Reclassification Criteria:
FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - Sites supporting metapopulations of the mission blue butterfly (see E/1 below) must be managed to ensure the maintenance of habitat that includes host plants and a diversity of nectar plants. Sites shall have in place a management plan approved by the U.S. Fish and Wildlife Service that supports grasslands and controls other threat to the species and its habitat. Long-term maintenance of the sites must be financially sustainable. Management tools including herbicides, mowing, burning, or livestock grazing should be implemented with appropriate methods and timing to avoid impacts to the butterfly and its nectar and host plants. (USFWS, 2019)

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - Monitoring must determine that all mission blue butterfly metapopulation sites support populations of both silver and summer lupine (Lupinus albifrons and L. formosus), including a variety of size and/or age classes. Species experts recommended multiple species of lupine as necessary for recovery. In some localities, habitat and/or microclimate is not appropriate for both of these species, and the presence of alternate lupine species may be more appropriate, as determined by property managers. Monitoring over a 15-year period, which includes at least two years that have above average local spring rainfall, must demonstrate natural recruitment of both lupine species and an average of 250 lupine plants/hectare. A 15-year period showing a stable population is recommended for threatened congeners (member of the same genus) Kincaid's lupine (Lupinus sulphureus ssp. kincaidii) (Service 2010b) and Tidestrom's lupine (L. tidestromii) (Service 1998). The criterion specifies at least two years with above average rainfall because the fungal pathogen that threatens silver lupine is most prevalent following wet, El Niño years. Recommended lupine cover in the habitat restoration guidelines in the San Bruno Mountain Habitat Management Plan is 2.5% over 0.125 acre or 100 plants in high quality patches, with approximately one high quality patch per acre (TRA Environmental Sciences 2007). This translates to 250 plants/hectare. Maintaining a healthy population of host plants will help to protect against threats posed by non-native grasses. Mission blue butterflies must be documented using both species of lupine. Using multiple host plants will add to population representation. (USFWS, 2019)

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range - Suitable habitat has a minimum of 250 nectar plants/hectare. This is the approximate recommended number of nectar plants in the San Bruno Mountain Habitat Management Plan, which specifies that there should be 100 nectar plants/acre (TRA Environmental Sciences 2007). Nectar flower abundance is also a criterion for the closely related Fender's blue butterfly (Service 2010b). (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Metapopulations are maintained or re-established in suitable habitat within the historical range of the species, including at least one metapopulation each in Marin, San Francisco, and San Mateo Counties. The original recovery plan stated that "Reclassification of the mission blue butterfly to threatened status can be considered when secure, self-sustaining colonies of this species are established and/or reestablished on Twin Peaks and Fort Baker (one colony at each site) and when colonies on San Bruno Mountain (as noted in the HCP) are secure. Multiple metapopulations across the species range ensures redundancy. The San Mateo County metapopulation must be maintained on San Bruno Mountain contain populations across Guadalupe Hills, Southeast Ridge, Radio Ridge, and Reservoir Hill. These San Bruno locations are mentioned as colony locations necessary for reclassification in the primary objective of the original recovery plan (Service 2010a). San Bruno Mountain is specified within San Mateo County because it is central in the historic range of the species and is listed in the original recovery plan. The metapopulation in Marin County must contain at least three populations. Having multiple populations ensures redundancy. Multiple populations are not required in San Francisco County because of the small areal amount of suitable habitat. (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Patches of suitable habitat must be at least 6 hectares (15 acres) to support each of the populations designated in E/1. This is the minimum patch size for an isolated population to persist in the absence of immigration from other patches in the Fender blue butterfly Recovery Plan, based on a conservative approach to studies showing a minimum patch size of 2-6 hectares (Service 2010b). Patches of occupied suitable habitat of this size that are contiguous to each other may also satisfy the numerical target for number of populations as defined in E/1 for metapopulations in Marin and San Francisco Counties (but see specific location requirements for San Bruno Mountain). Component habitat features (e.g., host plants, nectar plants) within each patch of suitable habitat must be free of barriers to movement between them. Suitable habitat patches must have stable or increasing grassland acreage over at least a 25-year period, with management focused on maintaining larger habitat patches. For each site, woody vegetation should make up no more than 15 percent of the absolute vegetative cover at the metapopulation level.Limiting woody vegetation to 15 percent absolute vegetative cover is part of the habitat quality guidelines for the closely related Fender's blue butterfly (Service 2010b). San Bruno Mountain must have a minimum of 1200 acres of grassland as designated in the Habitat Management Plan (TRA Environmental Sciences 2007). (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Population viability analysis determines that mission blue butterflies have a 90% probability of persistence over a 25-year period across all three counties of the historic range as referred to in E/1. Population viability analysis can be used to determine minimum or average population sizes to ensure persistence. This criteria is modelled after methodology used to develop minimum population sizes necessary for recovery of the closely related Fender's blue butterfly (Icaricia icarioides fender)(Service 2010b). This probability of persistence was chosen to ensure resiliency, and can be based on different monitoring protocols including, but not limited to, surveys of various life stages or to detect occupancy. Probability of persistence may be based on varying numbers of metapopulations or populations within each county. (USFWS, 2019)

Recovery Priority Number: 9

Delisting Criteria:
FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Metapopulations are maintained or re-established in suitable habitat within the historical range of the species, including at least one additional metapopulation in Marin County and three additional metapopulations in San Mateo County. The current range of mission blue butterflies is considered to include populations in the Marin Headlands in addition to Fort Baker, as well as a population in Oakwood Valley (Service 2010a). Observations in other locations (e.g. Tennessee Valley) suggest that other areas in the county may support mission blue butterflies. Mission blue butterflies have been documented in San Mateo County at Milagra Ridge, Sweeney Ridge, and the SFPW, which could all support metapopulations. The additional metapopulations in San Mateo County must be at locations other than San Bruno Mountain. Having multiple metapopulations ensures redundancy. Having contiguous occupied habitat outside of San Bruno Mountain which satisfies the patches sizes as defined in downlisting criteria E/2 to meet the

total number of habitat for this requirement may also satisfy this criteria (three patches of at least 6 hectares (15 acres) per metapopulation). (USFWS, 2019)

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence - Population viability analysis determines that mission blue butterflies have a 95% probability of persistence in Marin, San Francisco, and San Mateo Counties over a 100-year period. Probability of persistence may be based on varying numbers of metapopulations or populations. Population viability analysis can be used to determine minimum or average population sizes to ensure persistence. This criteria is modelled after methodology used to develop minimum population sizes necessary for recovery of the closely related Fender's blue butterfly (Icaricia icarioides fender)(Service 2010b). This probability of persistence was chosen to ensure resiliency. (USFWS, 2019)

Recovery Actions:

- Protect essential habitat of the mission blue butterfly (USFWS 1984).
- Prevent further degradation of habitat, and enhance habitat when possible (USFWS 1984).
- Develop and implement management plans for existing colonies of mission blue butterflies (USFWS 1984).
- Reestablish mission blue butterflies in restored or rehabilitated habitat within their historical ranges (USFWS 1984).
- Increase public awareness of the mission blue butterfly and its habitat (USFWS 1984).
- Enforce laws and regulations to protect the mission blue butterfly and its habitat (USFWS 1984).
- Since the publication of the Recovery Plan, new mission blue butterfly colonies have been discovered at the San Francisco Peninsula Watershed, Milagra Ridge, Sweeney Ridge, Skyline College, and the Marin Headlands; these should be incorporated into the recovery criteria. The location of hybrid zones should be defined to ensure protection of mission blue butterfly colonies near the hybrid zones (USFWS 2010).
- No formal guidelines containing conservation measures have been developed for this species. The U.S. Fish and Wildlife Service Mission Blue Butterfly 5-Year Review (2010) provides a number of recommendations for future actions, including:
- Develop measureable recovery criteria, including colony sizes and dynamics necessary for population to be self-sustaining in perpetuity (USFWS 2010).
- Search for new locations in the San Francisco Peninsula Watershed (USFWS 2010).
- Develop management plans for all habitat locations based on the findings of the working group (USFWS 2010).
- Create a local captive propagation facility if determined necessary by the working group (USFWS 2010).
- Create a plan for population augmentation and reintroduction if determined necessary by the working group (USFWS 2010).
- Ensure that the area between Sweeney Ridge and Milagra Ridge is maintained as suitable mission blue butterfly habitat, specifically the unprotected land around Skyline College (USFWS 2010).
- Evaluate the success of translocation efforts at Twin Peaks. Based on the results of the evaluation, determine whether additional translocation efforts are necessary (USFWS 2010).

- Create a mission blue butterfly working group to: a. Develop a consistent monitoring and surveying scheme. b. Coordinate synchronized and scheduled monitoring of all colonies. c. Map all currently known habitat locations, including size and extent of host plant cover. d. Define the species range, including hybrid zones (USFWS 2010).
- Establish captive breeding of mission blue butterflies at a captive breeding facility. This action will assist in the recovery of mission blue butterflies by further protecting existing populations and allowing for population augmentation in an effort to maintain and re-establish self-sustaining populations to persist in the long-term. (Priority 1) (USFWS, 2019)
- Conduct a population genetics study of the mission blue butterfly across the proposed range. This study will aid in genetic management at the captive breeding facility, and can more clearly define the boundaries of the species range. (Priority 3) (USFWS, 2019)
- Develop lupine propagation methods through seeding across the range of the mission blue butterfly. Lupine diversification research and techniques are important for successfully establishing multiple lupine host plant species at all sites. (Priority 2) (USFWS, 2019)
- Conduct population viability analyses for metapopulations of the mission blue butterflies. This action will assist in the recovery for the species by determining the target populations, minimum populations, or occupancy at each population or metapopulation site needed to achieve recovery criteria. (Priority 3) (USFWS, 2019)
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: We recommend the following actions, including some from the 2010 5-year review or the 2019 recovery plan amendment that remain valid: 1. Create a mission blue butterfly working group or Recovery Implementation Team. Recent mission blue butterfly regional summits in January 2019 (Root Wisdom 2019) and 2021 included many partners and presentations, and continued regular coordination would likely benefit recovery of the species. Synergies between the regional mission blue butterfly partners and other groups working on other Icaricia icarioides subspecies (e.g., Fenders blue and Puget Sound blue butterflies), or other rare or at-risk butterfly species, are likely to be beneficial towards advancing recovery objectives. 2. Establish captive breeding, rearing, or headstarting of mission blue butterflies at a captive breeding facility and create plans for population augmentation and reintroduction. This action will assist in the recovery of mission blue butterflies by further protecting existing populations and allowing for population augmentation in an effort to maintain and re-establish self-sustaining populations to persist in the long-term. Permitting and construction of a facility that is expected to include mission blue butterflies is underway; this facility will hold other listed species as described in Service (2020b, p. 62). Captive rearing of other closely related butterflies could be useful to inform methods for the facility, when appropriate. Captive rearing Puget blue butterflies (Icaricia icarioides blackmorei) (a subspecies of the mission blue butterfly species) collected eggs from the wild and used eggs laid by females brought into captivity (Schultz et al. 2009, p. entire). Laboratory rearing of the Karner blue butterfly (Lycaeides melissa samuelis), also in the Lycaenidae family, collected wild adults in the spring and reared eggs and larvae in growth chambers (Herms et al. 1996, entire). 3. Follow best practices for conservation translocations. Translocations of at-risk butterflies are discussed in Daniels et al. (2018), which were developed and tested based on the International Union for Conservation of Nature's Guidelines for Reintroductions and Other Conservation Translocations (IUCN 2013). Current translocation methods should be adapted to more closely align with these guidelines. 4. Continue population viability analyses for metapopulations of the mission blue butterflies, and/or analyses of existing butterfly monitoring data. This action will assist in the recovery for the species by determining the target populations, minimum populations, or occupancy at each population or metapopulation site needed to achieve recovery criteria. 5. Continue lupine propagation and diversification across the range of the mission blue butterfly. Lupine diversification research and techniques are important for successfully establishing multiple lupine host plant species at all sites. 6. Continue efforts to understand egg phenology and oviposition rates in mission blue butterflies. This information will improve our interpretation of egg monitoring data from monitoring mission blue butterflies at some sites. 7. Monitor habitat needs for sites where quantitative data are not readily available. For some recovery criteria where status in relation to the recovery criteria is unclear or possibly met, particularly those relating to grassland acreage and nectar plants, additional data collection or analysis may help track progress towards recovery. Information needs include: quantification or mapping of nectar plants, and mapping or analysis of grassland acreage and trends. 8. Continue habitat restoration and connectivity efforts. Scrub encroachment continues to reduce and fragment available mission blue butterfly habitat across the range of the species. (USFWS, 2022)

Additional Threshold Information:

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SPECIES ACCOUNT: *Ischnura luta* (Rota blue damselfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The species is relatively small in size, with males measuring 1.3 in (34 mm) in body length, with forewings and hindwings 0.7 in (18 mm) and 0.67 in (17 mm) in length, respectively. Both sexes are predominantly blue in color, particularly the thorax and portions of the male's abdomen are brilliant, iridescent blue. Both sexes have a yellow and black head with some yellow coloration on the abdomen. Females of this species may be distinguished by their slightly smaller size and somewhat paler blue body color (Polhemus et al. 2000, pp. 1–8) (USFWS, 2015).

Taxonomy

Grouped together with dragonflies in the order Odonata, damselflies fall within the suborder Zygoptera. The Rota blue damselfly belongs to the family Coenagrionidae, and it is the only known damselfly species endemic to the Mariana Islands. This species was first described in 2000 (Polhemus et al. 2000, pp. 1–2) based upon specimens collected in 1996 (USFWS, 2015).

Historical Range

It is endemic to the island of Rota (Marian Islands). The Rota blue damselfly was first discovered in April 1996, when a few individuals were observed and one male and one female specimen were collected outside the Talakhaya Water Cave (also known as Sonson Water Cave) located below the Sabana plateau (Camacho et al. 1997, p. 4; Polhemus et al. 2000, pp. 1–8) (USFWS, 2015).

Current Range

In January 2014, two male specimens were observed flying above a portion of the stream located at approximately 770 ft. (235 m) in elevation, and below the Talakhaya (Sonson) Water Cave (Richardson 2014, in litt.). In November 2015, Zarones et al. (2015b, in litt.) conducted a survey on Rota looking for the Rota blue damselfly and found one individual along a stream 744 yards (680 m) to the west of Water Cave area, not connected to the stream at the Water Cave (USFWS, 2015). Distribution: Rota (USFWS, 2020b).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

<u>Larvae:</u> Larval damselflies are predaceous, feeding on small aquatic invertebrates or fish (Williams 1936, p. 303) (USFWS, 2015).

Adult: Adult damselflies are predaceous and feed on small flying insects such as midges and other flies (USFWS, 2015).

Reproduction Narrative

Larvae: Naiads may take up to 4 months to mature (Williams 1936, p. 309) (USFWS, 2015).

Adult: Females lay eggs in submerged aquatic vegetation or in mats of moss or algae on submerged rocks, and hatching occurs in about 10 days (Williams 1936, pp. 303, 306, 318; Evenhuis et al. 1995, p. 18) (USFWS, 2015).

Habitat Narrative

Larvae: The immature larval life stages (naiads) of the vast majority of damselfly species are aquatic. Upon maturity, they crawl out of the water onto rocks or vegetation to molt into winged adults, typically remaining close to the aquatic habitat from which they emerged (USFWS, 2015).

Adult: It occurs within the stream ecosystem. Adults have been observed in association only with the single perennial stream on Rota. The primary source of the stream is spring water emerging at the limestone-basalt interface below the highly permeable limestone of the Sabana plateau (Polhemus et al. 2000, pp. 1–8; Keel et al. 2011, p. 1) (USFWS, 2015).

Dispersal/Migration

Dispersal/Migration Narrative

Larvae: Not available

Adult: Not available

Population Information and Trends

Population Trends:

Not available

Number of Populations:

1 (USFWS, 2023)

Population Size:

Unknown (USFWS, 2023)

Population Narrative:

The Rota blue damselfly appears to be extremely limited in range and researchers remain perplexed by its absence from other Mariana Islands (Polhemus et al. 2000, p. 8). Particularly striking is the fact that it has never been collected on Guam, despite the islands' larger size and presence of over 100 rivers and streams (USFWS, 20015). Number of Known Populations: 1. Number of Individuals in the Wild in the Marianas: Unknown (USFWS, 2023)

Threats and Stressors

Stressor: Predation (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Predation by nonnative fish is a serious threat to the Hawaiian Megalagrion damselfly naiads (Englund 1999, pp. 235–236). On a survey of the stream (Okgok River, also known as Babao) fed by the Talakhaya (Sonson) Water Cave, the presence of four native fish species was noted: The eel Anguilla marmorata, the mountain gobies Stiphodon elegans and Sicyopus leprurus, and the flagtail, or mountain bass, Kuhlia rupestris (Camacho et al. 1997, p. 8).

Stressor: Reduced stream flow (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The Rota blue damselfly's population site (Talakhaya watershed area) is afforded some protection from human impact by its remote and relatively inaccessible location; however, a reduction or removal of stream flow due to increased interception for municipal usage, and from lower water quantities resulting from the effects of future climate change, could eliminate one of the only two known populations of the species (USFWS, 2015).

Stressor: Nonnative fish (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Introduction of nonnative fish into the stream could also impact or eliminate the Rota blue damselfly naiads, leading to its extirpation (USFWS, 2015).

Stressor: Small population size (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Low numbers of individuals results in loss of vigor and genetic representation, and contributes to the vulnerability of the single known population of the Rota blue damselfly (USFWS, 2015).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 5C

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:

- Threat and Recovery Potential: Full species with a high degree of threat and a low degree of recovery potential plus (C): anticipated conflict with development. (USFWS, 2020b)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS – • Strategic planning – Develop a conservation plan for the Rota blue damselfly on Rota. The plan should include actions needed to protect and manage stream habitat as well as protect and restore the Talakaya watershed and the Sabana Plateau. • Conduct research to collect life history data and habitat requirements for the species at all life stages. • Conduct a watershed-wide survey for the species to determine where the species is found and if any additional populations exist outside of Okgok stream. • Habitat and natural process management and restoration – Develop and implement a native forest and stream restoration plan for the Talakaya watershed. The plan should include the removal or exclusion of feral ungulates from the Talakaya Watershed and areas of the Sabana Plateau vital to the aquifer. • Reintroduction / translocation – Develop and implement a plan for establishing Rota blue damselfly populations in additional streams on Rota and evaluate the feasibility of introducing the species to watersheds on Guam or Saipan • Outreach and education – Develop public support for the protection of this endemic species. (USFWS, 2020)

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SPECIES ACCOUNT: *Lednia tumana* (Meltwater Lednian stonefly)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The meltwater lednian stonefly is a small insect that begins life as an aquatic nymph and later matures into a winged adult that lives on land. The nymph, or aquatic juvenile stage, of the meltwater lednian stonefly is dark red-brown on its dorsal surface and pink on the ventral surface, with light grey-green legs (Baumann and Stewart 1980, p. 658). Mature nymphs can range in size from 4.5 to 6.5 millimeters (mm) (0.18 to 0.26 in.) (Baumann and Stewart 1980, p. 655). Nymphs mature into the adult terrestrial phase that has wings and body sizes ranging from 4 to 6 mm (0.16 to 0.24 in.) (Baumann 1975, p. 79).

Taxonomy

The genus Lednia belongs to the phylum Arthropoda, class Insecta, order Plecoptera (stoneflies), family Nemouridae, and subfamily Nemourinae (Baumann 1975, p. 19; Stewart and Harper 1996, p. 263; Stark et al. 2009, entire). The type specimens (specimens on which the original species description was based) for the meltwater lednian stonefly were collected in the Many Glaciers area of Glacier National Park (NP), Montana (Baumann 1982, pers. comm.). The species was originally described by Ricker in 1952 (Baumann 1975, p. 18) and, our recent review of the available literature indicates that the species is recognized as a valid species by the scientific community (Baumann 1975, p. 18; Baumann et al. 1977, pp. 7, 34; Newell et al. 2008, p. 181; Stark et al. 2009, entire; Baumann and Kondratieff 2010, p. 315). The meltwater lednian stonefly was considered the only member of the Lednia genus (monotypic genus) until 2010 when stonefly specimens discovered in the Sierra Nevada Mountains of California and Mount Rainier and North Cascades National Parks were formally described as two additional species in this genus (Baumann and Kondratieff 2010, entire).

Historical Range

The species was previously reported from the Waterton River system in Alberta, Canada (Donald and Anderson 1977, p. 114). Surveys conducted in Waterton Lakes NP (Canada) during 2007 and 2008 did not detect the species (Langor 2010, pers. comm.), although it is unclear if the proper habitat was surveyed (Johnston 2010, pers. comm.). Within the last 14 years, the meltwater lednian stonefly has been observed in 16 streams or hydrological drainages within the boundaries of Glacier NP, Montana (Muhlfeld et al. 2011, p. 341).

Current Range

The MWS currently occupies 113 streams across its known range, and the WGS currently occupies 16 streams across its known range; however, cumulatively, both species occupy relatively small amounts of habitat per stream on average, approximately 600 meters (1,968 feet) per stream. Both species occupy only these small amounts of area per stream because of their low thermal tolerances and the rapid warming of meltwater streams downstream of the meltwater sources, from full sun exposure in alpine environments. Further, both species inhabit the most upstream reaches of their meltwater habitats and cannot disperse further upstream if water temperatures warm beyond their thermal tolerances. This narrow distribution within streams and inability to disperse upstream increases the risk of harm due to stochastic events, such as drought or annual weather fluctuations. Thus, the current overall resiliency of the meltwater habitat and sources for both species is low (USFWS, 2021).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Nemourid stonefly larvae are typically herbivores or detritivores, and their feeding mode is generally that of a shredder or collector-gatherer (Baumann 1975, p. 1; Stewart and Harper 1996, pp. 218, 262).

Reproduction Narrative

Adult: Eggs and larvae of all North American species of stoneflies, including the meltwater lednian stonefly, are aquatic (Stewart and Harper 1996, p. 217). There is no information on the longevity of the meltwater lednian stonefly, but in general stoneflies can complete their life cycles within a single year or in 2 to 3 years (Stewart and Harper1996, pp. 217-218). Meltwater lednian stoneflies are thought to emerge from their aquatic environments in August and September to mature to adulthood and breed (Baumann and Stewart 1980, p. 658; Giersch 2010a, pers. comm.).

Geographic or Habitat Restraints or Barriers

Larvae: restricted to short sections of cold, high-elevation alpine streams directly below glaciers, permanent snowfields, and springs

Adult: restricted to short sections of cold, high-elevation alpine streams directly below glaciers, permanent snowfields, and springs

Spatial Arrangements of the Population

Larvae: clumped according to suitable habitat

Adult: clumped according to suitable habitat

Environmental Specificity

Larvae: Generalist feeder, but habitat requirements are specific

Tolerance Ranges/Thresholds

Larvae: low thermal tolerance, and probably sensitive to water quality issues

Adult: low thermal tolerance, and probably sensitive to water quality issues

Site Fidelity

Larvae: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Not applicable

Adult: Not applicable

Habitat Narrative

Adult: Plecopterans (stoneflies) are primarily associated with clean, cool, running waters (Stewart and Harper 1996, p. 217). Nemourids are usually the dominant Plecoptera family in mountain-river ecosystems, both in terms of total biomass and in numbers of species present (Baumann 1975, p. 1). Most aquatic invertebrates in stream environments in the northern Rocky Mountains exhibit very strong elevation and therefore temperature gradients in their distribution (Fagre et al. 1997, p. 763; Lowe and Hauer 1999, pp. 1637, 1640, 1642; Hauer et al. 2007, p. 110), and the meltwater lednian stonefly exhibits a similar distribution pattern. The meltwater lednian stonefly is restricted to short sections of cold, high-elevation alpine streams directly below glaciers, permanent snowfields, and springs (Muhlfeld et al. 2011, pp. 341-342). The species is a cold-water stenotherm (capable of surviving within a limited range of temperatures) because of its absence at sites with mean and maximum temperatures exceeding 10 degrees Centigrade (°C) and 18 °C (50 and 64.4 °Fahrenheit (F)), respectively (Muhlfeld 2011 et al. 2011, p. 342). Larval densities decrease with increased distance from a cold water source (Muhlfeld 2011 et al., p. 342).

Dispersal/Migration

Motility/Mobility

Larvae: moderate

Adult: high

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non migratory

Adult: non migratory

Dispersal

Larvae: low

Adult: moderate

Immigration/Emigration

Larvae: not likely

Adult: not likely

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: Not much is known about the dispersal of this species. They are more mobile as adults because they are capable of flying. They are not likely to have high dispersal because their habitat requirements are very restrictive. Nemouridae stoneflies disperse longitudinally (up or down stream) or laterally to the stream bank from their benthic (nymphal) source (Hynes 1976, p. 138; Griffith et al. 1998, p. 195; Petersen et al. 2004, pp. 944–945). Generally, adult stoneflies stay close to the channel of their source stream (Petersen et al. 2004, p. 946), and lateral movement into neighboring uplands is confined to less than 80 meters (262 feet) from the stream (Griffith et al. 1998, p. 197). Thus, Nemouridae stoneflies, and likely meltwater lednian and western glacier stoneflies, have limited dispersal capabilities (FR Vol. 81. No. 192).

Population Information and Trends

Population Trends:

Not assessed

Species Trends:

Not assessed

Resiliency:

The current overall resiliency of the meltwater habitat and sources for both species is low (USFWS, 2021).

Population Growth Rate:

unknown

Number of Populations:

16

Population Size:

unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
unknown

Additional Population-level Information:
The meltwater lednian stonefly can attain moderate to high abundance in certain locations (e.g., Logan Creek: NPS 2009); however, a more thorough understanding of the species distribution and abundance is needed. The best available survey information indicates that the meltwater lednian stonefly is a narrow endemic found only in Glacier NP.

Threats and Stressors

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms climate and climate change are defined by the Intergovernmental Panel on Climate Change (IPCC). Climate refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term climate change thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 814, 1819). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. Significant trends in water temperature and stream flow have been observed in the western United States (Stewart et al. 2005, entire; Kaushal et al. 2010, entire), and increased air temperatures and changes in precipitation are partially responsible. During the past 50 to 100 years in the western United States, the timing of runoff from snowmelt has shifted to occur 1 to 4 weeks earlier (Regonda et al. 2005, p. 380; Stewart et al. 2005, pp. 1136, 1141; Hamlet et al. 2007, p. 1468), presumably as a result of increased temperatures (Hamlet et al. 2007, p. 1468), increased frequency of melting (Mote et al. 2005, p. 45), and decreased snowpack (Mote et al. 2005, p. 41). Trends in decreased water availability also are

apparent across the Pacific Northwest (Luce and Holden 2009, entire). The western United States appears to be warming faster than the global average. In the Pacific Northwest, regionally averaged temperatures have risen 0.8 °C (1.5 °F) over the past century and as much as 2 °C (4 °F) in some areas. Since 1900, the mean annual air temperature for Glacier NP and the surrounding region has increased 1.33 °C (2.39 °F), which is 1.8 times the global mean increase (U.S. Geological Survey (USGS) 2010, p. 1). Mean annual air temperatures are projected to increase by another 1.5 to 5.5 °C (3 to 10 °F) over the next 100 years (Karl et al. 2009, p. 135). Warming also appears to be pronounced in alpine regions globally (e.g., Hall and Fagre 2003, p. 134 and references therein). The effects of projected climate change are considered the most significant threats to the suitability and persistence of habitat for the meltwater lednian stonefly. The environmental changes resulting from climate change may affect the meltwater lednian stonefly through two primary mechanisms: (1) Loss of glaciers and (2) changes in hydrology and increased water temperatures. Anticipated environmental changes were considered for the next 40-year period (to approximately 2050) based on the consistent agreement of various climate change models and emissions scenarios within that timeframe (Ray et al. 2010, p. 11).

Stressor: Loss of Glaciers and Permanent Snowfields
Exposure:
Response:
Consequence:
Narrative: Environmental changes resulting from climate change are assumed to be directly related to the documented loss of glaciers in Glacier NP (e.g. Hall and Fagre 2003, entire; Fagre 2005, entire). Glacier NP contained approximately 150 glaciers larger than 0.1 square kilometer (25 acres) in size when established in 1910, but presently only 25 glaciers larger than 0.1 square kilometer (25 acres) remain (Fagre 2005, pp. 13; USGS 2010, entire). Between 1966 and 2006, the 25 largest glaciers in Glacier NP shrank by an average of 26.4 percent, whereas smaller glaciers shrank at a quicker rate of 59.7 percent (USGS 2010, entire). Shrinking rates also vary by topography (e.g., Key et al. 2002, p. J370; Hall and Fagre 2003, p. 136). However, given the relative rate of shrinkage observed in smaller glaciers, nearly all glaciers should be gone from Glacier NP by 2030 (USGS 2010, entire; Hall and Fagre 2003, p. 138). The consequences of glacier shrinking, i.e. loss of permanent snowfields and loss to aquatic systems inhabited by the meltwater lednian stonefly, are expected to be significant (e.g., Fagre 2005, p. 8). Glaciers and permanent snowfields act as water banks, whose continual melt helps regulate stream water temperatures and maintain streamflows during late summer or drought periods (Hauer et al. 2007, p. 107; USGS 2010, entire). Loss of these sources may lead to direct dewatering of headwater stream reaches, thus desiccating habitats currently occupied by the meltwater lednian stonefly in close proximity to glaciers and permanent snowfields (Baumann and Stewart 1980, p. 658; Muhlfeld et al. 2011, p. 341). Permanent desiccation from loss of glaciers is expected to result directly in the loss of suitable habitat for the species and the extirpation of populations that are directly dependent on surface runoff from melting glaciers. The loss of glaciers and permanent snowfields may reduce the species range by 80 percent (Muhlfeld et al. 2011, p. 343) with the remainder living in small reaches of cold water not fed by glaciers. In some cases, streams could change from perennial (always flowing) to ephemeral (only flowing seasonally) as glaciers disappear (Hauer et al. 1997, p. 909). The meltwater lednian stonefly is adapted to

reproduce in a narrow ecological window of terrestrial emergence and reproduction in August and September. If the stream only flows seasonally, the species may still be able to complete its lifecycle if the nymph stage can withstand seasonal stream drying. However, at this time it is not known whether the meltwater lednian stonefly can complete its lifecycle in one year or more. Therefore, we consider the change from perennial to ephemeral flow to be a loss of habitat for this species. Loss of glaciers also may indirectly affect alpine streams by changing the riparian vegetation and nutrient cycling in stream ecosystems. For example, the reduced snowpacks that lead to glacier recession are predicted to allow high elevation trees to become established above the current treeline and in subalpine meadows, and thus to reduce the diversity of herbaceous plants (Hall and Fagre 2003, pp. 138139). Changes in riparian vegetation (such as a shift from deciduous to coniferous vegetation) may affect nutrient cycling in headwater streams and the quality of food resources available to herbivorous aquatic insects (e.g., Hisabae et al. 2010, pp. 57) such as the meltwater lednian stonefly and other aquatic macroinvertebrates.

Stressor: Changes to Streamflow and Water Temperature
Exposure:
Response:
Consequence:
Narrative: Reduced water volume of snowmelt runoff from glaciers (Fagre 2005, p. 7), combined with earlier runoff (Fagre 2005, p. 1) and increases in ambient temperatures expected under climate change (Karl et al. 2009, p. 135), may result in water temperatures above the physiological limits for survival or optimal growth for the meltwater lednian stonefly. Given the strong temperature gradients that influence the distribution of aquatic invertebrates (Fagre et al. 1997, p. 763; Lowe and Hauer 1999, pp. 1637, 1640, 1642; Hauer et al. 2007, p. 110) and the restricted distribution of the meltwater lednian stonefly to short sections of cold, high-elevation alpine streams (Muhlfeld et al. 2011, pp. 341-342), it is expected that there will be major changes in invertebrate communities with projected climate change scenarios. Species that currently occupy more downstream reaches may shift their distribution to higher elevations to track changing thermal regimes (Fagre 2005, p. 7). Displacement or extirpation or both could occur of stenothermic species that occupy headwater stream reaches (such as the meltwater lednian stonefly) due to thermal conditions that become unsuitable, encroaching aquatic invertebrate species that may be superior competitors, or changed thermal conditions that favor the encroaching species in competitive interactions between species. Consequently, the changes in timing and volume of streamflow coupled with increased summer water temperatures will likely reduce the extent of suitable habitat and result in the extirpation of some meltwater lednian stonefly populations. Fourteen percent of known meltwater lednian stonefly occurrences were found immediately below alpine springs (Muhlfeld et al. 2011, p. 341). Effects on populations found in spring habitats may lag behind those found in stream habitats directly associated with melting glaciers or snowfields. Chemical, hydrological and thermal conditions of both habitat types are ultimately influenced by melting snow and ice, but conditions in spring habitats are more stable (e.g., Hauer et al. 2007, p. 107; Giersch 2010b, pers. comm.) and should change more slowly because their groundwater sources are storing water from melted snow and ice. Although potentially less susceptible to streamflow and water temperature changes associated with climate change, spring habitats for the meltwater lednian stonefly may ultimately dry as their

groundwater sources are depleted and not replenished by glacial meltwater. In summary, we expect environmental changes resulting from climate change to affect the meltwater lednian stonefly through loss of glaciers, which can lead to the permanent or seasonal drying of currently occupied habitats, and through interrelated alterations to existing hydrologic and thermal regimes, which will reduce the extent of habitat suitable for this species because it has very specific thermal requirements (i.e., it is a cold-water obligate). Environmental changes resulting from climate change are ongoing based on the documented shrinking of glaciers in Glacier NP, and are expected to continue in the foreseeable future in Glacier NP (e.g., Fagre and Hall 2003, entire) and across western North America (USGS 2010, p.1; Karl et al . 2009, p. 135).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Habitat loss and modification resulting from the environmental changes due to climate change constitute the primary threat to the species. The United States is only beginning to address global climate change through the regulatory process (e.g., Clean Air Act (42 U.S.C. 7401)). There is no information at this time on what regulations may eventually be adopted, and when implemented, if they would address the changes in meltwater lednian stonefly habitat likely to occur in the foreseeable future. Therefore, the existing regulatory mechanisms are not adequate to address the threat of habitat loss and modification resulting from the environmental changes due to climate change.

Stressor: Restricted range
Exposure:
Response:
Consequence:
Narrative: The meltwater lednian stonefly is considered to be a narrow endemic found only within Glacier NP. The species restricted range makes it vulnerable to extirpation by localized disturbances or environmental conditions, such as fire, flood, and drought. The species restricted range does not constitute a threat in itself, especially as it occupies habitats that are generally considered pristine and should be comparatively resistant and resilient to disturbance compared to more intensively managed landscapes. However, the restricted range in concert with the threat of habitat loss and modification resulting from the environmental changes due to climate change is expected to increase the vulnerability of the species and is a threat in concert with climate change.

Stressor: habitat degradation and fragmentation due to climate change
Exposure:
Response:
Consequence:
Narrative: The primary threat to both stonefly species and their habitat is habitat degradation and fragmentation due to climate change. Both stonefly species are intimately tied to cold meltwater aquatic habitat, the sources of which are glaciers or snowfields. Thus, the viability of

both species is closely linked to the persistence of these glaciers and snowfields and their ability to continue to provide meltwater habitat in a warming climate. These meltwater sources vary in size, but most are predicted to completely melt by 2030. Warming air temperatures have already been implicated in faster melting of meltwater sources (glaciers and snowfields) in Glacier National Park and elsewhere. As these meltwater sources begin to disappear, streamflows are expected to become intermittent and water temperatures warmer (USFWS, 2021).

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
1. For MWS—A stable or increasing trend in the area of meltwater sources (glaciers and snowfields) and at least 1,250 hectares (3,087 acres) of meltwater sources for at least 15 years across the known range of MWS (USFWS, 2022).

2. For MWS—A stable or increasing trend in occupied stream miles, with at least 35 occupied stream miles for at least 15 years (USFWS, 2022).

Recovery Actions:
- The entire known range of the species is within Glacier NP. Conservation measures include continued management of these habitats occupied by the species to remain relatively pristine and generally free from direct human impacts.
- Continued monitoring and documentation of habitat needs, environmental tolerances and changes in its habitat are needed to evaluate the status, population trends, and vulnerability of the meltwater lednian stonefly.
- 1. Throughout the overall range, identify suitable habitat characteristics to support potential translocations (USFWS, 2022).
- 2. Throughout the overall range, increase public awareness of the effects of climate change on alpine biodiversity (USFWS, 2022).
- 3. Develop standard operating protocols for artificial propagation of MWS and WGS (USFWS, 2022).

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SPECIES ACCOUNT: *Lycaeides argyrognomon lotis* (Lotis blue butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/08/1976; California/Nevada Region (R8) (USFWS, 2016)

Physical Description

The lotis blue butterfly is a small butterfly, with a wingspan averaging of about 1 inch.

Taxonomy

The species Lycaeides argyrognomon (Lintner 1976), which includes the lotis blue butterfly and 12 other subspecies or forms, is also referred to as Lycaeides idas, or Plebejus argyrognomon, and as the northern blue butterfly (dos Passos 1964; Downey 1975). The northern blue butterfly occurs across northern North America. The lotis blue subspecies occurs at the southwestern edge of the northern blue butterfly's range.

Historical Range

The lotis blue butterfly historically was recorded from several coastal locations in Mendocino and northern Sonoma counties, California.

Current Range

From the mid-1970's to 1983, the lotis blue butterfly was known from only one location near the town of Mendocino, California, and the species has not been recorded at that site or elsewhere since 1983, despite multiple surveys of historic and potential habitat.

Distinct Population Segments Defined

not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Lotus blue larvae have apparently not been observed; therefore we do not know what plants the larvae require for food. Based on related species, native plants in the pea family (Fabaceae) are likely candidates. The coast trefoil is thought to be a larval food plant (Service 1985; Pratt 2003, 2004) . The coast trefoil is a small perennial plant that generally occurs in damp areas in meadows, roadside ditches, and forest edges and clearings. This plant grew at the last known lotis blue site, and a female lotis blue butterfly was showing egg-laying behavior on coast trefoil (Service 1985), although no eggs were observed. Other possible food plants include herbaceous species of lupine (Pratt 2004).

Adult: There is not a lot of information on the feeding behavior of this species.

Reproduction Narrative

Adult: Very little is known about the biology and life history of the lotis blue butterful. The putative life history of the lotis blue butterfly, like so much about this butterfly, is based on the known life history of closely related subspecies of the northern blue butterfly. The lotus blue probably has a single generation per year, with a relatively long adult flight period, extending from mid-April to early June (Downey 1975). Eggs are likely laid during the adult flight period. Newly hatched larvae begin to feed immediately, then overwinter in dormancy (diapause) as small larvae, then resume feeding the next spring. The larvae probably feed for about 4 to 6 weeks in the spring before pupating (Downey 1975). Asa Spade, Senior Biologist for Wynn Coastal Planning, provided information regarding an additional potential host plant: Hosackia rosea (rose flowered lotus). Spade noted that the distribution of H. rosea is more limited than H. gracilis and overlaps with our current understanding of the historical distribution of lotis blue. Also, Spade noted that H. rosea, more often than H. gracilis, is found with other plant species that were included in the habitat description in the Recovery Plan. The current assumption and application of H. gracilis as a larval host plant is based on a sole observation of a female lotis blue exhibiting oviposition behavior on this plant. Given the lack of historical information and current observations, these correlations suggest that H. rosea could also be a potential larval host of lotis blue butterfly. (USFWS, 2020)

Spatial Arrangements of the Population

Larvae: clumped

Adult: clumped

Environmental Specificity

Larvae: narrow; specialist

Adult: narrow; specialist

Site Fidelity

Larvae: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host plant

Adult: host plant

Habitat Narrative

Adult: The lotis blue butterfly likely inhabits wet meadows and sphagnum willow bogs. Without knowing the larval food plant with certainty, or more about the species' ecology in general, the specific habitat requirements for the species will remain something of a mystery (Arnold 1991, 1993; Pratt 2004). Other subspecies of the northern blue butterfly typically occur in wet meadows, bogs, seeps or springs, or in streamside areas (Arnold 1993). As noted above, the suspected food plant for larvae is the coast trefoil, which is relatively common along the Mendocino coast in damp coastal prairie. Although the last known location of the lotis blue butterfly was a sphagnum bog with pygmy forest, the coast trefoil, is not normally found in bogs within the historical range of the lotis blue butterfly (Pratt 2004). The importance of bogs to lotis butterflies is unclear. The last known site for the species was located in a sphagnum bog surrounded by pygmy forest dominated by Bishop pine (Pinus muricata) with an understory of species in the heath family. This suggests that such bogs may be lotis blue habitat; although other habitat types may exist that are not bogs. An extensive survey for lotis blue butterflies found that pygmy forest bogs did not provide many potential larval food plants, and suggested that bogs may not be typical habitat for the lotis blue (Pratt 2004). Also, a powerline corridor ran through the last known lotis blue site, thus it may not have been a typical, natural bog. Also, recent conditions at this site may not be indicative of optimal habitat, as historic aerial photos of the site show that the site and the surrounding area were much more open, meadow-like ground (Arnold 1991, 1993). Thus, habitat was different in the past, such as 1953, when, as noted above, the species was more abundant at the site. One factor that likely contributed to succession at this site was that the utility company ceased vegetation maintenance of the powerline corridor at the site in 1976 due to concerns that maintenance activities might further endanger the species (de Becker et al. 1991). Maintenance was resumed in 1992 under an agreement between the Service and the utility that permitted maintenance while minimizing potential impacts to the lotis blue butterfly.

Dispersal/Migration

Motility/Mobility

Larvae: low

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: not migratory

Adult: not migratory

Dispersal

Larvae: low

Adult: low

Immigration/Emigration

Larvae: unlikely

Adult: unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: mother

Adult: not applicable

Dispersal/Migration Narrative

Larvae: There is not any available information on the dispersal of this species.

Population Information and Trends

Population Trends:

unknown

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

0?

Population Size:

0?

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Only very limited information is available on population abundance or trends. The butterfly has not been observed since 1983, and no systematic population counts were conducted prior to that date. At the last known location, at least 26 adults were collected from this site in 2 days in 1953 (Arnold 1993), while only 16 adult butterflies were observed at this same location during 42 days of field work between 1977 and 1981 (Service 1985), and none after 1983, when 4 adults were observed during 14 days of observation (Arnold 1991).

Threats and Stressors

Stressor: Habitat destruction and degradation
Exposure:
Response:
Consequence:
Narrative: Habitat modification remains a threat, although the habitat requirements are not well known given our limited knowledge of the lotis blue. Changes in land use and management in historical range of the subspecies, and may have affected the lotis blue. Suppression of fires and other changes that reduced natural disturbance regimes are suspected to have led to the transition of more open habitats, such as meadows, forest openings, and coastal prairie, to areas dominated by forest and other taller, denser vegetation, which are less suitable for the species (de Becker et al. 1991; Arnold 1993; Pratt 2004). Development for housing and associated road-building has increased in recent decades, leading to loss and degradation of native habitats, and fragmentation of remaining habitat areas. Because the butterfly may be associated with bogs and other wetland habitats, actions which affect groundwater may also affect the habitat for the subspecies. No new information on this factor has become available since the previous five-year review.

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Butterfly collection is of concern. There are accounts of collection (Arnold 1991; 1993; de Becker et al. 1991). We believe that the lotis blue is particularily vulnerable to the collection trade because of its endangered status, limited distribution, and presumed small population size.

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Not available

Recovery Actions:
- Preserve and protect the known lotis blue butterfly populations and any newly discovered and/or reestablished sites.
- Establish three new, self-sustaining, viable populations each on at least 2 hectares of suitable, secure habitat.
- Conduct ecological studies to develop additional management recommendations and to determine criteria for reclassification and delisting.
- Develop public awareness of the lotis blue butterfly.
- Utilize existing laws and regulations protecting the lotis blue butterfly.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The Service recommends the expansion of exploratory surveys, research into larval biology of other Plebejus anna subspecies, and further systematics work on lotis blue butterfly specimens in natural history collections. (USFWS, 2020)

References

USFWS. 2020. 5-YEAR REVIEW Lotis blue butterfly (Plebejus anna lotis). 2 pp.

SPECIES ACCOUNT: *Lycaeides melissa samuelis* (Karner blue butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: KBB

Listing Status: Endangered; 12/14/1992; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

Karner blue butterflies are small with a wingspan of about 2.5 cm. (one inch). The forewing length of adult Karner blues is 1.2 to 1.4 cm for males and 1.4 to 1.6 cm for females (Opler and Krizek 1984). The wing shape is rounded and less pointed than L. m. melissa, especially in the female hind wing (Nabokov 1949). The upper (dorsal) side of the male wing is a violet blue with a black margin and whitefringed edge. The female upper side ranges from dull violet to bright purplish blue near the body and central portions of the wings, and the remainder of the wing is a light or dark gray-brown, with marginal orange crescents typically restricted to the hind wing. Both sexes are a grayish fawn color on the ventral side. Near the margins of the underside of both wings are orange crescents and metallic spots. The black terminal line along the margin of the hind wing is usually continuous (Klots 1979, Nabokov 1944) (USFWS, 2003).

Taxonomy

Several biological differences and the lack of intergrades suggest this is a separate species. However, all literature to date (December, 2011) treats it as subspecies. Also results of recent electrophoretic work by Laurence Packer and colleagues are most consistent with (but do not prove) subspecies status. There is some DNA evidence suggestive of differences between eastern populations and those farther west, but it does not seem likely taxonomic separation will prove warranted. Native populations of the eastern type survive now only in New York's Hudson Valley, but stock from there has been introduced to New Hampshire where the subpecies was native. See Recovery Plan for more details. This species has been put in Lycaeides by many recent authors, but research summarized in Opler and Warren (2002) has resulted in sinking of that genus and several others (NatureServe, 2015).

Historical Range

The historical range of the KBB in the United States has not changed although changes in the distribution of the KBB within its historic range have occurred since listing (USFWS, 2012). The Karner blue butterfly, Lycaeides melissa samuelis Nabokov (Lepidoptera: Lycaenidae), formerly occurred in a band extending across 12 states from Minnesota to Maine and in the province of Ontario, Canada (USFWS, 2003).

Current Range

The historic KBB range in the Oak Openings of northwest Ohio and southeast Michigan are now occupied by small KBB populations as a result of ongoing reintroductions. Of the eight states with KBBs in 1992 (Illinois, New Hampshire, New York, Indiana, Ohio, Michigan, Wisconsin and Minnesota) (USFWS 1992), KBBs remain present in all of the states except Illinois and possibly

Minnesota (USFWS, 2012). Changes in the distribution of the KBB within its historical range have occurred since the last 5-year review (USFWS 2012; Figure 1) and the number of KBB populations has decreased since listing. Of the eight states with KBBs at the time of listing in 1992 (Illinois, New Hampshire, New York, Indiana, Ohio, Michigan, Wisconsin and Minnesota) (USFWS 1992), KBBs are likely no longer present in Illinois, Minnesota, and Indiana. (USFWS, 2019)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Wild lupine is the only known larval food plant and is therefore closely tied to the butterfly's ecology and distribution (NatureServe, 2015). Thrugh surveys carried out at Concord Pine Barrens, New Hampshire, within native and restored wild lupine (Lupinus perennis) KBB habitat, Pascale and Thiet (2016, p. 633) found that both native and restored wild lupine (Lupinus perennis) supported both KBBs and larval-tending ants. They suggested that managers encourage the interaction between ants and butterflies by managing for particular habitat characteristics attractive to both. The authors also recommended additional studies to evaluate which ant species provide the most benefit to KBBs and noted that this may be an especially important consideration in management and conservation of KBBs and their habitat (Pascale and Thiet 2016, p. 640). (USFWS, 2019

Adult: A variety of understory plants associated with the habitat serve as nectar sources for the adults. Adult males also drink from moist sand (NatureServe, 2015). Karner blue adults are diurnal and initiate flight between 8:00-9:00 a.m. and continue until about 7:00 p.m. Butterflies become more active with increasing temperature and/or sunshine (Swengel and Swengel 1998). Adult activity decreases at temperatures lower than 75o F, and during heavy to moderate rains (Haack 1993). Studies by Grundel et al. (2000) at IDNL suggest that the Karner blue is opportunistic in selecting nectar plants, choosing species with the greatest total number of flowers or flowering heads. However, the studies also showed that the Karner blue preferred certain select nectar species and nectar plants with yellow or white flowers (USFWS, 2003).

Reproduction Narrative

Larvae: New eggs are laid on or near the lupine plants, and hatch in about one week, and the larvae feed for about three weeks. They then pupate and the second brood adults appear in the second or third week of July, sometimes earlier in advanced seasons (NatureServe, 2015). Immature stages (egg, larva and pupae) of the Karner blue butterfly have a mutualistic relationship with ants. Larvae tended by ants have a higher survival rate than those not tended by ants (Savignano 1990, 1994a; Lane 1999b), presumably because the ants provide some protection from the natural enemies of larvae. Some species of ants appear to provide greater protection than other species. For example, larvae last tended by Formica lasiodes had significantly higher survival than those last tended by other ant species (Savignano 1990, 1994a).

During pupal survival studies, Lane (1999b) observed eight ant species to be associated with Karner blue pupae (USFWS, 2003).

Adult: Apparently always two broods each year. Eggs that have overwintered from the previous summer hatch in April. Near the end of May or early in June, the larva pupate and adult butterflies emerge very late in May and well into June in most years. The adults are typically in flight for the first 10 to 15 days of June, when the wild lupine is in bloom. Adults typically fly into about mid August. Individual adults live an average of about five days, but females at least can occasionally live for two weeks. This time, the eggs are laid among plant litter or on grass blades at the base of the lupines, or on lupine pods or stems, and these eggs do not hatch until the following spring. Females lay eggs on or near wild lupine plants, and main requirement seems to be thousands of stems of lupine in the short term (NatureServe, 2015). At peak flight the sex ratio typically exceeds 50% males (USFWS, 2003).

Geographic or Habitat Restraints or Barriers

Adult: Succession (USFWS, 2003)

Spatial Arrangements of the Population

Adult: Their analyses found that KBB showed distinct clustering; two distinct groups were identifiable. The eastern population (KBB-East) consisted of occurrences in Illinois, Indiana, Michigan, Ohio, New York, and New Hampshire and Ontario, Canada and the western population (KBB-West) consisted of occurrences in Minnesota and Wisconsin. The authors urged considering both whole-species and population-level modeling before moving forward with management decisions (Hallfors et al. 2016, pp. 1158, 1167). (USFWS, 2019)

Environmental Specificity

Adult: Narrow (Natureserve, 2015)

Habitat Narrative

Adult: Terrestrial habitat is characterized as grassland/herbaceous, old field, sand/dune, savanna, woodland - conifer. In eastern New York and New Hampshire, habitat typically is in sandplain communities, such as grassy openings within very dry, sandy pitch pine/scrub oak barrens. In the Midwest, the habitat is also dry and sandy, including oak savanna and jack pine barrens, and less often dune communities. Within the overall coummunity remnant inhabited by a metapopulation any patch of foodplant in open to semi-shaded setting is likely to be used. Apparently persistence from xerothermic interval to present requires thousands of hectares of suitable community/habitat in which patches of occupied habitat probably shifted over time. The environmental specificity is narrow (specialist or community with key requirements common) (NatureServe, 2015). Habitats that support the KBBs are early successional habitats composed mainly of remnant oak savannas and pine barrens, and also include prairies and human altered habitats such as roads, utility rights-of ways and larger forested landscapes (USFWS, 2012). A shifting geographic mosaic that provides a balance between closed and open-canopy habitats is essential for the maintenance of large viable populations of Karner blue butterflies. Because habitat components can be lost to succession, Karner blue butterfly persistence is dependent on disturbance and/or management to renew existing habitat or to create new habitats (USFWS, 2003). Walsh (2017) found that factors affecting KBB microclimate were primary predictors in a model designed to predict KBB occupancy in Michigan and Ohio. He found that the heat load variable (index of incident solar radiation adjusted for differences in site aspect, slope, and elevation) accounted for 64-67% of the variation in the model. Density of flowering lupine, the density of ant tunnel entrances, and heat load were higher in occupied sites (Walsh 2017, pp. 222-224). Overall, the author found that habitat management for the species should incorporate a "heterogeneous habitat structure throughout the range" where there is canopy cover that can provide refugia balanced with enough openness to allow lupine to thrive. Further, the author suggested that managing for the persistence of higher lupine density and ant presence may allow for increased long-term health of KBB populations (Walsh 2017, pp. 224-227). (USFWS, 2019)

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Basically sedentary, but adults do sometimes move at least two kilometers, probably more. Most probably never go more than 100 - 200 meters from place of emergence. Some evidence that dispersal is most likely where habitat quality is declining or where nectar is scarce (NatureServe, 2015). It is widely believed that open-canopied areas through wooded landscapes provide the Karner blue with a dispersal corridor, but except for anecdotal observations, this hypothesis has remained unproven (USFWS, 2003).

Population Information and Trends

Population Trends:

Declining (USFWS, 2019)

Species Trends:

Declining (USFWS, 2019)

Number of Populations:

114 - 116 (USFWS, 2012)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Minimum Viable Population Size:

7,641-12,960 adults (first and second brood average) (USFWS, 2012)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Severe decline started in 1970's, 1987 - 1988 droughts finished off numerous remnant demes. Most current EOs (D-ranked) expected to be lost. Much habitat lost before 1970. No chance of survival now without management. This species has expereinced a long-term decline of 70-90%. The species has stabilized somewhat with federal listing. The estimated population size is 2,500 - 10,000 (NatureServe, 2015). Research by Fuller (2008) suggests that a minimal viable population of KBBs should be a first and second brood average of 7,641-12,960 adults, or 11,217- 19,025 second brood adults, maintained on average over five or more years and the average KBB number should fall within these ranges every year. Based on available information there were 114 and 116 KBB populations or sites in 1992 and 2011, respectively (USFWS, 2012). Swengel and Swengel (2018) compared survey trends on Wisconsin sites over 17 years for the KBB and two other species, the frosted elfin (Callophrus irus) and Persius Duskywing (Erynnis persius), which are found throughout much of the same habitat in the State. Although the authors reported declines for all 3 species, they found higher trends in abundance for all species at "reserve" properties (those “where recovery would be expected to occur”) than rights-of-way and forestry land and suggested a higher level of habitat management as the reason for this result. In light of observed population declines, the authors suggested continued conservation management (as was observed in “reserve” sites) as a means to promote conservation of the KBB and the other evaluated species (Swengel and Swengel 2018, pp. 8-9) (USFWS, 2019).

Threats and Stressors

Stressor: Habitat loss and degradation (NatureServe, 2015; USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Despite listing some habitats continue to deteriorate, for example due to deer at Albany. Inappropriate fire regimens, loss of habitat to urbanization and pine farms, and out of control deer have been major cause of local or general decline (NatureServe, 2015). The destruction, modification or curtailment of habitat due to commercial, industrial, and residential development remains a threat especially in New York, New Hampshire, and Indiana where recovery sites are limited in size and KBB population numbers are generally low. Habitat loss due to mineral development is a newer and increasing threat in the HMNF in Michigan. In addition, the majority of the Bigelow metapopulation area is in private landownership with habitat loss increasing on these lands due to development and planting of conifers for Christmas tree plantations (Heather Keough, HMNF, pers. comm., 2009). A new threat in Wisconsin is frac sand

mining. Frac sand is used to fracture rock (by pumping the sand into crevices) in order to extract oil and gas. High quality frac sand areas occur throughout the entire KBB high potential range in Wisconsin (Brown 2011) and can impact hundreds of acres of land. Currently vehicles, especially off-road-vehicles (ORV) and dispersed camping are threats at some locations on the HMNF (Heather Keough, HMNF, pers. comm., 2009) (USFWS, 2012).

Stressor: Small population size/stochastic events (NatureServe, 2015; USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Some populations may simply be too small to survive long term (NatureServe, 2015). The KBB recovery plan identified stochastic events such as unusual weather, large-scale wildfires, and aggressive exotic (non-native) plants as threats to the species as well as global warming. All of these threats remain. Additional threats include natural succession, pesticide use, hybridization, and genetic fitness at some sites with low population numbers (USFWS, 2012).

Stressor: Disease and predation (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The KBB recovery plan (USFWS 2003) identified insect predators, parasitoids and pathogens as threats to the KBB as well as birds, mammalian browsing of lupine, and lupine plant diseases (e.g., powdery mildew). These remain as continuing threats. In addition to the mammalian threats noted in the KBB recovery plan (e.g., birds, deer, rabbit and woodchuck) turkey browsing on lupine may also adversely affect the butterfly (Paul Samerdyke, WDNR, pers. comm., 2008). Threats due to deer browse appear to be increasing in the HMNF (Heather Keough, HMNF, pers. comm., 2009). Insect herbivores are a threat to KBBs at some sites. Thrips (Odontothrips loti) found at some New York sites may reduce the amount of nutrients (in lupine leaves) available to KBB larvae and affect seed production (Kathy O'Brien, NYSDEC, pers. comm., 2008). The blister beetle, Lytta sayi found at some Wisconsin sites can obliterate lupine flowering and seed production for a season. Findings also suggest that female KBBs may choose shaded lupine more frequently for ovipositioning to avoid lupine occupied by L. sayi (Swanson and Kleintjes-Neff 2007). KBB sites, especially those near agricultural fields, are at risk from predation by the seven spotted ladybird beetle (Coccinella septempunctata) (Shellhorn et al. 2005). The beetle co-occurs spatially and temporally with KBB eggs and larvae. Shellhorn et al. (2005) observed one beetle consuming two second instar KBB larvae. Modeling suggests that a predator density of 0.074 beetles per plant would cause about 6.0% KBB larval mortality, and an increased predator density of 0.37 beetles per plant would cause 27% larvae mortality. In 2010, an aphid infestation at some New York KBB sites, combined with late spring frosts and an unusually hot, dry summer, affected flower production and caused many plants to drop leaves (Kathy O'Brien, NYSDEC, pers. comm., 2010). Other lupine herbivores include the painted lady larvae (Vanessa cardui). Sang and Teder (2011) found that predation of butterflies by dragonflies can play a significant role in butterfly conservation efforts (USFWS, 2012).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Lack of state legislation to protect and manage KBB habitat was identified as a threat in the KBB recovery plan (USFWS 2003). This threat was reduced in 2010 when the NYSDEC implemented new incidental take regulations that help conserve KBBs in occupied habitat (Kathy O'Brien, NYSDEC, pers. comm., 2012). The KBB recovery plan (USFWS 2003) also recommended development of more flexible regulatory mechanisms to ensure a habitat base for the species. This threat has been addressed in part through development of programmatic HCP and Safe Harbor programs that provide regulatory flexibility and permit streamlining to private landowners. Lack of enforcement of local regulations prohibiting ORV use in KBB habitat areas is a newer concern; several recovery partners have identified ORV use as a threat (USFWS, 2012).

Stressor: Pesticide use (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Increased use of pesticides to control invasive species, if not designed to avoid or minimize harm to the KBB could adversely affect butterfly populations. Use of biocides is also a concern. The pollen of maize genetically engineered to contain the insecticidal endotoxin proteins from Bacillus thuringiensis (Bt) is a possible, (but likely more minor) threat to KBBs (Peterson et al. 2006). Modeling has shown some potential exposure of larvae to maize pollen, however maize pollen dispersal is most likely to occur after the majority of larval feeding on lupine. In addition, in most of the sites studied lupine was sufficiently separated from the treated agricultural field that high rates of larval mortality were anticipated to be low (USFWS, 2012).

Stressor: Hybridization (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Hybridization between L. melissa melissa (Melissa blue) found in western Wisconsin (near Hudson) with KBBs has the potential to threaten the genetic distinctness (as a taxon) of the KBB at some locations in western Wisconsin (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Global warming is an emerging threat. Global warming is predicted to result in a hotter longer growing season reducing KBB habitat quality in some areas and increasing threats from larval predators and insect herbivores (USFWS 2009b). Preliminary climate change projections suggest that global warming may render many current KBB sites in the U.S. uninhabitable in coming decades and that much of the suitable habitat will then be found in Ontario, Canada

(Jason Dzurisin, University of Notre Dame, pers. comm., 2011). A recent vulnerability assessment conducted by Olivia LeDee for the KBB found that climate change could cause increases in KBB larval as well as adult mortality (WICCI 2011, Wildlife Working Group Report). Adult KBBs exhibit heat stress at 96-98°F (Lane 1999), thus reducing foraging activity. In 2010, high heat [greater than 100 degrees F (37.8° C) for at least 2 days] resulted in the mortality of 600 captive reared KBB pupae that were nearing eclosure (in the field) and planned for released in the APBP (Neil Gifford, APBPC, pers. comm., 2010). By the end of the century, the Crex Meadows population in northwestern Wisconsin may experience an additional 2-9 days of temperatures greater than100°F (37.8° C) and populations in central Wisconsin may see 2-13 days of temperature greater than 100°F (37.8° C). Because KBBs are poor dispersers and occur in a fragmented landscape a population shift in climate niche is not anticipated but rather declines are likely under future climate conditions (WICCI 2011, Wildlife Working Group Report) (USFWS, 2012). The KBB is now thought to be extirpated at the southern edge of its range in Indiana. The population at Indiana Dunes National Park (INDU) declined in conjunction with documented warming conditions, despite habitat management, restoration, and population augmentation efforts (Hellmann et al. 2016, p. 93). Due in part to this discovery, the KBB recovery team recently designated a climate change sub-team tasked with exploring the species' sensitivity to climate change and its adaptive capacity. The sub-team developed a report and submitted it to the larger recovery team for their review in December 2017. Although the report from the sub-team is still in draft, it presents several key findings. The report used the population at INDU as a case study to explore the KBB's sensitivity and exposure to climate change. Findings indicate that the population's decline occurred in conjunction with documented warming conditions. The documented decline is considered consistent with scientists' expectations for how a population of a low-motility species at the trailing edge of climate-induced range shift would respond. It was found that the KBB likely has low adaptive capacity to tolerate changes associated with climate change, due to the limited capacity to adapt via dispersal, changing behavior (e.g., single larval host plant), or evolving in place. Further, the species' vulnerability to the direct and indirect effects of climate change to it and its host plant, wild lupine, is high. The sub-team suggested many possible strategies in light of the impact that climate change is and will have on the species. These strategies fall in one of two categories: persistence or directed change. The report defines a persistence strategy as one that "responds to climate change impacts to KBBs by seeking to maintain or restore the species, as we know it, where it has historically occurred (i.e., within its historical range and general habitat, including matching genotypes to specific historical geographies as closely as possible)," whereas a directed change strategy "does not resist climate change impacts or allow autonomous response to them, but instead attempts to steer change towards specific future desired conditions. In a KBB context, managers would pursue such strategies based on a conclusion that 1) some historical KBB sites are, or soon will be, outside their historical range of climate variability and unsuitable for their historical KBB genotype, and 2) the KBB populations lack the adaptive capacity to respond effectively to these changes." (see below for Recommendations for Future Actions for additional information; USFWS 2003; KBB Climate Response Sub Team Report DRAFT 2017). (USFWS, 2019)

Stressor: Recreational Use
Exposure:

Response:
Consequence:
Narrative: Recreational use: As previously reported in the 2012 5-year review, recreational use of KBB habitat is considered a concern for the species (Bennett et al. 2010; USFWS 2012). Bennett et al. (2013) used a modeling approach to address the response of the KBB to recreational use of its habitat. They found that KBB adults react to intruding humans in the same way they react to potential predators, by rapidly flying away from the perceived threat (Bennett et al. 2013). This has negative implications for fecundity and host plant selection, both of which strongly influence population dynamics (Bennett et al. 2013) (USFWS, 2019).

Recovery

Reclassification Criteria:
1. Establish VPs (viable metapopulations) and LPs (large viable metapopulations) of Karner blues in 13 recovery units (RUs) (USFWS, 2003).

2. Each VP shall have: 1. a management and monitoring plan, that is approved by the USFWS prior to the fifth consecutive year of monitoring, that will be implemented into the future and include: a. suitable buffering of the metapopulation against adverse disturbance and threats to survival, b. maintenance of a diverse and appropriate successional array of suitable Karner blue habitat (refer to APPENDIX G), and c. identification of appropriate responses to potential metapopulation declines, and 2. a sufficient number of individuals in an appropriate metapopulation structure, maintained for at least 5 consecutive years. The number of individuals shall be at least 3,000 first or second brood adults in the final year of evaluation and in four of the five years overall. In all years, the number of adults shall be greater than 1,500 in one of either the first or second brood. In some circumstances the 3,000 level may be too high or too low (refer to APPENDIX E). 3. connectivity between subpopulations so that the average nearest-neighbor distance between subpopulations is no more than 1 kilometer (0.62 miles), and the maximum distance between subpopulations is no greater than 2 kilometers (1.24 miles). In some cases the 1 kilometer dispersal distance may be too far; In addition, each LP shall have 4. a larger areal extent and more suitable habitat than required for a minimum VP, specifically: a. an areal extent of at least 10 contiguous square miles (10 mi2), in which approximately 10 percent or more of the area has suitable habitat (i.e., an equivalent of about 640 acres of suitable habitat in a 10 square mile area); b. the suitable habitat is distributed over two-thirds of the 10 square mile area. 5. a more robust metapopulation structure with larger numbers of individuals than a VP, specifically: a. connectivity between subpopulations so that the average nearest-neighbor distance between subpopulations is no more than 1 kilometer (0.62 miles), and the maximum distance between subpopulations is no greater than 2 kilometers (1.24 miles). In some cases the 1 kilometer (0.62 miles) dispersal distance may be too far. For subpopulations greater than 2 kilometers from their nearest-neighbor, validation that dispersal is occurring is needed prior to including that subpopulation into the LP (refer to APPENDIX G, INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION) b. at least 6,000 adult butterflies maintained for at least 5 consecutive years. At least 6,000 first or second brood adults shall be

present in the final year of evaluation and in 4 of the 5 years overall; 6. reduced monitoring and management requirements compared to those required for a VP (USFWS, 2003).

Delisting Criteria:
1. Establish VPs and LPs of Karner blues in 13 RUs (USFWS, 2003).

2. Same as Criterion 2 for reclassification with the addition that each VP shall be demonstrably self-reproducing, shall be maintained at or above minimum allowable population sizes, and shall be managed and monitored under the specified management and monitoring plans for at least 10 consecutive years. Each LP, after the initial 5 years of monitoring for reclassification purposes, shall be monitored sufficiently to demonstrate that the LP is being maintained (USFWS, 2003).

Recovery Actions:
- Protect and manage Karner blue and its habitat to perpetuate viable metapopulations (USFWS, 2003).
- Evaluate and implement translocation where appropriate (USFWS, 2003).
- Develop rangewide and regional management guidelines (USFWS, 2003).
- Develop and implement information and education program (USFWS, 2003).
- Collect important ecological data on Karner blue and associated habitats (USFWS, 2003).
- Review and track recovery progress (includes re-evaluation of recovery goals for Wisconsin) (USFWS, 2003).
- Because habitat loss due to vegetative succession continues to be a major threat, work to manage and restore habitat for the KBB remains a priority action rangewide. Habitat management is identified as a Priority 1 Action in the KBB recovery plan (USFWS 2003) for recovery sites in New Hampshire (Action 1.21), Minnesota (Action 1.22) and New York (Action 1.23), and as a Priority 2 Action for recovery sites in Michigan (Action 1.24), Indiana (Action 1.25), and Wisconsin (Action 1.26). The Spotlight Species Action Plan for the KBB (USFWS 2009b) also identifies habitat management in all of the states noted above plus Ohio, as priority tasks under the "Manage KBB Recovery Sites" strategic action (USFWS, 2012).
- KBB habitats should be designed to be heterogeneous to help reduce threats associated with seasonal weather conditions and to the more long term threats associated with climate change. Recovery sites should include a variety of sub habitats from open to more closed canopy sites and with varying moisture regimes, slopes and aspects, to provide suitable habitat for the KBB especially important during times of drought. Adequate nectar and lupine plants should be available; such measures will help enhance KBB occupancy and survival (USFWS, 2012).
- Continued KBB population and habitat monitoring is needed at all recovery properties. Population data is needed to assess progress in meeting recovery criteria. Population monitoring at Whitewater WMA (Minnesota) should continue in order to determine if KBBs are still present at this site. To promote the recovery of the KBB, habitat monitoring should be conducted, especially at recovery sites where KBB numbers are low to assess what actions may be taken to improve habitats (and sub habitats) (e.g., mowing, burning, herbicide work and/or planting of lupine and nectar plants). Population and habitat monitoring are identified as Priority 1 Actions in the KBB recovery plan (USFWS 2003) for New Hampshire (Actions 1.11), Minnesota (Action 1.12 re: KBB monitoring), and Michigan

(Action 1.13 re: KBB monitoring), and as Priority 2 Actions in New York (Action 1.14), Indiana (Action 1.15) and Wisconsin (Action 1.16). The Spotlight Species Action Plan for the KBB (USFWS 2009b) also identifies “Monitoring KBBs at Recovery Sites” as a strategic (recovery) action (USFWS, 2012).

- Work is needed to secure long term habitat protection and management for the KBB. Therefore it is important to develop long term protection and management plans (recovery implementation plans) for recovery sites lacking such plans. Plans should adopt the recovery criteria in the KBB recovery plan (USFWS 2003) and be flexible enough to incorporate any future changes to the recovery criteria based on new information and/or research. Development of protection and management plans is identified as a Priority 1, 2, or 3 Task (depending on the state) in the KBB recovery plan (USFWS 2003) (refer to Actions 1.311, 1.312, 1.313, 1.314, 1.315, 1.316 for Minnesota, New York, Indiana, Michigan, Wisconsin, and New Hampshire respectively). The Spotlight Species Action Plan for the KBB (USFWS 2009b) identifies development of KBB recovery implementation plans for Wisconsin recovery sites as a recovery task (under the “Protect KBB Recovery Sites” strategic action) (USFWS, 2012).
- It is important to continue research on the effects of climate change on the KBB. Information from these studies should be used to inform management decisions (e.g., what sub habitat features would more likely help conserve the KBB during times of droughts). Recovery partners should continue to collect information on third brood KBBs, e.g., year and place of occurrence. It would also be helpful to document KBB emergence timing, lupine/nectar plant availability, and weather-linked changes in KBB activity (Olivia LeDee, UW-Madison, pers. comm., 2011). Climate change is identified as a threat in the KBB recovery plan (USFWS 2003). Research on climate change is identified as a recovery task in the Spotlight Species Action Plan for the KBB (under the “Conduct Research” strategic action) (USFWS 2009b) (USFWS, 2012).
- It is also important to work with forest entities interested in helping to recover the KBB especially those that are or have the potential to serve as recovery sites for the species (e.g., Clark, Eau Claire, Jackson and possibly Burnett County Forests as well as the BRSF). Assist the forest in assessing whether forestry practices can support viable KBB metapopulations for the long term. Information that would be helpful for this assessment includes locations of KBB sites, KBB population sizes in dedicated barrens areas, and an understanding of how the shifting habitat mosaic created by forest activities contributes to the metapopulation dynamic and/or how it could be modified to better support a viable population. The number and locations of dedicated barrens areas (that can act as metapopulation core areas) appears key to insuring viable metapopulations though the long term. These areas provide refugia for KBBs, help maintain the population and provide colonizers of early successional habitats resulting from forestry activities. Forest management research has been identified as a Priority 2 recovery action (Action 5.25) in the KBB recovery plan (USFWS 2003). Assessing whether forests can support viable KBB populations is also identified as a recovery task in the Spotlight Species Action Plan for the KBB (under the “Conduct Research” strategic action) (USFWS 2009b) (USFWS, 2012).
- Research is needed to assess whether hybridization between L. m. melissa (Melissa blue) found in western Wisconsin (near Hudson) with KBBs has the potential to threaten the genetic distinctness of the KBB in western Wisconsin. Movement of L. m. melissa may be facilitated by the presence of crown vetch (Coronilla varia), one of their larval host plants which is found along many roadsides in Wisconsin (Dane and Lane 2005). This has been

identified as a recovery task ((under the “Conduct Research” strategic action) in the Spotlight Species Action Plan for the KBB (USFWS 2009b) (USFWS, 2012).

- Further assessment of the minimum viable population size necessary to recover the KBB for the long term would be helpful. Research by Fuller (2008) suggests that a minimal viable population (MVP) of KBBs should be a first and second brood average of 7,641- 12,960 adults, or 11,217-19,025 second brood adults, maintained on average over five or more years and the average KBB number should fall within these ranges every year. More clarification is needed relative to Fuller’s (2008) recommended MVP numbers e.g., for how long should these population numbers be maintained to preclude extinction, and what is the extinction risk associated with these numbers? Also, clarify the extinction risk associated with the VP and LP recovery criteria (3000 and 6000 KBBs respectively) recommended in the KBB recovery plan (USFWS 2003). Consider the results of the ongoing KBB genetics research (which should identify KBB effective population size for several recovery sites across the species range) to help inform this task (USFWS, 2012).
- The taxonomic name of KBB should be revised to Lycaeides samuelis if such a change continues to be supported by peer–reviewed literature. The taxonomic name revision would also direct a change in the recovery priority number to reflect the full species (rather than subspecies) status of the KBB (USFWS, 2012).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: • Restore and protect habitat in areas that do not have sufficient KBB numbers or acres to support them. • Continue to manage currently suitable habitat to ensure long-term availability to KBBs. • Continue to evaluate the impact of climate change on the species. The KBB Climate Response Sub-Team plans to finalize their report in the near future. Some of the recovery actions that were recommended in the draft report include: o Encourage entities (city, state, county, tribal, federal) with sandy soils north of the current range to plant wild lupine. o Collect and store KBB genetic material from all sites, prioritizing extirpated and most-at-risk populations. o Experiment with creating or maintaining habitat in cooler and wetter microsites within areas that are currently managed for KBB and provide tools for managers (with findings incorporated). o Reach out to different jurisdictions and new agency and private landowners that may have suitable soils and climate for KBB in the future. o Develop capacity to maintain captive populations for augmentation of existing small populations or establishing new populations. • Continue to plan and implement regular surveys, monitor occurrences, and document habitat conditions and population trends at all KBB locations throughout the range. • Increase standardization of KBB surveying and monitoring to allow better comparisons among survey locations. • Support research of poorly understood aspects of KBB biology (especially those relevant to adaptive capacity) and habitat management o Gain a better understanding of the quantity and quality of nectar resources available to KBBs, which could be important for restoration purposes (current research) • Conduct a KBB Species Status Assessment (SSA) to inform potential updates of the KBB Recovery Plan (USFWS, 2019).

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SPECIES ACCOUNT: *Lycaena hermes* (Hermes copper butterfly)

Species Taxonomic and Listing Information

Listing Status: Threatened (USFWS, 2021)

Physical Description

Hermes copper butterfly is a small, brightly-colored butterfly approximately 1 to 1.25 inches (2.5 to 3.2 centimeters (cm)) in length, with one tail on the hindwing. On the upperside, the forewing is brown with a yellow or orange area enclosing several black spots, and the hindwing has orange spots that may be merged into a band along the margin. On the underside, the forewing is yellow with four to six black spots, and the hindwing is bright yellow with three to six black spots (USGS 2006). Mean last instar (period between molts) larval body length is 0.6 inches (in) (15 millimeters (mm)) (Ballmer and Pratt 1988, p. 4). Emmel and Emmel (1973, pp. 62, 63) provide a full description of the early stages of the species (eggs, larvae, and pupae).

Taxonomy

Hermes copper butterfly was first described as Chrysophanus hermes by Edwards (1870, p. 21). Scudder (1876, p. 125) placed this species in the genus Tharsalea based on the presence of hindwing tails. Freeman (1936, p. 279) placed Hermes copper butterfly in the genus Lycaena as L. hermes based on the assessment of the male genetalia, finding that L. hermes was distinctly a lycaenid and not typical of the other taxa of Tharsalea. Miller and Brown (1979, p. 22) erected a monotypic genus to accommodate Hermes copper butterfly as Hermelycaena hermes. This segregation appears to be supported by allozyme data presented by Pratt and Wright (2002, p. 223); although these authors did not recommend separate genus or subgenus placement (Pratt and Wright 2002, p. 225). The broadly based morphological assessment of Miller and Brown (1979) coupled with the more recent allozyme work of Pratt and Wright (2002) support recognition of Hermes copper butterfly as a distinct genus; however, Lycaena hermes is the name predominantly used in recent literature (Scott 1986, p. 392; Faulkner and Brown 1993, p. 120; Emmel 1998, p. 832; Opler and Warren 2005, p. 22), and we recognize it as such for the purposes of this assessment.

Historical Range

Hermes copper butterfly is endemic to the southern California region, primarily occurring in San Diego County, California (Thorne 1963, p. 143). All records of Hermes copper butterflies in the United States are within San Diego County, with most occurrences concentrated in the southwest portion of the County (Marschalek and Klein 2010, p. 4). Notable exceptions to the southwestern distribution pattern are two old museum specimens collected in north San Diego County, one from the vicinity of the community of Bonsall in 1934, and another from the vicinity of the community of Pala in 1932. Historical data indicate Hermes copper butterflies ranged from the vicinity of the community of Pala, California, in northern San Diego County (CFWO GIS database) to approximately 18 mi (29 km) south of Santo Tomas in Baja California, Mexico, and from Pine Valley in eastern San Diego County to Mira Mesa, Kearny Mesa, and Otay Mesa in western San Diego County (Thorne 1963, pp. 143, 147). They have never been recorded immediately adjacent to the coast, and have not been found east of the western slopes of the Cuyamaca Mountains above approximately 4,264 ft (1,300 m) (Marschalek and Klein 2010, p. 4). The distribution of Hermes copper butterfly in Mexico is not well-known and researchers have not explored this area (Marschalek and Klein 2010, p. 4). Of the two museum specimens from Mexico, one collected in 1936 was labeled 12 miles north of Ensenada, and another collected in 1983 was labeled Salsipuedes (Marschalek and Klein 2010, p. 4). Assuming older specimens were usually collected relatively close to roads that existed at the time (Thorne 1963, p. 145), these Mexican locations probably were collected from approximately the same location, which is a popular surf destination known as Salsipuedes, located approximately 12 mi (19 km) north of Ensenada off the Esconica Tijuana-Ensenada (coastal highway to Ensenada). The known distribution in Mexico of spiny redberry is relatively contiguous with that in the U.S., extending to approximately 190 mi (312 km) south of the border into Mexico along the western Baja California Peninsula (Little 1976, p. 150). Hermes copper butterflies have been recorded as far south into Mexico as 18 mi (29 km) south of Santo Tomas, which is approximately half the distance of the extent of spiny redberrys Mexican range (Thorne 1963, p. 143). There is still uncertainty as to the distribution of Hermes copper butterfly within the known historical range because we have very little information on the status of the species in Mexico. A species range can be defined at varying relevant scales of resolution, from maximum geographic range capturing all areas within the outermost record locations (coarsest scale, hereafter called known historical range), to the scale of individual population distributions (finest scale, hereafter called population distributions). This concept was discussed by Thorne (1963, p. 143): However within this range [Hermes copper butterfly] distribution is limited to pockets where the larval food plant occurs, so that the total area where the insect actually flies is probably not more than a fraction of one percent of the maximum area. To more precisely determine the historical range of Hermes copper butterfly, we entered all Hermes copper butterfly observation records that had information about collection location in our GIS database as of 2013, and mapped all observed and museum specimen records with an appropriate level of detail and location description. To better determine the geographic locations of historical Hermes copper butterfly records mapped by Thorne (1963, p. 147), we overlaid a transparent image of his map on Google Earth imagery, and scaled it appropriately to ensure that geographic features and community locations corresponded with those of the imagery. Examination of Thornes (1963 p. 147) map expanded the known historical range as described by Deutschman et al. (2010, p. 3) to the southeast in the vicinity of the community of Pine Valley and Corte Madera Valley. The resulting known historical range of Hermes copper butterfly within the United States can be described as comprised of a narrow northern portion within the Central Valley and Central Coast ecoregions, north of Los Penasquitos Canyon and Scripps Poway Parkway (latitude midway between the northernmost record location and the international border), and a wider southern portion encompassing the Southern Coast, Southern Valley, and Southern Foothills ecoregions (see Figure 1 and Table 1 below; San Diego County Plant Atlas 2010). Although the distribution of Hermes copper butterfly populations in Mexico is not well understood, the U.S. populations minimally encompass half the species known historical latitudinal range. The results of our population distribution analysis indicate areas in the United States most likely to harbor possible extant undiscovered Hermes copper butterfly populations within the known historical range are primarily limited to a relatively narrow area within the southern portion of the range bordered on the north and south by the 2003 Cedar Fire and 2007 Harris Fire perimeters, and on the west and east roughly by Sycuan Peak and Long Valley.

Current Range

To evaluate the status of Hermes copper butterflys current range and populations, we considered all available historical data and recent research results as of 2013, including record locations, monitoring data, (Marschalek and Deutschman 2008; Marschalek and Klein 2010), movement data (Marschalek and Deutschman 2009; Marschalek and Klein 2010), and data from recent distribution studies (Deutschman et al. 2010; Deutschman et al. 2011; Strahm et al. 2012). To estimate the geographic population distribution of Hermes copper butterfly, we used all occurrence records as of 2013 and mapped areas within approximately 0.6 mi (1 km) of known observation sites. This distance is greater than the average recapture distance recorded by Marschalek and Klein (2010, p. 1), but just under the maximum recorded recapture distance, an approximate within-population movement distance further supported by Deutschman et al.s (2010, p. 16) genetic data. Locations within approximately 1.2 mi (2 km) (where 0.6 mi (1 km) movement distances overlapped) were considered part of the same population, unless topographic or genetic information indicated the possibility of barriers to movement. We used recent fire footprint data and aerial GIS information, in addition to the information referenced above, to determine which Hermes copper butterfly populations may be extant, extirpated, or of unknown status. A Hermes copper population was considered to be extant if the species was recorded based on recent survey records and not affected by recent fires. A Hermes copper population was considered to be extirpated if the area had been developed and no habitat remained, a fire footprint encompassed the area and subsequent surveys were negative, or if the record was very old with no recent detections. In some instances, we had no recent information to make a determination on Hermes copper butterflys current status and it was therefore classified as unknown. Since our 2012 species assessment (USFWS 2012), we received information on historic populations that were rediscovered. Of particular interest are two small, peripheral populations in the northern and western portion of the species distribution (Elfin Forest and Van Dam Peak) that were previously identified as unknown and extirpated, respectively, in the species assessment and are now considered extant. One individual was observed at each location in 2011; none were detected in 2012. Although these two populations are small and isolated by development, they could represent important refugia outside of the larger populations to the south (Strahm et al. 2012, p. 20). Also of interest is the large Boulder Creek Road population (Map #59) that was not known to us at the time of our 2012 species assessment, but was previously known by species experts as an historical population of unknown status within the perimeter of the 2003 Cedar Fire (Strahm et al. 2012, p. 21). Strahm et al. (2012, p. 21) confirmed this populations status as extant in 2012. Higher levels of genetic differentiation observed from individuals of this population support Strahm et al.s (2012, p. 31) hypothesis that this population survived the fire nearby in an unknown location that was not burned, rather than recolonizing the site from outside the fire perimeter approximately 3.6 mi (5.8 km) away. Thus, this population appears to be currently isolated from other populations by past fire disturbance. Finally, we received information on the Lakeside Downs population, whichsimilar to the Boulder Creek Road populationwas not known to us at the time of our 2012 species assessment, but was previously known as an historic population by species experts and confirmed as extant in 2004 (FEC 2004, p. 1) in an area isolated by the 2003 Cedar Fire and development. In summarizing the results of our analysis of Hermes copper butterflys current range and population distributions , information currently available identifies 59 total historic populations, of which 21 are extant, 27 are extirpated, and 11 are of unknown status. In the year 2000, 37 populations were thought to be extant. Since that time, 10 populations have been extirpated (1 by development, 1 by fire and development, 8 by fire alone) and 6 are of unknown status. In the northern portion of the range, most remaining suitable habitat is limited to the relatively isolated and fragmented undeveloped lands between the cities of San Marcos, Carlsbad, and Escondido and the community of Rancho Santa Fe, and the habitat islands containing the Black Mountain and Van Dam Peak observation locations. In the southern portion of the range, all extant populations except Lopez Canyon, the southern portion of Mission Trails Park, Lakeside Downs, and Boulder Creek Road (isolated from other extant populations by development and fire) are within relatively well-connected undeveloped lands east of the City of El Cajon between the 2003 Cedar Fire and 2007 Harris Fire perimeters. The Mission Trails Park population remains extant even after approximately 74 percent of the population area burned in 2003, presumably because burned areas were recolonized (after host plant and nectar sources regrew) by Hermes copper butterflies from nearby unburned areas. The best information available leads us to conclude that the northern portion of the species known historical range has contracted but supports small, peripheral populations, and we estimate that approximately 27 percent of the populations within the southern portion of the species known historical U. S. range that were extant in 2000 have been extirpated. Further investigation is needed to accurately determine the status of Hermes copper butterfly in Mexico (Marschalek and Klein 2010, p. 2). Klein (2010, pers. comm.) visited the Salsipuedes location in the first week of June 2005 for approximately 30 minutes. He did not observe any Hermes copper butterflies; however, he described the habitat as having a decent number of spiny redberry, a large amount of California buckwheat, and said he believed the area was very good for Hermes copper butterfly.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 1/20/2022.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine threatened species status under the Endangered Species Act of 1973 (Act), as amended, for the Hermes copper butterfly (Lycaena [Hermelycaena] hermes), a butterfly species from San Diego County, California, and Baja California, Mexico. We also designate critical habitat. In total, approximately 14,174 ha (35,027 ac) in San Diego County, California, fall within the boundaries of the critical habitat designation. This rule adds the species to the List of Endangered and Threatened Wildlife. We also finalize a rule under the authority of section 4(d) of the Act that provides measures that are necessary and advisable to provide for the conservation of this species. (USFWS, 2021)

Critical Habitat Designation

habitat units. Unit 1: Lopez Canyon Unit 1 consists of 166 ha (410 ac) within the geographical area currently occupied by the species and contains all of the essential physical or biological features. The physical or biological features may require special management to protect them from wildfire and land use change, although the latter is less likely in this unit (see Special Management Considerations or Protection above). This area encompasses the core Lopez Canyon occurrence, the only known extant occurrence that falls within the Coastal Terraces Ecological Unit (Table 1), and is therefore required to maintain species representation. Unit 1 is within the jurisdiction of the City of San Diego, associated with the communities of Sorrento Valley and Mira Mesa. This unit is surrounded by development. Habitat consists primarily of canyon slopes. The majority of this unit falls within the Los Pen˜ asquitos Canyon Preserve jointly owned and managed by the City and County of San Diego. The primary objective of Los Pen˜ asquitos Canyon Preserve is the preservation and enhancement of natural and cultural resources. The preserve master plan states that recreational and educational use by the public is a secondary objective, development should be consistent with these objectives, and public use should not endanger the unique preserve qualities. Land use in this unit is almost entirely recreation and conservation. Unit 2: Miramar/Santee Unit 2 consists of 2,870 ha (7,092 ac) within the geographical area currently occupied by the species and contains all of the essential physical or biological features. The physical or biological features may require special management to protect them from land use change and wildfire, although wildfire will be challenging to manage for in this unit because of its size and risk of megafire (see Special Management Considerations or Protection above). This area encompasses the core Sycamore Canyon, North Santee, and Mission Trails occurrences, as well as non-core occurrences connected to core occurrences also required for metapopulation resilience and continued species representation in two California Ecological Units (Coastal Hills and Western Granitic Foothills). This unit includes half of the extant/ presumed extant core occurrences in the Coastal Hills California Ecological Unit (the other half is in Unit 3). Unit 2 mostly surrounds the eastern portion of MCAS Miramar (lands encompassing areas that also meet the definition of critical habitat and would be included in this unit but are exempt from designation), falling primarily within the jurisdictions of the City of San Diego, but also within the City of Santee and unincorporated areas of San Diego County. In this unit, the City of San Diego owns and manages the over 2,830- ha (7,000-ac) Mission Trails Regional Park (887 ha (2,192 ac) in this unit) and the County owns and manages the 919- ha (2,272-ac) Gooden Ranch/Sycamore Canyon County preserve (198 ha (488 ac) included in this unit). Unit 3: Southeast San Diego Unit 3 consists of 11,139 ha (27,525 ac) within the geographical area currently occupied by the species and contains all of the essential physical or biological features. The physical or biological features may require special management to protect them from land use change and wildfire, although wildfire will be challenging to manage in this unit because of its size and risk of megafire (see Special Management Considerations or Protection above). This unit configuration would conserve essential contiguous habitat. This area includes half of the extant/presumed extant core occurrences in the Coastal Hills California Ecological Unit (the other half is in Unit 2), and all of the extant/presumed extant core occurrences in the Western Granitic Foothills and Palomar-Cuyamaca Peak California Ecological Units. The majority of the Crestridge core occurrence falls within the Crestridge Ecological Reserve jointly managed by the Endangered Habitats Conservancy and the California Department of Fish and Wildlife. The majority of the Alpine core occurrence falls within the Wright’s Field preserve owned and managed by the Back Country Land

Trust. Thirty-eight percent of this unit (4,213 ha (10,411 ac)) is owned and managed by the U.S. Fish and Wildlife Service, the USFS, and the BLM. (USFWS, 2021)

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of this species may require special management considerations or protection to reduce or mitigate the following threats: Wildfire, land use change, habitat fragmentation and isolation, and climate change and drought. In particular, habitat that has at any time supported a subpopulation will require protection from land use change that would permanently remove host plant patches and nectar sources, and habitat containing adult nectar sources that connects such host plant patches through which adults are likely to move. These management activities will protect from losses of habitat large enough to preclude conservation of the species. Additionally, when considering the conservation value of areas designated as critical habitat within each unit, especially among subpopulations within the same California Ecological Unit, maintenance of dispersal corridorconnectivity among them should be a conservation planning focus for stakeholders and regulators (such connectivity was assumed by the criteria used to delineate critical habitat units). (USFWS, 2021)

Life History

Feeding Narrative

Larvae: Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401).

Adult: Researchers report adults are rarely found far from spiny redberry (Thorne 1963, p. 143) and take nectar almost exclusively from Eriogonum fasciculatum (California buckwheat) (Marschalek and Deutschman 2008, p. 5). The densities of host plants and nectar sources required to support a Hermes copper population are not known. Hermes copper butterflies tend to remain inactive under conditions of heavy cloud cover and cooler weather (Marschalek and Deutschman 2008, p. 5). Across all four sites sampled by Marschalek and Deutschman, Hermes copper butterfly presence was positively associated with California buckwheat, but negatively associated with Adenostema fasciculatum (chamise) (Marschalek and Deutschman 2008, p. 102). Therefore, woody canopy openings with a northern exposure in stands of spiny redberry and adjacent stands of California buckwheat appear to be components of suitable habitat for Hermes copper butterfly.

Reproduction Narrative

Larvae: Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401).

Adult: Females deposit single eggs on Rhamnus crocea (spiny redberry) in the early summer, often where a branch splits or on a leaf (Marschalek and Deutschman 2009, p. 401). Eggs overwinter, with larvae reported from mid-April to mid-May (Marschalek and Deutschman 2009, p. 400) followed by pupation on the host plant (Emmel and Emmel 1973, p. 63). Hermes copper butterflies have one flight period (termed univoltine) typically occurring in mid-May to early July, depending on weather conditions and elevation (Marschalek and Deutschman 2008, p. 100; Marschalek and Klein 2010, p. 5). Emergence appears to be influenced by weather; however this relationship is not wellunderstood. For example, weather conditions in the spring of 2010 were cool and moist and resulted in a late emergence; however, the spring of 2006 was hot and dry and also resulted in a late emergence period (Deutschman et al. 2010, p. 4). We have no information regarding the ability of immature life stages to undergo multiple-year diapause (a low metabolic rate resting stage) during years with poor conditions (Deutschman et al. 2010, p. 4). Multiple year diapause is rare and can occur in stages more advanced than the egg, such as pupae or larvae, after larvae have fed and accumulated energy reserves (USFWS 2003, p. 8; Gullan and Cranston 2010, p. 169); it is less likely to occur with Hermes copper butterflies because they overwinter (diapause) as eggs. However, Strahm et al. (2012, p. 37) noted that three of six eggs they detected in 2012 did not hatch, which could indicate that Hermes copper butterfly eggs are capable of multiyear diapause. In 2013, these eggs will be monitored, and additional egg searches will continue with the goal of increasing the sample size.

Geographic or Habitat Restraints or Barriers

Larvae: restricted to habitat on canyon bottoms and on hillsides with a northern exposure

Adult: restricted to habitat on canyon bottoms and on hillsides with a northern exposure

Spatial Arrangements of the Population

Larvae: unknown; likely clumped according to suitable resources

Adult: unknown; likely clumped according to suitable resources

Environmental Specificity

Larvae: specialist

Adult: specialist

Tolerance Ranges/Thresholds

Larvae: unknown

Adult: unknown

Site Fidelity

Larvae: probably high considering low dispersal, adult microclimate preferences, and limited suitable habitat

Adult: high; higher near host plant stand edges than in the interior

Habitat Narrative

Larvae: Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401).

Adult: Hermes copper butterfly inhabits coastal sage scrub and southern mixed chaparral (Marschalek and Deutschman 2008, p. 98). Hermes copper butterfly larvae use only spiny redberry as a host plant (Thorne 1963, p. 143; Emmel and Emmel 1973, p. 62). The range of spiny redberry extends throughout coastal northern California, as far north as San Francisco (Consortium of California Herbaria 2010); however, Hermes copper butterfly has never been documented north of San Diego County (Carlsbad Fish and WildlifeOffice (CFWO) GIS database). Therefore, some factor other than host plant availability apparently has historically limited or currently limits the range of the species. Recent research has not added much to Thornes (1963, p. 143) basic description of Hermes copper butterfly habitat: It is very difficult to analyze the complex factors which determine why a certain plant has been successful in a given spot*** In the case of spiny redberry, the only consistent requirement seems to be a well-drained soil of better than average depth, yet not deep enough to support trees. Such soils occur along canyon bottoms and on hillsides with a northern exposure; therefore, it is in these situations that [Hermes copper butterfly] is generally found. Hermes copper butterflies exhibit a preference for micro-sites within stands of spiny redberry, which may berelated to temperature because adults become active around 72 degrees Fahrenheit (°F) (22 degrees Celsius (°C)) (Marschalek and Deutschman 2008, p. 5). Marschalek and Deutschman (2008, p. 3) recorded densities of Hermes copper butterflies on paired transects along edges and within the interior of host plant stands in rural areas. Their study indicates that Hermes copper butterfly densities are significantly higher near host plant stand edges than in the interior (Marschalek and Deutschman 2008, p. 102). Adult males have a strong preference for openings in the vegetation, including roads and trails, specifically for the north and west sides of canopy openings (Marschalek and Deutschman 2008, p. 102). These areas capture the first morning light and reach the temperature threshold for activity more quickly than other areas (Deutschman et al. 2010, p. 4).

Dispersal/Migration

Motility/Mobility

Larvae: limited

Adult: limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Adult: non-migratory

Dispersal

Larvae: limited

Adult: limited

Immigration/Emigration

Larvae: very unlikely

Adult: very unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Not much is known regarding larval biology, as this life stage is little-studied and extremely difficult to find in the field (Marschalek and Deutschman 2009, pp. 400, 401).

Adult: In general, Hermes copper butterflies have limited directed movement ability (Marschalek and Klein 2010, p. 1), though lyceanids can be dispersed by the wind (Robbins and Small 1981 p. 312). Marschalek and Klein (2010) studied intra-habitat movement of Hermes copper butterflies using mark-release-recapture techniques. They found the highest median dispersal distance for a given site in a given year was 146 ft (44.5 m), and their maximum recapture distance was 0.7 mile (mi) (1.1 kilometers (km)) (Marschalek and Klein 2010, p. 1). They also found no adult movement across non-habitat areas, such as type-converted grassland or riparian woodland (Marschalek and Klein 2010, p. 6). Hermes copper butterfly is typically relatively sedentary (Marschalek and Klein 2010, p. 1), although winds may aid dispersal (Robbins and Small 1981, p. 312). Studies infer that most individuals typically move less than 656 ft. (200 m) (Marschalek and Deutschman 2008, p. 102, Marschalek and Klein 2010, pp. 725726), supporting the assumption that Hermes copper butterflies are typically sedentary compared to other butterfly species such as painted ladies (Vanessa cardui). However, genetic research indicates that females may disperse longer distances than males (Deutschman et al. 2010, p. 16) contradicting previous methods used such as mark-release-recapture (Marschalek and Deutschman 2008, p. 102) that may not detect the movement of females and over sample territorial males. More information is needed to fully understand movement patterns of Hermes copper butterfly; however, dispersal is likely inhibited by lack of available habitat in many areas (Deutschman et al. 2010, p. 17).

Population Information and Trends

Population Trends:

Some populations possibly increases and some populations seem to be stable

Species Trends:

possibly stable or increasing

Population Growth Rate:

unknown

Number of Populations:
21 to 33

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
moderate

Adaptability:
moderately-low

Population Narrative:
Data from standardized transect monitoring of four reference populations from 2010 to 2013 indicate a possible upward trend in abundance. In 2013 a four year high in the total number of Hermes copper butterfly observations was recorded at Sycuan Peak and Lawson Peak, while the total count at the recently discovered Boulder Creek population was approximately 40 percent higher than 2012 (Marschalek and Deutschman 2013, p. 14; D. Marschalek pers. comm. 2014. Abundances at the Roberts Ranch population site stayed relatively stable, but it was a small sample size. Recent expansion of landscape genetic studies has allowed researchers to develop a more complete description of the genetic population structure of Hermes copper butterfly, with the goal of making inferences about dispersal (Strahm et al. 2012, p. 23). Individuals were found to be genetically similar to each other, with most of the differences found in individuals in peripheral populations in the northern and western portion of the Hermes copper butterfly distribution (Strahm et al. 2012, pp. 2, 32). Although these results provide evidence that individuals can disperse across much of the landscape, Strahm et al. (2012, p. 32) suggest these genetic patterns likely reflect historical processes, as genetic differences reflecting contemporary influences such as habitat fragmentation would probably require more time to reach detectable levels. Additionally, historic wildfire regimes included large fires, but recolonization events following large fires in 2003 and 2007 have been rare, suggesting that current dispersal is limited (Strahm et al. 2012, p. 32). However, historical dispersal data does not exist, thus the expected length of time for recolonization is unknown (Strahm et al. 2012, p. 33).

Threats and Stressors

Stressor: Development
Exposure:
Response:
Consequence:

Narrative: The current distribution of Hermes copper butterfly habitat in San Diego County is largely due to previous urban development within coastal and interior San Diego County which resulted in the loss and fragmentation of Hermes copper butterfly habitat (CalFlora 2010; Consortium of California Herbaria 2010; San Diego County Plant Atlas 2010). Of the 27 known extirpated Hermes copper butterfly populations, loss and fragmentation of habitat as a result of development has contributed to the extirpation of 13 populations (48 percent). Since the year 2000, occupied habitats containing Hermes copper butterflys host plant, spiny redberry, in Rancho Santa Fe and Sabre Springs were lost due to urban development. In the City of San Marcos, one spiny redberry stand near Jacks Pond was lost to development (Anderson 2010a, pp. 1, 2) and another spiny redberry stand was significantly reduced in the vicinity of Palomar College (Anderson 2010b, pp. 1, 2). The spiny redberry stand in Lopez Canyon is currently found within a relatively small preserve (roughly rectangular area 0.4 mi (0.6 km) by 0.5 mi (0.8 km)) that is contiguous with suitable Hermes copper butterfly habitat in Del Mar Mesa where development is ongoing. This stand of spiny redberry is likely all that remains of what was once a wider distribution, encompassing the community of Mira Mesa and the western portion of Miramar Naval Air Station (per Thornes 1963 map, p. 147).Although a significant amount of habitat has been lost due to development throughout the range of Hermes copper butterfly within the United States, the remaining currently occupied population areas are protected from destruction by development due to their presence on federally owned lands or on lands conserved under regional habitat conservation plans (approximately 48 percent of the total area currently occupied by Hermes copper butterfly populations occurs on Federal lands and non-federal conserved lands) and the remaining 52 percent of occupied habitat occurs on lands subject to local resource protection ordinances in San Diego County. Our GIS analysis indicates that of the total conserved area discussed above (48 percent of all occupied areas), approximately 19 percent (encompassing portions of 13 populations) is located within established regional habitat conservation plan preserve lands (see Factor D San Diego Multiple Species Conservation Program (MSCP) discussion below), approximately 20 percent (encompassing portions of 12 populations) falls within U.S. Forest Service lands, approximately 6 percent (encompassing portions of 4 populations) falls within U.S. Fish and Wildlife Service lands, and approximately 2 percent (encompassing portions of 4 populations) falls within Bureau of Land Management (BLM) land. These lands are therefore afforded protection from development. Additionally, as described in Factor D below, the County of San Diego now has in place two ordinances that restrict new development or other proposed projects within sensitive habitats. The Biological Mitigation Ordinance of the County of San Diego Subarea Plan (County of San Diego 1998, Ord. Nos. 8845, 9246) regulates development within coastal sage scrub and mixed chaparral habitats that currently support portions of 10 extant Hermes copper butterfly populations on non-federal land within the boundaries of the Countys MSCP subarea plan. The County of San Diego Resource Protection Ordinance (County of San Diego 2007) restricts development within coastal sage scrub and mixed chaparral habitats that currently support all extant Hermes copper butterfly populations on non-federal lands throughout the county. These ordinances provide some regulatory measures of protection for the remaining 52 percent of extant Hermes copper butterfly habitat throughout the species occupied range. Although past development in occupied Hermes copper butterfly habitat resulted in a substantial number of extirpations of Hermes copper butterfly populations, restrictions are in place to limit development and the corresponding destruction and modification of Hermes copper butterfly habitat in the future. Therefore, we do not believe future development alone will significantly reduce or fragment remaining Hermes copper butterfly habitat on non-federal lands. However, as discussed below under Habitat Fragmentation, we believe that the combined impacts of existing development, limited future small-scale development, existing dispersal barriers, and megafires could further fragment Hermes copper butterfly habitat and threaten the species. Within U.S. Forest Service lands, we anticipate that future development, if any, will be limited, and the Forest Service has incorporated measures to address threats to Hermes copper butterfly and its habitat as it implements specific activities within forest lands. The very limited number of Hermes copper butterfly populations within BLM lands are unlikely to face future development pressure. Therefore, we conclude that Hermes copper butterfly is not currently threatened by habitat loss due to future development alone.

Stressor: Wildfire
Exposure:
Response:
Consequence:
Narrative: The historical fire regime in southern California likely was characterized by many small lightning-ignited fires in the summer and a few, infrequent large fires in the fall of varying fire intensity (Keeley and Fotheringham 2003, p. 242243). These infrequent, large, high-intensity wildfires, so-called megafires (greater than 123,553 ac (50,000 ha) in size), burned the landscape long before Europeans settled the Pacific coast (Keeley and Zedler 2009, p. 90). As such, modern fire regimes in southern California have much in common with historical regimes (Keeley and Zedler 2009, p. 69). While some researchers claim that the fire regime of chaparral growing in adjacent Baja California is not affected by megafires due to a lack of fire suppression activities (cf. Minnich and Chou 1997, Minnich 2001), Keeley and Zedler (2009, p. 86) believe that the fire regime in Baja California similarly consists of small fires punctuated at periodic intervals by large fire events. The current fire regime in southern California consists of numerous small fires that are periodically impacted by megafires that are generally driven by extreme Santa Ana weather conditions of high temperatures, low humidity, and strong erratic winds (Keeley and Zedler 2009, p. 90). The primary difference between the current fire regime and historical fire regimes in southern California is that human-induced or anthropogenic ignitions have increased the frequency of fires, and in particular, megafires, far above historical levels. While this change may not have demonstrably affected the nectar sources of Hermes copper butterfly in San Diego County, especially within chaparral (Franklin et al. 2004, p. 701), frequent fires open up the landscape, particularly coastal sage scrub, making the habitat more vulnerable to invasive, nonnative plants (Keeley et al . 2005, p. 2117). However the primary concern with frequent megafires is the Hermes copper butterfly mortality associated with these extensive and intense events which precludes recolonization of burned areas by Hermes copper butterfly. The significance of this concern can be seen in the current distribution of the species in southern California. Analysis of GIS information indicates that, as of 2013, approximately 60 percent of the extant occurrences are found within the footprint of the 1970 Laguna Fire, which Minnich and Chou (1997, p. 240) reported last burned in 1920. In contrast, the areas north and south of the extant Hermes copper butterfly occurrences reburned several times between 2001 and 2007

(Keeley et al. 2009, pp. 287, 293). We examined maps of current high fire threat areas in San Diego County based on recent reports by the Forest Area Safety Task Force (Jones 2008, p. 1; SANDAG 2010, p. 1). Areas identified as most vulnerable include all occupied and potentially occupied Hermes copper butterfly habitats in San Diego County within the southern portion of the range bordered on the north and south by the 2003 Cedar Fire and 2007 Harris Fire perimeters. In light of the recent spate of drought-influenced wildfires in southern California, especially the 2007 fires, a future megafire affecting most or all of the area burned by the Laguna Fire in 1970 (40-year chaparral) is likely to occur and would pose a significant threat to Hermes copper butterfly in the United States because it would encompass the majority of extant populations. Spiny redberry are obligate resprouters after fires and are resilient to frequent burns (Keeley 1998, p. 258). Additionally, although Keeley and Fotheringham (2003, p. 244) indicated that continued habitat disturbance, such as fire, will result in conversion of native shrublands to nonnative grasslands, Keeley (2004, p. 7) also noted that invasive, nonnative plants will not typically displace obligate resprouting plant species in mesic shrublands that burn once every 10 years. Therefore, because spiny redberry is an obligate resprouter, it will likely recover in those areas that retain this burn frequency. Specific information regarding Hermes copper butterflys primary nectar source (California buckwheat) is less understood. California buckwheat is a facultative seeder and high proportions of this nectar source are likely killed by fire, and densities are reduced the following year within burned areas (Zedler et al. 1983, p. 814); however, California buckwheat does show minimal resprouting capability (approximately 10 percent) if individuals are young (Keeley 2006, p. 375). The extent of invasion of nonnative plants and type conversion in areas specifically inhabited by Hermes copper butterfly are unknown. However, information clearly indicates that wildfire results in at least temporary reductions in suitable habitat for Hermes copper butterfly and may result in lower densities of California buckwheat (Zedler et al. 1983, p. 814; Keeley 2006, p. 375; Marschalek and Klein 2010, p. 728). In areas where spiny redberry is capable of resprouting, the quantity of California buckwheat nectar source necessary to support a persisting Hermes copper butterfly population may be temporarily unavailable due to recent fire impacts. If areas are repeatedly burned, California buckwheat will not have the time necessary to become reestablished, rendering the habitat unsuitable for Hermes copper butterfly (Marschalek and Klein 2010, p. 728). Increased fire frequency may also pose a threat to Hermes copper butterfly through loss of host plant and nectar source habitat, and fire management plans are not expected to provide protection from megafires such as those that occurred in 2003 and 2007. Based on the above, we consider wildfire, specifically megafires that encompass vast areas and are increasing in frequency, a significant threat to Hermes copper butterfly.

Stressor: Habitat Fragmentation
Exposure:
Response:
Consequence:
Narrative: Habitat fragmentation can result in smaller, more vulnerable Hermes copper butterfly populations. The presence of suitable habitat on which Hermes copper butterflies depend often determines the size and range of the local population. Wildfires and past development have caused habitat fragmentation that separates populations and inhibits movement by creating a

gap in area that Hermes copper butterflies are not capable of traversing. The connectivity of habitat occupied by a butterfly population is not defined by host plant distribution at the scale of host plant stands or patches, but rather by adult butterfly movement that results in interbreeding (see USFWS 2003, pp. 22, 162165). Any loss of resource contiguity on the ground that does not affect butterfly movement, such as burned vegetation, may degrade habitat, but may not fragment habitat. Therefore, in order for habitat to be fragmented, movement must be prevented by a barrier, or the distance between remaining host plants where larvae develop must be greater than adult butterflies will move to mate or deposit eggs. Genetic analysis (Deutschman et al. 2010; p. 16) indicates that butterflies can show differentiation even when close in proximity, presumably due to physical barriers that may be a result of development or a landscape feature (i.e., the three McGinty Mountain sites that are on opposite sides of the mountain may be separated by topography). Alternately, sampling locations that are not close have shown little genetic differentiation, indicating that butterflies can also disperse long distances under the right conditions. Sampling at one location before and after a fire found genetically differentiated groups. Deutschman et al. (2010, p. 16) concluded their findings supported the idea that Hermes copper butterfly individuals are capable of long-distance movement, but developed areas and natural landscape features may enhance or restrict dispersal. It is important to note that although movement may be possible, the habitat must be suitable at the time Hermes copper butterflies arrive to ensure successful recolonization. Hermes copper butterfly habitat has become fragmented by both past urban development (permanently) and wildfires. Comparison of Hermes copper butterfly occurrences and host plant distribution with mapped wildfire perimeters indicates that wildfires cause short-term fragmentation of habitat, and, historically, Hermes copper butterfly habitat in San Diego County has been fragmented and lost due to the progression of development over the last 50 years. Analysis of the Hermes copper butterfly populations indicates that in the northern portion of the U.S. range, the habitat has been fragmented (and lost) permanently by development and further fragmented temporally by wildfires, resulting in extirpation of at least four Hermes copper butterfly populations. As described in the Biological Information section above and Factor E below, a historical Hermes copper butterfly population (Rancho Santa Fe) in the northern portion of the range has been lost since the year 2000, presumably because the habitat burned and became isolated to an extent that connectivity with other populations was lost. We stated in our 2012 species assessment (USFWS 2012, p. 13) that this area is not expected to be recolonized because the distance to the next nearest source population (13 mi (20 km)) exceeds the dispersal capability of the species, however, since our species assessment we learned the Elfin Forest population was rediscovered approximately 2.7 mi (4.3 km) away. Still, the Elfin Forest population is small, with only one individual detected in 2011. Further to the south, Lopez Canyon, Van Dam Peak, Lakeside Downs, and the extant portion of Mission Trails Park are isolated from other extant populations by development and burned areas that are no longer likely occupied. While we do not expect future development alone to threaten Hermes copper butterfly habitat, we believe that the combined impacts attributable to wildfire and small scale development may fragment habitat further and hence, threaten the species continued existence. Based on the above, we consider habitat fragmentation, due to the combined impact of existing development, possible future (limited) development, existing dispersal barriers, and megafires, a significant threat to Hermes copper butterfly.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- Investigations into aspects of Hermes copper butterfly biology that are poorly understood should be continued, specifically: 1) monitoring for adult Hermes copper butterflies at the larger, previously monitored sites to identify environmental variables important for annual densities of adults; 2) monitoring for adults Hermes copper butterflies at small populations in the northern portion of the distribution to determine detection rates; 3) monitoring of sites that experience recent wildfires and local extirpations to detect recolonization events, which would allow inferences about dispersal; 4) behavioral observations of female adult Hermes copper butterflies; and 5) egg searches and tracking larval development to estimate the rate of hatching, depredation, and diapause as well as better understand habitat requirements (Strahm et al. 2012, p. 44). Finally, investigations into in vitro rearing of Hermes copper butterfly could be conducted as an insurance policy against fire (Deutchman et al. 2011, p. 31).
- Hermes copper butterfly has indirectly benefitted from conservation measures implemented for other species by subarea plans of the MSCP. As of 2013, approximately 19 percent of the current range of Hermes copper butterfly is already conserved in preserves within the City of San Diego and County of San Diego subarea plans (USFWS 2013); therefore, these lands are protected from the threat of development.

Conservation Measures and Best Management Practices:

- Current Conservation Measures: As described above, the County of San Diego implements ordinances within the County that require Hermes copper butterfly surveys in potential habitat and specific measures to offset impacts to occupied Hermes copper butterfly habitat. In addition, presence of Hermes copper butterflies is a factor within San Diego County for prioritizing land acquisitions for conservation from Federal, State, and private funding sources. SANDAG has provided funding for Hermes copper butterfly surveys and research since 2010, as well as grants for acquisition of two properties that have been (or are) occupied by Hermes copper butterfly. Of particular importance is the SANDAG-funded translocation research undertaken by San Diego State University (Marschalek and Deutschman 2016b), which, if successful, would provide a means to mitigate and reverse wildfire impacts to populations. The most obvious way to capitalize on the potential for cooperative, collaborative planning and decision making in Hermes copper butterfly conservation is through scenario planning. Scenario planning (Rowland et al. 2014) can serve multiple purposes, including education and outreach, decision support, and research. It is particularly appropriate in complex situations where drivers are not controllable and introduce irreducible uncertainty, such as the wildfire stressor for Hermes copper butterfly. Other drivers of change external to species' resources and beyond managers' direct control include population growth and demographic changes, land use patterns, and financial resource availability. Such uncertainties that cannot be reduced within a decision timeframe because they are beyond managerial control and/or outside current scientific knowledge make it difficult or even impossible to develop informative predictive models. Scenario planning offers an alternative approach to considering future conditions as uncertainties and the level of complexity of a situation increases, the longer one looks into the future. Our objective is for this SSA to be a significant first step in the scenario planning process, which we believe has the potential to increase Hermes copper butterfly viability (USFWS, 2018).

- Current Conservation Measures As described above under Land Use Change, under the MSCP, the City and County of San Diego implement ordinances that require Hermes copper butterfly surveys in potential habitat and specific measures to offset impacts to occupied Hermes copper butterfly habitat. In addition, presence of Hermes copper butterflies is a factor within San Diego County for prioritizing land acquisitions for conservation from Federal, State, and private funding sources. SANDAG has provided funding for Hermes copper butterfly surveys and research since 2010, as well as grants for acquisition of two properties that have been (or are) occupied by Hermes copper butterfly. Of particular importance is the SANDAG-funded translocation research undertaken by San Diego State University (Marschalek and Deutschman 2016b), which, if successful, would provide a means to mitigate and reverse wildfire impacts to populations. (USFWS, 2021)
- Scenario 3 – Conditions stay the same, resulting in extinction risk staying the same While environmental conditions never stay the same, changes that negatively affect populations may be offset by positive ones, including continued habitat conservation, and management actions such as translocations to recolonize burned habitats. In this scenario, the risk of wildfire remains high, population sizes fluctuate but they persist, and enough recolonizations occur to balance losses. Occurrence extirpations and decreased resilience of some populations in this scenario are balanced by habitat recolonizations and increased resilience in others. The species viability index value would thus remain at approximately 25% relative to historical conditions (Table 3). We judge this scenario about as likely as not to occur in the next 30 years. (USFWS, 2021)
- Action Plan This action plan provides the interim conservation and management needed during the time between final listing under the Endangered Species Act and completion of the recovery plan. This is an integral part of the recovery outline that helps guide recovery actions and informs other activities. The action plan below identifies (1) survival needs that must be addressed immediately to help reverse population decline, and (2) key recovery actions that should be initiated immediately along with the primary threats these actions address and potential partners for implementation. 1) Survival needs that must be addressed immediately: o Protect sufficient habitat to support resilient populations within core occurrence distributions from fire. o Implement actions to support occupancy and abundance in core occurrence complexes to support resilient populations that contribute to species representation and redundancy. 2) Key recovery actions that should be initiated immediately. o Protect all core occurrences ▯ Primary threats the actions will address: • Habitat loss due to fire, drought, and land use change • Fragmentation due to fire and land use change ▯ Potential partners for implementation: • County of San Diego • City of Santee • SANDAG • SDMMP • CDFW • BLM • Non-governmental organizations o Ensure conservation of dispersal corridor connectivity between northern and southern portions of the range and among core occurrence complexes in the southern portion of the range. ▯ Primary threat the actions will address is isolation of core occurrence complexes due to development ▯ Potential partners for implementation: • County of San Diego • City of Santee • SANDAG • SDMMP • CDFW o Fire prevention and protection of all occupied sites (particularly Roberts Ranch South and Boulder Creek sites) from wildfire. ▯ The primary threat the actions will address is population loss/mortality due to wildfire. ▯ Potential partners for implementation: • U.S. Forest Service • CalFire • County of San Diego • California Department of Transportation o Continued and expanded monitoring of reference sites within core occurrence distributions. ▯ Primary threats the actions will address by informing

management needs: • Extirpation of populations due to wildfire. • Decline and extirpation correlated with drought. Potential partners for implementation: • Wildspring Ecology/Spring Strahm (species expert). • U.S. Forest Service, Cleveland National Forest. • Bureau of Land Management • U.S. Geological Survey (USGS) • Dr. Dan Marschalek (species expert). • San Diego Management and Monitoring Program (SDMMP) • County of San Diego • City of San Diego • Marine Corps Air Station Miramar o Modeling of potential habitat to inform identification of new areas to survey for additional populations Primary threats the action will address: This will address all primary threats by informing our knowledge of management needs. More populations spread risk and increase species' redundancy. Potential Partners for implementation: • USGS/SDMMP o Surveys of potential habitat Primary threats the action will address: All by informing management needs. Potential Partners for implementation: • USGS/SDMMP • USFS • BLM o Collection, rearing, and translocation of individuals from the Roberts Ranch South site (Descanso core occurrence) or other relatively large populations. Primary threats the actions will address: • Extirpation of populations due to wildfire. • Decline and extirpation correlated with drought. Potential partners for implementation: • Wildspring Ecology (consultant specializing in management of endangered butterfly reintroduction). • San Diego Wildlife Alliance (Zoo/Paige Howorth). • U.S. Forest Service, Cleveland National Forest. • Dr. Dan Marschalek (species expert) • County of San Diego • San Diego National Wildlife Refuge • California Department of Fish and Wildlife (USFWS, 2022)

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SPECIES ACCOUNT: *Manduca blackburni* (Blackburn's sphinx moth)

Species Taxonomic and Listing Information

Commonly-used Acronym: BSM

Listing Status: Endangered; 02/01/2000; Pacific Region (R1) (USFWS, 2016)

Physical Description

Blackburn's sphinx moth is Hawaii's largest native insect, with a wing span of up to 5 inches (12 centimeters). Like other sphinx moths, it has long, narrow forewings and a thick, spindle-shaped body tapered at both ends. It is grayish-brown in color with black bands across the top margins of the hindwings and five orange spots along each side of the abdomen. The large caterpillars occur in two color morphs, bright green or gray, both with scattered white speckles throughout the back and a horizontal white stripe on the side margin of each segment.

Taxonomy

Blackburn's sphinx moth is closely related to the tomato hornworm (Manduca quinquemaculata) and has been confused with this species. Blackburn's sphinx moth was described by Butler (1880) as Protoparce blackburni, and named in honor of the Reverend Thomas Blackburn, who collected the first specimens (USFWS, 2000); Due to varying taxonomic classifications of the BSM, Rubinoff et al. (2012) conducted the first molecular analysis of phylogeny to include BSM and verified that the taxon should be considered a full species, with the tomato hornworm (Manduca quinquemaculatus) of North America being its closest relative. Ongoing genetic work, expected to be completed in 2019, is investigating the structure of the populations on Maui and Hawaiʻi islands to determine whether differences exist between them (State of Hawaii Division of Forestry and Wildlife [DOFAW] 2017). This genetic work was identified as a research need in the recovery plan (USFWS 2005). (USFWS, 2019)

Historical Range

See current range/distribution

Current Range

Reports by early naturalists indicate that BSM was once widespread and abundant, at least during European settlement, on nearly all the main Hawaiian Islands (Riotte 1986, p. 88). Very few specimens of the moth had been seen since 1940, and after a concerted effort by staff at the Bishop Museum to relocate this species in the late 1970s, it was considered to be extinct (Gagné and Howarth 1985, p. 5). In 1984, a single population was rediscovered on Maui (Riotte 1986, p. 80), and subsequently, populations on Hawaii, Kahoolawe, and Lanai were rediscovered (USFWS 2005, pp. 9-10; Duvall, pers. comm., 2011). Moth population numbers are believed to be small based upon past sampling results, however, no reasonably accurate estimate of population exists due to the adult moths' wide-ranging behavior and its overall rarity (A. Medeiros, USGS-BRD, pers. comm., 2014; Van Gelder and Conant 1998, pp. 7-16). Before humans arrived, dry and mesic shrubland and forest covered about 2,034,369 ac (823,283 ha) on all the main islands, and it is likely the moth inhabited much of that area (USFWS 2005, p. 16). There are no population estimates for the BSM (USFWS 2009). The BSM has been recorded from the islands of Kauai, Kahoolawe, Oahu, Lanai, Molokai, Maui, and Hawaii, and has been observed from sea level to 5,000 ft (1,525 m) elevation (USFWS 2005, p. 10; Duvall, pers. comm., 2011). Most historical records were from coastal or lowland dry forest habitats in areas receiving less than 50 in (127 cm) annual rainfall. On the island of Kauai, the moth was recorded only from the coastal area of Nawiliwili. Populations were known from Honolulu, Honouliuli, and Makua on leeward Oahu, and Kamalo, Mapulehu, and Keopu on Molokai. On Hawaii, it was known from Hilo, Pahala, Kalaoa, Kona, and Hamakua. It appears this moth was historically most common on Maui, where it was recorded from Kahului, Spreckelsville, Makena, Wailuku, Kula, Lahaina, and West Maui. Historical records are lacking for the islands of Kahoolawe and Lanai. The moth has been observed there only in very recent years during biological surveys conducted for various restoration activities on these islands. ***FROM 2019 5-YEAR REVIEW: We now know that it is more widespread on at least Maui and Hawaiʻi. While key sites on Maui and Hawaiʻi were associated with the largest concentrations of ʻaiea on the respective islands, at least one of the original Maui sites and the population on Kahoʻolawe had no ʻaiea present. At these sites, the species appeared entirely dependent on tree tobacco; or on Maui, possibly on naturalized commercial tobacco (Nicotiana tabacum) (USFWS 2000). Our current knowledge of the overall distribution of BSM is based largely on incidental sightings. On Maui, observations of BSM have been made from the Kanaio area on leeward Haleakalā, ʻUlupalakua, Wailea/Mākena, Makawao, Launiupoko on west Maui, along Kuihelani Highway in the central valley, and along the north coast from Waiheʻe to Kanahā (USFWS 2005, USFWS unpubl. data). Island Distribution: Found on Maui and Hawaii. Extirpated on Kauai, Oahu, Molokai and Lanai (USFWS, 2021c)

Critical Habitat Designated

Yes; 6/10/2003.

Legal Description

On June 10, 2003, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the Blackburn's sphinx moth (Manduca blackburni), pursuant to the Endangered Species Act of 1973, as amended (Act). A total of approximately 22,440 hectares (55,451 acres) fall within the boundaries of the 9 critical habitat units designated on the Hawaiian islands of Hawaii, Kahoolawe, Maui, and Molokai for Blackburn's sphinx moth.

Critical Habitat Designation

Critical habitat includes habitat for the Blackburn's sphinx moth on the islands of Hawaii, Kahoolawe, Maui, and Molokai. Lands designated as critical habitat have been divided into 9 units.

Unit 1: Puu O Kali (Maui). Unit 1 consists of approximately 1,604 ha (3,965 ac) on State and private land, encompassing portions of the leeward slope of Haleakala and adjacent portions of the upper southeast isthmus. The unit is bounded on the north and the south by pasture lands, on the east by the lower slopes of Haleakala below the area of Kula, and on the west by the coastal town of Kihei. Natural features within the unit include widely spread, remnant dry forest communities, rugged aa lava flows, and numerous cindercones, including the highly visible Puu O Kali. Vegetation consists primarily of mixed-species mesic and dry forest communities composed of native and introduced plants (HHP 1993). Along with Units 2, 3, and 4, this unit contains what is probably the largest extant Blackburn's sphinx moth population or metapopulation. This unit is essential to the species' conservation because it is occupied and contains the native larval host plant Nothocestrum latifolium, and other nectar-supplying plants for adult moths. In addition to providing essential habitat for the Maui metapopulation, areas within this unit provide temporary (ephemeral) habitat for migrating Blackburn's sphinx moths.

Unit 2: Cape Kinau (Maui). Unit 2 consists of approximately 603 ha (1,490 ac) on State and private land, encompassing Cape Kinau and the entire Ahihi-Kinau NAR. The unit is bounded on the north by Puu Naio, to the south by the ocean, to the east by La Perouse Bay, and on the west by Ahihi Bay. Natural features within the unit include widely spread, remnant dry forest communities, and numerous rugged aa lava flows. Vegetation consists primarily of mixed-species dry forest communities composed of native and introduced plants, with smaller amounts of dry coastal shrubland (HHP 1993). Along with Units 1, 3, and 4, this unit contains what is probably the largest extant Blackburn's sphinx moth population or metapopulation. This unit is essential to the species' conservation because it is occupied and contains the native larval host plant Nothocestrum latifolium, and other nectar-supplying plants for adult moths. In addition to providing essential habitat for the Maui metapopulation, areas within this unit provide ephemeral habitat for migrating Blackburn's sphinx moths.

Unit 3: Kanaio (Maui). Unit 3 consists of approximately 2,421 ha (5,982 ac) on State and private land, encompassing portions of the leeward slope of Haleakala and adjacent portions of the upper southeast isthmus. The unit is bounded on the north by pasture lands, to the south by ocean, to the east by the Kanaio NAR boundary and Puu Hokukano, and on the west by the Kanaio Homesteads and Cape Hanamanioa. Natural features within the unit include widely spread, remnant dry forest communities, rugged aa lava flows, and numerous cindercones including the highly visible Puu Pimoe. Vegetation consists primarily of mixedspecies mesic and dry forest communities composed of native and introduced plants, with smaller amounts of dry coastal shrubland (HHP 1993). Along with Units 1, 2, and 4, this unit contains what is probably the largest extant Blackburn's sphinx moth population or metapopulation. This unit is essential to the species' conservation because it is occupied and contains the native larval host plant Nothocestrum latifolium, and other nectar-supplying plants for adult moths. In addition to providing essential habitat for the Maui metapopulation, areas within this unit provide ephemeral habitat for migrating Blackburn's sphinx moths.

Unit 4: Kahikinui (Maui). Unit 4 consists of approximately 4,799 ha (11,859 ac) on State and private land, encompassing portions of the leeward slope of Haleakala. The unit is bounded on the northeast by the 1,525 m (5,000 ft) elevation contour of Haleakala Volcano, to the south by the ocean, to the east by Poopoo Gulch, and on the west by Lualailua Hills. Natural features within the unit include widely spread, remnant dry forest communities, rocky coastline, numerous cindercones, and some of the most recent lava flows on Maui. Vegetation consists primarily of mixed-species mesic and dry forest communities composed of native and introduced plants, with smaller amounts of dry coastal shrubland (HHP 1993). Along with Units 1, 2, and 3, this unit contains what is probably the largest extant Blackburn's sphinx moth population or metapopulation. This unit is essential to the species' conservation because it is occupied and contains the native larval host plant Nothocestrum latifolium, and other nectar-supplying plants for adult moths. In addition to providing essential habitat for the Maui metapopulation, areas within this unit provide ephemeral habitat for migrating Blackburn's sphinx moths.

Unit 5: Kanaha Pond (Maui). Unit 5 consists of approximately 56 ha (139 ac) on State land, entirely comprised of the Kanaha Pond State Sanctuary on Maui. It is bounded on the south by the Kahului Airport, on the north by the ocean, on the east by coastline, and to the west by the town of Kahului. Natural features within the unit includes Kanaha Pond and remnant coastal dune communities. Vegetation consists primarily of mixed-species, dry coastal shrub land communities composed of native and introduced plants, including nonnative larval host plants (HHP 2000). Although devoid of naturally occurring Nothocestrum spp., the unit is essential to the species' conservation because it contains adult Blackburn's sphinx moth primary constituent elements, and recent observations of both larvae and adults have been documented within the sanctuary. Although this unit is lower in elevation than areas currently containing Nothocestrum plants, the persistent occurrence of Blackburn's sphinx moth within the Kanaha Pond State Sanctuary and other nearby areas indicates this site provides habitat for this area's moth population, and plays an important role in the species' population dynamics. Based upon an understanding of this species and other moth species' flight capabilities and migrational needs, we believe that designation of this area contributes to the available matrix of undeveloped habitat necessary as refugia for Blackburn's sphinx moths migrating to other areas of existing suitable host plant habitat on Maui (A. Medeiros, pers. comm. 1998; S. Montgomery, pers. comm. 2001; McIntyre and Barrett 1992; Roderick and Gillespie 1997; Van Gelder and Conant 1998).

Unit 6: Kanaha Park (Maui). Unit 6 consists of approximately 25 ha (62 ac) of State land, entirely comprised of coastal land on Maui. It is bounded on the south by the Kahului Airport, on the north by the ocean, on the east by other coastal lands, and immediately to the west by the Kanaha Pond State Sanctuary. Natural features within the unit include remnant coastal dune communities. Vegetation consists primarily of mixed-species, dry coastal shrub land communities composed of native and introduced plants, including nonnative larval host plants (HHP 2000). We have no recent and verified Blackburn's sphinx moth observations within this unit. However, the unit is considered essential to the species' conservation because it is within the geographical area occupied by the species at the time of listing and contains the moth's adult stage primary constituent elements. Furthermore, recent observations of both larvae and adults have been documented within the adjacent Kanaha Pond State Sanctuary and in the nearby KanahaSpreckelsville area. Although this unit is lower in elevation than areas currently containing Nothocestrum plants, the persistent occurrence of Blackburn's sphinx moth within the nearby Kanaha Pond State Sanctuary, and other nearby areas, indicates this site provides habitat for this area's moth population and plays an important role in the species' population dynamics. Based upon an understanding of this species and other moth species' flight capabilities and migrational needs, we believe that designation of this area contributes to the available matrix of undeveloped habitat necessary as refugia for adult Blackburn's sphinx moths migrating to other areas of existing suitable host plant habitat on Maui in order to forage or lay eggs (A. Medeiros, pers. comm. 1998; S. Montgomery, pers. comm. 2001; McIntyre and Barrett 1992; Roderick and Gillespie 1997; Van Gelder and Conant 1998).

Unit 7: Upper Kahoolawe (Kahoolawe) Unit 7 consists of approximately 1,721 ha (4,252 ac) on State land, encompassing portions of the upper elevational contour of Kahoolawe, approximately above 305 m (1,000 ft) in elevation. Kahoolawe is located approximately 11 km (6.7 mi) south of Maui and is approximately 11,655 ha (28,800 ac) in total land area. Natural features within the unit include the main caldera, Lua Makika, and Puu Moaulaiki. Vegetation within the unit consists primarily of mixed-species, mesic and dry grass and shrubland communities composed of primarily introduced plants and some native plant species (HHP 2000). This unit contains a large Blackburn's sphinx moth population, which may or may not be part of the larger Maui populations. Adult host plants identified as primary constituent elements are numerous within this area. Because the unit is occupied, harbors adult native host plants, and is in close proximity to the large Maui moth population, this unit is essential for Blackburn's sphinx moth conservation and would improve dispersal and migration corridors and thus expand population recruitment potential (P. Higashino, pers. comm. 2001).

Unit 8: Puuwaawaa—Hualalai (Hawaii). Unit 8 consists of approximately 9,954 ha (24,597 ac) on State and private land, encompassing portions of the flows and northwest slopes of Hualalai volcano on the island of Hawaii. It is bounded on the south by the KailuaKona region and large expanses of barren lava flows, on the north by Parker Ranch and large expanses of nonnative grass lands, to the east by the upper slopes of Hualalai volcano, and to the west by lava flows and coastal land. Natural features within the unit include Puuwaawaa cindercone and significant stands of native dry forest including the adult Blackburn's sphinx moth's nectar food plants and large numbers of Nothocestrum breviflorum host plants (Perry 2001). Vegetation consists primarily of mixed-species mesic and dry forest communities composed of native and introduced plants, with smaller amounts of dry coastal shrubland (HHP 2000). This unit is essential to the species' conservation because frequent and persistent observations of both Blackburn's sphinx moth larvae and adults throughout this unit indicate that Unit 8 contains the largest population of Blackburn's sphinx moth on the island of Hawaii. In addition to providing habitat for this area's population, Unit 8 provides refugia for moths migrating to other areas of existing suitable host plant habitat. As previously discussed, given the large size and strong flight capabilities of the Blackburn's sphinx moth, support for moth population linkages requires habitat in large contiguous blocks or within a matrix of undeveloped habitat (A. Medeiros, pers. comm.1998; S. Montgomery, pers. comm. 2001; McIntyre and Barrett 1992; Roderick and Gillespie 1997; Van Gelder and Conant 1998).

Unit 9: Kamoko Flats—Puukolekole (Molokai). Unit 9 consists of approximately 1,256 ha (3,105 ac) on State and private land, encompassing portions of the higher, yet drier portions of east Molokai. It is bounded on the north by wet forests, to the south by drier coastal land, to the east by rugged, dry gullies and valleys, and to the west by dry to mesic lowland forest. Natural features within the unit include numerous forested ridges and gullies. Vegetation consists primarily of mixed-species mesic and dry forest communities composed of native and introduced plants (HHP 2000). This unit is part of the historical range of the moth. Unit 9 is not known to currently contain a Blackburn's sphinx moth population, but it does contain native Nothocestrum host plants, including N. longifolium and N. latifolium (Wood 2001a), as well as adult native host plants. Because Unit 9 contains both larval and adult native host plants and is in close proximity to the large Maui population, it is essential for Blackburn's sphinx moth conservation. It would allow the species to expand into a former part of its historical range in very close proximity to its current range on the island of Maui. Furthermore, it may facilitate dispersal and provide a flight corridor for moths eventually migrating to the island of Oahu, which is also part of its historical range. Due to its proximity to the island of Maui where the current and presumed highest historical concentration of Blackburn's sphinx moth occurred, and because this unit contains currently and historically known dry and mesic habitats to support the larval and adult native host plants, scientists believe that the Blackburn's sphinx moth will reestablish itself on this unit over time (F. Howarth, pers. comm. 2001). Furthermore, this unit lacks some of the serious potential threats to the moth, three ant, and one wasp species (see Table 1). Conserving and restoring Blackburn's sphinx moth populations in multiple locations decreases the likelihood that the effect of any single alien parasite or predator or the combined pressure of such species and other threats could result in the diminished vigor or extinction of the moth. Including this unit also reduces the possibility of the species' extinction from catastrophic events impacting the existing populations on other islands. Designating critical habitat within this area on Molokai is complementary to existing and planned management activities of the landowners. The critical habitat unit lies within a larger existing conservation area to be managed for watershed conservation and the conservation of endangered and rare species. The landowners, State and Federal resource agencies, and local citizens groups are involved with these planned natural resource management activities on Molokai.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for the Hawaiian islands of Maui, Kahoolawe, Hawaii, and Molokai. The primary constituent elements of critical habitat for Blackburn's sphinx moth include specific habitat components identified as essential for the primary biological needs of foraging, sheltering, maturation, dispersal, breeding, and egg-laying.

(i) The primary constituent elements required by Blackburn's sphinx moth larvae for foraging and maturation are two larval host plant species in the endemic genus Nothocestrum (N. breviflorum and N. latifolium) and the habitats that support these plants, i.e., dry and mesic habitats between the elevations of sea level and 1,525 m (5,000 ft) that receive between 25 and 250 cm (10 and 100 in) of annual precipitation.

(ii) The primary constituent elements required by Blackburn's sphinx moth adults for foraging, sheltering, dispersal, breeding, and egg production are native nectar-supplying plants, including, but not limited to, Ipomoea spp., Capparis sandwichiana, and Plumbago zeylanica, and the habitats that support these plants, i.e., dry and mesic habitats between the elevations of sea level and 1,525 m (5,000 ft) that receive between 25 and 250 cm (10 and 100 in) of annual precipitation.

Special Management Considerations or Protections

Existing manmade features and structures within the boundaries of the mapped areas do not contain one or more of the primary constituent elements described for the species in paragraph (2) of this section, and therefore, are not included in the critical habitat designations. These features include, but are not limited to: buildings; roads; aqueducts and other water system features such as pumping stations, irrigation ditches, pipelines, siphons, tunnels, water tanks, gauging stations (section in a stream channel equipped with facilities for obtaining streamflow data), intakes, and wells; telecommunications towers and associated structures and equipment; electrical power transmission lines and associated rights-of-way; radars; telemetry antennas; missile launch sites; arboreta and gardens; heiau (indigenous places of worship or shrines); airports; other paved areas; lawns; and other rural residential landscaped areas.

Life History

Feeding Narrative

Larvae: Larvae feed on plants in the nightshade family (Solanaceae), which includes both native (e.g., Nothocestrum spp. [‘aiea]) and non-native (e.g., Nicotiana spp. [tobacco]) species. Nicotiana glauca (tree tobacco) is the most commonly used larval food plant for BSM caterpillars (USFWS, 2022).

Adult: Sphingid moths in general are known to exploit nutritious but low-density, low-apparency host plants such as vines and sapling trees (Kitching and Cadiou 2000), many which possess secondary compounds the larvae can metabolize and/or sequester for their own defense (Nishida 2002). Larvae of the BSM feed on plants in the nightshade family (Solanaceae). Native host plants include trees within the aiea genus Nothocestrum (Riotte 1986, p. 89), on which the larvae consume leaves, stems, flowers, and buds (B. Gagne, pers. comm., 2010). Three of the species in this genus are federally listed as endangered: Nothocestrum latifolium, located on Maui, Molokai, Lanai, Oahu and Kauai; Nothocestrum breviflorum, located on the island of Hawaii, and Nothocestrum peltatum, located only on the island of Kauai. There are also four native species in the popolo genus Solanum (i.e., Solanum americanum, S. incompletum, S. nelsonii, and S. sandwicense) that may also be host plants, though there is only evidence of moth larvae utilizing Solanum sandwicense (Rubinoff and San Jose 2010, p. 55) and Solanum americanum (E. Parsons, pers. comm., 2014). Many of the other host plants recorded for this species are not native to the Hawaiian Islands, and include commercial tobacco (Nicotiana tabacu), tree tobacco (Nicotiana glauca), and possibly Jimson weed (Datura stramonium) (Riotte 1986, p. 89).

Reproduction Narrative

Adult: BSM larvae sightings have been documented in all months but July, and it is likely that with good rainfall they could be found year-round, and adult moths have been found throughout the year (Riotte 1986, p. 88; DOFAW 2014; Rounds pers. comm. 2014). Moth larvae have been documented feeding on two Nothocestrum species, N. latifolium and N. breviflorum; it is likely that N. peltatum and N. longifolium are suitable host plants for larval moths as well, although N. peltatum has declined to such low numbers it would have been difficult for the moth to find any trees in recent years. This is supported not only by the fact that they are closely related to known larval hosts, but also because there are past historical records of the moth occurring on the islands of Kauai and Oahu, where aiea (N. latifolium) is not abundant and N. breviflorum does not occur. Furthermore, the species is known to feed on a variety of native and non-native Solanaceae. In general, sphingid moths can develop from egg to adult in as little as 56 days (Williams 1947, p. 10), but pupae may remain in a state of torpor (inactivity) in the soil for up to a year (B. Gagné, pers. comm., 2010; Williams 1931, p. 373). Adult sphingid moths have been found throughout the year (Riotte 1986, p. 88) and are known to feed on nectar. In general, sphingids are known to live longer than most moths because of their ability to feed and take in water from a variety of sources, rather than relying only upon stored fat reserves. Because they live longer than most moths, female sphingid moths have less time pressure to mate and lay eggs, and often will take more time in locating the best host plants for egg laying (Kitching and Cadiou 2000).

Habitat Narrative

Larvae: Rubinoff and San Jose (2010) examined larval host plant preferences for this species and confirmed findings of previous studies that BSM larvae could develop on a range of native and non-native plants in the Solanaceae (nightshade) family. In addition to using known larval hosts like the native and endangered ʻaiea (Nothocestrum spp.) and the invasive1 tree tobacco (Nicotiana glauca), BSM also have the ability to develop fully on the native ʻolohua (glossy nightshade; Solanum americanum) and pōpoloʻaikeakua (Solanum sandwicense) in a laboratory setting (Rubinoff and San Jose 2010). These potential larval host plants could provide additional restoration options for land managers that would benefit this species (Rubinoff and San Jose 2010). Closely related sphinx moth species have been found to feed on tobacco and then use the chemicals gained from the plant for their own defense (Kumar et al. 2014). It is possible that the BSM makes similar use of tree tobacco, which contains the extremely toxic (to humans) alkaloid anabasine, in addition to nicotine (Saitoh et al. 1985). Previous studies have shown that a potential predator of the BSM, the Argentine ant (Linepithema humile), may be deterred by nicotine from preying on a closely related species, the tobacco hornworm (Manduca sexta) (Cornelius and Bernays 1995). Increased survival of larvae due to a host shift could have positive implications for conservation management of this species in the future. (USFWS, 2019)

Adult: Sphingid moths in general are known to exploit nutritious but low-density, low-apparency host plants such as vines and sapling trees (Kitching and Cadiou 2000), many which possess secondary compounds the larvae can metabolize and/or sequester for their own defense (Nishida 2002). Larvae of the BSM feed on plants in the nightshade family (Solanaceae). Native host plants include trees within the aiea genus Nothocestrum (Riotte 1986, p. 89), on which the larvae consume leaves, stems, flowers, and buds (B. Gagne, pers. comm., 2010). Three of the species in this genus are federally listed as endangered: Nothocestrum latifolium, located on Maui, Molokai, Lanai, Oahu and Kauai; Nothocestrum breviflorum, located on the island of Hawaii, and Nothocestrum peltatum, located only on the island of Kauai. There are also four native species in the popolo genus Solanum (i.e., Solanum americanum, S. incompletum, S. nelsonii, and S. sandwicense) that may also be host plants, though there is only evidence of moth larvae utilizing Solanum sandwicense (Rubinoff and San Jose 2010, p. 55) and Solanum americanum (E. Parsons, pers. comm., 2014). Many of the other host plants recorded for this species are not native to the Hawaiian Islands, and include commercial tobacco (Nicotiana tabacu), tree tobacco (Nicotiana glauca), and possibly Jimson weed (Datura stramonium) (Riotte 1986, p. 89). The largest populations of BSM, on Maui and Hawaii, have been associated with remnant populations of trees in the genus Nothocestrum (Van Gelder and Conant 1998, pp.14-15), though the spread of tree tobacco may have changed this. The large stand of Nothocestrum trees within Kanaio Natural Area Reserve, Maui, is likely the largest in the State (Medeiros et al. 1993, p. 19), and may explain why it was able to persist in the Kanaio area (A. Medeiros, USGS-BRD, pers. comm., 1994). Nothocestrum is a genus of four species endemic to the Hawaiian Islands (Symon 1999, pp. 1251-1278). Nothocestrum species currently occur on Kauai, Oahu, Molokai, Lanai, Hawaii, and Maui. One species, N. longifolium, primarily occurs in wet forests, but can occur in mesic forests as well. Three species, N. latifolium, N. breviflorum, and N. peltatum, occur in dry to mesic forests, the habitat in which the moth has been most frequently recorded. Plant species composition in the moth’s habitat varies considerably depending on location and elevation, but some of the most common native plants in areas where the moth occur are lama (Diospyros sandwicensis), hao (Rauvolfia sandwicensis), ohe (Reynoldsia sandwicensis), alaa (Pouteria sandwicensis), aalii (Dodonaea viscosa), wiliwili (Erythrina sandwicensis), and naio (Myoporum sandwicense) (USFWS 2005, p. 13).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Very capable of moving between islands, although it is not known to what extent they do so. (NatureServe, 2015)

Additional Life History Information

Larvae: Blackburn’s sphinx moth larvae develop through five instars prior to burrowing into the ground to pupate (Elliot 2019, p. 22). Estimated larval development time is approximately three weeks: two weeks to complete instars one through four, then an additional week as a fifth instar (Rubinoff and San Jose 2010, p. 57; Elliot 2019, p. 22). Immediately prior to pupation, the fifth instar larva enters a wandering phase, leaving its natal host plant in search of a suitable spot to burrow, create its pupation chamber, and pupate (USFWS, 2022).

Population Information and Trends

Number of Populations:

4 (USFWS, 2021c)

Population Size:

unknown (USFWS, 2021c)

Population Narrative:

In 1984, a single population was rediscovered on Maui (Riotte 1986, p. 80), and subsequently, populations on Hawaii, Kahoolawe, and Lanai were rediscovered (USFWS 2005, pp. 9-10; Duvall, pers. comm., 2011). Moth population numbers are believed to be small based upon past sampling results, however, no reasonably accurate estimate of population exists due to the adult moths' wide-ranging behavior and its overall rarity (A. Medeiros, USGS-BRD, pers. comm., 2014; Van Gelder and Conant 1998, pp. 7-16). Before humans arrived, dry and mesic shrubland and forest covered about 2,034,369 ac (823,283 ha) on all the main islands, and it is likely the moth inhabited much of that area (USFWS 2005, p. 16). There are no population estimates for the BSM (USFWS 2009). The current population numbers of the BSM are currently unknown and it's unclear if the population is increasing, decreasing, or stable. Based on incidental sightings, their range is thought to be expanding. However, range size and abundance are not correlated, with range size alone being considered a weak predictor of density (Novosolov et al. 2017, p. 1,092). To accurately evaluate the BSM population status, multi-month surveys are needed on the islands of Hawaiʻi, Maui, and Kahoʻolawe (USFWS, 2022)

Threats and Stressors

Stressor: Present or threatened destruction, modification or curtailment of its habitat or range
Exposure:
Response:
Consequence:
Narrative: Blackburn's sphinx moths are found in dry to mesic forest habitats. Its habitats have been severely degraded due to past and present land management practices including ranching, the impacts of introduced plants and animals, wildfire, and agricultural development (Cuddihy and Stone 1990). Due to these factors, Nothocestrum peltatum on Kauai, N. breviflorum on Hawaii, and N. latifolium on Kauai, Lanai, Maui, Molokai and Oahu, all of which are potential native host plants for Blackburn's sphinx moth, are now either federally listed as endangered species or are candidates for listing (USFWS 1994a,1994b, 2006). Nothocestrum peltatum is known from seven populations totaling 23 individuals on Kauai while N. breviflorum is known from 171 individuals on the island of Hawaii (USFWS 2003b, 2007b). Nothocestrum latifolium is known from 19 populations totaling fewer than 1,100 individuals. Specifically, known numbers consist of 1 population of 1 individual on Kauai, 4 populations of 9 individuals on Lanai, 3 populations of over 1,000 individuals on Maui, 5 populations of 45 to 50 individuals on Molokai, and 6 populations totaling 10 individuals on Oahu (Hawaii Biodiversity and Mapping Program 2006; W. Moses, The Nature Conservancy of Hawaii, pers. comm. 2006; F. Starr, U.S. Geological Survey, Biological Resources Discipline, pers. comm. 2006; H. Oppenheimer, pers. comm. 2006). A fourth species, Nothocestrum longifolium, is found primarily in wet forest and occasionally in mesic forests on all of the main islands except Kahoolawe and Niihau (Wagner et al. 1999). This species is not federally listed or a candidate for listing at this time and information on the number of individuals and populations is not available. Efforts to outplant Nothocestrum species have been undertaken in Management Units on Maui and Hawaii (Allen 2000, Medeiros 2006). In addition, ungulate exclosures and, in some cases, ungulate control has been undertaken in Management Units on Kauai Lanai, Molokai, Maui, and Hawaii (Williams 2000; Medeiros 2006; Hawaii Department of Land and Natural Resources 2007; J. Higashino, USFWS, pers. comm. 2008). However, additional management is needed in these management units to help achieve the recovery of the species. (USFWS, 2009)

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes
Exposure:
Response:
Consequence:
Narrative: Sphinx moths, in general, are sought by collectors and as early as the 1950s there was a standing reward for specimens of another rare Hawaiian sphinx moth (Tinostoma smargditis) (Zimmerman 1958). Unrestricted collecting and handling for scientific purposes are also known to impact populations of other species of rare Lepidoptera (Murphy 1988). Collection for scientific purposes is now monitored and permitted, if appropriate, under Section 10 of the Endangered Species Act. No information is available on the level of illegal collection. (USFWS, 2009)

Stressor: Ants (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Ants, family Formicidae within the order Hymenoptera, are not a natural component of Hawaii's arthropod fauna, and native species evolved in the absence of predation pressure from ants. Ants can be particularly destructive predators because of their high densities, recruitment behavior, aggressiveness, and broad range of diet (Reimer 1993). Because they are generalist feeders, ants may affect prey populations independent of prey density, and may locate and destroy isolated individuals and populations (Nafus 1993a). At least 36 species of ants are known to be established in the Hawaiian Islands, and at least 3 particularly aggressive species have severely affected the native insect fauna (Zimmerman 1948). Most ant species have winged reproductive adults and once established anywhere in the State, they are likely to colonize suitable habitats on all islands in time. By the late 1870s, the big-headed ant (Pheidole megacephala) was present in Hawaii and its predation on native insects was noted by Perkins (1913) who stated, “it may be said that no native Hawaiian Coleoptera insect can resist this predator, and it is practically useless to attempt to collect where it is well established. Just on the limits of its range one may occasionally meet with a few native beetles, e.g., species of Plagithmysus, often with these ants attached to their legs and bodies, but sooner or later they are quite exterminated from these localities.” With few exceptions, in Hawaiian habitats where the big-headed ant is present, native insects, including most moths, are eliminated (Gagné 1979; Gillespie and Reimer 1993; Perkins 1913). The big-headed ant generally does not occur at elevations higher than 600 meters (2,000 feet), and is also restricted by rainfall, rarely being found in particularly dry (less than 35 to 50 centimeters (15 to 20 inches) annually) or wet areas (more than 250 centimeters (100 inches) annually) (Reimer et al. 1990). The big-headed ant is also known to be a predator of eggs and caterpillars of native Lepidoptera, and can completely exterminate populations (Zimmerman 1958). This ant occurs at all of the Maui Blackburn’s sphinx moth management units (A. Medeiros et al., in litt., 1993). Big-headed ants also occur on Kahoolawe and Hawaii (A. Medeiros, pers. comm., 1998; F. Starr, in litt., 2004). Oddly, there have been some recent observations of moth larvae in areas heavily populated by the big-headed ant (L. Loope, in litt., 2004), so it is possible that this species is not a significant threat to all insect species. The Argentine ant (Iridomyrmex humilis) was discovered on the island of Oahu in 1940

(Zimmerman 1941) and is now established on seven main islands. Unlike the big-headed ant, the Argentine ant is primarily confined to elevations higher than 500 meters (1,600 feet) in areas of moderate rainfall (Reimer et al. 1990). This species can reduce or even eliminate populations of native arthropods at high elevations in Haleakala National Park on Maui (Cole et al. 1992). On Maui, within 16 kilometers (10 miles) of the largest Blackburn's sphinx moth population, Argentine ants are significant predators on pest fruit flies (Wong et al. 1984). Argentine ants have also been reported on the islands of Kahoolawe and Hawaii (A. Asquith, Hawaii Sea Grant Program, pers. comm., 1998; A. Medeiros, pers. comm., 1998). The long-legged ant (Anoplolepis longipes) appeared in the State in 1952 and now occurs on Oahu, Maui, and Hawaii (Reimer et al. 1990). It inhabits elevations under 600 meters (2,000 feet), in rocky areas with low to high annual rainfall (Reimer et al. 1990). Direct observations indicate that Hawaiian arthropods are susceptible to predation by this species (Gillespie and Reimer 1993) and Hardy (1979) documented the disappearance of most native insects from Puaaluu in the Kipahulu District on Maui after the area was invaded by the long- legged ant. At least two species of fire ants, Solenopsis geminata and S. papuana, are also significant threats (Gillespie and Reimer 1993; Reagan 1986) and occur on all of the seven islands within some management units (Reimer et al. 1990). Ants, including the fire ant, S. geminata, are known to be the most signficant and consistent mortality factor on eggs, and probably larvae, of the butterfly Hypolimnas bolina (common eggfly) in Guam, even where both predator and prey are native (Nafus 1993a, 1993b). Solenopsis geminata is known to occur within both the two, large moth management units on Maui (A. Medeiros, pers. comm., 1998; F. Starr, in litt., 2004). Fortuitously, the red imported fire ant (Solenopsis invicta) has not yet made its way to the Hawaiian Islands, at least there are no documented occurrences of this species in Hawaii. Slowly spreading through the southeast region of the mainland U.S. since the 1930s, the red imported fire ant has in recent years become established in California where it is causing significant problems for wildlife, agriculture, and quality of life (Jetter et al. 2002). Based upon what we know of red imported fire ant's effects on the mainland U.S. and elsewhere, this species of fire ant would undoubtedly prey upon Hawaii's native insect fauna including the Blackburn's sphinx moth (Allen et al. 1994; Brinkley et al. 1991; Jetter et al. 2002). The report by Jetter et al. lists the red imported fire ant as a threat to the only other federally endangered sphinx moth in the U.S., the Kern primrose sphinx moth (Euproserpinus euterpe). Recently, the Hawaii Department of Health has taken a more proactive approach to the red imported fire ant threat in developing a strategy for preventing the species' establishment and also a contingency plan for addressing the potential scenario in the event of an unfortunate establishment (Hawaii Ant (Working) Group, in litt., 2001). The possibility of red imported fire ants becoming established is a serious potential threat which we must be prepared to address in order to ensure the recovery of Blackburn's sphinx moth as well as all remaining native ecosystems in Hawaii (Hawaii Ant (Working) Group, in litt., 2001). Ochetellus glaber (no common name), a recently reported ant introduction, occurs in the same habitat utilized on Kahoolawe by Blackburn's sphinx moth (A. Medeiros, pers. comm., 1998; F. Starr in litt., 2004), and is also found on Hawaii, Kauai, Maui, and Oahu. Ochetellus glaber has been found in relatively high numbers foraging on shrubs of Nicotiana sp. where Blackburn's sphinx moth eggs and larvae occur. In one instance, large numbers of O. glaber were observed emerging from a dead Blackburn's sphinx moth larvae they had either predated or scavenged (A. Medeiros, pers. comm., 1998). During the same study on Kahoolawe, Medeiros noted a large proportion of tagged Blackburn's sphinx moth eggs disappeared without hatching, potentially indicating high egg predation most likely by ants, but perhaps dislodged by birds (A. Medeiros, pers. comm., 1998). (USFWS, 2005); During recent surveys for BSM at Puʻu Anahulu, Argentine ants appeared to be expanding their range into areas currently occupied by the species (DOFAW 2017). Argentine ants are suspected as potential predators of the eggs and larvae of this species, though their ranges do not generally overlap, so this expansion downslope could be a significant development for the populations in the area. (USFWS, 2019)

Stressor: Natural or manmade factors affecting its continued existence (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: In addition to, or perhaps because of, habitat loss and fragmentation, Blackburn's sphinx moths are also susceptible to seasonal variations and weather fluctuations affecting their quality and quantity of available habitat and food. For example, during times of drought, it is expected nectar availability for adult moths will decrease. During times of decreased nectar availability, life spans of individuals may not be affected, but studies with butterflies have shown marked decreases in reproductive capacity for many species (Center for Conservation Biology Update 1994). In another study, Janzen (1984) reported that host plant availability directly affected sphingid reproductive activity. In fact, for some lepidopteran (butterflies and moths) species, if nectar intake is cut in half, reproduction is also cut approximately in half. Such resource stress may occur on any time scale, ranging from a few days to an entire season, and a pattern of continuous long-term adult feeding stress could affect the future viability of a population (Center for Conservation Biology Update 1994). Often, habitat suitability for herbivorous insects is determined by factors other than host plant occurrence or density. Micro-climatic conditions (Thomas 1991; Solbreck 1995) and predator pressure (Roland 1993; Roland and Taylor 1995; Walde 1995) are two such widely reported factors. In a study of moth population structure, habitat patch size and the level of sun exposure were shown to affect species occupancy, while patch size and the distance from the ocean coast were reported to affect moth density (Forare and Solbreck 1997). Moth populations in small habitat patches were more likely to become extinct (Forare and Solbreck 1997). (USFWS, 2005); Climatic changes associated with global warming could severely impact the distribution and availability of Blackburn's sphinx moth habitat. (USFWS, 2009)

Stressor: Parasitic Wasps (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Hawaii also has a limited fauna of native Hymenoptera, with only two native species in the family Braconidae (Beardsley 1961), neither of which are known to parasitize Blackburn's sphinx moth. In contrast, other species of Braconidae are common predators (parasitoids) on the larvae of the tobacco hornworm and the tomato hornworm in North America (Gilmore 1938). There are now at least 74 non-native species, in 41 genera, of braconid wasps established in Hawaii, of which at least 35 species were purposefully introduced as biological control agents

(Nishida 1997). Most species of alien braconid and ichneumonid wasps that parasitize moths are not host-specific, but attack the caterpillars or pupae of a variety of moths (Funasaki et al. 1988; Zimmerman 1948, 1978) and have become the dominant larval parasitoids even in intact, high-elevation, native forest areas of the Hawaiian Islands (F.G. Howarth et al., in litt., 1994; Zimmerman 1948). These wasps lay their eggs within the eggs or caterpillars of Lepidoptera. Upon hatching, the wasp larvae consume internal tissues, eventually killing the host. At least one species established in Hawaii, Hyposoter exiguae (no common name), is known to attack the tobacco hornworm and the related tomato hornworm in North America (Carlson 1979). This wasp is recorded from all seven islands with management units except Kahoolawe and Lanai (Nishida 1997) and is a recorded parasitoid of the lawn armyworm (Spodoptera maurita) on tree tobacco on Maui (Swezey 1927). Because of the rarity of Blackburn's sphinx moth, no documentation exists of alien braconid and ichneumonid wasps parasitizing the species. However, given the abundance and the breadth of available hosts of these wasps, they are considered significant threats to the moth (Gagné and Howarth 1985; Howarth 1983; Howarth et al., in litt., 1994; F. G. Howarth, pers. comm., 1994). Small wasps in the family Trichogrammatidae parasitize insect eggs, with numerous adults sometimes developing within a single host egg. The taxonomy of this group is confusing, and it is unclear if Hawaii has any native species from this family (Nishida 1997; J. Beardsley, University of Hawaii, pers. comm., 1994). Several alien species are established in Hawaii (Nishida 1997), including Trichogramma minutum (no common name), which is known to attack the sweet potato hornworm in Hawaii (Fullaway and Krauss 1945). In 1929, the wasp Trichogramma chilonis (no common name) was purposefully introduced into Hawaii as a biological control agent for the Asiatic rice borer (Chilo suppressalis) (Funasaki et al. 1988). This wasp parasitizes the eggs of a variety of Lepidoptera in Hawaii, including sphinx moths (Funasaki et al. 1988). Williams (1947) found 70 percent of the eggs of Blackburn's sphinx moth to be parasitized by a Trichogramma wasp that was probably Trichogramma chilonis. Over 80 percent of the eggs of the alien grass webworm (Herpetogramma licarsisalis) in Hawaii are parasitized by these wasps (Davis 1969). In Guam, Trichogramma chilonis effectively limits populations of the sweet potato hornworm (Nafus and Schreiner 1986), and the sweet potato hornworm is considered under complete biological control by this wasp in Hawaii (Lai 1988). While this wasp probably affects Blackburn's sphinx moth in a density-dependent manner (Nafus 1993a), and theoretically is unlikely to directly cause extinction of a population or the species, the availability of more abundant, alternate hosts (any other lepidopteran eggs) may allow for the extirpation of Blackburn's sphinx moth by this or other egg parasites as part of a broader host base (Howarth 1991; Nafus 1993b; Tothill et al. 1930). (USFWS, 2005)

Stressor: Parasitic Flies (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Hawaii has no native parasitic flies in the family Tachinidae (Nishida 1997). Two species of tachinid flies, Lespesia archippivora and Chaetogaedia monticola, were purposefully introduced to Hawaii for control of army worms (Funasaki et al. 1988; Nishida 1997). These flies lay their eggs externally on caterpillars, and upon hatching, the larvae burrow into the host, attach to the inside surface of the cuticle, and consume the soft tissues (Etchegaray and Nishida

1975b). In North America, Chaetogaedia monticola is known to attack at least 36 species of Lepidoptera in 8 families, including sphinx moths; Lespesia archippivora is known to attack over 60 species of Lepidoptera in 13 families, including sphinx moths (Arnaud 1978). These species are on record as parasites of a variety of Lepidoptera in Hawaii and are believed to depress populations of at least two native species of moths (Lai 1988). Over 40 percent of the caterpillars of the monarch butterfly (Danaus plexippus) on Oahu are parasitized by Lespesia archippivora (Etchegaray and Nishida 1975a) and the introduction of a related species to Fiji resulted in the extinction of a native moth there (Howarth 1991; Tothill et al. 1930). Both of these species occur on Maui and Hawaii (Nishida 1997) and are direct threats to Blackburn's sphinx moth. Based on the findings discussed above, non-native predatory and parasitic insects are considered significant factors contributing to the reduction in range and abundance of Blackburn's sphinx moth, and in combination with habitat loss and fragmentation, are a serious threat to its continued existence. As Table 2 indicates, the assemblage of potential alien predators and parasites on each island may slightly differ. Furthermore, the arthropod community may differ from area to area even on the same island based upon elevation, temperature, prevailing wind pattern, precipitation, or other factors (Nishida 1997). Conserving and/or restoring moth populations in multiple locations should decrease the likelihood that the effect of any single alien parasite or predator or combined pressure of such species could result in the diminished vigor or extinction of the moth. (USFWS, 2005)

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Alien predatory and parasitic insects are significant factors contributing to the reduction in Blackburn's sphinx moth abundance, and may be the most serious current, direct threat to its continued existence. Some of these alien species were intentionally introduced by the State of Hawaii's Department of Agriculture or other agricultural agencies (Funasaki et al. 1988) and importation and augmentation of lepidopteran parasitoids is still a potential threat. Federal regulations for the introductions of biological control agents have not adequately protected this species (Lockwood 1993). Presently, there are no Federal statutes requiring review of biological control agents before their introduction, and the limited Federal review process requires consideration of potential harm only to economically important species (Miller and Aplet 1993). Although the State of Hawaii requires pre-release review of new introductions (Hawaii Division of Forestry and Wildlife, Hawaii Revised Statues Chapter150A), post-release biology and host range cannot be predicted from laboratory studies (Gonzalez and Gilstrap 1992; Roderick 1992) and the purposeful release or augmentation of any lepidopteran predator or parasitoid is a potential threat to Blackburn's sphinx moth (Gagné and Howarth 1985; Simberloff 1992). (USFWS, 2005)

Recovery

Reclassification Criteria:

Downlisting Criteria: One Blackburn's sphinx moth population on each island of Hawaii, Kahoolawe, and Maui must be well-distributed, naturally reproducing, and stable or increasing in size through one to two El Niño events or for at least 5 consecutive years of average rainfall conditions before downlisting may be considered. This criterion assumes future genetic studies (see recovery action 3.5 and 3.6) will confirm the species currently consists of multiple populations. If additional research reveals the species is actually comprised of one population, this criterion will need to be revised. Stable Blackburn's sphinx moth populations are defined in this recovery plan as those in which observed population declines are followed by a population increase to pre-decline levels. These criteria should provide for the maintenance of genetic variation that occurs in natural populations of Blackburn's sphinx moth by protecting all known, natural populations and the habitats upon which they rely. Furthermore, these criteria should provide some assurance that a single catastrophic event will not destroy all populations of this species. More specific downlisting criteria can be developed when completion of some of the recovery actions provides necessary information on the life history and ecology of this species and its host plants.

Recovery Priority Number: 2C

Delisting Criteria:
Delisting Criteria: Before delisting of Blackburn's sphinx moth can be considered, all of the following four requirements must be met: (1) one moth population, within one management unit, must be naturally reproducing and stable or increasing in size, through one to two El Niño events or a minimum of 5 consecutive years of average rainfall within the Kauai-Oahu Recovery Unit; (2) four moth populations, within four management units, must be naturally reproducing and stable or increasing in size, through one to two El Niño events vi or a minimum of 5 consecutive years of average rainfall on three different islands within the Maui Nui Recovery Unit (of those four, one within windward and one within leeward Maui Island); (3) two moth populations, within two management units, must be naturally reproducing and stable or increasing in size, through one to two El Niño events or a minimum of 5 consecutive years of average rainfall within the Big Island (Hawaii Island) Recovery Unit; and (4) a post-delisting monitoring plan and agreements to conduct post-delisting monitoring are in place and ready for implementation at the time of delisting. These criteria assume genetic studies (see recovery actions 3.5 and 3.6) will confirm the species currently consists of multiple populations. If additional research actually reveals the species is comprised of one population, these criteria will need to be revised. More specific delisting criteria can be developed when completion of some of the recovery actions provides necessary information on the life history and ecology of this species and its host plants.

Recovery Actions:
- 1. Protect, manage, and restore habitat and control threats (overview) 1.1 Identify and map significant, wild Nothocestrum sp. host plant populations 69 1.2 Finalize delineation of recovery and management units as necessary 1.3 Ensure long-term protection of habitat 1.4 Identify and control threats to Blackburn's sphinx moths and their host plants 1.4.1 Construct and maintain fencing around those areas containing Nothocestrum sp. host plants within the Blackburn's sphinx moth management units and remove ungulates 1.4.2 Conduct

alien weed control 1.4.3 Provide necessary wildfire protection 1.4.4 Propagate and maintain Nothocestrum sp. host plant genetic stock ex situ 1.4.5 Protect management units from human disturbance 1.4.6 Control and manage purposeful and accidental introduction of potential predators and parasites 1.4.7 Control other threats as appropriate

- 2. Expand existing wild Nothocestrum sp. host plant populations 2.1 Select populations for expansion or sites for new populations 2.2 Prepare sites within management units and out-plant species of Nothocestrum known to be larval host plants
- 3. Conduct additional research essential to the recovery of Blackburn's sphinx moth 70 3.1 Conduct research to confirm or discount Nothocestrum longifolium, Nothocestrum peltatum, and Solanum nelsonii as suitable larval host plants 3.2 Determine adult Blackburn's sphinx moth host plant associations and potential limiting factors 3.3 Study the natural recruitment and fecundity of presumed larval host plants (Nothocestrum sp.) 3.4 Determine annual Blackburn's sphinx moth life history cycle for each management unit; investigate impacts of non-native predators and parasites 3.5 Determine if the species is comprised of metapopulations 3.6 Conduct studies on the demography, dispersal, and genetics of the Blackburn's sphinx moth 3.7 Evaluate research results and implement adaptive management as necessary
- 4. Develop and implement a detailed monitoring plan for the Blackburn's sphinx moth
- 5. Reestablish and augment, through captive propagation if necessary, wild Blackburn's sphinx moth populations within its historic range 5.1 Investigate feasibility and desirability of Blackburn's sphinx moth translocation 5.2 Develop and implement specific plans for Blackburn's sphinx moth translocation 71 5.3 If necessary for translocation, develop methods for laboratory-rearing of Blackburn's sphinx moth
- 6. Develop and initiate a public information program for the Blackburn's sphinx moth
- 7. Validate recovery objectives 7.1 Refine/revise downlisting and delisting criteria as necessary
- 8. Develop a detailed Post-Delisting Monitoring Plan for Blackburn's sphinx moth
- Map the occurrence of tree tobacco across the island chain to estimate the potential future BSM distribution. (USFWS, 2019)
- Continue regular monitoring of several populations to document the seasonal and annual variation in parasitism and predation of eggs and larvae. (USFWS, 2019)
- Conduct research on the factors limiting BSM distribution on tree tobacco (i.e., distance from occupied areas, presence of parasitoids, moisture, etc.). (USFWS, 2019)
- Continue efforts to inform action agencies and development projects about the potential presence of the BSM in disturbed areas. (USFWS, 2019)
- While it is believed that the adult BSM is a general nectarivore, only three feeding observations have been reported. Research into the needs of adults may assist in determining whether additional restoration is needed to improve adult survival. (USFWS, 2019)
- Conduct standardized surveys on Maui and Kahoʻolawe to document population trends and distribution. (USFWS, 2019)
- Continue and increase efforts to restore native dry forest habitat and suitable larval host plants in appropriate areas across the islands. Follow outplanting and restoration efforts with surveys to determine BSM occupancy. (USFWS, 2019)
- Conduct research on the threat of parasitoids and identify whether BSM on tree tobacco display any increased resilience to parasitism. (USFWS, 2019)

- Develop protocols to survey for and respond to parasitoids in habitats (both native and non-native) occupied by BSM. (USFWS, 2019)
- Commit dedicated funding and resources to fully implement the 2017 interagency biosecurity plan to limit the potential for new parasitoids to become established in the State of Hawaiʻi. (USFWS, 2019)
- Finalize the genetic analysis to determine whether different island populations are genetically distinct to inform future conservation and translocation efforts. (USFWS, 2019)
- Survey Lānaʻi and Molokaʻi for BSM and determine the distribution of any populations. (USFWS, 2019)
- Conduct ex situ research to investigate the suitability of Nothocestrum longifolium, N. peltatum, and/or Solanum nelsonii as suitable larval host plants and assess adult selection of these species, as well as S. americanum, S. sandwicense, and S. incompletum, for egg laying in the wild. (USFWS, 2019)
- Consider translocation to appropriate sites on Kauaʻi and/or Oʻahu where sufficient larval host plants occur and threat control for fire and parasitoids are in place. (USFWS, 2019)
- Compare suitability of native and non-native larval host plants through rearing studies to assess pupation and emergence rates. (USFWS, 2019)
- Work with partners to develop conservation/management plans for management of tree tobacco in high BSM use areas. (USFWS, 2019)
- • Site/area/habitat protection – Protection, management, and restoration of BSM and wild Nothocestrum spp. host plant populations.
- • Monitoring protocol development – Development and implementation of a detailed long-term monitoring program.
- • Reintroduction/ translocation implementation – Re-establish and augment wild moth populations within the species' historic range, through captive propagation if necessary.
- • Captive propagation protocol development – Continue efforts to develop and refine captive propagation techniques for the species; assess oviposition preference by female BSM on native vs. native host plants; and determine if larval development on native vs. non-native host plants confers egg or larval resistance to predation and parasitism.
- • Threats research – Identify primary predators, competitors, and parasites of BSM and develop and implement appropriate control measures.
- • Ungulate control – Remove ungulates and restore habitat in management units.
- Ongoing Conservation Actions: • Ungulate exclosure – Exclosures of various sizes have been constructed in management units on Kauai to protect potential host plants for the species (M. Clark, USFWS, pers. comm. 2008). In addition, ungulate exclosures and, in some cases, ungulate control has been undertaken in various locations on Kauai Lanai, Molokai, Maui, and Hawaii (Medeiros 2006, pp. 1-4; DLNR 2007, pp.1-9; J. Higashino, USFWS, pers. comm. 2008).
- • Habitat and natural process management and restoration – Forest restoration, including outplanting of aiea (Nothocestrum spp.), has been undertaken in management units on Kauai (M. Clark, USFWS, pers. comm. 2008). Efforts to outplant Nothocestrum species have been undertaken in various locations on Maui and Hawaii (Allen 2000, pp.1037-1041; Medeiros 2006, pp.1-4). However, additional management is needed in these management units to help achieve the recovery of the BSM.
- • Threats research – Efforts to develop control measures for some potential predators, like the big-headed ant (Pheidole megacephala) and Argentine ant (Linepithema humile), have met with some success (Peck et al. 2007, p. 91; Snook et al. 2008, p. 56).

- • Reintroduction / translocation protocol development – Rubinoff and San Jose (2010, pp. 53-59) undertook efforts to develop captive propagation techniques for the BSM in 2005 and 2009 which could support a reintroduction program on Kauai.

Conservation Measures and Best Management Practices:

- USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: Blackburn's Sphinx Moth (Manduca blackburni). Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaiʻi. 12 pp.

References

USFWS. 2019. 5-Year Review, Short Form Summary, Species Reviewed: Blackburn's Sphinx Moth (Manduca blackburni). Region 1, PIFWO. Available at: https://ecos.fws.gov/docs/five_year_review/doc6101.pdf

USFWS 2016. Status of the Species and Critical Habitat: Manduca blackburni (Blackburn's sphinx moth). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

U.S. Fish and Wildlife Service. 2000. Endangered and Threatened Wildlife and Plants

Determination of Endangered Status for Blackburn's Sphinx Moth from the Hawaiian Islands

Final Rule. 65 FR 4770 - 4779 (February 1, 2000). USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Blackburn's Sphinx Moth. Final rule. 68 FR 34710 - 34766 (June 10, 2003).

SFWS 2016. Status of the Species and Critical Habitat: Manduca blackburni (Blackburn's sphinx moth). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

USFWS. 2019. 5-Year Review, Short Form Summary, Species Reviewed: Blackburn's Sphinx Moth (Manduca blackburni). Region 1, PIFWO. Available at: https://ecos.fws.gov/docs/five_year_review/doc6101.pdf. USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: Blackburn's Sphinx Moth (Manduca blackburni). Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaiʻi. 12 pp.

SFWS 2016. Status of the Species and Critical Habitat: Manduca blackburni (Blackburn's sphinx moth). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and

Wildlife Service. Portland, Oregon. 109 pp. USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: Blackburn’s Sphinx Moth (Manduca blackburni). Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaiʻi. 12 pp.

USFWS. 2009. Blackburns' Sphinx Moth (Manduca blackburni), 5-Year Review, Summary and Evaluation. Region 1, PIFWO. Available at: https://ecos.fws.gov/docs/five_year_review/doc2527.pdf.

USFWS. 2009. Blackburns' Sphinx Moth (Manduca blackburni), 5-Year Review, Summary and Evaluation. Region 1, PIFWO. Available at: https://ecos.fws.gov/docs/five_year_review/doc2527.pdf

U.S. Fish and Wildlife Service. 2005. Recovery Plan for the Blackburn’s Sphinx Moth (Manduca blackburni). Portland, Oregon. 125 pp.

USFWS. 2005. Recovery Plan for the Blackburn’s Sphinx Moth (Manduca blackburni). Portland, Oregon. 125 pp.

Recommendations for Future Actions: • Map the occurrence of Nicotiana glauca across the island chain to estimate the potential future BSM distribution. • Conduct multi-month surveys on the islands of Hawaiʻi, Maui, and Kahoʻolawe to document the seasonal and annual variation in parasitism and predation of eggs and larvae. • Conduct research on the factors limiting BSM distribution on N. glauca (i.e., distance from occupied areas, presence of parasitoids, moisture, etc.). • Continue efforts to inform action agencies and development projects about the potential presence of the BSM in disturbed areas. • While it is believed that the adult BSM is a general nectarivore, only three feeding observations have been reported. Research into the needs of adults may assist in determining whether additional restoration is needed to improve adult survival. • Conduct standardized surveys on the islands of Hawaiʻi, Maui and Kahoʻolawe to document population trends and distribution. • Continue and increase efforts to restore native dry forest habitat and suitable larval host plants in appropriate areas across the islands. Follow outplanting and restoration efforts with surveys to determine BSM occupancy. • Conduct research on the threat of parasitoids and identify whether BSM on N. glauca display any increased resilience to parasitism. • Develop protocols to survey for and respond to parasitoids in habitats (both native and non-native) occupied by BSM. • Commit dedicated funding and resources to fully implement the 2017 interagency biosecurity plan to limit the potential for new parasitoids to become established in the State of Hawaiʻi. • Conduct genetic analyses to determine whether different island populations are genetically distinct to inform future conservation and translocation efforts. • Survey the islands of Lānaʻi and Molokaʻi for BSM and determine the distribution of any populations. • Conduct ex situ research to investigate the suitability of Nothocestrum longifolium, N. peltatum, and/or Solanum nelsonii (pōpolo) as suitable larval host plants and assess adult selection of these species, as well as S. americanum (ʻolohua), S. sandwicense (pōpoloʻaikeakua), and S. incompletum ((pōpolo kū mai), for egg laying in the wild. • Consider translocation to appropriate sites on the islands of Kauaʻi and/or Oʻahu where sufficient larval host plants occur and threat control for fire and parasitoids are in place. • Compare suitability of native and non-native larval host plants through rearing studies to assess pupation and emergence rates. • Work with partners to develop conservation/management plans for management of N. glauca in high BSM use areas (USFWS, 2022).

SPECIES ACCOUNT: *Megalagrion pacificum* (Pacific Hawaiian damselfly)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

This damselfly is a relatively small, darkcolored species, with adults measuring 1.3 to 1.4 in (34 to 37 mm) in length and having a wingspan of 1.3 to 1.6 in (33 to 42 mm). Both adult males and females are mostly black in color. Males exhibit brick-red striping and patterns, while females exhibit light-green striping and patterns. The only immature individuals of this species that have been collected were earlyinstar (an intermoult stage of development) individuals, and they exhibit flattened, leaf-like gills (Polhemus and Asquith 1996, p. 83). This species is most easily distinguished from other Hawaiian damselflies by the extremely long lower abdominal appendages of the male, which greatly exceed the length of the upper appendages.

Historical Range

Historically, the Pacific Hawaiian damselfly was known from lower elevations (below 2,000 ft (600 m)) on all of the main Hawaiian Islands except Kahoolawe and Niihau (Perkins 1899, p. 64).

Current Range

The Pacific Hawaiian damselfly is currently found in at least seven streams on Molokai and may possibly be extant in other unsurveyed streams on Molokai's northern coast that have not been invaded by nonnative fish (Englund 2008). On the island of Maui, the species is currently known from 14 streams. The Pacific Hawaiian damselfly is no longer found along the entire reaches of these Maui streams, but only in restricted areas along each stream where steep terrain prevents access by nonnative fish, which inhabit degraded, lower stream reaches (Polhemus and Asquith 1996, p. 13; Englund et al. 2007, p. 215). The species is known from a single population on the island of Hawaii, last observed in 1998. Maui, Hawaiʻi (extant); Kauaʻi, Oʻahu Molokaʻi, Lānaʻi (likely extirpated) (USFWS, 2021). Island Distribution: Found on Oahu, Lanai, Molokai, Maui and Hawaii. Extirpated on Kauai. (USFWS, 2021c) . Distribution: Molokaʻi, Maui, Hawaiʻi, (extant); Kauaʻi, Oʻahu, Lānaʻi (likely extirpated) (USFWS, 2022).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval odonates are predators that feed on invertebrates or small fish.

Adult: Adult odonates are predators that feed on invertebrates.

Reproduction Narrative

Adult: The general biology of Hawaiian damselflies is typical of other narrowwinged damselflies (Polhemus and Asquith 1996, pp. 2-7). The males of most species are territorial, guarding areas of habitat where females lay eggs (Moore 1983a, p. 89). During copulation, and often while the female lays eggs, the male grasps the female behind the head with terminal abdominal appendages to guard the female against rival males; thus males and females are frequently seen flying in tandem. Female damselflies lay eggs in submerged aquatic vegetation or in mats of moss or algae on submerged rocks, and hatching occurs in about 10 days (Williams 1936, pp. 303, 306, 318; Evenhuis et al. 1995, p. 18). In most species of Hawaiian damselflies, the immature larval stages (naiads) are aquatic, breathing through three flattened abdominal gills, and are predaceous, feeding on small aquatic invertebrates or fish (Williams 1936, p. 303). Naiads may take up to 4 months to mature (Williams 1936, p. 309), after which they crawl out of the water onto rocks or vegetation to molt into winged adults, typically remaining close to theaquatic habitat from which they emerged. The Pacific Hawaiian damselfly exhibits this typical aquatic life history.

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Adult: clumped according to suitable resources

Site Fidelity

Larvae: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: not applicable

Adult: not applicable

Habitat Narrative

Adult: This species was known to breed primarily in lentic (standing water) systems such as marshes, seepage-fed pools, large ponds at higher elevations, and small, quiet pools in gulches that have been cut off from the main stream channel (Moore and Gagne 1982, p. 4; Polhemus and Asquith 1996, p. 83). The Pacific Hawaiian damselfly is no longer found in most lentic habitats in Hawaii, such as ponds and taro (Colocasia esculenta) fields, due to predation by nonnative fish that now occur in these systems (Moore and Gagne 1982, p. 4; Englund et al. 2007, p. 215). Observations have confirmed that the Pacific Hawaiian damselfly is now restricted almost exclusively to seepagefed pools along overflow channels in the terminal reaches of perennial streams,usually in areas surrounded by thick vegetation (Moore and Gagne 1982, pp. 3-4; Polhemus 1994, p. 54; Englund 1999, p. 236; Englund et al. 2007, p. 216; Polhemus 2007, p. 238).

Dispersal/Migration

Motility/Mobility

Larvae: very limited; cannot swim

Adult: mobile, but not strong fliers compared to other damselflies

Migratory vs Non-migratory vs Seasonal Movements

Larvae: not migratory

Adult: not migratory

Dispersal

Larvae: no

Adult: no

Immigration/Emigration

Larvae: highly unlikely

Adult: highly unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Flying Earwing damselfly naiads cannot swim, so their mobility/dispersal is very limited.

Adult: Adults usually do not stray far from the vicinity of the breeding pools, perching on bordering vegetation and flying only short distances when disturbed (Polhemus and Asquith 1996, p. 83). This species is rarely seen along main stream channels, and its ability to disperse long distances over land or water is suspected to be poor compared to other Hawaiian damselflies (Jordan et al. 2007, p. 254).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

30 (20 Maui; 9 Molokai: 1 Hawaii) (USFWS, 2022).

Population Size:

Unknown (USFWS, 2022).

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

The conservation of this species was identified as a priority by the International Union for the Conservation of Nature and Natural Resources (Moore 1982, p. 209). The Pacific Hawaiian damselfly is now believed to be extirpated from the islands of Oahu, Kauai, and Lanai (Polhemus and Asquith 1996, p. 83). On the island of Oahu, due to its occupation of particularly vulnerable habitat within sidepools of lowland streams, the Pacific Hawaiian damselfly was rare by the 1890s and appears tohave been extirpated from this island by 1910 (Liebherr and Polhemus 1997, p. 494). It is unknown when the Kauai and Lanai populations of the Pacific Hawaiian damselfly disappeared. Until 1998, it was believed that the species was extirpated from the island of Hawaii. That year, one population was discovered within a small stream located just above, but isolated from, Maili Stream, which is known to be occupied by nonnative fish (Englund 1998, pp. 15-16). On Maui and Molokai, fewer than six populations of the Pacific Hawaiian damselfly could be located by the 1970s (Harwood 1976, pp. 251-253; Gagne 1980, pp. 119, 125; Moore and Gagne 1982, p. 1). No quantitative estimates of the size of the extant populations are available. Howarth (1991, p. 490) described the Pacific Hawaiian damselfly as the most common and most widespread of the native damselfly species at the end of the 19th century, and yet a decline in this species was observed as early as 1905 due to the effects of nonnative fishintroduced for control of mosquitoes. From 5-year review: A possible sighting of an adult Pacific Hawaiian damselfly occurred during 2009-2010 USGS surveys at 40 sites of 25 perennial streams on Maui where surveyors could wade (Wolff 2012). In May 2015, 10 sites were surveyed for pinapinao along the entire length of the Waioni stream corridor west of Hāna, Maui. Pacific Hawaiian damselfly was not observed, though three other native species of pinapinao were (Dan Polhemus 2015, personal communication). Follow up surveys of Waioni stream were conducted in 2017 for presence of any listed pinapinao (Polhemus 2017). The two-day survey concluded that listed pinapinao were not present at the 11 survey stations of Waioni stream. Currently, Pacific Hawaiian damselflies are found on Maui and Molokaʻi with one population found on Hawaiʻi island (USFWS 2010, 2011). (USFWS, 2018). The Pacific Hawaiian damselfly, Megalagrion pacificum, is an endangered invertebrate that was once found across the Hawaiian archipelago. This species is now believed to be limited to 30 populations: 20 on Maui, nine on Molokaʻi, and one on the island of Hawaiʻi (Polhemus and Haines 2020, pp. 10, 12, 14–15; Polhemus 2022, p. 23; USFWS 2022a, p. 3). There is no quantitative estimate of population size, although many populations of the Pacific Hawaiian damselfly are thought to be relatively small in size (< 100 individuals) (USFWS, 2023).

Threats and Stressors

Stressor: Habitat Destruction and Modification by Agriculture and Urban Development
Exposure:
Response:
Consequence:
Narrative: Although there has not been a comprehensive, site-by-site assessment of wetland loss in Hawaii (Erikson and Puttock 2006, p. 40), Dahl (1990, p. 7) estimated that at least 12 percent of lowland to upper-elevation wetlands in Hawaii had been converted to nonwetland habitat by the 1980s. If only coastal plain (below 1,000 ft (305 m) elevation) wetlands are considered, it is estimated that 30 percent have been converted for agricultural and urban development (Kosaka l990, p. 1). These marshlands and wetlands provided habitat for several damselfly species, including the Pacific Hawaiian damselfly. By the 1930s, water diversions had been developed on all of the main Hawaiian Islands, and by 1978, the stream flow in over one-half of all of the 366 perennial streams in Hawaii had been altered in some manner (Brasher 2003, p. 1055). All or most of the low or average flow of the stream was, and often still is, diverted into fields or reservoirs, leaving many stream channels completely dry (Takasaki et al. 1969, pp. 27-28; Harris et al. 1993, p. 12; Wilcox 1996, p. 56). The historical destruction and modification of habitat continues to impact the two Hawaiian damselflies, by restricting them to curtailed or isolated habitat areas that are often degraded in quality (for example, by the presence of predatory nonnative fishes). The present curtailment of the habitat or range of the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly due to past habitat destruction or modification in turn limits population size, distribution, and connectivity, resulting in an increased probability of local extirpation or even extinction of the two Hawaiian damselfly species. Although extensive filling of freshwater wetlands is rarely permitted today, loss of riparian or wetland habitats utilized by the Pacific and flying earwig Hawaiian damselflies, such as smaller areas of moist slopes, emergent vegetation, and narrow strips of freshwater seeps within anchialine pool complexes (landlocked bodies of water with a subterranean connection to the ocean), still occurs. In addition, marshes have been, and continue to be, slowly filled and converted to meadow habitat due to increased sedimentation resulting from increased storm water runoff from upslope development, the accumulation of uncontrolled growth of invasive vegetation, and blockage of downslope drainage (Wilson Okamoto & Associates, Inc. 1993, pp. 3-4 to 3-5). The effects of future conversion of

wetland and other aquatic habitat for agriculture and urban development are immediate and significant for the following reason: As noted above, an estimated 30 percent of all coastal plain wetlands in Hawaii have already been lost to agriculture and urban development, while the loss of lowland freshwater habitat in Hawaii already approaches 80 to 90 percent (Kosaka 1990, p. 1). Lacking the aquatic habitat features that the damselflies require for essential life history needs, such as marshes, ponds, and sidepools along streams (Pacific Hawaiian damselfly) and riparian habitat (flying earwig Hawaiian damselfly), these modified areas no longer support populations of these two Hawaiian damselflies. Agriculture and urban development have thus contributed to the present curtailment of the habitat of these two Hawaiian damselflies, and we have no indication that this threat is likely to be significantly ameliorated in the foreseeable future.

Stressor: Habitat Destruction and Modification by Stream Diversion
Exposure:
Response:
Consequence:
Narrative: Stream modifications began with the early Hawaiians, who diverted water to irrigate taro. However, unlike modern stream diversions which often completely dewater streams all year around, early diversions often took no more than half the stream flow, and typically were periodic to occasionally flood taro ponds at different times through the year, rather than continuously flood them (Handy and Handy 1972, pp. 58-59). The advent of plantation sugarcane cultivation led to far more extensive stream diversions, with the first diversion built in 1856 on Kauai (Wilcox 1996, p. 54). These systems were designed to tap water at upper elevations (above 984 ft (300 m)) by means of a concrete weir in the stream (Wilcox 1996, p. 54). All or most of the low or average flow of the stream was, and often still is, diverted into fields or reservoirs, leaving many stream channels completely dry (Takasaki et al. 1969, pp. 27-28; Harris et al. 1993, p. 12; Wilcox 1996, p. 56). As noted above, by the 1930s, water diversions had been developed on all of the main Hawaiian Islands, and by 1978, the stream flow in over one-half of all of the 366 perennial streams in Hawaii had been altered in some manner (Brasher 2003, p. 1055). Some stream diversion systems are extensive, such as the Waiahole Ditch, which diverts water from 37 streams within the range of the Pacific Hawaiian damselfly on the windward side of Oahu to the dry plains on the leeward side of the island via a tunnel cut through the Koolau mountain range (Stearns and Vaksvik 1935, pp. 399-403). On west Maui, as of 1978, over 49 miles (mi) (78 kilometers (km)) of stream habitat in 12 streams had been lost due to diversions, and all of the 17 perennial streams on west Maui are dewatered to some extent (Maciolek 1979, p. 605). This loss of stream habitat may have contributed to the extirpation of the Pacific Hawaiian damselfly population on west Maui. Given the affiliation of the flying earwig Hawaiian damselfly with riparian habitats, this loss of stream habitat may also potentially account for its absence on west Maui. Most lower-elevation stream segments on west Maui are now completely dry, except during storm influenced flows (Maciolek 1979, p. 605). The maintenance of natural hydrology is closely tied to the life history requirements of the Hawaiian damselflies, as the presence of standing or running water is essential to reproduction of the two species. In addition to providing breeding habitat for the adults, the aquatic larval stage of the Pacific Hawaiian damselfly is entirely dependent on water, and the maintenance of local soil hydrology is necessary for the persistence of uluhe ferns, which provide habitat for the larval stage of the flying earwig Hawaiian damselfly. The reduced flow or

complete dewatering of streams thus results in the destruction or degradation of habitat conditions for both the Pacific and flying earwig Hawaiian damselflies. The extensive diversion of streams on Maui island-wide has reduced the amount of stream habitat available to the Pacific Hawaiian damselfly, and potentially to the flying earwig Hawaiian damselfly as well. In addition to diverting water for agriculture and domestic water supply, streams in Hawaii have also been diverted for use in hydroelectric power. In some cases, the water used for power generation is already being diverted for another use; in other cases the water is returned to the stream of origin. There are a total of 18 active hydroelectric plants operating on Hawaiian streams on the islands of Hawaii, Kauai, and Maui, only one of which is located on a stream where a historical population of the Pacific Hawaiian damselfly was known on Kauai (Waimea). Another 28 sites have been identified as feasible for hydroelectric development on the islands of Hawaii, Kauai, Maui, and Molokai (Hawaii Stream Assessment 1990, pp. xxi, 96-97). Three of the sites identified as developable include current populations of the Pacific Hawaiian damselfly. A total of 10 streams have actually been proposed for development, with some overlap between the 28 streams identified as feasible. Notably, the stream adjacent to the single current remaining population site for the flying earwig Hawaiian damselfly on Maui is included among those proposed for hydroelectric development. Any additional diversion of stream flow for use in hydroelectric power could contribute to further loss of stream habitat for the Pacific Hawaiian damselfly and for the flying earwig Hawaiian damselfly.

Stressor: Habitat Modification and Destruction by Dewatering of Aquifers
Exposure:
Response:
Consequence:
Narrative: In addition to the diversion of stream water and the resultant downstream dewatering, many streams in Hawaii have experienced reduced or zero surface flow as a result of the dewatering of their source aquifers. Often these aquifers, which previously fed the streams, were tapped by tunneling or the injudicious placement of wells (Stearns and Vaksvik 1935, pp. 386-434; Stearns 1985, pp. 291-305). These groundwater sources were captured for both domestic and agricultural use and in some areas have completely depleted nearby stream and spring flows. For example, the Waikolu Stream on Molokai has reduced flow due in part to groundwater withdrawal (Brasher 2003, p. 1,056), which may have reduced stream habitat available to the Pacific Hawaiian damselfly. Likewise, on Maui, streams in the west Maui Mountains that flow into the Lahaina District are fed by groundwater leaking from breached high-elevation dikes. Downstream of the dike compartments, stream diversions are designed to capture all of the low stream flow, causing the streams downstream to be frequently dry (U.S. Geological Survey 2008a, p. 1), likely impacting available habitat for the Pacific Hawaiian damselfly, and potentially for the flying earwig Hawaiian damselfly, in the Honolua and Honokohau streams. The island of Lanai lies within the rain shadow of the west Maui Mountains, which reach 5,788 ft (1,764 m) in elevation. Lower in elevation than Maui, annual rainfall on Lanai's summit is 30 to 40 in (760 to 1,015 mm), but is much less over the rest of the island (University of Hawaii Department of Geography 1998, p. 13). Flows of almost every spring and seep on Lanai have been diverted (Stearns 1940, pp. 73-74, 85, 88, 95). Surface waters in streams have also been diverted by tunnels in stream beds. Historically, Maunalei Stream was the only perennial stream on Lanai, and Hawaiians constructed

taro loi (ponds for cultivation of taro) in the lower portions of this stream system. In 1911, a tunnel was constructed at 1,100 ft (330 m) elevation that undercuts the stream bed, diverting both the surface and subsurface flows and dewatering the stream from this point to its mouth (Stearns 1940, pp. 86-88). The Pacific Hawaiian damselfly, which depends on stream habitat, was historically known from Lanai but is no longer extant on this island. The Pacific Hawaiian damselfly was most likely impacted by the dewatering of this stream because it was the only permanent stream on Lanai prior to its dewatering. This example of the negative impact of dewatering leads us to conclude that dewatering poses a threat to the Pacific Hawaiian damselfly and the flying earwig Hawaiian damselfly on the remaining islandswhere the species persist.

Stressor: Habitat Modification and Destruction by Vertical Wells
Exposure:
Response:
Consequence:
Narrative: Surface flow of streams has also been affected by vertical wells drilled in the past, because the basal aquifer (lowest groundwater layer) and alluvial caprock (sediment-deposited harder rock layer) through which the lower sections of streams flow can be pierced and hydraulically connected by wells (Stearns 1940, p. 88). This allows water in aquifers normally feeding the stream to be diverted elsewhere underground. Dewatering of the streams by tunneling and earlier, less-informed well placement near or in streams was a significant cause of habitat loss, and these effects continue today. Historically, for example, there was sufficient surface flow in Makaha and Nanakuli streams on Oahu to support taro loi in their lower reaches, but this flow disappeared subsequent to construction of vertical wells upstream (Devick 1995, p. 1). The inadvertent dewatering of streams through the piercing of their aquifers (which are normally separated from adjacent waterbearing layers by an impermeable layer), by tunneling or through placement of vertical wells, caused the loss of Pacific Hawaiian damselfly habitat, and contributed to the Pacific Hawaiian damselfly’s extirpation on the islands of Oahu, Kauai, and Lanai (Polhemus and Asquith 1996, pp. 23-24). Such activities also reduced the extent of stream habitat for the Pacific Hawaiian damselfly on the islands of Maui, Molokai, and Hawaii. Most lowerelevation stream segments on west Maui and leeward east Maui are now completely dry, except during storm influenced flows (Maciolek 1979, p. 605). The flow of nearly every seep and spring on Lanai has been captured or bored with wells (Stearns 1940, pp. 73- 74, 85, 88, 95). The inadvertent drying of streams from earlier, uninformed well placement and other activities has contributed to the decline of the Pacific Hawaiian damselfly by reducing its habitat on all of the islands from which it was historically known. It should be noted that the Pacific Hawaiian damselfly was once among the most commonly observed aquatic insects in the islands (Howarth 1991, p. 40). The dewatering of streams on Maui and Hawaii may also have impacted habitat of the flying earwig Hawaiian damselfly. Although the State of Hawaii’s Commission on Water Resource Management is now more cognizant of the effects that groundwater removal has on streams via injudicious placement of wells, the Commission still routinely reviews new permit applications for wells (Hardy 2009, p. 1). Thus, the potential for additional well-drilling continues to be a threat, and the ongoing effects of previously constructed vertical wells continue to be an ongoing threat to the Hawaiian dragonflies.

Stressor: Habitat Modification and Destruction by Channelization
Exposure:
Response:
Consequence:
Narrative: In addition to the destruction of most of the stream habitat of the Pacific Hawaiian damselfly and the flying earwig Hawaiian damselfly, much of the remaining stream habitat has been, and continues to be, seriously degraded throughout the Hawaiian Islands. Stream degradation has been particularly severe on the island of Oahu where, by 1978, 58 percent of all the perennial streams had been channelized (lined, partially lined, or altered) to control flooding (Brasher 2003, p. 1055; Polhemus and Asquith 1996, p. 24), and 89 percent of the total length of these streams had been channelized (Parrish et al. 1984, p. 83). The channelization of streams creates artificial, wide-bottomed stream beds and often results in removal of riparian vegetation, increased substrate homogeneity, increased temporal water velocity (increased water flow speed during times of higher precipitation, including minor and major flooding), increased illumination, and higher water temperatures (Parrish et al. 1984, p. 83; Brasher 2003, p. 1052). Natural streams meander and are lined with rocks, trees, and natural debris, and during times of flooding, jump their banks. Channelized streams are straightened and often lack natural obstructions, and during times of higher precipitation or flooding, facilitate a higher water flow velocity. Hawaiian damselflies are largely absent from channelized portions of streams (Polhemus and Asquith 1996, p. 24). In contrast, undisturbed Hawaiian stream systems exhibit a greater amount of riffle habitat, canopy closure, higher consistent flow velocity, and lower water temperatures that are characteristic of streams to which the Hawaiian damselflies, in general, are adapted (Brasher 2003, pp. 1054-1057). Channelization of streams has not been restricted to lower stream reaches. For example, there is extensive channelization of the Kalihi Stream, on the island of Oahu, above 1,000-ft (300- m) elevation. Extensive stream channelization has contributed to the extirpation of the Pacific Hawaiian damselfly on Oahu (Englund 1999, p. 236; Polhemus 2008, pp. 45-46). Stream diversion, channelization, and dewatering represent significant and immediate threats to the Pacific Hawaiian damselfly for the following reasons: (1) They reduce the amount and distribution of stream habitat available to this species; (2) they reduce stream flow, leaving lower elevation stream segments completely dry except during storms, or leaving many streams completely dry year-round, thus reducing or eliminating stream habitat; and (3) they indirectly lead to an increase in water temperature that leads to the loss of Pacific Hawaiian damselfly naiads due to direct physiological stress. Because the probability of species extinction increases when ranges are restricted, habitat decreases, and population numbers decline, the Pacific Hawaiian damselfly is particularly vulnerable to extinction due to such changes in its stream habitats. In addition, stream diversion, dewatering, and vertical wells have the potential to negatively impact, and in some cases may have impacted, the flying earwig Hawaiian damselfly. Stream flow is essential to the adult flying earwig damselfly's breeding requirements and is also essential to maintaining localized soil hydrology necessary for persistence of uluhe ferns, which are known foraging and mating sites for the adults and may provide habitat for the larval stage. Should the species' population site stream experience either reduced flow or complete dewatering for an extended period of time, it is expected that the impact to surrounding soils and associated vegetation, including the uluhe ferns that are believed to be the species' likely larval-stage habitat, will be soil desiccation and prolonged vegetation dieback, respectively.

Stressor: Habitat Destruction and Modification by Feral Pigs
Exposure:
Response:
Consequence:
Narrative: One of the primary threats to the flying earwig Hawaiian damselfly is the ongoing destruction and degradation of its riparian habitat by nonnative animals, particularly feral pigs (Sus scrofa) (Polhemus and Asquith 1996, p. 22; Erickson and Puttock 2006, p. 42). Pigs of Asian descent were first introduced to Hawaii by the Polynesian ancestors of Hawaiians around 400 A.D. (Kirch 1982, pp. 3-4). Western immigrants, beginning with Captain Cook in 1778, repeatedly introduced European strains (Tomich 1986, pp. 120-121). The pigs escaped domestication and successfully invaded all areas, including wet and mesic forests and grasslands, on all of the main Hawaiian Islands. High pig densities and expansion of their distribution have caused indisputable widespread damage to native vegetation on the Hawaiian Islands (Cuddihy and Stone 1990, p. 63). Feral pigs create open areas within forest habitat by digging up, eating, and trampling native plant species (Stone 1985, p. 263). These open areas become fertile ground for nonnative plant seeds spread through the excrement of the pigs and by transport in their hair (Stone 1985, p. 263). In nitrogen-poor soils, feral pig excrement increases nutrient availability, enhancing establishment of nonnative weeds that are more adapted to richer soils than are native plants (Cuddihy and Stone 1990, p. 65). In this manner, largely nonnative forests replace native forest habitat (Cuddihy and Stone 1990, p. 65). In addition, feral pigs will root and dig for plant tubers and worms in wetlands, including marshes, on all of the main Hawaiian Islands (Erikson and Puttock 2006, p. 42). In a study conducted in the 1980s on feral pig populations in Kipahulu Valley on Maui, the deleterious effects of feral pig rooting on native forest ecosystems was documented (Diong 1982, pp. 150, 160-167). Rooting by feral pigs was observed to be related to the search for earthworms, with rooting depths averaging 8 in (20 cm), and rooting was found to greatly disrupt the leaf litter and topsoil layers, and contribute to erosion and changes in ground topography. The feeding habits of pigs were observed to create seed beds, enabling the establishment and spread of invasive weedy species such as Clidemia hirta (Koster’s curse). The study concluded that all aspects of the feeding habits of pigs are damaging to the structure and function of the Hawaiian forest ecosystem (Diong 1982, pp. 160-167). It is likely that pigs similarly impact the native vegetation used for perching by adult flying earwig Hawaiian damselflies. On Maui, feral pigs inhabit the uluhe-dominated riparian habitat of the flying earwig Hawaiian damselfly. Through their rooting and digging activities, they have significantly degraded and destroyed the habitat of the adult flying earwig Hawaiian damselfly (Foote 2008, p. 1). In addition to creating conditions that enable the spread of nonnative plant species, Mountainspring (1986, p. 98) surmised that rooting by pigs depresses insect populations that depend upon the ground layer at some life stage or that exhibit diel (day and night) movements. As a result, it is likely that the presumed habitat (seeps or damp leaf litter) of the naiads of the flying earwig Hawaiian damselfly is negatively impacted by feral pig activity, including the uprooting and denuding of native vegetation (Foote 2008, p. 1; Polhemus 2008, p. 48). Feral pigs are managed as a game animal for public hunting in the more accessible regions of the east Maui watershed (Jokiel 2008, p. 1). This management makes it likely that feral pigs will continue to exist on Maui, and thus likely that pigs will continue to destroy and degrade habitat of the flying earwig Hawaiian damselfly on the island

of Maui. The effects from introduced feral pigs are immediate and ongoing because pigs currently occur in the uluhe-dominated riparian habitat of the flying earwig Hawaiian damselfly. The threat of habitat destruction or modification from feral pigs is significant for the following reasons: (1) Trampling and grazing directly impact the vegetation used by adult flying earwig Hawaiian damselflies for perching and by the terrestrial or semiterrestrial naiads; (2) increased soil disturbance leads to mechanical damage to plants used by adults for perching and by the terrestrial or semiterrestrial naiads; (3) creation of open, disturbed areas, conducive to weedy plant invasion and establishment of alien plants from dispersed fruits and seeds, results over time in the conversion of a community dominated by native vegetation to one dominated by nonnative vegetation (leading to all of the negative impacts associated with nonnative plants, detailed below); and (4) increased watershed erosion and sedimentation upstream may degrade adult breeding habitat for the flying earwig Hawaiian damselfly. These threats are expected to continue or increase without control or elimination of pig populations in these habitats.

Stressor: Habitat Destruction and Modification by Nonnative Plants
Exposure:
Response:
Consequence:
Narrative: The invasion of nonnative plants, including Clidemia hirta (Koster’s curse), further contributes to the degradation of Hawaii’s native forests, including the riparian habitat of the flying earwig Hawaiian damselfly on Maui (Foote 2008, p. 1). Clidemia hirta is the most serious nonnative plant invader within the uluhe-dominated riparian habitat where the flying earwig Hawaiian damselfly occurs on Maui and where it formerly occurred on the island of Hawaii (Foote 2008, p. 1). A noxious shrub first cultivated in Wahiawa on Oahu before 1941, this plant is now found on all of the main Hawaiian Islands (Wagner et al. 1985, p. 41). Clidemia hirta forms a dense understory, shading out native plants and hindering their regeneration; it is considered a major nonnative plant threat in wet forest areas because it inhibits and eventually replaces native plants (Wagner et al. 1985, p. 41; Smith 1989, p. 64). Invasive nonnatives such as C. hirta are capable of modifying the natural environment at the microhabitat level by altering light availability and soil-water regimes, and may eventually replace the native plant community (Cuddihy and Stone 1990, p. 74; Vitousek 1992, pp. 33-35). As C. hirta can outcompete the native uluhe fern, this invasive nonnative species poses a threat by altering and degrading the native plant community utilized by the flying earwig Hawaiian damselfly. Presently, the most significant threat to natural ponds and marshes in Hawaii is the nonnative species Urochloa mutica (California grass). This sprawling perennial grass is likely from Africa (Erickson and Puttock 2006, p. 270). It was first noted on Oahu in 1924 and now occurs on all of the main Hawaiian Islands (O’Connor 1999, p. 1,504), where it is considered an aggressive invasive weed of marshes and wetlands (Erickson and Puttock 2006, p. 270). Found from sea level to 3,610 ft (1,100 m) in elevation (Erickson and Puttock 2006, p. 270), this plant forms dense, monotypic stands that can completely eliminate any open water by layering trailing stems (Smith 1985, p. 186). Marshlands eventually convert to meadowland when invaded by U. mutica (Polhemus and Asquith 1996, p. 23). At Kawainui Marsh, the most extensive marsh system remaining on Oahu, control of U. mutica to prevent conversion of the marsh to meadowland is an ongoing management activity (Wilson, Okamoto and Associates, Inc. 1993, pp. 3-4; Hawaii Ecosystems at Risk (HEAR) 2008, p.

1). The preferred habitat of the Pacific Hawaiian damselfly (primarily lowland, stagnant water, large ponds, and small pools) on all of the Hawaiian Islands has likely declined and continues to decline dueto the spread of U. mutica (Polhemus and Asquith 1996, p. 23). In conclusion, nonnative plants represent a significant and immediate and ongoing threat to the flying earwig Hawaiian damselfly through habitat destruction and modification for the following reasons: (1) They adversely impact microhabitat by modifying the availability of light; (2) they alter soilwater regimes; (3) they modify nutrient cycling processes; and (4) they outcompete, and possibly directly inhibit the growth of, native plant species; ultimately, native-dominated plant communities are converted to nonnative plant communities (Cuddihy and Stone 1990, p. 74; Vitousek 1992, pp. 33-35). This conversion negatively impacts and threatens the flying earwig Hawaiian damselfly, which depends upon native plant species, particularly uluhe, for essential life history needs. In addition, conversion of habitat from marshlands to meadowlands caused by the encroachment of the nonnative Urochloa mutica threatens the Pacific Hawaiian damselfly. These threats are expected to continue or increase without control or elimination of invasive nonnative plants in these habitats.

Stressor: Habitat Destruction and Modification by Hurricanes, Landslides, and Drought
Exposure:
Response:
Consequence:
Narrative: Stochastic (random, naturally occurring) events, such as hurricanes, landslides, and drought, alter or degrade the habitat of Hawaiian damselflies directly by modifying and destroying native riparian, wetland, and stream habitats (e.g., rocks and debris falling in a stream, by mechanical damage to riparian and wetland vegetation), and by indirectly by creating disturbed areas conducive to invasion by nonnative plants that outcompete the native plants used by damselflies for perching. We presume these events also alter microclimatic conditions (e.g., opening the tree canopy, leading to an increase in streamwater temperature; increasing stream sedimentation) so that the habitat no longer supports damselfly populations. Both the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly may also be affected by temporary habitat loss (e.g., desiccation of streams, die-off of uluhe) associated with droughts, which are not uncommon on the Hawaiian Islands. With populations that have already been severely reduced in both abundance and geographic distribution, and particularly in the case of the flying earwig Hawaiian damselfly, with only one known population, even such a temporary loss of habitat can have a severe negative impact on the species. Natural disasters such as hurricanes and drought, and local, random environmental events (such as landslides), represent a significant threat to native riparian, wetland, and stream habitat and the two damselfly species addressed in this final rule. These types of events are known to cause significant habitat damage (Polhemus 1993, p. 86). Because the two species addressed in this final rule now persist in low numbers or occur in restricted ranges, they are more vulnerable to these events and less resilient to such habitat disturbances. Hurricanes, drought, and landslides, even though unpredictable as to exact timing, have been and are expected to continue to be threats to the Hawaiian damselflies. Therefore, they pose immediate and ongoing threats to the two damselfly species and their habitat.

Stressor: Habitat Destruction and Modification by Climate Change
Exposure:
Response:
Consequence:
Narrative: Currently available information on global climate change is not sufficiently the habitats and ecosystems upon which these species rely. Consequently, the exact nature of the impacts of climate change on the aquatic and riparian habitats of the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly, are unknown. However, increasing temperatures and altered patterns of precipitation may affect aquatic habitats through reduced stream flow, evaporation of standing water, increased streamwater temperature, and the loss of native riparian and wetland plants that comprise the habitat in which these two species occur (Pounds et al. 1999, pp. 611-612; Still et al. 1999, p. 610; Benning et al. 2002, pp. 14,246 and 14,248). Oki (2004, p. 4) noted long-term evidence of decreased precipitation and stream flow in the Hawaiian Islands, based upon evidence collected by stream gauging stations. This long-term drying trend, coupled with existing ditch diversions and periodic El Nin˜ o– caused drying events, has created a pattern of severe and persistent stream dewatering events (Polhemus 2008, p. 52). Future changes in precipitation and the forecast of those changes are highly uncertain because they depend, in part, on how the El Nin˜ o–La Nin˜ a weather cycle (a disruption of the ocean atmospheric system in the tropical Pacific having important global consequences for weather and climate) might change (Hawaii Climate Change Action Plan 1998, pp. 2-10). The flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly may be especially vulnerable to extinction due to anticipated environmental change that may result from global climate change. Environmental changes that may affect these species are expected to include habitat loss or alteration and changes in disturbance regimes (e.g., storms and hurricanes), in addition to direct physiological stress caused by increased streamwater temperatures to which the native Hawaiian damselfly fauna are not adapted. The probability of a species going extinct as a result of these factors increases when its range is restricted, habitat decreases, and population numbers decline (Intergovernmental Panel on Climate Change 2007, p. 8). Both of these damselfly species have limited environmental tolerance ranges, restricted habitat requirements, small population size, and a low number of individuals. Therefore, we would expect these species to be particularly vulnerable to projected environmental impacts that may result from changes in climate, and subsequent impacts to their aquatic and riparian habitats (e.g., Pounds et al. 1999, pp. 611-612; Still et al. 1999, p. 610; Benning et al. 2002, pp. 14,246 and 14,248). We believe changes in environmental conditions that may result from climate change will likely impact these two species and, according to current climate projections, we do not anticipate a reduction in this threat any time in the near future; however, the magnitude of this potential threat cannot be determined at this time.

Stressor: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
Exposure:
Response:
Consequence:
Narrative: Individuals from what may be the single remaining population of the flying earwig Hawaiian damselfly were collected by amateur collectors as recently as the mid-1990s (Polhemus 2008, pp. 14-15). Although it is not known how many individuals were collected at that time,

Polhemus (2008, pp. 14-15) inferred that this collection resulted in a noticeable decrease in the population size. Furthermore, if there is only one population of the species left, the decreased reproduction that would result from the removal of potential breeding adults would have a significant negative impact on the species. There is a market for damselflies that may serve as an incentive to collect them. There are internet websites that offer damselfly specimens or parts (e.g., wings) for sale. In addition, the internet abounds with ‘‘how to’’ guides for collecting and preserving damselfly specimens (e.g., Abbott 2000, pp. 1-3; van der Heijden 2005). After butterflies and large beetles, dragonflies and damselflies are probably the mostfrequently collected insects in the world (Polhemus 2008, pp. 14-15). A rare specimen such as the flying earwig Hawaiian damselfly may be particularly attractive to potential collectors (Polhemus 2008, pp. 14-15)). Based on the history of collection of the flying earwig Hawaiian damselfly, the market for damselfly specimens or parts, and the vulnerability of this small population to the negative impacts of any collection, we consider the potential overutilization of the flying earwig Hawaiian damselfly to pose an immediate and significant threat to this species. Unlike the flying earwig Hawaiian damselfly, which is restricted to one remaining population site and which is known to have previously been of interest to odonata enthusiasts (collectors of insects in the order Odonata, including damselflies) (Polhemus 2008, pp. 14-15), we do not believe overcollection is currently a threat to the Pacific Hawaiian damselfly, because it is comparatively more widespread across several population sites on three islands and we are unaware of hobbyist collection of this species.

Stressor: Predation by Nonnative Ants
Exposure:
Response:
Consequence:
Narrative: Ants are not a natural component of Hawaii’s arthropod fauna, and the native species of the islands evolved in the absence of predation pressure from ants. Ants can be particularly destructive predators because of their high densities, recruitment behavior, aggressiveness, and broad range of diet (Reimer 1993, pp. 17-18). The threat of ant predation on the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly is amplified by the fact that most ant species have winged reproductive adults (Borror et al. 1989, p. 738) and can quickly establish new colonies in suitable habitats (Staples and Cowie 2001, p. 55). These attributes allow some ants to destroy otherwise geographically isolated populations of native arthropods (Nafus 1993, pp. 19, 22-23). At least 47 species of ants are known to be established in the Hawaiian Islands (Hawaii Ants 2008, pp. 1-11), and at least 4 particularly aggressive species have severely impacted the native insect fauna, likely including native damselflies (Zimmerman 1948b, p. 173; Reimer et al. 1990, pp. 40-43; HEAR database 2005, pp. 1-2): The bigheaded ant (Pheidole megacephala), the long-legged ant (also known as the yellow crazy ant) (Anoplolepis gracilipes), Solenopsis papuana (no common name), and Solenopsis geminata (no common name). Numerous other species of ants are recognized as threats to Hawaii’s native invertebrates, with a trend of new species of ants being established every few years (Staples and Cowie 2001, pp. 53). Due to their preference for drier habitat sites, ants are less likely to occur in high densities in the riparian and aquatic habitat currently occupied by the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly. However, some species of ants (e.g., thelong-legged ant and Solenopsis papuana) have

increased their range into these areas. The presence of ants in nearly all of the lower elevation habitat sites historically occupied by the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly may preclude the future recolonization of these areas by these two species. Damselfly naiads may be particularly susceptible to ant predation when they crawl out of the water or seek a terrestrial location for their metamorphosis into the adult stage. Likewise, newly emerged adult damselflies are susceptible to predation until their wings have sufficiently hardened to permit flight, or when the adults are simply resting on vegetation at night (Polhemus 2008, p. 59). The long-legged ant appeared in Hawaii in 1952, and now occurs on Kauai, Oahu, Maui, and Hawaii (Reimer et al. 1990, p. 42). It inhabits low to mid-elevation (less than 2,000 ft (600 m)) rocky areas of moderate rainfall (less than 100 in (250 cm) annually) (Reimer et al. 1990, p. 42). Direct observations indicate that Hawaiian arthropods are susceptible to predation by this species. Hardy (1979, p. 34) documented the apparent eradication of native insects within the Kipahulu area on Maui after this area was invaded by the long-legged ant. Although only cursory observations exist, long-legged ants are thought to be a threat to populations of the Pacific Hawaiian damselfly in mesic areas within its elevation range due to their particularly aggressive nature and large colony sizes (Foote 2008, p. 1). Solenopsis papuana is the only abundant, aggressive ant that has invaded intact mesic to wet forest from sea level to over 2,000-ft (600-m) elevation on all of the main Hawaiian Islands, and is still expanding its range (Reimer 1993, p. 14). Gillespie and Reimer (1993, p. 30) found a negative correlation between native spider diversity and areas invaded by this ant species. It is likely, based on our knowledge of the expanding range of this invasive ant, its aggressive nature, and dense populations (Reimer 1993, p. 14), that it may threaten populations of the Pacific Hawaiian damselfly in mesic areas up to 2,000-ft (600-m) elevation as well (Foote 2008, p. 1). The rarity or disappearance of native damselfly species, including the two species in this final rule, from historical observation sites over the past 100 years, is likely due to a variety of factors. There is no documentation that conclusively ties the decrease in damselfly observations to the establishment of nonnative ants in low to montane, and mesic to wet, habitats on the Hawaiian Islands. However, we do have evidence that introduced ants prey on Hawaiian damselflies. In 1998, during a survey of an Oahu stream, researchers observed predation by ants upon another damselfly species, the orangeblack Hawaiian damselfly (Megalagrion xanthomelas) (Englund 2008, pp. 56-57). The presence of nonnative ants in these habitats and parallel decline of damselfly observations in these habitats suggest that nonnative ants may have played a role in the decline of some populations of the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly. In summary, observations and reports have documented that ants are particularly destructive predators because of their high densities, broad range of diet, and ability to establish new colonies in otherwise geographically isolated locations, because the reproductive adult ants are able to fly. Damselfly naiads are particularly vulnerable to ant predation when they crawl out of water or seek a terrestrial location for metamorphosis into adults, and newly emerged adults are susceptible to predation until they can fly. In particular, the long-legged ant and Solenopsis papuana are two aggressive species reported from sea level to 2,000-ft (610-m) elevation on all of the main Hawaiian Islands. Since their range overlaps that of both the flying earwig and Pacific Hawaiian damselfly species, we consider these introduced ants to pose an immediate and significant threat to both damselfly species. Unless these aggressive nonnative ant predators are eliminated or controlled, we expect this threat to continue or increase.

Stressor: Predation by Nonnative Backswimmers
Exposure:
Response:
Consequence:
Narrative: Backswimmers, so called because they swim upside down, are aquatic ‘‘true bugs’’ (Heteroptera). Backswimmers are voracious predators and frequently feed on prey much larger than themselves, such as tadpoles, small fish, and other aquatic insects, including damselfly naiads (Heads 1985, p. 559; Heads 1986, p. 369). Backswimmers are not native to Hawaii, but several species have been introduced. Notonecta indica (no common name) was first collected on Oahu in the mid-1980s and is presently known from Oahu, Maui, and Hawaii. Species of Notonecta are known to prey on damselfly naiads and the mere presence of this predator in the water can cause naiads to reduce foraging (which can reduce naiad growth, development, and survival) (Heads 1985, p. 559; Heads 1986, p. 369). While there is no documentation that conclusively ties the decrease in damselfly observations to the establishment of nonnative backswimmers in Hawaiian streams and other aquatic habitat, the presence of backswimmers in these habitats, the documented predation of backswimmers on the naiads of other damselfly species, and the concurrent decline of damselfly observations in some areas suggest that these nonnative aquatic insects may have played a role in the decline of some damselfly populations, including those of the Pacific Hawaiian damselfly. We consider predation by nonnative backswimmers to pose a significant and immediate threat to the Pacific Hawaiian damselfly, because this species has an aquatic naiad life stage. In addition, the presence of these predators in damselfly aquatic habitat causes naiads to reduce foraging, which in turn reduces their growth, development, and survival. Backswimmers are reported on all of the main Hawaiian Islands except Kahoolawe. Without elimination or control of nonnative backswimmers, we expect this threat to continue or increase over time.

Stressor: Predation by Nonnative Fish
Exposure:
Response:
Consequence:
Narrative: Predation by nonnative fish is a significant threat to Hawaiian damselfly species with aquatic life stages, such as the Pacific Hawaiian damselfly. The aquatic naiads tend to rest and feed near or on the surface of the water, or on rocks where they are exposed and vulnerable to predation by nonnative fish. Hawaii has only five native freshwater fish species, comprised of gobies (Gobiidae) and sleepers (Eleotridae), that occur on all of the major islands. Because these native fish are benthic (bottom) feeders (Kido et al. 1993, pp. 43-44; Ego 1956, p. 24; Englund 1999, pp. 236-237), Hawaii’s stream-dwelling damselfly species probably experienced limited natural predation pressure due to their avoidance of benthic areas in preference for shallow side channels, sidepools, and higher velocity riffles and seeps (Englund 1999, pp. 236-237). While fish predation has been an important factor in the evolution of behavior in damselfly naiads in continental systems (Johnson 1991, pp. 8), it is speculated that Hawaii’s stream-dwelling damselflies adapted behaviors to avoid the benthic feeding habits of native fish species. Additionally, some species of damselflies, including some of the native Hawaiian species, are not

adapted to cohabitate with some fish species, and are found only in bodies of water without fish (Henrikson 1988, p. 179; McPeek 1990a, p. 83). The naiads of the aquatic Pacific Hawaiian damselfly tend to occupy more exposed positions and engage in conspicuous foraging behavior, thereby increasing their susceptibility to fish predation (Englund 1999, p. 232), unlike damselflies that coevolved with predaceous fish (Macan 1977, p. 48; McPeek 1990b, p. 1,714). In laboratory studies, Englund (1999, p. 232) found that naiads of the orangeblack Hawaiian damselfly and the Pacific Hawaiian damselfly invariably were eaten due to their behavior of swimming to the water surface when exposed to two nonnative freshwater fish. In the same study, naiads of nonnative damselfly species avoided predation by the same fish species by remaining still and avoiding surface waters (Englund 1999, p. 232). Over 70 species of nonnative fish have been introduced into Hawaiian freshwater habitats (Devick 1991, p. 190; Englund 1999, p. 226; Staples and Cowie 2001, p. 32; Brasher 2003, p. 1,054; Englund 2004, p.27; Englund et al. 2007, p. 232); at least 53 species are now established in the freshwater habitats of Hawaii (Freshwater Fishes of Hawaii 2008, p. 1). The initial introduction of nonnative fish to Hawaii began with the release of food stock species by Asian immigrants at the turn of the 20th century; however, the impact of these first introductions to Hawaiian damselflies cannot be assessed because they predated the initial collection of damselflies in Hawaii (Perkins 1899, pp. 64-76). In 1905, three species of fish within the Poeciliidae family, including the mosquito fish (Gambusia affinis) and the sailfin molly (Poecilia latipinna), were introduced for biological control of mosquitoes (Van Dine 1907, p. 9; Englund 1999, p. 225; Brasher 2003, p. 1054). In 1922, several additional species were introduced for mosquito control, including the green swordtail (Xiphophorus helleri), the moonfish (Xiphophorus maculatus), and the guppy (Poecilia reticulata). By 1935, some Oahu damselfly species, including the orangeblack Hawaiian damselfly, were becoming less common, and fish introduced for mosquito control were the suspected cause of their decline (Williams 1936, p. 313; Zimmerman 1948b, p. 341). The literature clearly indicates that the extirpation of the Pacific Hawaiian damselfly from the majority of its historical habitat sites on the main Hawaiian Islands is the result of predation by nonnative fish (Moore and Gagne 1982, p. 4; Liebherr and Polhemus 1997, p. 502; Englund 1999, pp. 235-237; Brasher 2003, p. 1,055; Englund et al. 2007, p. 215; Polhemus 2007, pp. 238-239). From 1946 through 1961, several additional nonnative fish were introduced for the purpose of controlling nonnative aquatic plants, and for angling (Brasher 2003, p. 1,054). In the early 1980s, several additional species of nonnative fish began appearing in stream systems, likely originating from the aquarium fish trade (Devick 1991, p. 189; Brasher 2003, p. 1,054). By 1990, there were an additional 14 species of nonnative fish established in waters on Hawaii, Maui, and Molokai. By 2008, there were at least 17 nonnative freshwater fish established on one or more of these islands, including several aggressive predators and habitat-altering species such as the channel catfish (Ictalurus punctatus) and cichlids (Tilapia sp.) (Devick 1991, pp. 191-192; FishBase 2008). The Pacific Hawaiian damselfly is currently found only in portions of stream systems without nonnative fish (Liebherr and Polhemus 1997, pp. 493- 494; Englund 1999, p. 228; Englund 2004, p. 27; Englund et al. 2007, p. 215). There is a strong correlation between the absence of nonnative fish species and the presence of Hawaiian damselflies in streams on all of the main Hawaiian Islands (Englund 1999, p. 225; Englund et al. 2007, p. 215), suggesting that the damselflies cannot coexist with nonnative fish. The distribution of some Hawaiian damselfly species is now reduced to stream reaches less than 312 ft (95 m) in length where invasive fish species do not occur (Englund 1999, p. 229; Englund 2004, p. 27). In

2007, a Statewide survey including 15 streams on the islands of Hawaii, Maui, and Molokai found the flying earwig Hawaiian damselfly was not observed in streams where the introduced Mexican molly (Poecilia mexicana) was present (Englund et al. 2007, pp. 214-216, 228). On Oahu, researchers found that the Oahu-endemic Hawaiian damselflies only occupied habitat sites without nonnative fish. For two of these species, a geologic or manmade barrier (e.g., waterfalls, steep gradient, dry stream midreaches, or constructed diversions) appears to prevent access by the nonnative fish species. For this reason, researchers have recommended that geologically isolated sites inaccessible to nonnative fishes, such as isolated anchialine ponds, high-gradient streams interrupted by manmade diversions, and streams entering the coast as waterfalls, be used as restoration sites for damselflies on all of the Hawaiian Islands (Englund 2004, p. 27). Of the two damselfly species considered in this final rule, the aquatic Pacific Hawaiian damselfly appears to have had the greatest range contraction due to predation by nonnative fish (Englund 1999, p. 235; Polhemus 2007, p. 234, 238-240). Once found on all of the main Hawaiian Islands, it is now found only on Molokai, Maui, and one stream on the island of Hawaii below 2,000 ft (600 m) in elevation; all are in stream reaches free of nonnative fish. The Pacific Hawaiian damselfly was extirpated from Oahu by 1910 (Liebherr and Polhemus 1997, p. 502), although Englund (1999, p. 235) found that Oahu still has abundant and otherwise suitable lowland and coastal water habitat to support this species. However, this aquatic habitat is infested with nonnative fish, with some nonnative species occurring up to 1,300- ft (400-m) elevation. In contrast, Englund (1999, p. 236) found that even at sea level, artificial wetlands (resulting from taro cultivation) on the island of Molokai can support populations of the Pacific Hawaiian damselfly because nonnative fish are absent. Even the geographically isolated stream headwaters and other aquatic habitats where the Pacific Hawaiian damselfly remains extant are not secure from the threat of predation by introduced fish species. There are many documented cases of people moving nonnative fish from one area to another (Brock 1995, pp. 3-4; Englund 1999, p. 237). Once nonnative fish species are introduced to aquatic habitatspreviously free of nonnative fish, they often become permanently established (Englund and Filbert 1999, p. 151; Englund 1999, pp. 232-233; Englund et al. 2007). An example of facilitated fish movement occurred in 2000, when an uninformed maintenance worker introduced Tilapia sp. into pools located on the grounds of Tripler Hospital that were maintained for the benefit of the remaining

Stressor: Predation by Introduced Frogs and Toads
Exposure:
Response:
Consequence:
Narrative: Currently, there are three species of introduced aquatic amphibians known in the Hawaiian Islands: The North American bullfrog (Rana catesbeiana), the cane toad (Bufo marinus), and the Japanese wrinkled frog (Rana rugosa). The bullfrog is native to the eastern United States and the Great Plains region (Moyle 1973, p. 18; Bury and Whelan 1985 in Earlham College 2002, p. 10), and was first introduced into Hawaii in 1899 (Bryan 1931, p. 63) to help control insects, specifically the nonnative Japanese beetle (Popillia japonica), a significant pest of ornamental plants (Bryan 1931, p. 62). Bullfrogs were first released and quickly became established in the Hilo region on the island of Hawaii (Bryan 1931, p. 63). Bullfrogs have demonstrated great success in establishing new populations wherever they have been introduced (Moyle 1973, p. 19), and

now occur on the islands of Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu (U.S. Geological Survey 2008b, p. 8). This species is flexible in both habitat and food requirements (Bury and Whelan 1985 in Earlham College 2002, p. 11), and can utilize any water source within its temperature range (60 to 75 degrees Fahrenheit (°F)) (16 to 24 degrees Celsius (°C)) (DesertUSA 2008). Introduced to areas outside its native range, the bullfrog's primary impact is typically the elimination of native frog species (Moyle 1973, p. 21). In Hawaii, where there are no native frogs, the bullfrog has not been definitively implicated in the extirpation of any particular native aquatic invertebrate species, but Englund et al. (2007, pp. 215, 219) found a strong correlation between the presence of bullfrogs and the absence of Hawaiian damselflies in their 2006 study of streams on all of the main Hawaiian Islands. As the bullfrog prefers habitats with dense vegetation and relatively calm water (Moyle 1973, p. 19; Bury and Whelan 1985 in Earlham College 2002, p. 9), it is likely of particular threat to the Pacific Hawaiian damselfly because this species also prefers calm water habitat that is surrounded by dense vegetation. Capable of breeding within small pools of water, bullfrogs are also a potential threat to the flying earwig Hawaiian damselfly within its uluhe-covered, steep, riparian, and moist talus-slope habitat on Maui. Because the effects of possible predation by the cane toad and the Japanese wrinkled frog on the flying earwig Hawaiian damselfly and the Pacific Hawaiian damselfly are unknown at this time, the magnitude or significance of this potential threat cannot be determined. We consider predation by bullfrogs to pose a significant and immediate threat to the Pacific Hawaiian damselfly, since Englund et al. (2007, pp. 215, 219) found a strong correlation between the presence of predatory nonnative bullfrogs and the absence of Hawaiian damselflies, and the preferred habitat of the bullfrog overlaps with that of the Pacific Hawaiian damselfly. Within its riparian habitat, the flying earwig Hawaiian damselfly may also be threatened by the bullfrog, which is capable of breeding within small pools of water. In the absence of the elimination or control of nonnative bullfrogs, we expect that this threat will continue or increase in the future. From 5-year review: Coqui frogs, Eleutherdactylus coqui, were introduced to the State of Hawaiʻi in the late 1980s (Woolbright et al 2006) and are present on Maui and Hawaiʻi island. The frogs have limited predators (mongoose, rats, and feral cats) enabling them to become successful invaders across wet forest habitats and allowing their populations to grow extraordinarily dense compared to in their native habitat of Puerto Rico (Woolbright et al. 2006). On Maui, populations of frogs are known in and around nurseries and hotels, residential areas, and there are several large populations in natural areas (Maui Invasive Species Committee 2018). It could likely expand into the habitat of the Pacific Hawaiian damselfly where it will compete for food resources. (USFWS, 2018)

Stressor: Inadeqate regulations
Exposure:
Response:
Consequence:
Narrative: The aquatic habitat of the flying earwig and the Pacific Hawaiian damselflies is under the jurisdiction of the State of Hawaii, which also has management responsibility for aquatic organisms. However, the State Water Code has no regulatory mechanism in place to protect these species or their habitat. The State Water Code does not currently provide for permanent or minimum instream flow standards for the protection of aquatic ecosystems upon which these damselfly species depend, and does not contain a regulatory mechanism for identifying and

protecting damselfly habitat under a Wild and Scenic River designation. To date, administration of the Clean Water Act permitting program by the U.S. Army Corps of Engineers has not provided substantive protection of damselfly habitat, including any requirements for retention of adequate instream flows. Existing State and Federal regulatory mechanisms are not adequately regulating the spread of nonnative animal species between islands and watersheds. Predation by nonnative animal species poses a major ongoing threat to the flying earwig and the Pacific Hawaiian damselflies. Because existing regulatory mechanisms are inadequate to maintain aquatic habitat for the damselflies and to regulate the spread of nonnative species, the in adequacy of existing regulatory mechanisms is considered to be a significant and immediate threat.

Stressor: Small Numbers of Populations and Individuals
Exposure:
Response:
Consequence:
Narrative: Species that are endemic to single islands or known from few, widely dispersed locations are inherently more vulnerable to extinction than widespread species because of the higher risks from genetic bottlenecks, random demographic fluctuations, climate change, and localized catastrophes such as hurricanes, landslides, and drought (Lande 1988, p. 1,455; Mangel and Tier 1994, p. 607; Pimm et al. 1988, p. 757). These problems are further magnified when populations are few and restricted to a limited geographic area, and the number of individuals is very small. Populations with these characteristics face an increased likelihood of stochastic extinction due to changes in demography, the environment, genetics, or other factors, in a process described as an ‘‘extinction vortex’’ by Gilpin and Soul´e (1986, pp. 24-25). Small, isolated populations often exhibit a reduced level of genetic variability or genetic depression due to inbreeding, which diminishes the species’ capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Soul´e 1987, pp. 4-7). The problems associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats. Historically, the two damselfly species were more widespread, present on several Hawaiian islands. An important benefit of this greater historical range, especially the fact they were on several islands from which they are now extirpated, resulted in an advantage of redundancy: Additional populations separated by some distance likely allowed some populations to be spared the impacts of localized or more discrete catastrophic events, such as narrow-track hurricanes or mud slides. However, this advantage of redundancy has been lost with the great reduction in the damselflies’ ranges. Jordan et al. (2007, p. 247) showed in historical processes responsible for genetic divergence within a species) of four Megalagrion species that the Pacific Hawaiian damselfly may be more susceptible to problems linked to low genetic diversity compared to other Hawaiian damselfly species. Both Maui and Molokai populations of this species were analyzed, and results suggested that the Pacific Hawaiian damselfly may not disperse well across both land and water, which may have led to the low genetic diversity observed in the two populations sampled. The authors proposed that populations of the Pacific Hawaiian damselfly be monitored and managed to help understand the conservation needs of this species and the threat of population bottlenecks (Jordan et al. 2007, p. 258). This study did not include an analysis of the flying earwig Hawaiian damselfly. However, given that this species

may now be reduced to a single population, the potential loss of genetic diversity and threat of inbreeding depression is a concern for the flying earwig Hawaiian damselfly as well. The small number of remaining populations of the flying earwig Hawaiian damselfly (now possibly reduced to a single remaining population) puts this species at significant risk of extinction from stochastic events, such as hurricanes, landslides, or prolonged drought (Jones et al. 1984, p. 209). For example, Polhemus (1993, p. 87) documented the extirpation of a related damselfly species, Megalagrion vagabundum, from the entire Hanakapiai Stream system on Kauai as a result of the impacts from Hurricane Iniki in 1992. Such stochastic events thus pose the threat of immediate extinction of a species with a very small and geographically restricted distribution, as in the case of the flying earwig Hawaiian damselfly. their genetic and comparative phylogeography analysis (study of historical processes responsible for genetic divergence within a species) of four Megalagrion species that the Pacific Hawaiian damselfly may be more susceptible to problems linked to low genetic diversity compared to other Hawaiian damselfly species. Both Maui and Molokai populations of this species were analyzed, and results suggested that the Pacific Hawaiian damselfly may not disperse well across both land and water, which may have led to the low genetic diversity observed in the two populations sampled. The authors proposed that populations of the Pacific Hawaiian damselfly be monitored and managed to help understand the conservation needs of this species and the threat of population bottlenecks (Jordan et al. 2007, p. 258). This study did not include an analysis of the flying earwig Hawaiian damselfly. However, given that this species may now be reduced to a single population, the potential loss of genetic diversity and threat of inbreeding depression is a concern for the flying earwig Hawaiian damselfly as well. The small number of remaining populations of the flying earwigHawaiian damselfly (now possibly reduced to a single remaining population) puts this species at significant risk of extinction from stochastic events, such as hurricanes, landslides, or prolonged drought (Jones et al. 1984, p. 209). For example, Polhemus (1993, p. 87) documented the extirpation of a related damselfly species, Megalagrion vagabundum, from the entire Hanakapiai Stream system on Kauai as a result of the impacts from Hurricane Iniki in 1992. Such stochastic events thus pose the threat of immediate extinction of a species with a very small and geographically restricted distribution, as in the case of the flying earwig Hawaiian damselfly.

Stressor: Habitat poisoning (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Habitat poisoning is a potential threat to the Pacific Hawaiian damselfly. Exposure to pesticide contamination can cause acute and chronic poisoning and lead to the mortality of non-target aquatic organisms (Gulliya et al. 2021, p. 10134; USFWS 2022a, pp. 14– 15). Pesticides applied to the aquatic environment during collection of Tahitian prawns (Macrobrachium lar) can poison and cause mortality to all aquatic life (HDLNR 2018a, entire; HDLNR 2020a, entire; USFWS 2022a, pp. 14–15). In one stream where pesticide was used for Tahitian prawn collection, anecdotal evidence indicates that the orangeblack Hawaiian damselfly (Megalagrion xanthomelas) has not been documented since pesticide application (Magnacca 2022, in litt., entire; USFWS 2022a, pp. 14–15). Hawaiian damselfly larvae and eggs can be exposed to pesticide contaminated water through direct contact. In addition, secondary poisoning can occur

to Hawaiian damselfly adults and larvae through bioaccumulation by the consumption of contaminated prey (USFWS, 2023).

Stressor: Hydra vulgaris (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: A predatory, freshwater invertebrate, Hydra vulgaris, is a newly identified threat to Hawaiian damselflies. Water studies by State of Hawaiʻi Department of Land and Natural Resources Division of Forestry and Wildlife Hawaiʻi Invertebrate Program have shown Hydra is a threat to the orangeblack Hawaiian damselfly population located at Tripler Army Medical Center. This common aquarium system pest appears to be preying on damselfly naiads in addition to their other prey that includes Moina and Culex larvae (USFWS, 2023).

Stressor: Habitat Destruction (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: A threat to the Pacific Hawaiian damselfly is the ongoing destruction and degradation of wetland and lowland stream habitat by nonnative animals, particularly feral pigs (Sus scrofa) (Polhemus and Asquith 1996, p. 22; Erickson and Puttock 2006, p. 42; USFWS 2022a, p. 13). Animals such as feral pigs, goats (Capra hircus), axis deer (Axis axis), black-tailed deer (Odocoileus hemionus), and cattle (Bos taurus) were introduced either by the early Hawaiians around 400 A.D. or more recently by European settlers for food and/or commercial ranching activities (Tomich 1986, pp. 120–121; USFWS 2022a, p. 13). Feral pigs threaten the existence of the Pacific Hawaiian damselfly by trampling the forest floor, thereby encouraging the establishment of nonnative plants, and by removing vegetation by wallowing in moist depressions (Stone 1985, p. 263; Cuddihy and Stone 1990, p. 65; USFWS 2022a, p. 13). In nitrogen-pool soils, feral pig excrement increases nutrient availability, enhancing establishment of nonnative weeds that are more adapted to richer soils than are native plants (Cuddihy and Stone 1990, p. 65; USFWS 2022a, p. 13). Rooting by feral pigs was observed to be related to the search for earthworms, with rooting depths averaging 8 inch (20 centimeters), and rooting was found to greatly disrupt the leaf litter and topsoil layers, and contribute to erosion and changes in ground topography (Diong 1982, pp. 150, 160–167; USFWS 2022a, p. 13). In addition, Mountainspring (1986, p. 98) surmised that rooting by feral pigs depresses insect populations that rely on ground litter for reproduction; this could impact prey availability for damselflies (Foote 2008, in litt., entire; Polhemus 2008, p. 48; USFWS 2022a, p. 13). Feral pigs are often managed as game animals for public hunting (The Nature Conservancy 2014, p. 12; USFWS 2022a, p. 13). In contrast to a total eradication program, this action makes it more likely that feral pigs will continue to exist in Hawaiʻi, and thus likely that feral pigs will continue to destroy and degrade habitat of the Pacific Hawaiian damselfly (USFWS, 2023)

Recovery

Reclassification Criteria:
Recovery Priority Number = 5 (USFWS, 2022)

Delisting Criteria:
Not available

Recovery Actions:
- Develop and implement a detailed monitoring plan for Megalagrion pacificum and its preferred habitat. (USFWS, 2018)
- Conduct targeted surveys for Megalagrion pacificum to determine the distribution of the species. (USFWS, 2018)
- Stabilize and protect extant populations of Megalgrion pacificum. (USFWS, 2018)
- Identify the primary habitat features and characteristics necessary for Megalagrion pacificum recovery. (USFWS, 2018)
- Identify and evaluate the primary biological characteristics necessary for Megalagrion pacificum recovery. (USFWS, 2018)
- Develop the recovery plan for Megalagrion pacificum. (USFWS, 2018)
- Refine and calibrate the indexes for invertebrate communities that are used for monitoring programs to improve stream habitat. (USFWS, 2018)
- Eliminate or manage nonnative predators of Megalagrion pacificum. (USFWS, 2018)
- Survey, document, and manage threats to Megalagrion pacificum. (USFWS, 2018)
- Once habitat requirements are understood, translocate Megalagrion pacificum to other suitable sites. (USFWS, 2018)

Conservation Measures and Best Management Practices:
- Recommendations for Future Actions: • Develop and implement a detailed monitoring plan for Megalagrion pacificum and its preferred habitat. • Conduct targeted surveys for Megalagrion pacificum to determine the distribution of the species. • Based on survey results, stabilize and protect extant populations of Megalagrion pacificum and implement the recovery plan. • Identify the primary habitat features and characteristics necessary for Megalagrion pacificum recovery. • Identify and evaluate the primary biological characteristics necessary for Megalagrion pacificum recovery. • Maintain and protect the habitat of Megalagrion pacificum. • Refine and calibrate the indices for invertebrate communities that are used for monitoring programs to improve stream habitat. • Eliminate or manage nonnative predators of Megalagrion pacificum. • Survey, document, and manage threats to Megalagrion pacificum. • Once habitat requirements are understood, translocate Megalagrion pacificum to other suitable sites (USFWS, 2023)

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SPECIES ACCOUNT: *Neonympha mitchellii francisci* (Saint Francis' satyr butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: SFS

Listing Status: Endangered; 4/18/1994; Southeast Region (R4) (USFWS, 2017)

Physical Description

Saint Francis' satyr is a fairly small dark brown butterfly and is a typical member of the Satyrinae, a subfamily of the Nymphalidae, which includes many species commonly called satyrs and wood nymphs. The wingspan for the species (including both subspecies) ranges from 34 to 44 millimeters (Opler and Malikul 1992, Parshall and Kral 1989). Saint Francis' satyr and Mitchell's satyr, N. m. mitchellii, (also listed as endangered) are nearly identical in size and show only a slight degree of sexual size dimorphism (Hall 1993, Parshall and Kral 1989). Like most species in the wood nymph group, Saint Francis' satyr has conspicuous eyespots on the lower surfaces of the wings. These eyespots have a dark maroon-brown center, and within the eyespots are lighter opalescent patches that reflect a silver cast in certain lights. Unlike the sympatric N. areolata septentrionalis (David) (the Georgia satyr), which often has small patches of yellow within the maroon eyespots, Saint Francis' satyr has only the opalescent patches, without the yellow. The border of these dark eyespots is straw-yellow in color, with an outermost border of dark brown. The eyespots are usually round to slightly oval and are well-developed on the forewing as well as on the hind wing. The spots are accented by two bright orange bands along the posterior wing edges and two somewhat darker orange-brown bands across the central portion of each wing. Saint Francis' satyr, like Mitchell's satyr (the nominate subspecies), can be distinguished from its North American congener, N. areolata, by the latter's well-marked eyespots on the upper wing surfaces and brighter inner orange bands on the hind wing, as well by a lighter overall coloration in the female (Service 1991, McAlpine et al. 1960, Wilsman and Schweitzer 1991, Hall 1993). The shape of the inner post-median band (the band immediately on the inside of the eyespots) is relatively straight on most Saint Francis' satyrs and noticeably indented on Georgia satyrs (USFWS, 1996).

Taxonomy

Following its discovery, the SFS was listed as a subspecies of the Mitchell's satyr (Neonympha mitchelliana) complex. The nominate species is N. m. mitchellii, which is distributed sparsely in the mid- and eastern US, including in Michigan, Alabama, Mississippi, and Virginia, and formerly in New Jersey. Although the Alabama, Mississippi, and Virginia populations were discovered after the recovery plan for SFS was written and are morphometrically similar to SFS, current molecular genetic evidence supports that they are distinct from SFS, and that SFS should remain as a separate subspecies from all other populations in the Neonympha complex (Goldstein et al. 2004) (USFWS, 2013).

Historical Range

The historic range for SFS consists solely of the area currently known to be occupied by the species within Ft. Bragg (Stephen Hall, NC Natural Heritage Program, June 28, 2010, pers. comm.) (USFWS, 2013).

Current Range

Fort Bragg is about 250 square miles, of this about 100 square miles is in long leaf pine communities, and this butterfly ranges through only a relatively small portion of this. See Kuefler et al. (2008) (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larvae have been seen eating a variety of sedges (USFWS, 1996).

Adult: Adult food habits not really known. L (Natureserve, 2015)

Reproduction Narrative

Adult: Larval host plant has been discovered (Carex mitchelliana) (USFWS, 2013). Species lays eggs on host plant and has two reproductive cycles per year. A great deal of new information about the SFS biology and life history has been discovered in the past 25+ years (summarized by Kuefler et al. 2008, U.S. Fish and Wildlife Service 2013, this report) including insights on flight periods, predators, lifespan and survival, dispersal ability, larval host plants, and advances in captive breeding. This information is still accumulating and new research will be important to furthering ongoing conservation and restoration efforts. The St. Francis' satyr is bivoltine, with adults emerging in May through early June and again in July through early August. The onset of each of two flight periods can vary; the first flight period is highly predictable based on climate patterns classified into growing degree days, which accounts for heat input into ecosystems. The peak activity of the second flight period is approximately 62 days after the peak of the first flight period. The last brood overwinters in a larval stage and then resumes feeding and development before pupating in the spring (Figure 1). Caterpillars are very difficult to detect in the field and have only been observed twice since efforts began in 2002. Both detections were on or near a presumed larval host plant, Mitchell's sedge, Carex mitchelliana. (USFWS, 2020)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow (USFWS, 1996; NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 1996; NatureServe, 2015)

Site Fidelity

Adult: High (inferred from USFWS, 1996; NatureServe, 2015)

Habitat Narrative

Adult: The habitat occupied by this satyr consists primarily of wide wet meadows dominated by a high diversity of sedges (Carex spp.) and other wetland graminoids. In the North Carolina sandhills, such meadows are often relicts of beaver activity. Saint Francis' satyr has also been observed in pitcher plant (Sarracenia flava) swales, with cane (Arundinaria tecta), and with the rare plants rough-leaved loosestrife (Lysimachia asperulaefolia, federally listed as endangered) and pocosin lily (Lilium iridollae, a species of Federal concern). It is, however, unknown whether the satyr uses such swale habitat for feeding, breeding, and perching, or simply as a dispersal corridor. Unlike the habitat of Mitchell's satyr, the North Carolina species' habitat cannot properly be called a fen because the waters of this sandhills region are extremely poor in inorganic nutrients (USFWS, 1996). Known only from a few sedge wetlands in close proximity. Habitat apparently open seepage areas dominated with Carex. Habitat is successional or disclimax with both beaver and fires being apparently critical factors in maintaining it (Natureserve, 2015). Clumped spatial arrangement and narrow environmental specificity are based on specific habitat requirements of the species as are high ecological integrity and site fidelity and low tolerance range (USFWS, 1996; NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Basically a weak flier and fairly sedentary. However some dispersal does occur, although distances involved are poorly known. Probably very rarely wanders more than a kilometer.; Nonmigrant: N; Local migrant: N; Distant migrant: N; (Natureserve, 2015)

Population Information and Trends

Population Trends:

Stable (Natureserve, 2015)

Species Trends:

Species status: Improving. The St. Francis' satyr is predisposed to local extinction due to its small population size and dependence on regular disturbance events. Without disturbance, these habitats become unsuitable and can result in local extinction (USFWS, 2020)

Number of Populations:

1 (USFWS, 2020)

Population Size:

~500 (USFWS, 2020)

Population Narrative:

Habitats are dynamic and the essential processes that maintain them, mainly beavers and fires, are likely to be lethal to any individuals present in the affected area. The species is a good short distance colonizer. There is no actual evidence that this subspecies ranged more widely, although it probably did. Regardless there is no basis to assess long term trend (Natureserve, 2015). NatureServe (2015) also notes that the short-term population trend is stable. Low resiliency, representation and redundancy are inferred based on low number of populations and limited habitat. After the original subpopulation of SFS was first detected outside impact areas, broad, base-wide surveys were conducted irregularly for several years to determine general population size and distribution (Hall 1993, Hall and Hoffman 1994, Hall et al. 2001, Hall 2003). Starting in 2002, several large colonies were monitored annually during each flight period to obtain systematic population counts. Monitoring was performed using both transect counts (a modified PollardYates method; Pollard 1977) and mark-release-recapture techniques (Kuefler et al. 2008), both of which can provide robust estimates of population size (Gross et al. 2007, Haddad et al. 2008). Since regular surveys began in 2002, monitoring data show populations peaked in 2004 (Cayton et al. 2019; Figure 2). The overall population stabilized near 500 individuals for several years, although subpopulation levels fluctuated annually. Rapid declines occurred in 2010 and 2011 and by 2012, several subpopulations declined or went extinct (in 2003, 2005, 2008-2010) and the overall population size was fewer than 100 individuals (Cayton et al. 2013, Haddad 2015). This decline is most likely due to several factors that have continued to impact populations in the past several years, most notable dry environmental conditions and hardwood and cane succession (Cayton et al. 2015, 2019). The number of subpopulations outside of the dudded impact areas has been reduced from five to one in last 20 years. As of 2020, only two historic sites outside the impact areas support a population, mainly as a result of active restoration activities and releases of captive-bred butterflies. One of these areas were extirpated but repopulated in 2012 (N. Haddad, pers. comm., March 9, 2020). (USFWS, 2020)

Threats and Stressors

Stressor: Fire Suppression (USFWS, 1996)
Exposure:
Response:
Consequence: Loss of habitat

Narrative: Periodic fires are necessary to maintain the species sedge wetland habitat (USFWS, 1996).

Stressor: Loss of beavers in habitat (USFWS, 1996)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Beavers had been virtually eliminated from North Carolina by the turn of the century. Reintroductions began in 1939, but it was several decades before they again became an agent for the creation of the sedge meadow habitats favored by Saint Francis' satyr (Hall 1993, Woodward and Hazel 1991) (USFWS, 1996).

Stressor: Collection/Illegal Trade (USFWS, 1996)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Both subspecies of Neonympha mitchellii are highly prized by collectors, including commercial collectors who often systematically collect every individual available. Two populations of the nominate subspecies are strongly suspected to have been extirpated by collectors, and others are believed extremely vulnerable to this threat (Service 1991). As mentioned earlier, the single known population of Saint Francis~ satyr was so hard hit by collectors in the 3 years following its initial discovery that it was believed to have been collected to extinction. The Service is aware of an illegal trade in listed, protected, and rare butterflies. Collecting of butterfly species that exist in small colonies or the repeated handling and marking (particularly of females and/or in years of low abundance) can seriously damage the populations through loss of individuals and genetic variability (Gall 1984, Murphy 1988, Singer and Wedlake 1981). The collection of females dispersing from a colony can also reduce the probability that new colonies will be founded. Butterfly collectors pose a threat because they may be unable to recognize when they are depleting colonies below the thresholds of survival or recovery, especially when the area is visited for a short period of time (Collins and Morris 1985). Although collectors generally do not adversely affect the healthy, well-dispersed populations of common butterfly species, a number of rare species, such as those that are highly valued by collectors, are vulnerable to extirpation or extinction from collecting. Species with small populations at only a few sites may be adversely affected by the cumulative effects of removal of very few individuals from a site by a few collectors. Unscrupulous collectors, who take every specimen they can find on successive days, could eliminate populations of some species in just a few years (USFWS, 1996).

Stressor: Fires at wrong time (USFWS, 1996)
Exposure:
Response:
Consequence: Loss of colony (ies)
Narrative: Although the habitat occupied by this species is dependent upon some form of disturbance to set back succession (e.g., periodic fire and/or beaver impoundments), intense fires at critical times during the life cycle of the species can eliminate small colonies. Historically, this

wouldn't have been a problem since there were undoubtedly other adjacent populations that could recolonize extirpated sites. However, the sole surviving metapopulation of this species now consists of 20 small colonies. The actual area occupied by the species totals approximately 57 acres. This fact makes Saint Francis' satyr more vulnerable to such threats as catastrophic climatic events, inbreeding depression (depending on actual population size), disease, and parasitism (USFWS, 1996).

Stressor: Toxic chemicals/pest control (USFWS, 1996)
Exposure:
Response:
Consequence:
Narrative: Part of the occupied area is adjacent to regularly traveled roads, where there is the threat of toxic chemical spills into the species' wetland habitat. Current military use of the impact areas is favorable to this species; the frequent fires associated with shelling are undoubtedly a principal reason why the species is surviving on military land and not on the surrounding private land. Department of Defense personnel are aware of the species' plight and have been cooperative in protection efforts (USFWS, 1996).

Stressor: Heavy siltation (USFWS, 1996)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Heavy siltation is a problem on this military installation; it could threaten the small drainages occupied by the species (USFWS, 1996).

Recovery

Reclassification Criteria:
1. Protect and manage existing populations and essential habitat. Monitor existing populations. Protect existing populations. Manage for the long-term survival of existing populations. (USFWS, 1996).

2. Continue research into the species' life history. ecology, and reasons for decline (USFWS, 1996).

3. Conduct searches for additional populations (USFWS, 1993).

4. Establish additional wild populations within historic range (USFWS, 1996).

5. Develop information and education programs (USFWS, 1996).

Delisting Criteria:
1. The recovery plan for the SFS states that the species will be considered for downlisting when the existing metapopulation has been stable or increasing in numbers for at least 10 to 15 years

and when a long-term protection and management plan is in place to ensure its continued survival. Delisting will be considered when the existing metapopulation has been protected and stabilized and when at least three other populations have been discovered or established in the sandhills region and they have been stable or increasing for 10 to 15 years. Population fluctuations are believed to be substantial; a period of 10 to 15 years is believed to be essential to define “naturally occurring” fluctuations. Protection and management plans must be implemented for all populations before reclassification can be considered (USFWS, 2013).

Recovery Actions:

- A long-term monitoring system has been in place since 2002 to estimate population size at all major butterfly sites occurring outside artillery impact areas. Several steps have been taken to protect existing populations. All SFS sites are buffered, with clear markings that sites are off limits to military training activities. In one subpopulation that is in a heavily trafficked navigation training area, military training activities have been greatly reduced and training routes re-drawn. Most sites are inaccessible and see virtually no military traffic. Some attempt is made by Environmental Compliance Specialists at Ft. Bragg to regularly patrol sites during adult flight periods and law enforcement officials on Ft. Bragg are briefed annually on the need to deter collection at SFS sites. Locations are kept confidential among researchers and some military personnel, thereby minimizing opportunities for collection of the species for unlawful commercial gain. The DoD has provided extensive support to maintain habitat and continue research on the SFS USFWS, 2013). A long-term management plan to address the habitat requirements and threats at occupied sites remains incomplete, primarily because we do not have a complete understanding of disturbance factors, particularly beaver inundation and fire, operating at the landscape scale to maintain high quality habitat (described below; Kuefler et al. 2008). In addition, because of where the subpopulations are located, planning habitat management must minimize interference with military training activity. Until we can clearly articulate the optimal disturbance management for the butterfly, it will be difficult to specify a management plan. Researchers and the military are currently working closely to retain beaver activity in focal areas and to allow fires through wetlands. Although most wetlands occupied by SFS are not used by military personnel, there may be other landscape-level factors, like the density of roads, which affect beaver activity or wetland suitability.
- Extensive research into life history and ecology of SFS has been conducted since the recovery plan was written. Of particular importance is the recognition of the dependence of SFS on disturbance, particularly by beaver. These relationships were discovered during initial surveys and have been verified with continued observation and habitat restoration research. Most SFS subpopulations are found in abandoned beaver dams or along streams with active beaver complexes. SFS cannot survive in sites that are either inundated by flooding or succeed to riparian forest. Thus, SFS often requires disturbance by beaver to maintain its habitat. However, anecdotal evidence of several sites inside the impact areas showed that they remained occupied by SFS with little if any influence of beaver activity (E. Hoffman, Ft. Bragg, June 17, 2010, pers. comm.). The challenge for future management is to understand the ideal activity level of beaver to maintain SFS. One conundrum in understanding SFS dependence on disturbance is one site in the artillery impact area, an extensive canebreak that is apparently maintained by frequent fire, but with little evidence of beaver. Outside artillery impact areas, controlled and wild fires have been observed to severely reduce SFS population size without later recovery. Yet, SFS is maintained by fire in at least one site.

Therefore, more research is needed to understand why and how fire maintains this subpopulation, especially if fire is to be used as a management tool elsewhere. Fire has failed to maintain SFS populations in two sites outside artillery impact areas. Understanding the importance of fire, beaver activity, and the interplay between the two is critical to successfully manage suitable SFS habitat (USFWS, 2013).

- Currently all known subpopulations are restricted to Ft. Bragg and populations have not been located on private land or elsewhere (Hall, 1993, Haddad et al. 2009). Initial baseline surveys were conducted by Ft. Bragg from 1994 to 1996, with 21 SFS sites with at least one butterfly present discovered across the installation, including 14 sites within the impact areas (E. Hoffmann, Ft. Bragg, June 17, 2010, pers. comm.). Since the recovery plan was written, a number of additional sub-populations have been discovered, including two active subpopulations and one currently inactive subpopulation, all located outside artillery impact areas. The number and size of SFS subpopulations within artillery impact areas are still largely unknown. Although impact areas have potential as high quality habitat due to frequent artillery and flares that cause annual fires, access to these areas is restricted and only granted on an extremely limited basis (Hall et al. 2001). In 2009, four of the originally detected 14 subpopulations, plus two new subpopulations, were confirmed to be active with large populations (hundreds of individuals, and at two sites, possibly thousands of individuals). Of the original 14 sites, four have been observed to have low population numbers (with two having substantially reduced numbers), and three are now thought to be inactive. Three sites discovered in 1994 cannot be checked because they are in highly restricted areas. Because sites have been accessed so infrequently, it is difficult to estimate population sizes. There are likely other sites within impact areas that support subpopulations but cannot be accessed (USFWS, 2013).
- The historic range for SFS consists solely of the area currently known to be occupied by the species within Ft. Bragg (Stephen Hall, NC Natural Heritage Program, June 28, 2010, pers. comm.). No new populations have been established. Efforts are currently underway to augment existing populations at Ft. Bragg with releases of captive-reared adults. A limited number of adults were released in July and August 2009 at an unoccupied site in the northwest sector of Ft. Bragg in a pilot attempt to establish a new breeding population. In 2011, an experimental habitat restoration project created four additional sites to establish new subpopulations. Over the past two years, adults have been successfully released to these sites (USFWS, 2013).
- Most efforts to increase public awareness about SFS have been through publication in scientific journals of relevant species' ecology and life history traits, although some popular press articles have been released. Ft. Bragg's Endangered Species Branch has collaborated with scientists to develop partnerships with the scientific community. Some educational programs targeted to school-age children, as suggested in the recovery plan, have been developed by Ft. Bragg since 1996. During special events, such as Earth Day celebrations and Career Day, school children from Ft. Bragg and the surrounding community schools have been targeted through educational presentations. In addition, educational booths have been set up at local community events, including BugFest at the NC Museum of Natural Sciences, to educate the general public. Several Boy Scout troops and Eagle Scout projects have targeted educating school children about the SFS. In 2011, the SFS was highlighted in the Service's Endangered Species Bulletin as well as in the Wildlife in North Carolina magazine (USFWS, 2013).
- Continued long-term monitoring of all sites with known SFS populations and all historically known sites outside artillery impact areas. The recovery plan calls for detailed monitoring for

at least 10-15 years that shows populations as stable or increasing, and this trend cannot be shown with current information (USFWS, 2013).

- Increased monitoring of populations within impact areas. It is crucial to obtain accurate estimates of subpopulation sizes within impact areas to determine the total number of SFS remaining in the wild. Even short annual surveys performed during one flight period would provide population information needed to evaluate recovery and understand habitat factors needed for restoration (USFWS, 2013).
- Preservation of existing suitable habitat. Rapid decline in high quality wetland habitat from succession, drought, or other environmental factors could quickly eliminate large established populations that could act as source populations for further colonization. If these potential source populations decline, there will be additional reliance on using captive-raised individuals to establish new sites which could result in reduced genetic variation in the metapopulation overall. More work is needed on how to manage disturbances to optimize habitat suitability (USFWS, 2013).
- Restoration of new suitable habitat for colonization. These sites should closely resemble already established sites and provide high quality habitat for breeding individuals with low potential for human disturbance. Ideally these sites would be established through planned management practices and subsequently maintained through natural periodic disturbance regimes. Determining the effects of fire on SFS habitat and metapopulation dynamics requires more investigation. Efforts to restore habitat through hardwood removal and temporary inundation could prove important in increasing the area of suitable habitat for the butterfly (USFWS, 2013).
- Continued augmentation of existing populations using captive-reared individuals. The sedentary lifestyle of adults and infrequently observed dispersal events of individuals suggests that colonization of new sites may be difficult to accomplish through regular dispersal among fragmented sites, but could occur with assisted releases. Captive-reared individuals provide an excellent source from which to create new colony sites and could create a link between fragmented populations that would allow population growth (USFWS, 2013).
- Establishment of experimental populations off of Ft. Bragg. To be delisted, SFS will need to occur in two additional populations outside of Ft. Bragg. There are public lands in the vicinity of Ft. Bragg such as the Sandhills Gamelands and the Sandhills National Wildlife Refuge, as well as lands held by non-profit conservation organizations that may be ideal areas to identify or restore habitat suitable for experimental populations. Additional research to determine the exact species historic range would aid and possibly expand choices for population establishment off base (USFWS, 2013).
- Continued habitat surveys to determine key vegetation characteristics of high quality sites. Surveys should be conducted at sites both inside and outside artillery impact areas. These should incorporate possible effects of sedimentation and erosion of roads on vegetation (USFWS, 2013).
- Continued improvement of habitat suitability models through ground-truthing. These can potentially lead the discovery of new SFS populations, which would greatly improve species outlook and may add additional information on habitat requirements (USFWS, 2013).
- Develop a Memorandum of Agreement between Ft. Bragg, USFWS and the NC Natural Heritage Program that sets specific policies that coordinate SFS, beaver and fire management. Further, Ft. Bragg should share (with the above listed parties) their records of

where, when and how specific beaver and fire management operations were and will be conducted (USFWS, 2013).
- Additional study for SFS dispersal mechanisms and behavior. Understanding their dispersal dynamics will have important management implications (USFWS, 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Continued long-term monitoring of all sites with known SFS populations and all historically known sites outside dudded impact areas. The recovery plan callsfor detailed monitoring for at least 10-15 years that shows populations as stable or increasing, and this trend cannot be shown with current information. • Increased monitoring of populations within impact areas. It is crucial to obtain accurate estimates of subpopulation sizes within impact areas to determine the total number of SFS remaining in the wild. Ideally, access would be consistently permitted to allow regular monitoring—minimally weekly during the flight periods—in order to create consistent population indices to provide population information needed to evaluate recovery and understand habitat factors needed for restoration. Access to date has been limited to ~2 personnel. By increasing group size where/when possible, researchers can better evaluation population trends and search for additional potential habitats and subpopulations. • Preservation of existing suitable habitat. Rapid decline in high quality wetland habitat from succession, drought, or other environmental factors could quickly eliminate large established populations that could act as source populations for further colonization. If these potential source populations decline, there will be additional reliance on using captive-raised individuals to establish new sites which could result in reduced genetic variation in the metapopulation overall. More work is needed on how to manage both beaver and fire disturbances to optimize habitat suitability. • Restoration of existing and new suitable habitat for colonization. It is clear that active restoration or regular disturbance is needed to maintain SFS habitat and subpopulations outside the impact areas. Restoration is not a single event, but requires repeated alterations. These sites should closely resemble already established sites and provide high quality habitat for breeding individuals with low potential for human disturbance. Ideally, these sites would be established through planned management practices and subsequently maintained through natural periodic disturbance regimes. Restoration work on or near existing and historic SFS sites should continue to be a high priority as these efforts allow the establishment of butterfly complexes with connectivity to multiple sections of a stream network. Restoration efforts should also focus on increasing connectivity between sites to address more landscape-level impacts. Determining the effects of fire on SFS habitat and metapopulation dynamics requires more investigation. Efforts to restore habitat through hardwood removal and temporary inundation could prove important in increasing the area of suitable habitat for the butterfly. Researchers at NC State University and Michigan State University together with personnel from the Ft. Bragg Endangered Species Branch have developed a long-term management plan for SFS restoration efforts with both installation-wide and site-specific recommendations (Cayton et al. 2019). We recommend continued collaboration with the Army to integrate these conservation targets and standardized management actions into future planning and Integrated Natural Resources Management Plans. A SFS Management Plan should be added to the Integrated Natural Resources Management Plan Appendices under Required Plans. Specific management actions should include: extending prescribed burning efforts through riparian areas outside impacts areas, closing firebreaks at stream crossings near SFS populations to reduce habitat fragmentation and sedimentation downstream, development of a regular maintenance schedule in restoration sites, continued housing and support of captive breeding efforts, and coordination of access for monitoring existing SFS populations and searching for additional habitats and subpopulations within the live-fire ranges. • Continue collaboration with Ft. Bragg to inform the Integrated Natural

Resource Management Program with updated monitoring and management goals for SFS populations. These updates should include specific policies that coordinate SFS, beaver and fire management. To aid ongoing restoration activities, Ft. Bragg should share theirrecords of where, when and how specific beaver and fire management operations were and will be conducted. SFS conservation management activities should be integrated into various habitat prescriptions for specific training area groups and annual burn plans. • Continued augmentation of existing populations using captive-reared individuals. The sedentary lifestyle of adults and infrequently observed dispersal events of individuals suggests that colonization of new sites may be difficult to accomplish through regular dispersal among fragmented sites, but could occur with assisted releases. Captivereared individuals provide an excellent source from which to create new colony sites and could create a link between fragmented populations that would allow population growth. Lessons learned from successful captive propagation of SFS can also inform the larger scientific community and ongoing conservation efforts for other species. Displays of captive-bred individuals outside of Ft. Bragg could both provide research collaboration efforts and offer public outreach opportunities. • Continued habitat surveys to determine key vegetation characteristics of high quality sites. Surveys should be conducted at sites both inside and outside impact areas. These should incorporate possible effects of sedimentation and erosion of roads on vegetation. Expansion of the greenhouse facility would also allow for experiments on impacts of different conditions (including various disturbances) on sedge host plants. • Establishment of experimental populations off Ft. Bragg. To be delisted, SFS will need to occur in two additional populations outside of Ft. Bragg. There are public lands in the vicinity of Ft. Bragg such as the Sandhills Game Lands and the Carolina Sandhills National Wildlife Refuge, as well as lands held by non-profit conservation organizations that may be ideal areas to identify or restore habitat suitable for experimental populations. Any areas considered for additional populations will need to have a strong fire management program to support ongoing efforts to burn riparian areas in order to create high quality SFS habitats long-term. Additional research to determine the exact species historic range would aid and possibly expand choices for population establishment off post. • Continued improvement of habitat suitability models through ground-truthing. Habitat models have been helpful identifying high quality habitats. Updated models created with developing technologies can further inform recovery efforts. Additional research efforts should examine interactions between fire and beaver disturbances and the impacts of disturbance interval and intensity on habitat quality and duration of suitability. These models also can potentially lead the discovery of new SFS populations or suitability of habitats outside of Ft. Bragg for establishment of additional populations. (USFWS, 2020)

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SPECIES ACCOUNT: *Neonympha mitchellii mitchellii* (Mitchell's satyr Butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: MSB

Listing Status: Endangered; Great Lakes-Big Rivers Region (R3) (USFWS, 2015)

Physical Description

MSB is a dark-brown, medium-sized butterfly. A distinctive series of sub-marginal yellow-ringed black circular eyespots (ocelli) with silvery centers are found on the lower surfaces of both pair of wings. The eyespots are accented by two orange bands along the posterior wing edges, as well as by two orange bands along the central portion of each wing. Females tend to be larger and lighter in color than males. MSB has a characteristic slow bobbing flight pattern and typically does not travel great distances.

Taxonomy

See full species. All populations other than N. m. francisci are included. (NatureServe, 2015)

Historical Range

See current range/distribution.

Current Range

Although this species historically occurred in five states it is currently known to occur in only Michigan and Indiana. It is found at 17 sites in southern Michigan, and 2 sites in northern Indiana. An additional subspecies, the St. Francis satyr (Neonympha mitchellii francisci Parshall and Kral) (SFS), is known from North Carolina. Recently, populations have been discovered in Virginia, Alabama and Mississippi; however, the taxonomy of these populations are currently unknown (i.e., it is not known to which subspecies, N. m. mitchelli (MSB) or N. m. francisci (SFS), they belong). A genetics study is currently underway that is examining the relationships and conservation status within the N. mitchellii complex (pers. comm. John Shuey, IN TNC, 2004). The following paragraphs detail the historical and present distribution of MSB in each state. Michigan MSB is historically known from 11 counties in Michigan, and extant populations are known from nine of those (Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, St. Joseph, Van Buren, and Washtenaw Counties). At least 22 MSB sites have been reported in Michigan, with 17 sites currently known to support extant populations. Several of these sites and many other potential habitats have been intensively surveyed in recent years (Wilsmann and Schweitzer 1991, Hyde et al. 2001). Since the Recovery Plan's publication in 1998, four sites previously thought to be extirpated have been re-confirmed as having extant populations. All Michigan sites are described in more detail in Table 1. Currently, only nine occupied sites in Michigan are considered to have potential for long-term population viability (Hyde et al. 2001). These sites consistently support medium to high densities of adults, and seem to represent fen complexes which have adequate habitat to support viable populations of MSB into the foreseeable future.

These sites include Berrien County South, Berrien County North, Branch County site, Cass County Southwest, Cass County East, Jackson County Central, St. Joseph County West, and Van Buren County Northwest. MSBs at the remaining sites typically occur in much lower numbers or the amount of habitat is limited in size or by threats to the site, making their long-term viability uncertain (Hyde et al 2001). Monitoring is occurring at the majority of sites, and some form of active management is occurring at many sites. Various factors have contributed to the decline of MSB in Michigan. Habitat loss and alteration may be the most important factor threatening the species. Threats to MSB in Michigan include altered hydrology, off-road vehicle use, livestock grazing, development and land-use changes, lack of landowner interest in managing for MSB, point and non-point sources of pollution, and the invasion of exotic species (Hyde et al. 2001). Illegal collection at two Michigan sites may also be a significant threat to the MSB populations at those sites. Indiana In Indiana, a total of four or five sites are known to have supported MSB. Two sites still support MSB populations—the LaGrange County West and LaPorte County sites. The LaGrange County West site is the best known Indiana wetland supporting MSB. It is well known in the scientific and general literature and was heavily utilized by entomologists curious about the butterfly from the 1950s until listing (Shull 1987). The LaPorte County site is voluntarily protected through The Nature Conservancy's (TNC) and the Department of Natural Resources' (DNR) Natural Areas Registry Program. Glossy buckthorn invasion has been a problem at this site. Adjacent unoccupied habitat at this site is owned and managed by TNC. TNC is managing the site and controlling Phragmites and purple loosestrife invasion. The LaGrange County site is privately owned by two families. The bulk of the site is in the Natural Areas Registry Program. This site supports a two population metapopulation, both of which support a high density of butterflies. However, suitable habitat patches are relatively small, so there are likely no more than 500 butterflies at this site (pers. comm. John Shuey, IN TNC, 2003). The Steuben County site is an extensive fen complex covering several hundred acres. Homer Price, a northwestern Ohio naturalist, collected a pair of specimens from here in 1960. The fens are in excellent condition and are largely protected as a Wetland Conservation Area. Recent efforts (Martin 1987, Shuey 1986) to locate MSB here have been unsuccessful. However, it is possible that the butterfly is still present but was overlooked because the wetland is so large relative to the butterfly's typical localized distribution. A possible additional historical site was reported as occurring in northeast Steuben County (Badger 1958). Martin (1987) interpreted the vague location description to a possible modern location. Wetlands including fens occur in a band and extend west in patchwork form along a creek which flows into the Steuben County Site. Roads and railroads, likely access points for Badger, intersect these wetlands at three points. Shuey (1986) surveyed the eastern portion of this area without discovering MSB. However, some nearby wetlands have not been searched for this butterfly. Some of these wetlands have been heavily disturbed or drained and are probably not suitable habitat today. Martin (1987) surveyed 28 fens in northern Indiana for the presence of MSB but only found MSB at two sites. Because of personnel limitations, large complexes such as the Steuben County site could not be completely surveyed. Some sites, especially sedge meadows, which seemingly contain suitable habitat for the butterfly, were not surveyed. Wilsmann and Schweitzer (1991) summarize Martin's findings. Ohio MSB was last reliably documented in Ohio in 1925 from Portage County. There have been two other possible records of the species: one in 1905 in Seneca County and one in 1950 in Portage County (Shuey 1997). No MSB were found despite extensive surveys

(1981-1998) of all known likely habitats (Ohio DNR (ODNR) and Parshall 1999). The primary site, located in Portage County, Ohio, was disjunct from all other known population sites and is approximately 200 km (125 mi) from the nearest known site in Michigan. This site was surveyed in 1998 and portions of the fen contained suitable habitat. Current management of the site has maintained open sedge meadow, with a dominance of C. stricta and Potentilla fruitcosa, bordered by low shrubs and scattered tamaracks (ODNR and Parshall 1999). This site has been suggested as a potential future reintroduction site (ODNR and Parhsall 1999). The Seneca County record (1905) was for the Georgia satyr (Neonympha areolata). No specimen was collected, and the presence of the Georgia satyr butterfly in Ohio is unlikely. In north-central Ohio, there are only two potential species likely to be confused with the Georgia satyr butterfly: the little wood satyr and MSB (Iftner et al. 1992). The little wood satyr is common throughout Ohio and should have been well known to any collector during the early 1900s. Seneca County is located in north-central Ohio, approximately half way between Portage County and the nearest sites supporting MSB in Michigan and Indiana. Seneca County at one time had numerous wetlands including at least one extensive prairie fen complex (Andreas and Knoop 1992). Most of the wetlands in Seneca County that may have once supported MSB have been extensively degraded, and the remainder has been eliminated. New Jersey Two well-known sites within Sussex (Rutkowski 1966) and Warren Counties supported this species in the recent past. The confirmed sites are both fens located in areas of limestone bedrock within the same watershed. MSB was collected to extirpation at these sites and was subsequently re-ranked to State Historic status by the New Jersey Heritage Program in 1989 (Schweitzer 1989). A possible additional historical locality, the Morris County site, was reported by Pallister (1927) who mentioned a specimen collected July 10, 1890, by Charles W. Johnson, a respected entomologist. The vague locality data reflects the norm for that period and could easily refer to almost any locality within 16-32 km (10-20 mi) of the Morris County site, including the Sussex or Warren County populations. Schweitzer (1996) argues that evidence supports the likelihood that the Johnson specimen is from a population separate from the Sussex or Warren County populations. However, no extant fens occur at this location now. The specimen existed until 1989 but has since been destroyed by dermestid beetles (Dermestidae) (Schweitzer 1996). Fens are relatively rare in New Jersey, and known occurrences of this community type have been surveyed for MSB by experienced biologists (Shuey 1997). The species was last documented from New Jersey in 1985. Numerous surveys of the known historic sites and similar habitats have documented no evidence of MSB in the state. Maryland MSB was reportedly collected in 1945, near Ft. Meade, by an expert amateur lepidopterist that was familiar with both MSB and the Georgia satyr. However, because voucher specimens do not exist, and because suitable habitats are no longer evident near Ft. Meade, the validity of this report will always be questionable. In summary, although MSB historically occurred in five states, it is now restricted to only Michigan and Indiana. MSB is currently known from only 19 sites, 17 of which are in southern Michigan, and two in northern Indiana. Loss of suitable fen habitat appears to be the main threat to the species.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adult food sources are poorly known, but apparently it does not visit flowers. Larvae almost certainly feed on Carex, but the actual species is not known. Several such sedges are acceptable in captivity. John Shuey points out (see e.g. the USFWS recovery plan) that Carex stricta is the dominant sedge in Midwestern habitats and Dale Schweitzer found this to be the dominant graminoid at the two recent NJ sites. Shuey points out that most wetland Satyrinae oviposit primarily on the dominant graminoid in their habitat.; Food Habits: Herbivore (Immature), Unknown (Adult)Adults fly for about two weeks out of the year, at some time between about June 25 and July 20. There were apparently no June records in NJ. Larvae occur from about the end of July well into the following June.; (NatureServe, 2015)

Reproduction Narrative

Adult: Butterflies undergo complete metamorphosis and progress through four stages of development: egg, larvae, pupae, and adult. Larvae molt five times; each stage between molts is known as an instar. MSB has only one generation per year. The flight period lasts two to three weeks, occurring in mid-June to late July. Oviposition occurs close to the ground on a variety of small forbs and sedges during the afternoon. More research is needed, but it appears that several factors may be important in oviposition site selection, including partial shade, humidity, predator avoidance, food plant availability and density, and niche segregation (Darlow 2000). Larvae undergo three molts before entering diapause in the fall. The over-wintering location is unknown but it is suspected to be in the duff. Two additional molts occur in the following spring, and larvae pupate in mid-June. The primary MSB larval host plant is believed to be fine-leaved Carex species based on various laboratory and semi-natural caged experiments (McAlpine et al. 1960, Legge and Rabe 1996) and the close association between adult MSB and dense stands of sedge (C. stricta, C. lasiocarpa) (Shuey 1997).

Habitat Narrative

Adult: Although MSB habitat requirements are not yet fully understood, the butterfly appears to be restricted to calcareous wetlands that range along a continuum from open fen, wet prairie, sedge meadow, shrub-carr, tamarack savanna, and numerous variations and combinations of these community types (Shuey 1997, Szymanski 1999, Hyde et al. 2001). It appears that the MSB occupies areas in these fen communities where woody and herbaceous vegetation occurs as a mosaic (Szymanski and Shuey 2002). Important structural components of the habitat include presence of peat or muck soil (Shuey 1997), scattered deciduous shrubs or coniferous trees (Shuey 1997), seeps (McKinnon and Albert 1996) and a herbaceous community dominated by C. stricta. MSB habitat also appears to exhibit large variability in vegetative structure and composition at the habitat patch scale, suggesting the importance of habitat heterogeneity (Szymanski 1999). Recent research has further reinforced the importance of the edge component; in the later part of the adult flight period (i.e., during the time of oviposition), males and females tend to be found within one meter of a tree or shrub (Barton 2003).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Sedentary. Probably originally did disperse along streams. Few individuals leave their habitats which are usually a few acres out of large wetland complexes. At present habitats are so few and scattered that there is probably strong selection against dispersal.(NatureServe, 2015)

Population Information and Trends

Population Trends:

stable or declining (USFWS, 2021)

Population Growth Rate:

The overall range is poorly understood, and there is no basis for speculation about how many occurrences there originally were. It is known that the three in New Jersey and one in Ohio are gone as are a few in Michigan. So there has been a long-term substantial reduction in range. Unknown (NatureServe, 2015)

Number of Populations:

~64 (USFWS, 2021)

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

The overall range is poorly understood, and there is no basis for speculation about how many occurrences there originally were. It is known that the three in New Jersey and one in Ohio are gone as are a few in Michigan. So there has been a long-term substantial reduction in range. Unknown This is an educated guess. Barton and Bach (2005) provide an MRR estimate of about 1100 for a Michigan site in 2003. This is probably the largest extant population of the species. Populations in larger stable relict habitats probably do not fluctuate drastically, but all butterfly populations fluctuate somewhat. Some information on fluctuations may be available from Michigan Natural Features Inventory. Since it seems nearly certain that excessive collecting really did contribute to the extirpation of this species in New Jersey, as far as known, a unique case among North American butterflies, it is very likely that populations there were only a few dozen adults per year by that time. Casual observation suggests some in Michigan are also dozens to at most a few hundred. The geographic range is large enough that populations would not fluctuate synchronously range-wide. Populations in Virginia may also number in the hundreds or more (S. Roble, pers. comm.). While there is no estimate for most populations and MRR for very few, it is quite unlikely the total adults is under 1000 in any given year. The number of discrete viable occurrences is unclear. The 17 "subpopulations" in Alabama (Kuefler et al. (2008) need to be better evaluated. Many of the more northern populations are apparently quite small and some may no longer exist. (NatureServe, 2015). Although this species historically occurred in five states it is currently known to occur in only Michigan and Indiana. It is found at 17 sites in southern Michigan, and 2 sites in northern Indiana. An additional subspecies, the St. Francis satyr (Neonympha mitchellii francisci Parshall and Kral) (SFS), is known from North Carolina. Recently, populations have been discovered in Virginia, Alabama and Mississippi; however, the taxonomy of these populations are currently unknown (i.e., it is not known to which subspecies, N. m. mitchelli (MSB) or N. m. francisci (SFS), they belong). A genetics study is currently underway that is examining the relationships and conservation status within the N. mitchellii complex (pers. comm. John Shuey, IN TNC, 2004). Currently, there are nine Mitchell’s satyr populations in Michigan (six viable), which is a decline from 16 since the previous 5-year review (2014). Population trends have been stable or declining in recent years. None of these sites occur on state or federal land and many Michigan populations occur on lands not formally committed to conservation into perpetuity. There is one population in Indiana that is not considered viable and recently acquired by local government. Populations in Virginia (11) are confined to 1 county, despite wide ranging surveys. Only three of these populations are considered to be good to fair viability, with one partially owned by the state and three under a conservation easement. Mississippi has 15 populations across five counties, an increase from the 11 populations noted in the 2014 review; however, viability is unknown. While some of these populations occur on state and federal lands, status of monitoring or management are not known. There is no new information regarding or surveys for the Alabama Mitchell’s satyr populations since the 2014 5-year review. There are 28 sites in four counties of unknown viability that occur on federal land that is managed via prescribed burning but monitoring is unknown (USFWS, 2021).

Threats and Stressors

Stressor: human-induced destruction of MSB habitat (urban development, conversion to agriculture, or highway construction)
Exposure:
Response:
Consequence:
Narrative: The primary threat to the continued survival of MSB is the loss and disruption of suitable fen habitats. Urbanization, agricultural conversion, and highway construction have led to disruption of key ecological processes that are necessary to create and maintain MSB habitat (Wilsmann and Schweitzer 1991, Shuey 1997). Wetland alteration or complete draining has resulted in the loss of the single known Ohio population of the butterfly and in the loss of populations at several sites in Michigan (USFWS 1998). Wetland alteration may also lead to nuisance plant invasions such as purple loosestrife, common buckthorn, glossy, and reed canary grass. The loss of fen habitat for the species is complicated by the disruption of landscape-scale processes that may be crucial for the maintenance of habitat suitability and the creation of new habitats for MSB. Historical disturbance regimes such as wildfire, fluctuations in hydrologic regimes, and the flooding caused by beaver have been all but eliminated or modified throughout the range of MSB. Surviving populations now occupy highly isolated fens in which successionary processes are slowed, but not eliminated, by the discharge of calcium carbonate laden groundwater. Eventually, in the absence of some process that resets succession to an earlier stage, the surviving fen habitats will become increasingly unsuitable as habitat for MSB. As habitats become more isolated, dispersal between populations and suitable unoccupied habitats

becomes increasingly unlikely, and the rate of extirpation out-paces the establishment of new populations. This may account for the disappearance of several historically known populations at pristine wetland sites. In many areas of MSB habitat, management is necessary to maintain fairly open, sedge-dominated communities.

Stressor: Invasive Species and Encroachment
Exposure:
Response:
Consequence:
Narrative: Purple loosestrife, glossy buckthorn, reed canary grass, and cattails form monocultures and reduce species diversity at MSB sites. The fine-leaved sedges that the larvae use as a food plant are light demanding and can be quickly crowded out by these invasives. Although we do not know which microhabitat variables are most critical to the MSB at various stages of its life cycle, it is clear that these invasive species drastically alter the community structure and microhabitat in the wetlands where they occur (Hyde et al. 2001). Natural succession of encroachment by woody vegetation and non-native invasive species establishment form monocultures and closed canopy conditions that reduces herbaceous species diversity within fens occupied by Mitchell's satyr. Reed canarygrass and hybrid cattails (Typha spp.) are present within the introduction site in Noble County, Indiana and TNC is conducting treatments to control the spread of these non-native invasive species (Herbert 2018). An increase in woody vegetation, primarily alder and non-native multiflora rose, was observed and active management is needed to reduce encroachment, especially to maintain the largest population of Mitchell's satyr in Virginia (Chazal 2015).

Stressor: Overcollection
Exposure:
Response:
Consequence:
Narrative: The recovery plan noted that over-collection by butterfly collectors was a threat to the continued existence of the species. For example, Mitchell's satyr is observed along major roads in Virginia, and it is suggested that law enforcement be notified of potential illegal collection (Chazal 2015).However, illegal collection is not known to be a significant threat and the Service has not received any recent reports of collection activities.

Stressor: pesticides and neonicotinoid insecticides
Exposure:
Response:
Consequence:
Narrative: Pesticides and neonicotinoid insecticides use may also be contributing to decline of Mitchell's satyr as has been suspected for other native butterfly populations (Main et al. 2014, Pisa et al. 2014, Warner et al. 2020).

Stressor: Mowing and grazing
Exposure:
Response:

Consequence:
Narrative: Overgrazing by domesticated animals and frequent mowing creates conditions unsuitable for the species (Roble et al. 2001, Chazal 2014). Many Virginia populations occur near roads and there is concern that roadside mowing of potential nectar sources may threaten Mitchell's satyrs (Chazal 2014). Mowing outside of the flight period can minimize negative impacts on the species and communication of these efforts to local Virginia Department of Transportation is needed. Vehicle collisions may also directly kill individuals and research is needed to evaluate whether it is a major threat to Virginia populations (Chazal 2014).

Stressor: Human or Natural Alterations to Hydrology
Exposure:
Response:
Consequence:
Narrative: Fens may be more sensitive to hydrological disturbances because of their requirement of a whole-system recharge from both local and regional sources (Abbas 2011, Sampath et al. 2016). Alteration of hydrology, leading to changes in fen vegetation, has been suspected as the cause of declines in Mitchell's satyr numbers at several sites and possibly even extirpation at some sites in Michigan (MNFI, unpubl. data). Some previously occupied wetlands in Virginia were dry during recent Mitchell's satyr surveys. Structures that alter hydrology, including ditches, drain tiles, culverts, and a water pump, were observed at most Virginia wetlands (Roble et al. 2001, Chazal 2014). Natural alterations to hydrology may also impact populations. A beaver wetland had been drained at one site and beaver appeared to have abandoned another site creating unfavorable conditions for Mitchell's satyr at two previously occupied locations along the Natchez Trace Parkway in Mississippi (Hill et al. 2015). Mitchell's satyrs may have declined at the newly discovered site in Washtenaw county, Michigan due to very high-water levels that decreased suitable fen habitats (Cuthrell and Hyde 2018).

Stressor: Reproductive Parasites (Wolbachia)
Exposure:
Response:
Consequence:
Narrative: Disease and predation were not known threats to Mitchell's satyr at the time of the Recovery Plan. No new diseases or predators have been identified since the previous 5-year review. However, there is updated information on the presence of Wolbachia, which is a genus of maternally inherited bacteria that are considered reproductive parasites and are commonly found in arthropods. If an individual is infected by Wolbachia, only pairings of males and females infected with the same strain result in fertile offspring (Nice et al. 2009, Hamm and Landis 2010). Cytoplasmic incompatibility is the most widespread effect to hosts, where Wolbachia infection can lead to the death of embryos and immature offspring when infected males mate with uninfected females or females infected with a different strain (Hoffmann et al. 2015). Recovery partners are trying to better understand the implications of Wolbachia infection on Mitchell's satyr populations in the wild and in captivity. Presence of Wolbachia status has increased in recent years and has been documented in new populations. Satyrs collected by Toledo Zoo from a fen in Branch County in 2015 and 2016 all tested negative for Wolbachia(Toledo Zoo 2016, Hyde

2017, Toledo Zoo 2017). In 2019, there was unusually low survival of offspring in the captive rearing program at Toledo Zoo (Walsh 2019). Six adults and four reared larvae that had been collected at the same Branch County site were tested for Wolbachia. Two larvae tested positive for Wolbachia and the other two were unable to be processed (Walsh 2019). Further analysis of Wolbachia tests and mortality rates revealed a 99% mortality rate in larvae that tested positive or had a positive parent (Walsh 2019). The surviving larvae had at least one parent test negative for Wolbachia. Decreased fertility due to Wolbachia infection has been observed in species of Lepidoptera (Fenner et al. 2017, Hamm et al. 2014). Larval mortality of Mitchell's satyr has not been previously observed or noted in the literature, however, successful rearing may have provided a means for new observations. Wolbachia has been documented in Mitchell's satyr populations in other Michigan counties (Cass and Jackson counties) and in Mississippi (Prentiss and Monroe counties) (Fenner et al. 2017). Individuals from Alabama or Virginia tested negative for Wolbachia, but little wood satyr (Megisto cymela) from these states tested positive. Wolbachia is present in all occupied Mitchell's satyr areas, however, there appears to be limited transmission between the satyr species within the study (Fenner et al. 2017). Therefore, caution must be used when conducting surveys and collecting individuals to minimize the spread of the bacteria. The presence of Wolbachia in the Mitchell's satyr population at the fen in Branch County, Michigan, appears to correlate with recent declines in wild populations. It is likely Wolbachia is a major factor in MSB decline across Michigan (Walsh 2019). Due to recent low numbers of surviving ex situ larvae and prevalence of Wolbachia, the status and effects of Wolbachia infection must continue to be evaluated annually in order to inform captive rearing and other recovery efforts. In particular, the captive propagation program must continue to carefully avoid inadvertent introduction of Wolbachia into uninfected populations or introduction of a new strain into wild populations.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change and extreme weather events may be straining rare butterflies (Patterson et al. 2019) and their habitats, including Mitchell's satyr. Approximately 4-5 inches of rain within 48 hours flooded the occupied site in LaGrange County, Indiana. Only one butterfly was observed during surveys and visible sediment deposits indicated high water marks that were at least a foot above normal levels (S. Fetters, USFWS, pers. comm. 2019). The temperature is projected to rise roughly 10 times as fast over the next 40 years as it has over the past 100 years in the state of Michigan (Hoving et al. 2013). Michigan has experienced relatively little year-to-year variation in precipitation which makes species more vulnerable to future change. The state is predicted to become drier, which will disproportionately affect wetland species with the most vulnerable groups being amphibians, mollusks, fish, and insects. A climate change vulnerability assessment concluded that the Mitchell's satyr is extremely vulnerable to climate change in Michigan (Hoving et al. 2013). Climate change will impact Mitchell's satyr across its disjunct range, but the level of impact may vary from state-to-state.

Recovery

Recovery Actions:

- The Recovery Plan for Mitchell's Satyr Butterfly was approved on April 2, 1998. The objective of the Recovery Plan is to perpetuate viable populations of MSB throughout its former range thereby allowing reclassification, and ultimately removal, from the Federal List of Endangered and Threatened Wildlife and Plants. MSB may be considered for reclassification from endangered to threatened when 16 geographically distinct, viable populations or metapopulations are established or discovered range-wide. These 16 populations must include at least 12 populations in southern Michigan, two in Indiana, one in Ohio, and one in New Jersey. In addition, at least 50 percent of these sites must be protected and managed to maintain MSB habitat in order for it to be considered for reclassification to threatened. Delisting the species will be considered when nine additional for a total of 25, geographically distinct, viable populations or metapopulations are established or discovered range-wide and remain viable for five consecutive years following reclassification. A minimum of 15 of these sites must be protected and managed to maintain MSB habitat by state or federal agencies or by private conservation organizations before delisting will be considered. The recovery tasks listed in the Recovery Plan are: 1) Conduct surveys and monitor; 2) Address research needs; 3) Protect all known occurrences, placing priority on achieving effective protection for the highest ranking occurrences and essential habitat; 4) Develop an outreach program; and 5) Reintroduce into suitable but unoccupied habitats.

Conservation Measures and Best Management Practices:

- Recommendations for future actions includes collecting more information about the southern populations, confirming genetics across the range, increasing survey efforts, and assessing viability. Additional studies are necessary to learn if genetics from southern populations can be mixed with northern populations to avoid small population threats genetic depressions. Research and adaptive management should continue regarding the use of prescribed fire and the effects on populations and larvae. Additional future actions should include the continued effort to acquire occupied habitat. (USFWS, 2021).
- Recovery Actions since the last status review: Great Lakes Recovery Initiative: Since 2010 GLRI has provided approximately $1.9 million to support habitat restoration, land acquisition, monitoring, research, and captive rearing efforts for Mitchell's satyr. Most of these funds have been spent in the past five years (i.e., 2015-2020, the time covered by this five-year review), with just over $1 million spent on Mitchell's satyr recovery efforts during this time period. Other Investments in Mitchell's satyr: Other funding sources have included the Endangered Species Recovery Land Acquisition grants, the Service's Partners for Fish and Wildlife Program, State Wildlife Action Grants, land trusts, zoos, conservation organizations, and private donors. This support has allowed for habitat restoration, land acquisition, and captive rearing. Since 2010, this investment has been at least $1.7 million (in addition to GLRI funding). Safe Harbor Agreement: In 2016, the Service developed a Safe Harbor Agreement (SHA) for non-Federal landowners in Michigan and Indiana willing to voluntarily participate in conservation activities that benefit and advance the recovery of Mitchell's satyr (81 FR 33543). The purpose of the agreement is to reintroduce butterflies to historic sites and/or to suitable fens that occur within its historic range. Habitat Conservation Plan and Habitat Management Plans: In 2016, Michigan Natural Features Inventory, in collaboration with the MSBWG, completed management plans for six Mitchell's satyr sites within Berrien, Branch, Cass, Jackson, and Van Buren counties, Michigan. In addition, they developed plans for one planned introduction site within Noble County, Indiana, and two potential introduction sites within Kalamazoo and Washtenaw counties,

Michigan (Hyde 2017).The Michigan Department of Natural Resources (DNR) and Indiana Department of Natural Resources developed a Habitat Conservation Plan (HCP; Recovery Plan Recovery Action 3.7, Promote protection of occurrences on privately owned land) for Mitchell's satyr butterfly and Poweshiek skipperling (Oarisma poweshiek) (83 FR 45136) in 2018 to apply for an Incidental Take Permit with the Service under Section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended. Conservation Strategy: In 2013, the MSBWG developed a Conservation Strategy to provide the framework for a coordinated and cooperative approach for the Working Group to implement recovery actions. The latest version, the 2019-2024 Mitchell's Satyr Conservation Strategy, replaces the previous 5-year strategy and continues to provide an updated and stepped-down approach for the recovery partners to accomplish objectives identified in the Recovery Plan. Captive Rearing: Captive rearing efforts to support reintroductions began in 2015 (Cuthrell et al. 2015). The goal of the captive rearing program is to collect eggs from wild-caught females and raise them in a controlled environment to release back into the wild as adults in order to rapidly increase the population and help maintain genetic diversity (USFWS 2016). Currently, both the Toledo Zoo and Kalamazoo Nature Center serve as captive rearing facilities for Mitchell's satyr (Recovery Plan Recovery Action 5.1, Establish Mitchell's satyr breeding facilities). Land Acquisition: The landowners of the only known Mitchell's satyr site in Indiana parceled their property for sale in 2018 and it included the occupied fens (T. Swinford, IDNR, pers. comm. 2018). The Service contacted the landowners about acquiring the site for conservation and collaborated with LaGrange County Parks to obtain the occupied fen in 2020 (S. Fetters, FWS, pers comm. 2020). A landowner agreement between the Parks Department and the Service is expected to be completed in the near future to obligate Great Lakes Restoration Initiative funds towards restoration. In addition, an adjacent six acres fen may become available for acquisition (S. Fetters, FWS, pers. comm. 2020; Recovery Plan Recovery Action 3.10, Encourage land acquisition). In late 2016, 189 acres were purchased in Van Buren County to protect fen supporting Mitchell's satyr populations. The site is owned by Southwest Michigan Land Conservancy who manages the land for Mitchell's satyr. In 2019, Southwest Michigan Land Conservancy acquired a 25 acre parcel adjacent to a likely viable Mitchell's satyr site in Branch County, Michigan; and TNC purchased 20 acres to the south of a site in Jackson County, Michigan (MSBWG 2019; Recovery Plan Recovery Action 3.10, Encourage land acquisition). (USFWS, 2021)

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SPECIES ACCOUNT: *Nicrophorus americanus* (American burying beetle)

Species Taxonomic and Listing Information

Commonly-used Acronym: ABB (USFWS, 2008)

Listing Status: Endangered/Experimental Population, Non-Essential; 07/13/1989, 07/22/2011; Southwest Region (R2), Great Lakes-Big Rivers Region (R3) (USFWS, 2016). Reclassified to Threatened November 16, 2020.

Physical Description

The body of the American Burying Beetle is shiny black; the elytra are smooth and also shiny black, and each elytron has two scalloped orange-red markings. The most diagnostic feature of this beetle is the large orange-red marking on the raised portion of the pronotum, a feature shared by no other members of the genus in North America. The species also has an orange-red frons and a single orange-red marking below the frons. The antennae are large, orange at the tip, and abruptly clubbed. (USFWS, 1991). The ABB is the largest silphid (carrion beetle) in North America, reaching 1.0 to 1.8 inches (25- 35 cm) in length (Anderson 1982, p. 362; Backlund and Marrone 1997, p. 53). The beetles are black with orange-red markings (Figure 2-1). Their hardened elytra (wing coverings) are smooth, shiny black, and each elytron has two scallop shaped orange-red markings. The pronotum over the mid-section between the head and wings is circular in shape with flattened margins and a raised central portion (Ratcliff 1996, pp. 54, 62). The most diagnostic feature of the ABB is the large orange-red marking on the raised portion of the pronotum, a feature shared with no other members of the genus in North America (USFWS 1991, pp. 2-4). The ABB also has an orange-red frons (the upper, anterior part of the head), and a single orange-red marking on the clypeus, which can be viewed/considered as the lower "face" located just above the mandibles. Antennae are large, with notable orange club-shaped tips for chemoreception (USFWS, 2019).

Taxonomy

The American burying beetle (ABB) Nicrophorus americanus is a member of the beetle family Silphidae (subfamily Nicrophorinae); these beetles are known by their habit of burying vertebrate carcasses for reproductive purposes and for exhibiting parental care of young. The genus Nicrophorus contains about 70 species world-wide, of which 15 occur in North America (Peck and Kaulbars 1987, entire). Globally, burying beetles are restricted to temperate climates, and high elevations in tropical climates (Arnett 1946; Howden & Peck 1972; Cornaby 1974; Young 1978; Howden & Peck 1985; Peck & Anderson 1985; Trumbo 1990; Smith et al. 2000; Ruddiman 2001; Sikes & Venables 2013). Both population densities and species diversity of Nicrophorus are higher in northern localities where habitat generalists and habitat specialists occur in sympatry (Scott 1997 et al., entire). Reasons for burying beetles' lack of success in southern locales include increased competition with ants, flies, and perhaps vertebrates, as well as increased temperatures and rates of carcass decomposition (Anderson 1982, entire; Trumbo 1990, p. 6-7; Scott et al. 1997, entire). Nicrophorus americanus is probably most closely related to the similarly sized, Nicrophorus germanicus of the Old World. In its extant populations, the geographic distribution of Nicrophorus americanus overlaps with N. carolinus, N. marginatus, N. pustulatus, N. tomentosus, and N. orbicollis, from which it differs physically in coloration and size. Within North American Nicrophorus, Nicrophorus americanus is most similar to N. orbicollis. Nicrophorus americanus was first described by Olivier in 1790 (Entomologie, II, Paris), with the type locality undesignated (USFWS, 2019).

Historical Range

Nicrophorus americanus has been recorded historically from at least 150 counties in 35 states (including the District of Columbia) in the eastern and central United States (Peck and Kaulbars 1987, Madge 1958), as well as along the southern fringes of Ontario, Quebec, and Nova Scotia in Canada (Peck and Anderson 1985; Appendix 1). Its historical range can thus roughly be described as most of temperate eastern North America. (USFWS, 1991)

Current Range

Currently, the ABB is known to occur in nine states: on the East Coast, it is found on Block Island off the coast of Rhode Island, and a reintroduced population now occurs on Nantucket Island off the coast of Massachusetts (Figure 4-2). It is also found in eastern Oklahoma, western Arkansas (Carlton and Rothwein 1998, entire), Loess Canyons in south-central Nebraska and Sandhills in north-central Nebraska (Ratcliffe 1996, 60–65; Bedick et al. 1999, entire), south-central South Dakota (Backlund and Marrone 1997, entire; Ratcliffe 1996, 60–65), Chautauqua Hills region of southeastern Kansas (Miller and McDonald, entire), northeast Texas (Godwin 2003, entire), and a newly reintroduced colony in Missouri is showing success (personal communication with Bob Mertz, St. Louis Zoo, May 30, 2013). The ABB population in Missouri is a nonessential experimental population (under section 10(j) of the ESA) that was reintroduced to the area in 2012. A reintroduction effort in Ohio is ongoing, but no overwinter survival of the introduced ABBs has been documented and no viable or self-sustaining populations are known in that state. A potential report of an ABB in Michigan in 2017 is being investigated and surveys in 2018 failed to confirm the report of ABBs. Additional surveys are planned in 2019 and we do not have enough information on the Michigan report to confirm or assess the status of ABBs in these areas. (USFWS, 2019) The current range is much larger than originally thought when the species was listed and there are several large populations with relatively good genetic diversity and relatively low current risks. However, the future threat of increased temperature puts the species at risk of extinction in the foreseeable future. The large areas of known and potential habitat in the Southern Plains buffer the effects of most land use changes. The Arkansas River and Flint Hills analysis areas are adjacent to each other and combined provide over 17 million acres of potential habitat. These analysis areas support large populations with moderate to high resiliency (see chapter 4 of the SSA report). The Red River Analysis Area has over 2 million acres of suitable habitat but has a very limited population with low resiliency. The Northern Plains populations are also relatively large with a combined area of over 11 million acres of suitable habitat in the Niobrara and Sandhills analysis areas that currently support populations with moderate to high resiliency. A smaller area of suitable habitat (1,686,948 acres) supports a smaller population with low to moderate resiliency in the Loess Canyons analysis area. The New England analysis area currently supports two populations on separate islands. The Block Island population is relatively small with only about 2,000 acres of suitable habitat, but it supports a population with moderate resiliency with continued active management. Nantucket Island is a reintroduced population on a larger island, but resiliency is low and active management with carcass supplementation is required to maintain this population. In summary, the current status includes at least five populations with moderate to high resiliency and several of these populations are relatively large. We find that the species is not currently in danger of extinction as it faces relatively low near-term risk of extinction. Thus, after assessing the best available information, we conclude that the American burying beetle is not currently in danger of extinction throughout all of its range. Therefore, we proceeded with determining whether the American burying beetle is likely to become endangered within the foreseeable future throughout all of its range (USFWS, 2020).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Adults bury vertebrate carcasses, upon which larvae feed, typically between 80 and 100 grams of weight (range 35-206 grams). Block Island populations utilize abundant carrion resources of Ring-necked Pheasant chicks and American Woodcock. Oklahoma beetles feeding on small mammals such as Hispid Cotton Rat (Kozol, pers. comm.). Food resources dependent upon carrion availability in particular area. Carrion is shaved, rolled into a ball, and treated with secretions by adults. It may be moved laterally several feet to suitable substrate. (NatureServe, 2015) The female beetle lays eggs in a brood chamber near the preserved carcass. After eggs hatch, the parents move the altricial, first instar larvae to the carcass, where the larvae solicit feeding by stroking the mandibles of the parents. Both parents may remain with the carcass and larvae, feeding their offspring with regurgitated meat until the larvae are capable of feeding themselves on the carrion. (USFWS, 2008) Larvae feed continuously throughout the 24 hour day, emerging as teneral (after molting) adults in July and August. Newly emerged adults are dormant throughout the winter, reproducing the following spring. (NatureServe, 2015) Larvae beg and are fed by parents (Pukowski 1933, p 569; Fetherston et al. 1990, p. 184; Smiseth et al. 2003, entire; Leigh and Smiseth 2012, entire), or they can feed directly from the treated carcass. Larvae of large Nicrophorus species, are extremely dependent on parental regurgitation and will die before they reach second instar (second stage of larval development) if they receive no parental care (Scott 1998a, p. 602). Additionally, ABBs will cull their brood through cannibalism to increase size and survival of larvae in response to a less than adequately sized carcass (Billman et al. 2014a, entire; 2014b, entire). The reproductive process from carcass burial to eclosure (emergence from pupae) is about 30 to 65 days (Smith and Clifford 2006, p. 11: 31-42 days; Kozol 1995, pp. 2, 99: 55-65 days; Kozol 1988, p. 16: 48-65). (USFWS, 2019)

Adult: Adult ABB are classified as opportunistic scavengers, feeding on anything dead, but they also catch and kill other insects (Raithel, 1991). (NatureServe, 2015)

Reproduction Narrative

Adult: Reproduction occurs from late April through mid-August. Block Island populations are reproductively active in June and July, but Oklahoma beetles breed as early as April, or as late as August. Reproductive activity includes the burial of a carcass, building of a chamber, and laying eggs. The number of eggs produced is not known, but anywhere from 1 to 36 larvae have been observed on carcass (Kozol, pers. comm.). One or both parents feed, tend, and guard larvae throughout this stage (48-60 days). The beetle generally raises only one brood per year, but in Oklahoma it is possible that 2 broods are raised during the year (Raithel, 1991). It is doubtful that adults remain reproductively viable for more than one season, they apparently die off after reproduction or during the subsequent winter (Raithel, 1991). (NatureServe, 2015) Reproductive activity for the ABB usually begins in May to June once ambient nocturnal air temperatures in the general area approach 59°F (15.5°C) consistently and ABBs cease burying carcasses by mid-August (Kozol 1988, pp. 36-37; Kozol 1990a, p. 6; Creighton pers. comm. 2016). Immediately upon emergence from their winter hibernation, ABBs begin searching for a mate and proper sized carcass for reproduction. Burying beetles are capable of finding a carcass between one and 48 hours following death of prey and at a distance of at least two mi (3.2 km), but finding them after 24 hours is more typical (Conley 1982, entire). Success in finding carrion depends upon many factors including availability of optimal habitats for small vertebrates (Lomolino and Creighton 1996, entire), density of competing invertebrate and vertebrate scavengers, individual searching ability, reproductive condition (Wilson and Knollenberg 1984, p. 165) and nighttime air temperature (Wilson et al. 1984, p. 211; Ratcliffe 1996, pp.60-65; Wilson and Fudge 1984, pp.197-198). The ABB has been shown to be attracted to an array of vertebrate carcasses including mammals, birds, (Kozol et al. 1988, p. 170) and herptiles (Bedick 1997, p. 32) and Kozol et al. (1988, p. 170) found no preference for avian verses mammalian carcasses. Consequently, it is widely believed that ABB will use any carcass for reproduction, as long as it is within the favored weight class to maximize fecundity, but further investigation is required to determine the actual resource ABB uses in situ. (USFWS, 2019)

Spatial Arrangements of the Population

Adult: Random (inferred from USFWS, 1991)

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 1991)

Site Fidelity

Adult: Low (NatureServe, 2015)

Habitat Narrative

Adult: The American burying beetle exhibits broad vegetational tolerances, though natural habitat may be mature forests. Species is recorded from grassland, old field shrubland, and hardwood forests. Vegetational communities in which the species occurs range from large mowed and grazed fields to dense shrub thickets. Block Island population occurs on glacial moraine dominated by maritime scrub-shrub community. Oklahoma habitats vary from deciduous oak-hickory and coniferous forests atop ridges or hillsides to deciduous riparian corridors and pasturelands on valley floors. Soil characteristics also important to the beetle's ability to bury carrion. Historic collections were made when forests had been cleared and the land was largely agricultural. Adults live primarily above ground. Eggs are laid in soil adjacent to buried carcass. After molting, adults overwinter in soil (Raithel, 1991; Creighton, et al, 1992). (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015)

Dispersal

Adult: High (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: The American burying beetle is a strong flier, travelling moderate distances. It is probably capable of flying from mainland to Block Island (approx. 8 miles), but there is no evidence confirming this. It is suspected that beetles are capable of moving all over Block Island (6400 acres) (Kozol, pers. comm.). (NatureServe, 2015) American burying beetles are nocturnal and have been reported moving distances up to 18 miles (mi) (29 kilometers (km)) in a single night in Nebraska, in the direction of the prevailing wind (Jurzenski 2012, p. 36; Jurzenski et al. 2011, p. 135; Bedick et al 2004, pp.66-67). While Raithel et al. (2006, entire) previously found that wind direction plays a role when ABB are traveling long distances; wind direction showed no affect for short distance moves, and longer distance moves tended to be downwind. Bedick et al. (2004, p. 66) reported five recaptures from distances of 2-4 mi (3–6 km). However, Bedick et al. (1999, p. 176) found that of the 158 ABBs recaptured, 85% moved 0.3 mi (0.5 km) or less per night. Creighton and Schnell (1998, p. 284) reported ABB movements between sites averaged 0.74 mi (1.23 km) nightly in their search for carrion (n=23 movements between sites) with a range from 0.16 mi (0.25km) for 1 night to a maximum of 6.2 mi (10.0 km) over 6 nights. (USFWS, 2019)

Population Information and Trends

Population Trends:

Stable to increasing (USFWS, 2008)

Species Trends:

Stable to increasing (USFWS, 2008)

Resiliency:

• 6 analysis areas with moderate to high resiliency • 1 analysis area with low resiliency and 2 reintroduced populations •Extirpated from about 90% of the historic range (USFWS, 2019)

Representation:

Moderate (USFWS, 2019)

Redundancy:

Moderate (inferred from USFWS, 2008). •Current redundancy could range as high as 9 “populations” (including reintroduced populations) • 6 populations, if we only count populations that are considered self-sustaining (USFWS, 2019)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Resistance to Disease:

Uncertain (USFWS, 2008)

Adaptability:

Low (inferred from USFWS, 2008)

Population Narrative:

The widespread decline of the ABB indicates vulnerability, perhaps to loss of suitably-sized carrion. About 1,000 or fewer adults survive through winter to breed next year. (NatureServe, 2015) While only two highly disjunct populations were known when the ABB was listed, numerous searches since that time have resulted in the discovery of additional ABB occurrences in Oklahoma, Nebraska, Arkansas, Texas, Kansas, and South Dakota. The species is now known to occur in five of the nine eco-regions where it was once found west of the Mississippi and in one of seven eco-regions east of the Mississippi; about four eco-regions support ABB populations estimated at >1,000 individuals. Of three reintroduction efforts, the one on Penikese Island, RI failed, the one in Ohio has shown few signs of success, and the one on Nantucket Island, RI is too recent to assess. (USFWS, 2008)

Threats and Stressors

Stressor: Habitat loss, fragmentation, and degradation (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: The cutting of forests and tilling and pasturing of the prairies not only led to declines in ground nesting birds, but also created more edge habitat, ideal for predators and scavengers that directly compete with the ABB for carrion. Cultivation loosened soil and grazing compacted soil resulting in unfavorable conditions for making and maintaining burrows in which to bury carrion for the young. (USFWS, 2008)

Stressor: Lack of carrion of appropriate size (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: As the forests were cut and the prairies grazed and cultivated, there was a concomitant and dramatic change in the faunal aspects on a continental scale. While some small rodents may have adapted well to the new habitats, most small mammals are too small for the ABB, which prefers an 80-100 gram carcass upon which to raise its young (Kozol et al. 1988). The passenger pigeon and eastern prairie chicken chicks and juveniles were ideal carrion size for the beetle. The loss of "ideal" carrion size is considered one of the major reasons for reduction in ABB numbers. (USFWS, 2008) Since the middle of the 19th century, certain animal species in the favored weight range for ABBs have either been eliminated from North America or significantly reduced over their historic range (USFWS 1991), including the passenger pigeon (Ectopistes migratorius), Carolina parakeet (Conuropsis carolinensis), greater prairie-chicken (Tympanchus cupido), bobwhite quail (Colinus virginianus) and wild turkey (Meleagris gallopavo) to name a few. The passenger pigeon was estimated at one time to have been the most common bird in the world, numbering 3 to 5 billion (Ellsworth and McComb 2003, p 1549). There were once as many passenger pigeons within the approximate historic range of the ABB as there are numbers of birds of all species overwintering in the United States today. Young wild turkeys are briefly at a suitable size during the active season, occurred throughout the range of the ABB, and until recently, were extirpated from much of their former range. Black-tailed prairie dogs (Cynomys ludovicianus) which occur in the Northern Plains analysis area have drastically declined (Miller et

al. 1990, p 763) and based on the extent of overlap between the prairie dog's initial range and that of the ABB, previously dense populations of prairie dogs may also have supported ABBs. (USFWS, 2019)

Stressor: Insect control (USFWS 1989)/Insecticides and Herbicides (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: In addition to the degradation of ABB habitat associated with tilling of grassland and prairie, row-crop agriculture may also include pesticide spraying, e.g., for grasshopper control, which may have more direct harmful effects on the ABB. The degree to which the ABB has been affected by this factor is unknown. Other species of burying beetles have been adversely affected by bug zappers; it is expected that this could be a concern for the ABB also. But as with pesticides, the actual effect is unknown. (USFWS, 1989) For any man-made toxin, to be a significant factor in the decline of ABB populations, we would have to account for the lack of equivalent impact on the sympatric congeners of the ABB. Unfortunately, there is limited historical information (e.g., Trumbo and Thomas (1998, entire) regarding Nicrophorus community structure with which to assess effects of past DDT spraying or other contaminants. It is possible that some ABB, and presumably other Nicrophorus, populations may have been extirpated by pesticide use, but there is no existing information to indicate that pesticide use has caused declines or extirpations over large areas of the ABB range (Sikes and Raithel 2002, p. 105). Most of the existing ABB range does not experience any widespread pesticide applications. Most of the known occupied habitat on the western portions of the ABB range is grassland or woodland/grassland mix that has grazing or hay production as an agricultural use and pesticides are not routinely or widely used (such as aerial or broadcast spraying) in these types of agriculture. Pesticides are frequently used for row crops that may be within the ABB range, but ABBs are rarely found in row crops. Pesticide applications for grasshoppers has been proposed in past years for grassland portions of the ABB range in NE and SD, but has rarely been implemented on a large scale. In NE and SD, a large portion of the known ABB distribution overlaps with distributions of economically damaging grasshoppers that are managed using Dimilin and Malathion pesticides. Dimilin was found to have some negative effects on N. orbicollis brood success when carcasses were exposed to the pesticide and then later used for larval development. Malathion caused direct mortality of N. marginatus Fabricius, a diurnal species, when sprayed directly, but would be unlikely to directly harm nocturnal ABBs. Indirectly, Malathion on a carcass might stress parental beetles and cause changes in brood size(Jurzenski 2012, pp. 112–115). These pesticides have potential adverse effects for ABBs, but the potential effects vary with the pesticide and application method, scale and timing. Herbicides are more likely to be used in portions of the current range, but are less likely to directly affect ABBs. ABBs are below ground most of the time and would have limited exposure to most herbicides. Herbicides are used to some degree in portions of the ABB range to control broad-leave weeds (forbs) and reduce competition for grasses in pastures. Herbicides that reduce forbs in rangeland could reduce habitat diversity and food sources for potential carrion sources. This could indirectly reduce habitat suitability for reproduction and feeding for ABBs. (USFWS, 2019)

Stressor: Competition from vertebrate scavengers (USFWS, 2008)
Exposure:
Response:
Consequence:

Narrative: Many small vertebrate scavengers and predators have benefitted from habitat changes to increase their populations. The increase in such competitors, combined with a diminution in size of potential carrion, has resulted in scarcity of the appropriate carrion size needed by the ABB. (USFWS, 2008)

Stressor: Red-imported fire ant (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: The red-imported fire ant has become a formidable competitor for carrion and a potential source of mortality for Nicrophorus beetles when they co-occur at a food source (Warriner 2004, Godwin and Minich 2005). The diet of foraging worker ants consists of dead animals, including insects, earthworms, and vertebrates (Collins and Scheffrahn 2005). Warriner noted that insects in traps he set for Nicrophorus burying beetles that were discovered by fire ants were generally dead, and Vinson and Sorenson (1986) in Collins and Scheffrahn (2005) noted that red-imported fire ants may reduce ground-nesting populations of rodents and birds and, in some instances, may completely eliminate ground-nesting species from a given area. (USFWS, 2008) Fire ants may reduce ground-nesting populations of rodents and birds, and in some instances, may completely eliminate ground nesting species from a given area (Collins and Scheffrahn 2005, Wilcox and Giuliano 2006, p. 4). Fire ant infestations are not evenly distributed; rather, they tend to be more numerous in open, disturbed habitats (Gleim et al. 2013, pp. 270, 271). Of the states containing populations of ABB, fire ants are known to infest all or parts of Arkansas, Oklahoma, and Texas (USDA 2003, online). (USFWS, 2019)

Stressor: Disease/Pathogens (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: A pathogen hypothesis could account for the ABBs pattern of decline. Any pathogen that could be transmitted among adult burying beetles, and was non-fatal to congeners of ABB could affect or eliminate most contiguous ABB populations, and leave only peripheral isolated populations intact (Sikes and Raithel 2002, p. 102). Raithel (in US Fish and Wildlife Service (1991, p.18) suggested this hypothesis and also pointed out that no evidence of a disease or pathogen had been found. However, there has been only limited investigation to test this hypothesis. Further, there is a bacterium that has potential to affect ABB. Wolbachia are members of the Order Rickettsiales (α-Proteobacteria), a diverse group of symbionts with parasitic, mutualistic or commensal lifestyle (Negri and Pellecchia 2012, p. 356). Wolbachia are common intracellular bacteria that are found in arthropods and nematodes. These alphaproteobacteria endosymbionts(a major group of gram-negative bacteria) are transmitted vertically through host eggs and alter host biology in diverse ways, including the induction of reproductive manipulations, such as feminization, parthenogenesis, male killing and sperm–egg incompatibility. Evidence of Wolbachia infection has been found in five sympatric species of nicrophorine burying beetles, including the ABB. Studies have only begun to look at the effects to ABB and any population level effects of these infections is unclear and untested. Although there is limited existing evidence of disease/pathogens affecting populations, it could be a future risk for ABBs. (USFWS, 2019)

Stressor: Climate Change (USFWS, 2019)

Exposure:
Response:
Consequence:
Narrative: The taxonomy and life history of ABBs indicate a limited ability to tolerate warmer temperatures. Nicrophorus abundance and diversity are higher in cooler climates. There are 15 Nicrophorus species in the United States and Canada, but only 2 endemic to Central America and they occur at higher elevations. Reasons for burying beetles' lack of success in warmer climates include increased competition with flies and ants, as well as increased rates of carcass decomposition. Carcass decomposition is dominated by dipteran species (true flies) and the diversity of dipteran species using carcasses increases in warmer climates. Based on species distributions and existing climate conditions, few Nicrophorus species appear to be capable of maintaining populations in areas with average summer mean-maximum temperatures at or exceeding the 95 ° F threshold (N. carolinus,and possibly pustulatus and marginatus) and there are no Nicrophorus species in areas with average summer mean maximum temperatures exceeding 100 ° F. Under the RCP 8.5 emissions scenario (approximately current rate of climate change) all Southern Plains ABB populations would be projected to have summer mean maximum temperatures of 98-100° F by 2040-2070 and 102-104° F by 2070-2099. All Nicrophorus species are at risk of extirpation within the Southern Plains ABB range under these projected climate conditions. Increased air temperatures, changes in precipitation, increased evaporative losses, and prolonged droughts may stress or kill individual ABBs and reduce reproductive success or reduce the time periods with suitable conditions for reproduction. Temperature tolerances for ABBs are currently unknown, but high air temperatures have been documented to kill or sterilize ABBs at captive colonies when air conditioning systems have failed, resulting in colony temperatures at 85-90°F for about two weeks (Bob Merz Personal Comm. October 6, 2016). Survey protocols require traps to be checked in the morning because ABB mortalities have occurred when they are confined in traps during warm days. More indirect effects of increased temperatures and reduced precipitation or soil moisture may be related to competition. Congeners with higher temperature and or lower moisture tolerances, like N. carolinus, may be more competitive and reduce or eliminate ABBs in southern populations (Abbott and Abbott 2013, p. 2). (USFWS, 2019)

Stressor: Artificial Lighting (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Circumstantial support for artificial lights as a factor in the decline could be derived from the fact that most extant populations of ABB occur in relatively remote, lightless areas, and artificial lighting was becoming widespread during the late 1800s (Bright 1949, entire), concurrent with the beginning of N. americanus' disappearance from the Northeast. However, fluorescent lights (including blacklights like those used in "Bug Zappers") are considerably more attractive to night-flying insects, and these are a relatively recent feature of the landscape (Sikes and Raithel 2002, p. 106). Additionally, it is difficult to separate the effects of lights and the related land use changes and fragmentation that usually coincide with the lights. Both N. orbicollis and Necrodes surinamensis, and other light-attracted silphids, remain abundant in some areas with lights. It remains at least possible that artificial lights, if they are responsible for a chronic, albeit low, level of adult attrition, could be affecting ABB populations. Nevertheless, it presently seems that if artificial lighting has had a negative effect on ABB it has been minor relative to other influences (Sikes and Raithel 2002, p. 106). (USFWS, 2019)

Recovery

Reclassification Criteria:

Reclassification will be considered when (a) 3 populations have been established (or discovered) within each of 4 geographical areas (Northeast, Southeast, Midwest, and the Great Lake states), (b) each population contains 500+ adults, (c) each population is self-sustaining for 5 consecutive years, and, ideally, each primary population contains several satellite populations. (USFWS, 1991)

Delisting Criteria:

Due to unknowns in the extent of suitable habitat and the reasons for decline, no delisting criteria are proposed at this time, although delisting remains the ultimate objective of the recovery program. (USFWS, 1991)

Recovery Actions:

- Populations of the ABB need to be protected, monitored, and managed. (USFWS, 1991)
- Existing captive populations need to be maintained for purposes of research and propagation. Additional captive populations need to be established. Beetles need to be reared for reintroduction purposes. (USFWS, 1991)
- The Penikese Island reintroduction effort should be continued, monitoring and augmenting the reintroductions. Supplemental carrion should be added and competition for carcasses should be reduced. (USFWS, 1991)
- Population modeling should be conducted and should include investigation of ecological relationships, determining and quantifying vertebrate composition, investigating competition by other Nicrophorus species, investigating land use relationships to the beetle, and identifying and evaluating other potential limiting factors. (USFWS, 1991)
- Prioritize areas to survey for additional wild populations, conduct surveys, and protect and manage for any additional populations found. (USFWS, 1991)
- Habitat should be characterized for all known localities. (USFWS, 1991)
- Additional areas should be assessed for potential reintroductions. After reintroductions have been made, these populations should be monitored and managed. (USFWS, 1991)
- Research into the reasons for the species decline should be continued. (USFWS, 1991)
- An information and education program should be developed and conducted. (USFWS, 1991)
- Revise the recovery plan, to include updating new species biology, ecology and distribution information that has become available since listing, setting a goal to return the ABB to an ecologically-based distribution, embracing the conservation biology principles of representation, resiliency, and redundancy, setting reclassification and delisting criteria that address the five listing factors, providing clear recommendations and direction to the ex situ community as to how best they can serve the recovery program, considering the conservation of genetic material and the need for connectivity between populations. (USFWS, 2008)
- Investigate declining ABB populations to better understand the relationship and correlation with forest stand conversion (timber harvest), road construction, and ice storm damage with the increase of the red-imported fire ant and the concurrent decline of the ABB. (USFWS, 2008)

- Standardize survey protocol methodology so that trapping success rates and ABB density estimates are comparable across the species range. (USFWS, 2008)
- Develop conservation strategies that emphasize the protection of essential features of large occupied habitats (minimally fragmented landscapes with abundant carrion species) and de-emphasize small scale, site specific project reviews. (USFWS, 2008)
- Develop Programmatic Biological Opinions with Federal agencies where appropriate to address section 7 consultation regarding the ABB at the landscape level, rather than by individual projects. This will not only afford the ABB protection and minimization of take but can better aid in the long-term conservation of the ABB. (USFWS, 2008)
- 6. Encourage the development of Statewide or multi-county HCPs and Safe Harbor Agreements in States where there are many scattered ABB occurrences and more efficient methods are needed to address small incremental losses and/or fragmentation of habitat. (USFWS, 2008)
- Seek opportunities to partner with the Natural Resource Conservation Service and large private landowners to enroll ABB habitat in the Conservation Reserve Program CRP program and to utilize other USDA and USFWS programs to restore or enhance ABB habitat through native species management. (USFWS, 2008)
- Pursue long-term management and monitoring agreements with State and Federal agencies, and non-profit resource agencies, many of which have already demonstrated support for the recovery program. Emphasize the importance of establishing "sentinel" populations in each State or eco-regional province that shall be monitored annually. (USFWS, 2008)
- Conduct recovery coordination meetings every three years during which information can be shared on research, changes in status and protection efforts. (USFWS, 2008)
- Utilize the ABB Population and Habitat Viability Assessment results (Amaral et al. [eds.] 2005) to guide implementation of research priorities for the ABB. Update research priority ranking as needed. (USFWS, 2008)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Revise the recovery plan, to include: a. updating all the new species biology, ecology and distribution information that has become available since listing, b. setting a goal to return the ABB to a distribution within its historic range that is based on the use of physiographic, eco-regional provinces rather than State boundaries and that embraces the conservation biology principles of representation, resiliency, and redundancy, c. setting reclassification and delisting criteria that address the five listing factors, d. providing clear recommendations and direction to the ex situ community as to how the American Zoological Association can best serve the recovery program for this species, and e. taking into consideration the conservation of genetic material within populations and the need for connectivity between populations. 2. Investigate declining ABB populations, such as the Weyerhaeuser HCP Area, to better understand the relationship and correlation with forest stand conversion (timber harvest), road construction, and ice storm damage with the increase of the red-imported fire ant and the concurrent decline of the ABB. 3. Standardize survey protocol methodology so that trapping success rates and ABB density estimates are comparable across the species range. 4. Develop conservation strategies that emphasize the protection of essential features of large occupied habitats (minimally fragmented landscapes with abundant carrion species) and de-emphasize small scale, site specific project reviews. 5. Develop Programmatic Biological Opinions with Federal agencies where appropriate to address section 7 consultation regarding the ABB at the landscape level, rather than

by individual projects. This will not only afford the ABB protection and minimization of take but can better aid in the long-term conservation of the ABB. 6. Encourage the development of Statewide or multi-county HCPs and Safe Harbor Agreements in States where there are many scattered ABB occurrences and more efficient methods are needed to address small incremental losses and/or fragmentation of habitat. 7. Seek opportunities to partner with the Natural Resource Conservation Service and large private landowners to enroll ABB habitat in the Conservation Reserve Program CRP program and to utilize other USDA and USFWS programs to restore or enhance ABB habitat through native species management. 8. Pursue long-term management and monitoring agreements with State and Federal agencies, and non-profit resource agencies, such as the U.S. Forest Service, Federal Highway Administration, National Park Service, Bureau of Land Management, National Guard Bureau, U.S. Army Corps of Engineers, and The Nature Conservancy, many of which have already demonstrated support for the recovery program. Emphasize the importance of establishing "sentinel" populations in each State or eco-regional province that shall be monitored annually. 9.
Conduct recovery coordination meetings every three years during which information can be shared on research, changes in status and protection efforts. 10. Utilize the ABB PHVA (Amaral et al. [eds.] 2005), which provides the ranked research needs of the ABB, to guide implementation of research priorities for the ABB. Update research priority ranking as needed. (USFWS, 2008)

- Protected Areas – The impacts due to urban expansion are anticipated to be partially offset by increases in protected lands. Block Island is 6,111 acres in size, and has a large area of conservation lands (2,523 acres; 41%). Nantucket, 36,321 acres in size, is similar, with a large proportion held by land trusts or other protected status (11,934 acres; 33%). Combined there is a total of 42,431 acres with 25,865 suitable habitat acres and 14,457 acres of protected lands. The areas of protected lands are not expected to change under scenario 2 and most of the protection is not specifically related to the ABB. The condition for protected areas is considered poor due to the limited area on the islands (less than 100,000 acres), but the percentage of protected lands for the New England Analysis Area is higher than all other analysis areas and does help protect habitat into the future. The high percentage of protected lands improves the resiliency of this analysis area. (USFWS, 2019)

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SPECIES ACCOUNT: *Oarisma poweshiek* (Poweshiek skipperling)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11-24-2014

Physical Description

Poweshiek skipperlings are small and slender-bodied, with a wingspan generally ranging from 2.3 to 3.0 cm (0.9 to 1.2 in). The upper wing surface is dark brown with a band of orange along the leading edge of the forewing. Ground color of the lower surface is also dark brown, but the veins of all but the anal third of the hindwing are outlined in hoary white, giving an overall white appearance to the undersurface.

Taxonomy

The Poweshiek skipperling (Oarisma poweshiek) is a member of the skipper family, Hesperiidae. The Poweshiek skipperling is most easily confused with the Garita skipperling (Oarisma garita), which can be distinguished from Poweshiek skipperling by their smaller size, quicker flight, and overall goldenbronze color (Royer and Marrone 1992b, p. 3). Another distinguishing feature is the color of the anal area of the ventral hindwing (orange in Garita; dark brown in Poweshiek).

Historical Range

The Poweshiek skipperling is historically known from eight States, ranging widely over the native wetmesic to dry tallgrass prairies from eastern North and South Dakota (Royer and Marrone 1992b, pp. 4–5) through Iowa (Nekola and Schlicht 2007, p. 7) and Minnesota (Minnesota DNR, Division of Ecological Resources, unpubl. data), with occurrences also documented in northern Illinois (Dodge 1872, p. 218), Indiana (Blatchley 1891, p. 898), Michigan (Holzman 1972, p. 111; McAlpine 1972, p. 83), and Wisconsin (Borkin 2011, in litt.; Selby 2010, p. 22). The relatively recent discovery of Poweshiek skipperling populations in the Canadian province of Manitoba further extends its known historical northern distribution (Westwood 2010, pp. 7–22; Dupont 2010, pers. comm.).

Current Range

Summary: Out of the 298 historically documented Poweshiek skipperling sites, there are currently 7 sites where the species is considered present1 (at the time of listing, 12 sites were considered to have Poweshiek skipperling present). Michigan: All six sites where the Poweshiek skipperling was considered extirpated at the time of listing are still considered extirpated. Additionally, Liberty Fen (Grand River Fen) is now considered extirpated (unknown at the time of listing), as no Poweshiek were sighted in four consecutive seasons (from 2013 to 2016). Bullard Lake is also now considered extirpated (unknown at the time of listing), as no Poweshiek have been sighted in four consecutive surveys (2008, 2009, 2014, and 2015). There are four sites that were considered present at the time of listing, but have since changed status. Liberty Bowl Fen is now considered possibly extirpated, as the last sighting was in 1996. Park Lydon, Goose Creek Grasslands (also known as Little Goose Lake Fen), and Snyder Lake are all now considered unknown, each with two negative surveys since the time of listing. Five Michigan sites are currently classified as present, out of the nine that had present status at the time of listing. However, the numbers of individuals detected at these remaining present sites have decreased since listing, with high daily counts of 1, 2, and 9 individuals in 2018 at Halstead Lake Fen, Holly Fen (Brandt Road), and Buckhorn Lake (Big Valley), respectively. The stronghold of Long Lake Fen (2 sites, including the Eaton Road site) has not had a high daily count above 49 since listing, with a high daily count of 28 in 2018 (compared to multiple counts in the hundreds in the five years preceding listing). Similarly, numbers are down for the maximum number of Poweshiek skipperlings observed per minute at these sites relative to the recent years before listing (Figure 1). Belitz and colleagues (2019, p. 645) estimated the adult Poweshiek abundance in Michigan prairie fens to be 231 (95% CI 160-332). Furthermore, no additional sites have been found, even though a habitat model identified approximately 33 sites that may have significant potential to be inhabited by Poweshiek skipperling. Of the potential sites surveyed thus far, no new Poweshiek skipperling sites have been found (MNFI 2017, unpublished). Manitoba: One prairie complex in Manitoba is still considered present since the time of listing. Since listing, surveys have detected between 5 and 72 total Poweshiek skipperlings in Manitoba per year (Westwood, pers. comm. 2013; Pearn et al. 2014, p. 1; The Nature Conservancy Canada, unpubl. data 2018; Figure 2). Poor survey conditions in 2016 likely affected the low number of Poweshiek skipperlings observed that year (The Nature Conservancy Canada 2017, unpubl. data). Wisconsin: At the time of listing, there were three sites with unknown occupancy and one site where Poweshiek skipperling were present. The three sites with previously unknown occupancy are now all considered extirpated. The site with Poweshiek skipperling presence, Puchyan Prairie, is still considered to be present. Since 2012, no more than three Poweshiek skipperlings have been observed in a given year at that site. In both 2017 and 2018, there was one individual sighted, however no photo documentation confirms these sightings. Minnesota: Poweshiek skipperling was once widespread and abundant in Minnesota; however there have been no confirmed sightings of the species in the state since 2007 (U.S. Fish and Wildlife Service 2019, unpub. data). One unconfirmed sighting in 2013 occurred at a prairie complex owned and managed primarily by the Minnesota Department of Natural Resources (MNDNR) in the Chicog Wildlife Management Area (WMA). This area has had recent adult observations over multiple years (2004-2007, and unconfirmed in 2013). Follow-up surveys since in 2014 and 2016 resulted in no detections of the species at Chicog WMA (MNDNR 2017, unpub. data). Indiana, Illinois, Iowa, North Dakota, and South Dakota: Since the time of listing, there have been no sightings in Indiana, Illinois, Iowa, North Dakota, and South Dakota. There are no sites where the Poweshiek skipperling is currently considered present in those states. (USFWS, 2019)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 10/1/2015.

Legal Description

On October 1, 2015, the U.S. Fish and Wildlife Service designated critical habitat for the Poweshiek skipperling (Oarisma poweshiek). In total, approximately 25,888 acres (10,477 hectares) in Cerro Gordo, Dickinson, Emmet, Howard, Kossuth, and Osceola Counties, Iowa; Hilsdale, Jackson, Lenawee, Livingston, Oakland, and Washtenaw Counties, Michigan; Chippewa, Clay, Cottonwood, Douglas, Kittson, Lac Qui Parle, Lincoln, Lyon, Mahnomen, Murray, Norman, Pipestone, Polk, Pope, Swift, and Wilkin Counties, Minnesota; Richland County, North Dakota; Brookings, Day, Deuel, Grant, Marshall, Moody, and Roberts Counties, South Dakota; and Green Lake and Waukesha Counties, Wisconsin, fall within the boundaries of the critical habitat designation for Poweshiek skipperling. The effect of this regulation is to designate critical habitat for the Dakota skipper (Hesperia dacotae) and the Poweshiek skipperling (Oarisma poweshiek) under the Endangered Species Act.

Critical Habitat Designation

56 units are designated as critical habitat for Poweshiek skipperling. Those 56 units are: (1) PS Iowa Units 1–11; (2) PS Michigan Units 1–9; (3) PS Minnesota Units 1–20; (4) PS North Dakota Units 1 and 2; (5) PS South Dakota Units 1–8, 15–18; and (6) PS Wisconsin Units 1 and 2.

Individual unit descriptions not available.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Cerro Gordo, Dickinson, Emmet, Howard, Kossuth, and Osceola Counties in Iowa; in Hilsdale, Jackson, Lenawee, Livingston, Oakland, and Washtenaw Counties in Michigan; Chippewa, Clay, Cottonwood, Douglas, Kittson, Lac Qui Parle, Lincoln, Lyon, Mahnomen, Murray, Norman, Pipestone, Polk, Pope, Swift, and Wilkin Counties in Minnesota; Richland County in North Dakota; Brookings, Day, Deuel, Grant, Marshall, Moody, and Roberts Counties in South Dakota; and Green Lake and Waukesha Counties in Wisconsin. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of Poweshiek skipperling consist of four components:

(i) Primary Constituent Element 1— Wet-mesic to dry tallgrass remnant untilled prairies or remnant moist meadows containing: (A) A predominance of native grasses and native flowering forbs; (B) Undisturbed (untilled) glacial soil types including, but not limited to, loam, sandy loam, loamy sand, gravel, organic soils (peat), or marl that provide the edaphic features conducive to Poweshiek skipperling larval survival and native-prairie vegetation; (C) If present, depressional wetlands or low wet areas, within or adjacent to prairies that provide shelter from high summer temperatures and fire; (D) If present, trees or large shrub cover less than 5 percent of area in dry prairies and less than 25 percent in wetmesic prairies and prairie fens; and (E) If present, nonnative invasive plant species occurring in less than 5 percent of area.

(ii) Primary Constituent Element 2— Prairie fen habitats containing: (A) A predominance of native grasses and native flowering forbs; (B) Undisturbed (untilled) glacial soil types including, but not limited to, organic soils (peat), or marl that provide the edaphic features conducive to Poweshiek skipperling larval survival and native-prairie vegetation; (C) Depressional wetlands or low wet areas, within or adjacent to prairies that provide shelter from high summer temperatures and fire; (D) Hydraulic features necessary to maintain prairie fen groundwater flow and prairie fen plant communities; (E) If present, trees or large shrub cover less than 25 percent of the unit; and (F) If present, nonnative invasive plant species occurring in less than 5 percent of area.

(iii) Primary Constituent Element 3— Native grasses and native flowering forbs for larval and adult food and shelter, specifically: (A) At least one of the following native grasses available to provide larval food and shelter sources during Poweshiek skipperling larval stages: Prairie dropseed (Sporobolus heterolepis), little bluestem (Schizachyrium scoparium), sideoats grama (Bouteloua curtipendula), or mat muhly (Muhlenbergia richardsonis); and (B) At least one of the following forbs in bloom to provide nectar and water sources during the Poweshiek skipperling flight period: Purple coneflower (Echinacea angustifolia), black-eyed Susan (Rudbeckia hirta), smooth ox-eye (Heliopsis helianthoides), stiff tickseed (Coreopsis palmata), palespike lobelia (Lobelia spicata), sticky tofieldia (Triantha glutinosa), or shrubby cinquefoil (Dasiphora fruticosa ssp. floribunda).

(iv) Primary Constituent Element 4— Dispersal grassland habitat that is within 1 km (0.6 mi) of native highquality remnant prairie (as defined in Primary Constituent Element 1) that connects high-quality wet-mesic to dry tallgrass prairies, moist meadows, or prairie fen habitats. Dispersal grassland habitat consists of the following physical characteristics appropriate for supporting Poweshiek skipperling dispersal: Undeveloped open areas dominated by perennial grassland with limited or no barriers to dispersal including tree or shrub cover less than 25 percent of the area and no row crops such as corn, beans, potatoes, or sunflowers.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 2, 2015.

Management activities should be of the appropriate timing, intensity, and extent to be protective of Dakota skipper and Poweshiek skipperling during all life stages (e.g., eggs, larvae, pupae, and adults) and to maximize habitat quality and quantity. Some management activities, depending on how they are implemented, can have intensive impacts to the species, its habitat, or both. Depending on site-specific conditions, management that includes prescribed fire and some low-intensity grazing must affect no more than onequarter to one-third of the occupied habitat at a site in any single year to ensure that the resulting mortality or effects to reproduction do not have undue impacts on population viability. Management activities should protect the primary constituent elements for the species by conserving the extent of the habitat patches, the quality of habitat within the patches, and connectivity among occupied patches (e.g., see Schmitt, 2003). Appropriate management helps increase the number of individuals reproducing each year by minimizing the activities that may harm Dakota skippers or Poweshiek skipperling during adult, larval, or pupal stages. Such special management activities may be required to protect the physical or biological features and support the conservation of Dakota skipper and Poweshiek skipperling by preventing or reducing the loss, degradation, and fragmentation of native prairie landscapes. Additionally, management of critical habitat lands can increase the amount of suitable habitat and enhance connectivity among Dakota skipper and Poweshiek skipperling populations through the restoration of areas that were previously composed of native tallgrass and mixed-grass prairie communities. The limited extent of native tallgrass and mixed-grass prairie habitats, particularly the eastern portion of the Poweshiek skipperling range, emphasizes the need for additional habitat into which the Poweshiek skipperling could expand to survive and recover as well as to allow for adjustment to changes in habitat availability that may result from climate change.

Life History

Feeding Narrative

Adult: The preferred larval food plant for some populations of Poweshiek skipperling is prairie dropseed (Borkin 1995, p. 6); larvae have also been observed feeding on little bluestem (Schizachyrium scoparium) (Borkin 1995, pp. 5–6) and sideoats grama (Bouteloua curtipendula) (Dana 2005a, pers. comm.). Poweshiek skipperling larvae have been observed feeding on Carex sp. (Borkin 1994, p. 6; Borkin 1996, p. 2), although not through the entire larval development (Borkin 2014, pers. comm.). Poweshiek skipperling have been observed laying eggs (ovipositing) on mat muhly (Muhlenbergia richardsonis) (Cuthrell 2012a, pers. comm.), a grass in Michigan's prairie fens (Penskar and Higman 1999, p. 1). Captive-reared caterpillars fed most successfully on prairie dropseed, and older caterpillars (late 2-day instar and older) successfully fed on little bluestem, big bluestem, and side-oats gramma (Runquist 2013, pers. comm.). One post-diapause Poweshiek skipperling was successfully reared to adulthood on Pennsylvania sedge (Carex pensylvanica) (Runquist 2013, pers. comm.).

Reproduction Narrative

Adult: Poweshiek skipperlings lay their eggs near the tips of leaf blades and overwinter as larvae on the host plants (Bureau of Endangered Resources in Swengel and Swengel 1999, p. 285, Borkin 2000, p. 7). Poweshiek skipperlings have also been documented laying eggs on the entire length of grass leaf blades and on low-growing deciduous foliage (Dupont 2013, p. 133). McAlpine (1972, pp. 85–93) observed hatching of larval Poweshiek skipperling after about 9 days. McAlpine's records were incomplete, and he did not have any observations past the 7th instar, but he believed that there should have been one or two additional instars, followed by the chrysalis (pupa) and then the imago (adult) stages (McAlpine 1972, pp. 85–93). Captive Poweshiek skipperling eggs hatched 8 to 9 days after oviposition (Runquist 2013, pers. comm.). After hatching, Poweshiek skipperling larvae crawl out near the tip of grasses and may remain stationary, with their head usually pointing downward (McAlpine 1972, pp. 88–92). Unlike Dakota skippers, Poweshiek skipperling do not form shelters underground (McAlpine 1972, pp. 88– 92; Borkin 1995, p. 9; Borkin 2008, pers. comm.), instead the larvae overwinter up on the blades of grasses and on the stem near the base of the plant (Borkin 2008, pers. comm.; Dana 2008, pers. comm.). Borkin (2008, pers. comm.) observed larvae moving to the tips of grass blades to feed on the outer and thinner edges of the blades, with later movement down and among blades.

Geographic or Habitat Restraints or Barriers

Adult: Roads and crop fields

Spatial Arrangements of the Population

Adult: Clumped according to suitable microhabitat

Environmental Specificity

Adult: High

Tolerance Ranges/Thresholds

Adult: Sensitive

Site Fidelity

Adult: High

Habitat Narrative

Larvae: After hatching, Poweshiek skipperling larvae crawl out near the tip of grasses and may remain stationary, with their head usually pointing downward (McAlpine 1972, pp. 88–92). Unlike Dakota skippers, Poweshiek skipperling do not form shelters underground (McAlpine 1972, pp. 88– 92; Borkin 1995, p. 9; Borkin 2008, pers. comm.), instead the larvae overwinter up on the blades of grasses and on the stem near the base of the plant (Borkin 2008, pers. comm.; Dana 2008, pers. comm.). Borkin (2008, pers. comm.) observed larvae moving to the tips of grass blades to feed on the outer and thinner edges of the blades, with later movement down and among blades.

Adult: Poweshiek skipperling habitats include prairie fens, grassy lake and stream margins, moist meadows, sedge meadow, and wet-to-dry prairie. McCabe and Post (McCabe and Post 1977, pp. 36–38) describe the species' habitat in North Dakota as ''. . . high dry prairie and low, moist prairie stretches as well as old fields and meadows.'' Royer and Marrone (1992b, p. 12) describe Poweshiek skipperling habitat in North Dakota and South Dakota as moist ground in undisturbed native tallgrass prairies. Poweshiek skipperling habitat throughout Iowa and Minnesota is described as both ''high dry'' and ''low wet'' prairie (McCabe and Post 1977, pp. 36–38). The only documented Illinois record was associated with high rolling prairie (Dodge 1872, p. 218); the only documented Indiana record was from marshy lakeshores and wetlands (Blatchley 1891, p. 398; Shull 1987, p. 29). Southern dry prairies in Minnesota are described as having sparse shrub cover (less than 5 percent) composed primarily of leadplant, with prairie rose, wormwood sage, or smooth sumac present and few, if any, trees (Minnesota DNR 2012a, p. 1). Southern mesic prairies also have sparse shrubs (5–25 percent cover) consisting of leadplant and prairie rose with occasional wolfberry (Symphoricarpos occidentalis) and few, if any, trees (Minnesota DNR 2012b, p. 1). The disjunct populations of Poweshiek skipperlings in Michigan have more narrowly defined habitat preferences, variously described as wet marshy meadows (Holzman 1972, p. 114), bog fen meadows or carrs (Shuey 1985, p. 181), sedge fens (Bess 1988, p. 13), and prairie fens (Michigan Natural Features Inventory 011, unpubl. data; Michigan Natural Features Inventory 2012, unpubl. data). Bess (1988, p. 13) found the species primarily in the drier ortions of Liberty Fen, Jackson County, dominated by ''low sedges'' and an abundance of nectar sources. Summerville and Clampitt (1999, p. 231) noted that the population was concentrated in areas dominated by spikerush and that only 10–15 percent of the fen area was occupied despite the abundance of nectar sources throughout. Poweshiek skipperling have been described as occupying peat domes within larger prairie fen complexes in areas either dominated by mat muhly or prairie dropseed (Cuthrell 2013a, pers. comm.). Poweshiek skipperling populations in Wisconsin are also disjunct from the population to the west and are associated with areas that contain intermixed wet prairie, wet-mesic, and dry-mesic prairie habitats (Borkin 1995, p. 6; Swengel 2013, pers. comm.). The dry-mesic habitats in the Scuppernong Prairie contain ‘‘extensive patches of prairie dropseed and little bluestem grasses’’ (Borkin 1995, p. 7). Survival in wetter areas, which tend to burn cooler and less completely, coupled with low recolonization rates, or the disproportionate loss of wet versus dry prairie could give the false impression that the wet areas were their preferred habitat (Borkin 1995, p. 7). Puchyan Prairie consists of wet-mesic prairie that grades lower into sedge meadow (WI DNR Web site http://dnr.wi.gov/topic/Lands/naturalareas/ index.asp?SNA=172; Swengel 2013, pers. comm.) and adult Poweshiek Skipperlings have been observed in wet prairie there, although it is not known if these areas function as successful larval habitat (Swengel 2013, pers. comm.). Like the Dakota skipper, it has been hypothesized that Poweshiek skipperling larvae may be vulnerable to desiccation during dry summer months (Borkin 2012a, pers. comm.) and require movement of shallow groundwater to the soil surface or wet low areas to provide relief from high summer temperatures or dry conditions (Royer et al. 2008, pp. 2, 16; Borkin 2012a, pers. comm.). Humidity may also be an essential factor to larval survival during winter months since the larvae cannot take in water during that time and depend on humid air to minimize water loss through respiration (Dana 2013, pers. comm.). Royer (2008, pp. 14–15) measured microclimatological (climate in a small space, such as at or near the soil surface) levels within ‘‘larval nesting zones’’ (0 to 2 cm above the soil surface) at six known Poweshiek skipperling sites, and found an acceptable rangewide seasonal (summer) mean temperature range of 18 to 21 °C (64 to 70 °F), rangewide seasonal mean dew point ranging from 14 to 17 °C (57 to 63 °F), and rangewide seasonal mean relative humidity between 73 and 85 percent. Plant species generally associated with upland, drier portions of the mesic tallgrass prairies in Manitoba include: Big bluestem, pale-spike lobelia, prairie dropseed, mountain death camas, stiff goldenrod, black-eyed Susan, and meadow blazing-star (Environment Canada 2012, p. 6). In lower, wetter prairies with Poweshiek skipperlings, the following species are listed as often seen: Willow (Salix spp.), sedges (Carex spp.), rushes (Juncus spp.), groundsels (Pakera spp.), tufted hairgrass, creeping bentgrass (Agrostis stolonifera), mat muhly, elliptic spike-rush, fourflowered yellow loosestrife (Lysimachia quadriflora), and common self-heal (Environment Canada 2012, p. 6). The soils where the Poweshiek skipperling occurs in Manitoba are described as shallow, rocky, and highly calcareous (Westwood and Borkowsky 2004 in Dupont 2013, p. 19). Prairie fen habitat soils in Michigan are described as saturated organic soils (sedge peat and wood peat) and marl, a calcium carbonate ($CaCO_3$) precipitate (MINFI Web site accessed August 3, 2012). In other States, soil textures in Poweshiek skipperling habitats are classified as loam, sandy loam, or loamy sand (Royer et al. 2008, pp. 3, 10); soils in moraine deposits are described as gravelly, except the deposits associated with glacial lakes. The Poweshiek larvae overwinter up on the blades of grasses and on the stem near the base of the plant (Borkin 2008, pers. comm.; Dana 2008, pers. comm.)

Dispersal/Migration

Motility/Mobility

Larvae: Larvae are very sedentary.

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal

Adult: Very limited

Immigration/Emigration

Adult: Not likely

Dispersal/Migration Narrative

Adult: Poweshiek skipperlings have low mobility and are non-migratory. Their dispersal is very limited and they are unlikely to immigrate. Larvae are very sedentary.

Additional Life History Information

Adult: Larvae are very sedentary.

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2019)

Population Growth Rate:

Steep negative

Number of Populations:

12 with 7 currently being occupied (USFWS, 2019)

Population Size:

Unknown; small

Resistance to Disease:

Unknown

Population Narrative:

Recent survey data indicate that Poweshiek skipperling has declined to zero or to undetectable levels at 96 percent of sites where it has ever been recorded. Until about 2003, Poweshiek skipperling was regarded as the most frequently and reliably encountered prairie-obligate skipper butterfly in Minnesota, which contains approximately 48 percent of all known Poweshiek skipperling locations rangewide. Numbers and distribution dropped dramatically in subsequent years, however, and the species was not seen in Minnesota from 2007 through 2012. Two individuals were observed at one site in 2013 (Weber 2014, in litt.; Dana 2014, pers. comm.). In Iowa, the Poweshiek skipperling was found at 2 of 33 sites with previous records surveyed in 2007; the species was last observed at one site in 2008. Iowa contains about 14 percent of documented sites rangewide. Unidentified threats to the species have acted to extirpate or sharply diminish populations at all or the vast majority of sites in Iowa and Minnesota (Dana 2008, p. 16; Selby 2010, p. 7). South Dakota historically contained about 23 percent of the rangewide sites with documented presence of Poweshiek skipperling, although recent surveys in that State also suggest an emergent and mysterious decline. The species was last observed in South Dakota in 2008, at three sites. Surveys conducted in 2009–2013 flight seasons in South Dakota resulted in zero detections of the species. North Dakota historically contained about six percent of the rangewide sites with documented presence of Poweshiek skipperling; the species was last observed in North Dakota in 2001. Survey efforts in North Dakota have been minimal between 1998 and 2011, but surveys conducted in 1997 documented more than 10 Poweshiek skipperlings at 1 site; 6 individuals were counted at 1 site, and 0 were detected at 6 other sites. Surveys conducted during the 2012 and 2013 flight seasons in North Dakota resulted in zero detections of the species. Seven Michigan sites were recently ranked as having good or better ''viability,'' a habitat-based element occurrence rank assigned by the Michigan Natural Features Inventory (2011); however, the number of individuals observed at a few of those sites has declined in recent years, and the species is presumed extirpated from one of those sites. Currently, four of the ten extant occurrences of Poweshiek skipperling in Michigan are considered to have good or better viability (Michigan Natural Features Inventory (2011, unpubl. data). Each of those faces threats of at least low to moderate magnitude, and the State contains only about 6 percent of all known historical Poweshiek skipperling records. One population of Poweshiek skipperlings in Wisconsin had fairly consistent numbers observed over the last 5 years (17 to 63 individuals counted using modified Pollard transect covering 15 ac (6 ha) in approximately 40 minutes), but the species was not observed in 2013 surveys. One population in Manitoba has fairly consistent numbers (typically hundreds of individuals observed each year). To summarize, of the 298 documented sites, there are 12 sites where we consider the Poweshiek skipperling to be present, 111 sites with unknown status, 96 possibly extirpated sites, and 79 where we consider the species to be extirpated. Sites where Poweshiek skipperling are currently present have seen a 41.7% decrease (from 12 to 7) since the time they were listed as endangered in 2014. Even with extensive survey efforts, Poweshiek skipperling numbers continue to be low at the remaining sites and they have not been found at any additional sites. With the majority of Poweshiek skipperling individuals concentrated at two locations (Michigan and Manitoba), the species is highly vulnerable to extirpation from a catastrophic event. Population numbers are low at all sites, making them vulnerable to stochastic events. Work is being done by a coalition of partners to conserve this butterfly, including habitat restoration and acquisition, captive propagation head starting efforts, pesticide sampling, and outreach. However, even with this conservation work, the threats for Poweshiek skipperling have not been ameliorated. These threats include habitat degradation through invasive species and lack of disturbance, pesticides, the effects of climate change, altered hydrology, and the negative impacts of low population sizes. Due to the continued decrease of Poweshiek skipperling population numbers and because threats persist for the remaining populations, we have concluded that there is no information to indicate that the species status should change from endangered (USFWS, 2019).

Threats and Stressors

Stressor: Habitat destruction and conversion
Exposure:
Response:
Consequence:
Narrative: Conversion of prairie for agriculture may have been the most influential factor in the decline of the Poweshiek skipperling since Euro-American settlement, but the impacts of such conversion on extant populations is not well known. By 1994, tallgrass prairie had declined by 99.9 percent in Illinois, Iowa, Indiana, North Dakota, Wisconsin, and Manitoba; and by 99.6 percent in Minnesota; and 85 percent in South Dakota (Samson and Knof 1994, p. 419). Conversion for agriculture on lands suitable for such purposes is a current, ongoing stressor of high level of impact to the Poweshiek skipperling populations in areas where such lands still remain. Advances in technology may also increase the potential of conversions in areas that are currently unsuitable for agriculture.

Stressor: Energy development
Exposure:
Response:
Consequence:
Narrative: Energy development (oil, gas, and wind) and associated roads and facilities result in the loss or fragmentation of suitable prairie habitat (Reuber 2011, pers. comm.). Catastrophic events, such as oil and brine spills, could cause direct mortality of Poweshiek skipperling larvae that are in shelters at the soil surface. Such spills may also cause the loss of larval host and nectar plants in the spill path. Additional plants may be lost during spill response, particularly if the response involves burning. Wind energy turbines and associated infrastructure (e.g., maintenance roads) are likely stressors to Poweshiek skipperling populations, particularly on private land in South Dakota (Skadsen 2002, p. 39; Skadsen 2003, p. 47; Skadsen 2012d, pers. comm.). Similar to oil and gas development, wind development would destroy native-prairie habitat in the footprint of the structure, add access roads and other infrastructure that may further fragment prairies, and could be catalysts for the spread of invasive species. Further, it is unknown if the noise and flicker effects associated with wind turbines may impact Poweshiek skipperling populations beyond direct impacts from the turbines and/or infrastructure.

Stressor: Invasive species
Exposure:
Response:
Consequence:
Narrative: Poweshiek skipperlings typically occur at sites embedded in agricultural or developed landscapes, which make them more susceptible to nonnative or woody plant invasion. Nonnative

species including leafy spurge, Kentucky bluegrass, alfalfa, glossy buckthorn, smooth brome, purple loosestrife (Lythrum salicaria), Canada thistle (Cirsium arvense), reed canary grass, and others, have invaded Poweshiek skipperling habitat throughout their ranges (Orwig 1997, pp. 4, 8; Michigan Natural Features Inventory 2011, unpubl. data; Skadsen 2002, p. 52; Royer and Royer 2012b, pp. 15–16, 22–23). Once these plants invade a site, they replace or reduce the coverage of native forbs and grasses used by adults and larvae of both butterflies. Thus, a prevalence of these grasses reduces food availability for the larvae. The stressor from nonnative invasive herbaceous species is compounded by the encroachment of woody species into native-prairie habitat. Glossy buckthorn and gray dogwood encroachment, for example, is a major stressor to Poweshiek skipperling populations. Invasion of tallgrass prairie and prairie fens by woody vegetation such as glossy buckthorn reduces light availability, total plant cover, and the coverage of grasses and sedges (Fiedler and Landis 2012, pp. 44, 50–51). This in turn reduces the availability of both nectar and larval host plants for Poweshiek skipperlings. If groundwater flow to prairie wetlands is disrupted (e.g., by development) or intercepted (e.g., digging a pond in adjacent uplands or installing wells for irrigation or drinking water), it can quickly convert to shrubs or other invasive species (Fiedler and Landis 2012, p. 51; Michigan Natural Features Inventory 2012, p. 4). For example, roads and residential development likely disrupted the hydrology of a prairie fen where the Poweshiek skipperling was last observed in 2007 and where 2008 and 2009 surveys for Poweshiek skipperlings were negative (Michigan Natural Features Inventory 2011, unpubl. data). When prairie is converted to shrubland, forest, or semi-forested habitat types and facilitates invasion of adjacent native prairie by exotic, cool-season grasses, such as smooth brome. Moreover, the trees and shrubs provide perches for birds that may prey on the butterflies (Royer and Marrone 1992b, p. 15; 1992a, p. 25).

Stressor: Fire
Exposure:
Response:
Consequence:
Narrative: Poweshiek skipperling populations existed historically in a vast ecosystem maintained in part by fire. Due to the great extent of tallgrass prairie in the past, fire and other intense disturbances (e.g., locally intensive bison grazing) likely affected only a small proportion of the habitat each year, allowing for recolonization from unaffected areas during the subsequent flight period (Swengel 1998, p. 83). Fire can improve Poweshiek skipperling (Cuthrell 2009, pers. comm.) (e.g., by helping to control woody vegetation encroachment), but it may also kill most or all of the individuals in the burned units and alter entire remnant prairie patches, if not properly managed (e.g., depends on the timing, intensity, etc.). Accidental wildfires also may burn entire prairie tracts (Dana 1997, p. 15). Intentional fires, without careful planning, may also have significant adverse effects on populations of Poweshiek skipperlings, especially after repeated events (McCabe 1981, pp. 190–191; Dana 1991, pp. 41– 45, 54–55; Swengel 1998, p. 83; Orwig and Schlicht 1999, pp. 6, 8). The effects of fire on prairie butterfly populations are difficult to ascertain (Dana 2008, p. 18), but the apparent hypersensitivity of Poweshiek skipperlings indicates that it is a stressor in habitats burned too frequently or too broadly. The Poweshiek skipperling are not known to disperse widely (Swengel 1996, p. 81; Burke et al. 2011, p. 2279); therefore, in order to reap the benefits of fire to habitat quality, Poweshiek skipperlings must

either survive in numbers sufficient to rebuild populations after the fire or recolonize the area from a nearby unburned area. In addition, the return interval of fires needs to be infrequent enough to allow for recovery of the populations between burns. Therefore, fire is a stressor to Poweshiek skipperlings at any site where too little of the species' habitat is left unburned or where patches are burned too frequently. When all or large portions of prairie remnants are burned, many or all prairie butterflies may be eliminated at once. Complete extirpation of a population, however, may not occur after a single burn event (Panzer 2002, p. 1306), and the extent of effects would vary depending on time of year and fuel load. Poweshiek skipperlings lay their eggs near the tips of leaf blades, and they overwinter as larvae on the host plants (Borkin 200, p. 2), where they are exposed to fires during their larvalstages. Poweshiek skipperlings have also been documented laying eggs on the entire length of grass leaf blades and on low-growing deciduous foliage (Dupont 2013, p. 133). Poweshiek skipperlings do not burrow into the soil surface (McAlpine 1972, pp. 88–92; Borkin 1995, p. 9), which makes them more vulnerable to fire (and likely more vulnerable to chemicals such as herbicides and pesticides) throughout their larval stages.

Stressor: Grazing
Exposure:
Response:
Consequence:
Narrative: Grazing may maintain habitat for the Poweshiek skipperling, but as with any management practice, appropriate timing, frequency, and intensity are important. The level of impact of grazing on Poweshiek skipperling populations also depends on the type of habitat that is being grazed. In addition, grazing may be a valuable tool for controlling smooth brome invasion and maintaining native diversity in prairies, especially where circumstances make the use of fire difficult or undesirable (Service 2006, p. 2; Smart et al. 2013, pp. 685–686). Conversely, grazing may stimulate brome growth and reduce native plant diversity. Bison (Bison bison) grazed at least some Poweshiek skipperling habitats historically (McCabe 1981, p. 190; Bragg 1995, p. 68; Schlicht and Orwig 1998, pp. 4, 8; Trager et al. 2004, pp. 237–238), but cattle (Bos taurus) are now the principal grazing ungulate in both species' ranges. Bison and cattle both feed primarily on grass, but have some dissimilar effects on prairie habitats (Damhoureyeh and Hartnett 1997, pp. 1721–1725; Matlack et al. 2001, pp. 366–367). Cattle consume proportionally more grass and grasslike plants than bison, whereas bison consume more browse and forbs (flowering herbaceous plants) (Damhoureyeh and Hartnett 1997, p. 1719). Grasslands grazed by bison may also have greater plant species richness and spatial heterogeneity than those grazed by cattle (Towne et al. 2005, pp. 1553–1555). Both species remove forage for larvae (palatable grass tissue) and adults (nectar-bearing plant parts), change vegetation structure, trample larvae, and alter larval microhabitats.

Stressor: Haying and mowing
Exposure:
Response:
Consequence:

Narrative: Haying (mowing grasslands and removing the cuttings) may maintain habitat for the Poweshiek skipperling , but as with any management practice, appropriate timing, frequency, and intensity are important. Haying generally maintains prairie vegetation structure, but it may favor expansion of invasive species such as Kentucky bluegrass. If done during the adult flight period, haying may kill the adult butterflies or cause them to emigrate, and if done before or during the adult flight period, it may reduce nectar availability (McCabe 1979, pp. 19–20; McCabe 1981, p. 190; Dana 1983, p. 33; Royer and Marrone 1992a, p. 28; Royer and Marrone 1992b. p. 14; Swengel 1996, p. 79; Webster 2003, p. 10). Haying is a current and ongoing stressor of moderate to high level of impacts to Poweshiek skipperlings at the few sites where the site is normally hayed before August and where annual haying is reducing availability of larval food and adult nectar plants. However, fall haying is beneficial, specifically if it is conducted after the flight period (after August 1), no more than every other year, and there is no indication that native plant species diversity is declining due to timing or frequency of haying. Haying is a current stressor at a small number of sites.

Stressor: Lack of management/disturbance
Exposure:
Response:
Consequence:
Narrative: Prairies that lack periodic disturbance become unsuitable for Poweshiek skipperlings due to expansion of woody plant species (secondary succession), litter accumulation, reduced densities of adult nectar and larval food plants, or invasion by nonnative plant species (e.g., smooth brome) (McCabe 1981, p. 191; Dana 1983, p. 33; Dana 1997, p. 5; Higgins et al. 2000, p. 21; Skadsen 2003, p. 52).

Stressor: Demographics (population size and isolation)
Exposure:
Response:
Consequence:
Narrative: Small, isolated populations face a current and ongoing stressor of moderate to high severity. The stressor has a high impact to populations when isolation is combined with small habitat fragments or small populations; for example, where the population is too small to supplement nearby populations without adverse genetic consequences to the source population. Isolated populations occur throughout both species' entire ranges; only 4 of the 12 Poweshiek sites with present status are within the estimated maximum dispersal distance from one another. The small populations are subject to erosion of genetic variability leading to inbreeding, which lowers the ability of the species to adapt to environmental change. Small populations occur rangewide; for example, surveyors have counted fewer than 100 individuals in all but 4 Poweshiek skipperling sites in 2011, all but one site surveyed in 2012, and all sites surveyed in 2013.

Stressor: Herbicide and/or pesticide use
Exposure:
Response:

Consequence:
Narrative: Herbicide and pesticide use may have direct or indirect effects on Poweshiek skipperling. Although such activities occur, there is no evidence that these activities alone have significant impacts on either species, since their effects are often localized. However, these factors may have a cumulative effect on the Poweshiek skipperling when added to habitat curtailment and destruction because dramatic population declines have occurred.Invasive species and woody vegetation management helps to maintain prairie habitats and can also be beneficial to populations of both species, for example, when concentrated on affected areas through spot spraying. Ivermectin, a widely used and persistent veterinary pharmaceutical used to treat cattle, is a chemical of emerging concern to the Poweshiek skipperling. Ivermectin is an anthelmintic (drugs that are used to treat infections with parasitic worms) that is spread to prairie environments via the dung of grazing cattle (Lange et al. 2009, p. 2238). Lange et al. (2009, pp. 2234, 2238) found that skipper butterflies are particularly vulnerable to ivermectin, due to their low dispersive capacities and habitat preferences for soil. Pesticide sampling has been done at both occupied and previously occupied (but now unoccupied) sites in Michigan, Manitoba, Minnesota, and South Dakota (Warner and Grantham 2019, unpaginated; Runquist 2019, unpaginated). Researchers sampled for a suite of 214 pesticides in sedge leaves, grass leaves, duff, and floral nectar sources. Certain pesticides were detected at both Michigan and Manitoba sites at low concentration levels. In Michigan, a greater number of pesticides were detected at the now unoccupied sites than at the currently occupied sites. It is difficult to ascertain the impact of these low level pesticides on Poweshiek skipperlings because of limited research on Poweshiek skipperling or similar species. There are additional results pending. Landscape GIS analyses of Michigan Poweshiek skipperling sites and the areas upwind revealed that unoccupied sites were surrounded by more agriculture than currently occupied sites (52% agricultural foot print vs. 17%), although this trend was reversed at Manitoba sites (7% vs. 13%; Warner and Grantham 2019, unpaginated). The field skipper (Atalopedes campestris) is being used as a surrogate in toxicity studies to better understand the impacts of pesticides on Poweshiek skipperling (Runquist 2019, unpaginated). Additional work was also done with both the field skipper and the Dakota skipper (Hesperia dacotae) on the impacts of bifenthrin on survivorship, and results are forthcoming (Runquist 2019, unpaginated). (USFWS, 2019)

Recovery

Reclassification Criteria:
A minimum number of healthy populations of Poweshiek skipperling exist in each of the 4 conservation units (Figure 1) as specified in Table 1. 1: Southeastern Manitoba, Northwestern Minnesota, and Northeastern North Dakota. 6 Healthy Populations. 2: Southeastern North Dakota, Central and Southwestern Minnesota, Northeastern South Dakota, and Central and Northern Iowa. 23 Healthy Populations. 3: Southeastern Wisconsin and Northeastern Illinois. 2 Healthy Populations. 4: Michigan. 5 Healthy Populations (USFWS, 2022).

Delisting Criteria:
Criterion B1: Downlisting criteria have been met. Thirty-six populations distributed among the 4 Conservation Units, as described above (USFWS, 2022).

Criterion B2: Threats and causes of decline have been reduced or eliminated and mechanisms are in place that provide a high level of certainty that the downlisting criteria will continue to be met into the foreseeable future (USFWS, 2022).

Date of Recovery: If all actions are fully funded and implemented as outlined, including full cooperation of partners needed to achieve recovery, we anticipate delisting could be achieved as soon as 2072. Assuming the declines could be halted within the next 10 years, it would likely take at least another 30 years to reverse the decline and increase the numbers, followed by an additional 10 years to monitor the response of populations. Thus, we estimate that recovery could be accomplished in 50 years. We recognize, however, that it may take longer than this estimate to recover and delist the species. (USFWS, 2022).

Recovery Actions:

- Not addressed (see conservation measures)
- Habitat protection: Protection or restoration of habitat quality at these isolated sites is critical to the survival of this species, although stochastic events still pose some risk, especially for smaller populations and at small sites.
- Grazing BMPs: The level of impact of grazing to populations would be low if the dry/mesic slopes were grazed only before June 1 with at least one year of rest between rotations and if the pasture were only spot-sprayed with herbicides when and where necessary. Dakota skippers and Poweshiek skipperlings may benefit when prairie habitat is rested from grazing for at least a part of each growing season, if livestock are precluded from removing too much plant material (e.g., are moved when stubble heights are 6–8 in (15–20 cm) (Skadsen 2007, pers. comm.), and if the timing of grazing for each field varies from year to year (Skadsen 2007, pers. comm.). Britten and Glasford (2002, p. 373) recommended minimizing disturbance habitat during the flight period (late June to early July) to maximize genetically effective population sizes (the number of adults reproducing) to offset the effects of genetic drift of small populations (change in gene frequency over time due to random sampling or chance, rather than natural selection).
- Fire management: Burn habitat in early spring instead of late spring. An increase in purple coneflower, an important nectar source for Dakota skippers and Poweshiek skipperlings, may last for 1– 2 years after early spring fires, and females may preferentially oviposit near concentrations of this nectar source (Dana 2008, p. 20). Rotational burning may benefit prairie butterflies by increasing nectar plant density and by positively affecting soil temperature and near-surface humidity levels due to reductions in litter (Dana 1991, pp. 53–55; Murphy et al. 2005, p. 208; Dana 2008, p. 20). Fire presents a low level of impact to populations at sites where the species' habitat is divided into at least four burn units and no unit is burned more frequently than once every 4 years; or, the species' habitat is divided into three or more burn units, at least three units are burned no more frequently than once every 4 years, and the site contains more than 140 ha (346 ac) of native prairie or where the site is separated from another occupied site by less than 1 km (1.6 mi).
- Enforce regulations: Enforce Endangered Species Act protections; Lacey Act
- Perform research: Research on pesticides to determine significance as a threat; research on Wolbachia (disease) to determine significance as a threat

- 1. Manage, protect, and enhance populations including, but not limited to, the following: a. Augment existing populations through captive rearing techniques (for example, headstarting), in accordance with established controlled propagation policy (USFWS 2000), including genetics and disease considerations (for example, Smith et al. 2016). b. Restore key historical populations through reintroductions or translocations, (for example, using captive-bred individuals), in accordance with established controlled propagation policy and genetics plans. c. Develop and refine captive rearing collection, husbandry, and release techniques. d. Conduct research to understand biological and ecological, genetic, and life-history requisites to maintain or restore populations. Estimated cost: $19,500,000 (USFWS, 2022).
- 2. Manage, protect, and enhance habitat including, but not limited to, the following: a. Create and implement population-specific adaptive land management and protection plans. b. Maintain and enhance habitat at existing populations and at potential reintroduction sites. c. Create and implement best management practices across the range. d. Conduct land acquisition as needed to maintain or enhance existing and new populations. e. Monitor habitat restoration and refine management using adaptive management f. Conduct research to understand habitat requisites and management practices to maintain or restore populations. Estimated cost: $17,100,000 (USFWS, 2022).
- 3. Assess population and habitat status through monitoring and surveys including, but not limited to, the following: a. Develop and use rigorous standardized protocols to monitor population health, habitat, and threats at existing populations and future new populations. b. Conduct surveys at potential Poweshiek skipperling locations to document previously undetected but existing populations. c. Conduct research to improve the effectiveness of monitoring techniques. Estimated cost: $17,425,000 (USFWS, 2022).
- 4. Increase understanding of threats and alleviate threats into the foreseeable future including, but not limited to, the following: a. Research to determine the pesticide loads at extant sites and potential reintroduction sites and to determine the effects of pesticides on Poweshiek skipperling or an appropriate surrogate species. b. Research the effects of climate on the species and determine measures to alleviate those effects. c. Research the effects of pests, pathogens, and parasites and determine measures to alleviate those effects. d. Research the effects of interacting and emerging threats and determine measures to alleviate those effects. e. Implement informed practices to reduce the effects of threats. Estimated cost: $2,860,000 (USFWS, 2022).
- 5. Engage the public and partners in Poweshiek skipperling conservation including, but not limited to, the following: a. Develop outreach products to raise awareness and garner support for Poweshiek skipperling conservation at local and regional levels. b. Disseminate targeted outreach to relevant partners and communities. c. Integrate planning and coordination among recovery partners Estimated cost: $295,000 (USFWS, 2022).
- Estimated Cost of Delisting: The estimated costs associated with implementing rangewide recovery actions for delisting are $57,180,000. Cost estimates reflect costs for species actions needed to achieve Poweshiek skipperling recovery. Some costs for recovery actions are not determinable at this time, therefore, the total cost for recovery may be higher than this estimate (USFWS, 2022).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Due to the species highly imperiled status, the top priority is to increase the number of individuals at existing sites as quickly as possible (in order to maintain the remaining genetic diversity and to buffer against demographic stochasticity) and then increase the number of populations. Many of the below actions will contribute to those immediate-term goals. Continue research to better understand key life history traits of Poweshiek skipperling, including host plant preference, ideal growing conditions (e.g., humidity and temperature), and dispersal ability. Understand key sources of mortality, which may include natural enemies, pesticides, drought conditions, and management practices Continue to develop and refine the technology and protocols for head starting immature Poweshiek skipperling butterflies with partners for future reintroductions. Continue captive breeding trials using a surrogate species and develop breeding methods for Poweshiek skipperling. Maintain and increase suitable habitat for Poweshiek skipperling, including increasing habitat connectivity. Continue work on pesticide sampling, pesticide toxicity, and landscape-level analyses. Monitor invasive species and continue to investigate invasive species control measures. Prioritize sites for land acquisition and acquire suitable additional suitable habitat for Poweshiek skipperling. Identify and strategically implement new and current conservation actions. Determine what factors influence adult movement and Poweshiek skipperling responses to prairie fen management (burning, herbicide applications to control invasive plants), including what limits dispersal within portions of larger prairie fens. Conduct research to better understand hydrology at Poweshiek skipperling sites, including obtaining further information on groundwater flow and identification of recharge areas. Develop a recovery plan for the species. (USFWS, 2019).

- Conservation Work: Conservation work has been an active area for the Poweshiek skipperling over the past five years. Major activities that have taken place include: Ex Situ Feasibility Assessment and Planning Workshop to create an adaptive management framework for captive propagation work (Delphey et al. 2016, entire; Smith et al. 2016, entire). This plan has since been put into action and is in year 3 of the field season (see Captive Propagation Work section below). Captive Propagation Work: Implementation of the plan to head start Poweshiek skipperling began in 2016, with our first successful releases back to the wild occurring in 2018 (Smith et al. 2016). The head starting work at these zoos has not only provided adults to release back to their natal sites, but has also provided us important biological insights (see section 2.3.1.1 New information on the species' biology and life history). Habitat Acquisition: In 2018, Springfield Township (Michigan) was awarded Great Lakes Restoration Initiative (GLRI) grant money to partially fund the fee title purchase of approximately 55 acres of land from a willing seller, and associated land acquisition costs, for a critically important tract of land containing designated critical habitat and high quality wetland and upland areas adjacent to occupied Poweshiek skipperling habitat. This parcel has since been incorporated as part of Springfield Township's Shiawassee Basin Preserve. Habitat Restoration: In Michigan, within and around Poweshiek skipperling critical habitat, management over the past five years has included chemical and mechanical removal of invasive plants, including buckthorn, narrow leaved cattail, and phragmites. Burning has occurred at sites classified as potential and dispersal habitat (Losey 2017, unpaginated). Outreach: Outreach has focused on informing the public about the decline of the Poweshiek skipperling and increasing awareness and support for conservation activities, including captive propagation work and securing Poweshiek skipperling sites. Signage and closure of Poweshiek skipperling sites has occurred to deter photographers and butterfly collectors from disturbing a number of the sensitive Michigan sites. Funding: Partners have secured various sources of funds for Poweshiek skipperling conservation work, including but not limited to funds from Legislative-Citizen Commission on Minnesota Resources (LCCMR), GLRI, Association of Zoos andAquariums (AZA), USFWS station funds, and National Geographic Society's "Species on the Brink" fund.

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SPECIES ACCOUNT: *Polyphylla barbata* (Mount Hermon June beetle)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered, January 24, 1997 (62 FR 3616).

Physical Description

The Mount Hermon June beetle (Polyphylla barbata) adult male is a cryptic, small scarab beetle with a black head, dark blackish-brown elytra (thick leathery forewings) clothed with scattered long brown hair, and a striped body. The stripes are broken, often discontinuous, clumps of scales that still form identifiable lines. Females have a black head, chestnut-colored clypeus (plate on lower part of face) and elytra, and golden hairs on the head, thorax, and legs. It ranges from 20 to 22 millimeters in length (0.79 to 0.87 inch), with the females being generally slightly smaller than males (62 FR 3616; USFWS 2009).

Taxonomy

The Mount Hermon June beetle is a member of the family Scarabaeidae. It was first described by Cazier in 1938 from Mount Hermon, Santa Cruz County, California (62 FR 3616). The status of Polyphylla barbata as a full species was supported by Cazier in 1940 and again by Young in 1988, who recently made several nomenclature adjustments to the genus Polyphylla (lined June beetles), but retained P. barbata (USFWS 2009). Three other wide-ranging species of Polyphylla occur in the Ben Lomond-Mount Hermon-Scotts Valley area, and the Mount Hermon June beetle is distinguished from these three other species by the presence of relatively dense, long, erect hairs scattered randomly over the elytra, and short erect hairs on the pygidium (abdominal segment) (62 FR 3616; USFWS 2009).

Historical Range

Historically, the Mount Hermon June beetle is known only from the Zayante sand hills ecosystem in the Ben Lomond-Mount Hermon-Scotts Valley area of Santa Cruz County, California, in sand parkland and other sandy areas in chaparral and ponderosa pine (Pinus ponderosa) stands (USFWS 2009).

Current Range

The current range of the Mount Hermon June beetle is restricted to the Zayante sand hills habitat of the Ben Lomond-Mount Hermon-Scotts Valley area (USFWS 2009). Its estimated range is less than 100 to 250 square kilometers (less than about 40 to 100 square miles) (NatureServe 2015), and is primarily distributed over an area that is likely less than 25.9 square kilometers (10 square miles)(USFWS 2009).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: The larvae are strictly subterranean and feed on plant roots. Although larvae are generally considered to be grass and pine root feeders, the Mount Hermon June beetle also may feed on the roots of monkeyflower (Mimulus sp.), oak (Quercus sp.), fern (phylum Pteridophyta), and other plants found in the Zayante sand hills ecosystem, as well as subterranean stem material and fungal mycorrhizae (62 FR 3616; USFWS 2009).

Adult: Adults females live primarily underground; they emerge from burrows only to mate, and immediately return underground. It is likely, given their short lifespan and small mouth parts, that adult male Mount Hermon June beetles do not feed, focusing instead on reproduction. Adult female feeding behaviors are unknown (62 FR 3616; USFWS 2009).

Reproduction Narrative

Larvae: See adult life stage.

Adult: The Mount Hermon June beetle is believed to require about 2 to 3 years to mature from an egg through the adult form. However, data on the rate of growth of laboratory-reared larvae suggests that they may complete their life cycle within 1 year (62 FR 3616; USFWS 2009). Based on mark and recapture studies, adult males are believed to live no more than 1 week (USFWS 2009). Males emerge at dusk and are believed to locate females by tracking female pheromone signals during flight. This mechanism would ensure reproductive success in the limited time available for mating (62 FR 3616; USFWS 2009).

Geographic or Habitat Restraints or Barriers

Larvae: See adult life stage.

Adult: Mount Hermon June beetle occurs only in the Zayante sand hills ecosystem, which is sand parkland characterized by sparsely vegetated, sandstone-dominated ridges and saddles that support a wide array of annual and perennial herbs and grasses. Scattered ponderosa pine trees are often present. Although overall vegetation cover is generally less than 20 percent, sand parkland supports more than 90 specifically adapted plant species (62 FR 3616; USFWS 2009).

Spatial Arrangements of the Population

Larvae: See adult life stage.

Adult: Clumped according to resources.

Environmental Specificity

Larvae: See adult life stage.

Adult: Narrow/specialist.

Site Fidelity

Larvae: See adult life stage.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: None

Adult: None

Habitat Narrative

Larvae: See adult life stage.

Adult: Mount Hermon June beetle occurs in the Zayante sand hills ecosystem, which is sand parkland characterized by sparsely vegetated, sandstone-dominated ridges and saddles that support a wide array of annual and perennial herbs and grasses. Mount Hermon June beetle is still known to occur in low-quality sand parkland and sand chaparral habitat, which may consist of a continuous understory of grass. High-quality habitat often consists of scattered, widely spaced ponderosa pine trees (Pinus ponderosa) with a barren, open sand understory. Although overall vegetation cover is generally less than 20 percent, sand parkland supports more than 90 specifically natural-fire regime-adapted plant species. Loose, sandy soil is required by all life stages, and stabilized or compacted soils with high-organic material content are considered unsuitable to support Mount Hermon June beetle populations (USFWS 2009).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Low to moderate to high; males can fly (with reasonable potential for movement throughout all suitable habitat areas); females are flightless and emerge from burrows only to mate (62 FR 3616; USFWS 2009).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Larvae: The larval life stage lives in underground burrows, and has low motility and no ability to disperse (62 FR 3616; USFWS 2009.

Adult: It is unlikely that this species would disperse widely, because the flightless females cannot emigrate to isolated habitat areas where a new sub-population could be established. It is unknown how far females can disperse over land; they are restricted geographically to a relatively small area. Because males can fly, it may be assumed that they are primarily responsible for genetic mixing in the one known extant population (and historically among populations). Soils that are modified, compacted, or too isolated for females to recolonize by crawling are not likely to support persistent occupancy (62 FR 3616; USFWS 2009).

Additional Life History Information

Larvae: The larval life stage lives in underground burrows, and has low motility and no ability to disperse (62 FR 3616; USFWS 2009.

Adult: It is unknown how far females can disperse over land; they are restricted geographically to a relatively small area. Because males can fly, it may be assumed that they are primarily responsible for genetic mixing in the one known extant population and historically among populations (USFWS 2009).

Population Information and Trends

Population Trends:

Potentially stable to decreasing; limited study of monitored populations indicates that these populations may be stable in size, but efforts to restore degraded habitat have not been successful (USFWS 2009).

Species Trends:

Decreasing, assumed based on continued loss and alteration of habitat across the entirety of its range (USFWS 2009).

Number of Populations:

The Mount Hermon June beetle is limited to eight populations: Quail Hollow County Park; Quail Hollow Quarry area; the area between East Zayante Road, Olympia Wellfield, and Mount Hermon Road; the Mount Hermon area from just across Graham Hill Road in Henry Cowell State Park to Mount Hermon Road, and from the eastern side of the old Kaiser/Hanson Quarry almost to East Zayante Road on the western side; the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley; north of Quail Hollow County Park in the West Lompico area; Redwood Glen area, off Bean Creek Road in Scotts Valley; and private lands in the Bonny Doon area west of the Bonny Doon Ecological Reserve (USFWS 2009).

Population Size:

Population surveys of three monitored populations, conducted between 2000 and 2006, indicate stable population size, but the limited duration of monitoring efforts are insufficient to draw meaningful conclusions regarding population trends range-wide (USFWS 2009).

Resistance to Disease:

Unknown; not considered a threat at this time (USFWS 2009).

Adaptability:

Low

Additional Population-level Information:

This species is a narrow endemic, known to occur only in the Zayante sand hills ecosystem in Santa Cruz County, California (USFWS 2009).

Population Narrative:

The Mount Hermon June beetle is limited to eight populations: Quail Hollow County Park; Quail Hollow Quarry area; the area between East Zayante Road, Olympia Wellfield, and Mount Hermon Road; the Mount Hermon area from just across Graham Hill Road in Henry Cowell State Park to Mount Hermon Road, and from the eastern side of the old Kaiser/Hanson Quarry almost to East Zayante Road on the western side; the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley; north of Quail Hollow County Park in the West Lompico area; Redwood Glen area, off Bean Creek Road in Scotts Valley; and private lands in the Bonny Doon area west of the Bonny Doon Ecological Reserve. Population surveys were conducted between 2000 and 2006 at three populations: Quail Hollow Quarry, Hanson Quarry, and Freeman Mitigation Site. Results of these surveys suggest that populations are stable; however, population trends over only a few seasons cannot be considered accurate due to the normal, high-variation in population fluctuations that are characteristic of R-selected species. Additionally, the limited duration of monitoring efforts is insufficient to draw meaningful conclusions regarding population trends range-wide. A lack of consistent monitoring makes interpretation of population trends speculative. The most reliable measure is the amount of suitable habitat available. Threats to the Mount Hermon June beetle have likely resulted in declining population numbers. Sand parkland was reduced by 80 percent over 60 years, largely by sand mining; habitat conversion due to fire suppression is also a continuing threat. Under these conditions, extinction of the species could occur in as little as 50 years (USFWS 2009). In the 2009 5-year review (USFWS 2009, pp. 7–8), we reported that there were differing perspectives on the total number of occupied areas and/or populations of MHJB, and for the purposes of that review, we considered MHJB to be limited to eight general areas where populations were believed to persist. Currently, information indicates that MHJB are not limited to these core areas but occur or have potential to occur in any areas with a mosaic of Zayante and transitional soils throughout the sandhills area (McGraw et al. 2019, p. 2). Additionalsurveys are needed to accurately delineate species occurrence. (USFWS, 2021)

Threats and Stressors

Stressor: Sand mining
Exposure: Sand mining destroying or degrading habitat.
Response: Removal or destruction of habitat, injury, mortality, and reduced growth.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: At the time this species was listed, sand mining occurred on a large scale. Approximately 80 percent of the original 405 hectares (ha) (1,000 acres [ac.]) of sand parkland habitat has been altered, much due directly to sand mining. This destruction of limited habitat was the primary threat to the Mount Hermon June beetle. The majority of the mines have closed, and the ones still operating are covered under a Habitat Conservation Plan (HCP). The HCP covers 44.5 ha (110 ac.) of sandhills chaparral, sand parkland, and open sand parkland. Restoration efforts in sandhill parkland are yet unproven (USFWS 2009).

Stressor: Urban development
Exposure: Habitat is developed in to urban and other uses.
Response: Injury, mortality, reduced growth, and habitat removal and degradation.
Consequence: Habitat fragmentation.
Narrative: Residential housing development was another primary threat at the time of listing of Mount Hermon June beetle. Development has slowed, but is still present in four of the species' eight main population areas (USFWS 2009).

Stressor: Recreational use
Exposure: Pedestrian, vehicle, and horse traffic; sandboarding; and other soil-disturbing activities.
Response: Injury, mortality, reduced growth, and habitat removal and degradation.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Recreational use was considered an important threat at the time of listing, and continues to threaten the Mount Hermon June beetle. Fences and signs have been erected in the Quail Hollow County Park area; however, fences are often cut and local equestrians use the area, resulting in large quantities of erosion. Hikers, dog walkers, and sandboarders also use the Quail Hollow Quarry area despite signage (USFWS 2009).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Inadequate conservation measures.
Response: Injury, mortality, reduced growth, and habitat removal and degradation.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Existing regulatory mechanisms were not preventing continued habitat modification and fragmentation prior to listing. Sensitive Habitat Protections are being implemented by Santa Cruz County for the Mount Hermon June beetle. The county and the City of Scotts Valley are developing an HCP for the sandhills region; mitigation may be directed to the Zayante Hills Conservation Bank, where habitat will be preserved, enhanced, or restored (USFWS 2009).

Stressor: Fire suppression and forest/chaparral succession
Exposure: Fires are actively suppressed in the native, fire-adapted ecosystem, allowing for buildup of plant litter and establishment of nonnative, pioneering plant species. Manual litter removal methods may disrupt upper layers of soil.

Response: Injury, mortality, reduced growth, and habitat removal and degradation.
Consequence: Extirpation or reduction in population numbers, and decreased fitness.
Narrative: Fire suppression results in the loss of the natural fire cycle, which in turn results in unchecked vegetative succession and dramatic increases in average woody plant canopy cover. This is likely the most serious threat to the Mount Hermon June beetle at the present time. The sandhills vegetation communities are fire-adapted, and fire plays a major role in resetting soil succession. Fire largely prevents the permanent establishment of pioneering native plant species, and reduces establishment of nonnative, invasive species. Fire suppression in fire-adapted habitats allows rapid colonization of pioneering and nonnative species, and alters sandy soils by allowing leaf litter buildup. Soil alteration (changes to temperature and humidity of soil from altered canopy cover as well as manual methods of leaf-litter removal) may have a direct effect on Mount Hermon June beetle eggs, larvae, and adult survival. The habitat alteration also fragments or replaces the sandhill parkland habitat essential for this species (USFWS 2009).

Stressor: Habitat fragmentation
Exposure: Succession of sand parkland into dense chaparral.
Response: Lower likelihood of genetic exchange between population as distance and isolation increases.
Consequence: Decreased habitat, inbreeding depression, decrease in overall diversity, and increased vulnerability of populations to stochastic events.
Narrative: As succession continues, and core and parkland areas shrink, it is likely that further fragmentation of the habitat patches will occur. As the habitat shrinks, there is a corresponding increase in distance between patches. As the distance between patches increase, the likelihood of genetic exchange between patches decreases and the extinction rate of original species dependent on the habitat increases. The result of the effect is a decrease in overall diversity of the original species within the patch. Drivers of the effect may be any of a variety of factors such as: the eventual exclusion of critical resources, inbreeding depression, or a reduction in the population to a level where stochastic fluctuation make the potential for extinction increasingly likely. Since flight dispersal is limited, the possibility of fragmentation dividing population occurrences is a threat. The limitation on female dispersal also has implications for extinction events on individual habitat patches (USFWS 2009).

Recovery

Reclassification Criteria:
Interim downlisting criteria for Mount Hermon June beetle includes (USFWS 1998):

Securing the 28 known occurrence sites through fee-title acquisition, conservation easements, or HCPs for Graniterock Quarry, Kaiser Sand and Gravel Felton Plant, County of Santa Cruz, and the city of Scotts Valley.

Development and implementation of management plan for Quail Hollow Ranch County Park.

Population numbers are stable or increasing.

Delisting Criteria:

Delisting is considered feasible for this species with development and implementation of habitat protection and appropriate management actions. Specific delisting criteria have not been established for this species. Definitive delisting criteria will be developed for each species as more information becomes available on biology, range, and distribution through research and surveys. When the downlisting criteria have been met for a species, the species can be considered for delisting if threats are reduced or eliminated so that populations are capable of persisting without significant human intervention, or perpetual endowments are secured for management necessary to maintain the continued existence of the species (USFWS 1998).

Recovery Actions:

- Protect habitat for Santa Cruz Mountains species on private land through HCPs and landowner agreements (USFWS 1998)
- Manage habitat for Santa Cruz Mountains species (USFWS 1998).
- Conduct research on the life history, ecology, and population dynamics of these species that will contribute to appropriate management strategies (USFWS 1998).
- Locate additional habitat/populations within the historic range of the species (USFWS 1998).
- Develop and implement a public outreach program (USFWS 1998).
- Evaluate progress of recovery and effectiveness of management and recovery actions, and revise management plans (USFWS 1998).
- The recovery plan should be updated. Measurable recovery criteria should be included, and the current downlisting criteria should be clarified. Specifically, the sites listed for fee-title acquisition should be clearly identified so that they may be located and surveyed (USFWS 2009).
- Active management should be employed to prevent encroachment of both native and nonnative plant species in fire-suppressed areas that threaten habitat type conversion that may lead to extirpation of individual populations. Prescribed burns mimicking natural fire cycles may be used to create a habitat mosaic inclusive of persistent denuded areas (USFWS 2009).
- Surveys and monitoring should be undertaken for all known populations and potentially suitable habitat areas to ensure that all populations are identified, population trends are tracked, and reliable demographic information is collected (USFWS 2009).
- Genetic analysis should be undertaken to determine the relatedness of individuals from different populations (USFWS 2009).
- The Interim Programmatic HCP and eventually the Regional HCP should be completed. These plans will streamline permitting and conservation efforts and allow more effective use of the Zayante Hills Conservation Bank as a mitigation tool (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Identify specific sites needed for recovery and work to conserve these sites through fee-title acquisition, conservation easements, or Habitat Conservation Plans, including mediumpriority and high-priority parcels as defined in the recovery criteria for ZBWG and MHJB. 2. Undertake surveys and monitoring for all known populations and potential suitable habitat. Ensure all populations are identified and population trends are tracked.

Several areas of Zayante and transitional soils are present outside the “sandhills” area proper and should be investigated for presence of ZBWG and MHJB. Outreach to owners of private holdings with potential populations should be attempted and permission secured to survey where necessary. 3. Employ active management to prevent encroachment of both native and non-native plant species in fire suppression/exclusion areas threatened with habitat type conversion. Prescribed burns mimicking natural fire cycles may be used to create a habitat mosaic more suitable for ZBWG and MHJB. 4. Investigate and implement MHJB and ZBWG reintroductions/translocations into restored or potentially suitable areas. 5. Undertake genetic analyses to determine effective population size and gene flow between populations. Results may help identify and delineate areas in need of protection for meeting one of the interim downlisting criteria. 6. Continue working with partners to protect all areas that contain suitable habitat for the species. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Pseudocopaeodes eunus obscurus* (Carson wandering skipper)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; August 7, 2002.

Physical Description

The Carson wandering skipper is a small butterfly with a forewing of approximately 13 millimeters (0.51 inch [in.]) from base to apex. It is brownish orange in color, with a black terminal line and veins. It is believed to be one of five subspecies and can be distinguished from the others by its browner and less intensely orange dorsal surface, and thicker black coloring along the veins and outer margin. The bright yellow and orange ground color, especially on the ventral side, is interrupted by broadly darkened veins (USFWS 2006).

Taxonomy

The Carson wandering skipper can be distinguished from other subspecies by a combination of several characteristics. It is duller in color than other subspecies, with a tawny orange ground color and thick black coloring along the outer margin of the wings and especially on the ventral surface, along the veins.

Historical Range

The Carson wandering skipper can be found locally distributed within or near saltgrass dominated sites on alkaline substrates, generally withing larger salt-scrub communities, in northeastern California and northwestern Nevada, at elevations of less than 1,524 meters (5,000 feet). The Carson wandering skipper is generally found from the Carson River in Carson City and Douglas Counties, Nevada, north to the Honey Lake area in Lassen County, California. Currently there are three known, extant populations: Carson River, Carson City and Douglas Counties, Nevada; Warm Springs Valley, Washoe County, Nevada; and Honey Lake Valley, Lassen County, California. There are two known extirpated populations: Carson City, Carson City County, Nevada, and Spanish Springs Valley, Washoe County, Nevada. The subspecies likely represents a remnant of a more widely distributed complex of populations in the western Lahontan basin (Brussard et al. 1999). No information is available on historical population numbers of the Carson wandering skipper. It is possible that a fairly large population of the subspecies occurred from the vicinity of Carson Hot Springs, south to the Carson River, in Carson City and Douglas Counties. Outflow from the springs likely supported a water table high enough to support Distichlis spicata and a variety of nectar sources. Urban development, water diversions, and wetland manipulations have eliminated most of the habitat type in this area (Brussard 2000). Likewise, it is possible that more appropriate habitat once existed for the Carson wandering skipper between the existing populations in Lassen County, California, and Washoe County, Nevada (P. Brussard, pers. comm. 2001). Over time, habitat between these populations has become unsuitable and fragmented due to natural drying and human activities, and they may have become isolated from one another. The extant populations are spread across approximately 100 miles, and while the dispersal capability of the Carson wandering skipper is unknown, it is unlikely that genetic exchange currently occurs between populations. This is because skippers, in general, seldom fly far (Scott 1986).

Current Range

Currently there are three known, extant populations: Carson River, Carson City and Douglas Counties, Nevada; Warm Springs Valley, Washoe County, Nevada; and Honey Lake Valley, Lassen County, California. The extant populations are spread across approximately 100 miles, and while the dispersal capability of the CWS is unknown, it is unlikely that genetic exchange currently occurs between populations. The two extirpated populations fell within this existing 100 mile spread and thus opportunity for connectivity between the poplations has been further reduced. The three extant populations are found on a mix of ownership including, federal, state, local jurisdition, and private lands. The Warms Springs population is mostly found within an Area of Critical Environmental Concern established specifically for the species, on land managed by the Bureau of Land Management. Beyond that there are no lands with specific protections for the species. Carson River, Carson City and Douglas Counties, Site In 2004, a Carson wandering skipper population was found along the Carson River on BLM land (D. Murphy, in litt. 2004, R. Niell, in litt. 2004). This site, located in Carson Valley, is about 2 miles south of Carson City. Additional suitable habitat was confirmed to be occupied on adjacent City of Incline Village land and Northern Nevada Correctional Center land in 2011 (Sanford 2011). Nectar sources used by Carson wandering skipper at this site include Lotus corniculatus and Crepis runcinata (Sanford 2011). Distichlis spicata occurs throughout the habitat and is interspersed with an overstory of Artemisia sp. (sagebrush), Sarcobatus vermiculatus (greasewood), and Atriplex sp. (saltbush). Other attributes of this area suggest compatibility for Carson wandering skipper: there is an accumulation of salt on the soil surface in the area; the City of Incline Village land supports wetlands (R. Niell, in litt. 2004); and hot springs are located about 1.5 miles south of the site (U.S Fish and Wildlife Service 2007). Suitable habitat within these three properties totals approximately 125 acres (Sanford 2011). Warm Springs Valley, Washoe County, Sites # 1 and #2 This site was discovered in 1998 and included a combination of Bureau of Land Management (BLM) and private lands, divided almost evenly in area (Brussard et al. 1999). In 2005, 80 acres of the private property with the nectar site were acquired by the BLM through Southern Nevada Public Land Management Act (Public Law 105-263) funding (W. Devaurs, BLM, in litt. 2005). Because land management activities differed between the public and formerly private parcels, we distinguish between the two halves of site #1 (BLM and Private) when appropriate; however, at this time management between the sites is essentially the same. The nectar source Pyrrocoma racemosus is abundant throughout the site, as is Distichlis spicata. A small drainage way meanders through the site and springs are located within about 1 mile of the nectar areas (U.S. Fish and Wildlife Service 2007). This entire site is approximately 320 acres in size (U.S. Fish and Wildlife Service 2006). Lassen County Sites A 1970s Carson wandering skipper collection record exists for Lassen County, California, but the location details are described as vague (Brussard et al. 1999, P. Brussard, pers. comm. 2001). Specific locations were first documented in 1998 (Brussard et al. 1999) and extensive surveys were conducted around Honey Lake in 2004 and 2005 for the purposes of transferring ownership of Honey Lake (57,632 acres; lands below the legal high water mark) to the Center for Urban Watershed Renewal Honey Lake LLC, and subsequently to the State of California for natural resource conservation purposes. During these surveys, and others in the early 2000s (HLCT 2014), Carson wandering skipper were documented around the north, east, and southern shores of Honey Lake with some documented up to 2 miles from the lakeshore. These sites are generally broken into the following 6 areas: North Shore, East Shore, Cross Depot Access, Northern Shore Island, Western Shore Island, and Southern Shore Island. These six Carson wandering skipper areas generally correlate with the distribution of the subspecies' host plant, Distichlis spicata, around the Lake. Carson wandering skipper habitat is primarily located on the lakebed and wetlands on or adjacent to Honey Lake. Distichlis spicata stands are widely distributed along the shore of the lake, including its northern and eastern shores and along the periphery of The Island from the Cross Depot Access area on the eastern side to The Island to the northern tip of The Island extending south along the western shore of The Island and around the southern shore of The Island. The D. spicata distribution at Honey Lake is a general indicator of potential Carson wandering skipper habitat along with nectar sources and suitable microtopography. Distichlis spicata stands around Honey Lake vary from almost pure D. spicata monocultures to areas dominated by D. spicata with mixed communities of other grasses and herbaceous species. Due to seasonal and yearly fluctuations in water levels within and around Honey Lake, the extent of available habitat can change naturally over the course of weeks or years (HLCT 2014).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Carson wandering skipper larvae feed solely on succulent, green leaves of saltgrass (USFWS 2007).

Adult: Adult Carson wandering skippers rely on a variety of nectar sources (USFWS 2012).

Reproduction Narrative

Larvae: Not applicable.

Adult: After several instar stages, the pupae emerge as adults in May or June. The life span of an adult is 1 to 2 weeks, but they may live longer where abundant nectar sources exist. Carson wandering skippers produce only one brood per year during the June to mid-July flight season (USFWS 2006).

Geographic or Habitat Restraints or Barriers

Larvae: Urban development, water diversions, and wetland manipulations have eliminated most of the suitable habitat and caused habitat fragmentation. Greater than 5,000 elevation. Micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999).

Adult: Urban development, water diversions, and wetland manipulations have eliminated most of the suitable habitat and caused habitat fragmentation. Greater than 5,000 elevation. Micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999).

Spatial Arrangements of the Population

Larvae: Located east of the Sierra Nevada in northwestern Nevada and northeastern California at elevations of less than 1,524 m (5,000 ft.). The current distribution represents a remnant of a more widely distributed complex of populations in the western Lahontan Basin (USFWS 2012).

Adult: Located east of the Sierra Nevada in northwestern Nevada and northeastern California at elevations of less than 1,524 m (5,000 ft.). The current distribution represents a remnant of a more widely distributed population in the western Lahontan Basin (USFWS 2012).

Environmental Specificity

Larvae: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Egg: High

Larvae: High

Juvenile: High

Adult: The extant populations are spread across approximately 100 miles, and while the dispersal capability of the CWS is unknown, it is unlikely that genetic exchange currently occurs between populations. This is because skippers, in general, seldom fly far (Scott 1986).

Dependency on Other Individuals or Species for Habitat

Egg: Dependent on saltgrass

Larvae: Dependent on saltgrass for a larval food source and larval nest sites.

Adult: Dependent on the availability of abundant nectar sources and available saltgrass for egg laying.

Habitat Narrative

Egg: he habitat requirements of butterflies in general are quite straightforward. They include the presence of the proper larval hostplant; the appropriate environment for larval development, diapause, and adult mate location; and, usually, one or more nectar source species (flowers on which adult butterflies can feed). Suitable habitats for Carson wandering skipper are found within or near saltgrass dominated sites on alkaline substrates, generally withing larger salt-scrub communities. Necessary attributes include the larval hostplant, salt-grass, Distichlis spicata var. stricta, (Scott 1986), a common grass in wet, alkaline soils in this community, and a suitable nectar source (Brussard 2002). Based on observations of known, occupied sites, suitable habitat for the Carson wandering skipper in any given year has the following characteristics: elevation of less than 5,000 feet; located east of the Sierra Nevada; presence of green Distichlis spicata during March through June with a nectar source. Other characteristics may include open areas near springs or water; and possible geothermal activity (Brussard et al. 1999). There are no data in the literature on the micro-habitat requirements of the Carson wandering skipper (Brussard et al. 1999). However, it is likely that suitable larval habitat is related to the water table. Salt-grass usually occurs only where the free water table is high enough to keep its roots saturated for most of the year (West 1988). Many Distichlis spicata areas are inundated in the spring. During wet years, larval survival likely depends on D. spicata areas being above standing water. In dry years, survival is probably related to the timing of the host plant senescence. Therefore, micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999). Since the few historic collections of the Carson wandering skipper have been near hot springs, Brussard et al. (1999) suggests this subspecies may require the higher water table or ground temperatures associated with these areas to provide the appropriate temperatures for successful larval development. However, some Carson wandering skipper sites are not located in immediate vicinity of geothermal springs, but several are. Larval development may not rely on specific temperatures but rather on the presence of good quality D. spicata provided by more permanent water source, or some other attribute correlated with geothermal resources. Adult Carson wandering skipper require nectar for food. For a Distichlis spicata area to be appropriate habitat for the Carson wandering skipper, an appropriate nectar source must be present and in bloom during the flight season. Few plants that can serve as nectar sources grow in the highly alkaline soils occupied by D. spicata. Plant species known to be used by the Carson wandering skipper for nectar include Crepis runcinata (fiddleleaf hawksbeard), Thelypodium crispum (crisped thelypody), Sisymbrium altissimum (tumble mustard), Pyrrocoma racemosus (racemose golden-weed), Cirsium arvense (Canada thistle), C. vulgare (bull thistle), Lotus corniculatus, Cleomella parviflora (small-flowered cleomella), C. plocasperma (twisted cleomella), Cressa truxillensis (spreading alkaliweed), Heliotropium curassavicum (heliotrope), Potentilla sp. (cinquefoil), Astragalus douglasii (Douglas's milkvetch), Malvella leprosa (alkali mallow), and Sesuvium verrucosum (western sea-purslane) (Brussard et al. 1999, R. Niell, University of Nevada, Reno, in litt. 2003, D. Murphy, University of Nevada, Reno, pers. comm. 2004, Honey

Lake Conservation Team (HLCT) 2007, HLCT 2009, Sanford 2011, U.S. Fish and Wildlife Service 2012). If alkaline-tolerant plant species are not present but there is a fresh-water source to support alkaline-intolerant nectar sources adjacent to the larval host plant, the area may provide suitable habitat (Brussard et al. 1999). Nectar sources depend on various environmental conditions and are likely to be transitory. Thus, nectar sites used by the Carson wandering skipper may change from year to year.

Larvae: The habitat requirements of butterflies in general are quite straightforward. They include the presence of the proper larval hostplant; the appropriate environment for larval development, diapause, and adult mate location; and, usually, one or more nectar source species (flowers on which adult butterflies can feed). Suitable habitats for Carson wandering skipper are found within or near saltgrass dominated sites on alkaline substrates, generally withing larger salt-scrub communities. Necessary attributes include the larval hostplant, salt-grass, Distichlis spicata var. stricta, (Scott 1986), a common grass in wet, alkaline soils in this community, and a suitable nectar source (Brussard 2002).   Based on observations of known, occupied sites, suitable habitat for the Carson wandering skipper in any given year has the following characteristics: elevation of less than 5,000 feet; located east of the Sierra Nevada; presence of green Distichlis spicata during March through June with a nectar source. Other characteristics may include open areas near springs or water; and possible geothermal activity (Brussard et al. 1999).   There are no data in the literature on the micro-habitat requirements of the Carson wandering skipper (Brussard et al. 1999). However, it is likely that suitable larval habitat is related to the water table. Salt-grass usually occurs only where the free water table is high enough to keep its roots saturated for most of the year (West 1988). Many Distichlis spicata areas are inundated in the spring. During wet years, larval survival likely depends on D. spicata areas being above standing water. In dry years, survival is probably related to the timing of the host plant senescence. Therefore, micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999). Since the few historic collections of the Carson wandering skipper have been near hot springs, Brussard et al. (1999) suggests this subspecies may require the higher water table or ground temperatures associated with these areas to provide the appropriate temperatures for successful larval development. However, some Carson wandering skipper sites are not located in immediate vicinity of geothermal springs, but several are. Larval development may not rely on specific temperatures but rather on the presence of good quality D. spicata provided by more permanent water source, or some other attribute correlated with geothermal resources.   Adult Carson wandering skipper require nectar for food. For a Distichlis spicata area to be appropriate habitat for the Carson wandering skipper, an appropriate nectar source must be present and in bloom during the flight season. Few plants that can serve as nectar sources grow in the highly alkaline soils occupied by D. spicata. Plant species known to be used by the Carson wandering skipper for nectar include Crepis runcinata (fiddleleaf hawksbeard), Thelypodium crispum (crisped thelypody), Sisymbrium altissimum (tumble mustard), Pyrrocoma racemosus (racemose golden-weed), Cirsium arvense (Canada thistle), C. vulgare (bull thistle), Lotus corniculatus, Cleomella parviflora (small-flowered cleomella), C. plocasperma (twisted cleomella), Cressa truxillensis (spreading alkaliweed), Heliotropium curassavicum (heliotrope), Potentilla sp. (cinquefoil), Astragalus douglasii (Douglas's milkvetch), Malvella leprosa (alkali mallow), and

Sesuvium verrucosum (western sea-purslane) (Brussard et al. 1999, R. Niell, University of Nevada, Reno, in litt. 2003, D. Murphy, University of Nevada, Reno, pers. comm. 2004, Honey Lake Conservation Team (HLCT) 2007, HLCT 2009, Sanford 2011, U.S. Fish and Wildlife Service 2012). If alkaline-tolerant plant species are not present but there is a fresh-water source to support alkaline-intolerant nectar sources adjacent to the larval host plant, the area may provide suitable habitat (Brussard et al. 1999). Nectar sources depend on various environmental conditions and are likely to be transitory. Thus, nectar sites used by the Carson wandering skipper may change from year to year.

Juvenile: The habitat requirements of butterflies in general are quite straightforward. They include the presence of the proper larval hostplant; the appropriate environment for larval development, diapause, and adult mate location; and, usually, one or more nectar source species (flowers on which adult butterflies can feed). Suitable habitats for Carson wandering skipper are found within or near saltgrass dominated sites on alkaline substrates, generally withing larger salt-scrub communities. Necessary attributes include the larval hostplant, salt-grass, Distichlis spicata var. stricta, (Scott 1986), a common grass in wet, alkaline soils in this community, and a suitable nectar source (Brussard 2002). Based on observations of known, occupied sites, suitable habitat for the Carson wandering skipper in any given year has the following characteristics: elevation of less than 5,000 feet; located east of the Sierra Nevada; presence of green Distichlis spicata during March through June with a nectar source. Other characteristics may include open areas near springs or water; and possible geothermal activity (Brussard et al. 1999). There are no data in the literature on the micro-habitat requirements of the Carson wandering skipper (Brussard et al. 1999). However, it is likely that suitable larval habitat is related to the water table. Salt-grass usually occurs only where the free water table is high enough to keep its roots saturated for most of the year (West 1988). Many Distichlis spicata areas are inundated in the spring. During wet years, larval survival likely depends on D. spicata areas being above standing water. In dry years, survival is probably related to the timing of the host plant senescence. Therefore, micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999). Since the few historic collections of the Carson wandering skipper have been near hot springs, Brussard et al. (1999) suggests this subspecies may require the higher water table or ground temperatures associated with these areas to provide the appropriate temperatures for successful larval development. However, some Carson wandering skipper sites are not located in immediate vicinity of geothermal springs, but several are. Larval development may not rely on specific temperatures but rather on the presence of good quality D. spicata provided by more permanent water source, or some other attribute correlated with geothermal resources. Adult Carson wandering skipper require nectar for food. For a Distichlis spicata area to be appropriate habitat for the Carson wandering skipper, an appropriate nectar source must be present and in bloom during the flight season. Few plants that can serve as nectar sources grow in the highly alkaline soils occupied by D. spicata. Plant species known to be used by the Carson wandering skipper for nectar include Crepis runcinata (fiddleleaf hawksbeard), Thelypodium crispum (crisped thelypody), Sisymbrium altissimum (tumble mustard), Pyrrocoma racemosus (racemose golden-weed), Cirsium arvense (Canada thistle), C. vulgare (bull thistle), Lotus corniculatus, Cleomella parviflora (small-flowered cleomella), C. plocasperma (twisted cleomella), Cressa truxillensis (spreading alkaliweed), Heliotropium curassavicum (heliotrope), Potentilla sp. (cinquefoil), Astragalus douglasii (Douglas's milkvetch), Malvella leprosa (alkali mallow), and Sesuvium verrucosum (western sea-purslane) (Brussard et al. 1999, R. Niell, University of Nevada, Reno, in litt. 2003, D. Murphy, University of Nevada, Reno, pers. comm. 2004, Honey Lake Conservation Team (HLCT) 2007, HLCT 2009, Sanford 2011, U.S. Fish and Wildlife Service 2012). If alkaline-tolerant plant species are not present but there is a fresh-water source to support alkaline-intolerant nectar sources adjacent to the larval host plant, the area may provide suitable habitat (Brussard et al. 1999). Nectar sources depend on various environmental conditions and are likely to be transitory. Thus, nectar sites used by the Carson wandering skipper may change from year to year.

Adult: The habitat requirements of butterflies in general are quite straightforward. They include the presence of the proper larval hostplant; the appropriate environment for larval development, diapause, and adult mate location; and, usually, one or more nectar source species (flowers on which adult butterflies can feed). Suitable habitats for Carson wandering skipper are found within or near saltgrass dominated sites on alkaline substrates, generally withing larger salt-scrub communities. Necessary attributes include the larval hostplant, salt-grass, Distichlis spicata var. stricta, (Scott 1986), a common grass in wet, alkaline soils in this community, and a suitable nectar source (Brussard 2002). Based on observations of known, occupied sites, suitable habitat for the Carson wandering skipper in any given year has the following characteristics: elevation of less than 5,000 feet; located east of the Sierra Nevada; presence of green Distichlis spicata during March through June with a nectar source. Other characteristics may include open areas near springs or water; and possible geothermal activity (Brussard et al. 1999). There are no data in the literature on the micro-habitat requirements of the Carson wandering skipper (Brussard et al. 1999). However, it is likely that suitable larval habitat is related to the water table. Salt-grass usually occurs only where the free water table is high enough to keep its roots saturated for most of the year (West 1988). Many Distichlis spicata areas are inundated in the spring. During wet years, larval survival likely depends on D. spicata areas being above standing water. In dry years, survival is probably related to the timing of the host plant senescence. Therefore, micro-topographic variation is probably important for larval survival because it provides a greater variety of appropriate habitat over time (Brussard et al. 1999). Since the few historic collections of the Carson wandering skipper have been near hot springs, Brussard et al. (1999) suggests this subspecies may require the higher water table or ground temperatures associated with these areas to provide the appropriate temperatures for successful larval development. However, some Carson wandering skipper sites are not located in immediate vicinity of geothermal springs, but several are. Larval development may not rely on specific temperatures but rather on the presence of good quality D. spicata provided by more permanent water source, or some other attribute correlated with geothermal resources. Adult Carson wandering skipper require nectar for food. For a Distichlis spicata area to be appropriate habitat for the Carson wandering skipper, an appropriate nectar source must be present and in bloom during the flight season. Few plants that can serve as nectar sources grow in the highly alkaline soils occupied by D. spicata. Plant species known to be used by the Carson wandering skipper for nectar include Crepis runcinata (fiddleleaf hawksbeard), Thelypodium crispum (crisped thelypody), Sisymbrium altissimum (tumble mustard), Pyrrocoma racemosus (racemose golden-weed), Cirsium arvense (Canada thistle), C. vulgare (bull thistle), Lotus corniculatus, Cleomella parviflora (small-flowered cleomella), C. plocasperma (twisted cleomella), Cressa truxillensis (spreading alkaliweed), Heliotropium curassavicum (heliotrope), Potentilla sp. (cinquefoil), Astragalus douglasii (Douglas's milkvetch), Malvella leprosa (alkali mallow), and Sesuvium verrucosum (western sea-purslane) (Brussard et al. 1999, R. Niell, University of Nevada, Reno, in litt. 2003, D. Murphy, University of Nevada, Reno, pers. comm. 2004, Honey Lake Conservation Team (HLCT) 2007, HLCT 2009, Sanford 2011, U.S. Fish and Wildlife Service 2012). If alkaline-tolerant plant species are not present but there is a fresh-water source to support alkaline-intolerant nectar sources adjacent to the larval host plant, the area may provide suitable habitat (Brussard et al. 1999). Nectar sources depend on various environmental conditions and are likely to be transitory. Thus, nectar sites used by the Carson wandering skipper may change from year to year.

Dispersal/Migration

Motility/Mobility

Larvae: Low

Juvenile: None

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Not applicable.

Adult: Nonmigratory

Dispersal

Larvae: Not applicable.

Adult: The extant populations are spread across approximately 100 miles, and while the dispersal capability of the CWS is unknown, it is unlikely that genetic exchange currently occurs between populations. This is because skippers, in general, seldom fly far (Scott 1986).

Immigration/Emigration

Larvae: No information available.

Adult: No information available.

Dependency on Other Individuals or Species for Dispersal

Larvae: Not applicable.

Adult: Not applicable.

Dispersal/Migration Narrative

Larvae: Not applicable.

Adult: The extent of dispersal is likely limited due to increasingly unsuitable and fragmented habitat across the species range (USFWS 2012).

Additional Life History Information

Larvae: Not applicable.

Adult: Although the dispersal capability of the Carson wandering skipper is unknown, it is unlikely that any current genetic exchange occurs between the remaining populations because skippers, in general, seldom fly far.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

While trend in the data available is not clear, numbers suggest that populations are stable or decreasing, not increasing.

Number of Populations:

Currently there are three known, extant populations: Carson River, Carson City and Douglas Counties, Nevada; Warm Springs Valley, Washoe County, Nevada; and Honey Lake Valley, Lassen County, California. There are two known extirpated populations: Carson City, Carson City County, Nevada, and Spanish Springs Valley, Washoe County, Nevada. Extirpation of the Carson City site was found to occur around 1998 and the Spanish Springs site by 2015.

Population Size:

Portions of the Carson River site have been surveyed between 2016 and 2020 with 22 to 86 individuals seen over the course of each season (Haworth 2016b, Haworth 2017, Haworth et al. 2019, Enders et al. 2018, Enders et al. 2020). Prior to 2016, surveys were inconsistent and incomplete, but CWS were detected most years (R. Niell, in litt. 2004, Haworth and Funari 2005a, Haworth 2007a, M. Sanford, University of Nevada, Reno, in litt. 2009, Sanford 2011, Sanford 2012, M. Haworth, U.S. Fish and Wildlife Service 2016). The Warm Springs Valley site has been surveyed consistently since 2011 with 23 to 137 individuals seen over the course of a season (Haworth, 2012; Haworth, 2013; Haworth, 2014; Haworth, 2015; Haworth, 2016a; Haworth, data 2017; Haworth et al. 2019, Enders et al. 2018, Enders et al. 2020). Prior to 2011 surveys were inconsistent and incomplete, but CWS were detected most years (V. Rivers, Truckee Meadows Community College, pers. comm. 2001a; Haworth et al. 2002; Haworth and Devaurs 2003;

Haworth and Funari 2004; Haworth and Funari, 2005b; Haworth 2006; Haworth, 2007b; Haworth, 2008; Haworth, 2009; J. Levy, consultant, in litt. 2009; Haworth and Ziegler 2010; Haworth et al. 2011). The Carson wandering skipper found across the Lassen County sites may be comprised of one large population rather than a metapopulation. Further research is needed to determine the population structure in this area. Table 1 presents results for surveys conducted between 2004 and 2008 as these years have the most comprehensive survey data for the Lassen County sites. Since 2008, few consistent surveys have occurred, but some CWS have been detected most years when surveyed (Yssel Environmental Services 2011, Schrag 2012, Yssel Environmental Services 2012, Haworth and Nelson 2017, Enders et al. 2018, Enders et al. 2020). However these more recent surveys have not found nearly the numbers in the 2004 to 2008 period but it is unclear if that is due to level of effort. Table 1. 2004-2008 CWS Population Distribution and Abundance at Honey Lake Number of CWS Observed (Adapted from Table 4-4 HLCT 2014). Location 2004 2005 2006 2007 2008 North Shore 27 115 61 32 89 East Shore 343 611 437 634 537 Cross Depot Access 21 5 10 29 6 Northern Shore Island 79 39 55 152 44 Western Shore Island 10 4 9 92 126 Southern Shore Island 0 3 45 120 59 Totals 480 777 617 1,059 861 Extirpated Populations Carson City, Carson City County, formerly Ormsby County, Site The Carson wandering skipper was first collected in 1965 at a location north of U.S. Highway 50, Carson City, Nevada. This is the type locality for the subspecies. Habitat at this site has been greatly modified, fragmented, or eliminated over time from drainage manipulations for residential and commercial development, and from construction of Interstate 580. These impacts resulted in extirpation of the subspecies at this site by 1998 (U.S. Fish and Wildlife Service 2012). Spanish Springs Valley, Washoe County, Sites #1 and #2 This population was found in 2004. A habitat conservation plan for the Carson wandering skipper was developed in 2005 to address and mitigate the loss of 39 acres of habitat at site #1 (Lionel Sawyer & Collins 2005). An off-site mitigation area of 39 acres was acquired by the developers to mitigate for this loss. Habitat at this site #1 has been greatly modified or eliminated over time from the impacts of residential and commercial development. Site #2 located adjacent to site #1 was determined to be extirpated in 2015 (U.S. Fish and Wildlife Service. 2016).

Minimum Viable Population Size:

No information available.

Resistance to Disease:

No information available.

Adaptability:

No information available.

Additional Population-level Information:

Not applicable.

Population Narrative:

The CWS is generally found from the Carson River in Carson City and Douglas Counties, Nevada, north to the Honey Lake area in Lassen County, California. The subspecies likely represents a remnant of a more widely distributed complex of populations in the western Lahontan basin (Brussard et al. 1999). No information is available on historical population numbers of the CWS. It is possible that a fairly large population of the subspecies occurred from the vicinity of Carson Hot Springs, south to the Carson River, in Carson City and Douglas Counties. Outflow from the springs likely supported a water table high enough to support Distichlis spicata and a variety of nectar sources. Urban development, water diversions, and wetland manipulations have eliminated most of the habitat type in this area (Brussard 2000). Currently there are three known, extant populations: Carson River, Carson City and Douglas Counties, Nevada; Warm Springs Valley, Washoe County, Nevada; and Honey Lake Valley, Lassen County, California. There are two known extirpated populations: Carson City, Carson City County, Nevada, and Spanish Springs Valley, Washoe County, Nevada. Extirpation of the Carson City site was found to occur around 1998 and the Spanish Springs site by 2015. Population surveys have been conducted on the three extant populations, however trend at these populations are unclear due to wide variablity in yearly observations.

Threats and Stressors

Stressor: Habitat degradation and destruction - urban and residential development
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Urban and residential development can destroy Carson wandering skipper habitat by directly converting existing habitat to developed lands, such as the case at the two extirpated populations. Development can further degrade habitat through indirect impacts, such as changes to hydrology (surface and groundwater patterns and availability), increase in invasive plant species, changes to micro climate.

Stressor: Habitat degradation and destruction - irrigation, groundwater withdrawal and diversion/modification projects
Exposure:
Response:
Consequence:
Narrative: Any projects that effect the hydrology in the vicinity of Carson wandering skipper habitat could impact the species if those changes in hydrology affect the saltgrass and nectar sources that support the Carson wandering skipper. If the groundwater table is lowered or raised, surface water patterns/availability modified and these changes affect the salt grass community and plant composition, tbe Carson wandering skipper may be impacted. Examples include wetland modifications for water fowl management or mitigation, groundwater exportation projects, increase in number of domestic wells, development of wastewater treatment facilities, geothermal energy exploration or production, irrigation/ agricultural water use impacts to availability of surface and groundwater and patterns of surface water flow.

Stressor: Habitat degradation and destruction - Invasive plant species
Exposure:
Response:
Consequence:
Narrative: The invasion of non-native plant species specifically, but not limited to tall whitetop (Lepidium latifolium), is a threat to the Carson wandering skipper and its habitat. Tall whitetop is an aggressive invader that displaces other vegetation and can form monotypic stands (an area comprised of one species), decreasing biodiversity, and degrading wildlife habitat as well as reducing the value of agricultural lands (Young et al. 1995; Donaldson and Johnson 1999; Krueger and Sheley 1999; Howard 2000). The species is known to grow in alkaline soils (Hickman 1993; Young et al. 1995; Howard 2000) but is not restricted to them. Tall whitetop can invade disturbed and undisturbed sites including roadsides, agricultural fields, pastures, riparian areas, alkaline wetlands, natural areas, and irrigation canals (Donaldson and Johnson 1999; Howard 2000). It has become widely established in Lassen County and is found in Honey Lake Valley, California (Howard 2000). We are concerned that tall whitetop will displace the Carson wandering skipper's nectar source at the Lassen County site. We are also concerned that tall whitetop may displace salt grass, the Carson wandering skipper's larval host plant. According to Young et al. (1998), infestation areas, once well established, rarely contain other plant species. Tall whitetop is present within all three populations.

Stressor: Habitat degradation and destruction - Agriculture – type conversion
Exposure:
Response:
Consequence:
Narrative: The greatest threat and significant impact to the CWS at Honey Lake has been from the conversion of its habitat to primarily agricultural land uses such as hayfields, alfalfa, row and seed crops. Almost all of the Sagebrush Steppe Association on the northern and western sides adjoining Honey Lake has been converted to agriculture. Agricultural practices that have converted native vegetation to hay fields have probably reduced the populations of saltgrass, salt heliotrope and sea purslane along the lake’s margin, although exact acreages cannot be determined since historic baseline conditions were not mapped (HLCT 2014).

Stressor: Habitat degradation and destruction -Pesticide/Herbicides/Insecticides
Exposure:
Response:
Consequence:
Narrative: Direct application of pesticides that are lethal to lepidoptera at any life stage to Carson wandering habitat is a threat to the species. Mormon cricket (Anabrus simplex) infestations are common across the range of the Carson wandering skipper. Two main treatments, a ground bait (apple-based carbaryl) and an insect growth regulator (Dimilin, which is an aerial spray) have been used to control the crickets in the past. Carbaryl bait is severely toxic to most terrestrial invertebrates if ingested. Carbaryl incorporated into bran flakes or other solid media acts only upon ingestion by the organism and is considered to be more selective than other chemical control methods. The ULV form Dimilin® is highly toxic to most terrestrial invertebrate larvae.

Direct effects of the ULV application of Dimilin® to invertebrate larvae are increased due to the limited mobility to move out of the treated area during larval stages. The aerial spray is not toxic to mammals but treated invertebrates are affected and die after their next molt. It is possible that if infestations are left unchecked, crickets could possibly feed on the nectar source plants that the CWS are dependent upon (USDA, 2005). The use of pesticides for agricultural needs adjacent to the Carson wandering skipper habitat could be a potential threat if pesticide drift occurred because of the proximity of the agricultural fields to the species' habitat across its range (USFWS 2002).

Stressor: Habitat degradation and destruction - Livestock and wildhorse grazing
Exposure:
Response:
Consequence:
Narrative: We recognize that different grazing intensities and management practices can impact areas differently, and potential for impacts at each site must be evaluated independently based on site characteristics and grazing management practices. Livestock grazing can impact: (1) Species composition of communities by decreasing the density and biomass of species, reducing species richness, and changing community organization; (2) ecosystem function including the disruption of nutrient cycling and succession; and (3) ecosystem structure including altering vegetation stratification, contributing to soil erosion and reducing the availability of water to biotic communities (Fleischner 1994), Hutchinson and King (1980) found abundance and biomass of invertebrates (including butterflies (Lepidoptera)) were reduced (with the exception of ants (Hymenoptera)) with increases in sheep numbers. Excessive grazing that reduces the availability of salt grass for Carson wandering skipper larvae and availability of nectar sources for the adults is considered a threat. Grazing that results in trampling of the larvae is also considered a threat (USFWS 2002). Moderate winter grazing by livestock may not necessarily impact populations negatively (Brussard et al. 1999) Livestock operators have introduced birdfoot trefoil into the western U.S., as a source of additional forage for cattle. The introduction of birdfoot trefoil has provided the CWS another nectar source to utilize partially compensating for the effects of over-grazing in its habitat (HLCT 2014).

Stressor: Habitat degradation and destruction - Recreation
Exposure:
Response:
Consequence:
Narrative: Driving off-road vehicles (ORVs) and All-Terrain Vehicles (ATVs) within CWS habitat has the potential to destroy habitat by crushing host and nectar plants, as well as larvae. While saltgrass can withstand some pressure, high levels of recreational use can result in surface impacts that remove vegetation (USFWS 2002, HLCT 2014).

Stressor: Habitat Fragmentation
Exposure:
Response:
Consequence:

Narrative: Habitat loss from any of the above threats that degrade or destroy habitat will result in further fragmentation at the local or range-wide scale. In the case of the CWS, its populations may have historically been discontinuous or were patchily distributed (remnants), so the species was already geographically isolated (Sanford, 2006). Unless fragmentation serves to disrupt patterns of migration among the populations of CWS that remain, it may have somewhat diminished effect than fragmentation would have on butterfly species that exhibit a continuous distribution pattern (HLCT 2014). One of the persistent results of fragmentation is that remaining habitat patches may effectively be smaller than they seem, leading to greater population instability and the narrowing of the gene pool for a given species (Baur and Braschle, 2004). Perhaps the greatest potential effect of habitat fragmentation, particularly for butterfly species, is the loss of genetic variability and population density that attends either the loss of habitat area (Krauss et al., 2003), or increasing habitat isolation (Rickets et al., 2001). Continued habitat fragmentation is a substantial concern for the future of CWS, given the extreme isolation of its habitat and the narrow patches of habitat across its remaining populations (HLCT 2014).

Stressor: Narrow ranging species with few and small populations
Exposure:
Response:
Consequence:
Narrative: The apparent low numbers of the Carson wandering skipper make it vulnerable to risks associated with small, restricted populations (Shaffer 1981, 1987; Groom et al. 2006). Because the Carson wandering skipper occurs at only three known isolated locations and in fairly small numbers, this subspecies is susceptible to extinction as a result of naturally occurring stochastic environmental or demographic events. These events could include wildfire, disease or predation, and severe weather events such as flooding. Random demographic effects (such as skewed sex ratios) and loss of genetic variability also may result in individuals and populations being less able to cope with environmental change, and could cause the loss of one or more populations. In addition, the loss of habitat compromises the ability of the Carson wandering skipper to disperse. Populations remain isolated with no opportunity to migrate or recolonize if conditions become unfavorable (USFWS 2012).

Recovery

Reclassification Criteria:
The population in Nevada must have been occupied for 6 years out of the most recent 10-year sequence with no downward trend in abundance. In California, suitable habitat patches equivalent to 50 percent or more of the currently known suitable habitat must be managed to address threats, and each of these habitat patches must have been occupied for 6 years out of the most recent 10-year sequence with no downward trend in abundance across the population.

Adaptive management plans must address appropriate management for the Carson wandering skipper with regard to habitat and land uses that may affect quality, including but not limited to development (urban, residential, water, gas, and geothermal), livestock grazing, recreation, invasive plant control, pesticide use, and public education.

No information available.
No information available.
No information available.
No information available.

Delisting Criteria:
Each population in Nevada must have been occupied for 6 years out of the most recent 10-year sequence after down listing criteria are met, with no downward trend in abundance. In California, suitable habitat patches equivalent to 75 percent or more of the currently known suitable habitat patches must be managed to effectively address threats, and each of these habitat patches must have been occupied for 6 years out of the most recent 10-year sequence after down listing criteria are met, with no downward trend in abundance across the population/metapopulation. Appropriate landscape connectivity must exist among patches (i.e., land use between most sites is considered open space and not urban or suburban), to potentially facilitate movement of the Carson wandering skipper among patches.

Adaptive management plans have been developed and implemented with adequate long-term funding, either individually or comprehensively, for the three populations in delisting criterion #1. These plans must address appropriate management for the Carson wandering skipper with regard to habitat and land uses that may affect habitat quality, including but not limited to development (urban, residential, water, gas, and geothermal), livestock grazing, recreation, invasive plant control, pesticide use, and public education.

In addition to the populations in delisting criterion #1, for at least one additional Carson wandering skipper population or metapopulation—including a known population or any that may be discovered or established within Carson wandering skipper historical range—management has been established in perpetuity to effectively address threats to the species and ensure persistence of the population, unless we conclude (through intensive, comprehensive surveying) that additional populations or metapopulations do not exist, and it would not be ecologically feasible to establish/reestablish one or more of them within Carson wandering skipper's historical range.

Lepidium latifolium invasion into known and presumed suitable habitat for the Carson wandering skipper has been eliminated, or reduced and managed to levels that do not pose a threat to the persistence of the Carson wandering skipper.

A long-term conservation plan and conservation agreements have been developed to guide management throughout the range of the Carson wandering skipper after it has been delisted.

A monitoring plan to cover a minimum of 5 years post-delisting of the Carson wandering skipper has been developed, and is ready to be implemented to ensure the ongoing conservation of the species and the continuing effectiveness of management actions.

Recovery Actions:

- Manage existing populations and essential habitat on public and private lands to minimize threats.
- Establish a research program to determine the ecological requirements and life history of the Carson wandering skipper, and develop a program to survey for additional populations and monitor existing populations and habitats for trends and threats.
- Develop and implement an outreach program to keep local communities informed of the Carson wandering skipper's status, and of the means to carry out recovery actions.
- Evaluate the progress of recovery and the effectiveness of management and recovery actions; revise management plans and recovery criteria as necessary.
- No information available.
- No information available.
- Identify and map known occupied sites.
- Establish appropriate long-term management of known occupied sites, especially those of suspected source populations.
- Support mapping, monitoring, and control of Lepidium latifolium by federal, state, and local agencies.
- Coordinate with federal, state, and local agencies to address issues of large-scale groundwater pumping that may adversely affect Carson wandering skipper habitat.
- Establish a research program to determine the ecological requirements and life history of the Carson wandering skipper.
- Determine the relationship between livestock grazing and the Carson wandering skipper and its habitat.

Conservation Measures and Best Management Practices:

- Timing: Conduct as many activities as possible outside of the CWS adult flight period (May 25 to July 10) to reduce impacts to adults. Location: Relocate as many project components outside of CWS habitat as possible. Appropriate buffer depends on action/component. CWS habitat impacted: Maintain native soils on site to use during restoration, as appropriate. Reseed impacted areas with Distichlis spicata and local nectar species, or as appropriate to match vegetation community present prior to impact.
- 1. Annual surveys should be completed following the USFWS 2009 Interim Survey Guidelines for the Carson Wandering Skipper. In additional an assessment of habitat suitability should be completed across the project area by an experienced and qualified biologist, based on the methods outlined in WP Natural Resource Consulting and Yssel Environmental Services. 2010. Carson Wandering Skipper Habitat Assessment for the Fleming and Dakin Units of the Honey Lake Wildlife Area. Prepared for California Department of Fish and Game. March 2010. 25 pp.+. All reports as well as GPS and GIS information gathered regarding the CWS survey efforts along with metadata will be provided to the Service upon completion as part of this project. All GPS and GIS data collected will be provided to the Service in UTM NAD 83 with Federal Geographic Data Committee (FGDC) compliant metadata. 2. Per the survey guidelines, an experienced and qualified biologist will complete the initial year surveys. The experienced qualified biologist may train project personnel in species identification and on protocol level survey techniques so that they may be able to conduct proper surveys in subsequent years. 3. Based on the results of the habitat assessment and survey effort, project proponent will evaluate their management activities and continue practices which are beneficial, and where necessary eliminate and/or modify management practices to avoid and/or minimize impacts to Carson wandering skipper and its habitat. Necessary management actions needed, which

cannot avoid impacts to Carson wandering skipper and are outside those anticipated in this biological opinion, will require consultation with the Service. 4. The applicant will coordinate with the Service on designing and implementing appropriate measures to avoid, maintain and possibly enhance CWS habitat in this area. This will include the commitment of necessary water resources by the applicant to maintain and possibly enhance existing stands of salt grass and nectar plants in this area for the CWS. Other items may include: future access for CWS surveys on private property, seeding of nectar plants, limited pesticide/ herbicide use, invasive weed control, ground water monitoring and reporting, and habitat monitoring and reporting. These conservation measures will be incorporated into a relevant management plan. 5. Necessary mowing within CWS habitat will be conducted at a minimum height of a 1east five inches off the ground surface. Again avoidance during adult flight period (May 25- July 15) is recommended 6. Road grading, road repairs and culvert repairs within Carson wandering skipper habitat will be on an as needed basis and will not be performed between May 25 – July 15 (flight period of Carson wandering skipper 7. All vehicles and project equipment should maintain a speed limit of no more than 15 mph. 8. Construction actions that result in removal or movement of topsoil or vegetation should be designed to reduce impacts to Carson wandering skipper habitat (e.g. do not place spoils on habitat). 9. Temporarily disturbed areas in the project area will be revegetated and a monitoring program will be implemented for a minimum of two years following construction to determine success; remedial measures will be implemented if needed; full restoration will be achieved no later than 3 to 5 years from disturbance; 10. Staging of equipment and storage of any liquids will not occur within/near CWS habitat.

- Address invasion of non-native species. BMPs to reduce risk of introduction.
- Draft guidance for tall whitetop (Lepidium latifolium; TWT) treatments within known Carson wandering skipper habitat Actions should occur outside of flight period (May 25 - July 15) as much as possible. In areas where nectar sources are interspersed with TWT, low density infestation: • Hand held/back pack style gas cutter used to cut back TWT in May/June/July • Hand spot spraying or herbicide wiping with glyphosate will be used. August/September • Treatments in these areas may occur during the flight season, but limit the number of days and person-hours (4 days, 3 people) to reduce presence/noise/trampling. If areas where there is no nectar source for CWS interspersed and a larger monoculture infestation where it would not be effective with handheld/backpack style cutters: • A brush-hog type gas mower may be used. If salt grass is present within infestation, set mower height at 6” height. Before May 25. • A proven broadleaf herbicide with an aquatic label (e.g., Weedar 64) sprayed by tractor boom. August/September. • Discussion with FWS to determine if appropriate to occur during flight season. Limit the number of days and person-hours to reduce presence/noise/trampling Surfactants and colored dye (e.g., blue) will be added to the herbicide to increase its effectiveness and visibility. Mapping of TWT extent pre and post treatment to understand effectiveness.
- Pesticide use for mormon cricket infestation: There will be no aerial application of carbaryl bait within 152.4 m (500 ft.) of the edge of Carson wandering skipper habitat. There will be no aerial application of the ULV form of Dimilin® within 1.6 km (1 mi) of the edge of Carson wandering skipper habitat. There will be no spraying within 152.4 m (500 ft.) of lakes, reservoirs, ponds, intermittent and perennial streams and rivers, wetlands, and springs. Bait will not be placed near waterlines or intertidal areas. AThere will be no aerially applied malathion within 0.4 km (0.25 mi) of the edge of Carson wandering skipper habitat.

Additional Threshold Information:

- No information available.
- No information available.

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Modified from various Biological Opinions completed for the species.

Not applicable.

SPECIES ACCOUNT: *Somatochlora hineana* (Hine's emerald dragonfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 01/26/1995; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

A dragonfly with bright, emerald-green eyes. It is a fairly large metallic brown dragonfly with 2 yellow stripes on each side of the thorax, and in life, bright green eyes (Needham and Westfall, 1955; Williamson, 1931). Adults have wings that are clear and may have an amber hue towards the base of the hind wings. After emerging as an adult, the eyes are initially brown and turn emerald green within 1 to 3 days. Toward the end of the adult life span, the wings may turn from clear to a slightly opaque, smoky color (USFWS, 2001) (NatureServe, 2015).

Taxonomy

Note similarities in appearance and shared habitat with Somatochlora tenebrosa (Walker and Smentowsky, 2003). Genetic analysis of haplotype distribution in related Somatochlora species (Somatochlora tenebrosa, Somatochlora linearis, Somatochlora ensignera, Somatochlora hineana) revealed greater genetic diversity in the unglaciated portion of the species' range, and lower diversity in the northern glaciated portion (Purdue et al., 1999). Genetic analysis of varying populations is underway via non-lethal tissue sampling (Monroe et al., 2010) (NatureServe, 2015). Somatochlora hineana is in the Family Corduliidae ("emeralds") which includes 384 species (USFWS, 2001).

Historical Range

This is primarily a species of the Great Lakes region that was originally only known from Ohio and Indiana (Bick, 1983), but additional investigations also found locations in Illinois, Wisconsin (Vogt and Cashatt, 1990; 1991; 1994), Michigan and Missouri (USFWS, 2001). In the summer of 1997 it was found on the Upper Peninsula of Michigan in Mackinac County and in 2007 it was found at a wetland complex in southern Ontario (Ontario CDC has details). A single adult male has been reliably reported from Alabama. Also, recently recorded from Missouri (Walker and Smentowsky, 2003) which suggests there may be more populations in the southern part of potential range. It is apparently extirpated from Indiana and Ohio (USFWS, 1995; 2001). There are four historic occurrences in Ohio, one in Indiana, and one in Alabama; the species is believed to be extirpated from these states (USFWS, 2001; NatureServe, 2015).

Current Range

Currently known from 42 locations (not all viable): 9 in Illinois (Will, Cook, DuPage Cos.; most not viable), 20 in Wisconsin (Door, Kewaunee, Ozaukee Cos.), 10 in Michigan (Mackinac, Presque Isle, Alpena Cos.), and at least 3 sites in Missouri (Reynolds, Iron Cos.) (USFWS, 2001). The first Canadian occurrence was documented in 2007 in Simcoe County, Ontario (Colin Jones, ON CDC, pers. comm., July 2007) (NatureServe, 2015). While there is not information indicating a significant change in population numbers, there have been seven new sites confirmed since the last 5-year review in 2013. Two of the recently confirmed sites have verified breeding habitat that have geological characteristics that are different than what is typical for Hine's emerald dragonfly habitat, specifically the soil depth to bedrock. (USFWS, 2019)

Critical Habitat Designated

Yes; 9/5/2007.

Legal Description

On April 23, 2010, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the Hine’s emerald dragonfly (Somatochlora hineana) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 26,531.8 acres (ac) (10,737 hectares (ha)) in 37 units fall within the boundaries of critical habitat designation. The critical habitat units are located in Cook, DuPage, and Will Counties in Illinois; Alpena, Mackinac, and Presque Isle Counties in Michigan; Crawford, Dent, Iron, Phelps, Reynolds, Ripley, Washington, and Wayne Counties in Missouri; and Door and Ozaukee Counties in Wisconsin.

Critical Habitat Designation

37 units are designated as critical habitat for the Hine’s emerald dragonfly.

Illinois Unit 1 —Will County, Illinois. Illinois Unit 1 consists of 419 ac (170 ha) in Will County, Illinois. This unit was occupied at the time of listing and includes the area where the Hine’s emerald dragonfly was first collected in Illinois as well as one of the most recently discovered locations in the State. Adults and larvae are found within this unit. The unit consists of larval and adult habitat with a mosaic of upland and wetland communities, including fen, marsh, sedge meadow, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; illegal all-terrain vehicles; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The majority of the unit is a dedicated Illinois Nature Preserve that is managed and leased by the Forest Preserve District of Will County. Although a current management plan is in place, it does not specifically address the Hine’s emerald dragonfly or its PCEs. This unit also consists of a utility easement that contains electrical transmission and distribution lines and a railroad line used to transport coal to a power plant. In addition, a remaining small portion of this unit is located between a sewage treatment facility and the Des Plaines River. This unit is planned to be incorporated in a HCP that is being pursued by a large partnership, which includes the landowners of this unit. Though we are pleased with the progress made to date on the HCP, it is still far from complete and too early to judge its ultimate outcome. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 2 —Will County, Illinois. Illinois Unit 2 consists of 439 ac (178 ha) in Will County, Illinois. This unit was occupied at the time of listing and has repeated adult and larval observations. The unit consists of larval and adult habitat with a mosaic of plant communities including fen, marsh, sedge meadow, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The unit is privately owned and includes a utility easement that contains electrical transmission and distribution lines and a railroad line used to transport coal to a power plant. This unit is planned to be incorporated in a HCP that is being pursued by a large partnership, which includes the landowners of this unit. Though we are pleased with the progress made to date on the HCP, it is still far from complete and too early to judge its ultimate outcome. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 3 —Will County, Illinois. Illinois Unit 3 consists of 337 ac (136 ha) in Will County, Illinois. This unit was occupied at the time of listing and includes one of the first occurrences of Hine’s emerald dragonfly known after the discovery of the species in Illinois. The unit consists of larval and adult habitat with a mosaic of upland and wetland communities including fen, sedge meadow, marsh, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The majority of the unit is a dedicated Illinois Nature Preserve that is owned and managed by the Forest Preserve District of Will County. Although a current management plan is in place, it does not specifically address the Hine’s emerald dragonfly. This unit also consists of a utility easement that contains electrical transmission and distribution lines. This unit is planned to be incorporated in a HCP that is being pursued by a large partnership, which includes the landowners of this unit. Though we are pleased with the progress made to date on the HCP, it is still far from complete and too early to judge its ultimate outcome. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 4 —Will and Cook. Counties, Illinois Illinois Unit 4 consists of 607 ac (246 ha) in Will and Cook Counties in Illinois. This unit was occupied at the time of listing and includes one of the first occurrences of Hine’s emerald dragonfly that was verified after the discovery of the species in Illinois. Repeated observations of both adult and larval Hine’s emerald dragonfly have been made in this unit. The unit consists of larval and adult habitat with a mosaic of upland and wetland communities including fen, sedge meadow, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The unit is owned and managed by the Forest Preserve District of Will County and the Forest Preserve District of Cook County. Construction of the Interstate 355 extension began in 2005 and the corridor for this project intersects this unit at an elevation up to 67 ft (20 m) above the ground to minimize potential impacts to Hine's emerald dragonflies. This unit also consists of a utility easement that contains electrical transmission lines. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 5—DuPage County, Illinois. Illinois Unit 5 consists of 326 ac (132 ha) in DuPage County, Illinois. This unit was occupied at the time of listing and has repeated adult observations. The unit consists of larval and adult habitat with a mosaic of upland and wetland plant communities including fen, marsh, sedge meadow, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The majority of the unit is owned and managed by the Forest Preserve District of DuPage County. This unit also consists of a railroad line and a utility easement with electrical transmission lines. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 6— Cook County, Illinois. Illinois Unit 6 consists of 387 ac (157 ha) in Cook County, Illinois. This unit was occupied at the time Hine's emerald dragonfly was listed. There have been repeated adult observations as well as observations of teneral (newly emerged) adults and male territorial patrols suggesting that breeding is occurring within close proximity. The unit consists of larval and adult habitat with a mosaic of upland and wetland plant communities including fen, marsh, and sedge meadow. The wetlands are fed by groundwater that discharges into the unit from seeps that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. The area within this unit is owned and managed by the Forest Preserve District of Cook County. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Illinois Unit 7 —Will County, Illinois. Illinois Unit 7 consists of 480 ac (194 ha) in Will County, Illinois. This unit was occupied at the time of listing and includes one of the first occurrences of Hine's emerald dragonfly known after the discovery of the species in Illinois. Adults and larvae have been found within this unit. The unit consists of larval and adult habitat with a mosaic of upland and wetland communities including fen, marsh, sedge meadow, and dolomite prairie. The wetlands are fed by groundwater that discharges into the unit from seeps and upwelling that have formed small flowing streamlet channels that contain crayfish burrows. Known threats to the PCEs in this unit that may require special management include ecological succession and encroachment of invasive species; utility and road construction and maintenance; management and land use conflicts; and groundwater depletion, alteration, and contamination. A portion of the unit is a dedicated Illinois Nature Preserve that is managed and owned by the ILDNR. This unit also consists of a railroad line and a utility easement that contains electrical distribution lines. This unit is planned to be incorporated in a HCP that is being pursued by a large partnership, which includes the landowners of this unit. Though we are pleased with the progress made to date on the HCP, it is still far from complete and too early to judge its ultimate outcome. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Michigan Unit 1—Mackinac County, Michigan. Michigan Unit 1 contains 9,452 ac (3,825 ha) in Mackinac County in the Upper Peninsula of Michigan. This area was not known to be occupied at the time of listing. The unit contains at least four breeding areas for Hine’s emerald dragonfly, with female oviposition or male territorial patrols observed at all breeding sites. Adults have also been observed foraging at multiple locations within this unit. The unit contains a mixture of fen, forested wetland, forested dune and swale, and upland communities that are important for Hine’s emerald dragonfly breeding and foraging. The habitat is mainly springfed rich cedar swamp or northern fen. The breeding areas are open with little woody vegetation or are sparsely vegetated with northern white cedar (Thuja occidentalis). Small shallow pools and seeps are common. Crayfish burrows are found in breeding areas. Corridors between the breeding areas make it likely that adult dragonflies could travel or forage between the breeding sites. The majority of this unit is owned by the Hiawatha National Forest. Known threats to the PCEs in this unit that may require special management include nonnative species invasion, woody encroachment, off-road vehicle use, logging, and utility and road right-of-way maintenance. Small portions of the unit are owned by the State of Michigan and private individuals. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors.

Michigan Unit 2—Mackinac County, Michigan. Michigan Unit 2 consists of 3,511 ac (1,421 ha) in Mackinac County in the Upper Peninsula of Michigan. This area was not known to be occupied at the time of listing. The unit contains at least four breeding areas for Hine’s emerald dragonfly, with female oviposition or male territorial patrols observed at all breeding sites. The unit contains a mixture of fen, forested wetland, forested dune and swale, and upland communities that are important for Hine’s emerald dragonfly breeding and foraging. The breeding habitat varies in the unit. Most breeding areas are northern fen communities with sparse, woody vegetation (northern white cedar) that are probably spring-fed with seeps and marl pools present. One site is a spring-fed marl fen with sedgedominated seeps and marl pools. Crayfish burrows are found in breeding areas. Corridors between the breeding areas, including a large forested dune and swale complex, make it likely that adult dragonflies could travel or forage between the breeding sites. The majority of this unit is owned by the Hiawatha National Forest and is designated as a Wilderness Area. Known threats to the PCEs in this unit that may require special management include nonnative species invasion, woody encroachment, and off-road vehicle use. About 1 percent of the unit is owned by private individuals. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Michigan Unit 3—Mackinac County, Michigan. Michigan Unit 3 consists of 50 ac (20 ha) in Mackinac County on Bois Blanc Island in Michigan. This area was not known to be occupied at the time of listing, but is currently occupied. The unit contains one breeding area for Hine's Emerald dragonfly with male territorial patrols and more than 10 adults observed in 1 year. The unit contains a small fen that is directly adjacent to the Lake Huron shoreline and forested dune and swale habitat that extends inland. The unit contains seeps and small fens, some areas with marl. Known threats to the PCEs in this unit include maintenance of utility and road right of way, and development of private lots and septic systems. Road work and culvert maintenance could change the hydrology of the unit. Approximately half of the unit is owned by the State of Michigan; the remaining portion of the area is owned by The Nature Conservancy or is subdivided private land. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species range.

Michigan Unit 4—Presque Isle County, Michigan. Michigan Unit 4 consists of 959 ac (388 ha) in Presque Isle County in the northern lower peninsula of Michigan. This area was not known to be occupied at the time of listing but is currently occupied. The unit contains one breeding area for Hine's Emerald dragonfly, with female oviposition and adults observed in more than one year. The unit contains a fen with seeps and crayfish burrows present. The fen has stunted, sparse white cedar and marl flats dominated by beaked spike rush (Eleocharis rostellata). The threats to Hine's emerald dragonflies in this unit are unknown. The majority of this unit is a State park owned by the MIDNR, the remainder of the unit is privately owned. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Michigan Unit 5— Alpena County, Michigan. Michigan Unit 5 consists of 156 ac (63 ha) in Alpena County in the northern lower peninsula of Michigan. This area was not known to be occupied at the time of listing but is currently occupied. All PCEs for the Hine's emerald dragonfly are present in this unit. The unit contains one breeding area for Hine's Emerald dragonfly, with adults observed in more than one year and crayfish burrows present. The unit contains a mixture of northern fen and wet meadow habitat that are used by breeding and foraging Hine's emerald dragonfly. Known threats to the PCEs in this unit that may require special management include possible hydrological modification due to outdoor recreational vehicle use and a nearby roadway. The majority of the site is privately owned and the remaining acreage is owned by the State of Michigan. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Michigan Unit 6—Alpena County, Michigan. Michigan Unit 6 consists of 220 ac (89 ha) in Alpena County in the northern lower peninsula of Michigan. This area was not known to be occupied at the time of listing but is currently occupied. The unit contains one breeding area for Hine's emerald dragonfly, with male territorial patrols and adults observed. The unit contains a marl fen with numerous seeps and rivulets important for breeding and foraging Hine's emerald dragonfly. Known threats to the PCEs in this unit that may require special management include possible hydrological modification due to outdoor recreational vehicle use and development. The unit is owned by a private group. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Missouri Unit 1—Crawford County, Missouri. Missouri Unit 1 consists of 90 ac (36 ha) in Crawford County, Missouri, and is under U.S. Forest Service ownership. This fen is in close proximity to the village of Billard and is associated with James Creek, west of Billard. This area was not known to be occupied at the time of listing. The fen provides surface flow, and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and an adjacent open pasture provide foraging habitat that is surrounded by contiguous, closed-canopy forest. To date, only larvae have been documented from this locality. Known threats to the PCEs in this unit that may require special management include feral hogs and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 2a—Dent County, Missouri. Missouri Unit 2a is comprised of 15 ac (6 ha) in Dent County, Missouri, and is under U.S. Forest Service and private ownership. It is located north of the village of Howes Mill and in proximity to County Road (CR) 438. This area was not known to be occupied at the time of listing. The fen provides surface flow, and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and an adjacent open old field provide foraging habitat and are surrounded by contiguous, closed-canopy forest. Adults have been documented from this unit. Known threats to the PCEs in this unit that may require special management include allterrain vehicles, feral hogs, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors. This unit includes the Forest Service-owned portion of Missouri Unit 2 as it was described in the July 26, 2006, proposal (71 FR 42442).

Missouri Unit 4—Dent County, Missouri. Missouri Unit 4 is owned and managed by the U.S. Forest Service, and consists of 14 ac (6 ha) in Dent County, Missouri. This fen is associated with a tributary of Watery Fork Creek in Fortune Hollow and is located east of the juncture of Highway 72 and Route MM. This area was not known to be occupied at the time of listing. The fen provides surface flow, and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and adjacent old fields provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. To date, only larvae have been documented from this locality. Known threats to the PCEs in this unit that may require special management include feral hogs and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 5—Iron County, Missouri. Missouri Unit 5 is comprised of 50 ac (20 ha) in Iron County, Missouri, and is under U.S. Forest Service ownership. This fen is adjacent to Neals Creek and Neals Creek Road, southeast of Bixby. This area was not known to be occupied at the time of listing. The fen consists of surface flow and is fed, in part, by a wooded slope north of Neals Creek Road. This small but high-quality fen provides larval habitat and adjacent cover for resting and predator avoidance. The fen, adjacent fields, and open road provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. Both adults and larvae have been documented from this unit. Known threats to the PCEs in this unit that may require special management include all-terrain vehicles, feral hogs, road construction and maintenance, beaver dams, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 7—Phelps County, Missouri. Missouri Unit 7 consists of 33 ac (13 ha) in Phelps County, Missouri, and is owned and managed by the U.S. Forest Service. This area was not known to be occupied at the time of listing. This fen is associated with Kaintuck Hollow and a tributary of Mill Creek, and is located south-southwest of the town of Newburg. This high-quality fen provides larval habitat and adjacent cover for resting and predator avoidance. The fen, adjacent fields, and open road provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. Despite repeated sampling for adults and larvae, only one exuviae (shed larval exterior) has been documented from this unit. Known threats to the PCEs in this unit that may require special management include all-terrain vehicles, feral hogs, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 8—Reynolds County, Missouri. Missouri Unit 8 includes Bee Fork West, a portion of the Bee Fork complex. The unit consists of 4 ac (2 ha) in Reynolds County, Missouri, and is owned and managed by the U.S. Forest Service. This locality is part of a series of three fens adjacent to Bee Fork Creek, extending from east-southeast of Bunker east to near the bridge on Route TT over Bee Fork Creek. This area was not known to be occupied at the time of listing. The fen provides surface flow and is fed, in part, by a small spring that originates from a wooded ravine just north of the county road bordering the northernmost fen in the complex. The unit, in conjunction with the rest of the complex (Units 9 and 10, which are excluded from this final designation), is one of the highest quality representative examples of an Ozark fen in the State. The fen provides larval habitat and adjacent cover for resting and predator avoidance. The fen, adjacent fields, and open road provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. Both adults and larvae have been documented from this unit. The entire complex is an extremely important focal area for conservation actions that benefit Hine's emerald dragonfly. It is likely that the species uses Bee Fork Creek as a connective corridor between adjacent components of the complex. Known threats to the PCEs in this unit that may require special management include feral hogs, ecological succession, utility maintenance, application of herbicides, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors.

Missouri Unit 11a—Reynolds County, Missouri. Missouri Unit 11a is under U.S. Forest Service ownership and consists of 22 ac (9 ha in Reynolds County, Missouri. The unit is a series of small fen openings adjacent to a tributary of Bee Fork Creek, and is located east of the intersection of Route TT and Highway 72, extending north to the Bee Fork Church on County Road 854. This area was not known to be occupied at the time of listing. This unit contains a portion of one of the highest quality representative examples of an Ozark fen in the State. The fen provides surface flow and includes larval habitat and adjacent cover for resting and predator avoidance. The fen, adjacent fields, and open path provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. Adults have been documented from this unit. Known threats to the PCEs in this unit that may require special management include feral hogs, beaver dams, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors. This unit includes the Forest Service-owned portion of Missouri Unit 11 as it was described in the July 26, 2006 proposal (71 FR 42442).

Missouri Unit 21—Ripley County, Missouri. Missouri Unit 21 is a small fen and consists of 6 ac (2 ha) in Ripley County, Missouri. It is under U.S. Forest Service ownership and is located west of Doniphan. This area was not known to be occupied at the time of listing. The fen provides surface flow and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and adjacent open, maintained county road provide habitat for foraging and are surrounded by contiguous, closedcanopy forest. To date, only larvae have been documented from this locality. Known threats to the PCEs in this unit that may require special management include feral hogs, all-terrain vehicles, equestrian use, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors.

Missouri Units 23 and 24—Washington County, Missouri. Missouri Units 23 and 24 comprise the Towns Branch and Welker Fen complex and consist of 75 ac (31 ha) near the town of Palmer in Washington County, Missouri. The complex consists of two fens that are under U.S. Forest Service ownership. This area was not known to be occupied at the time of listing. These fens provide surface flow and include larval habitat and adjacent cover for resting and predator avoidance. The fens and adjacent open, maintained county roads provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. To date, only larvae have been documented from this complex. Known threats to the PCEs in this unit that may require special management include feral hogs, all-terrain vehicles, road construction and maintenance, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors.

Missouri Unit 25—Washington County, Missouri. Missouri Unit 25 consists of 33 ac (13 ha) and is located northwest of the town of Palmer in Washington County, Missouri. The fen is associated with Snapps Branch, a tributary of Hazel Creek, and is owned and managed by the U.S. Forest Service. This area was not known to be occupied at the time of listing. The fen provides surface flow, and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and adjacent old logging road with open canopy provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. To date, only larvae have been documented from this locality. Known threats to the PCEs in this unit that may require special management include feral hogs, all-terrain vehicles, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 26—Wayne County, Missouri. Missouri Unit 26 is owned and managed by the U.S. Forest Service and consists of 5 ac (2 ha). This small fen is located near Williamsville and is associated with Brushy Creek in Wayne County, Missouri. This area was not known to be occupied at the time of listing. The fen provides surface flow and includes larval habitat and adjacent cover for resting and predator avoidance. The fen and adjacent logging road with open canopy provide habitat for foraging and are surrounded by contiguous, closed-canopy forest. To date, only larvae have been documented from this unit. Known threats to the PCEs in this unit that may require special management include feral hogs, all-terrain vehicles, and habitat fragmentation. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Missouri Unit 27—Crawford County, Missouri. Missouri Unit 27 is owned and managed by the U.S. Forest Service and is approximately 3.3 miles (5.2 kilometers) west and southwest of Brazil , Missouri, or about 0.3 mile (0.4 kilometer) southeast of Center Post Church in Crawford County, Missouri. The unit consists of less than 1 ac (0.8 ac (0.3 ha)). This unit was not known to be occupied at the time of listing. Adult Hine's emerald dragonflies have been observed at the site and successful breeding was confirmed (Vogt 2008, p. 10). Surface water consists primarily of seepage pools and small rivulets. Parts of the fen include an open field with scattered shrubs and eastern red cedar (Juniperus virginiana) that is likely used as a foraging area by adults. Known threats to the PCEs that may require special management or protections include invasive plant species, feral hogs, all-terrain vehicles, and equestrian use. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species' range, where habitat is under threat from multiple factors.

Wisconsin Unit 1—Door County, Wisconsin. Wisconsin Unit 1 consists of 157 acres (64 hectares) on Washington Island in Door County, Wisconsin. This unit was not known to be occupied at the time of listing but is currently occupied. Three adults were observed at this site in July 2000, as well as male territorial patrols and female ovipositioning behavior; crayfish burrows, seeps, and rivulet streams are present. The unit consists of larval and adult habitat including boreal rich fen, northern wet-mesic forest, emergent aquatic marsh on marl substrate, and upland forest. Known threats to the PCEs that may require special management or protections include loss of habitat due to residential development, invasive plants, alteration of the hydrology of the marsh (low Lake Michigan water levels can result in drying of the marsh), contamination of groundwater, and logging. A portion of one State Natural Area owned by the Wisconsin Department of Natural Resources occurs within the unit; the remainder of the unit is privately owned. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Wisconsin Unit 2—Door County, Wisconsin. Wisconsin Unit 2 consists of 814 acres (329 hectares) in Door County, Wisconsin. This unit was occupied at the time of listing. The first adult recorded in Wisconsin was from this unit in 1987. Exuviae and numerous male and female adults have been observed in this unit. The unit, which encompasses much of the Mink River Estuary, contains larval and adult habitat including wet-mesic and mesic upland forest (including white cedar wetlands), emergent aquatic marsh, and northern sedge meadows. Known threats to the PCEs that may require special management include loss of habitat due to residential development, invasive plants, alteration of wetland hydrology, contamination of the surface and ground water, and logging. The majority of the land in this unit is owned by The Nature Conservancy and other private landowners with a small portion of the unit owned by the State. Forest areas with 100-percent canopy that occur greater than 328 ft (100 m) from the open forest edge of the unit are not considered critical habitat.

Wisconsin Units 3, 4, 5, 6, and 7—Door County, Wisconsin. Wisconsin Units 3 through 7 are located in Door County, Wisconsin and comprise the following areas: Unit 3 consists of 66 ac (27 ha); Unit 4 consists of 407 ac (165 ha); Unit 5 consists of 3,093 ac (1,252 ha); Unit 6 consists of 230 ac (93 ha); and Unit 7 consists of 352 ac (142 ha). Units 3, 5, 6, and 7 were occupied at the time of listing. Unit 4 was not known to be occupied at the time of listing but is currently occupied. All of the units are within 2.5 mi (4 km) of at least one other unit, making exchange of dispersing adults likely among units. Adult numbers recorded from these units varies. Generally fewer than eight adults have been observed at Units 4, 6, and 7 during any one season. A study by Kirk and Vogt (1995, pp. 13– 15) reported a total adult population in the thousands in Units 3 and 5. Male and female adults have been observed in all the units. Adult dragonfly swarms commonly occur in Unit 5. Swarms ranging in size from 16 to 275 dragonflies and composed predominantly of Hine's emerald dragonflies were recorded from a total of 20 sites in and near Units 5 and 6 during 2001 and 2002 (Zuehls 2003, pp. iii, 19, 21, and 43). In addition, the following behaviors and life stages of Hine's emerald dragonflies have been recorded from the various units: Unit 3—mating behavior, male patrolling behavior, crayfish burrows, exuviae, and female ovipositioning (egg-laying); Unit 4—larvae and exuviae; Unit 5— teneral adults, mating behavior, male patrolling, larvae, female ovipositioning (egglaying), and crayfish burrows; and Unit 6—mating behavior, evidence of ovipositioning, and crayfish burrows. Unit 5 contains two larval areas, while Units 3, 4, 5, 6, and 7 each contains one larval area. Units 3 through 7 all include adult habitat, which varies from unit to unit but generally includes boreal rich fen, northern wet-mesic forest (including white cedar wetlands), upland forest, shrub-scrub wetlands, emergent aquatic marsh, and northern sedge meadow. Known threats to the PCEs that may require special management include loss of habitat due to residential and commercial development, ecological succession, invasive plants, utility and road construction and maintenance, alteration of the hydrology of wetlands (for example, via quarrying or beaver impoundments), contamination of the surface and ground water (for example, via pesticide use at nearby apple/cherry orchards (Unit 7)), agricultural practices, and logging. The majority of the land in the unit is conservation land in public and private ownership; the remainder of the land is privately owned. Forest areas with 100 percent closed canopy that occur greater than 328 ft (100 m) from the open forest edge of the unit but that are too small for us to map out are not considered critical habitat. Unit 4 is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Wisconsin Unit—8 Door County, Wisconsin. Wisconsin Unit 8 consists of 70 ac (28 ha) in Door County, Wisconsin and includes Arbter Lake. This unit was not known to be occupied at the time of listing but is currently occupied. Numerous male and female adults as well as ovipositing has been observed in this unit; crayfish burrows and rivulets are present. The unit consists of larval and adult habitat with a mix of upland and lowland forest, and calcareous bog and fen communities. Known threats to the PCEs that may require special management include encroachment of larval habitat by invasive plants and alteration of local groundwater hydrology (for example, via quarrying activities), contamination of surface and groundwater, and logging. Land in this unit is owned by The Nature Conservancy and other private landowners. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Wisconsin Unit—9 Door County, Wisconsin. Wisconsin Unit 9 consists of 1,193 ac (483 ha) in Door County, Wisconsin associated with Keyes Creek. This unit was not known to be occupied at the time of listing but is currently occupied. Numerous male and female adults have been seen in this unit; ovipositing females have been observed. Crayfish burrows are present. The unit consists of larval and adult habitat with a mix of upland and lowland forest, scrub-shrub wetlands, and emergent marsh. Known threats to the PCEs that may require special management or protections are loss and degradation of habitat due to development, groundwater depletion or alteration, surface and groundwater contamination, alteration of the hydrology of the wetlands (for example, via stream impoundment, road construction and maintenance, and logging). The majority of the land in this unit is a State Wildlife Area owned by the Wisconsin Department of Natural Resources with the remainder of the land privately owned. Forest areas with 100 percent closed canopy that occur greater than 328 ft (100 m) from the open forest edge of the unit are not considered critical habitat. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species' range.

Wisconsin Unit—10 Ozaukee County, Wisconsin. Wisconsin Unit 10 consists of 2,312 ac (936 ha) in Ozaukee County, Wisconsin, and includes much of Cedarburg Bog. This unit was not known to be occupied at the time of listing but is currently occupied. Known threats to the PCEs that may require special management or protections are loss and degradation of habitat due to development, groundwater depletion or alteration, surface and groundwater contamination, and alteration of the hydrology of the wetlands. Numerous male and female adults have been seen in this unit including teneral adults; ovipositing females have been observed, as well as larvae. Crayfish burrows are present. The unit consists of larval and adult habitat with a mix of shrub-carr, ‘‘patterned’’ bog composed of forested ridges and sedge mats, wet meadow, and lowland forest. The majority of area in the unit is State land and the remainder of the land is privately owned. This unit is essential to the conservation of the species because it provides habitat essential to accommodate populations of the species to meet the conservation principles of redundancy and resiliency throughout the species’ range.

Wisconsin Unit 11—Door County, Wisconsin. Wisconsin Unit 11 consists of approximately 147 acres (59 hectares) in Door County, Wisconsin. This unit was not known to be occupied at the time of listing but is currently occupied. Known threats to the PCEs that may require special management or protections are loss and degradation of habitat due to development, groundwater depletion or alteration, surface and groundwater contamination, and alteration of the hydrology of the wetlands. Adults have been observed in this unit over multiple years. Male patrolling behavior has been observed, and crayfish burrows are present. The unit consists of larval and adult habitat, including a floating sedge mat and lowland and upland conifer and deciduous forest. All land in the unit is privately owned. The northern portion of the unit is owned by the Door County Land Trust. This unit is essential to the conservation of the species because it provides for the redundancy and resilience of populations in this portion of the species’ range, where habitat is under threat from multiple factors.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Cook, DuPage, and Will Counties in Illinois; Alpena, Mackinac, and Presque Isle Counties in Michigan; Crawford, Dent, Iron, Phelps, Reynolds, Ripley, Washington, and Wayne Counties in Missouri; and Door and Ozaukee Counties in Wisconsin. The primary constituent elements of critical habitat for the Hine’s emerald dragonfly are:

(i) For egg deposition and larval growth and development: (A) Organic soils (histosols, or with organic surface horizon) overlying calcareous substrate (predominantly dolomite and limestone bedrock); (B) Calcareous water from intermittent seeps and springs and associated shallow, small, slow-flowing streamlet channels, rivulets, and/or sheet flow within fens; (C) Emergent herbaceous and woody vegetation for emergence facilitation and refugia; (D) Occupied burrows maintained by crayfish for refugia; and (E) Prey base of aquatic macroinvertebrates, including mayflies, aquatic isopods, caddisflies, midge larvae, and aquatic worms.

(ii) For adult foraging, reproduction, dispersal, and refugia necessary for roosting, for resting, for adult females to escape from male harassment, and for predator avoidance (especially during the vulnerable teneral stage): (A) Natural plant communities near the breeding/larval habitat which may include fen, marsh, sedge meadow, dolomite prairie, and the fringe (up to 328 ft (100 m)) of bordering shrubby and forested areas with open corridors for movement and dispersal; and (B) Prey base of small, flying insect species (e.g., dipterans).

Special Management Considerations or Protections

Critical habitat does not include human-made structures existing on the effective date of this rule and not containing one or more of the primary constituent elements, such as buildings, lawns, old fields, hay meadows, fallow crop fields, manicured lawns, pastures, piers and docks, aqueducts, airports, and roads, and the land on which such structures are located. We define ''old field'' here as cleared areas that were formerly forested and may have been used as crop or pasture land that currently support a mixture of native and nonnative herbs and low shrubs. ''Fallow field'' is defined as a formerly plowed field that has been left unseeded for a season or more and is presently uncultivated. In addition, critical habitat does not include open-water areas (i.e., areas beyond the zone of emergent vegetation) of lakes and ponds.

The essential physical or biological features within the areas proposed as critical habitat may require some level of management to address current and future threats to the Hine's emerald dragonfly, including the direct and indirect effects of habitat loss and degradation from urban development; the introduction of nonnative invasive plant species; and recreational activities. Nonnative invasive plant species and unauthorized recreational activities (for example, all-terrain vehicles or horseback riding) may alter the vegetation composition or physical structure identified in the PCEs to an extent that the area does not support breeding habitat or refuge for Hine's emerald dragonflies. Additionally, invasive species and unauthorized recreational activities may alter hydrology and alter conditions so that the habitat is unsuitable for crayfish burrows that provide essential wintering refugia for Hine's emerald dragonflies. In summary, the areas designated as critical habitat contain the features essential to the conservation of the Hine's emerald dragonfly, and that these features may require special management considerations or protection. Special management considerations or protection may be required to eliminate, or reduce to negligible level, the threats affecting each unit and to preserve and maintain the essential features that the critical habitat units provide to the Hine's emerald dragonfly. Additional discussions of threats facing individual sites are provided in the individual unit descriptions.

Life History

Feeding Narrative

Larvae: Larvae may become less active or crawl into tight spaces (i.e. crayfish burrows) during cooler water temperatures in late fall to early spring (Soluk et al., 1998). Similarly, larvae can withstand drought during these times by crawling under objects for protection in small streamlets when they dry up; enabling them to survive short-term drought conditions (Soluk et al., 1998). Larvae are sit and wait predators and are more active at night. Larvae feed on oligochaetes and larval mayflies and caddisflies (USFWS, 2001). As the larva grows, it feeds on prey items of increasingly larger size (NatureServe, 2015).

Adult: Adults are active during daylight hours while larvae are active at night (Soluk et al., 1998). Adults are general predators, feeding on insects they can capture while flying (NatureServe, 2015).

Reproduction Narrative

Adult: Nymphs live in water for 2 to 4 years then crawl out and shed for a final time, emerging as a flying adult (Soluk et al., 1996; Vogt and Cashatt, 1994). Females most likely lay more than 500 eggs during their lives. Larvae begin to emerge as adults possibly as early as late May in Illinois and late June in Wisconsin and continue to emerge throughout the summer. Known flight season lasts up to early October in Illinois and to late August in Wisconsin. Females oviposit by repeatedly dipping their abdomens up to 200 times in shallow water from June to late August in Illinois and early to late July in Wisconsin; usually in seepage marshes, seepage sedge meadows, sedge hummocks, muck along sluggish water, and in small muck-bottomed pools (see Vogt and Cashatt, 1994; Soluk et al., 1996; USFWS, 2001). Reproductive adults establish breeding sites and territories, using these areas to mate and oviposit. Males start patrolling territories 7 to 10 days after emergence (NatureServe, 2015). The sex ratio at emergence is approximately 1:1 and emergence is synchronous between the sexes (Foster and Soluk 2004, p. 17). The adult stage may last as long as four to six weeks (Foster and Soluk 2004, p. 18) (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Larvae: Small clusters (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Solitary or in mixed species swarms averaging 74 dragonflies (USFWS, 2013)

Environmental Specificity

Adult: Moderate (NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Larvae: Cambarus diogenes (NatureServe, 2015)

Habitat Narrative

Larvae: Larval individuals can occur in small clusters within their habitat and remain independent. Larval individuals may overwinter in crayfish (Cambarus diogenes) burrows (NatureServe, 2015).

Adult: In Illinois and Wisconsin, adults of this species occurs in shallow, calcareous seepage marshes; or marshy margins of small, sluggish, calcareous streams overlaying dolomite bedrock (Vogt and Cashatt, 1994). The seepage marshes are often dominated by Typha spp. and can be broadly defined as fen or fen-like communities. The species lives in wetlands dominated by grass or grass-like plants that are groundwater fed and shallow. Soil types range from organic muck to mineral soils like marl. A nearby forest edge is also important (USFWS, 2001). The environmental specificity is moderate; the fen-like communities are somewhat fragile and are sensitive to changes in underlying hydrology. Apparently, populations may depend on crayfish borrows during drought periods to survive desiccation (Soluk et al., 1998) (NatureServe, 2015). Zuehls (2003) recorded new information on dragonfly swarming behavior in Door County, Wisconsin, where swarms studied were dominated (75% of individuals) by Hine’s emerald dragonflies.

Swarms, thought to be associated with abundant localized prey, averaged 74 dragonflies (range 16 to 275). Adult Hine's emerald dragonflies spend significant time foraging outside of swarms (USFWS, 2013). Two of the recently confirmed sites have verified breeding habitat that have geological characteristics that are different than what is typical for Hine's emerald dragonfly habitat, specifically the soil depth to bedrock. This new information suggests that the species is not as habitat limited as previously understood; however, this information does not change our understanding of the species' needs or how the species is influenced by threats or stressors. (USFWS, 2019)

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low to moderate (inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. It is assumed that dispersal between populations on the order of 10 km apart would be feasible for this species, but populations separated by a distance of > 50 km would not have frequent exchange of individuals (USFWS, 2001). Distance traveled during dispersal events ranged from 3.3 km to 5.4 km, often through dispersal corridors (see Cashatt and Vogt, 1996). Adult males defend small breeding territories, pursuing and mating with females who enter. Foraging flights for reproductive adults may be 1 to 2 km from breeding sites and can last 15 to 30 minutes (Cashatt et al., 1991). Pre-reproductive adults may fly 1 to 3 km from emergence sites (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 10 - 90% (NatureServe, 2015)

Species Trends:

Illinois: declining (USFWS, 2013)

Number of Populations:

42 (see current range/distribution)

Population Size:

> 30,000 (NatureServe, 2015); Illinois: 86 - 313 adults (USFWS, 2013)

Minimum Viable Population Size:

1,500 adults (USFWS, 2013)

Population Narrative:

The once widespread distribution of this species to disjunct populations, many with unique or unshared haplotypes, indicates individuals do not disperse between populations and loss of genetic variability from unique populations is more susceptible (USFWS, 2001). It is apparently extirpated from Ohio (3 former sites in Lucas, Logan, Williams Cos.), Indiana (one former site in Lake Co.), and Alabama (only known from one specimen in Jackson Co.) and obviously has lost a lot of habitat and populations elsewhere (USFWS, 2001). This species has experienced a long-term decline of 10 - 90%. Based on mark recapture work in Illinois and Wisconsin, probably > 30,000 individuals globally; 20,000 of these may occur in Door County, Wisconsin (Vogt, pers. comm. 1998). Probably > 50 occurrences globally (Vogt, pers. comm. 1998) (NatureServe, 2015). The Illinois population, is estimated to be within the range of 86 - 313 adults and is on a downward trend (estimate includes standard error - Soluk and Mierzwa 2012, pp. 22-25), far from the recovery criteria of 1,500 adults and well below what most research (Shtickzelle et al. 2005; Trailla et al. 2007; Frankham et al. 2010) suggests is required to maintain a viable insect population (USFWS, 2013). Two new breeding sites were verified in Illinois since the 2013 5-year Review: Galloping Hill Fen - Spring Creek Valley Forest Preserve, Cook County, Illinois and Argonne National Laboratory, DuPage County , Illinois. At Galloping Hill Fen - Spring Valley Forest Preserve in June 2014, an Ecologist with the Forest Preserve District of Cook County, Deborah Antlitz identified and photographed an adult male Hine's emerald dragonfly at Galloping Hill Fen in northwest Cook County, Illinois. The photograph was verified to be a Hine ' s emerald dragonfly by Dr. Daniel Soluk, University of South Dakota, Dr. Everett Cashatt, Illinois Museum (now retired), and Kristopher Lah, Service - Chicago Illinois Field Office. As a result of the multiple adult observations and behavior indicative of breeding, a larval habitat assessment and sampling was conducted to confirm breeding habitat (June through August 2015). A streamlet and flowage systems at Galloping Hill Fen in the Spring Creek Forest Preserve was sampled to confirm that this area in Cook County as breeding habitat for Hine's emerald dragonfly (Soluk et al. 2016). At the Argonne National Laboratory in 2016 and 2017, adults and larvae Hine's emerald dragonfly were verified in different areas of Argonne National Laboratory property by surveys performed under contract by Dr. Soluk at the University of South Dakota (T. Velat, Forest Preserve District of DuPage County, e-mail and maps July 22, 2016 and Dr. D. Soluk, University of South Dakota, e-mail and maps June 30, 2017). The discovery of larval habitat at the Argonne National Laboratory as well as those at Spring Lake Valley Forest Preserve are particularly interesting because the dolomitic bedrock at these sites is approximately 20 meters below the surface (typical I-line ' s emerald dragonfly larval habitat has bedrock within a few meters of the surface). (USFWS, 2019) The following locations in Illionis had adult Hine' s Emerald Dragonfly observations verified since the 2013 5-year Review: Spring Lake Nature Preserve -Spring Creek Valley Forest Preserve, Cook County, Illinois; Cherry Hill Woods and Horsetail Lake, Cook County Illinois; Palos Fen Nature Preserve, Cook County, Illinois; and private property, Winnebago County, Illinois. At Spring Lake Nature Preserve - Spring Creek Valley Forest Preserve, multiple observations of adult male Hine's emerald dragonflies have been reported for Spring Lake Nature Preserve in 2014, 2015 and 2016 (Cashatt, 2016, Garrison 2015 and 2016). At Cherry Hill

Woods and Horsetail Lake in 2014 to 2016, Marla Garrison observed and photographed both male and female Hine's emerald dragonfly at Cherry Hill Woods near potential breeding habitat and nearby Horsetail Lake (Cashftt 2015 and 2016; Garrison 2016). However, in the fall of 2016, biologists with the Service, Illinois Department of Natural Resources, and the Forest Preserve District of Cook County were not able to confirm the presence of Hine's emerald dragonfly. At Palos Fen Nature Preserve in 2012, a citizen reported observing an adult male Hine's emerald dragonfly conducting a territorial patrol, which is indicative of larval habitat at Palos Fen Nature Preserve in Cook County, Illinois. Photographs were submitted and multiple Hine's emerald dragonfly experts confirmed that the pictures were of an adult Hine's emerald dragonfly. In 2014, Marla Garrison surveyed Palos Fen and reported an unidentified Somatochlora female that was seen flying an area of standing shallow water with low vegetation on the southeast side of the fen. In 2016, Garrison (2016) verified the presence of up to four adult male Hine's emerald dragonflies at the fen as well as 2-3 female unidentified Somatochlora. On private property in Winnebago County in July 2018, Hine's emerald dragonflies were confirmed from photographs submitted by Joyce Gibbons and Edward Cope, Natural Lands Institute. The photograph identifications were confirmed by Dr. Daniel Soluk, University of South Dakota, Dr. Everett Cashatt, Illinois Museum (retired) and Kristopher Lah, Service to be Hine's emerald dragonflies. In Michigan in 2015, an adult Hine's Emerald Dragonfly observation was verified since the 2013 5-year Review at Summerby Swamp, increasing the occurrence distribution (Cashatt 2016). The species was found during a meander survey just south of Summerby Swamp, south of Highway M-123 where a large wetland complex consists of mainly cedar swamp with small pockets of open areas of northern fen habitat. In Missouri in 2014, the Missouri Hine's Emerald Dragonfly Study Group estimated the population size of Hine' s emerald dragonfly at Johnson Shut-ins State Park in Reynolds County, Missouri (Walker and Smentowski 2014). They did a mark-recapture study where they marked and released 112 Hine's emerald dragonflies, 80 males and 32 females, from June 16 through June 20. They made 154 recapture observations starting June 17 through July 13. The estimate of the population is 176 individuals, 103 males and 73 females. Cashatt reported (2016) that in 2015. Another mark-recapture study was conducted in Missouri at Centerville Slough, Reynolds County. A total of 99 individuals were marked; 49 were recaptured. Researchers noted that the study may have been impacted by the rain events early in the first week. Additional observations were made between June 29 and July 7, 2015 to identify previously marked individuals. In Missouri, an adult Hine's Emerald Dragonfly observation was verified since the 2013 5-year Review. On private property in Reynolds County, Missouri in 2015, Richard Day surveyed for new potential Hine's emerald dragonfly habitat in Reynolds County revealed a new site at a fen on private property. (USFWS, 2019)

Threats and Stressors

Stressor: Habitat loss and fragmentation (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Extant occurrences are threatened by the following activities: petroleum refineries and other heavy industry, a proposed highway project, quarrying, urban non-point water pollution,

and ATV use in Illinois; agricultural non-point water pollution (surface and groundwater) and recreational development in Wisconsin. Most significant threats are habitat/alteration/destruction plus fragmentation from development of commercial and residential areas, quarrying, creating landfills, constructing pipelines, and filling of wetlands. Habitats are often closely associated with surface dolomite deposits which are often quarried. Changes in surface or subsurface hydrology has the potential to reduce suitable breeding habitat (NatureServe, 2015).

Stressor: Contamination (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Contamination from landfills (including leaching) and chemical fertilizer and pesticide application is a past and potential future threat (NatureServe, 2015). Preliminary results have shown effects in growth, feeding and behavior of larvae from exposure to various concentrations of herbicides (Soluk et al. 2011, p. 14). Recently a new contaminant, oil from pipeline breaks, threatened two Illinois sites. In September 2010, an oil pipeline break occurred outside of Romeoville Prairie Nature Preserve (K. Lah, observed. 2010). In December 2010, another pipeline broke releasing oil into Hine's emerald dragonfly habitat at the Long Run/ComEd site. Efforts to clean-up this spill and assess impacts to the species and its habitat are ongoing (USFWS, 2013).

Stressor: Roadway/vehicle mortality (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Secondary threats include off-road and highway vehicle mortality and associated mortality from roadway development (USFWS, 2001) (NatureServe, 2015).

Stressor: Invasive vegetation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Invasive vegetation can potentially impact Hine's emerald dragonfly behavior and habitat. The encroachment of cattails (Typha spp.) and woody vegetation has the potential to affect adult flight behavior and movement. Mierzwa et al. (2007, p. 10) suggests that adult breeding habitat is being encroached upon by the accumulation of layers of cattail thatch at marshes in Illinois sites that have not been maintained by continued prescribed fire. Other invasive plant species can impact habitat features that help fulfill life history requirements. For example, a necessary component of larval habitat is groundwater. Encroachment of woody invasive species in upland areas has the potential to allow greater runoff of precipitation and loss of subsurface water through evapotranspiration (Parish and Sellar 2006, pp. 14-15). Herbaceous invasive species can also impact necessary breeding habitat features. For example, common reed (Phragmites australis) is believed to displace crayfish (D. Soluk, pers. comm., 2009), and hence

their burrows that serve as refugia for Hine's emerald dragonfly larvae, possibly due to the thick rhizomatous mat that develops in monocultures of the species (USFWS, 2013).

Stressor: Invasive animals and livestock (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Feral hogs, armadillos, and beavers could potentially destroy Hine's emerald dragonfly habitat in Missouri (Vogt 2005, p. 38; Walker and Smentowski 2006, p. 28), as well as in northern parts of the species range. Feral hogs are known to rut while foraging for tubers, insects and other organisms and this rutting behavior can cause significant impacts to fens and other wetland communities. Currently feral hogs do not pose a threat to Hine's emerald dragonfly habitat outside of Missouri but feral hogs are known to occur in southern Illinois and western Wisconsin. Likewise, the nine-banded armadillo (Dasypus novemcinctus) foraging behavior has the potential to destroy habitat. Armadillos dig-up insect larvae for food and will forage in underground burrows during cold periods. The armadillo's range expansion is expected to continue (Taulman and Robins 1996). Beaver dams can cause flooding of wetland communities supporting the Hine's emerald dragonfly. High density of livestock or prolonged periods of grazing have the potential to alter the floristic quality of fens. Overgrazing can reduce or remove sensitive native plant species and can promote the establishment of increaser species (i.e., plant species that increase in relative amount under heavy grazing pressure) species such as poison hemlock (Conium maculatum) and invasive species such as multiflora rose (Rosa muliflora) and meadow fescue (Festuca pratensis) (Moore 2005, p. 3). Large livestock also has the potential to trample habitat features like crayfish burrows that serve as refugia for larvae. Grazing is viewed as a threat at several sites in Missouri (Moore 2005, p.7; Walker and Smentowski 2005, pp.5-20) (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: While there is uncertainty about the exact nature and severity of climate change related impacts anticipated within the Hine's emerald dragonfly's range, a number of scientific studies project that there will be increased duration and intensity of heat waves in summer, higher levels of humidity and evaporation; changing patterns of precipitation with fewer rain events of greater intensity; increased frequency and more severe dry spells; and more flooding from heavy rains (Easterling and Karl 2000, pp. 168–169, 172, 176; Hall and Stuntz 2007, pp. 5-7; Intergovernmental Panel on Climate Change 2007, pp. 30- 46). Climatic changes may impact the Hine's emerald dragonfly and its habitat in a variety of direct and indirect ways including: changes in hydrology; loss of suitable habitat; loss of inter-specific relationships with crayfish; and increased threats from invasive species. As a result, these changes have the potential to have demographic impacts on the species. For example, data on population sizes in Illinois reveal that declines in the population correlate with short-term droughts (Soluk and Mierzwa 2012, pp. 22-25). In years when droughts occur, there is very low recruitment which leads to a small cohort.

While the population eventually recovers slightly, it appears to not return to its pre-drought size (USFWS, 2013).

Recovery

Reclassification Criteria:
1. Each of the two Recovery Units contains a minimum of two populations, each composed of at least three subpopulations. Each subpopulation contains a minimum of 500 sexually mature adults for 10 consecutive years (USFWS, 2001).

2. Within each subpopulation, there are at least two breeding habitat areas, each fed by separate seeps and/or springs (USFWS, 2001).

3. For each population, the habitat supporting at least two subpopulations should be legally or formally protected and managed for Hine's emerald dragonfly, using long-term protection mechanisms such as watershed protection, deed restrictions, land acquisition, or nature preserve dedication. In addition, mechanisms protecting the up gradient groundwatershed should also be in place (USFWS, 2001).

4. A monitoring must be established for each population within 5 years to estimate population size on an annual basis for the purpose of determining whether recovery criteria have been achieved (USFWS, 2001).

Delisting Criteria:
1. Each of the two Recovery Units contains a minimum of three populations composed of at least three subpopulations. Each subpopulation contains a minimum of 500 reproductive adults for 10 consecutive years (USFWS, 2001).

2. Within each subpopulation, there are at least two breeding habitat areas, each fed by separate seeps and/or springs (USFWS, 2001).

3. For each population, the habitat supporting at least three subpopulations should be legally or formally protected and managed for Hine's emerald dragonfly, using long-term protection mechanisms such as watershed protection, deed restrictions, land acquisition, or nature preserve dedication. In addition, mechanisms protecting the up gradient groundwatershed will also be in place within 5 years (USFWS, 2001).

Recovery Actions:
- Protect and manage extant populations (USFWS, 2001).
- Conduct studies (USFWS, 2001).
- Conduct searches for additional Hine's emerald populations (USFWS, 2001).
- Conduct an information and education program (USFWS, 2001).
- Conduct a reintroduction and augmentation program (USFWS, 2001).
- Review and track recovery progress (USFWS, 2001).

- Implement Environmental Deoxyribonucleic acid (eDNA) survey protocols with partners across the species historic range. Environmental DNA is especially promising for reducing the time and personnel costs associated with surveying for the Hine's emerald dragonfly within complex landscapes. Using Hine's emerald dragonfly and devil crayfish eDNA detection protocols simultaneously in the field, will allow the Service to more efficiently prioritize survey locations on a landscape level even at spatial scales where Hine's emerald dragonfly is relatively rare. (USFWS, 2019)
- Captive Rearing - For mass captive rearing to successfully augment the Lower DesPlaines River Valley population and reduce its chances of being extirpated, there will need to be substantial increases in the effort to collect females and obtain eggs. Given that the population in the Lower DesPlaines River Valley may be experiencing steep declines , collecting more females and eggs will be difficult in the near future. (USFWS, 2019)
- Continue to implement Hine's emerald dragonfly captive rearing and augmentation in the Lower DesPlaines River Valley population. (USFWS, 2019)
- Coordinate efforts with partners to restore and manage larval and adult (including recharge areas) habitat in existing, historic , and new sites as they are verified. (USFWS, 2019)
- Assist in groundwater and habitat protection, enhancement, and management efforts. (USFWS, 2019)
- Identify and survey potential larval habitat. (USFWS, 2019)
- Conduct a range wide species distribution model using a GIS-based method to produce predictive maps of where Hine's emerald dragonfly larval habitat is likely to occur. (USFWS, 2019)
- Monitor and estimate the size of Hine's emerald dragonfly populations. (USFWS, 2019)
- To prevent Hine’s emerald dragonfly populations from being extirpated, continued efforts need to be made to better understand and address threats to the species and its habitat. The impacts of some threats, like invasive species, are well understood and their control will require ongoing management and maintenance. However, additional research is needed to more clearly understand the direct and indirect effects of herbicides (used to control invasive species) on the various life stages of the dragonfly and to improve the decision model on herbicide use that is nearing completion (USFWS, 2013).
- Other threats like habitat fragmentation and the impact of hydrologic changes on the Hine’s emerald dragonfly and its habitat are not as well understood especially as these threats may affect the viability of the species. Research needs to be designed and conducted to address these threats and methods to avoid or mitigate potential impacts caused by the threats implemented as necessary to enable the species to survive and recover (USFWS, 2013).
- Modeling the population dynamics of the Hine’s emerald is a high priority recovery action. One of the current criteria to delist the species is that each population consist of at least 1,500 adults (i.e., three subpopulations of 500 adults). However, a population of 1,500 adults is not considered to be very large for an insect. Frankham et al. (2010, p. 519) recommend census sizes >6,000 are a good target for long-term persistence in invertebrates; however, due the complicated life history of the Hine’s emerald dragonfly (overwintering eggs, larval stage of for four-five years, overlapping generations, etc.) the species may have persisted at smaller population sizes than other insects. A better understanding of a minimum viable population size for Hine’s emerald dragonfly is needed. Population viability modeling should be used to compare and identify alternative population and metapopulation structures that provide equivalent persistence probabilities. These results and the knowledge we have gained regarding the species genetic diversity may be used to revise recovery criteria or to

determine whether an alternative population distribution provides long-term stability. New information on the size of populations and their genetic structure and diversity should be included in the model as it becomes available (USFWS, 2013).

- Another high priority recovery action is to determine the size of Hine's emerald dragonfly populations and to monitor the populations on a regular basis. To date most of the population monitoring for the species has been done in Illinois. This is partly due to the small size and accessibility of the sites in Illinois which are more conducive to the population survey protocols that have been developed for monitoring adult and larval Hine's emerald dragonflies. Some population surveys, though not as extensive, have also been done in Wisconsin. Survey protocols may need to be established for each state or for different habitat structures. In addition, a schedule for monitoring sites should be developed that would allow for monitoring that could be done periodically, yet adequately capture changes and trends in a subpopulation (USFWS, 2013).
- While a great deal of research has recently been conducted on the genetic structure and diversity of Hine's emerald dragonfly populations, this work needs to be expanded to cover the entire range of the species. To date, analysis on the population structure has not included sites in Missouri and more samples are needed in other parts of the species range (e.g. Southwest Wisconsin). Recent research on genetic diversity has expanded our understanding of the importance of the smaller populations in the Southern Recovery Unit. A more complete understanding of the population structure within and among populations of the Hine's emerald dragonfly will provide the necessary information to determine the most appropriate recovery criteria, as well as serve as a guide in implementing recovery actions (USFWS, 2013).
- Protocols for successful rearing of Hine's emerald dragonfly larvae from eggs to adult emergence have been developed over the last 5 to7 years (Satyshur 2009, Soluk et al. 2008-2012). Methods have been developed to safely harvest eggs from females in the field, hatch them and rear them with up to 50% rates of survival. In the field, survival rates of eggs to mature larvae are likely less than 1%, so the of benefit of captive rearing is that it may be able to generate larvae and adults from those that would have most likely died. These captive-reared individuals can then be used to conduct crucial studies or buffer natural populations from local extinction events. Captive-reared larvae are being used for evaluations of herbicide toxicity, quality assessment for created/restored habitat, genetic structuring of populations and various other life history and ecological studies. Given that the size of the entire Illinois population of the Hine's emerald dragonfly appears to currently average approximately 200 adults and is on a downward trend (Soluk and Mierzwa 2012), activities such as population augmentation and head-starting seem increasingly essential if the population is to remain viable and the species will survive (USFWS, 2013).
- Captive Rearing - The Lower DesPlaines River Valley (Cook, DuPage and Will Counties of Illinois) population of Hine's emerald dragonfly is in the most danger of near-term extirpation; a rapidly developing urban matrix has fragmented the habitat into small patches. Soluk and Mierzwa (2012) estimated that the Lower DesPlaines River Valley population generates only 86-313 adults per year and has been on a downward trend since the 1990s. This exposes the population to extirpation by demographic stochasticity. Given the urgency of the situation, two strategies have been implemented to recover the population: I) habitat restoration/creation, and 2) augmentation of the population in existing and restored habitat. The ongoing captive rearing and population augmentation project was designed to produce individuals for reintroduction or augmentation without requiring significant impact to adult production from existing sites. It accomplishes this by having

trained personnel collect either eggs or recently hatched or young of year larvae from the field, where they have very little chance of surviving 5 years as larvae to become adults, and moving them into captivity where they may have more than a 30% survival rate to adult. In 2015, over 1,600 eggs were collected from 9 females. ln addition, 880 (approx.) eggs were collected from Door County, Wisconsin (Soluk 2016a). In 2016, Overall number of eggs collected from the Illinois population was approximately 865 from 9 females, for a yield of only 8.3 eggs per person hour (Soluk 2016b). In 2016, 16 adults were released into the Lower DesPlaines River Valley population (Soluk 2017). In 2017, approximately 1,758 eggs were collected from 13 females in the Lower DesPlaines River Valley population for a yield of only 8.3 eggs per person x hour. In addition, 958 eggs were collected from 5 females in Wisconsin (Soluk 2018). In 2017, 18 adults had emerged in e-cages, and 11 were from Illinois and were released into the Lower DesPlaines River Valley population (Soluk 2018). In 2018, approximately 3,579 eggs were collected from 15 females in the Lower DesPlaines River Valley (25 total females captured). In addition, approximately 2,030 eggs were collected from 11 females in Wisconsin of the 21 total females captured (Soluk 2018). In 2018, 45 Hine's emerald dragonfly larvae had emerged successfully as adults and 43 of these were released back into the Lower DesPlaines River Valley population (Soluk 2018). For mass captive rearing to successfully augment the Lower DesPlaines River Valley population and reduce its chances of being extirpated, there will need to be substantial increases in the effort to collect females and obtain eggs. Given that the population in the Lower DesPlaines River Valley may be experiencing steep declines , collecting more females and eggs will be difficult in the near future. (USFWS, 2019)

- Research and Development of Environmental Deoxyribonucleic acid - Environmental Deoxyribonucleic acid (eDNA) has been an exciting area of research and development for to address the time consuming and costly challenge of locating Hine's emerald dragonfly habitat and verifying breeding habitat. Historically, Hine's emerald dragonfly habitats were detected using adult or larval surveys. However, adult Hine' s emerald dragonfly can range over distances of at least 5.4 km (3.4 miles) (Cashatt and Vogt 1996), so observing an adult Hine' s emerald dragonfly is only indicative of the presence of the species in a general area. Adult surveys are also difficult because the entire flight period is only 4-6 weeks and during that time adults are only active on sunny days when temperature and wind conditions are suitable. Field surveys for Hine's emerald dragonfly larvae occur over a longer season and identify specific areas of habitat within a wetland system. An alternative to costly and time-intensive surveys for HED is the use of eDNA, DNA extracted directly from the environment. This methodology has been used to successfully detect the presence of rare species or those of conservation concern in the last few years (Francis-Thomsen et al. 2011). Environmental DNA is especially promising for reducing the time and personnel costs associated with surveying for the Hine's emerald dragonfly within complex landscapes.The relatively simple sample collection methods used in eDNA monitoring will also work well with potential Hine's emerald dragonfly habitat because of the low flows and volumes in most systems where the larvae are present. Furthermore , the ability to collect samples from areas downstream of larval streamlet habitat may ameliorate issues of access to larval habitat that can limit surveying in some cases. Working under a Service funded Science Support Partnership Grant, researchers at the U.S. Geological Survey and University of South Dakota mapped the complete mitochondrial genome of the endangered Hine's emerald dragonfly and developed two eDNA markers each for the Hine's emerald dragonfly and the devil crayfish (Cambarus Diogenes) (Jackson et al. 2018). These, markers have successfully detected eDNA from both species in lab and field samples. Results from lab experiments with these markers suggest optimum sampling temperatures and duration of eDNA persistence in the environment. We have used the Hine's emerald dragonfly markers to identify unknown larvae from Michigan collected in 2015 as Hine's emerald dragonfly. They also determined that the markers can be used to identify Hine's emerald dragonfly exuviae. Identification of small larvae and exuviae will be useful to managers. Using Hine's emerald dragonfly and devil crayfish eDNA detection protocols simultaneously in the field, will allow the Service to more efficiently prioritize survey locations on a landscape level even at spatial scales where Hine's emerald dragonfly is relatively rare. This is because areas that do not contain devil crayfish are unlikely to support the dragonfly. As with Hine's emerald dragonfly the development of the eDNA markers has included extensive testing to minimize the probability of false positives generated by other species. However, defining the detection limits under field conditions will still require substantial additional efforts that will need to include evaluating eDNA presence for this species across a wide range of densities and field conditions. (USFWS, 2019)

- A habitat conservation plan (HCP) was approved and a 20-year incidental take permit was issued to Commonwealth Edison in 2014 (Commonwealth Edison, 2014 Low-Effect Habitat Conservation Plan for the Hine's emerald Dragonfly, Blanding's Turtle, Spotted Turtle, Black-billed Cuckoo, Lakeside Daisy and Leafy Prairie Clover). The area of land that is subject to this HCP includes a Planning Area that is approximately 2.901 acres that also consists of a Permit Area that is approximately 403 acres. The overriding biological goal of this HCP is to contribute to the conservation of the federal and state threatened and endangered species found in the permit area: Federal and Illinois endangered Hine' s emerald dragonfly, and its critical habitat in Illinois; Illinois endangered Blanding's turtle (Emydoidea blandingii); Illinois endangered spotted turtle (Clemmys guttata); Illinois threatened black-billed cuckoo (Coccyzus erythropthalmus); Federal threatened and Illinois endangered lakeside daisy (Hymenoxys acaulis); Federal and Illinois endangered leafy prairie clover (Dalea foliosa). (UWFWS, 2019)

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SPECIES ACCOUNT: *Speyeria callippe callippe* (Callippe silverspot butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; December 5, 1997 (62 FR 64306).

Physical Description

The callippe silverspot butterfly (Speyeria callippe callippe) is a medium-sized butterfly with a wingspan of about 5.5 centimeters (2.2 inches) and upper wings that are brown showing extensive black spots and lines, and having melanic (dark colored) basal areas. The undersides of the wings are brown, orange-brown, and tan, showing black lines and distinctive black and bright silver spots. The body and basal area of the wings of the callippe silverspot butterfly are densely pubescent (covered with hair). This butterfly has five larval instars, and develops for 2 weeks in a pupal case before emerging as an adult (USFWS 2009). The larvae (caterpillars) are dark-colored with many branching sharp spines on their back (USFWS 2015).

Taxonomy

The callippe silverspot butterfly is a member of the brush foot family (Nymphalidae). The subspecies complex of Speyeria callippe has 19 members, with a combined range that includes most of the Pacific Northwest eastward to the Rocky Mountains, north to lower southwestern Canada, and south along the California coast and Central Valley to northern Baja California, Mexico. Two other subspecies in the Speyeria callippe complex are described to occur in proximity to S. c. callippe: Comstock's fritillary (S.c. comstockii) occurs to the south and east of the historic range of S.c. callippe, and the Liliana fritillary (S.c. liliana) occurs to the north of S.c. callippe in and around the Napa Valley (62 FR 64306; USFWS 2009). Identification of the subspecies is challenging in some parts of its range because it can hybridize with Lilian's and Comstock's silverspot butterflies, producing offspring that are intermediate in appearance (USFWS 2015).

Historical Range

The subspecies was known historically to occur in grassland habitat in the seven counties bordering San Francisco Bay in California. The historic range included the inner coast range on the eastern shore of San Francisco Bay from northwestern Contra Costa County south to the Castro Valley area in Alameda County. On the west side of the Bay, it ranged from San Francisco south to the vicinity of La Honda in San Mateo County (USFWS 2015).

Current Range

Five colonies of callippe silverspot butterfly, including the one at Twin Peaks in San Francisco, were extirpated. The remaining colonies exist on mostly privately owned land, but also on city, county, and state-owned land. Since 1988, callippe silverspot butterflies have been recorded at San Bruno Mountain and Sign Hill near South San Francisco (San Mateo County), in the hills near

Pleasanton (Alameda County), at Sears Point (Sonoma County), and in the hills between Vallejo and Cordelia (USFWS 2015).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: The larvae of the callippe silverspot butterfly feed solely on the vegetation of one food plant, Johnny-jump-up (Viola pedunculata). Johnny-jump-up in the San Francisco Bay area is associated with deep soils that have established grass cover. Topography of the grassland is an important factor influencing larval host plant growth and survival (USFWS 2009). Larvae hatch and feed on their larval food plant for about a week. Larvae have been observed feeding in the late afternoon and at twilight; this has been suggested to serve as predator avoidance, and is a behavior that was correlated to illumination levels but not to ambient temperature (USFWS 2009). They then wander a short distance and spin a silk pad, on which they spend the summer and winter in diapause. In the spring, they immediately seek out Johnny-jump-up plants (Black and Vaughan 2005).

Adult: Adult callippe silverspot butterflies are nectarivorous and feed on a variety of flowering plants in continuous grasslands of the San Francisco Bay area. Preferred nectar sources include nonnative thistles (Carduus spp.), native Alameda County thistle (Cirsium quercetorum), nonnative blessed milk thistle (Silybum marianum), and native coyote wildmint (Monardella villosa). Other nectar sources used by the butterfly include hairy false goldenaster (Heterotheca villosa), coast buckwheat (Eriogonum latifolium), mourning bride (Scabiosa atropurpurea), California buckeye (Aesculus californica), mule ears (Wyethia angustifolia), and California horkelia (Horkelia californica). A 2006 study of callippe silverspot butterfly nectar sources at the King/Swett Ranch in the Cordelia Hills revealed that adults may travel up to 1 mi. to nectar from the native California buckeye (Aesculus californica), and that the favorite nectaring plants of the callippe silverspot butterfly at the King/Swett Ranch apparently include mints, particularly Monardella. The callippe silverspot butterfly requires hilltops that have connectivity with grasslands containing nectar sources and larval host plants. Ideal topography includes cooler north- and east-facing slopes (USFWS 2009).

Reproduction Narrative

Larvae: Callippe silverspot butterfly larvae have a variable lifespan; shortly after hatching, larvae enter diapause. Most larvae remain in diapause from early summer until the following spring, at which point they develop through five instars (USFWS 2015), then construct a pupal case; after 2 weeks of structural transformation, the adult ecloses (emerges) from the pupal case, continuing the life cycle (USFWS 2009). Female callippe silverspot butterflies do not oviposit directly on the host plan, but instead on dirt, dry grass, plant debris, and rodent trails and holes at a distance ranging from a few centimeters to 0.9 m (3 ft.) away from the host plant. Further observation revealed that females oviposit at sites that are shaded by grasses or forbs, usually between 10 a.m. and 2 p.m. Females oviposit throughout the early summer. Larvae feed exclusively on the herbaceous foliage of the Johnny-jump-up, which has suitable foliage available only during a short time of the year (USFWS 2009).

Adult: The adult flight and mating period begins after eclosing (emerging) from the pupal case. Callippe silverspot butterflies are univoltine, and can lay more than 600 eggs. The average adult callippe silverspot butterfly lifespan was determined to be about 5 days for males and 7 days for females. Adult callippe silverspot butterflies require a variety of flowering nectar plants, as well as the presence of the larval host plant, Johnny-jump-up, where they "haphazardly" lay their eggs. Breeding season occurs from mid-May to mid-July (USFWS 2009).The callippe silverspot butterfly requires appropriate topography, including hilltops. Hilltopping behavior is practiced by this butterfly, which allows males and receptive females to congregate on topographic summits to find mates. Mating commonly occurs soon after the females emerge from the pupae, with males that, owing to protandry, have reached sexual maturity earlier than females. One observed mating ritual of this species involves a spiraling flight together of male and females. Females will reject advances of other males once mating is completed. Females tend to go through an inactive period (diapause) prior to oviposition, and then will search for oviposition sites near host plants, down off the hill tops (USFWS 2009).

Geographic or Habitat Restraints or Barriers

Adult: Callippe silverspot butterflies are rarely found west of a distinct fog line—which is determined by topography—even in an area where Johnny-jump-up and nectar sources are abundant (USFWS 2009).

Spatial Arrangements of the Population

Larvae: See adult life stage.

Adult: Clumped

Environmental Specificity

Larvae: See adult life stage.

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Larvae: See adult life stage.

Adult: Low

Site Fidelity

Larvae: See adult life stage.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Presence of Viola pedunculata.

Adult: Callippe silverspot butterfly require the presence of suitable nectar plants and the larval food plant, Johnny-jump-up.

Habitat Narrative

Larvae: See adult life stage.

Adult: The callippe silverspot is found in native grassland and associated habitat. Essential features of the callippe silverspot butterfly habitat include:-Grasslands with proper topography in the San Francisco Bay area;-Sufficient larval host plant (Viola pedunculata);-Adequate nectar sources;-A location within the area influenced by coastal fog; and-Hilltops for mating congregations (USFWS 2009)The callippe silverspot butterfly is rarely found west of a distinct fog line—which is determined by topography—even in an area where the larval food plant (Johnny-jump-up) and adult nectar sources are abundant. In the San Francisco Bay area, Johnny-jump-up is associated with deep soils that have established grass cover. Studies have demonstrated that the best grassland habitat for the callippe silverspot butterfly, based on the distribution of adults, included cooler north- and east-facing slopes with fairly dense occurrences of both the larval host plant and nectar source plants. Continuous grassland is also important, because it will support a variety of nectar sources; the callippe is a large and vagile butterfly that can have a home range up to many hectares of grassland habitat (USFWS 2009).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: The mobility of the callippe silverspot butterfly is moderate; the species has a home range covering many hectares (dozen of acres) of grassland habitat (Weiss and Murphy 1990).

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Low

Adult: Moderate; hilltops and ridgelines acts as foci for adult butterflies dispersing from surrounding slopes that support plant resources (Weiss and Murphy 1990).

Dispersal/Migration Narrative

Larvae: When callippe silverspot larvae hatch, they wander a short distance and spin a silk pad, on which they pass the summer and winter in diapause (USFWS 2015).

Adult: The callippe silverspot butterfly has an adult home range covering many hectares (dozens of acres) of grassland habitat. Hilltops and ridgelines act as foci for adult butterflies dispersing from surrounding slopes that support plant resources (Weiss and Murphy 1990). The callippe silverspot butterfly is found in the fog-influenced zone that surrounds San Francisco Bay at a regional level; however, at a local, site-specific level, it appears that the distribution of this butterfly may be limited by avoidance of fog during the flight season. Adults of the Speyeria genus of butterflies are known to be strong fliers and can disperse over relatively long distances, up to 1.2 km (0.8 mi.) between breeding colonies. Callippe silverspot adults may travel up to 1.6 km (1 mi.) to nectar plants (USFWS 2009).

Additional Life History Information

Adult: The callippe silverspot butterfly is found in the fog-influenced zone that surrounds San Francisco Bay at a regional level; however, at a local, site-specific level, it appears that the distribution of this butterfly may be limited by avoidance of fog during the flight season. Adults of the Speyeria genus of butterflies are known to be strong fliers and can disperse over relatively long distances, up to 1.2 kilometers (km) (0.8 mi.) between breeding colonies. Adults may travel up to 1.6 km (1 mi.) to nectar plants (USFWS 2009).

Population Information and Trends

Population Trends:

Stable (USFWS 2009)

Species Trends:

Stable (USFWS 2009)

Number of Populations:

Four (USFWS, 2020a)

Population Size:

50 to 1,000 individuals (NatureServe 2015). The only consistent surveys were conducted at San Bruno Mountain: 443 in 2006, and 476 in 2008. Surveys conducted at Cordelia Hills (King/Sweet Ranch) in 2009 did not estimate the population size (USFWS 2009).

Adaptability:

Low

Additional Population-level Information:

Monitoring surveys conducted to evaluate the correlation between environmental factors and butterfly abundance revealed an association between increased rainfall during the wet season and an increase in the number of adults when compared to years with less rainfall (USFWS

2009).The population at the city park in Alameda County has not been surveyed since 1973; the grassland habitat appears to have been significantly altered and is likely extirpated. Other populations that have been described as possible callippe silverspot butterfly populations have not yet been taxonomically verified (USFWS 2009).

Population Narrative:

Currently, there are two known remaining extant populations of callippe silverspot butterflies: San Bruno Mountain and at Cordelia Hills. Since 1980, bi-annual surveys of the adult callippe silverspot butterfly population at San Bruno Mountain have been the only consistent surveys conducted for this species. Although surveys were not performed some years, the average population trend appears to be stable. In 2006, the fixed transect method of surveying revealed a total of 443 callippe silverspot butterflies. In 2008, there was a slight increase in the number of butterflies sighted (476 total). The population in the Cordelia Hills has been observed as recently as spring 2009 at the King/Swett Ranch area; however, surveys to estimate population size have not been conducted for this population.Monitoring surveys conducted to evaluate the correlation between environmental factors and butterfly abundance revealed an association between increased rainfall during the wet season and an increase in the number of adults when compared to years with less rainfall (USFWS 2009).The population at the city park in Alameda County has not been surveyed since 1973; the grassland habitat appears to have been significantly altered and is likely extirpated. Other populations that have been described as possible callippe silverspot butterfly populations have not yet been taxonomically verified (USFWS 2009). Currently, one population is in moderate condition and the remaining three are in low condition. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat loss and fragmentation
Exposure: Urban development.
Response: Loss of continuous grassland habitats.
Consequence: Reduction in population, loss of genetic exchange between populations, and risk of extirpation.
Narrative: The remaining callippe silverspot butterfly populations and habitat areas are threatened by a number of proposed developments. Development may directly destroy butterfly habitats or it may cause further fragmentation of available habitat, causing isolation of small populations over time and preventing dispersal and genetic exchange between populations. Both the loss and fragmentation of suitable habitat by urban and industrial development are still considered to be valid threats throughout the historic range of the callippe silverspot butterfly (USFWS 2009).

Stressor: Illegal collection
Exposure: Collection by lepidopterists.
Response: May reduce a small population below sustainable numbers.
Consequence: Reduction in population and risk of population extirpation.

Narrative: The current amount of illegal collection of this species is not known. However, at the time of listing, collection of the callippe silverspot was a significant threat. Currently, it is still considered to be a potential threat because butterflies in small populations are vulnerable to harm due to the removal of adults. A population may be reduced below sustainable numbers (Allee effect) by removal of females, reducing the probability that new colonies will be founded. Collectors may not realize when they are depleting colonies of butterflies to below threshold limits for the survival or recovery of the colony (USFWS 2009).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Protections under the various federal and state laws and regulations.
Response: Adverse impacts and incidental take may occur under state or federal law.
Consequence: Reduction in population and risk of extirpation.
Narrative: The callippe silverspot butterfly receives some protections under the various federal and state laws and regulations. However, the protection afforded the species in many cases relies on the ESA. Because the various federal and state laws that are in place do not always protect against incidental take of the species, or other adverse impacts, the regulatory mechanisms are inadequate to meet the conservation needs of this subspecies (USFWS 2009).

Stressor: Invasive nonnative plants and succession to coastal scrub
Exposure: Nonnative grasses and forbs, grazing, and the absence of fire or grazing.
Response: Loss of habitat and important nectar species and host plants, thatch inhibiting natural reproduction cycle and altering soil chemistry and composition, and succession to coastal scrub.
Consequence: Reduction in population, and habitat fragmentation.
Narrative: Invasion of California grasslands by nonnative grasses and forbs, as well as conversion to coastal scrub through succession, are serious threats to the callippe silverspot butterfly, the larval foodplant, and nectar plants on which the butterfly depends. European annual grasses and forbs have displaced native forbs in California native grasslands, and in turn have contributed to the decline of the callippe silverspot butterfly. This invasion was facilitated by widespread and intensive grazing. Thatch produced as a result of the buildup of dead invasive grasses and forbs may inhibit the natural reproductive cycle of native plants, and may also adversely alter soil chemistry and composition. Some of the coastal California grasslands may succeed to coastal scrub in the absence of disturbance mechanisms such as fire and grazing, which may prevent coastal scrub encroachment (USFWS 2009).

Stressor: Pesticides
Exposure: Drifting spray from insecticides, or from other treatments like disease-causing bacteria specific to butterflies and moths, or herbicide applications.
Response: Lethal to larva of various species in the genus Speyeria.
Consequence: Reduction in populations, and harm to the larvae.
Narrative: The use of pesticides and herbicides may be a threat to the callippe silverspot butterfly if used in proximity to occupied habitat. Pesticides are not commonly used in the areas that support the callippe silverspot butterflies; however, drifting spray from insecticides, or from other treatments like disease-causing bacteria specific to butterflies and moths, may pose a threat.

Commonly used herbicides may harm the early life stages of a common metalmark butterfly at normal concentrations if directly applied to the larvae (USFWS 2009).

Stressor: Inappropriate grazing regimes
Exposure: Overgrazing
Response: Trampling and overgrazing of vegetation, and reduction in food plants and nectar sources.
Consequence: Destruction of larva, food-plants, and nectar sources.
Narrative: The final listing discussed inappropriate grazing as a potential threat to the callippe silverspot butterfly, particularly if grazing occurs at harmful levels, so that the vegetation is overgrazed and the food plants and nectar sources of the butterfly are greatly reduced in abundance. As an indirect result, trampling by grazing animals was also considered a potential threat because it may lead to the destruction of larva, food-plants, and nectar sources. Improperly managed cattle grazing remains a potential threat to the callippe silverspot butterfly. The population in the Cordelia Hills at Kings/Swett Ranch exists in an area where cattle grazing is used to manage the landscape. This property is the subject of a study that began in 2008 to monitor the effects of the grazing on the species (USFWS 2009).

Stressor: Fire suppression
Exposure: Suppression of naturally occurring grassland fires.
Response: Succession of grasslands and coastal prairie.
Consequence: Elimination of habitat, and more severe fires.
Narrative: Suppression of naturally occurring grassland fires may lead to the succession of grasslands and coastal prairie, thus eliminating habitat that would support the larval host plant. Fire suppression may also lead to the accumulation of dead vegetation, which smothers the host plant, and burns hotter and moves more slowly across the landscape than fires in areas where naturally occurring, periodic fires have removed thatch build-up. The larvae of the callippe silverspot butterfly may survive in the areas where naturally occurring, periodic fires move rapidly though the grassland, and are blown around under windy conditions, leaving patchy areas untouched by fire (USFWS 2009).

Stressor: Small population size
Exposure: Significantly low population levels.
Response: Decreased genetic variability or heterozygosity, the risk of extinction through a single catastrophic event, and difficulty finding a mate.
Consequence: Reduced fitness of a population, and extirpation of a population.
Narrative: The current numbers of individuals in each of the populations remain unknown, and it is possible that some of the populations may drop to significantly lower levels during certain years. This may decrease genetic variability and also places the populations at a greater risk of extinction from a single catastrophic event, such as an infectious disease, or through stochastic demographic fluctuations. Certain density-dependent effects, not directly related to genetics but also stemming from low population numbers, are considered a threat to the callippe silverspot butterfly. These effects include reduced reproduction potential that results from the lack of necessary social interactions, or the difficulty in finding a mate (USFWS 2009).

Stressor: San Bruno Mountain quarries
Exposure: Airborne dust generated from nearby quarries.
Response: Dust and wind-blown grit can harm insects at all life stages.
Consequence: Injury or mortality to individuals.
Narrative: The airborne dust generated from nearby San Bruno Mountain quarries was considered to threaten the butterfly with injury or mortality by clogging their respiratory organs or spiracles. The quarry continues to operate near known occurrences of the callippe silverspot butterfly (USFWS 2009).

Stressor: Human interface activities
Exposure: Interaction with humans, including equestrians, hikers, bicyclists, and off-road vehicles.
Response: Loss of host plant, degradation of habitat, and trampling of eggs and larvae.
Consequence: Potential for extirpation of remaining populations.
Narrative: The increase in the Bay Area's human population has increased the chances of human interaction with this butterfly. The interaction may be destructive and harmful to the butterfly, such as inadvertent trampling of eggs and larvae by hikers; or crushing of eggs, larvae, or pupae by mountain bikes, dirt bikes, or other off road vehicles, both motorized and human-propelled. Degradation of the grassland habitat and loss of the larval host plant due to human impacts continue to threaten the callippe silverspot butterfly (USFWS 2009).

Stressor: Road mortalities
Exposure: Close proximity to roads.
Response: Direct strikes and mortality.
Consequence: Injury or mortality to individuals.
Narrative: Mortalities of callippe silverspot butterflies due to direct strikes of individuals by cars could potentially be significant to those populations existing near roadways (USFWS 2009).

Stressor: Air pollution
Exposure: Proximity to heavily used roads, highways, and freeways.
Response: Pollution from cars can increase depositions of nitrogen compounds, and can facilitate the spread of invasive grasses and forbs.
Consequence: Decrease in population size.
Narrative: Many potential sites with suitable habitat for the callippe silverspot butterfly exist near heavily used roads, highways, and freeways. Pollution in these locations can increase deposition of nitrogen compounds into the soil, thus facilitating the spread of invasive grasses and forbs which may out-compete the native plants, including the host plant, Viola pedunculata. This could result in a decrease in the numbers of host-dependent butterflies (USFWS 2009).

Stressor: Climate change
Exposure: Increase in global temperatures due to climate change.
Response: Disrupt annual weather patterns.
Consequence: Loss of habitat, local extinction, mortality, and range contraction.

Narrative: According to predictions, California will suffer significant consequences as a result of global warming. These may include more winter flooding and summer drought, as well as higher temperatures in lakes and coastal areas. Additionally, global warming increases the frequency of extreme weather events. Extreme events may in turn cause mortality of individuals and range contractions, and may result in a loss of habitat or local extinctions (USFWS 2009).

Recovery

Reclassification Criteria:
There is no published, final, approved recovery plan or approved draft recovery plan that provides objective, measurable criteria for the callippe silverspot butterfly (USFWS 2009).

Delisting Criteria:
There is no published, final, approved recovery plan or approved draft recovery plan that provides objective, measurable criteria for the callippe silverspot butterfly (USFWS 2009).

Recovery Actions:
- Conduct a detailed phylogenetic study throughout the historic range of the callippe silverspot butterfly. Populations of the three local conspecifics (callippe silverspot butterfly, Comstock's silverspot butterfly, and Liliana's silverspot butterfly) must be analyzed genetically at a fine level of discrimination, using the proper molecular markers, to classify them genetically at a sub-species level (USFWS 2009).
- Conduct a nonintrusive study to determine whether there are morphological characteristics that best distinguish the subspecies callippe silverspot butterfly from Comstock's silverspot butterfly and Liliana's silverspot butterfly, and that can be used in the field (USFWS 2009).
- Conduct surveys for the callippe silverspot butterfly throughout the known historic range of the subspecies, include the following locations: Solano County (Lake Herman Open Space Area, Northgate); Contra Costa County (Briones Regional Wilderness); Alameda County (Sunol Regional Wilderness, Ohlone Regional Wilderness, Del Valle Park, Joaquin Miller Park, and Redwood Regional Park); Santa Clara County (Joseph D. Grant County Park, Lick Observatory); and San Mateo County (Russian Ridge Open Space Preserve, Skyline Ridge Open Space Preserve, and La Honda Creek Open Space Preserve). Surveys for undiscovered populations of the butterfly should focus on properties in the San Francisco Bay area that have all of these components: 1) Grasslands with proper topography in the San Francisco Bay area; 2) sufficient larval host plant (Viola pedunculata); 3) adequate nectar sources; 4) a location within the area influenced by coastal fog; and 5) presence of hilltops for mating congregations (USFWS 2009).
- Search for and purchase properties within the historic range of the callippe silverspot butterfly for preservation in perpetuity, which support populations of or have the required habitat components for supporting the callippe silverspot butterfly. Develop individual management plans once the properties have been purchased that will address the needs of the butterfly, the host plant, and a variety of nectar plants (USFWS 2009).
- Review, update, and publish the existing internal draft recovery plan as a final, threats-based recovery plan for the callippe silverspot butterfly. The existing internal draft is based on extensive research and was completed under contract to Dr. Travis Longcore of Urban Wildlands, Inc., in 2004 (USFWS 2009).

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Conservation Measures and Best Management Practices:

- Conservation Banks A mitigation bank or conservation bank (bank) is a property or suite of properties (i.e., umbrella bank, phased bank, etc.), providing habitat or other conservation values that are conserved and managed in perpetuity, and provides ecological functions and services for specified listed species or resources. Mitigation and conservation banks function to offset adverse impacts that occurred elsewhere; therefore, the Service approves a specified number of credits that the bank owner may sell to developers or other project proponents for use as compensation to offset adverse impacts their projects will likely have on listed species. The money from the initial investment and bank credit sales is then used to permanently protect and manage the land for those species and resources. More information about conservation banks within the Sacramento Fish and Wildlife Office's Service area can be found at: https://www.fws.gov/sacramento/es/ConservationBanking/Banks/In-Area/. There are two active conservation banks for the callippe silverspot butterfly. Ridge Top Ranch Wildlife Conservation Bank is a 745-acre (301 ha) grazed grassland property in unincorporated Solano County, and Ohlone West Conservation Bank is a 640-bank in Alameda County. Permittee Responsible Mitigation Permittee-responsible mitigation, also sometimes referred to as turn-key mitigation, includes activities or projects undertaken by a permittee (or authorized agent) to provide compensatory mitigation to offset impacts from a single project. The permittee retains full responsibility for this mitigation. Ideally, permittee-responsible mitigation projects are established in advance of the project-related impacts they are offsetting; however, this typically does not occur due to multiple factors. Permittee-responsible mitigation for the callippe silverspot butterfly has occurred throughout the species range for several projects. More information, including biological opinions rendered by the Service, are available at https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I019. Habitat Conservation Plans Habitat Conservation Plans (HCPs) are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded. HCPs can apply to both listed and non-listed species, including those that are candidates or have been proposed for listing. Regional HCPs develop large-scale conservation strategies within a specific region that are designed to conserve functional ecological systems and the covered species that depend on them. Such HCPs aim to avoid a fragmented conservation landscape by working with local land use authorities and a designated implementing entity to conserve, enhance, and manage a preserve system. Project-level HCPs are designed to fully offset the impacts associated with the permitted activity by contributing to a larger conservation design. Being included as a covered species under an HCP can result in habitat being set aside and managed for the species as mitigation for impacts associated with covered activities, such as planned urban development, within the HCP permit area. In addition to mitigation, avoidance, minimization, and other conservation measures (e.g. monitoring, seasonal work windows, habitat management, etc.) are implemented. HCPs can also utilize banks, in-lieu fee programs, or other mechanisms to preserve habitat in perpetuity and contribute to a regional conservation strategy. There are two current HCPs and one expired HCP that include the callippe silverspot butterfly as a covered species (Table 6); specifics for each HCP are included within each agreement. The Solano Multispecies HCP is an additional HCP in preparation within the range of the callippe silverspot butterfly. More information about HCPs that include the callippe silverspot butterfly as a covered species can be found at: https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I019. (USFWS, 2020)

- RECOMMENDATIONS FOR FUTURE ACTIONS x Continue demographic monitoring: Continued surveys for populations will assist with assessing status and trends. x Monitor nectar plants across populations and establish quantitative metrics for assessing condition of nectar plants. Understanding nectar plant diversity and abundance at each of the populations will be helpful in assessing condition. Establishing quantitative metrics for assessing condition of nectar plants can be used in subsequent versions of the SSA report. x Survey host plants across population sites. As with nectar plants, understanding the density and/or linear coverage of host plants at each of the population sites will help with assessing population condition in future status assessments. x Implement a pilot grazing study on San Bruno Mountain. Grazing is expected to reduce non-native grasses, thatch, and scrub encroachment, thereby improving habitat for callippe silverspot butterfly nectar and host plant species. Cattle grazing as a habitat management tool should be consistent with other rare plant needs on San Bruno Mountain. x Review, update, and publish a Recovery Plan and Recovery Implementation Schedule: Update the internal draft recovery plan using the SSA report. The Recovery Plan and Recovery Implementation Schedule will describe the vision and criteria for recovery of the species and identify specific activities needed. x Establish a callippe silverspot butterfly working group or recovery implementation team: The group would serve to coordinate and facilitate recovery actions and implementation. By conducting organized discussions with relevant parties, coordination in conservation efforts will be increased. (USFWS, 2020a)

Additional Threshold Information:

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SPECIES ACCOUNT: *Speyeria zerene behrensii* (Behren's silverspot butterfly)

Species Taxonomic and Listing Information

Commonly-used Acronym: BSB

Listing Status: Endangered; December 5, 1997 (62 FR 64306).

Physical Description

Behren's silverspot (Speyeria zerene behrensii, BSB) is in the family Nymphalidae, or brush-footed butterflies. It is a medium-sized butterfly with a wingspan of approximately 5.5 centimeters (2.2 inches). The dorsal wing surfaces are golden brown with numerous black spots and lines. Ventral surfaces are brown, orange-brown, and tan with black lines and distinctive silver and black spots. Basal areas of the wings and body are densely pubescent (Black and Vaughan 2005).

Taxonomy

The Behren's silverspot butterfly has been identified as one of 15 subspecies of Speyeria zerene. Subspecies of S. zerene are clustered into five major groups that are genetically distinct but not genetically isolated; some interbreeding likely occurs. These groupings are: (1) the bremnerii group in the Pacific Northwest west of the Cascade Range and on the California Coast, of which Behren's silverspot is a member; (2) the typical zerene group in the Sierra Nevada, southern Cascade, Siskiyou, and Salmon mountains and in the northern California Coast Range; (3) the carolae group along the eastern slope of the Sierra Nevada and in southern California; (4) the garretti group east of the Cascade Range in the Pacific Northwest and through the Rocky Mountains; and (5) the gunderi group in the Great Basin (USFWS 2015). Silverspot butterfly populations near Jenner in central coastal Sonoma County appear to have intermediates between the Myrtle's (or potentially the currently unrecognized Point Reyes) silverspot butterfly (S. z. myrtleae and proposed S. z. puntareyes) and the Behren's silverspot butterfly (USFWS 2015). The Behren's silverspot butterfly differs from the Oregon silverspot butterfly (S. z. hippolyta) primarily by its darker suffusion of color on the upper sides of the wings near the base, and its relatively larger size. The Myrtle's silverspot butterfly (S. z. myrtleae) is larger and lighter in color than the Behren's silverspot butterfly (USFWS 2015).

Historical Range

The Behren's silverspot butterfly is historically known from six coastal terrace prairie locations which extended from the vicinity of the City of Mendocino, Mendocino County, south to the area of Salt Point State Park, Sonoma County. The six locations, from north to south are: (1) Mendocino headlands; (2) Point Arena; (3) south Anchor Bay headlands (type location); (4) Sea Ranch; (5) Stewarts Point; and (6) north of Salt Point. The record is unclear regarding specimens collected to the south near Jenner, at the mouth of the Russian River. Some older records from the 1930s, 1940s, and into the 1970s indicate that S.z. behrensii may have extended as far north as Orick, Humboldt County, California. However, the Humboldt County records are most likely the gloriosa silverspot butterfly (S. z. gloriosa), which exhibits a range of phenotypic variation overlapping with S. z. behrensii (USFWS 2015).

Current Range

The current distribution of the Behren's silverspot butterfly is not well known. The largest numbers of individuals are likely near Point Arena, Mendocino County, California. Generally, the range is considered to be north of the Russian River, Sonoma County, to the vicinity of Laguna Point in MacKerricher State Park, Mendocino County. Because the type location is north of the current range, and suitable habitat extends to Laguna Point, the range of the species may extend further north than document in 1997 (at listing) (USFWS 2015).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: On hatching, the first-instar caterpillars eat the lining of the eggshell, prior to their pre-diapause (i.e., physical dormancy) movement. Larvae of the Behren’s silverspot butterfly rely solely on their larval host plant, early blue violet (Viola adunca) for feeding. Early blue violets have a widespread distribution in western North America; within the Behren's silverspot range, this violet species is associated with coastal grasslands. During the spring and early summer, larvae pass through six instars (stages of larval development) as they grow, before forming a pupa. After termination of their diapause in the spring, caterpillars immediately seek out the food plant, and resume feeding (USFWS 2012; USFWS 2015).

Adult: Observations of nectaring by adult Behren's silverspot butterflies are scant, but plant species used include thistles (Cirsium spp.), false dandelion (Hypochaeris radicata), gumplant (Grindelia stricta), and reportedly lupines (Lupinus spp.). Nectar plants most frequently used by other subspecies include members of the Asteraceae, including goldenrods (Solidago spp.), tansy ragwort (Senecio jacobaea), California aster (Aster chilensis), pearly everlasting (Anaphalis margaritacea), thistles (including C. vulgare and C. arvense), gumplant, seaside daisy (Erigeron glaucus), mule-ears (Wyethia sp.), and yarrow (Achillea millefolium). Reported nectar species from other plant families include yellow sand verbena (Abronia latifolia), sea-pink (Armeria maritima), and western pennyroyal (Monardella undulata). Species used less frequently by Oregon silverspots include coyote bush (Baccharis pilularis), woolly sunflower (Eriophyllum lanatum), smooth hawksbeard (Crepis capillaris), and false dandelion. As with most butterflies, adults fly mainly when the sun shines, and often roost on or near the ground in low vegetation when overcast and cooler. Behren’s silverspot butterfly require a coastal terrace prairie that contains both caterpillar host plants and adult nectar sources. Adults may feed on nectar for as long as 5 minutes, returning to the same plant repeatedly (USFWS 2012).

Reproduction Narrative

Larvae: During the larval phase in the early spring and summer, larvae pass through six instars as they grow, before forming a pupa. On hatching, larvae pass the fall and winter in diapause. Upon ending diapause in the spring, the larvae pass through five instars before forming a pupa. The pupal stage lasts for about 2 weeks (USFWS 2011).

Adult: The adults emerge after about 2 weeks in the pupa stage and live for approximately 3 weeks (USFWS 2012). Depending on environmental conditions, the flight period ranges from about July through August or early September. Adult Behren's silverspot butterflies require abundant supplies of the larval food plant and abundant nectar sources (USFWS 2011). As is typical for Speyeria, including other Speyeria zerene subspecies, Behren's females presumably oviposit (lay eggs) on or near early blue violets, during the July to September period. Based on studies of the Oregon silverspot butterfly, Behren's females likely selectively oviposit in areas of higher violet density and lower vegetation height (USFWS 2012).

Geographic or Habitat Restraints or Barriers

Larvae: See Adult life stage.

Adult: Habitat fragmentation (USFWS 2015).

Spatial Arrangements of the Population

Larvae: See Adult life stage.

Adult: Clumped

Environmental Specificity

Larvae: See Adult life stage.

Adult: Narrow

Tolerance Ranges/Thresholds

Larvae: See Adult life stage.

Adult: Moderate

Site Fidelity

Larvae: See Adult life stage.

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: See Adult life stage.

Adult: Behren's silverspot butterfly is dependent on the presence of the early blue violet and abundant nectar sources (USFWS 2011).

Habitat Narrative

Larvae: See Adult life stage.

Adult: The Behren's silverspot butterfly inhabits coastal terrace prairie habitat west of the Coast Range in southern Mendocino and northern Sonoma counties, California. This habitat is strongly influenced by proximity to the ocean, with mild temperatures, moderate rainfall, and frequent summer fog. An occupied site must have two key resources: 1) caterpillar host plants; and 2) adult nectar sources. Coastal terrace prairie is a dense grassland dominated by perennial grasses, on sandy loam soils on marine terraces below about 305 meters (m) (1,000 ft.) elevation and in the zone of coastal fog. In addition to perennial and annual grasses, the coastal prairie vegetation includes bracken ferns (Pteridium aquilinum) and woody shrubs, and trees such as coyote brush (Baccharis pilularis), red alder (Alnus rubra), salal (Gaultheria shallon), and conifers. Behren's silverspot butterflies require trees and large shrubs, as well as topographic features to provide sheltered pockets from the wind (USFWS 2011). Movement and dispersal of Behren's silverspot butterflies is restricted by habitat fragmentation (USFWS 2012).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Low

Adult: Unknown (USFWS 2015)

Immigration/Emigration

Larvae: See Adult life stage.

Adult: Unlikely, due primarily to habitat fragmentation (USFWS 2015).

Dependency on Other Individuals or Species for Dispersal

Larvae: See Adult life stage.

Adult: Behren's silverspot butterfly is dependent on the presence of early blue violet (USFWS 2015).

Dispersal/Migration Narrative

Larvae: See Adult life stage.

Adult: The Behren's silverspot butterfly is nonmigratory, with moderate mobility. Information related to dispersal is largely unknown. Historically, the Behren's silverspot butterfly likely occurred as a number of metapopulations at geographically separated localities, each of which was composed of one to several subpopulations interlinked by occasional movement of individuals (USFWS 2015). Interbreeding between populations in a metapopulation likely helped maintain the genetic diversity necessary for a viable metapopulation (USFWS 2015). Currently, immigration/emigration is unlikely due to habitat fragmentation (USFWS 2015).

Additional Life History Information

Larvae: See Adult life stage.

Population Information and Trends

Population Trends:

Short-term trend of decline of <30 percent to relatively stable (NatureServe 2015).

Species Trends:

Long-term trend of decline of 50 to 90 percent. Currently, the trend is one of slow decline to relatively stable (NatureServe 2015).

Number of Populations:

Four: Salt Point, Stewart's Point, Point Arena, and Manchester (USFWS 2015).

Population Size:

Unknown (USFWS 2015). 50 to 2,500 (NatureServe 2015).

Resistance to Disease:

Unknown (USFWS 2012)

Adaptability:

Low

Additional Population-level Information:

Little is known about the amount and distribution of suitable habitat for the Behren's silverspot butterfly. Remaining coastal prairie habitat is highly fragmented by agricultural and residential use, roads, and other human development. The population status of Behren's silverspot is not well known, but surveys suggest that numbers are very low (USFWS 2011).

Population Narrative:

Little is known regarding the current or historic status of the Behren's silverspot butterfly. Currently, there are four metapopulations: in Salt Point, Stewart's Point, Point Arena, and Manchester. The long-term trend has been one of significant decline of between 50 to 90 percent. Currently, the trend is one of slow decline to relative stability (NatureServe 2015). Presence surveys conducted in 2005 located adult Behren's silverspot butterflies at Salt Point, Stewart's Point, Point Arena, and Manchester.Although individual butterflies have been observed at Salt Point, Stewart's Point, and in the Point Arena-Manchester area in the past 5 to 10 years, the size and viability of populations are unknown, and estimates are wide-ranging (population size is somewhere between 50 and 2,500 individuals (NatureServe 2015; USFWS 2015). Little is known about the amount and distribution of suitable habitat for the Behren's silverspot. Remaining coastal prairie habitat is highly fragmented by agricultural and residential use, roads, and other human development. The population status of Behren's silverspot is not well known, but surveys suggest that numbers are very low (USFWS 2011).

Threats and Stressors

Stressor: Succession
Exposure: Disturbance mechanisms (such as wildfire) that maintain grassland butterfly habitat continue to be suppressed.
Response: Shrubs and trees encroaching on and ultimately replacing coastal prairies.
Consequence: Loss of habitat, and reduction in populations.
Narrative: Disturbance regimes have changed dramatically over the last century. To some degree, landslides; burrowing by small mammals; and herbivory by invertebrates, small mammals, and large native ungulates likely played a role in creating or maintaining open conditions. Fire, likely set by indigenous peoples, was an important factor that maintained coastal terrace prairie habitat. The timing and frequency of the historical fire regime is not well understood for the Mendocino and Sonoma coasts of California. Most fires probably occurred in late summer and early fall, although some may have occurred in January or February during dry periods. Fire can dictate plant species composition, and influence their distribution. In addition, fire can make host violets accessible to butterflies by removing the buildup of thatch, composed of dead vegetation. Ash, a result of fires, is an important nutrient and soil component. Fire also has the potential to kill butterfly eggs and caterpillars (i.e. larvae), potentially affecting population numbers (USFWS 2015).

Stressor: Exotic vegetation
Exposure: Loss of disturbance patterns and regimes.
Response: Increase in nonnative plants, and decrease in access to host plants.
Consequence: Reduced population size.
Narrative: Loss of major disturbance patterns has accelerated succession at historical and potential Behren’s silverspot butterfly sites. A number of plants increase under lower disturbance levels. Lack of historical disturbance regimes has probably accelerated expansion of several nonnative plant species that are a threat to Behren’s silverspot butterfly populations, in addition to facilitating encroachment of native shrubs and trees. The spread of nonnative plants has likely reduced, degraded, or eliminated habitat for the Behren’s silverspot butterfly at several sites by

making larval host plants and nectar sources difficult to access. Tall shrubs and grasses impede an individual butterfly's ability to find and use low-laying violets for egg-laying. Similarly, nectar sources can be difficult to reach as well. Tall grasses and deep thatch depth prevent the Behren's silverspot butterfly from accessing violets, which are a necessary component to larval (caterpillar) development. Failure to access early blue violets prevents female butterflies from successfully ovipositing their eggs (USFWS 2015).

Stressor: Livestock grazing
Exposure: Grazing occurs at the Point Arena site, as well as on Stewarts Point.
Response: Possible degradation of habitat, and cause of erosion.
Consequence: Reduction in availability of nectar plants and early blue violets, and reduction in populations.
Narrative: Poor grazing management can denude vegetation and reduce habitat quality. In addition, it is conceivable that the use of livestock in an area where Behren's silverspot butterfly larvae are densely populated could result in the trampling of larvae and host plants. Grazing of host plants and trampling could be a significant source of butterfly mortality for Behren's silverspot butterfly. Potentially, grazing could result in eggs and larvae being incidentally consumed by livestock along with violets (USFWS 2015).

Stressor: Development
Exposure: Residential and agricultural development.
Response: Reduction in the amount and quality of remaining habitat.
Consequence: Decline of populations, and risk of extirpation.
Narrative: Agricultural, residential, and commercial development have removed or degraded habitat for the Behren's silverspot butterfly. For example, coastal terrace prairie has been converted to agricultural uses, especially row crops. The Sea Ranch residential community in Sonoma County likely resulted in the degradation and loss of Behren's silverspot butterfly habitat, and the construction of U.S. Highway 1 along the coast has affected ecosystem processes on coastal terrace prairies by traversing watercourses, stabilizing soils at some locations, creating cuts at others, and providing public access. In addition, fire suppression associated with settlement of the region has greatly increased the rate of succession. As a result, native coastal terrace prairie habitats have been altered, changing vegetation communities from those preferred by the Behren's silverspot butterfly to plant assemblages that are less suitable (USFWS 2015).

Stressor: Butterfly collecting
Exposure: Collection
Response: Removal of individuals from population.
Consequence: Reduction or elimination of populations, loss of individuals, and loss of genetic variability.
Narrative: For a number of butterfly species that exist in small colonies, collection or repeated handling and marking (particularly of females and in years of low abundance) can seriously affect populations through loss of individuals and loss of genetic variability. Collection of females dispersing from a colony also can reduce the probability that new populations will be established.

Species with small populations at only a few sites, such as Behren's silverspot butterfly, may be adversely affected by the cumulative effect of removal of only one or very few individuals from a site by a few collectors. Collectors who take every specimen they can find on successive days could easily eliminate populations of some species in just a few years (USFWS 2015).

Stressor: Disease and parasitoids (parasites on butterflies)
Exposure: There is a potential for the species to be infected with bacteria of the genus Wolbachia.
Response: Adverse effects of the Wolbachia infection on the reproductive biology of the host.
Consequence: In some cases, male and female butterflies with different strains of Wolbachia cannot produce viable offspring.
Narrative: Disease could be a threat that has not yet been identified for the Behren's silverspot butterfly. Wolbachia, an intercellular bacterium, has been detected in other butterfly species and can potentially affect the health of small populations of butterflies. Although not detected in the genus Speyeria, Wolbachia bacteria have been identified in other species of butterflies in the family Nymphalidae. Similarly, parasitoids or parasites are a possible threat that could depress or deplete metapopulation numbers by killing caterpillars. For example, some wasp and fly larvae feed on butterfly caterpillars and can affect local butterfly populations. However, no parasitoids or parasites are known to affect the Behren's silverspot butterfly, although no studies have been conducted to determine whether this is the case (USFWS 2015).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Many federal and state regulatory mechanisms provide discretionary protections for the species, based on current management direction.
Response: This does not guarantee protection for the species absent its status under the federal Endangered Species Act (ESA).
Consequence: Most laws and regulations, aside from the federal ESA, have limited ability to protect the species in the absence of ESA.
Narrative: There has been no change in the imminence of this threat factor since the time of listing. The original listing rule did not address regulatory mechanisms. The California Environmental Quality Act (CEQA) affords limited protection for the species under state law, due to its status as a federally endangered species. The California Coastal Act of 1976 applies when habitat is in the coastal zone. However, the Coastal Zone Management and the California Coastal Acts do not address the injury or death of butterflies, and only reduce loss or degradation of habitat. These Acts do not necessarily prevent a net loss of habitat or loss of individual butterflies. Butterflies and habitat on nonfederal lands are subject to provisions in Section 10 of the ESA, and CEQA (state law) (USFWS 2015).

Stressor: Climate change
Exposure: Grazing occurs at the Point Arena site as well as on Stewarts Point.
Response: Some models predict warmer average temperatures.
Consequence: May result in extended flight periods, or could result in a change in the Behren's silverspot butterfly's range.

Narrative: Changes in climate may cause the migration of multiple subspecies of Speyeria butterflies to alter their distribution as they seek to adjust to changes in temperature, moisture, storm frequency, and habitat changes that result from climate change, thereby increasing their likelihood to overlap. The resulting overlap may result in interbreeding that dilutes the genetic uniqueness of each of the subspecies. Under this scenario, the varying subspecies of silverspot butterflies could become a single species with little genetic variation. As the climate generally gets warmer, the Behren's life cycle may adjust, with egg and caterpillar development being shorter, and the adult flight period being earlier. Depending on the type of climate change and its degree, there is a potential for the effects of climate change to hasten population decreases. Under some models, sea-level rise is expected to increase up to 4 ft. over the next century. An increase in sea level, storm frequency, and intensity can result in erosion of coastal terrace and sand dune habitats, reducing the amount of habitat available to the butterfly. In addition, vegetation composition could change depending on rainfall and temperature trends. Changes in vegetation may favor invasive species that tend to have a better ability to adapt to changing conditions than endemic, or site-specific species. Furthermore, we anticipate that an increase in wind, particularly during the flight period, may affect the ability for Behren's silverspot butterflies to oviposit. In summary, climate change has the potential to affect butterfly habitat, food sources, distribution, genetics, and survivorship. However, it should be noted that supporting data are lacking, and this is our best estimate based on climate change models (USFWS 2015).

Recovery

Reclassification Criteria:
The Behren's silverspot butterfly can be reclassified to threatened status when:

Three metapopulations in Mendocino County and one metapopulation in Sonoma County occupy (currently known, discovered, or reintroduced) sites that reflect historical distribution (four metapopulations represent the historical distribution).

All four metapopulations are protected and managed in perpetuity (USFWS 2015).

Adequate funding for management of all four sites is ensured, and U.S. Fish and Wildlife Service-approved adaptive management plans that control threats to the habitat—such as succession, exotic vegetation, and livestock grazing—have been developed and are being implemented (USFWS 2015).

Annual monitoring has shown that the range-wide population cumulatively supports a minimum of 4,000 adults for at least 10 consecutive years, with no individual protected metapopulation having fewer than 1,000 adults in any year. This figure is consistent with metapopulation sizes in closely related taxa, but may be revised as more species-specific information becomes available. Each metapopulation needs to reflect a stable or increasing population trend over the 10-year period (USFWS 2015).

Delisting Criteria:

Delisting the Behren’s silverspot butterfly can be considered when all of the following conditions have been met after downlisting:

Metapopulations have been established at six protected locations: two in Sonoma County and four in Mendocino County (USFWS 2015).

The six protected metapopulations are protected and managed in perpetuity for Behren's silverspot butterfly, and threats are sufficiently controlled or ameliorated through the active implementation of management plans (USFWS 2015).

Each of the six protected metapopulations supports a minimum viable population of 1,000 adult butterflies for at least 10 years (i.e., 6,000 butterflies across the range). This figure is consistent with metapopulation sizes in closely related taxa, but may be revised as more species-specific information becomes available. Each metapopulation needs to reflect a stable or increasing population trend over the 10-year period (USFWS 2015).

Recovery Actions:
- Protect habitat for the Behren's silverspot butterfly (USFWS 2015).
- Determine ecological requirements, population constraints, and management needs of the Behren's silverspot butterfly (USFWS 2015).
- Monitor the Behren's silverspot butterfly's status and habitat (USFWS 2015).
- Reduce take (USFWS 2015).
- Undertake public information and outreach programs (USFWS 2015).
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Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: Genetics To date, no work on the genetics of Behren’s silverspot has been completed. Work to determine local genetic substructure of Behren’s silverspot would be helpful in determining the metapopulation structure for the species as well as guide best practices for reintroduction and augmentation efforts in the future. Identification of the Comptche specimen As referenced in previous 5-Year Reviews, there exists a 1973 specimen identified as Behren’s silverspot from Comptche in Mendocino County. This would represent a proportionally large range extension for the subspecies and is in habitat much different than all other populations. Other related subspecies exist nearer to this location (i.e., S. z. zerene). Resolution of this would provide a more full understanding of the distribution of this subspecies. Additional searches for populations and follow up on previous detections Given the very low numbers of butterflies counted each year, it is possible that unknown populations exist and contribute to the persistence of these small, known populations. Private land exists along the coast, which includes grazed lands, which have been shown to benefit violet growth, which are important in Behren’s life cyle. Any novel detections of Behren’s are notable and could substantially contribute to the recovery of the species. Establishment of captive rearing program Small populations are vulnerable to stochastic events which may substantially decrease population viability. Captive rearing and augmentation will help prevent extinction of Behren’s silverspot by bolstering existing populations. Additionally, the recovery criteria for Behren’s silverspot include population size targets as well as population number targets. Augmentation and reintroduction can help achieve these goals more quickly. Population indices are far from recovery targets and have not shown increasing trends for the past several years.

Captive rearing and augmentation of Oregon silverspot has proven to be useful to prevent extirpation at several locations in Oregon and is being considered for a critically imperiled population in northern California. Similar efforts may be critical to prevent extirpation and in recovering Behren's silverspot butterfly. The work completed on Oregon silverspot captive rearing protocols and establishment of facilities provides an advantage to establishing a captive rearing program for Behren's silverspot. If captive rearing is to be done, reliance on these protocols and facilities will be essential for success. (USFWS, 2020)

Additional Threshold Information:

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USFWS. 2020. 5-YEAR REVIEW Behren’s silverspot butterfly (Speyeria zerene behrensii). 3 pp.

SPECIES ACCOUNT: *Speyeria zerene hippolyta* (Oregon silverspot butterfly)

Species Taxonomic and Listing Information

Listing Status: Threatened; October 15, 1980 (45 FR 44935).

Physical Description

The Oregon silverspot butterfly (Speyeria zerene hippolyta) is a small, darkly marked coastal subspecies of the Zerene fritillary (S. zerene). It is an orange and brown butterfly with silver spots on the underwings. The Oregon silverspot butterfly is one of five subspecies in the bremnerii group. Diagnostic characters of the bremnerii group are as follows: 1. Ground color on dorsal wings is medium to reddish orange with heavy dark basal suffusion; 2. Veins of dorsal male forewing thickened with dark androconial scales; 3. Ventral hindwing with a dark reddish brown disc; 4. Ventral hindwing with a narrow yellow to lavender submarginal band; and 5. Ventral hindwing with small, metallic silver spots in discal, median, and submarginal areas of the wing (45 FR 44935; USFWS 2001).

Taxonomy

The Oregon silverspot butterfly belongs to true fritillary, or silverspot butterflies, which comprise the genus Speyeria within the family Nymphalidae. The Oregon silverspot butterfly is one of 15 subspecies of S. zerene. The wings are small (the male forewing length is 24 to 29 millimeters [mm], and the mean is 27 mm). The Oregon silverspot butterfly is similar in appearance to two other coastal subspecies of Speyeria zerene, the Behren's silverspot butterfly (S. z. behrensii) and Myrtle's silverspot butterfly (S. z. myrtleae), both of which are also federally listed. The primary differences of the Oregon silverspot from the Behren's silverspot are its less dark basal suffusion on the upper sides of the wings, its relative smaller size, and its clear yellow submarginal band (as opposed to the lavender bands in Behren's silverspot). The Myrtle's silverspot is larger in size than the Oregon silverspot. Both the Myrtle's and Behren's silverspot butterflies occur well to the south of the Oregon silverspot (45 FR 44935; USFWS 2001; USFWS 2011).

Historical Range

The historical range of the subspecies extends from Westport, Grays Harbor County, Washington, south to Del Norte County, California. At least 20 separate locations were known to support Oregon silverspot butterfly in the past, between 1895 and 1975 (USFWS 2011). Within its range, the butterfly is known to have been extirpated from at least 11 colonies (two in Washington, eight in Oregon, and one in California) (USFWS 2001).

Current Range

At the time of listing, only one out of eight known populations was considered viable (at Rock Creek-Big Creek in Lane County, Oregon, managed by the U.S. Forest Service in Siuslaw National Forest). Additional Oregon silverspot butterfly populations were discovered at Cascade Head, Bray Point, and Clatsop Plains in Oregon, to the north on the Long Beach Peninsula in Washington, and to the south in Del Norte County, California (USFWS 2001). Currently, only five populations are known to be extant: the Rock Creek-Big Creek, Bray Point, Cascade Head, and Mt. Hebo populations in Oregon; and the Del Norte County population in California (USFWS 2011).

Critical Habitat Designated

Yes; 10/15/1980.

Legal Description

On July 2, 1980, the U.S. Fish and Wildlife Service designated critical habitat for Speyeria zerene hippolyta (Oregon silverspot butterfly) under the Endangered Species Act of 1973, as amended. The critical habitat designation is in Lane County, Oregon (45 FR 44935-44939).
The critical habitat designation for Speyeria zerene hippolyta includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Speyeria zerene hippolyta.

Critical Habitat Designation

Critical habitat for the Oregon silverspot butterfly is designated in Lane County, Oregon: T. 16 S., R. 12 W. These portions of section 15 and of the south half of section 10 which are west of a line parallel to and 1500 feet west of, the east section boundaries of sections 10 and 15.

Primary Constituent Elements/Physical or Biological Features

Constituent biological elements essential to the continued existence of the Oregon silverspot butterfly within the critical habitat include:

(i) the larval foodplant (Viola odunca),

(ii) grasses and forbs in which the larvae find shelter,

(iii) the composite plants from which the adults obtain nectar, and

(iv) the spruce woods in which the adults find shelter.

Special Management Considerations or Protections

Activities that may adversely modify habitat include: 1. Real estate development in the coastal salt spray meadows. 2. Increased recreational use, including trampling, vehicles, and trail development. 3. Modification of forest areas adjoining the salt spray meadows.

Life History

Feeding Narrative

Larvae: Oregon silverspot larvae feed exclusively on leaves of violets (Viola sp.). Newly hatched first-instar larvae immediately enter diapause (physiological dormancy) after eating the lining of the eggshell. They remain in diapause until host plants send up new growth in spring. The larvae go through a total of six instar growth cycles before entering their pupal stage and final metamorphosis into an adult. Larvae require stands of early blue violets abundant enough to provide sufficient food; these stands occur only in relatively open and low-growing grasslands, where violets may be an abundant component of the plant community. Based on laboratory studies, 200 to 300 violet leaves, or 534 cm2 of leaf area, are needed to allow an Oregon silverspot butterfly to develop from caterpillar to pupae. In the wild, a caterpillar would require a clump of approximately 16 violet plants for development, assuming each violet could provide about 12 to 20 leaves (USFWS 2011; USFWS 2001). However, recent data suggests that estimating violet plant needed per larvae is an inadequate metric, as each plant averages different leaf area, violets grow continually throughout the season. Rather, the density of violet plant/leaves may be more important for larval forage capability.

Adult: Adult Oregon silverspot butterflies feed on nectar from several species. Most frequently, they feed on nectar from Canada goldenrod (Solidago canadensis), dune goldenrod (Solidago spathulata), California aster (Aster chilensis), pearly everlasting (Anaphalis margaritacea), dune thistle (Cirsium edule), and yarrow (Achillea millefolium). Oregon silverspot butterflies are also known to nectar on two common introduced species: tansy ragwort (Senecio jacobaeae) and false dandelion (Hypochaeris radicata). Less frequently used species in the aster family include introduced thistles in the genus Cirsium, chaparral broom (Baccharis pilularis), smooth hawksbeard (Crepis capillaris), and woolly sunflower (Eriophyllum lanatum). Based on studies of other butterflies, nectar abundance and quality are important to adult survival, particularly fecundity (USFWS 2011, NatureServe 2015; USFWS 2001).Feeding adults emerge between July and September. Feeding is dependent on the flowering nectar plants, which require early successional grassland habitat. Individuals will fly several kilometers (km) (couple of miles) to reach food sources, and require protection from strong coastal winds and spray for movement through their habitat. Adults are diurnal, being most active during calm weather and inactive during storms and windy periods (USFWS 2001).

Reproduction Narrative

Adult: The Oregon silverspot butterfly reaches sexual maturity between 10 and 12 months (the time from eclosion to emergence as an adult). Mating usually takes place in relatively sheltered areas from mid-July into early September. Early blue violet (Viola adunca) is the main plant that Oregon on which silverspot butterflies lay their eggs, though several other species in the Viola genus may be used by different populations. Field studies have demonstrated that female butterflies select areas with high early blue violet (Viola adunca) densities for egg laying (USFWS 2011). Females seemed to preferentially search for ovipositing sites in areas with vegetation heights of 22 to 25 cm (8.6 to 10 in.) in bluffs and other areas, for protection from inclement weather. Males tend to appear several weeks before females, which is typical of Speyeria butterflies. The species’ reproductive strategy is oviparity (females lay eggs, with little or no other embryonic development within the mother) and univoltine (has a single reproductive event per year). The number of eggs per clutch varies, depending on genetic and environmental factors. During efforts to rear butterflies in the lab in 1985, 450 caterpillars were reared from eggs taken from four females. This would average approximately 112 eggs per female (USFWS

2001). Annual reports of captive rearing from the Oregon and Woodland Park Zoos indicidate the females can lay, on average, 279 eggs in captivity and nectar resource and quality most likely effects fecundity rates. The species' adult lifespan is variable; it may live up to several weeks (USFWS 2001).

Geographic or Habitat Restraints or Barriers

Larvae: Restricted to host plant location.

Adult: Adult butterflies are typically found in areas that are sheltered from the wind (USFWS 2001).

Spatial Arrangements of the Population

Larvae: Same as adult.

Adult: Clumped

Environmental Specificity

Larvae: Narrow/specialist.

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Larvae: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: Same as adult.

Adult: Requires blue violet and other members of Viola genus. Requires several plant species to use as a nectar source.

Habitat Narrative

Larvae: Oregon silverspot larvae are habitat specialists, occupying early successional, coastally-influenced grassland habitat. These habitats include montane/grasslands, marine terraces and headlands, and stabilized dunes. The larvae use dense stands of blue violet or related Viola genus plants as a food source and to provide protection from predation. Small stands of violets found in small forest clearings isolated from open grasslands are not adequate to support the butterfly. At Lake Earl, populations of Aleutian violets (Viola langsdorfii) grow in wet areas adjacent to areas with early blue violets, and may serve as secondary food plants for silverspot caterpillars (USFWS 2001; USFWS 2011).

Adult: Oregon silverspot butterfly adults are generalists that require early successional, coastally-influenced grassland habitat. These habitats include montane/grasslands, marine terraces and headlands, and stabilized dunes, and are typically found in areas that are sheltered from the wind. They use dense stands of blue violet or related Viola genus plants as a place to lay their eggs, with studies showing females seeming to preferentially search for ovipositing sites in areas with a high density of early blue violets (25 plants), <10cm height of native low forbs, a presence of native oatgrass or fescue, 5-17.5% native strawberry and 5-17.5% bar soil or rock (Glavich 2021). Their habitat also must be able to maintain a variety of nectar sources for feeding. Observations suggest that distribution, abundance, and temporal availability of nectar sources may affect the stability of Oregon silverspot butterfly populations (USFWS 2001).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Travel very short distances for purpose of feeding on their host plant.

Adult: Oregon silverspot butterfly may travel several hundred meters (couple hundred feet) or more to find available nectar sources and mates, or to escape windy and foggy conditions (USFWS 2001).

Immigration/Emigration

Adult: Further study is needed into the movement of individuals between populations (USFWS 2001).

Dispersal/Migration Narrative

Larvae: Oregon silverspot larvae travel very short distances in the area of their local violet plant, onto which they hatch. Individuals will feed on the local plant and will remain until emergence as adults (USFWS 2001).

Adult: Oregon silverspot butterfly is nonmigratory, though it may travel several hundred meters (couple hundred feet) for feeding and mating. Individuals may travel between known populations, but further study into the matter is required. The species may require the presence of bluffs and other areas that provide protection from strong winds for movement (USFWS 2001).

Population Information and Trends

Population Trends:

Of the five known populations, two are stable (Mt. Hebo and Del Norte) and the remaining three (Cascade Head, Bray Point, and Rock Creek) are increasing; however, these populations are being augmented with captive reared individuals from the Mt. Hebo population (USFWS 2011).

Species Trends:

Overall, the species has been stable and increasing; however, this is most likely due in large part to augmentation at three population sites (USFWS 2011).

Population Growth Rate:

The Mt. Hebo population has been observed to have a negative growth rate (1999 through 2009) and a chance of extinction within less than 50 years. The other populations are stable or slightly increasing, but require the Mt. Hebo population for augmentation (USFWS 2011).

Number of Populations:

Five (USFWS 2020).

Population Size:

Approximately 2,800 individuals (USFWS 2020).

Minimum Viable Population Size:

Currently available information suggests the minimum size for a population to be viable is approximately 200 to 500 butterflies (USFWS 2001; USFWS 2011).

Resistance to Disease:

Low

Adaptability:

Low

Additional Population-level Information:

Observations suggest that distribution, abundance, and temporal availability of nectar sources may affect the stability of Oregon silverspot butterfly populations (USFWS 2001).

Population Narrative:

The combined threats of isolated populations, habitat degradation, and climate change continue to endanger the species throughout its range. Without augmentations the three coastal Oregon populations would likely be extirpated leaving only the Mt. Hebo and Del Norte, CA populations.

We have concluded that due to: the decrease in butterfly populations from 8 at the time of listing to five known isolated populations, the small size of three of the populations which have triggered augmentations to avoid extirpation, the decrease in suitable habitat quality and quantity, including the loss of one half of critical habitat to succession, the increase in threats in number and range, therefore, we find the Oregon silverspot butterfly in danger of extinction throughout its range. (USFWS, 2020)

Threats and Stressors

Stressor: Invasion by exotic species
Exposure: Introduction of exotic species.
Response: Habitat degradation, reduction of plants available for reproduction and feeding, and barriers to species movement.
Consequence: Reduction in population, and extirpation.
Narrative: Introduction of invasive and nonnative plants can dramatically change the butterfly's habitat, reducing available plants for both reproduction and feeding during their adult stage. Invasives are capable of outcompeting plants the species uses as a food source, and possible creating barriers for movement throughout a habitat. These changes can cause a decline and possible extirpation of populations (USFWS 2001).

Stressor: Natural succession/fire suppression
Exposure: Without proper management, habitat can transition to successional state.
Response: Loss of food sources for larvae and adults, as well as ovipository host plant; and reduction in fecundity.
Consequence: Reduction in population, and extirpation.
Narrative: Three factors affect rates of succession of the Oregon silverspot butterfly's grassland habitats: soil conditions, salt spray and mist from breaking waves, and disturbance regimes. Without these limiting factors, succession is rapid under favorable growing conditions at coastal marine terrace and dune habitats. Although succession is somewhat slower at coastal mountain sites, successional changes in habitat conditions are one of the major remaining threats at all Oregon silverspot butterfly sites (USFWS 2001).

Stressor: Land development/agriculture
Exposure: Development and agriculture.
Response: Habitat fragmentation and degradation; and barriers to species movement.
Consequence: Reduction in population, and extirpation.
Narrative: Both land development and agriculture have caused the loss of Oregon silverspot populations. Development can fragment and destroy habitat, and create potential barriers for movement for individuals within a population. In particularly small populations, this can potentially lead to extirpation of the population (USFWS 2001).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.

Response: Loss of habitat or habitat degradation from populations, and potential for populations to not be properly identified and maintained.
Consequence: Reduction in population, extirpation, habitat loss, and degradation.
Narrative: Critical habitat for the Oregon silverspot butterfly was designated at the time of listing, and comprises portions of Sections 10 and 15 of Oregon's Lane County Township 16, Range 12 West. This designation protects just one population, the only known heathy population at the time. This is of particular concern in the Clatsop Plains area, where the butterfly numbers have declined to such an extent that no individuals have been observed since 1998. In areas like the Clatsop Plains, there is currently no mechanism to conserve unoccupied habitat from which the butterfly has disappeared. State-level protection for the Oregon silverspot butterfly is limited to Washington state, where the Washington Fish and Wildlife Commission listed the Oregon silverspot butterfly as an endangered species. However, the Oregon silverspot butterfly is believed to be extirpated in the state of Washington; therefore, potential or historic habitat is vulnerable to alteration and loss. The state of Oregon's state Endangered Species Act was enacted by the Oregon Legislature in 1987, but the it does not protect invertebrates. The California Endangered Species Act protects some invertebrate species, but does not provide protections for insect species (USFWS 2011).

Stressor: Vehicle traffic
Exposure: Increased traffic bisecting habitat.
Response: Loss of individuals run over or struck by vehicles.
Consequence: Reduction in population.
Narrative: Road kill from vehicle traffic has been and remains a concern since the listing of the species more than 30 years ago. Highway traffic has increased since that time. Highway 101 bisects the coastal Rock Creek-Big Creek critical habitat area. Summer traffic along this stretch of highway is very high during the butterfly flight period. A road mortality study conducted in 2009 reported that between 1 and 10 percent of the butterfly population was likely killed by vehicle collisions. A butterfly movement study in 2010 found the traffic volume to be highest during the time when the butterflies were most active, with traffic volume through the habitat area at 36 to 67 vehicles every 10 minutes between 10:00 a.m. and 4:00 p.m. (USFWS 2011).

Stressor: Climate change
Exposure: Changes to climate, affecting ecological systems.
Response: Species becoming out of sync with host plant and food sources; and habitat degradation over time.
Consequence: Reduction in population, extirpation, habitat loss, and degradation.
Narrative: Climate change and associated weather pattern changes may also affect the continued existence of the Oregon silverspot butterfly. In the Pacific Northwest, temperatures have increased 0.5 degrees Celsius (1.5 degrees Fahrenheit) in the twentieth century, and are expected to increase an additional 3 to 10 degrees Fahrenheit in the next century. The frequency of some extreme weather events has increased, and there is evidence that recent warming is strongly affecting terrestrial biological systems. These changes are resulting in an earlier onset of springtime events as well as poleward range shifts in plant and animal species. Experiments and historic records show that increased temperature is linked with earlier budding, leafing, and

flowering in plants. Animals often alter the timing of their emergence or migration to match plant phonologies, but are not as temporally flexible as plants. Phonological shifts in the plant community on which the Oregon silverspot butterfly depends could lead to a situation where butterfly's needs for plant resources are out of sync with the availability of those resources (USFWS 2011).

Stressor: Disease and predation
Exposure: Bacterial disease and insect predators.
Response: Disease may cause sterility; predation reduces already small and isolated populations.
Consequence: Reduced fitness, reduced population, and extirpation.
Narrative: The potential exists for the species to be infected with a bacteria of the genus Wolbachia. Wolbachia parasitizes its host by inserting mitochondrial DNA, affecting the reproductive biology of the host. As many as 65 percent of invertebrate species are thought to carry a strain of Wolbachia. The infection is passed down to offspring maternally. In some cases, male and female butterflies with different strains of Wolbachia cannot produce viable offspring. The endangered Karner's blue butterfly (Lycaeides melissa) is now known to harbor different strains of Wolbachia within different populations, potentially limiting options for reintroductions or population augmentations. Demographic models have predicted lower invertebrate adult numbers in infected populations, and the infection has increased the potential for extirpation, particularly in small populations. Whether Oregon silverspot butterfly populations carry Wolbachia or different strains of Wolbachia is not known. Research to determine whether Wolbachia is a threat to Oregon silverspot butterfly populations has been proposed prior to reintroduction efforts. Nonnative animal species continue to imperil listed butterflies through predation, parasitism, and possibly competition. These include earwigs (Forficula auricularia), sow bugs (Armadillidium vulgare), and yellow jacket wasps (Vespula pensylvanica). Sow bugs and earwigs are predators on eggs, larvae, and pupae of butterflies. Oregon silverspot butterfly caterpillars were observed being predated on by ants during a foraging study. A large spider was observed eating Oregon silverspot butterfly adults on Mt. Hebo (USFWS 2011).

Recovery

Reclassification Criteria:
The 5-Year Review for Oregon silverspot butterfly recommended an uplisting of the species from threatened to endangered (USFWS 2011). However, formal reclassification criteria have not been developed for the Oregon silverspot butterfly.

Recovery Priority Number: 3

Delisting Criteria:
At least two viable Oregon silverspot butterfly populations exist in protected habitat in each of the following areas: Coastal Mountains, Cascade Head, and Central Coast in Oregon; and Del Norte County in California. At least one viable Oregon silverspot butterfly population exists in protected habitat in each of the following areas: Long Beach Peninsula, Washington, and Clatsop

Plains, Oregon. This includes development of comprehensive management plans (USFWS 2001; USFWS 2011).

Habitats are managed long-term to maintain native, early successional grassland communities. Habitat management maintains and enhances early blue violet (Viola adunca) abundance; provides a minimum of five native nectar species dispersed abundantly throughout the habitat and flowering throughout the entire flight period; and reduces the abundance of invasive nonnative plant species (USFWS 2001; USFWS 2011).

Managed habitat at each population site supports a minimum viable population of 200 to 500 butterflies for at least 10 years (USFWS 2001; USFWS 2011).

Recovery Actions:

- Protect and enhance existing habitat in each of six habitat conservation areas (Long Beach Peninsula, Clatsop Plains, Coastal Mountains, Cascade Head, Central Coast, and Del Norte) (USFWS 2001).
- Determine ecological requirements, population constraints, and management needs of the Oregon silverspot butterfly (USFWS 2001).
- Monitor the butterfly's status and its habitat (USFWS 2001).
- Reduce take (USFWS 2001).
- Uplist the Oregon silverspot butterfly to endangered (USFWS 2011).
- Revise the 2001 Oregon silverspot butterfly recovery plan to include additional locations for reintroductions, to meet the recovery criteria of 10 populations. These updates may include: a. Replacing the small Fairview Mountain site with Saddle Mountain in Clatsop County, Oregon, if it is found to be suitable for reintroduction. Saddle Mountain was historically occupied by the Oregon silverspot butterfly, last observed there in 1973. The Oregon Parks and Recreation Department has expressed an interest in exploring Saddle Mountain as a potential reintroduction site. b. Include the Willapa National Wildlife Refuge Tarlet Slough site in the Long Beach, Washington, Habitat Conservation Area. c. Include the Cannery Hill Unit of the Nestucca Bay National Wildlife Refuge, 11 km (7 miles) north of Cascade Head, if habitat restoration, initiated in 2011, proves successful. d. The Del Norte Habitat Conservation Area has just one population, and another site would need to be identified to meet recovery criteria (USFWS 2011).
- Continue the annual index counts to monitor population levels and direct augmentation or reintroduction efforts (USFWS 2011).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Uplist the Oregon silverspot butterfly to endangered. 2. Revise the 2001, Oregon silverspot butterfly recovery plan to include additional locations for reintroductions to meet the recovery criteria of 10 populations. These updates may include; a. Replacing the small Fairview Mountain site with Saddle Mountain, located in Clatsop County, OR, if it is found to be suitable for reintroduction (Van Buskirk 2010). Saddle Mountain was historically occupied by the Oregon silverspot butterfly, last observed there in 1973 (McCorkle et al. 1980). OPRD has expressed an interest in exploring Saddle Mountain as a potential reintroduction site. b. Include the Willapa National Wildlife Refuge Tarlet Slough site into the Long Beach, WA, Habitat

Conservation Area. c. Include the Cannery Hill Unit of the Nestucca Bay National Wildlife Refuge, located 11 km (7 miles) north of Cascade Head, if habitat restoration, initiated in 2011, proves successful (Van Buskirk 2010). d. The Del Norte Habitat Conservation Area has just one population and another site would need to be identified to meet recovery criteria. 3. Continue the annual index counts to monitor population levels and direct augmentation or reintroduction efforts. (USFWS, 2020)

Additional Threshold Information:

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SPECIES ACCOUNT: *Speyeria zerene myrtleae* (Myrtle's silverspot butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 22, 1992 (57 FR 27848).

Physical Description

Myrtle's silverspot butterfly (Speyeria zerene myrtleae) is a medium-sized butterfly and a member of the brush-foot family (Nymphalidae). The wingspan of the Myrtle's silverspot butterfly averages 55 to 60 millimeters (2.1 to 2.3 inches), with the upper surface of both hind and fore wings being golden brown to fulvous with many conspicuous black spots, lines, and other markings; and the undersides of the wings being light tan, reddish brown, and brown with black lines and distinctive silver spots and black spots. The base of the wings, as well as the body, is covered with hairs (USFWS 2009).

Taxonomy

Myrtle's silverspot is a member of family Nymphalidae and the subspecies myrtleae in the Zerene fritillary (Speyeria zerene) species. There has been inconsistency as to just how this subspecies name has been applied. If S. z. puntareyes is recognized as a valid taxon, then S. z. myrtleae is an extinct taxon known only from Pescadero Point, San Mateo County, California. The extant taxon intended as Federally Endangered would then be S. z. puntareyes. At the time of listing, both were combined as one subspecies and there appears to be no compelling reason why they cannot be a single subspecies (57 FR 27848; NatureServe 2015).

Historical Range

The historic range of the Myrtle's silverspot butterfly is believed to have included the northern California coastal dunes and bluffs from the southern bank of the Russian River in Sonoma County, southward to Point Año Nuevo in San Mateo County. When listed, four areas were known to be inhabited by the subspecies in western Marin and southwestern Sonoma counties, as follows: one population was inhabiting the coastal dunes at the Point Reyes National Seashore, two populations occurred in state beaches in Sonoma County, and a single female was found about 13 kilometers (km) (8 miles [mi.]) inland from the community of Bodega Bay, which may represent a single member of a colony or a dispersing individual (USFWS 2009).

Current Range

The current range of Myrtle's silverspot includes two populations that inhabit Point Reyes National Seashore in coastal dune habitat, instead of a single population as described in the listing. There may be additional separate populations at the Point Reyes National Seashore, but this is difficult to determine without a mark recapture program. The Bodega Bay population described in the listing has not been observed for the last 15 years, with the exception of the sighting of a single individual in foggy weather in 2003. The Valley Ford population, just north of Point Reyes National Seashore, appears to be larger and more dense than originally described.

The area from Bodega Head and southward has not been recently surveyed, and the property that was proposed for a golf course was purchased by private landowners (USFWS 2009).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Feeding is difficult to observe, apparently occurring at dusk and possibly at night. Myrtle's silverspot larvae feeds exclusively on western dog violet (Viola adunca). The western dog violet occurs in vernally moist meadows, damp streambanks, and meadow edges in conifer forest. When individuals hatch, they feed for 7 to 10 weeks, remaining on the plant until their emergence from their pupal stage. When the larvae first hatch, they crawl a short distance into the surrounding foliage or litter, and spin a silk pad on which they spend the fall and winter. The larvae may be able to extend their diapause for more than 1 year. Upon termination of diapause in the spring, the caterpillar finds a nearby violet and begins feeding (USFWS 1998).

Adult: Myrtles silverspot butterfly become nectar generalists in their feeding habits as adults. Individuals will feed on the nectar of numerous coastal sand dune and prairie plants, including gum plants (Grindelia sp.), mule ears (Wyethia sp.), yellow sand verbena (Abronia latifolia), coyote mints (Monardella spp., especially Monardella undulata), bull thistle (Cirsium vulgare), and seaside daisy (Erigeron glaucus). Both sexes are good flyers and can travel several km (couple of mi.) in search of nectar (USFWS 1998).The species' feeding and activity is closely tied to weather conditions; they are active during calm weather and inactive during windy periods (USFWS 1998). Growth of the species is fast, and the pupal stage lasts for about 2 weeks before adults emerge (USFWS 2009).

Reproduction Narrative

Larvae: Larvae live approximately 9 to 12 months, first eclosing in late June to early September and then emerging as an adult in mid-June to mid-July (USFWS 2009).

Adult: Myrtle's silverspot butterfly has one mating event each season during the summer months (late June to early September), which can occur during varying time frames depending on environmental cues. Females oviposit single eggs solely on the dried leaves and stems of the host plant, western dog violet. Males emerge before females and patrol widely looking for females, a behavior that may tend to bias survey counts in their favor. The species requires 9 to 12 months (the time from eclosion to emergence as an adult) to reach sexual maturity, and have a lifespan of up to 5 weeks as an adult. Similar to most insects, the species leave their young to fend for themselves after depositing the eggs. Females lay between 200 and 250 eggs over their lifetime and it is guessed that, as in other Speyeria species, males place a plug after copulation, limiting females to one mating event (57 FR 27848; USFWS 1998; USFWS 2009; NPS 2007).

Geographic or Habitat Restraints or Barriers

Larvae: Restricted to occurrences of host plant.

Adult: Requires areas that provide protection from strong coastal winds (USFWS 2009).

Spatial Arrangements of the Population

Larvae: Same as adult.

Adult: Clumped

Environmental Specificity

Larvae: Narrow/specialist.

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: Low

Adult: Low

Site Fidelity

Larvae: Low

Adult: Low

Dependency on Other Individuals or Species for Habitat

Larvae: Requires western dog violet for feeding, and pupation.

Adult: Requires western dog violet for laying eggs.

Habitat Narrative

Larvae: Many of the habitat requirements for Myrtle's silverspot larvae are similar to those of the adult. Myrtle's silverspot larvae are especially dependent on open prairie and grasslands. The larvae are habitat specialists and are restricted to their host plant, western dog violet. The species also requires a relatively thick density of the host plant for protection from the elements and predation (USFWS 2009).

Adult: Myrtle's silverspot butterfly adults occur in areas with coastal dunes and bluffs, as well as coastal terrace prairie, coastal bluff scrub, and associated nonnative grassland habitats (USFWS 1998). They require open prairie and grasslands near the coast that allow the growth of western dog violet, which they use to lay their eggs. The population is spatially clumped throughout its habitat, with adults being generalists. The species also depends on bluffs and other natural protection from strong coastal winds. Adults are typically found below 250 m (820 ft.) in elevation and within 4.8 km (3 mi.) of the coast (USFWS 2009; Black and Vaughan 2005).

Dispersal/Migration

Motility/Mobility

Larvae: Low

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigratory

Adult: Nonmigratory

Dispersal

Larvae: Travel very short distances for feeding on larval host plant.

Adult: Myrtle's silverspot butterfly may travel several km (couple of mi.) for feeding and mating. Individuals may travel between known populations (USFWS 2009).

Immigration/Emigration

Adult: Further study is needed into the movement of individuals between populations (USFWS 2009).

Dispersal/Migration Narrative

Larvae: Myrtle's silverspot larvae travel very short distances in the immediate vicinity of the western dog violet plant onto which they hatch. Individuals will feed on the local plant and will remain until emergence as adults (USFWS 1998).

Adult: Myrtle's silverspot butterfly are nonmigratory, but may travel several km (couple of mi.) for feeding and mating. Individuals may travel between known populations, but further study into the matter is required. Even though both males and females are known to be strong flyers, the species may require the presence of bluffs and other areas that provide protection from strong winds for movement (USFWS 2009).

Additional Life History Information

Adult: Although the adults of both sexes are known to be fairly strong flyers, Myrtle’s silverspot butterfly prefer areas that are sheltered from the prevailing winds (USFWS 2009).

Population Information and Trends

Population Trends:

Stable, possibly increasing (USFWS 2009).

Species Trends:

Stable, possibly increasing (USFWS 2009).

Population Growth Rate:

Low

Number of Populations:

Three (USFWS 2009)

Population Size:

Approximately 10,000 individuals (USFWS 2009).

Minimum Viable Population Size:

Unknown (USFWS 2009)

Resistance to Disease:

Low

Adaptability:

Low

Additional Population-level Information:

Myrtle's silverspot butterfly may undergo a diapause (period of inactivity) either as a larvae or as an adult female (reproductive diapause where ovarian development occurs after mating); this can occur as a result of climatic cues, as is seen in many butterfly species inhabiting Mediterranean climates. These diapause periods may affect adult emergence and result in underestimates of true population size (USFWS 2009).

Population Narrative:

Myrtle's silverspot butterfly is broken up into three populations, which may represent either satellite populations or core populations. The total population for the species is estimated to be 10,000 individuals, but due to the need for consistent surveying over several seasons, the accuracy of this estimate is unknown. At the time of listing, four populations of Myrtle's silverspot butterflies were known and described, which included the sighting of a single animal that was assumed to be part of a larger population near Valley Ford. Its distribution and abundance has not changed significantly since listing. It appears that at least three stable populations of Myrtle's silverspot butterfly currently exist. Two populations are protected in the Point Reyes National Seashore at North Beach and at the Tomales Bay headlands, while another relatively dense population remains unprotected on private lands in the area west of the small town of Valley Ford. There may be up to three more separate populations at the Point Reyes National Seashore, but this cannot be determined without a mark-recapture study. Additional populations may occur at Bodega Head and along the coastal terrace southward to Dillon Beach, but these areas have not been recently surveyed. Myrtle's silverspot butterfly may undergo a diapause either as a larvae or as an adult female; this can occur as a result of climatic cues, as is seen in many butterfly species inhabiting Mediterranean climates. These diapause periods may affect adult emergence and result in underestimates of true population size (USFWS 1998; USFWS 2009).

Threats and Stressors

Stressor: Habitat disturbance
Exposure: Threat of development in and near habitat.
Response: Loss of food sources, host plant for laying eggs, and area for dispersal.
Consequence: Reduction in population, and populations possibly extirpated.
Narrative: One of the most dominant threats to the Myrtle's silverspot butterfly when listed was the proposed construction of a 507-hectare (1,254-acre) golf course north of Dillon Beach, which would have eliminated one of the most populous sections of Myrtle's silverspot butterfly habitat. The proposed golf course was not built; a smaller, low-density residential development was proposed, but never constructed. Development in this area will remain a threat until sufficient habitat for the Myrtle's silverspot butterfly is acquired and protected. Any urban development of the private lands to the north of the Point Reyes National Seashore should be considered a threat, because the Myrtle's silverspot butterfly habitat is so severely limited in area and range (USFWS 2009).

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes
Exposure: Collection of specimens.
Response: Individual and offspring death from being stepped on or removed from population.
Consequence: Reduction in population.
Narrative: Myrtle's silverspot butterfly are spread over just a few locations, which increases their sensitivity to the loss of individuals from each population. Specimens of Myrtle's silverspot butterfly are known to have been illegally collected in Point Reyes National Seashore. Although collectors generally do not adversely affect the healthy, well-dispersed populations of many butterfly species, a number of rare species, highly valued by collectors, are vulnerable to extirpation from collecting. For butterfly species that exist in small colonies, collection or repeated handling and marking (particularly of females and in years of low abundance) can seriously damage populations through loss of individuals and genetic variability. Adult specimens of Myrtle's silverspot butterfly are also highly valued by private collectors, and an international market exists for illegally collected specimens, as well as other listed and rare butterflies (USFWS 1998; USFWS 2009).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: Loss of habitat or habitat degradation from populations, and potential for populations to not be properly identified and maintained.
Consequence: Reduction in population, and populations possibly extirpated.

Narrative: The Myrtle’s silverspot butterfly receives some protections under the various federal and state laws and regulations. However, in many cases the protection afforded the species relies on the species status under the Endangered Species Act. Therefore, regulatory mechanisms are inadequate to meet the conservation needs of this subspecies (USFWS 2009).

Stressor: Small population size
Exposure: Smaller populations; and natural and manmade changes.
Response: Loss of individuals, and fragmented populations.
Consequence: Reduction in fitness and population; possible extirpation of population.
Narrative: In general, small populations demonstrate decreased genetic variability or heterozygosity. Low populations of any organism are also threatened by extinction through a single catastrophic event, such as an abnormally violent storm, a prolonged drought, or other climatic event; from an infectious disease; or from “stochastic” demographic fluctuations, and are more susceptible to genetic drift and fragmentation. Other effects include reduced reproduction potential resulting from the lack of necessary social interactions, or the difficulty in finding a mate. Another example of a density-dependent factor that may reduce a population’s fitness is the consequences of asynchronous reproduction (male and female sexual maturity is offset in time), which may be favorable in greater population densities but deleterious in low densities. Fragmented populations often exhibit poor metapopulation connectivity, where the dispersal distance between populations is outside the capability of the species, and thus makes the species less likely to disperse to other population sites or recolonize sites that may have been extirpated (USFWS 2009).

Stressor: Invasive and nonnative species
Exposure: Invasive plants replacing native plants.
Response: Loss of food source for larvae, and reduction in fecundity.
Consequence: Reduction in population.
Narrative: Myrtle's silverspot butterfly is entirely dependent on western dog violet for laying its eggs, which the larvae use as a food source. Invasive and nonnative plants can dramatically change the butterfly's habitat, reducing available plants for both reproduction and feeding during their adult stage. Sea fig or iceplant (Carpobrotus chilensis) and European beachgrass (Ammophilia arenaria) are consistently identified as invasive plant species that could outcompete and eliminate the host plant for this subspecies as well as several of its nectar sources, particularly in the absence of grazing or fires. Although heavy grazing is thought to have adverse impacts on nectar plants for the butterfly, and possibly also on the larval host plant, complete absence of grazing may also have adverse effects. Heavy growth of nonnative grasses and other plants and accumulation of dead plant litter on top of the ground can result in overgrowth or shading of the larval host plant. Little is known about how to balance these factors in California coastal prairie or dune scrub. Point Reyes National Seashore is funded for and continues to reduce the threat of European beachgrass spreading at several key locations on the park property—including Kehoe Beach, which may provide nectar plants for one of the two populations at the National Seashore (USFWS 1998; USFWS 2009).

Stressor: Roads

Exposure: Population in proximity to roads.
Response: Injury or mortality.
Consequence: Reduced population numbers.
Narrative: Mortalities of Myrtle's silverspot butterfly due to direct strikes of individuals by cars appear to be significant. Multiple individuals have been observed along the roadside at North Beach that appeared to have been killed and/or mutilated by vehicle strikes. The threat of road mortalities to butterfly populations have been confirmed in several studies. Posting reduced speed limits during the adult flight period may help reduce this threat (USFWS 2009).

Stressor: Climate change
Exposure: Heat waves, droughts, storms, extreme events, and subtle temperature changes.
Response: Loss of habitats and prey; and increased number of predators, parasites, and diseases.
Consequence: Mass mortality, change in range extents, and local extinction.
Narrative: California will suffer significant consequences as a result of global warming. Global warming increases the frequency of extreme weather events, such as heat waves, droughts, and storms. Extreme events in turn may cause mass mortality of individuals and significantly contribute to determining which species will remain or occur in natural habitats. As the global climate warms, terrestrial habitats are moving northward and upward, but in the future, range contractions are more likely than simple northward or upslope shifts. Ongoing global climate change likely imperils many species of California butterflies and the resources necessary for their survival. Because climate change threatens to disrupt annual weather patterns, it may result in a loss of their habitats and/or prey, and/or increased numbers of their predators, parasites, and diseases. Where populations are isolated, a changing climate may result in local extinction, with range shifts precluded by lack of habitat. Studies have demonstrated that the distribution and range of many species of butterflies are susceptible to subtle shifts in the local climate, particularly temperature changes. The range of the Myrtle's silverspot butterfly will, therefore, most likely be similarly affected in the upcoming years if global temperatures continue to rise (USFWS 2009).

Recovery

Reclassification Criteria:
The habitat of the northwestern Marin County/southwestern Sonoma County population of this species is protected in perpetuity. (USFWS, 2021)

Two new populations have been discovered or reintroduced at suitable sites that have been protected in perpetuity. (USFWS, 2021)

Adequate funding for management of all sites is assured and adaptive management plans have been developed and are being implemented. (USFWS, 2021)

Annual monitoring has shown the five populations (three existing, two new) cumulatively to have a total of more than 10,000 adults in each of ten years, with no individual population having fewer than 200 adults in any year and no recent severe declines. (USFWS, 2021)

Delisting Criteria:
Nine total populations have been established on habitat that is protected in perpetuity. If appropriate sites have been identified in the screening and prioritization process, at least two of these populations should be south of the Golden Gate (USFWS 1998; USFWS 2009).

Adequate funding for management for all sites is ensured, and adaptive management plans have been developed or are being implemented (USFWS 1998; USFWS 2009).

Annual monitoring has shown that the nine populations cumulatively have a total of more than 45,000 adults in at least 8 of 10 years, no fewer than 10,000 adults cumulatively in any year, no individual populations having fewer than 100 adults in any year, and no recent severe declines (USFWS 1998; USFWS 2009).

Recovery Actions:
- Protect habitat for the Myrtle's silverspot butterfly and their occurrences on private lands (USFWS 1998).
- Minimize threats to the butterfly. Invasive nonnative plant species are immediate biological threats to the Myrtle's silverspot (i.e., competition with native larval and adult food plants). Infestations of invasive plant species need to be controlled (USFWS 1998).
- Develop management strategies through a research program to document the listed species life histories and their responses to vegetation management (USFWS 1998).
- Manage occurrences and habitats. Management of the species and its habitat will depend on information gained from monitoring, threat analysis, and the evaluation of protection alternatives. It will be important to involve the expertise of local landowners, land managers, and species experts to develop conservation programs. The management program selected will require periodic review to ensure that it is effective in protecting the species (USFWS 1998).
- Monitor occurrences and threats to determine effectiveness of management, and to establish delisting criteria (USFWS 1998).
- Coordinate recovery actions to protect other listed species and species of special concern (USFWS 1998).
- Develop and implement an outreach program. Increasing public awareness of the Myrtle’s silverspot butterfly will facilitate efforts to preserve these species, associated rare species, and the coastal dune ecosystem (USFWS 1998).
- Renew annual surveys of the three known populations of the Myrtle’s silverspot butterfly using a consistent survey methodology (USFWS 2009).
- Search for new populations of Myrtle’s silverspot butterfly throughout its historic range (USFWS 2009).
- Acquire property with suitable habitat for the Myrtle’s silverspot butterfly, and protect the habitat at these new locations. Restore and maintain habitat for the Myrtle’s silverspot butterfly host plant and known nectar sources at all protected habitat locales. Develop management plans for the specific locale (USFWS 2009).
- Conduct life history and behavior research for the Myrtle’s silverspot butterfly. Topics of interest for investigation include diapause (life stages, intervals, and triggering cues); metapopulation dynamics; the effects of management practices on the butterfly and host

plant (examples include the use of herbicides or disking); the autecology of the host plant; the responses of the host plant to climatic fluctuations (global climate change), natural successional changes, and competition from invasive, nonnative plants; and finding an estimated minimum population size that will be self-sustaining in specified normal habitat conditions (USFWS 2009).

- Captive breeding for this species may be determined to be necessary to prevent extirpation or extinction; therefore, studies that assist in implementing future captive breeding or rearing efforts for this species should be funded or encouraged (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: In this section we propose recommendations which will aid in the recovery and conservation of Myrtle's silverspot butterfly. Some of these recommendations have already been discussed in previous recovery documents (Service 1998; Service 2009) and remain valid. • Create a Speyeria working group and investigate potential synergies from working with biologists across listed congeners. • Renew (or begin) annual surveys of the known populations of the Myrtle's silverspot butterfly using a consistent survey methodology. Importantly, surveys should be conducted over a multi-day period (or optimally, throughout the flight period) so that foggy conditions do not influence an artificially low abundance count for the species. • Search for additional populations of Myrtle's silverspot butterfly throughout its historical range. • Acquire property with suitable habitat for the Myrtle's silverspot butterfly and protect the habitat at these locations. Restore and maintain habitat for the Myrtle's silverspot butterfly host plant and known nectar sources at all protected habitat locales. Develop management plans for the specific locales. In general, management plans should recommend that the non-native nectar source bull thistle (Cirsium vulgare) not be eradicated in the absence of a comparable native replacement. • Conduct life history and behavior research of the Myrtle's silverspot butterfly and the autecology of the host plant, Western dog violet (Viola adunca). Topics of interest for investigation include, but are not limited to: diapause (life stages, intervals, triggering cues); metapopulation dynamics, including population viability and minimum viable population size; the effects of management practices on the butterfly, host plant, and nectar sources [examples include grazing (both native and domestic), disking, pesticide use, and mowing thistles]; and the response of the host plant to climatic fluctuations, natural successional changes, and competition from invasive, non-native plants. • Captive breeding for this species may be determined necessary to prevent extirpation or extinction, thus studies which assist in implementing future captive breeding or rearing efforts for this species should be funded or encouraged. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Strymon acis bartrami* (Bartram's hairstreak Butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 9/11/2014; Southeast Region (R4) (USFWS, 2016)

Physical Description

A small butterfly approximately 1 inch (in) (25 millimeters (mm)) in length with a forewing length of 0.4 to 0.5 in (10 to 12.5 mm) and has an appearance characteristic of the genus. Despite its rapid flight, this hairstreak is easily observed if present at any density as it alights often, and the brilliance of its grey underside marked with bold white post-discal lines beneath both wings provides an instant flash of color against the foliage of its hostplant, pineland croton (Croton linearis) (USFWS, 2016).

Taxonomy

The Bartram's scrub-hairstreak butterfly (Strymon acis bartrami) was first described by Comstock and Huntington in 1943. Seven subspecies of Strymon acis have been described (Smith et al. 1994, p. 118). The ITIS (2013, p. 1) uses the name Strymon acis bartrami and indicates that this subspecies' taxonomic standing is valid. FNAI (2012, p. 21) uses the name S. a. bartrami (USFWS, 2014a).

Historical Range

The entire species is a Caribbean and Floridian endemic (NatureServe, 2015). The Bartram's scrub-hairstreak was historically less common and sporadic in occurrence north of Miami-Dade County (Smith et al. 1994, pp. 118; Salvato and Hennessey 2004, p. 223) (USFWS, 2014b).

Current Range

At present, the Bartram's scrubhairstreak butterfly is extant on Big Pine Key, within ENP, and several pineland fragments on mainland Miami-Dade County (Smith et al. 1994, p. 118; Salvato and Salvato 2010b, p. 154), the smallest being Navy Wells Pineland Preserve outparcel number 39 (7 ha (18 ac)), which represents the minimum known extant sustained population size (USFWS, 2014b).

Critical Habitat Designated

Yes; 8/12/2014.

Legal Description

On August 12, 2014, the U.S. Fish and Wildlife Service designated critical habitat for Bartram's scrub-hairstreak (Strymon acis bartrami) butterflies under the Endangered Species Act. Approximately 4,670 hectares (11,539 acres) in Miami-Dade and Monroe Counties, Florida, fall within the boundaries of the critical habitat designation for the Bartram's scrub-hairstreak butterfly.

Critical Habitat Designation

Seven units are designated as critical habitat for the Bartram's scrubhairstreak. The seven areas designated as critical habitat are: (1) BSHB1 Everglades National Park, Miami-Dade County, Florida; (2) BSHB2 Navy Wells Pineland Preserve, Miami-Dade County, Florida; (3) BSHB3 Camp Owaissa Bauer, Miami-Dade County, Florida; (4) BSHB4 Richmond Pine Rocklands, Miami-Dade County, Florida; (5) BSHB5 Big Pine Key, Monroe County, Florida; (6) BSHB6 No Name Key, Monroe County, Florida; and (7) BSHB7 Little Pine Key, Monroe County, Florida.

Unit BSHB1: Everglades National Park, Miami-Dade County, Florida. Unit BSHB1 consists of 3,235 ha (7,994 ac) in Miami-Dade County. This unit is composed entirely of lands in Federal ownership, 100 percent of which are located within the Lone Pine Key region of ENP. This unit is currently occupied by the Bartram's scrub-hairstreak and contains all the PBFs, including suitable habitat (pine rockland habitat of sufficient size), hostplant presence, natural or artificial disturbance regimes, low levels of nonnative vegetation and larval parasitism, and restriction of pesticides, and the unit contains the PCE of pine rockland. The PBFs in this unit may require special management considerations or protection to address threats of a lack of adequate fire management, habitat fragmentation, poaching, and sea level rise. However, in most cases these threats are being addressed or coordinated with the NPS to implement needed actions. ENP is currently in the process of updating its FMP and environmental assessment, which will assess the impacts of fire on various environmental factors, including listed, proposed, and candidate species (Land 2011, pers. comm.; Sadle 2013a, pers. comm.). ENP is actively coordinating with the Service, as well as other members of the IBWG, to review and adjust the prescribed burn practices outlined in the FMP to help maintain or increase Bartram's scrub-hairstreak population sizes, protect pine rocklands, expand or restore remnant patches of hostplants, and ensure that short-term negative effects from fire (i.e., loss of hostplants, loss of eggs and larvae) can be avoided or minimized.

Unit BSHB2: Navy Wells Pineland Preserve, Miami-Dade County, Florida. Unit BSHB2 consists of 203 ha (502 ac) in Miami-Dade County. This unit is comprised of lands in State (62 ha (153 ac)) and private or other (141 ha (349 ac)) ownership. The 120-ha (296-ac) Navy Wells Pineland Preserve is jointly owned by Miami-Dade County (85 ha (211 ac)) and the State (35 ha (85 ac)). State lands are interspersed within Miami-Dade County Parks and Recreation Department lands, which are managed for conservation. This unit begins in Homestead, Florida, on SW 304 Street, between SW 198 Avenue to SW 204 Avenue; then resumes between SW 340 Street and SW 344 Street, between SW 213 Avenue and SW 214 Avenue; then resumes between SW 344 Street and SW 360 Street on SW 209 Avenue; then resumes along SW 268 Street, between SW 202 Avenue and SW 205 Avenue; then resumes along SW 360 Street, between SW 202 Avenue and SW 188 Avenue; then resumes between SW 7 Street and SW 158 Street, in the vicinity of SW 180 Avenue; then resumes along Palm Drive and SW 3 Terrace, between SW 6 Avenue and SW 8 Avenue. This unit is occupied by the Bartram's scrub-hairstreak butterfly and contains all the PBFs, including suitable habitat, hostplant, adult food sources, breeding sites, disturbance regimes, and restriction of pesticides, and the unit contains pine rockland and rockland hammock PCEs. The PBFs in this unit may require special management considerations or protection to address threats of a lack of adequate fire management, habitat fragmentation, poaching, and sea level rise.

However, in most cases these threats are being addressed or coordinated with our partners and landowners to implement needed actions.

Unit BSHB3: Camp Owaissa Bauer, Miami-Dade County, Florida. Unit BSHB3 consists of 146 ha (359 ac) in Miami-Dade County. This unit is comprised of lands in State (29 ha (71 ac)) and private or other (117 ha (288 ac)) ownership, of which one large fragment (40 ha (99 ac)) is owned by Miami-Dade County-Camp Owaissa Bauer. State lands are interspersed within Miami-Dade County Parks and Recreation Department lands, which are managed for conservation. This unit begins in Homestead, Florida, on SW 147 Ave, between SW 216 Street and SW 200 Street; then resumes on both sides of SW 157 Avenue, between SW 216 Street and SW 228 Street; then resumes along SW 232 Street, between SW 142 Avenue and SW 144 Avenue; then continues south of SW 232 Street along both sides of SW 142 Ave to SW 248 Street; then resumes along SW 248 Street, south to SW 256 Street, between SW 144 Avenue and the vicinity of SW 157 Avenue; then resumes along SW 240 Street, north to the vicinity of SW 238 Street, between SW 152 Avenue and SW 147 Avenue; then resumes between SW 264 Street and SW 272 Street, along both sides of SW 155 Avenue; then resumes along both sides of SW 264 Street in the vicinity of SW 162 Avenue. This unit is occupied by the Bartram's scrub-hairstreak butterfly and contains all the PBFs, including suitable habitat, hostplant, adult food sources, breeding sites, disturbance regimes, and restriction of pesticides required by the subspecies, and the unit contains the pine rockland and rockland hammock PCEs. The PBFs in this unit may require special management considerations or protection to address threats of a lack of adequate fire management, habitat fragmentation, poaching, and sea level rise. However, in most cases these threats are being addressed or coordinated with our partners and landowners to implement needed actions.

Unit BSHB4: Richmond Pine Rocklands, Miami-Dade County, Florida. Unit BSHB4 consists of 438 ha (1,082 ac) in Miami-Dade County. This unit comprises lands in both Federal (U.S. Coast Guard (Homeland Security) (29 ha (72 ac)), U.S. Army Corps of Engineers (DoD) (8 ha (20 ac)), National Oceanic Atmospheric Administration (NOAA) (4 ha (9 ac)), Federal Bureau of Prisons (DoJ) (9 ha (21 ac))), State (32 ha (79 ac)), and private or other (356 ha (881 ac)) ownership. The unit includes some of the largest remaining contiguous fragments of pine rockland habitats outside of ENP known to be occupied by the Bartram's scrub-hairstreak butterfly. This unit begins in Miami, Florida, at SW 120 Street, north to SW 112 Street, between SW 142 Avenue and the vicinity of SW 137 Avenue; then resumes along SW 124 Street south to SW 128 Street, between SW127 Avenue and the vicinity of SW 137 Avenue; then resumes in the vicinity of SW 136 Street and SW 122 Avenue; then resumes on Coral Reef Drive (State Road 992) south to SW 168 Street, between U.S. 1 and SW 117 Avenue; then resumes from Coral Reef Drive south to SW 184 Street, between FL–832 and SW 137 Avenue. This unit is currently occupied by the Bartram's scrub-hairstreak butterfly and contains all the PBFs, including suitable habitat, hostplant, adult food sources, breeding sites, disturbance regimes, and restriction of pesticides, and the unit contains the pine rockland and rockland hammock PCEs. The PBFs in this unit may require special management considerations or protection to address threats of a lack of adequate fire management, habitat fragmentation, poaching, and sea level rise. However, in most cases these threats are being addressed or coordinated with our partners and landowners to implement needed actions. The

U.S. Army Corps of Engineers lands do not have an integrated natural resources management plan (INRMP) or other natural resource management plan.

Unit BSHB5: Big Pine Key, Monroe County, Florida. Unit BSHB5 consists of 559 ha (1,382 ac) in Monroe County. This unit includes Federal lands within NKDR (365 ha (901 ac)), State lands (90 ha (223 ac)), and property in private or other ownership (104 ha (258 ac)). State lands are interspersed within NKDR lands and managed as part of the Refuge. The unit begins on northern Big Pine Key on the southern side of Gulf Boulevard, continues south on both sides of Key Deer Boulevard (CR 940) to the vicinity of Osprey Lane on the western side of CR 940 and Tea Lane to the east of CR 940; then resumes on both sides of CR 940 from Osprey Lane to rest south of the vicinity of Driftwood Lane; then resumes south of Osceola Street, between Fern Avenue to the west and Baba Lane to the east; then resumes north of Watson Boulevard in the vicinity of Avenue C; then continues south on both sides of Avenue C to South Street; then resumes on both sides of CR 940 south to U.S. 1 between Ships Way to the west and Sands Street to the east; then resumes south of U.S. 1 from Newfound Boulevard to the west and Deer Run Trail to the east; then resumes south of U.S. 1 from Palomino Horse Trail to the west and Industrial Road to the east. This unit is currently occupied by the Bartram’s scrub-hairstreak butterfly. This unit contains several of the PBFs, including suitable habitat, hostplant, adult food sources, and breeding sites required by the subspecies, and it contains the pine rockland and rockland hammock PCEs. The PBFs in this unit may require special management considerations or protection to address threats of disturbance regimes (fire) and pesticide applications, as well as habitat fragmentation, poaching, and sea level rise. However, in most cases these threats are being addressed or coordinated with our partners and landowners to implement needed actions.

Unit BSHB6: No Name Key, Monroe County, Florida. Unit BSHB6 consists of 50 ha (123 ac) in Monroe County. This unit includes Federal lands within NKDR (30 ha (75 ac)), State lands (9 ha (22 ac)), and property in private or other ownership (11 ha (26 ac)). State lands are interspersed within NKDR lands and managed as part of the Refuge. The unit extends from Watson Road entirely on National Key Deer Refuge lands just south of the vicinity of Spanish Channel Drive eastward to the vicinity of Paradise Drive, then resumes north of Watson Road from No Name Drive east to Paradise Lane. This unit is not currently occupied by the Bartram’s scrub-hairstreak butterfly but is essential for the conservation of the subspecies because it serves to protect habitat needed to recover the subspecies, reestablish wild populations within the historical range of the subspecies, and maintain populations throughout the historical distribution of the subspecies in the Florida Keys, and the unit provides area for recovery in the case of stochastic events that otherwise hold the potential to eliminate the subspecies from the one or more locations where it is presently found. The Lower Florida Keys National Wildlife Refuge’s CCP management objective number 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Bartram’s scrub-hairstreak butterfly.

Unit BSHB7: Little Pine Key, Monroe County, Florida. Unit BSHB7 consists of 39 ha (97 ac) in Monroe County. This unit comprises entirely lands in Federal ownership, 100 percent of which are located within NKDR. This unit is not currently occupied by the Bartram’s scrubhairstreak butterfly but is essential to the conservation of the subspecies because it serves to protect habitat needed to recover the subspecies, reestablish wild populations within the historical range of the subspecies, and maintain populations throughout the historical distribution of the subspecies in the Florida Keys, and it provides area for recovery in the case of stochastic events that otherwise hold the potential to eliminate the subspecies from one or more locations where it is presently found. The Lower Florida Keys National Wildlife Refuge's CCP management objective number 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Bartram's scrub-hairstreak butterfly.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Miami-Dade and Monroe Counties, Florida. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Bartram's scrubhairstreak butterfly are:

(i) Areas of pine rockland habitat, and in some locations, associated rockland hammocks and hydric pine flatwoods. (A) Pine rockland habitat contains: (1) Open canopy, semi-open subcanopy, and understory. (2) Substrate of oolitic limestone rock. (3) A plant community of predominately native vegetation. (B) Rockland hammock habitat associated with the pine rocklands contains: (1) Canopy gaps and edges with an open semi-open canopy, subcanopy, and understory. (2) Substrate with a thin layer of highly organic soil covering limestone or organic matter that accumulates on top of the underlying limestone rock. (3) A plant community of predominately native vegetation. (C) Hydric pine flatwood habitat associated with the pine rocklands contains: (1) Open canopy with a sparse or absent subcanopy, and dense understory. (2) Substrate with a thin layer of poorly drained sands and organic materials that accumulates on top of the underlying limestone or calcareous rock. (3) A plant community of predominately native vegetation.

(ii) Competitive nonnative plant species in quantities low enough to have minimal effect on survival of Bartram's scrub-hairstreak butterfly.

(iii) The presence of the butterfly's hostplant, pineland croton, in sufficient abundance for larval recruitment, development, and food resources, and for adult butterfly nectar source and reproduction;

(iv) A dynamic natural disturbance regime or one that artificially duplicates natural ecological processes (e.g. fire, hurricanes or other weather events, at appropriate intervals) that maintains the pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities.

(v) Pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities that allow for connectivity and are sufficient in size to sustain viable populations of Bartram's scrub hairstreak butterfly.

(vi) Pine rockland habitat and associated rockland hammock and hydric pine flatwood plant communities with levels of pesticide low enough to have minimal effect on the survival of the butterfly or its ability to occupy the habitat.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on September 11, 2014.

Management actions or activities that could ameliorate sea level rise include providing protection of suitable habitats unaffected or less affected by sea level rise. Fire management of pine rocklands in NKDR is hampered by the pattern of land ownership and development; residential and commercial properties are embedded within or in close proximity to pineland habitat (Snyder et al. 2005, p. 2; Anderson 2012, pers. comm.). Ongoing management activities designed to ameliorate this threat include the use of small-scale prescribed burns or mechanical clearing to maintain the native vegetative structure in the pine rockland required by the subspecies.

Life History

Feeding Narrative

Larvae: The Bartram's scrub-hairstreak butterfly is dependent on pine rocklands that retain the butterfly's sole hostplant, pineland croton. The immature stages of this butterfly feed on the croton for development (Minno and Emmel 1993, p. 129; Worth et al. 1996, p. 62) (USFWS, 2014b).

Adult: Adult Bartram's scrub-hairstreaks actively visit flowers for nectar (Minno and Emmel 1993, p. 129; Worth et al. 1996, p. 65; Calhoun et al. 2002, p. 14; Salvato and Hennessey 2004, p. 226; Salvato and Salvato 2008, p. 324) within open pine areas and edges and openings within associated rockland hammocks and hydric pine flatwoods (USFWS, 2014b). This species exhibits a diurnal phenology (NatureServe, 2015). The Bartram's scrub-hairstreak relies primarily on the pineland croton (Croton linearis) to complete the larval stage of its life cycle; adults have been seen feeding on nectar of other flowering plant species (Worth et al. 1996; Calhoun et al. 2000; Salvato and Hennessey 2004; Salvato and Salvato 2008) (USFWS, 2024).

Reproduction Narrative

Adult: The butterfly has been observed during every month throughout its range; however the exact number of broods appears to be sporadic from year to year, with varying peaks in seasonal abundance (Baggett 1982, p. 81; Hennessey and Habeck 1991, pp. 17–19; Emmel et al. 1995, pp. 14–15; Minno and Minno 2009, pp. 70–76; Salvato and Salvato 2010b, p. 156; Anderson 2012, pers. comm.; Sadle 2013b, pers. comm.) (USFWS, 2014b). Eggs are laid singly on the flowering racemes of pineland croton (Worth et al., 1996, p. 62; Salvato and Hennessey 2004, p. 225) (USFWS, 2014a).

Spatial Arrangements of the Population

Adult: Upt o 6.3 adults/ha (USFWS, 2014a)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Habitat Narrative

Adult: Bartram's scrub-hairstreak butterfly's entire lifecycle occurs within pine rockland habitat and occasionally associated rockland hammock and hydric pine flatwoods interspersed in these pinelands. Adult Bartram's scrub-hairstreaks prefer more open pine areas, at the edges and openings of associated rockland hammocks and hydric pine flatwoods. Pine rockland is dependent on some degree of disturbance, most importantly from natural or prescribed burns (Loope and Dunevitz 1981, p. 5; Carlson et al. 1993, p. 914; Slocum et al. 2003, p. 93; Snyder et al. 2005, p. 1; Bradley and Saha 2009, p. 4; Saha et al. 2011, pp. 169–184; FNAI 2010, p. 1). These fires are a vital component in maintaining native vegetation, such as pineland croton, within this ecosystem. Without fire, successional climax from tropical pineland to rockland hammock is too rapid, and displacement of native species by invasive, nonnative plants often occurs. Hurricanes and other significant weather events create openings in the pine rockland habitat (FNAI 2010, p. 3) (USFWS, 2014b). Salvato and Salvato (2010b, p. 159) and Salvato (2014, pers. comm.) have encountered as many as 6.3 adult Bartram's scrub-hairstreaks per ha (2.5 per ac) annually from 1999 to 2013, based on monthly surveys in Long Pine Key (USFWS, 2014a). The environmental specificity is narrow; this species is limited to open tropical pinelands with an abundance of woolly croton (Croton linearis) (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2014b)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2014b)

Dispersal

Adult: Low (inferred from USFWS, 2014b)

Dispersal/Migration Narrative

Adult: Studies indicate butterflies are capable of dispersing throughout the landscape, sometimes as far as 5 km (3 mi), and utilizing high-quality habitat patches (Davis et al. 2007, p. 1351; Bergman et al. 2004, p. 625). Stepping stones may be particularly useful to the Bartram's scrub-hairstreak, which exhibits low vagility (movement), rarely venturing from the pine rockland habitat or away from large areas of contiguous patches of hostplant. Therefore, pine rockland habitats and associated rockland hammock and hydric pine flatwoods that are at least 7 ha (18 ac) in size and are located no more than 5 km (3 miles) apart are necessary to allow for habitat connectivity for this butterfly (USFWS, 2014b).

Population Information and Trends

Population Trends:

Extirpated from 93% of historical range (USFWS, 2014a)

Number of Populations:

2 (USFWS, 2024)

Population Size:

Unknown, estimated hundreds (USFWS, 2014a)

Minimum Viable Population Size:

1,000, based on taxon (USFWS, 2014a)

Adaptability:

Low (inferred from USFWS, 2014a)

Population Narrative:

The Bartram's scrub-hairstreak has been extirpated from nearly 93 percent of its historical range; only five isolated populations remain on Big Pine Key in Monroe County, Long Pine Key in ENP, and relict pine rocklands adjacent to the Park in Miami-Dade County. Ongoing surveys conducted by ENP staff from 2005 to present have encountered a total of approximately 24 and 30 hairstreak adults and larvae, respectively, throughout Long Pine Key (Land 2012, pers. comm.; Sadle 2013b, pers. comm.). Abundance of the Bartram's scrub-hairstreak is not known, but is estimated to number in the hundreds, and at times, possibly much lower. Although highly dependent on individual species considered, a population of 1,000 has been suggested as marginally viable for an insect (Schweitzer 2003, pers. comm.). Because populations are isolated and the butterfly has a limited ability to recolonize historically occupied habitats that are now highly fragmented, it is vulnerable to natural or human-caused changes in its habitats. The remaining populations become less resilient and are not capable of recovering from the threats (USFWS, 2014a). The butterfly's historical range included pine rockland habitat in Miami-Dade and Monroe Counties, however, the butterfly is presumed extirpated from Big Pine Key (Monroe County; Daniels pers. comm. 2023; Henry pers. comm. 2023). Due to development and fragmentation of pine rockland habitat in South Florida, its range is now restricted to two populations in isolated remnants of pine rockland habitat in Miami-Dade County (Figure 1), including in the Long Pine Key Region of Everglades National Park and a few sites in MiamiDade County, particularly areas east of the National Park (i.e., Navy Wells Pineland and areas within the Richmond Pine Rocklands; Salvato 1999, 2001, 2003; Salvato and Hennessey 2004; Salvato and Salvato 2010a; Possley et al. 2016) (USFWS, 2024)

Threats and Stressors

Stressor: Habitat loss (USFWS, 2014a)
Exposure:

Response:
Consequence:
Narrative: Destruction of the pinelands for economic development has reduced this habitat community by 90 percent on mainland south Florida (including within ENP) (O'Brien 1998, p. 208). Any unknown extant populations of these butterflies or suitable habitat that may occur on private land or non-conservation public land, such as within the Richmond Pine Rocklands, are vulnerable to habitat loss. Similarly, most of the ecosystems on the Florida Keys have been impacted by humans, through widespread clearing of habitat in the 19th century for farming, or building of homes and businesses; extensive areas of pine rocklands have been lost (Hodges and Bradley 2006, p. 6). Overall, the human population in Monroe County is expected to increase from 79,589 to more than 92,287 people by 2060 (Zwick and Carr 2006, p. 21). All vacant land in the Florida Keys is projected to be developed by then, including lands currently inaccessible for development, such as islands not attached to the Overseas Highway (US 1) (Zwick and Carr 2006, p. 14) (USFWS, 2014a).

Stressor: Fire management (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: The threat of habitat destruction or modification is further exacerbated by a lack of adequate fire management (Salvato and Salvato 2010a, p. 91; 2010b, p. 154; 2010c, p. 139). Without fire, successional climax from tropical pineland to hardwood hammock is rapid, and displacement of native species by invasive nonnative plants often occurs. The influence of prescribed burns on the status and distribution of the hairstreak and croton is being evaluated by ENP throughout Long Pine Key. The effects of new burn techniques on the Bartram's scrub-hairstreak within Long Pine Key were not immediately obvious (Salvato and Salvato 2010b, p. 159). Recent natural or prescribed burn activity on Big Pine Key and adjacent islands within NKDR appears to be insufficient to prevent loss of pine rockland habitat (Carlson et al. 1993, p. 914; Bergh and Wisby 1996, pp. 1–2; O'Brien 1998, p. 209; Snyder et al. 2005; Bradley and Saha 2009, pp. 28–29; Saha et al. 2011, pp. 169–184). Fire management of pine rocklands in NKDR is hampered by the pattern of land ownership and development; residential and commercial properties are embedded within or in close proximity to pineland habitat (Snyder et al. 2005, p. 2; Anderson 2012a, pers. comm.) (USFWS, 2014a).

Stressor: Climate change (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: Extant populations of Bartram's scrub-hairstreak in the pine rocklands on Big Pine Key are located just slightly above mean sea level, and saturation or increase in salinity of the soil would correspondingly change the vegetation and habitat structure making the butterfly's survival at this location in the Keys very unlikely (Minno 2013, page numbers not applicable). Drier conditions and increased variability in precipitation associated with climate change are expected to hamper successful regeneration of forests and cause shifts in vegetation types

through time (Wear and Greis 2011, p. 58). Climate changes are forecasted to extend fire seasons and the frequency of large fire events throughout the Coastal Plain (Wear and Greis 2011, p. 65). Increases in the scale, frequency, or severity of wildfires could also have severe ramifications on the Bartram's scrub-hairstreak, considering its dependence on pine rocklands and general vulnerability due to reduced population size, restricted range, few colonies, low fecundity, and relative isolation (USFWS, 2014a).

Stressor: Collection (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: Rare butterflies and moths are highly prized by collectors, and an international trade exists in specimens for both live and decorative markets, as well as the specialist trade that supplies hobbyists, collectors, and researchers (Collins and Morris 1985, pp. 155–179; Morris et al. 1991, pp. 332–334; Williams 1996, pp. 30–37). At present, even limited collection from the small, remaining populations could have deleterious effects on reproductive and genetic viability and thus could contribute to their eventual extinction. The potential for collection of eggs, larvae, pupae, and adult butterflies exists, and such collection could go undetected, despite the protection provided on Federal or other public lands (USFWS, 2014a).

Stressor: Research activities (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: Some techniques (e.g., capture, handling) used to understand or monitor the leafwing and hairstreak butterflies have the potential to cause harm to individuals or habitat. Visual surveys, transect counts, and netting for identification purposes have been performed during scientific research and conservation efforts with the potential to disturb or injure individuals or damage habitat. Mark-recapture, a common method used to determine population size, has been used by some researchers to monitor Florida leafwing and Bartram's scrub-hairstreak populations (Emmel et al. 1995, p. 4; Salvato 1999, p. 24). While mark-recapture may be preferable to other sampling estimates (e.g., count-based transects) in obtaining demographic data when used in a proper design on appropriate species, such techniques may also result in deleterious impacts to captured butterflies (Mallet et al. 1987, pp. 377–386; Murphy 1988, pp. 236– 239; Haddad et al. 2008, pp. 929–940) (USFWS, 2014a).

Stressor: Predation/parasitism (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: Native parasites and predators have been documented to impact Bartram's scrub-hairstreaks. Hennessey and Habeck (1991, p. 19) collected an older hairstreak larva on Big Pine Key from which a single braconid wasp emerged during pupation. During 2010, Salvato et al. (2012b, p. 113) encountered a hairstreak larva within Long Pine Key that had been parasitized by

C. scutellaris. These are the only known records for a larval parasitoid on this butterfly. Salvato and Salvato (2010d, p. 71) observed erythraeid larval mite parasites on an adult Bartram's scrub-hairstreak in Long Pine Key. Although mite predation on butterflies is rarely fatal (Treat 1975, pp. 1–362), the role of parasitism by mites in the natural history of the hairstreak requires further study. Salvato and Salvato (2008, p. 324) have observed dragonflies (Odonata) preying on adult hairstreaks. Crab spiders, orb weavers, ants, and a number of other predators discussed as mortality factors for the leafwing have also been frequently observed on croton during hairstreak surveys and may also prey on hairstreak adults and larvae (Salvato and Hennessey 2004, p. 225; Salvato 2012, pers. comm.). NKDR biologists have witnessed nonnative Cuban anoles (Anolis equestris) attempting to prey on adult Bartram's scrub-hairstreaks (Anderson 2013, pers. comm.). Minno and Minno (2009, p. 72) also cite nonnative predators such as ants as a major threat to both butterflies (USFWS, 2014a).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: Although ENP was not able to provide specific information concerning poaching of butterflies or enforcement of NPS regulations protecting the butterflies and their habitats from harm, the apparent online sales of the butterflies suggests that poaching could be occurring. The Bartram's scrub-hairstreak butterfly is not currently listed by the State of Florida as a protected species under Chapter 68A–27, Rules Relating to Endangered or Threatened Species, so there are no existing State regulations designated to protect it. However, all State-owned property and resources are generally protected from harm in Chapter 62D– 2.013(2), and animals are specifically protected from unauthorized collection in Chapter 62D–2.013(5) of the Florida Statutes. There is no information to suggest that counties other than Miami-Dade within the range of the hairstreak have regulatory mechanisms that provide any protections for this butterfly (USFWS, 2014a).

Stressor: Small population size/stochastic events (USFWS, 2014a)
Exposure:
Response:
Consequence:
Narrative: The Bartram's scrub-hairstreak is vulnerable to extinction due to severely reduced range, reduced population size, lack of metapopulation structure, few remaining populations, and relative isolation. Given the possible limited dispersal abilities of this butterfly, the distance between occupied sites, (Worth et al. 1996, p. 63; Salvato and Hennessey 2004, p. 223) and their fragmentation, it is unlikely there is any genetic exchange between locations. Given the substantial reduction in the historical range of this butterfly in the past 50 years, the threat and impact of tropical storms and hurricanes on the remaining populations is much greater than when its distribution was more widespread (Salvato and Salvato 2010a, p. 96; 2010b, p. 157; 2010c, p. 139) (USFWS, 2014a).

Stressor: Pesticide use (USFWS, 2014a)

Exposure:
Response:
Consequence:
Narrative: To control mosquito populations, organophosphate (naled) and pyrethroid (permethrin) adulticides are applied by mosquito control districts throughout south Florida. In a rare case in upper Key Largo, another organophosphate (malathion) was applied in 2011 when the number of permethrin applications reached its annual limit. All three of these compounds have been characterized as being highly toxic to nontarget insects by the U.S. Environmental Protection Agency (2002, p. 32; 2006a, p. 58; 2006b, p. 44). The use of such pesticides (applied using both aerial and ground-based methods) for mosquito control presents a potential risk to nontarget species, such as the Bartram's scrub-hairstreak. Actual impacts to the Bartram's scrub-hairstreak from mosquito control are unknown at this time; however, additional research is under way to quantify risk (USFWS, 2014a).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 3C

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- The comprehensive conservation plan (CCP) for the Lower Florida Keys National Wildlife Refuges (NKDR, Key West National Wildlife Refuge, and Great White Heron National Wildlife Refuge) provides a description of the environment and priority resource issues that were considered in developing the objectives and strategies that guide management over the next 15 years. The CCP promotes the enhancement of wildlife populations by maintaining and enhancing a diversity and abundance of habitats for native plants and animals, especially imperiled species that are found only in the Florida Keys. The CCP also provides for obtaining baseline data and monitoring indicator species to detect changes in ecosystem diversity and integrity related to climate change. In the Lower Key Refuges, CCP management objective 11 provides specifically for maintaining and restoring butterfly populations of special conservation concern, including the Bartram's scrub-hairstreak and Florida leafwing butterflies (USFWS, 2014a).
- The NPS is also currently preparing a revised General Management Plan (GMP) for ENP (Sadle 2013a, pers. comm.). ENP's current Management Plan (initiated in 1979) serves to protect, restore, and maintain natural and cultural resources at the ecosystem level (NPS 2000, p. 10). The current GMP is not regulatory, and its implementation is not mandatory. In addition, this GMP does not specifically address either the Florida leafwing or Bartram's scrub-hairstreak (USFWS, 2014a).
- Fairchild Tropical Botanic Gardens (FTBG), with the support of various Federal, State, local, and nonprofit organizations, has established the ''Connect to Protect Network.'' The

objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping-stone gardens and rights-of-way with native pine rockland species, and restoring isolated pine rockland fragments. By doing this, FTBG hopes to increase the probability that pollinators can find and transport seeds and pollen across developed areas that separate pine rocklands fragments to improve gene flow between fragmented plant populations and increase the likelihood that these species will persist over the long term. Although this project may serve as a valuable component toward the conservation of pine rockland species, it is dependent on continual funding, as well as participation from private landowners, both of which may vary through time (USFWS, 2014a).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES Recovery Activities This species does not have a final recovery plan. During this status review, we have identified the following potential recovery activities which are included below. ● Protect, restore, and manage remnant pine rocklands and associated habitats to increase functionality and connectivity throughout the Bartram's scrubhairstreak's range to aid in butterfly dispersal between larger occupied fragments and conservation lands in Florida. ● Acquire, protect, and restore tracts of degraded or historical pine rocklands. ● Promote adequate fire management (such as prescribed burning) within pine rocklands to mitigate the negative effects of habitat loss and degradation on Bartram's scrub-hairstreak population viability. ● Limit the application of mosquito control pesticides on and around Bartram's scrub-hairstreak habitat, particularly in sites where the butterfly is known to occur. ● Conduct invasive species removal efforts to target predators and parasites of Bartram's scrub-hairstreaks. ● Conduct greater enforcement of poaching laws to limit illegal collection of the species. ● Develop captive propagation and reintroduction plans. Monitoring / Research Activities ● Continue to monitor existing populations and suitable habitat patches for presence/abundance of the butterfly. ● Work with partners to continue to: • Evaluate the genetic viability of the Bartram's scrub-hairstreak, as well as that of pineland croton throughout Miami-Dade and Monroe Counties. • Conduct research on Bartram's scrub-hairstreak ecology and habitat requirements to inform future recovery actions, including reintroduction protocols. • Evaluate the potential effects towards the pine rocklands and listed species within resulting from changes in regional hydrology from Everglades restoration in Everglades National Park. • Study the predicted effects of sea level rise, other climate change induced weather events (e.g., hurricanes and droughts) and temperature increases, and increased development on pine rockland habitat and the species. • Study how extent of pineland croton will change under sea level rise and climate change scenarios to best plan for where Bartram's scrub-hairstreak can occur in the future (USFWS, 2024)

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USFWS 2014b. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Florida Leafwing and Bartram's Scrub-Hairstreak Butterflies

Final Rule. 79 Federal Register 155. August 12, 2014. Pages 47179 - 47220

USFWS 2014a. Endangered and Threatened Wildlife and Plants

Endangered Status for the Florida Leafwing and Bartram's Scrub-Hairstreak Butterflies

Final Rule. 79 Federal Register 155. August 12, 2014. Pages 47221 - 47244.

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SPECIES ACCOUNT: *Stygoparnus comalensis* (Comal Springs dryopid beetle)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Adult Comal Springs dryopid beetles are about 3.0–3.7 mm (1/8 inch) long. They have vestigial (non-functional) eyes, are weakly pigmented, translucent, and thin-skinned.

Taxonomy

This species is the first subterranean aquatic member of its family to be discovered (Brown and Barr 1988; Barr, in litt. 1990; Barr and Spangler 1992).

Historical Range

The Comal Springs dryopid beetle is known from Comal Springs and Fern Bank Springs (Hays County).

Current Range

The Comal Springs dryopid beetle is known from Comal Springs and Fern Bank Springs (Hays County).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 10/23/2013.

Legal Description

On October 13, 2013, the U.S. Fish and Wildlife Service (Service), revised the critical habitat for the Comal Springs dryopid beetle (Stygoparnus comalensis) under the Endangered Species Act of 1973, as amended (78 FR 63100 - 63127).

Critical Habitat Designation

Critical habitat for Stygoparnus comalensis is designated in Units 1 and 3.

Unit 1: Comal Springs Unit. The purpose of this unit is to independently support a population of Comal Springs dryopid beetle, Comal Springs riffle beetle, and Peck's cave amphipod in a functioning spring system with associated streams and underground spaces immediately inside of or adjacent to springs, seeps, and upwellings that provide suitable water quality, supply, and detritus (decomposed plant material). Unit 1 contains Comal Springs and consists of 124 ac (50 ha) of subsurface critical habitat for the Comal Springs dryopid beetle and the Peck's cave amphipod (Tables 2 and 4). Unit 1 also contains 38 ac (15 ha) of surface habitat for these two species and the Comal Springs riffle beetle (Table 3). This unit was occupied at the time of listing and is still occupied by the Comal Springs dryopid beetle, Comal Springs riffle beetle, and Peck's cave amphipod (Table 1). Portions of the Comal Springs Unit are owned by the State of Texas, City of New Braunfels, and private landowners in southern Comal County, Texas. A large portion of the unit is operated as a city park (Landa Park) with private residences and landscaped yards along the edge of the lower part of the unit. The surface water and bottom of Landa Lake are State-owned. The City of New Braunfels owns approximately 40 percent of the land surface adjacent to the lake, and private landowners own approximately 60 percent. This nearly L-shaped lake is surrounded by the City of New Braunfels. The spring system primarily occurs as a series of spring outlets that lie along the west shore of Landa Lake and within the lake itself. Practically all of the spring outlets and spring runs associated with Comal Springs occur within the upper part of the lake above the confluence of Spring Run No. 1 to the lake. This unit contains all of the essential physical and biological features for these species. The physical or biological features in this unit require special management or protection because of the potential for depletion of spring flow from water withdrawals, hazardous materials spills from a variety of sources in the watershed, pesticide use throughout the watershed, excavation and construction surrounding the springs and in the watershed, stormwater pollutants in the watershed, and invasive species impacts on the surface habitat.

Unit 3: Fern Bank Springs. The purpose of this unit is to independently support a population of Comal Springs dryopid beetle in a functioning spring system with associated streams and underground spaces immediately inside of or adjacent to springs, seeps, and upwellings that provide suitable water quality, supply, and detritus (decomposed plant material). Unit 3 contains Fern Bank Springs and consists of 15 ac (6 ha) of subsurface and 1.4 ac (0.56 ha) of surface critical habitat for the Comal Springs dryopid beetle (Table 2). This unit was occupied at the time of listing and is still occupied by the Comal Springs dryopid beetle (Table 1). The Fern Bank Springs Unit is on private land in Hays County, Texas, approximately 0.2 mi (0.4 km) east of the junction of Sycamore Creek with the Blanco River. The property and surrounding area are primarily undeveloped. However, there is one rural residential home, which is a small portion of this unit. The spring system consists of a main outlet and a number of seep springs that occur at the base of a high bluff along the Blanco River. This unit contains all of the essential physical and biological features for this species. The physical or biological features in this unit require special management because of the potential for depletion of spring flow from water withdrawals, pesticide use throughout the watershed, and excavation and construction surrounding the springs and in the watershed.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for this species in Comal and Hays Counties, Texas. Within these areas, the primary constituent elements of the physical or biological features essential to the Comal Springs riffle beetle consist of these components:

(i) Springs, associated streams, and underground spaces immediately inside of or adjacent to springs, seeps, and upwellings that include: (A) High-quality water with no or minimal pollutant levels of soaps, detergents, heavy metals, pesticides, fertilizer nutrients, petroleum hydrocarbons, and semivolatile compounds such as industrial cleaning agents; and (B) Hydrologic regimes similar to the historical pattern of the specific sites, with continuous surface flow from the spring sites and in the subterranean aquifer;

(ii) Spring system water temperatures that range from approximately 68 to 75 °F (20 to 24 °C); and

(iii) Food supply that includes, but is not limited to, detritus (decomposed materials), leaf litter, living plant material, algae, fungi, bacteria, other microorganisms, and decaying roots.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing on the surface within the legal boundaries on November 22, 2013.

For the Comal Springs dryopid beetle, threats to adequate water quantity and quality (PCEs 1 and 2) include alterations to the natural flow regimes affecting the aquifer recharge system and its associated springs, streams, and riparian areas. Threats to water quantity and quality include water withdrawals, impoundment, and diversions; hazardous material spills; stormwater drainage pollutants including soaps, detergents, pharmaceuticals, heavy metals, fertilizer nutrients, petroleum hydrocarbons, and semivolatile compounds such as industrial cleaning agents; pesticides and herbicides associated with pathogenic organisms or invasive species; invasive species altering the surface habitat; excavation and construction surrounding the springs and in the watershed; and climate change. All of these threats are known to be ongoing at various levels in and around the Edwards Aquifer ecosystem. Examples of special management actions that would ameliorate these threats include: (1) Maintenance of sustainable groundwater use and subsurface flows; (2) use of adequate buffers for water quality protection; (3) selection of appropriate pesticides and herbicides; and (4) implementation of integrated pest management plans to manage existing invasive species as well as prevent the introduction of additional invasive species.

Life History

Feeding Narrative

Adult: Although specific food requirements of this species are unknown, potential food sources include detritus (decomposed plant materials), leaf litter, and decaying roots. It is possible that the Comal Springs dryopid beetle feeds on microorganisms such as bacteria and fungi associated with decaying riparian vegetation. It is likely a detritivore (detritus-feeding animals) that consume detrital materials from spring influenced riparian (associated with rivers, creeks, or other water bodies) zones (Brown 1987, p. 262; Gibson et al. 2008, p. 77). Riparian vegetation is likely important for these species, as they are typically found on roots where they feed on fungus and bacteria (Gibson et al. 2008, p. 77; Gibson 2012c, pers. comm.). The terrestrial larvae of the Comal Springs dryopid beetle, found an association with roots, debris, and soil lining the ceilings of subterranean cavities, are also presumed to feed on bacteria and fungi (Barr and Spangler 1992, p. 41).

Reproduction Narrative

Adult: There is not a lot of available information on this species' reproduction.

Geographic or Habitat Restraints or Barriers

Adult: restricted to subterranean air-filled voids

Spatial Arrangements of the Population

Adult: clumped

Environmental Specificity

Adult: very narrow; specific habitat requirements

Tolerance Ranges/Thresholds

Adult: low; sensitive to water quality degradation

Site Fidelity

Adult: high

Dependency on Other Individuals or Species for Habitat

Adult: not applicable

Habitat Narrative

Adult: The Comal Springs dryopid beetle is known from Comal Springs and Fern Bank Springs (Hays County). The water flowing out of each of these spring orifices comes from the Edwards Aquifer (Balcones Fault Zone—San Antonio Region), which extends from Hays County west to Kinney County. Comal Springs are located in Landa Park, which is owned and operated by the City of New Braunfels, and on private property adjacent to Landa Park. Hueco Springs and Fern Bank Springs are located on private property. The San Marcos Springs are located on the property of Southwest Texas State University. They are presumed to be associated with air-filled voids inside the spring orifices since all other known dryopid beetle larvae are terrestrial. Elmid and dryopid beetles have a mass of tiny, hydrophobic (unwettable) hairs on their underside where they maintain a thin bubble of air through which gas exchange occurs (Chapman 1982). This method of respiration loses its effectiveness as the level of dissolved oxygen in the water decreases. A number of aquatic insects that use dissolved oxygen rely on flowing water to obtain oxygen. The Comal Springs dryopid beetle is a spring adapted, aquatic species dependent on high-quality, unpolluted groundwater that has low levels of salinity and turbidity. The species is generally associated with water that has adequate levels of dissolved oxygen for respiration (Brown 1987, p. 260; Arsuffi1993, p. 18). High-quality discharge water from springs and adjacent subterranean areas help sustain habitat components essential to this species. The temperature of spring wateremerging from the Edwards Aquifer at Comal and San Marcos Springs ordinarily occurs within a narrow range of approximately 72 to 75 degrees Fahrenheit (°F) (22 to 24 degrees Celsius (°C)) (Fahlquist and Slattery 1997, pp. 3–4; Groeger et al. 1997, pp. 282–283). Hueco Springs and Fern Bank Springs have temperature records of 68 to 71 °F (20 to 22 °C) (George 1952, p. 52; Brune 1975, p. 94; Texas Water Development Board 2006, p. 1). The three listed invertebrate species complete their lifecycle functions within these relatively narrow temperature ranges.

Dispersal/Migration

Motility/Mobility

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Adult: not migratory

Dispersal

Adult: very limited

Immigration/Emigration

Adult: unlikely

Dispersal/Migration Narrative

Adult: They are presumed to be associated with air-filled voids inside the spring orifices since all other known dryopid beetle larvae are terrestrial.The Comal Springs dryopid beetle does not swim, so it may have a limited range within the aquifer. The exact depth and subterranean extent of the Comal Springs dryopid beetle are not precisely known because of a lack of methodologies available for studying karst aquifer systems and the organisms that inhabit such systems. Presumably an interconnected area, the subterranean portion of this habitat, provides for feeding, growth, survival, and reproduction of the Comal Springs dryopid beetle and Peck's cave amphipod. However, no specimens of these species have appeared in collections from 22 artesian and pumped wells flowing from the Edwards Aquifer (Barr 1993) suggesting that these species may be confined to small areas surrounding the spring openings and are not distributed throughout the aquifer. Barr (1993) also surveyed nine springs in Bexar, Comal, and Hays counties considered most likely to provide habitat for endemic invertebrates and found Stygoparnus comalensis only at Comal and Fern Bank springs and Stygobromus pecki only at Comal and Hueco springs.

Population Information and Trends

Population Trends:

Unknown

Species Trends:

Unknown

Population Growth Rate:
unknown

Number of Populations:
1 to 5

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Although this species is fully aquatic, the absolute low water limits for survival are not known. They survived the drought of the middle 1950's, which resulted in cessation of flow at Comal Springs from June 13 through November 3, 1956. Hueco Springs is documented to have gone dry in the past (Brune 1981, Barr 1993) and, although no information is available for Fern Bank Springs, given its higher elevation, it has probably gone dry as well (Glenn Longley, Edwards Aquifer Research and Data Center, personal communication, 1993). This species is not likely adapted to surviving long periods of drying (up to several years in duration) that may occur in the absence of a water management plan for the Edwards Aquifer that accommodates the needs of these invertebrates. Stagnation of water may be a limiting condition.

Threats and Stressors

Stressor: Human water use and removal from aquifer
Exposure:
Response:
Consequence:
Narrative: The main threat to the habitat of these aquatic invertebrates is a reduction or loss of water of adequate quantity and quality, due primarily to human withdrawal of water from the San Antonio segment of the Edwards (Balcones Fault Zone) Aquifer and other activities. Total withdrawal from the San Antonio region of the Edwards Aquifer has been increasing since at least 1934. There is an integral connection between the water in the aquifer west of the springs and the water serving as habitat for these species. Water in the Edwards Aquifer flows from west to east or northeast and withdrawal or contamination of water in the western part of the aquifer can have a direct effect on the quantity and quality of water flowing toward the springs and at the spring openings. The Panel also stated that in the year 2000, if pumping continues to grow at

historical rates and a drought occurs, Comal Springs would go dry for a number of years (Technical Advisory Panel 1990).

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: Other possible effects of reduced spring flow exist. These include changes in the chemical composition of the water in the aquifer and at the springs, a decrease in current velocity and corresponding increase in siltation, and an increase in temperature and temperature fluctuations in the aquatic habitat (McKinney and Watkins 1993). Another threat to the habitat of these species is the potential for groundwater contamination. Pollutants of concern include, but are not limited to, those associated with human sewage (particularly septic tanks), leaking underground storage tanks, animal/feedlot waste, agricultural chemicals (especially insecticides, herbicides, and fertilizers) and urban runoff (including pesticides, fertilizers, and detergents). Pipeline, highway, and railway transportation of hydrocarbons and other potentially harmful materials in the Edwards Aquifer recharge zone and its watershed, with the attendant possibility of accidents, present a particular risk to water quality in Comal and San Marcos Springs. Comal and San Marcos Springs are both located in urbanized areas. Hueco Springs is located alongside River Road, which is heavily traveled for recreation on the Guadalupe River, and may be susceptible to road runoff and spills related to traffic. Of the counties containing portions of the San Antonio segment of the Edwards Aquifer, the potential for acute, catastrophic contamination of the aquifer is greatest in Bexar, Hays, and Comal counties because of the greater level of urbanization compared to the western counties. Although spill or contamination events that could affect water quality do happen to the west of Bexar County, dilution and the time required for the water to reach the springs may lessen the threat from that area. As aquifer levels decrease, however, dilution of contaminants moving through the aquifer may also decrease. The TWC reported that in 1988 within the San Antonio segment of the Edwards Aquifer, Bexar, Hays, and Comal counties had the greatest number of land-based oil and chemical spills in central Texas that affected surface and/or groundwater with 28, 6, and 4 spills, respectively (TWC 1989). As of July, 1988, Bexar County had between 26 and 50 confirmed leaking underground storage tanks, Hays County had between 6 and 10, and Comal County had between 2 and 5 (TWC 1989) putting them among the top 5 counties in central Texas for confirmed underground storage tank leaks. The TWC estimates that, on average, every leaking underground storage tank will leak about 500 gallons per year of contaminants before the leak is detected. These tanks are considered one of the most significant sources of groundwater contamination in the state (TWC 1989). The TWC (1989), using the assessment tool DRASTIC (Aller, et al. 1987), classified aquifers statewide according to their pollution potential. The Edwards Aquifer (Balcones Fault Zone—Austin and San Antonio Regions) was ranked among the highest in pollution potential of all major Texas aquifers.
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Recovery

Reclassification Criteria:

Not available?

Delisting Criteria:
Not available?

Recovery Actions:

- The goals of recovery are: 1) to secure the survival of these species in their native ecosystems; 2) to develop an ecosystem approach using strategies to address both local, site-specific, and broad regional issues related to recovery; and 3) to conserve the integrity and function of the aquifer and spring-fed ecosystems that these species inhabit.
- 1. Assure sufficient water levels in the Edwards aquifer and flows in Comal and San Marcos Springs to maintain habitat for all life stages of the five listed species and integrity of the ecosystem upon which they depend.
- 2. Protect water quality.
- 3. Establish and maintain populations for all five listed species in their historic habitats.
- 4. Conduct biological studies necessary for successful monitoring, management, and restoration.
- 5. Encourage partnerships with landowners and agencies to develop and implement conservation strategies.
- 6. Develop and implement a regional Aquifer Management Plan.
- 7. Develop and implement local management and restoration plans to address multiple threats.
- 8. Promote public information and education.

References

Final Listing Rule

Final Critical Habitat Rule

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

Revised Critical Habitat for the Comal Springs Dryopid Beetle, Comal Springs Riffle Beetle, and Peck's Cave Amphipod. Final rule. 78 FR 63100 - 63127 (October 23, 2013).

final listing rule

Nature Serve

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1996

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1997

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 1998

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SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 2001

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 2002

SAN MARCOS & COMAL SPRING & ASSOCIATED AQUATIC ECOSYSTEMS (REVISED) RECOVERY PLAN 2003

SPECIES ACCOUNT: *Trimerotropis infantilis* (Zayante band-winged grasshopper)

Species Taxonomic and Listing Information

Commonly-used Acronym: ZBWG

Listing Status: Endangered; January 24, 1997 (62 FR 3616).

Physical Description

The Zayante band-winged grasshopper (Trimerotropis infantilis; ZBWG) is a small, pale-gray-to-light-brown grasshopper, with dark cross bands on the forewings and pale yellow hindwings. It ranges from 13.7 to 21.6 millimeters (0.54 to 0.85 inches) in length, with females generally being larger than males. The lower hind tibiae are blue-gray, and there is a band running at an upward slant from front to back across each eye (USFWS 2009).

Taxonomy

The Zayante band-winged grasshopper, order Orthoptera and Family Acrididae, was first described from near Mount Hermon in the Santa Cruz Mountains, Santa Cruz County, California, in 1984 (66 FR 9219). The Zayante band-winged grasshopper is 1 of 56 species in the genus Trimerotropis. This species is similar in appearance to Trimerotropis occulans and Koebele's grasshopper (Trimerotropis koebelei); neither of these species is known from the Zayante sandhills region. Thalassica grasshopper (Trimerotropis thalassica) and pallid-winged grasshopper (Trimerotropis pallildipennis pallidipennis) have been caught nearby but are morphologically distinct from it and appear to prefer different microhabitats (62 FR 3616; 66 FR 9219).

Historical Range

Little is known of the historical distribution of the species. A review of museum specimens yielded Zayante band-winged grasshopper from "Santa Cruz Mountains, no date," "Alma, 1928," "Felton, 1959," and "Santa Cruz, 1941." No subsequent collections have been recorded that substantiate the existence of a population in the vicinity of Alma. The Zayante band-winged grasshopper is narrowly restricted to sand parkland habitat found on ridges and hills in the Zayante sandhills ecosystem in Santa Cruz County. Approximately 200 to 240 hectares (ha) (500 to 600 acres [ac.]) of sand parkland existed historically (66 FR 9219).

Current Range

The Zayante band-winged grasshopper is known only from Santa Cruz County, California. By 1986, only 100 ha (250 ac.) of sand parkland remained intact. By 1992, sand parkland was reportedly reduced to only 40 ha (100 ac.). A more recent assessment revised that estimate up to 78 ha (193 ac.) because of identification and inclusion of additional lower quality sand parkland (USFWS 1998). The Zayante band-winged grasshopper is currently believed to be limited to the five remaining areas of open sand parkland habitat; however, there are differing perspectives on the total number of occupied areas and/or populations. The five areas where populations presently occur are: 1) Quail Hollow County Park; 2) Quail Hollow Quarry area; 3) the area between East Zayante Road, Olympia Wellfield, and Mt. Hermon Road; 4) Mt. Hermon area between Graham Hill and Mt. Hermon Roads and from the old Kaiser/Hanson Quarry to East Zayante Road; and 5) the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley (USFWS 2009).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 2/7/2001.

Legal Description

On February 7, 2001, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the Zayante bandwinged grasshopper (Trimerotropis infantilis) under the Endangered Species Act of 1973, as amended (Act). The designation includes an approximately 4,224 hectare (10,560 acre) area in Santa Cruz County, California, which includes all areas known to be occupied by the Zayante band-winged grasshopper.

Critical Habitat Designation

The Critical Habitat Unit (Unit) that is designated encompasses approximately 4,230 ha (10,560 ac) between Highways 9 and 17. Most of the lands designated as critical occur from the southeastern portion of Henry Cowell Redwoods State Park west to the City of Scotts Valley and north to the communities of Ben Lomond, Lompico, and Zayante. A small area designated as critical habitat is located east of Zayante in the vicinity of Weston Road.

Primary Constituent Elements/Physical or Biological Features

The unit of critical habitat is designated in Santa Cruz County, California. Within this area, the primary constituent elements for the Zayante band-winged grasshopper are those physical and biological elements that provide conditions that are essential for the primary biological needs of thermoregulation, foraging, sheltering, reproduction, and dispersal. The primary constituent elements are:

(a) the presence of Zayante soils,

(b) the occurrence of Zayante sand hills habitat and the associated plant species, and

(c) certain microhabitat conditions, including areas that receive large amounts of sunlight, widely scattered tree and shrub cover, bare or sparsely vegetated ground, and loose sand.

Special Management Considerations or Protections

Critical habitat does not include existing developed sites consisting of buildings, roads, aquaducts, railroads, airports, paved areas, and similar features and structures.

Life History

Feeding Narrative

Adult: The Zayante band-winged grasshopper is a diurnal herbivore. Sixty percent of the diet of the Zayante band-winged grasshopper is composed of the foliage of the silver bush lupine (Lupinus albifrons) (USFWS 2009). Activity rates of this species are low; they spend most of their time resting (46 percent) or walking, jumping, or flying (45 percent); reproductive (4 percent) and feeding (5 percent) activities occur much less frequently (McGraw 2004). The Zayante band-winged grasshopper require the presence of Zayante soils, and the occurrence of Zayante sandhills habitat and the associated plant species (66 FR 9219).

Reproduction Narrative

Adult: Females oviposit eggs directly into loose, sandy soil. The eggs overwinter in the soil and nymphs will begin to appear in May, with the first adults appearing in July. Breeding season occurs between July and November, and adults live for approximately 1 month. They rely heavily on the presence of silver bush lupine (Lupinus albifrons), which makes up more than 60 percent of their diet (USFWS 2009).

Geographic or Habitat Restraints or Barriers

Adult: Narrowly restricted to open sandy areas with sparse, low annual and perennial herbs in the sandy parkland habitat (USFWS 1998).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Feeds primarily on silver bush lupine (Lupinus albifrons) (USFWS 2009).

Habitat Narrative

Adult: The Zayante band-winged grasshopper is narrowly restricted to open sandy areas with sparse, low annual and perennial herbs on high ridges with sparse chaparral or ponderosa pine (Pinus ponderosa) stands on the Zayante sandhills (NatureServe 2015). Key resources for this species include the presence of Zayante soils in the Zayante sandhills habitat and the associated plant species, as well as certain microhabitat conditions that include areas that receive large amounts of sunlight, widely scattered tree and shrub cover, bare or sparsely vegetated ground, and loos sand (66 FR 9219). A suite of associated plants and insects, including three other federally-endangered species—the Ben Lomond spineflower (Chorizanthe pungens ssp. hartwegiana), the Ben Lomond wallflower (Erysimum teretifolium), and the Santa Cruz cypress (Hesperocyparis abramsiana)—are endemic to the Zayante sandhills. The Ben Lomond wallflower frequently co-occurs with Zayante band-winged grasshopper. Although no direct link has been found between these two taxa, their co-occurrence is probably a result of similar habitat requirements (USFWS 2009).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low; average dispersal distances range between 28 to 37 meters (m) (91 and 123 feet [ft.]), while the longest dispersal distance observed was 283 m (930 ft.) (McGraw 2004).

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The Zayante band-winged grasshopper has low mobility and is nonmigratory. The average dispersal distances range between 28 to 37 m (91 to 123 ft.), while the longest dispersal distance observed was 283 m (930 ft.). Between deme (a local population in which individuals are genetically similar), dispersal of the Zayante band-winged grasshopper may require sunlit openings or corridors in the surrounding forest or chaparral with sunlit barren or sparsely-vegetated loose sandy soils to facilitate movement of the grasshopper. In the sandhills, dense tree cover may limit dispersal of the Zayante band-winged grasshopper. (McGraw 2004)

Additional Life History Information

Adult: Between deme (a local population in which individuals are genetically similar), dispersal of the Zayante band-winged grasshopper may require sunlit openings or corridors in the surrounding forest or chaparral with sunlit barren or sparsely-vegetated loose sandy soils to facilitate movement of the grasshopper. In the sandhills, dense tree cover may limit dispersal of the Zayante band-winged grasshopper (McGraw 2004).

Population Information and Trends

Population Trends:

Specific trend information is unavailable, but species experts believe that the populations are in serious decline and the reduction of habitat due to successional process may drive the species to eventual extinction (USFWS 2009).

Species Trends:

Declining

Number of Populations:

Five: Quail Hollow County Park; Quail Hollow Quarry area; the area between East Zayante Road, Olympia Wellfield, and Mt. Hermon Road; Mt. Hermon area between Graham Hill and Mt. Hermon Roads and from the old Kaiser/Hanson Quarry to East Zayante Road; and the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley. There are differing perspectives on the total number of occupied areas and/or populations (USFWS 2009).

Population Size:

Population surveys of Zayante band-winged grasshopper have been conducted only at locations where HCPs have been approved. These locations are: Quail Hollow Quarry; Hanson Quarry; and the Freeman Site, the offsite mitigation parcel for Hanson Quarry. Data from these three sites may not reflect population trends for the Zayante band-winged grasshopper across the entirety of its range. The most current survey results estimate the Quail Hollow Quarry population at 23,805 in 2007, the Hanson Quarry population at 3,361 in 2006, and the Freeman Mitigation Site population at 18,134 in 2006 (USFWS 2009).

Resistance to Disease:

Moderate

Adaptability:

Low

Additional Population-level Information:

Although specific trend information is unavailable, it is believed that Zayante band-winged grasshopper populations are in a serious decline, and that the reduction in available habitat due to successional processes may drive the Zayante band-winged grasshopper to eventual extinction. This concern may be supported indirectly by declines observed in the federally endangered Ben Lomond wallflower. The range of the Ben Lomond wallflower is shrinking, there have been recent extirpations of some populations, and the population overall is declining largely due to habitat loss and alteration. Although no direct links have been found between the two taxa, it has been suggested that their co-occurrence is a result of similar habitat requirements (USFWS 2009).

Population Narrative:

The Zayante band-winged grasshopper is currently believed to be limited to the five remaining areas of open sand parkland habitat: Quail Hollow County Park; Quail Hollow Quarry area; the area between East Zayante Road, Olympia Wellfield, and Mt. Hermon Road; Mt. Hermon area between Graham Hill and Mt. Hermon Roads and from the old Kaiser/Hanson Quarry to East Zayante Road; and the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley. There are differing perspectives on the total number of occupied areas and/or populations. Population surveys of Zayante band-winged grasshopper have been conducted only at locations were HCPs have been approved. These locations are: Quail Hollow Quarry; Hanson Quarry; and the Freeman Site, the offsite mitigation parcel for Hanson Quarry. Data from these three sites may not reflect population trends for the Zayante band-winged grasshopper across the entirety of its range. The most current survey results estimate the Quail Hollow Quarry population at 23,805 in 2007, the Hanson Quarry population at 3,361 in 2006, and the Freeman Mitigation Site population at 18,134 in 2006. Although specific trend information is unavailable, it is believed that Zayante band-winged grasshopper populations are in a serious decline, and that the reduction in available habitat due to successional processes may drive the Zayante band-winged grasshopper to eventual extinction. This concern may be supported indirectly by declines observed in the federally endangered Ben Lomond wallflower. The range of the Ben Lomond wallflower is shrinking, there have been recent extirpations of some populations, and the population overall is declining largely due to habitat loss and alteration. Although no direct links have been found between the two taxa, it has been suggested that their co-occurrence is a result of similar habitat requirements (USFWS 2009). Populations of ZBWG are currently concentrated in the same small area as identified in our previous 5-year review (USFWS 2009, p. 6), between the communities of Mt. Hermon to the south, Bonny Doon to the west, Scotts Valley to the east, and Quail Hollow County Park to the north. The five areas where populations are currently known to occur are: 1) Quail Hollow County Park; 2) Quail Hollow Quarry (Graniterock Quarry) area; 3) the area between East Zayante Road, Olympia Wellfield, and Mt. Hermon Road; 4) Mt. Hermon area between Graham Hill and Mt. Hermon Roads and from the old Kaiser/Hanson Quarry to East Zayante Road; and 5) the area between Kings Village Road/Blue Bonnet Lane and Green Valley Road in the city of Scotts Valley. (USFWS, 2021)

Threats and Stressors

Stressor: Sand mining
Exposure: Sand mining.
Response: Habitat loss.
Consequence: Extirpation of populations of Zayante band-winged grasshopper.
Narrative: At the time of the listing of the Zayante band-winged grasshopper, sand mining was occurring on a large scale on many of the remaining deposits of Zayante sandhills soils. Most of the commercial sand mines have closed or are near closure due to increased environmental controls. However, sand mining is responsible for a loss of 80 percent of the original sand parkland habitat to which the Zayante band-winged grasshopper is endemic (USFWS 2009).

Stressor: Urban development

Exposure: Two of the five areas occupied by Zayante band-winged grasshopper contain residential development.
Response: Habitat loss.
Consequence: Extirpation of populations of Zayante band-winged grasshopper.
Narrative: Urban development has significantly slowed in the sandhills area. However, the lasting effects of past development remain, and two of the five occupied areas with suitable habitat contain residential areas (USFWS 2009). One occupied area is within 350 m (0.2 mile [mi.]), and all the remaining occupied habitat is within 75 m (0.05 mi.) of residential areas (USFWS 2009).

Stressor: Recreational use
Exposure: Hiking, walking, biking, and equestrian use.
Response: Erosion
Consequence: Habitat loss and extirpation.
Narrative: Recreation use was considered to be an important threat at the time of the listing. A habitat conservation plan (HCP) and a recreation plan are being developed for Quail Hollow County Park, and fences and signs have been erected to protect sandhill habitat. Fences and signs that have been erected to protect sandhills habitat are often cut. Several recreational activities have been observed, and hiking and some biking are common at most sandhills areas. Such threats may cause erosion to the habitat (USFWS 2009).

Stressor: Fire suppression
Exposure: Suppression of fire in a fire-adapted ecosystem.
Response: Proliferation of nonnative species, succession of the ecosystem, and habitat conversion.
Consequence: Habitat loss and reduced fitness.
Narrative: Widespread habitat conversion in the Santa Cruz sandhills will continue to occur due to fire suppression. This conversion will lead to increased canopy density and litter levels that will eventually result in conversion to habitat types that may not support species that are specialists endemic to sandhills parkland, such as the Zayante band-winged grasshopper. Specifically, the availability of exposed sandy soil in open sand parkland habitat required for egg-laying is affected (USFWS 2009).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Some threats to this species are not addressed by land-use regulations.
Response: Regulatory restrictions are currently inadequate to conserve this species.
Consequence: Habitat loss.
Narrative: Although regulatory protections have improved for these species since they were listed, some of the threats to the species are either currently unregulated or of a kind not addressed by land-use regulations (i.e., invasive species encroachment, fragmentation effects). Thus, regulatory restrictions that focus primarily on direct habitat destruction and take, even when applicable, are currently inadequate to conserve these species (USFWS 2009).

Stressor: Habitat fragmentation
Exposure: Habitat succession; fragmentation.

Response: Increased distance between habitat patches.
Consequence: Decrease in likelihood of genetic exchange.
Narrative: Fire suppression and succession continue to shrink the core sand parkland areas, leading to further fragmentation and isolation of habitat patches. As the distance between patches increases, the likelihood of genetic exchange between patches decreases, and the extinction rate of original species dependent on the habitat increases (USFWS 2009).

Recovery

Reclassification Criteria:
The seven discrete areas of sand parkland containing the ten currently known collection sites have been secured through fee-title acquisition, conservation easements, or HCPs—including HCPs for Graniterock Quarry, Kaiser Sand and Gravel Felton Plant, and the County of Santa Cruz (USFWS 1998).

Management plan for Quail Hollow Ranch County Park developed and being implemented (USFWS 1998).

Population numbers are stable or increasing (USFWS 1998).

Delisting Criteria:
Definitive delisting criteria will be developed for each species as more information becomes available on biology, range, and distribution through research and surveys. When the downlisting criteria have been met, the species can be considered for delisting if:

Threats are reduced or eliminated so that populations are capable of persisting without significant human intervention, or perpetual endowments are secured for management necessary to maintain the continued existence of the species (USFWS 1998).

Recovery Actions:
- Protect species habitats through acquisition, conservation easements, and HCPs and landowner agreements (USFWS 1998).
- Manage habitat for Santa Cruz Mountains species (USFWS 1998).
- Conduct research on the life history, ecology, and population dynamics of these species that will contribute to appropriate management strategies (USFWS 1998).
- Locate additional habitat/populations within the historic range of the species (USFWS 1998).
- Develop and implement a public outreach program (USFWS 1998).
- Evaluate progress of recovery effectiveness of management and recovery actions, and revise management plans (USFWS 1998).
- The recovery plan should be updated. Measurable recovery criteria should be included, and the current downlisting criteria should be clarified. Specifically, the sites listed for fee-title acquisition should be clearly identified so that they may be located and surveyed (USFWS 2009).
- Active management should be employed to prevent encroachment of both native and nonnative plant species in fire-suppressed areas that threaten habitat type conversion that

- may lead to extirpation of individual populations. Prescribed burns mimicking natural fire cycles may be used to create a habitat mosaic inclusive of persistent denuded areas (USFWS 2009).
- Surveys and monitoring should be undertaken for all known populations and potentially suitable habitat areas to ensure that all populations are identified, population trends are tracked, and reliable demographic information is collected (USFWS 2009).
- Genetic analysis should be undertaken to determine the relatedness of individuals from different populations (USFWS 2009).
- The Interim Programmatic HCP and eventually the Regional HCP should be completed. These plans will streamline permitting and conservation efforts and allow more effective use of the Zayante Hills Conservation Bank as a mitigation tool (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Identify specific sites needed for recovery and work to conserve these sites through fee-title acquisition, conservation easements, or Habitat Conservation Plans, including mediumpriority and high-priority parcels as defined in the recovery criteria for ZBWG and MHJB. 2. Undertake surveys and monitoring for all known populations and potential suitable habitat. Ensure all populations are identified and population trends are tracked. Several areas of Zayante and transitional soils are present outside the “sandhills” area proper and should be investigated for presence of ZBWG and MHJB. Outreach to owners of private holdings with potential populations should be attempted and permission secured to survey where necessary. 3. Employ active management to prevent encroachment of both native and non-native plant species in fire suppression/exclusion areas threatened with habitat type conversion. Prescribed burns mimicking natural fire cycles may be used to create a habitat mosaic more suitable for ZBWG and MHJB. 4. Investigate and implement MHJB and ZBWG reintroductions/translocations into restored or potentially suitable areas. 5. Undertake genetic analyses to determine effective population size and gene flow between populations. Results may help identify and delineate areas in need of protection for meeting one of the interim downlisting criteria. 6. Continue working with partners to protect all areas that contain suitable habitat for the species. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Vagrans egistina* (Mariana wandering butterfly)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Mariana wandering butterfly (Vagrans egistina) is endemic to the islands of Guam and Rota in the Mariana archipelago. Like most nymphalid butterflies, orange and black are the two primary colors exhibited by this species. Males and females appear similar in color and size. The overall color is black with a large orange splotch (irregular pattern) that extends from the posterior portion of the forewings to the anterior portion of the hindwings. Obvious stripes or rows of spots are lacking (Schreiner and Nafus 1997, plate 9). The caterpillar larva of this species is brown in color with black-colored spikes (Schreiner and Nafus 1996, p. 10).

Taxonomy

The Mariana wandering butterfly was originally named Issoria egistina (Swezey 1942). In 1934, Hemming published the genus Vagrans as a replacement name for the genus Issoria. Schriener and Nafus (1997) recognize this species as Vagrans egistina which is the most recent and accepted taxonomy. We have carefully reviewed the available taxonomic information and have concluded the species is a valid taxon.

Historical Range

The Mariana wandering butterfly, originally described from Guam in 1932, was considered to be rare, but widespread at that time (Swezey 1942). The species was first collected on Rota in the 1980s (Schreiner and Nafus 1996, p. 10).

Current Range

The Mariana wandering butterfly has not been seen on the island of Guam since 1979, where it was collected in Agana, and it is currently considered likely extirpated from Guam (Schreiner and Nafus 1996, pp. 1-2); Rubinoff, in litt. 2013, p. 1). During several 1995 surveys on Rota, the Mariana wandering butterfly was recorded at only one location among six different sites surveyed on Rota. The area is known as the IChenchon Park Bird Sanctuary and includes limestone karst forest habitat and has been preserved as a nature park and rare bird sanctuary (Schreiner and Nafus 1996, p. 1). Within this area and most areas surveyed on Rota, the host plant, Maytenus thompsonii, was found to be abundant (Schreiner and Nafus 1996, p. 1). IChenchon Park Bird Sanctuary is one of three areas on the island of Rota owned and under the jurisdiction and protection of the CNMI Division of Fish and Wildlife (DFW) (DFW 2013). The DFW has designated the site as a wildlife conservation area and removal of both plants and animals is prohibited. In 2004, the entire IChenchon Park Bird Sanctuary was designated as part of a larger critical habitat unit for the Mariana crow (Corvus kubaryi). Distribution: Guam and Rota (USFWS, 2020b)

Distinct Population Segments Defined

Not Applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: The larvae of this butterfly feed on the plant species, Maytenus thompsonii (luluhut) in the Celastraceae family, which is endemic to the Mariana Islands (Swezey 1942; Schreiner and Nafus 1996, p. 1). M. thompsonii is known to occur on the island of Guam and within the CNMI on the islands of Rota, Saipan, and Tinian (Vogt and Williams 2004, p. 121). It grows as a small tree or shrub and reaches 2 meters (m) (6.5 feet (ft)) in height. Its form may appear quite variable, either full or intertwined with nearby plants, and it is primarily found within native limestone karst forest habitat (Vogt and Williams 2004, p. 121). While apparently restricted to native limestone karst forest habitat, researchers have found individual M. thompsonii plants not uncommon within suitable habitat (Schreiner and Nafus 1996, p. 1; Rubinoff, in litt. 2013, p. 1).

Reproduction Narrative

Adult: There is not much information regarding reproduction of this species.

Geographic or Habitat Restraints or Barriers

Larvae: restricted to native limestone karst forest habitat

Spatial Arrangements of the Population

Larvae: clumped on suitable resources

Environmental Specificity

Larvae: Specialist. Relies on one particular host plant

Tolerance Ranges/Thresholds

Larvae: Unknown

Adult: Unknown

Site Fidelity

Larvae: high

Adult: moderate

Dependency on Other Individuals or Species for Habitat

Larvae: M. thompsonii

Habitat Narrative

Larvae: M. thompsonii (the plant that the larvae is dependent on) is known to occur on the island of Guam and within the CNMI on the islands of Rota, Saipan, and Tinian (Vogt and Williams 2004, p. 121). It grows as a small tree or shrub and reaches 2 meters (m) (6.5 feet (ft)) in height. Its form may appear quite variable, either full or intertwined with nearby plants, and it is primarily found within native limestone karst forest habitat (Vogt and Williams 2004, p. 121). According to Vogt and Williams (2004, p. 121. While apparently restricted to native limestone karst forest habitat, researchers have found individual M. thompsonii plants not uncommon within suitable habitat (Schreiner and Nafus 1996, p. 1; Rubinoff, in litt. 2013, p. 1).

Dispersal/Migration

Motility/Mobility

Larvae: low

Adult: moderate

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Adult: non-migratory

Dispersal

Larvae: low

Adult: moderate

Immigration/Emigration

Larvae: unlikely

Adult: unlikely because of habitat fragmentation

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: The Mariana wandering butterflies are known to be good fliers, and in an undisturbed setting probably existed as a series of meta-populations (Harrison et al. 1988), with considerable movement and interbreeding between local and stable populations and continued colonization and extinction in disparate localities.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

1 (USFWS, 2020b)

Population Size:

Unknown last seen on Guam in 1979 and on Rota in 1995 (USFWS, 2020)

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

low

Population Narrative:

During several 1995 surveys on Rota, the host plant of the Mariana wandering butterfly, Maytenus thompsonii, was found to be abundant, but only one butterfly population was recorded at IChenchon Park Bird Sanctuary on the southeaster portion of the island. During one survey at IChenchon Park, a total of seven individuals (believed to be all males based on their behavior) were observed. However, no eggs or larvae could be found on any of the host plants at IChenchon during three separate surveys at the site (Schreiner and Nafus 1996, pp. 1-2). The Mariana wandering butterfly was last seen on Guam in 1979 and on Rota in 1995, despite survey attempts since these dates. The native limestone forest in Guam and Rota that supports the wandering butterfly’s presumed host plant continues to decline due to development and modification, ungulate pressure, typhoons, nonnative plants, and fire. The primary direct stressors to the butterfly likely include high egg mortality and predation from native and nonnative insects including ants and parasitic wasps. Most of these threats are currently unmanaged. Due to the lack of a current known population and continuing threats, the Mariana wandering butterfly remains endangered throughout its range. (USFWS, 2020)

Threats and Stressors

Stressor: Invasive species
Exposure:

Response:
Consequence:
Narrative: Numerous nonnative insect predators and parasitoids of Lepidoptera have become established, purposefully or adventitiously in the Mariana Islands, including on Guam and Rota. Some of these insects have been documented to attack and significantly impact certain species of native butterflies (Peterson 1957; Schreiner and Nafus 1986; Nafus 1989, 1992, 1993a, b, c). While there is little documentation, these nonnative predators and parasitoids undoubtedly contribute to the decline of this butterfly. The parasitoid Trichogramma chilonis (no common name (NCN)) was purposefully released on Rota in 1935 and on Guam in the early 1970s to control pest lepidopterans and has become established on both these islands (Nafus and Schreiner 1989). Nafus (1993a) documented the heavy parasitism of eggs of the common eggfly (Hypolimnas bolina), which is also a nymphalid butterfly, by T. chilonis and two native parasitoid wasps Telenomus sp. (NCN) and Ooencyrtus sp. (NCN). The two wasp species also occur on Rota and have been documented to attack the eggs of the Mariana wandering butterfly (Schreiner and Nafus 1996). Nafus (1992) also found the major pupal parasitoid wasp to be Brachymeria lasus (NCN), another deliberate biological control introduction. Nafus (1992) stated that the Mariana wandering butterfly may have been affected by B. lasus. Nafus (1993a) found nonnative ants to be major predators of the eggs and larvae of the common eggfly. The most commonly observed ants were dwarf pedicel ants (Tapinoma minutum), tropical fire ants (Solenopsis geminata), white-footed ants (Technomyrmex albipes), and bi-colored trailing ants (Monomorium floricola). Many ant species are known to prey on all immature stages of Lepidoptera and can completely exterminate populations (Zimmerman 1958). During some times of the year, nonnative ants destroyed virtually all the eggs of the common eggfly in Guam (Nafus 1992), and predation by ants is the primary cause of mortality (>90 percent) in the Mariana eight spot butterfly (Hypolimnas octocula marianensis) (Schreiner and Nafus 1996), another nymphalid butterfly that also occurs on the island of Guam. Nonnative ants are known to occur on the island of Rota, and are likely to include many of the same species recorded on Guam (Amidon and Marshall 2007, pers. comm.).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The Mariana wandering butterfly currently receives no protection under the federal Endangered Species Act (16 U.S.C. §1531-1544) or the Commonwealth of the Northern Mariana Islands (CNMI) Endangered Species List (Public Law 2-51 CMC 5108b). It does receive protection under the Guam Endangered Species Act (5GCA § 63205(c)).

Stressor: Fragmented/Isolated populations
Exposure:
Response:
Consequence:
Narrative: The Mariana wandering butterfly has been extirpated from Guam and persists in extremely low numbers on Rota. This circumstance makes it vulnerable to extinction due to a

variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation 1994; Mangel and Tier 1994). Small populations are also demographically vulnerable to extinction caused by random fluctuations in population size and sex ratio and to catastrophes such as typhoons (Lande 1988).

Recovery

Reclassification Criteria:
not applicable

Delisting Criteria:
not applicable

Recovery Actions:

- Develop a recovery plan
- Develop and implement surveys for the Mariana wandering butterfly throughout their known historic range and in potentially suitable habitat
- Develop and implement monitoring surveys to better understand the status of the host plant species
- confirm whether the host plant is susceptible to grazing by feral ungulates including pigs and deer, and if so, develop and implement control to protect the host plant
- Research and conduct parasite control
- Research and conduct ant control
- Conservation Measures Planned or Implemented: In 2009, field information sheets were provided with color pictures and descriptions of the Mariana wandering butterfly and its host plants to over 20 professional staff currently working in the field on the islands of Rota, Tinian, and Saipan. The sheets request that pictures, GPS points and field notes be provided to the U.S. Fish and Wildlife Service (FWS) in an effort to obtain information on this species (Hawley, in litt. 2009). A survey led by the FWS was conducted on the island of Tinian, CNMI, from June through October, 2008, to determine the presence or absence of the Mariana wandering butterfly and the Mariana eight-spot butterfly. While Tinian is not known to be part of either species historical range, the likelihood of introduced pests arriving on Tinian due to an increase in sea and air transports to this island is a concern for a suite of native butterfly species, including the Mariana wandering butterfly. Additionally, any reduction of host plant sites for either butterfly species may be of conservation concern if translocation to Tinian is considered in future recovery or enhancement plans. While several Maytenus thompsonii host plant population sites were identified and monitored in limestone forest habitat on Tinian, no life stages of the Mariana wandering butterfly were found (Hawley, in litt. 2009). In 2011, the FWS contracted with Dr. Dan Rubinoff, a University of Hawaii lepidopterist, to conduct surveys for both the Mariana wandering butterfly and the Mariana eight-spot butterfly on Guam and Saipan. These surveys were completed in in July, 2011.
- Threat and Recovery Potential: Full species with a high degree of threat and a low degree of recovery potential. (USFWS, 2020b)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Determine population status and current distribution • Resurvey potential sites on Guam and Rota that contain Maytenus thompsonii • If rediscovered, determine the definite host plant of the species to aid in additional survey methods. • If rediscovered, conduct research on the species to clarify life history and key threats, including breeding biology, population dynamics, and other seasonality. • Feral ungulate management to protect existing limestone forest and the host plants from feral ungulates, which may also threatened any presence of butterfly eggs. • Establish protected areas containing sufficient limestone forest resources, including high-densities of the putative host plant, Maytenus thompsonii. • If rediscovered, consider establishing a captive propagation and reintroduction plan to increase the number of populations and the resiliency of remaining populations. (USFWS, 2020)

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SPECIES ACCOUNT: *Zapada glacier* (Western glacier stonefly)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Western glacier stoneflies are small insects that begin life as eggs, hatch into aquatic nymphs, and later mature into winged adults, surviving briefly on land before reproducing and dying. Western glacier stonefly adults are generally brown in color with yellowish brown legs and possess two sets of translucent wings (Baumann and Gaufin 1971, p. 275). Adults range from 6.5 to 10.0 millimeters (mm) (0.26 to 0.39 inches (in)) in body length (Baumann and Gaufin 1971, p. 275). Western glacier stonefly nymphs cannot be distinguished from other Zapada nymphs using gross morphological characteristics (USFWS, 2016).

Taxonomy

The western glacier stonefly is in the same family as the meltwater lednian stonefly (i.e., family Nemouridae; Baumann 1975, pp. 1, 31; Service 2011, p. 18688), but a different genus (Zapada). Members of the Zapada genus are the most common of the Nemouridae family (Baumann 1975, p. 31). The western glacier stonefly is recognized as a valid species by the scientific community (Baumann 1975, p. 30; Stark 1996, entire; Stark et al. 2009, p. 8), and no information is available that disputes this finding (USFWS, 2016).

Historical Range

Known only from Glacier National Park, Montana (NatureServe, 2015).

Current Range

The MWS currently occupies 113 streams across its known range, and the WGS currently occupies 16 streams across its known range; however, cumulatively, both species occupy relatively small amounts of habitat per stream on average, approximately 600 meters (1,968 feet) per stream. Both species occupy only these small amounts of area per stream because of their low thermal tolerances and the rapid warming of meltwater streams downstream of the meltwater sources, from full sun exposure in alpine environments. Further, both species inhabit the most upstream reaches of their meltwater habitats and cannot disperse further upstream if water temperatures warm beyond their thermal tolerances. This narrow distribution within streams and inability to disperse upstream increases the risk of harm due to stochastic events, such as drought or annual weather fluctuations. Thus, the current overall resiliency of the meltwater habitat and sources for both species is low (USFWS, 2021).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Nemouridae nymphs are typically herbivores or detritivores, and their feeding mode is generally that of a shredder or collector-gatherer (Baumann 1975, p. 1; Stewart and Harper 1996, pp. 218, 262) (USFWS, 2016).

Adult: Not available

Reproduction Narrative

Adult: Typically, Nemouridae stoneflies complete their life cycles within a single year (univoltine) or in 2 to 3 years (semivoltine) (Stewart and Harper 1996, pp. 217–218). After mating, females deposit a mass of fertilized eggs in water where they are widely dispersed or attached to substrates by sticky coverings or specialized anchoring devices (Hynes 1976, p. 141; Stewart and Harper 1996, p. 217). Eggs may hatch within a few weeks or remain in diapause (dormancy) for much longer periods if environmental conditions, such as temperature, are not conducive to development (Hynes 1976, p. 142) (USFWS, 2016).

Geographic or Habitat Restraints or Barriers

Adult: Possibly daily maximum water temperatures > 43oF

Spatial Arrangements of the Population

Adult: 37 - 213 per square foot (USFWS, 2016)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Larvae: Eggs and nymphs of Nemouridae stoneflies are aquatic (Stewart and Harper 1996, p. 217), and nymphs rely on perennial water sources to breathe through gills, similar to fish (USFWS, 2016).

Adult: Mature stonefly nymphs emerge from the water and complete their development in the terrestrial environment as short-lived adults on and around streamside vegetation or other structures (Hynes 1976, pp. 135– 136; Stewart and Harper 1996, p. 217). Western glacier stoneflies are found on relatively short reaches of streams in close proximity to meltwater sources [means = 508 m (1,667 ft.); range = 15–1407 m (49–4,616 ft.)] (Giersch and Muhlfeld 2015, in progress). Western glafier stoneflies can attain moderate densities [(400–2,300 per square m) (37–213 per square ft)] (Giersch 2016, pers. comm.). Western glacier stoneflies are found in high-elevation, fishless, alpine streams closely linked to the same meltwater sources as the meltwater lednian stonefly (Giersch and Muhlfeld 2015, in progress). all recent collections of the western glacier stonefly in GNP have occurred in habitats with daily maximum water temperatures less than 6.3 °C (43 °F) (Giersch et al. 2015, p. 61). In general, Nemouridae stoneflies are primarily associated with clean, cool or cold, flowing waters (Baumann 1979, pp. 242–243; Stewart and Harper 1996, p. 217) (USFWS, 2016). The environmental specificity is very narrow (specialist or community with key requirements scarce) (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2016)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2016)

Dispersal

Adult: Low (USFWS, 2016)

Dispersal/Migration Narrative

Adult: Nemouridae stoneflies disperse longitudinally (up or down stream) or laterally to the stream bank from their benthic (nymphal) source (Hynes 1976, p. 138; Griffith et al. 1998, p. 195; Petersen et al. 2004, pp. 944–945). Generally, adult stoneflies stay close to the channel of their source stream (Petersen et al. 2004, p. 946), and lateral movement into neighboring uplands is confined to less than 80 meters (262 feet) from the stream (Griffith et al. 1998, p. 197). Thus, Nemouridae stoneflies, and likely western glacier stoneflies, have limited dispersal capabilities (USFWS, 2016).

Population Information and Trends

Population Trends:

Not available

Redundancy:

The current overall resiliency of the meltwater habitat and sources for both species is low (USFWS, 2021).

Number of Populations:

4 (USFWS, 2016)

Population Size:

10,000+ (USFWS, 2016)

Population Narrative:

Four populations of the western glacier stonefly are known to occur, all within the boundaries of Glacier National Park (GNP). range of densities and a coarse assessment of available habitat, the abundance of the western glacier stonefly is estimated to be in the tens of thousands of individuals (USFWS, 2016).

Threats and Stressors

Stressor: Climate change (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The western United States appears to be warming faster than the global average. In the Pacific Northwest, regionally averaged temperatures have risen 0.8 °C (1.5 °F) over the last century and as much as 2 °C (4 °F) in some areas. Since 1900, the mean annual air temperature for GNP and the surrounding region has increased 1.3 °C (2.3 °F), which is 1.8 times the global mean increase (U.S. Geological Survey (USGS) 2010, p. 1). Mean annual air temperatures are projected to increase by another 1.5 to 5.5 °C (3 to 10 °F) over the next 100 years (Karl et al. 2009, p. 135). Warming also appears to be pronounced in alpine regions globally (e.g., Hall and Fagre 2003, p. 134 and references therein). The alteration or loss of meltwater sources and perennial habitat has direct consequences on western glacier stonefly populations. When established in 1910, GNP contained approximately 150 glaciers larger than 0.1 square kilometer (25 acres) in size, but presently only 25 glaciers larger than this size remain (Fagre 2005, pp. 1–3; USGS 2005, 2010). Hall and Fagre (2003, entire) modeled the effects of climate change on glaciers in GNP's Blackfoot-Jackson basin using then-current climate assumptions (i.e., doubling of atmospheric carbon dioxide by 2030). Under this scenario, glaciers were predicted to completely melt in GNP by 2030, and predicted increases in winter precipitation due to climate change were not expected to buffer glacial shrinking (Hall and Fagre 2003, pp. 137–138). In general, the Service expects all meltwater sources to decline under a changing climate, given the relationship between climate and glacial melting (Hall and Fagre 2003, entire; Fagre 2005, entire) and recent climate observations and modeling (IPCC 2014, entire). It is likely that seasonal snowpack levels will be most immediately affected by climate change, as the frequency of more extreme weather events increases (IPCC 2014, p. 8). These extremes may result in increased seasonal snowpack in some years and reduced snowpack in others. It is also expected that permanent snowpack and ice masses will decline and completely melt within the near future. After 2030, flow reductions and water temperature increases due to continued warming are expected to further reduce or degrade remaining refugia habitat (alpine springs and glacial lake outlets) for western glacier stoneflies. Predicted habitat changes are based on observed patterns of flow and water temperature in similar watersheds within GNP and elsewhere where glaciers have already melted. In addition, we have observed a declining trend in western glacier stonefly distribution over the last 50 years, as air temperatures have warmed in GNP (USFWS, 2016).

Stressor: Drought (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The restricted range of the western glacier stonefly makes this species vulnerable to the stochastic threat of drought. Although not considered a current threat, drought will likely affect this species negatively within the near future. There is potential for extirpation of entire

populations as a result of dewatering events caused by drought, after the complete loss of glaciers predicted by 2030 (USFWS, 2016).

Stressor: habitat degradation and fragmentation due to climate change
Exposure:
Response:
Consequence:
Narrative: The primary threat to both stonefly species and their habitat is habitat degradation and fragmentation due to climate change. Both stonefly species are intimately tied to cold meltwater aquatic habitat, the sources of which are glaciers or snowfields. Thus, the viability of both species is closely linked to the persistence of these glaciers and snowfields and their ability to continue to provide meltwater habitat in a warming climate. These meltwater sources vary in size, but most are predicted to completely melt by 2030. Warming air temperatures have already been implicated in faster melting of meltwater sources (glaciers and snowfields) in Glacier National Park and elsewhere. As these meltwater sources begin to disappear, streamflows are expected to become intermittent and water temperatures warmer (USFWS, 2021).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Not available

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