Appendix K-A5 - *The following integration and synthesis analyses were done in a step-wise approach that addresses vulnerability, risk, and usage, applicable conservation measures and our conclusion. Please see cover page of this appendix for additional information.*

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Stygobromus hayi	Hay's Spring amphipod	475

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The original site known for this species was a spring on National Zoo property adjacent to Rock Creek in the District of Columbia. The other six sites (confirmed and probable) consist of five springs and one interstitial sample from the sediments of Rock Creek, all within Rock Creek Park in the District of Columbia. Collectively, all seven known and probable sites are within a 3-mile reach of the Rock Creek floodplain and all are subject to similar environmental conditions.

Because Rock Creek Park is a heavily used recreation area and because its watershed outside the park is highly urbanized, there are many activities that may be degrading the species' habitat. Intensive recreational use adjacent to the springs in Rock Creek Park increases the potential for pollution of the springs, and intensive development and associated increases in impermeable surfaces may decrease water quality and quantity in the springs. Past and ongoing changes in the hydrology of the watershed are associated with intensive urban development (Feller 1997). These activities were identified as threats at the time of the species' listing but have likely increased in intensity since 1982. Because this species inhabits seeps or springs, the quality and quantity of the groundwater supply feeding these habitats is of particular concern. Culver and Sereg (2004) provide information indicating that water quality is degraded at several of the springs along Rock Creek within the range of Hay's Spring amphipod. In addition, reduced flows have been observed in many of the springs, with the most pronounced flow reductions occurring in Ross Drive Spring (essentially dry) and Carter Barron Spring (Bill Yeaman, pers. comm. 2012). Existing regulatory mechanisms provide adequate authority to protect the species from any threats originating within the boundaries of these parks. However, non-point source pollution and changes in hydrology originating outside these boundaries are likely to adversely affect this species (Feller 1997) and are extremely difficult to regulate in the urban landscape surrounding these parks.

EB/CE Source: U.S. Fish and Wildlife Service. Hay's Spring amphipod (*Stygobromus hayi*) 5-Year Review: Summary and Evaluation. Chesapeake Bay Field Office, Annapolis, Maryland. June 2013. 9 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Hay's spring amphipod will experience mortality from any malathion uses at the maximum rates in bin 2. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 57.92% of Hays amphipods exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die. For mosquito adulticide, we anticipate 81.42% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	57.92%
MOSQUITO CONTROL	
Mortality effects	81.42%

Risk modifiers:

Bin 2 only; only 2 layers for this species: mosquito control and developed, both well above 99% LC50 HC05

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	7,932	81.42	0	0	2	2H
Developed	D	5,637	57.92	281	2.90	2	2H
Sub-TOTAL (D):		5,637	57.92	281	2.90	-	-

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Other uses with effects[3]							
TOTAL[4]:		13,569	100.00[§]	281	2.90		

1. Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
2. Estimated usage in the range is based on information about annual past usage.
3. Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
4. TOTAL includes usage on all use sites with effects, including mosquito control.
[§]Use overlaps with range are additive and cannot be greater than 100%.

 # acres in species range: 9,732 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 2,122 acres, 21.81%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Hay's Spring amphipod. As discussed below, even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Hay's Spring amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portions of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 57.92% mortality of individuals, and 81.42% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized. Populations may be exposed from upland and non-point sources of malathion as runoff from use sites. Where exposure occurs, malathion uses may result in a disproportionate number of individuals being killed because of the species’ clumped distribution.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year, and we anticipate that usage be low, and limited to approximately 2.9%

of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species, and the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While we anticipate direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Hay's Spring amphipod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Antrolana lira	Madison Cave isopod	476

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The listing was based on a number of factors including, but not limited to: its known range, vandalism, siltation events, and potential mercury contamination. Threats to the Madison Cave isopod (MCI) include: thermal and chemical pollution from urban development and agricultural runoff (e.g., poultry farming), physical pollution, and human disturbance (cave vandalism and visitation). Obstacles to recovery include a lack of ecological and life history information for MCI and a lack of information regarding the physical limits of recharge zones that affect MCI habitat (Service 1996).

The MCI is a stygobite, freshwater subterranean aquatic crustacean, first described by T. E. Bowman in 1964. It is the only member of the genus *Antrolana* and the only freshwater cirolanid isopod north of Texas. It is also the only known stygobitic cirolanid whose habitat is completely isolated from the marine environment. The population size of the MCI is unknown at most sites. MCI can be difficult to capture at known locations other than Madison Cave and Steger' s Fissure, so little information is available on abundance for most sites and no meaningful population trend data is available. To date, Madison Cave and the adjacent Steger's Fissure have consistently yielded numerous individuals when sampled. Population abundance has been calculated for those sites and Irvin King Well #2, West Virginia. Fong (2007) conducted a series of mark re-capture studies at the Madison Cave and Steger's Fissure sites. He sampled in 1995, 1997, 2004, and 2006. His work estimated the population in Madison Cave ranged from 360 to 1,020 individuals and from 2,240 to 3,420 individuals in Steger's Fissure. Between 1997 and 2006 there was little fluctuation. Four sites were sampled in Jefferson County, West Virginia where MCI was known to occur (Hutchins and Omdorff 2009). MCI have been recorded from 16 locations within the Shenandoah Valley from Leetown, West Virginia south to Lexington, Virginia: a range 136.4 miles long and 24.8 miles wide (Hutchins 2007).

MCI habitat is degraded by altering water flow patterns, which can lead to a reduction in available habitat if water is diverted or if the system becomes flashy and sediment and contaminant loads increase. Water flow patterns are altered by many factors including increased impervious surfaces, filling sinkholes, and shifting subsurface formations and hydrology. Flow patterns may change depending on the amount of impervious surfaces in the recharge zone. MCI habitat is susceptible to groundwater contamination due to its porous nature and limited filtering

abilities. In rural areas, agricultural practices such as large scale biosolids and pesticide application are ongoing and may threaten the quality of the habitat. In 2006/2007, the U.S. Geological Survey (USGS) sampled groundwater for contaminant levels from wells in potential MCI habitat in Jefferson and Berkeley Counties, West Virginia. Samples were analyzed for a broad spectrum of contaminants, including pharmaceuticals and pesticides. USGS found the herbicide atrazine in low levels in four of the six sites. One site in Jefferson County contained detectable concentrations of atrazine, prometon (herbicide), tetrachloroethylene (dry-cleaning or degreasing solvent), 1-4 dichlorobenzene (insecticide and deodorizer in some manufacturing processes), and bisphenol-A (widely used plasticizer) (Boughton 2007). The levels of these chemicals were found below their Ambient Water Quality Criteria, developed by the Environmental Protection Agency for the protection of aquatic organisms, but reveal the susceptibility of groundwater to contamination by surface contaminants.

EB/CE Source: U. S. Fish and Wildlife Service. Biological Opinion, Warren County Power Station Low Effect Habitat Conservation Plan, Virginia Ecological Services Field Office, Gloucester, Virginia. November 21, 2011. 17 pp. + appendices.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Madison Cave isopod will experience mortality from most malathion uses at the maximum rates in all bins (bins 5 and 6). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 9.90% of Madison Cave isopods exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 14.21% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	9.90%
MOSQUITO CONTROL	
Mortality effects	14.21%

Risk modifiers:

Bins 5, 6

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas. All uses are high for bins 5 and 6, with the exception of Developed, which is low for both bins 5 and 6.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	171,354	14.21	0	0	5,6	5H 6H
Other Crops	D	3,993	0.33	100	<0.01	5,6	5H 6H
Christmas Trees	D	47	<0.01	47	<0.01	5,6	5H 6H
Other Grains	D	4,195	0.35	801	0.07	5,6	5H 6H
Corn	D	50,940	4.22	895	0.07	5,6	5H 6H
Cotton	D	1	<0.01	0	<0.01	5,6	5H 6H
Developed	D	49,899	4.14	2,495	0.21	5,6	5L 6L
Nurseries	D	390	0.03	390	0.03	5,6	5H 6H
Wheat	D	3,170	0.26	701	0.06	5,6	5H 6H
Vegetables & Ground Fruit	D	71	<0.01	56	<0.01	5,6	5H 6H
Orchards & Vineyards	D	3,379	0.28	1,824	0.15	5,6	5H 6H
Other Row Crops	D	14	0.01	14	<0.01	5,6	5H 6H
Pasture	D	3,069	0.25	1,206	0.10	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		119,168	9.90	8,529	0.74		
TOTAL[4]:		290,522	24.11	8,529	0.74		

1. Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
2. Estimated usage in the range is based on information about annual past usage.

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

3. Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
4. TOTAL includes usage on all use sites with effects, including mosquito control.

 # acres in species range: 1,206,003 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 24,297 acres, 2.015%

Overall Usage: ☐ High ☐ Medium ☒ Low

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable

number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Madison Cave isopod. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Madison Cave isopod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal lands portion of the range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 9.90% mortality of individuals and 14.21% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 5, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized. Populations may be exposed from upland and non-point sources of malathion runoff from use sites. Where exposure occurs, malathion uses may result in a disproportionate number of individuals being killed because of the species' clumped distribution.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.74% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals if malathion is used within the non-Federal range of the species. However, even though the vulnerability and risk are high for this species, the likelihood of

exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While we anticipate that direct exposure from use sites will to result in low levels of mortality (small numbers of individuals) over the duration of the Action we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Madison Cave isopod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Stygobromus (=Stygonectes) Pecki	Peck's cave amphipod	477

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

Peck's cave amphipod is known from Comal Springs and Hueco Springs, both in Comal

County. Peck's cave amphipod is a subterranean, aquatic crustacean in the family Crangonyctidae. Over three hundred specimens have been collected (USFWS 1995). This species is known from two springs; one specimen only from one of the springs.

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). The primary threat to this species is a decrease in water quantity and quality as a result of water withdrawal and other human activities throughout the San Antonio segment of the Edwards Aquifer. In 2013, the Service finalized the Edwards Aquifer Authority Recovery Implementation Program Habitat Conservation Plan (EARIP HCP) and issued an Incidental Take Permit for 11 federally-listed species. The EARIP HCP is a mult-stakeholder water conservation and aquifer management program developed by the Applicants in coordination with the Service and other interested parties to protect threatened, endangered, and other rare aquatic species in central Texas. The EARIP HCP Applicants have agreed to avoid, minimize, and mitigate adverse effects to Peck's Cave amphipod (*Stygobromus pecki*), and several other species over a period of 15-years. The HCP addressed the regulation and production of groundwater in accordance with State law for irrigation, industrial, municipal, domestic, and livestock purposes; the use of the Comal River and San Marcos River for recreational uses; operational and maintenance activities that could affect Comal Springs, San Marcos Springs, and the associated river systems; and activities necessary to manage potential habitat for the covered species within the 17 county action and permit area. The EARIP HCP requires water quality and quantity protections including expanded groundwater and surfacewater monitoring and annual reporting to demonstrate compliance with the terms and conditions of the incidental take permit. The annual report to the Service includes: information on EAA permitted withdrawals, reference well levels, springflows at Comal and San Marcos Springs, aquifer hydrology and discharge from wells and springflow, location of sampling sites, water quality data and methodology of water quality sampling and anaylses. The reports document HCP management activities including the status of implementation of minimizaton

and mitigation measures and their effectiveness, interim updates of any research or published studies related with the EARIP or HCP, any changes to the objectives for the monitoring program, effects on the covered species or permit area, and evaulation of progress toward the biological goals and objectives to ensure as needed that adaptive management strategies are implemented to meet the goals of the conservation program outlined in the HCP. Each year the EAA monitors the quality of water in the Edwards Aquifer by sampling approximately 80 wells, eight surface water sites, and major springs across the region. Tests include measurements of temperature, pH, conductivity, alkalinity, major ions, minor elements (including heavy metals), total dissolved solids, nutrients, pesticides, herbicides, VOCs, and other analytes. EAA testing of over 100 wells and spring groups from Edwards Aquifer and Trinity Aquifer sources did not detect any pesticides or herbicides above EPA's primary drinking water standards, or the maximum contaminant limit (MCL) (EAA 2016). The only pesticide or herbicide detected in Edward Aquifer wells during the 2016 sampling year was a single detection of the herbicide compound 2, 4,-D; however, the level did not exceed its MCL (EAA 2016).

EB/CE Sources:

Edwards Aquifer Authority (EAA). 2016. 2016 Water Quality Summary. 6 pp. https://www.edwardsaquifer.org/wp-content/uploads/2019/04/2016-Water-Quality-Summary-Report.pdf

U. S. Fish and Wildlife Service. 1997. Endangered and Threatened Wildlife and Plants; Final Rule To List Three Aquatic Invertebrates in Comal and Hays Counties, TX, as Endangered. Final Rule. Federal Register 62:66295-66304.

U. S. Fish and Wildlife Service. 2013. Biological and Conference Opinions for the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan- Permit TE-63663A-0. Austin Ecological Services Field Office, Austin, Texas.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK

(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Peck's cave amphipod will direct experience mortality from most malathion uses at the maximum rates for bin 2. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 9.01% of Peck's cave amphipod exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 7.76% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	9.01%
MOSQUITO CONTROL	
Mortality effects	7.76%

Risk modifiers:

Bin 2

Area of occupied habitat covered by EAA, and EARIP HCP

Annual water quality monitoring by EAA HCP and reports to the Service

Edwards Aquifer is a critical source of drinking water and water quality and quantity are closely monitored and regulated to ensure safety and compliance with Safe Drinking Water Act.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☒ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control		28,426	7.76	0	0	2	2H
Other Crops	D	878	0.24	0	<0.01	2	2H
Nurseries	D	135	0.04	135	0.04	2	2H
Other Grains	D	5,762	1.57	5762	1.67	2	2H
Corn	D	4,885	1.33	2,081	0.57	2	2H
Cotton	D	313	0.09	288	0.08	2	2H
Developed	D	18,367	5.01	918	0.25	2	2H
Other Row Crops	D	50	0.01	52	0.01	2	2H
Wheat	D	2,525	0.69	2,525	0.72	2	2H
Vegetables & Ground Fruit	D	1	<0.01	1	<0.01	2	2H
Orchards & Vineyards	D	20	<0.01	16	<0.01	2	2H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Pasture	D	<1	<0.01	<1	<0.01	2	2H
Sub-TOTAL (D): *Other uses with effects*[3]		32,936	9.01	11,778	3.38	2	
TOTAL[4]:		61,362	16.77	11,778	3.38		

[1]Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

 # acres in species range: 366,294 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 178 acres, 0.049%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Peck's cave amphipod. As discussed below, the vulnerability is high, the risk of exposure is medium and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Peck's cave amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is medium. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion. A small portion of the species range overlaps Federal lands (0.049%).

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 9.01% mortality of individuals and 7.76% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would

result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized. Populations may be exposed from upland and non-point sources of malathion runoff from use sites. Where exposure occurs, malathion uses may result in a disproportionate number of individuals being killed because of the species' clumped distribution.

We do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 3.38% of the non-Federal species range annually based on standard past usage data. The listing final rule in 1997 mentioned that this species is threatened from groundwater contamination (i.e., pesticides, specifically insecticides) from roadway runoff and agricultural activities in the area surrounding where this species is found. However, as discussed above, since this time, the EARIP HCP was finalized in 2013 and covers a 15 year period stipulating protections for groundwater and surface water quantity and quality, as well as other provisions for the benefit of listed species. We anticipate loss of individuals if malathion is used within the non-Federal range of the species. However, based on usage data indicating low overall levels of usage, the expanded groundwater and surface water quality monitoring and reporting prescribed by the EARIP HCP, the emphasis of water quality and water quantity safeguards related to the reliance upon Edwards Aquifer for drinking water, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

Thus, while direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals)over the duration of the Action, we do not anticipate species level effects and we do not anticipate that the Action would appreciably reduce survival and recovery of the Peck's Cave amphipod.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Orconectes shoupi	Nashville crayfish	478

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered; Proposed for delisting due to recovery
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Single population
Species Trends: Increasing population(s)
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The species can be found in large numbers at certain locations within the Mill Creek drainage and the species has been found in several additional tributaries to Mill Creek over the past 20 years. Although the Metropolitan Nashville area is experiencing significant growth, with numerous residential, commercial, utility, and other infrastructure developments occurring in the watershed, these populations have been documented to be stable or increasing in size. Additionally, there have been consistent stormwater and sediment inputs to the Mill Creek watershed, as well as frequent spills/releases of raw sewage and hazardous substances, yet the Nashville crayfish persists in high numbers. The species exhibits a high degree of resistance to disturbance, indicating that the species has a low susceptibility to threats and high degree of stability.

The Tennessee Ecological Services Field Office is actively engaged with federal, state, and local agencies, and nongovernmental organizations to address potential habitat loss for the species. Development, siltation, and pollution, nutrient, herbicide and pesticide run-off are all contributing factors to habitat degradation. This 108-square mi network of streams, creeks and tributaries that makes up the Mill Creek watershed drains southeastern Davidson County and northeastern Williamson County into the Cumberland River. Of Mill Creek's 20 total miles, more than 16 are listed as "impaired" by the state. Cooperative restoration projects have also been implemented. Service leaders in Tennessee are organizing the Mill Creek Watershed Association for individuals interested in preserving the area. Restoration efforts include community-driven cleanups of Mill Creek and stenciling "No Dumping" signs on the more than 8,000 storm drains in the watershed. Nashville Zoo staff initiated the Nashville Crayfish Project in collaboration with Tennesee Department of Environment and Conservation, Tennesee Water Resources Authority and the Service. One of the project's main objectives focuses on involving the community in Mill Creek's revitalization, simultaneously improving and protecting crayfish habitat. Nashville Zoo is also developing a breeding program for the crayfish.

EB/CE Source: U. S. Fish and Wildlife Service. Nashville Crayfish (*Orconectes shoupi*) 5-Year Review: Summary and Evaluation. Tennessee Ecological Services Field Office, Cookeville, Tennessee. February 2017. 28 pp.

Overall Vulnerability: ☐ **High** ☒ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Nashville crayfish will experience direct morality from most uses of malathion at maximum rates in bin 3. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 23.67% of Nashville crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 72.56% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	23.67%
MOSQUITO CONTROL	
Mortality effects	72.56%

Risk modifiers:

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	50,201	72.56	0	0	3	H
Other Crops	D	4	<0.01	0	<0.01	3	H
Nurseries	D	24	0.03	24	0.03	3	H
Other Grains	D	6	<0.01	6	<0.01	3	H
Corn	D	173	0.25	190	0.27	3	H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Cotton	D	26	0.04	32	0.05	3	H
Developed	D	16,111	23.29	806	1.16	3	H
Wheat	D	8	0.01	5	<0.01	3	H
Vegetables & Ground Fruit	D	<1	<0.01	<1	<0.01	3	H
Other Row Crops	D	1	<0.01	1	<0.01	3	H
Pasture	D	<1	<0.01	<1	<0.01	3	H
Sub-TOTAL (D): *Other uses with effects*[3]		16,353	23.67	1,064	1.57		
TOTAL[4]:		66,554	96.23	1064	1.57		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 69,185 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 0 acres, 0.000%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Nashville crayfish. As discussed below, even though the vulnerability is medium and risk is high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Nashville crayfish has a medium vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high, as described above. The estimated usage within the range is low based on standard usage data.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 23.67% mortality of individuals and 72.56% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their small size and low water flow.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 1.57% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability is medium and risk is high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions and aquatic habitat buffers will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Nashville crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Pacifastacus fortis	Shasta crayfish	479

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

Shasta crayfish are thought to have always been restricted to the Pit River and Hat Creek drainages. Since listing and completion of the recovery plan, the Shasta crayfish has decreased in numbers and distribution. At the time of listing, the spread of two exotic crayfish, signal crayfish (*Pacifactacus leniusculus*) and fantail crayfish (*Orconectes virilis*), into the range of Shasta crayfish was identified as a major threat. These exotic species, especially signal crayfish, are aggressive competitors that mature quickly (2 years), have a higher reproductive ability (100-150 eggs per female), grow faster, and are larger (Momot 1967; Bouchard 1977; Shimizu and Goldman 1981, Eng and Daniels 1982). The mechanism by which the signal crayfish excludes the Shasta crayfish is by a combination of competition and predation.

The main impacts to Shasta crayfish habitat (development of reservoirs for hydroelectric facilities) were in place long before the listing. While the structures and facilities for the hydroelectric operations have not changed, the flow regimes were modified with the 2003 license renewal for Pit 1 (FERC Project Number 2687) and Hat Creek (FERC Project Number 2661) (PG&E 2003a, 2003b). Additionally, the water flow regime in these two drainages was altered in 2003. This change in water management resulted in increased water temperature, which favors the exotic signal crayfish due to its higher tolerance of water temperatures and its ability to grow and mature faster. In 2007, two crayfish barriers were constructed, one in upper Fall River and the other at the downstream end of Spring Creek. These barriers should protect these upstream habitats from new invasions of non-native crayfish, while efforts to remove the remaining non-native crayfish in these areas continue (Spring Rivers Ecological Sciences 2007). Without the continued exotic crayfish removal efforts funded by PG&E, Shasta crayfish populations may be more imperiled.

Due to the low number of individuals, loss of subpopulations, increased dispersal barriers, and increased threat from signal crayfish, Shasta crayfish are imminently threatened with extinction. Of the 29 sites surveyed in 2004-2006, 12 no longer have Shasta crayfish, 8 have fewer than 10 individuals, and only 3 have more than 100 individuals. Small populations may be subject to inbreeding depression and genetic drift, and also to chance extinction from stochastic environmental and demographic incidents (Gilpin and Soule 1986; Goodman 1987; Shaffer 1987). Genetic analyses conducted by Petersen and May (2008) show that, in general, there is a

great deal of genetic variation in the remaining Shasta crayfish populations despite the demographic data showing a severe reduction in population size.

EB/CE Source: U.S. Fish and Wildlife Service. Shasta Crayfish (*Pacifastacus fortis*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. September 2009. 24 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Shasta crayfish will experience direct malathion for most uses of malathion at maximum rates for all bins (2, 3, and 4). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 0.9% of Shasta crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 28.82% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	0.9%
MOSQUITO CONTROL	
Mortality effects	28.82%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	467,291	28.82	21,767	1.34	2,3,4	2H 3 4
Rice	D	13	<0.01	398	0.02	2,3,4	**
Nurseries	D	10	<0.01	59	<0.01	2,3,4	2H 3 4
Developed	D	3,669	0.23	184	0.01	2,3,4	2H 3 4
Vegetables & Ground Fruit	D	390	0.02	32	<0.01	2,3,4	2H 3 4
Pasture	D	3,314	0.2	245	0.04	2,3,4	2H 3 4
Sub-TOTAL (D): *Other uses with effects*[3]		7,396	0.47	918	0.09		
TOTAL[4]:		474,687	29.29	22,685	1.43		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.
**This use not in R-Plot.

 # acres in species range: 1,621,379 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 1,057,563 acres, 65.226%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Shasta crayfish. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Shasta crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the non-Federal portions of its range is high. The estimated usage within the non-Federal portion of the range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 0.90% mortality of individuals and 28.82% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 1.43% of the non-Federal portions of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the

species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions and aquatic habitat buffers will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals). over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Shasta crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Palaemonias alabamae	Alabama cave shrimp	480

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining (Although Shelta Cave population is declining, a new population was verified in another county and aquifer formation on Wheeler National Wildlife Refuge in 2019)
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

On September 7, 1988, the species was proposed as endangered (Federal Register, Vol. 53, No. 173, 34696-34698). According to the 2016 5-year review, the species is considered stable due to persisting populations in the known locations of Bobcat, Hering, Glover, and Brazelton caves; the shrimp has not been documented in the type locality, Shelta Cave, since 1973. In Bobcat Cave, which has received the most monitoring, oocytes or ova have been observed most years though there is a rise and fall in the number of individuals observed. The range has been extended with the confirmation of Alabama cave shrimp in Muddy Cave, Madison County, Alabama.

Presently, there are five known populations of Alabama cave shrimp identified from Madison County and Jackson County. Populuations within Madison County include Shelta Cave, Bobcat Cave, Muddy Cave, and the hydrologically connected BHG cave complex (consisting of Brazelton, Glover, and Hering Caves). A newly identified population on the Wheeler National Wildlife Refuge was identified from Fern Cave in Jackson County (Niemiller et al. 2019). Shelta Cave lies within the northwest limits of Huntsville, Alabama. It is located in Warsaw limestone of Mississippian age in the Interior Low Plateau (Cooper 1975). Shelta Cave consists of three large rooms with smaller alcoves. Water is present in all of the cave areas during wet periods of the year. Water levels fluctuate several feet during the year and some areas of the cave become seasonally dry. The two pit entrances to Shelta Cave are owned by the National Speleological Society and are gated to control activity in the cave. Bobcat Cave is located on Redstone Arsenal, under the control of the U.S. Army, and as with Muddy Cave and Fern Cave, access is restricted. Brazelton, Glover and Hering Caves are on private land.

Surveys conducted between 2012-2019 have confirmed extant populations from Fern Cave, Muddy Cave, Hering Cave (part of the BHG complex), and Bobcat Cave (Niemiller et al. 2019). The available information indicates the population in Shelta Cave has declined and may be extirpated. Over an 11-year period, Cooper and others collected or observed from one to 25 shrimp on each of 19 visits (Cooper 1975). On two of these visits, the shrimp were not counted,

but described as plentiful. During the period from December 1985 to April 1986, biologists made monthly trips to observe aquatic life in Shelta Cave but did not find any shrimp. No shrimp were observed in Shelta Cave despite twice monthly observations of the aquatic fauna for almost a year (initiated in April 1986). However, recent suveys conducted between 2012-2019 have confirmed the species from Fern Cave, Muddy Cave, Hering Cave, and Bobcat Cave. The discovery of the species from Fern Cave in western Jackson County expands the known distrubtion of the species, and morphological and DNA analyses indicate that the Fern Cave population in western Jackson County is closely allied with other populations in Madison County (Niemiller et al. 2019).

Groundwater contamination represents a major threat to this cave-dwelling species. Both Shelta and Bobcat caves are within the Huntsville Spring Branch and Indian Creek drainages, known areas of DDT contamination (Environmental Protection Agency 1986). They are not known to be in the direct path of the contaminated flow at the present time. In any area where sinkholes occur, however, surface pollutants can easily and rapidly enter the sub-surface aquifer. Apparent low reproductive abilities, confined habitat, and inability to elude captors make the Alabama cave shrimp susceptible to collecting. Cooper (1975) found only eight attached eggs on Alabama cave shrimp and indicated this species produced only one-third to one-half as many eggs as females of the endangered Kentucky cave shrimp. Other cave species are known to have extremely low reproductive rates compared to closely related surface species (Paulson 1961; Cooper 1975). As a result, any collection of adults can significantly affect population levels.

The Alabama cave shrimp occurs with the southern cavefish (*Typhlichthys subterraneus*), the cave salamander, (*Gyrincthilus palleucus*), and the cave crayfish (*Avitiacambarus jonesi*) in one or both Bobcat and Shelta caves (Cooper 1975). It is probable that all three prey upon young cave shrimp (Barr and Kuehne 1971; Cooper 1975). Its small population levels and low reproductive capabilities are natural limitations to the ability of this species to recover from any adversity.

EB/CE Sources: 1988 Listing Document, 53 FR 34696 – 34698, Final Rule listing *Palaemonias alabamae* as an Endangered Species

U.S. Fish and Wildlife Service. Alabama Cave Shrimp (*Palaemonias alabamae*) 5-Year Review: Summary and Evaluation. Alabama Ecological Services Field Office, Daphne, Alabama. January 2016. 22 pp.

U. S. Fish and Wildlife Servie. Alabama Cave Shrimp (*Palaemonias alabamae*) Recovery Plan Amendment 1. Atlanta, Georgia. September 25, 2019.

Niemiller ML, Inebnit T, Hinkle A, Jones BD, Jones M, Lamb J, Mann N, Miller B, Pinkley J, Pitts S, Sapkota KN, Slay ME (2019) Discovery of a new population of the federally endangered Alabama Cave Shrimp,(*Palaemonias alabamae*), Smalley, 1961, in northern Alabama. Subterranean Biology 32: 43-59. https://doi.org/10.3897/subtbiol.32.38280

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Alabama cave shrimp will experience direct mortality for most uses of malathion at maximum rates in all bins (2 and 3). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 14.15% of Alabama cave shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 68.75% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	14.15%
MOSQUITO CONTROL	
Mortality effects	68.75%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Five of seven known occupied caves are not likely at risk for mosquito adulticide use: Muddy Cave and Fern Cave are on federal lands, BHG cave complex (3 caves) is on rural private lands.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☒ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	153,088	68.75	36,300	16.3	2,3	2H 3
Other Crops	D	250	0.11	0	<0.01	2,3	2H 3
Nurseries	D	308	0.14	308	0.14	2,3	2H 3
Other Grains	D	47	0.02	45	0.02	2,3	2H 3
Corn	D	7,753	3.48	183	0.08	2,3	2H 3
Cotton	D	3,919	1.76	2,948	1.32	2,3	2H 3
Developed	D	18,895	8.49	945	0.42	2,3	2H 3
Christmas Trees	D	1	<0.01	1	<0.01	2,3	2H 3
Wheat	D	226	0.1	92	0.04	2,3	2H 3
Vegetables & Ground Fruit	D	17	<0.01	13	<0.01	2,3	2H 3
Other Row Crop	D	3	<0.01	3	<0.01	2,3	2H 3
Orchards & Vineyards	D	2	<0.01	2	<0.01	2,3	2H 3
Pasture	D	1	<0.01	<1	<0.01	2,3	2H 3
Sub-TOTAL (D): *Other uses with effects*[3]		31,422	14.15	4,540	2.08		
TOTAL[4]:		184,510	82.90	40,840	18.38		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

 # acres in species range: 222,672 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 42,699 acres, 19.176%

The values above are preliminary, as we will be confirming whether the analysis include the new population discovered at Wheeler National Wildlife Refuge in 2019, as described above.

Overall Usage: ☐ High ☒ Medium ☐ Low

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted for within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this

measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Alabama cave shrimp. As discussed below, the vulnerability is high for this species; however, the risk and likelihood of exposure (i.e., usage) are medium for this species. We anticipate loss of individuals if malathion is used within the non-Federal range of the species would result in loss of individuals. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Alabama cave shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the non-Federal portion of its range is medium. The estimated usage within the range is high based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion. A portion of the species range overlaps Federal lands (19.17%). One cave with known occupancy is under the control of the U.S. Army, one cave with known occupancy is managed by the National Speleological Society, a non-Federal organization, another is on Wheeler National Wildlife Refuge and all three caves have restricted access.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. Populations may be exposed from upland and non-point sources of malathion runoff from use sites. Where exposure occurs and all individuals or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat is unlikely to be quickly recolonized.

We estimate that across the non-Federal portions of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 14.15% mortality of individuals and 68.75% mortality of individuals from mosquito control efforts. However, potential exposure from infiltration of contaminated surface water from mosquito control is not expected to be a significant route of exposure based on the location of five of the seven occupied caves on either federal or private, rural lands, the amount of ingredient applied per area, the species underground habitats distance from likely areas where mosquito control would occur, and the persistence of malathion. Mosquito control, if it occurs, would most likely be associated with Shasta Cave as it is adjacent to near population center/urban area. Therefore, we anticipate that the usage data for mosquito control overestimates the likelihood of exposure for malathion, and the likelihood of exposure from malathion is medium. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans.

The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow. However, bin 2 habitats used as a surrogate to model the species habitat likely do not most accurately reflect the flow patterns and volume of subterranean occupied groundwater habitats of the Tuscumbia and Monteagle limestone formations, which are extensive.

Based on the medium likelihood of exposure and the relatively isolated nature of the populations, we anticipate only very small numbers of individuals of this species would be exposed to malathion and adversely affected by this exposure over the duration of the Action as described above, and we do not anticipate species-level effects.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur. Therefore, we anticipate that the Action would not appreciably reduce survival and recovery of the Alabama cave shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Syncaris pacifica	California freshwater shrimp	481

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (numerous)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

Although the known distribution of the California freshwater shrimp has expanded from 12 streams to 23 streams since the species was listed, eight of the eleven newly discovered streams do not represent new populations, but rather the discovery of California freshwater shrimp in tributaries of already known populations. In addition, the stability of the species in a few occupied streams is questionable.

Primary threats to the species continue to be degradation and loss of habitat as a result of increased urbanization (i.e., water diversion, urban runoff, loss of riparian vegetation, and bank stabilization), agricultural development and inappropriate grazing practices (i.e., loss of riparian vegetation, reduced water quality from manure runoff, water diversion, and increased sedimentation), pollutants and contaminants, and water development (i.e., barriers to migration, conversion of glide to pool habitat, introduced predators, altered hydrology, and reduced stream flows). Only one stream was protected at the time of our 2011 review, Lagunitas Creek, and no progress has been made at protecting any additional streams inhabited by the species. Watershed plans have been developed for a number of streams with these shrimp and the implementation of these plans, although not guaranteed and participation is voluntary, is likely to result in increased habitat quality and quantity. However, due to the time required for a stable undercut stream bank with adventitious living root material to form, it will likely be decades before the beneficial effects of these plans to shrimp populations are realized. Because there has been no apparent change in the imminence of the threats to this species, we conclude the California freshwater shrimp continues to meet the definition of endangered.

EB/CE Source: U.S. Fish and Wildlife Service. California Freshwater Shrimp (*Syncaris pacifica*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. September 2011. 27 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the California freshwater shrimp will experience direct mortality for most uses of malathion at maximum rates for all bins (2 and 3). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 11.11% of California freshwater shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 80.56% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	11.11%
MOSQUITO CONTROL	
Mortality effects	80.56%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made that specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters.

Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	1,646,280	80.56	0	0	2,3	2H 3
Developed	D	124,659	6.1	6,233	0.31	2,3	2H 3
Orchards and Vineyards	D	75,597	3.7	187	0.01	2,3	2H 3
Other Grains	D	10,009	0.49	0	0	2,3	2H 3
Other Crops	D	6,307	0.31	0	0	2,3	2H 3
Pasture	D	5,575	0.27	0	0	2,3	2H 3
Wheat	D	1,698	0.08	0	0	2,3	2H 3
Vegetables and Ground Fruit	D	1,193	0.06	14	<0.01	2,3	2H 3
Other Row Crops	D	1,038	0.05	0	0	2,3	2H 3
Nurseries	D	432	0.02	37	<0.01	2,3	2H 3
Corn	D	404	0.02	0	0	2,3	2H 3
Cotton	D	8	<0.01	0	0	2,3	2H 3
Sub-TOTAL (D): *Other uses with effects*[3]		226,920	11.11	6,471	0.34		
TOTAL[4]:		1,873,200	91.67	6,471	0.34		

^ We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 2,043,487 acres
% of range in California (i.e., where CalPUR data is available): 100%

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Range overlap with Federal lands: 117,857 acres, 5.767%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted for within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the California freshwater shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The California freshwater shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 11.11% mortality of individuals and 80.56% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.34% of the species range annually based on standard past usage data. We anticipate loss of a small number of individuals if malathion is used within the non-Federal portion of the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to

reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals)over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the California freshwater shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Palaemonias ganteri	Kentucky cave shrimp	482

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

A brief synopsis of the Kentucky cave shrimp's appearance, biology, and habitat was provided by U.S. Fish and Wildlife Service (1994). Aquarium studies have resulted in life span estimates of 10 to 15 years. Female shrimp have been found with eggs at all times of the year; consequently, reproduction appears to be continual and not seasonal. Some evidence suggests, however, that seasonal reproduction does occur subsequent to flooding events and the subsequent additional food supply. Females carry their clutch of eggs (up to 33) tucked under their abdomen. The only additional information on the species' biology and habitat was provided by Pearson and Jones (1998), who conducted faunal inventories and habitat analyses at 10 sites within the Mammoth Cave System over a three-year period from 1993 to 1995. They observed individuals of *P. ganteri* at 6 of 10 historic sites, with the greatest abundances observed in 1995. Individuals of *P. ganteri* were observed at Colossal River in 1994 (1 shrimp); Mystic River in 1993 (8), 1994 (33), and 1995 (233); Golden Triangle Area in 1994 (25) and 1995 (45); Roaring River in 1994 (32) and 1995 (34); Shrimp Pools at Roaring River in 1995 (4); and Echo/Styx River in 1994 (6) and 1995 (2). For sites where Kentucky cave shrimp was present, estimates of shrimp density ranged from 0.0006 shrimp/m^2 (0.00005/ft^2) to 0.262 shrimp/m^2 (0.24/ft^2). Earlier density estimates provided by Holsinger and Leitheuser (1982b; 1983) were based on one dimension – the length of passage – resulting in numbers of shrimp per linear meter (or foot) of passage. These estimates ranged from 0.006 shrimp/m (0.002 shrimp/ft) to 0.66 shrimp/m (0.2 shrimp/ft). Tentative population estimates for each groundwater basin were provided in the recovery plan (USFWS 1988). These included Echo River Spring (750 individuals) Ganter Spring (150), Running Branch Spring (300), Mile 205.7 Spring (50), Pike Spring (5,000 to 10,000), Double Sink (unknown), Turnhole Spring (unknown), McCoy Blue Spring (unknown), and Suds Spring (500). More recent population estimates are unavailable.

Permanent protection has been achieved for three of the nine groundwater basins known to support populations of the species - Echo River Spring, Ganter Spring and Running Branch Spring. The latter two basins lie entirely within Mammoth Cave National Park in Kentucky, and except for a small area along its southeastern border, the majority of the Echo River Spring groundwater basin also occurs within the park. Portions of three other basins, Mile 205.7 Spring, Pike Spring, and Turnhole Spring, are afforded some protection because they occur within the

park. No recent information exists on population size or viability (per the 2010 5-year review), so it is not known if any of the Kentucky cave shrimp populations are viable and/or reproducing.

While the basins are considered protected from many stressors and threats due to their occurrence in the park, the 2016 5-year review notes that pesticides and other contaminants remain a concern for some groundwater basins. Groundwater contamination represents the greatest threat to the Kentucky cave shrimp (USFWS 1988). Sources of this contamination include random traffic accidents (e.g., trucks carrying toxic chemicals) along Interstate 65 (I-65) and other local highways; oil and gas activities; agriculture; permitted discharges from industry, wastewater treatment plants, and other sources; and general nonpoint-source pollution (USFWS 1988). Because of the extensive karst systems in the Mammoth Cave region, pollutants associated with these contaminant sources can quickly enter groundwater basins through sinkholes, sinking streams, and other karst features and travel rapidly downstream to where they can adversely affect cave shrimp populations. The recovery plan provided details on three separate traffic accidents in the mid-1980s that had the potential to adversely affect the species (USFWS 1988). A tanker truck overturned on I-65 in May 1985 near the Cumberland Parkway interchange (mile 43), spilling cresol (an organic compound commonly used as a disinfectant or deodorizer). A spill of hazardous synthetic solvents occurred on I-65 (mile 59) near its crossing of the Green River in November 1985. A train derailment in November 1985 threatened to send approximately 3,400 liters (900 gallons) each of an unidentified pesticide and methyl alcohol into the cave systems important to the shrimp. Fortunately, in each of these cases, state and federal authorities were able to successfully contain the spill prior to leakage into groundwater systems. Traffic accidents continue to represent a threat to the species as truck traffic along I-65 and other local highways has actually increased over time (Dave Harmon, KYTC, pers. comm., 2008). According to Kentucky Department of Wildlife (KDOW2006), nonpoint-source impacts on groundwater in Kentucky are caused primarily by agriculturally related nutrients and pesticides. Pollutants of concern include nitrates (from fertilizer application, manure storage and application, and animal feeding operations), and pesticides.

EB/CE Source: U. S. Fish and Wildlife Service. Kentucky Cave Shrimp (*Palaemonias ganteri*) 5-year review: Summary and Evaluation. Kentucky Ecological Services Field Office, Frankfort, Kentucky. 2016. 18 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Kentucky cave shrimp will experience direct mortality for most uses of malathion at maximum rates for all bins (2 and 3). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 7.66% of Kentucky cave shrimp exposed to malathion via all uses except

mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 4.29% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	7.66%
MOSQUITO CONTROL	
Mortality effects	4.29%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	48,678	4.29	0	0	2,3	2H 3
Corn	D	63,755	5.62	1,729	0.15	2,3	2H 3
Developed	D	14,888	1.31	744	0.07	2,3	2H 3
Other Row Crops	D	3,889	0.34	379	0.03	2,3	2H 3
Pasture	D	2,029	0.18	487	0.04	2,3	2H 3
Wheat	D	1,258	0.11	183	0.02	2,3	2H 3
Other Grains	D	457	0.04	202	0.02	2,3	2H 3

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Other Crops	D	173	0.02	0	<0.01	2,3	2H 3
Nurseries	D	111	<0.01	111	<0.01	2,3	2H 3
Vegetables and Ground Fruit	D	14	<0.01	14	<0.01	2,3	2H 3
Orchards and Vineyards	D	<1	<0.01	<1	<0.01	2,3	2H 3
Cotton	D	<1	<0.01	0	<0.01	2,3	2H 3
Sub-TOTAL (D): *Other uses with effects*[3]		86,574	7.66	3,849	0.36		
TOTAL[4]:		135,252	11.95	3,849	0.36		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 1,135,129 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 51,624 acres, 4.548%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases,

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Kentucky cave shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Kentucky cave shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in

about 7.66% mortality of individuals and 4.29% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow. The groundwater basins where this species is found are considered protected from many stressors and threats due to their occurrence in Mammoth Cave National Park, but pesticides and other contaminants (i.e., not specifically insecticides) remain a concern for some groundwater basins. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.36% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of individuals may occur if malathion is used within the non-Federal range of the species or in areas adjacent to the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. Thus, while direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Kentucky cave shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Thermosphaeroma thermophilus	Socorro isopod	483

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: All populations stable, with none known to be increasing or decreasing
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The Socorro isopod is a rare crustacean that survives in only one spring located on private land in Socorro County, New Mexico. The habitat of the Socorro isopod consists of two concrete pools and the plumbing system of an abandoned bathhouse supplied with water from Sedillo Spring. Most of the isopod population is confined to the larger of the two pools, which is approximately 1 by 2.7 m (3.3 by 8.8 ft). Water temperature is relatively constant throughout the year (31-33˚ C) (Shuster 1981a). Females are iteroparous (meaning many reproductive cycles over its lifetime) and breed throughout the year, although peaks in reproduction occur in the spring and fall. Up to three broods of 3-20 individuals are produced. Juveniles (mancas) reach sexual maturity within 6-8 weeks, with males growing faster and maturing faster than females (Shuster 1981a,b).

The effects of climate change, if they include widespread drought, decreased spring discharge, or a change in water chemistry is a newly recognized threat that could eliminate the species. This species only occurs in one location where it could easily be extirpated by biological or environmental threats.

EB/CE Source: U. S. Fish and Wildlife Service. Socorro Isopod (*Thermosphaeroma thermophilus*) 5-Year Review: Summary and Evaluation. Albuquerque, New Mexico. November 2009. 14 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Socorro isopod will experience direct mortality from most uses of malathion at maximum rates for bin 5. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 0.22% of Socorro isopod exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 42.37% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	0.22%
MOSQUITO CONTROL	
Mortality effects	42.37%

Risk modifiers:

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	1,802,937	42.37	0	0	5	5H
Pasture	D	3,070	0.07	2,119	0.05	5	5H
Developed	D	3,031	0.07	152	<0.01	5	5H
Orchards and Vineyards	D	217	<0.01	217	<0.01	5	5H
Vegetables and Ground Fruit	D	90	<0.01	88	<0.01	5	5H
Corn	D	63	<0.01	63	<0.01	5	5H
Other Crops	D	59	<0.01	0	<0.01	5	5H
Wheat	D	50	<0.01	29	<0.01	5	5H
Other Grains	D	47	<0.01	47	<0.01	5	5H
Cotton	D	4	<0.01	1	<0.01	5	5H
Nurseries	D	1	<0.01	1	<0.01	5	5H
Sub-TOTAL (D): *Other uses with effects*[3]		6,632	0.22	2,717	0.13		

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
TOTAL[4]:		1,809,569	42.59	2,717	0.13		

 # acres in species range: 4,255,697 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 2,240,798 acres, 52.654%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Socorro isopod. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Socorro isopod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-

[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Federal portion of the range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 0.22% mortality of individuals and 42.37% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 5, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to fragmented habitat and limited mobility of the species.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.13% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate loss of a small number of individuals may occur if malathion is used within the non-Federal range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future. Furthermore, we anticipate the additional conservation measures above, including rain restrictions and aquatic habitat buffers, will further reduce the likelihood of exposure of the species, their prey, and their habitat. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Socorro isopod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Gammarus acherondytes	Illinois cave amphipod	484

VULNERABILITY

(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

Historically, the Illinois cave amphipod was known to occur in six cave systems in Monroe and St. Clair Counties, Illinois. Its presence has not been reconfirmed in Madonnaville Cave, Monroe County and it appears to be extirpated from Stemler Cave, St. Clair County. Additional populations have been found in eight groundwater systems in Monroe County.

Habitat loss and degradation of groundwater quality resulting from urbanization, agricultural activities, and an influx of human and animal waste are the principle threats. Little is known of the biology and habitat requirements of this species although it has been collected in mainstream gravel riffles, smaller tributary streams, rimstone pools, and from streams with silt overlying bedrock. As a group, amphipods require cool water temperatures and are intolerant of wide ranges in temperature.

Limiting factors may include increased nutrient load, sedimentation, hydrologic changes and changes in water quality. Land use in the area is dominated by agriculture, with both livestock and row crops interspersed with forested tracts and rural housing. Crops grown in the region include milo, alfalfa, soybeans, wheat, corn and barley. There are several examples of pesticide issues that have been recognized. Insecticides used on alfalfa include carbaryl, carbofuran, malathion, permethrin and phosmet and are typically applied in May and again in July or August. Herbicides are applied in April and May (timing is dependent on field conditions) and include alachlor, atrazine, bentazon, chlorimuron, cyanazine, glyphosate, imazaquin, imazethapyr, metolachlor, sethoxydim and trifluralin (M. Roegge, Cooperative Extension Service, University of Illinois, pers. comm. 1993). Over half of the private sewage disposal systems used in the Sinkhole Plain do not meet State of Illinois minimum requirements for discharge of fecal coliform bacteria and at least 10% of the systems have no treatment at all (Panno et al. 1997). All three sources described above (croplands, livestock and sewage disposal systems) contribute to relatively high concentrations of nitrates.

The species' survival is threatened by factors affecting shallow karst groundwater. These include agricultural and residential pesticides and fertilizers; human and animal wastes from residential

sewage disposal systems and livestock; sedimentation from agricultural and residential runoff; oil well production; surface runoff from roads, storm sewers, and increased surface paving due to urban development; sinkhole dumping of solid waste; and disruption of groundwater flow paths from quarry operations. Excessive visitation to caves and over-collecting for scientific purposes may also threaten the species.

EB/CE Source: U. S. Fish and Wildlife Service. Illinois Cave Amphipod (*Gammarus acherondytes*) 5-Year Review. Rock Island Ecological Services Field Office, Moline, Illinois. September 2011. 20 pp.

U. S. Fish and Wildlife Service. Illinois Cave Amphipod (*Gammarus acherondytes*) 5 –Year Review. Illinois-Iowa Field Office, Moline, Illinois. April 2020. 9 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK

(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate that, for most uses, individuals exposed to malathion in bins 2 and 3 would be at high risk of mortality. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range: The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 33.12% of the Illinois cave amphipods exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 98.38 % of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	33.12%
MOSQUITO CONTROL	
Mortality effects	98.38%

Risk modifiers: As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE

(Anticipated usage within the range based on past usage data)

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	674,950	98.38	0	0	2,3	2H 3
Corn	D	126,807	18.48	16,312	2.38	2,3	2H 3
Developed	D	92,246	13.45	4,612	0.67	2,3	2H 3
Wheat	D	3,348	0.49	2,028	0.3	2,3	2H 3
Pasture	D	2,239	0.33	1,924	0.28	2,3	2H 3
Other Crops	D	1,826	0.27	<1	<0.01	2,3	2H 3
Nurseries	D	185	0.03	185	0.03	2,3	2H 3
Other Grains	D	116	0.02	116	0.02	2,3	2H 3
Vegetables and Ground Fruit	D	98	0.01	98	0.02	2,3	2H 3
Orchards and Vineyards	D	39	<0.01	17	<0.01	2,3	2H 3
Other Row Crops	D	3	<0.01	1	<0.01	2,3	2H 3
Christmas Trees	D	<1	<0.01	<1	<0.01	2,3	2H 3
Cotton	D	<1	<0.01	0	<0.01	2,3	2H 3
Sub-TOTAL (D): *Other uses with effects*[3]		226,907	33.12	25,293	3.74		
TOTAL[4]:		901,857	100.00 [§]	25,293	3.74		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

[§]Use overlaps with range are additive and cannot be greater than 100%.

 # acres in species range: 686,084 acres

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)

[2] Estimated usage in the range is based on information about annual past usage.

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.

[4] TOTAL includes usage on all use sites with effects, including mosquito control.

% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 3,269 acres, 0.477%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

Species specific measures: In addition to the general label changes that would apply to all uses specified on the label, which would be protective of a wide range of species, the registrants have also agreed to an additional conservation measure:

For the Illinois cave amphipod, the registrant has incorporated the following species specific measure: *Within the range of the Illinois cave amphipod (St. Clair and Montclair counties of western Illinois), do not apply malathion: Aerially within 100 feet of caves/sinkholes, or By ground within 50 feet of caves/sinkholes within the Salem Plateau Section physiographic division.*

We anticipate this species-specific measure will reduce exposure and effects to the species for the following because additional application buffers are designed to further reduce spray drift from entering sensitive non-target areas, thereby providing additional protection to species. While the exact amount of spray drift reduction will vary depending on traits of the ecosystem (e.g. flow rate, volume, etc.) as well as the application method, based on AgDRIFT modeling we can expect spray drift reductions ranging from 82 to 90%.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Illinois cave amphipod. As discussed below, the vulnerability and risk are high and the likelihood of exposure to malathion is low, and the implementation of species-specific and general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected within the non-Federal range of the species over the duration of the Action, we do not expect species-level effects to occur.

The Illinois cave amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal lands portion of the range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion. A small portion of the species range overlaps Federal lands (0.48%).

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides, and specifically malathion, have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in 33.12% mortality of individuals and 98.38% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if

exposed due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to fragmented habitat and limited mobility of the species. However, this species may recover rapidly in the absence of a complete extirpation due to their short maturation time and ability to reproduce twice per year, provided sufficient numbers of individuals (and genetic diversity) remain when exposure occurs.

While we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year, we anticipate that usage will occur in up to 3.74% of the non-Federal portion of the species range annually based on standard past usage data. We do not anticipate malathion usage for mosquito adulticide in the range of the Illinois cave amphipod. We anticipate a loss of individuals may occur if malathion is used within the non-Federal range of the species. However, we anticipate the additional conservation measures above, including species-specific measures and general measures including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The species-specific measure described above, an additional application buffer (50 feet for ground application and 100 feet for aerial applications) within the range of the Illinois cave amphipod, is designed to further reduce spray drift from entering sensitive non-target areas, thereby providing additional protection to species. From modeled values, we anticipate the reduction to be in excess of 80%.

In addition to the species-specific measure, the general measures will also reduce the likelihood of exposure and effects to the species. For example, the rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While one of the primary threats to this species is degradation of groundwater quality, specifically use of malathion, we anticipate these measures will preclude infiltration and degradation of groundwater. Thus, direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not anticipate loss of individuals will result in species-level effects.

Therefore, we anticipate that the Action would not appreciably reduce survival and recovery of the Illinois cave amphipod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Lirceus usdagalun	Lee County cave isopod	486

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

Although the subterranean habitat of *L. usdagalun* at Sim's Spring and the springs near Flanary Bridge are not accessible and abundance estimates of the Lee County cave isopod are therefore not obtainable, occurrence data have been acquired from captures at the resurgent springs during moderate to high flows. Historic density and population estimates have been reported for Thompson Cedar Cave and Gallohan Cave (Estes 1978). The isopod was formerly abundant in Thompson Cedar Cave (Holsinger and Bowman 1973, Estes 1978). Estes (1978) reported the average density *of L. usdagalun* in the section of Thompson Cedar Cave immediately downstream of the cave entrance to be 109/m^2. Furthermore, densities in shallow riffles which the isopod prefers averaged over 200/m^2. Based on available habitat where *L. usdagalun* predominated, the total population was estimated at 100,000 animals. According to data collected by the Service and DNH, *L. usdagalun* is extremely rare to absent in the section of the cave stream just below the cave entrance, and specimens become more prevalent further downstream as dissolved oxygen levels increase. Quantitative analysis of the cave populations is needed to more accurately evaluate their status. Presently, the Mason cave stream appears to have recovered and is of good water quality. Where suitable habitat is accessible, *L. usdagalun* occurs in high densities, greater than 100/m^2.

The primary threat to the Lee County cave isopod is destruction and modification of its habitat. Degradation of water quality, in particular, serves as the greatest stressor to the species over its entire range. Six major threats that contribute to the destruction and modification of habitat have been identified, including: development, logging, industry, agriculture, vandalism, and toxic spills. An eighteen-hole golf course has been in operation since 1966 within the watershed that feeds the Flanary Bridge springs. The golf course lies directly within a large sinkhole that feeds the system. Maintenance of the golf course with fertilizer and pesticides may pose a significant threat to the isopod population of the Flanary Bridge spring system. As of 2008, the greens were maintained using Integrated Pest Management (D. Gilbert, Cedar Hill Country Club, pers. comm. 2007). Deconil 2787 (Tetracholoroisophthalonitrile), a chlorinated benzonitrile fungicide, is commonly used and is known to be toxic to fish and invertebrates. Agricultural activities, including livestock operations, pose a moderate threat to the Lee County cave isopod over a substantial portion of its range.

EB/CE Source: U. S. Fish and Wildlife Service. Lee County Cave Isopod (*Lirceus usdagalun*) 5-Year Review: Summary and Evaluation. Southwestern Virginia Field Office, Abingdon, Virginia. September 2008. 34 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Lee County cave isopod will experience direct mortality from most uses of malathion at maximum rates in bin 2. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 2.78% of the Lee County cave isopod exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site.

ALL USES except mosquito control	
Mortality effects	2.78%
MOSQUITO CONTROL	
Mortality effects	0%

Risk modifiers:

Bin 2

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ **High** ☒ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	0	0	0	0	2	NA

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Developed	D	1,093	2.35	55	0.12	2	2H
Corn	D	96	0.21	62	0.13	2	2H
Other Crops	D	45	0.1	0	<0.01	2	2H
Pasture	D	16	0.03	16	0.04	2	2H
Other Row Crops	D	9	0.02	9	0.03	2	2H
Nurseries	D	8	0.02	8	0.02	2	2H
Other Grains	D	1	<0.01	1	<0.01	2	2H
Orchards and Vineyards	D	<1	<0.01	<1	<0.01	2	2H
Vegetables and Ground Fruit	D	<1	<0.01	<1	<0.01	2	2H
Wheat	D	<1	<0.01	<1	<0.01	2	2H
Christmas Trees	D	<1	<0.01	<1	<0.01	2	2H
Sub-TOTAL (D): *Other uses with effects*[3]		1,268	2.78	151	0.39		
TOTAL[4]:		1,268	2.78	151	0.39		

 # acres in species range: 46,576 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 0 acres, 0.000%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Lee County cave isopod. As discussed below, even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be adversely affected over the duration of the proposed Action, we do not expect species-level effects to occur.

The Lee County cave isopod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is medium. The estimated usage within the range is low based on standard usage data. As discussed below, even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low. While we anticipate that small numbers of individuals may be affected over the duration of the Action, we do not expect species-level effects to occur.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 2.78% mortality of individuals and no mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from

spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to fragmented habitat and limited mobility of the species.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.39% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Lee County cave isopod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Palaemonetes cummingi	Squirrel Chimney Cave shrimp	487

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Single population
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The last surveys of the Squirrel Chimney were conducted between 1994 and 1996. Surveys of nearby cave systems were also conducted in 1995 and 1996. There are no more than a dozen collections of the SCCS recorded since its discovery in 1953 and the most recent documentation was in 1973. This species is only known from the Squirrel Chimney, a sinkhole, near Gainesville, Alachua County. It is in private ownership and maintained as an oak hammock and pine plantation. The area immediately surrounding the Squirrel Chimney is pasture, agriculture and planted pine plantation. With its close proximity to the City of Gainesville and Interstate 75, planned neighborhoods are to the east of the Squirrel Chimney and there are also a series of industrial mineral extraction pit mines located 3 miles to the west of Squirrel Chimney. Potentially occupied sites including nearby Cherry Pits Cave, Herzog Cave and Hog Sink were each surveyed twice; and Bat Cave was surveyed once. No SCCS or evidence (e.g., shed exoskeletons) were collected or observed during these surveys. Other potentially occupied sites were identified but were not surveyed because either the land owner would not allow access, sites had become degraded and ephemeral, or the sites could not be located (Doonan 2001). There have been no surveys of Squirrel Chimney in recent years. Opportunistic surveys of nearby cave systems have not documented the presence or evidence of SCCS (Paul Moler, Florida Fish and Wildlife Conservation Commission-retired, personal communication, 2007).

The listing rule noted that potential residential development and changes in land use were the primary threats to the squirrel chimney cave shrimp (SCCS). As this species is known from only Squirrel Chimney, a small sinkhole that leads to a flooded cave system, any detrimental change to the sinkhole or the underlying aquifer has the potential to adversely affect or cause the extinction of the species. These factors continue as the primary threats to the species today. This species is known from one site that could be seriously damaged by a single act of vandalism. This is still a threat today. The population size of the species is unknown but is likely small and vulnerable to impacts from scientific or other collecting. The 1990 listing noted that disease and predation were not known to be affecting the species. However, Morris and Butt (1992) documented the presence of a new fish species within the Squirrel Chimney, the redeye chub, a small predatory fish capable of eating crustaceans the size of SCCS larvae. In the 1997 petition to delist the SCCS due to extinction, the presence of the redeye chub was identified as a plausible

explanation for the apparent absence and possible extinction of the SCCS from Squirrel Chimney. Therefore, predation has been identified as a new threat since listing. Since there is no information on the species' sensitivity to common pollutants, Federal water quality laws (e.g., Clean Water Act) and those laws administered by the State, may or may not be protective of the species, especially since limitations and monitoring of groundwater are not common regulatory practices. Other natural or anthropogenic factors were not known to be affecting the species at the time of listing. However, natural droughts, as well as water withdrawals for human use, can impact cave water levels. Changes in land use in the recharge area can accelerate pollutants delivery to the aquifer system associated with the Squirrel Chimney system. Other potential threats include contaminant spills in the recharge area.

EB/CE Source:

U. S. Fish and Wildlife Service. Squirrel Chimney Cave Shrimp (*Palaemonetes cummingi*) 5-Year Review: Summary and Evaluation. Jacksonville Ecological Services Field Office, Jacksonville, Florida. July 2016. 12 pp.

U.S. Fish and Wildlife Service. Squirrel Chimney Cave Shrimp (*Palaemonetes cummingi*) 5-Year Review: Summary and Evaluation. Jacksonville Ecological Services Field Office, Jacksonville, Florida. September 2021. 19 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Squirrel Chimney Cave shrimp will experience direct mortality from most uses of malathion at maximum rates for all bins (2 and 3). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 5.85% of the Squirrel Chimney cave shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 93.92 % of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	5.85%
MOSQUITO CONTROL	
Mortality effects	93.92%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in

such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

A reassessment of crop UDL showed that usage data in the "Other Row Crops" may be overestimated. This UDL is composed of sunflower, peanuts, tobacco, sugar beets, and hops, of which, only hops is a registered use site on malathion labels and is thus the only crop in this layer that is relevant in our analysis. USDA data shows that 96% of hops are grown in the Pacific Northwest region (Idaho, Oregon, and Washington), with some small farms in Florida reporting occasional hop production. Given the highly specific regions that hops are grown in, we can assume that the potential exposure to malathion from "other row crops" use sites is 0 outside the areas indicated above.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	482,545	93.92	224,400	36.18	2,3	2H 3
Developed	D	15,162	2.44	758	0.12	2,3	2H 3
Other Row Crops	D	7,473	1.2	3,020	0.49	2,3	2H 3
Other Crops	D	5,665	0.91	0	<0.01	2,3	2H 3
Other Grains	D	3,072	0.5	2,871	0.46	2,3	2H 3
Corn	D	2,209	0.36	94	0.02	2,3	2H 3
Orchards and Vineyards	D	1,522	0.25	37	<0.01	2,3	2H 3
Cotton	D	344	0.06	314	0.05	2,3	2H 3
Vegetables and Ground Fruit	D	318	0.05	327	0.05	2,3	2H 3

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Wheat	D	240	0.04	61	<0.01	2,3	2H 3
Nurseries	D	194	0.03	194	0.03	2,3	2H 3
Pasture	D	1	<0.01	1	<0.01	2,3	2H 3
Sub-TOTAL (D): *Other uses with effects*[3]		36,200	5.85	7,677	1.25		
TOTAL[4]:		518,745	99.77	232,077	37.43		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 620,275 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 1 acres, 0.000%

Overall Usage: ☒ **High** ☐ **Medium** ☐ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Squirrel Chimney Cave shrimp. As discussed below, the vulnerability and risk are high for this species. However, the likelihood of exposure (i.e., usage) is likely overestimated based upon the land uses surrounding the single known locale, and conservation measures will be implemented that would further reduce the likelihood of exposure and effects to this species. While we anticipate that small numbers of individuals will be adversely affected over the duration of the Action within the non-Federal range of the species, we do not expect species-level effects to occur.

The Squirrel Chimney Cave shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the range is high based on standard usage data. Only 1 acre (~0%) of the species range overlaps Federal lands and we did not quantitatively evaluate use or usage on Federal lands that overlap with the species range.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. Pesticides, specifically malathion, have been identified as a contaminant of groundwater for this species and they may originate from surface use sites (multiple uses, see R-Plots) that reach groundwater on which the species depends. We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 5.85% mortality of individuals and 93.92% mortality of individuals from mosquito control

efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow. Populations may be exposed from upland and non-point sources of malathion runoff from use sites.

While we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year, we anticipate that usage will occur in up to 37.43% of the species range annually based on standard past usage data and we anticipate similar levels in the future. If exposure occurs and all individuals of the population are lost, or large proportion of the population is lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized. In the 5-Year Review, we described evidence that suggests the Squirrel Chimney Cave system is connected to nearby cave systems by underwater passageways that could shelter this species and provide for dispersal. The only known occurrence of this species is found in the Squirrel Chimney Cave, but the species range covers several other potentially occupied areas that have not been surveyed due to limited access (i.e., private land ownership). Furthermore, groundwater contaminants (including pesticides) have been highlighted as a concern for this species in the listing final rule. Though insecticides have not been specifically mentioned in the listing rule or recovery documents, malathion usage overlaps a large portion of the species range.

However, the most recent recovery documentation (USFWS 2021) states that the land uses surrounding Squirrel Chimney Cave appear stable and are comprised of an oak hammock and pine plantation, forested uses that would not be susceptible to malathion contamination through agricultural application or from mosquito adulticide uses, which is considered the primary driver of risk for the species. We anticipate that, while Squirrel Chimney Cave is within karst that allows for rapid water penetration and little natural filtration, the buffer provided by the surrounding land uses are likely to be stable, and the threat of malathion contamination through mosquito adulticide use is likely minimized by the surrounding forest cover. Malathion is not approved for forest use and the presence of forest vegetation would tend to restrict the effects of spray drift, if any. The karst aquatic caves in Florida are generally in a state of decline from various stressors, including groundwater contamination. However, malathion’s brief half-life and generally rapid degradation also limit the likelihood of exposure through groundwater contamination.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as

necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. Thus, while direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action we do not anticipate species-level effects.

Therefore, we anticipate that the Action would not appreciably reduce survival and recovery of the Squirrel Chimney Cave shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Cambarus zophonastes	Hell Creek Cave crayfish	488

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: All populations stable, with none known to be increasing or decreasing
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
C. zophonastes was first described from five specimens collected from Hell Creek Cave (Hobbs and Bedinger 1964). This cave crayfish is stygobitic, lacks pigment and eyes, and has an overall body length reaching 2.5 to 3.0 inches. *C. zophonastes*' biology and life history are not understood with no data available regarding life span, fecundity, egg and fry survival, or other aspects of the species' ecology. An ovigerous (egg bearing) female was discovered in Hell Creek Cave, suggesting reproduction occurs in the late winter and spring months with higher water levels and nutrient inputs triggering reproduction (Smith 1984). Work on cave crayfish in Florida suggest life spans of 40 years or more (Hobbs pers. comm.), although no work has been conducted on *C. zophonastes* to determine its life span. Hell Creek Cave was the only known location for this species until determinations verified presence in Nesbitt Spring Cave in 2005 and preliminary genetic analysis suggests the species' presence at an additional site in 2009. This newest site is a groundwater upwelling in Town Branch, a normally dry stream bed, and it is extremely rare that additional cave crayfish are observed there. Interestingly, the location of the newest site is approximately 40 miles northwest of the other known sites, which are found near one another, suggesting a much wider subterranean distribution of the species. Population genetics data are available, but not published (Koppelman, pers. comm.). Genetic data have been useful in confirming the identification of specimens from newly discovered populations of cave crayfish throughout the Ozarks, including *C. zophonastes* from Nesbitt Spring Cave in 2005 and Town Branch in 2009. During exploraton of Hell Creek Cave's sump in 1961, Bedinger and Stephens located 5 individuals; however, subsequent monitoring through 2009 indicates variation in observed numbers that have ranged from 2 to 15 individuals. Nesbitt Spring Cave is also a limestone phreatic conduit developed in the Plattin Formation of Ordovician Age. Work by the U.S. Geological Survey (USGS) was conducted to determine the size of the surface recharge zone for Nesbitt Spring. Losing stream reaches and sinkholes within the predicted recharge zone are likely direct conduits for introduction of surface waters to the cave. In 1992, "dozens" of stygobitic crayfish were reported during a combined surface and cave dive survey, and in 2005 members of the Ozark Cave Diving Alliance sighted nine stygobitic crayfish and collected six with subsequent pereopod removal for genetic analysis. All specimens were

returned to the cave alive, with the exception of one that was injured during capture and preserved as a voucher specimen. Genetic analysis conducted by Jeff Koppelman with the Missouri Department of Conservation determined these crayfish to be *C. zophonastes*.

EB/CE Source: U. S. Fish and Wildlife Service. Hell Creek Cave Crayfish (*Cambarus zophonastes*) 5-Year Review: Summary and Evaluation. Arkansas Ecological Services Field Office, Conway, Arkansas. August 2012. 19 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Hell Creek Cave crayfish will experience direct mortality for most uses of malathion for all bins (6 and 7). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 0.76% of Hell Creek cave crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site.

ALL USES except mosquito control	
Mortality effects	0.76%
MOSQUITO CONTROL	
Mortality effects	0%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☐ Medium ☒ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	0	0	0	0	6,7	6H 7H
Developed	D	5,237	0.65	262	0.03	6,7	6H 7H
Corn	D	235	0.03	235	0.03	6,7	6H 7H
Other Crops	D	72	<0.01	0	<0.01	6,7	6H 7H
Wheat	D	12	<0.01	7	<0.01	6,7	6H 7H
Orchards and Vineyards	D	8	<0.01	3	<0.01	6,7	6H 7H
Other Grains	D	4	<0.01	4	<0.01	6,7	6H 7H
Vegetable and Ground Fruit	D	3	<0.01	3	<0.01	6,7	6H 7H
Nurseries	D	1	<0.01	1	<0.01	6,7	6H 7H
Cotton	D	<1	<0.01	<1	<0.01	6,7	6H 7H
Pasture	D	<1	<0.01	<1	<0.01	6,7	6H 7H
Sub-TOTAL (D): *Other uses with effects*[3]		5,572	0.76	515	0.12		
TOTAL[4]:		5,572	0.76	515	0.12		

 # acres in species range: 800,019 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 107,000 acres, 13.375%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Hell Creek Cave crayfish. As discussed below, even though the vulnerability is high for this species, the risk and likelihood of exposure to malathion are low. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Hell Creek Cave crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is low. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. While insecticides were not specifically noted as threats for this species, it is reasonable to assume the species would be vulnerable to pesticide exposure like similar species. We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 0.76% mortality of individuals and no mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.12% of the non-Federal species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the species. Even though the vulnerability is high for this species, risk and usage overlap with the species range are low and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Hell Creek Cave crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Cambarus aculabrum	Benton County Cave crayfish	489

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: All populations stable, with none known to be increasing or decreasing
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
Graening et al. (2006) summarize the range wide status and distribution of *C. aculabrum*. Logan Cave has been surveyed 21 times from 1986-2006, but only seven of these surveys covered the entire accessible portions of the cave stream. Counts range from 1-47 individuals, with number of individuals observed ranging from 20-47 since 2000 (entire accessible stream habitat was not surveyed in 2004 when 20 individuals were observed). The most recent survey (January 22, 2009) documented 43 individuals in Logan Cave (M. Slay 2010, pers. comm.). Bear Hollow Cave, the second location known at listing, is located approximately 38 km (23 mi) from Logan Cave. The stream system within Bear Hollow Cave is approximately 200 m (660 ft) in length. Bear Hollow Cave has been surveyed 13 times from 1986-2006, but only 10 of these surveys covered the entire accessible portions of the cave stream. Counts range from 1-9 individuals, with number of individuals observed ranging from 5-9 since 2000 when the entire accessible stream habitat was surveyed. The most recent survey (April 29, 2009) recorded the highest numbers to date, documenting 13 individuals. Two new potential *C. aculabrum* populations have been identified since listing; Elm Springs and Old Pendergrass. Both populations have been confirmed as *C. aculabrum* through genetic analysis (Graening et al. 2006).

It is difficult to ascertain what is occurring underground and the exact status of this species. Given an understanding of the functionality of the karst landscape in which this and the other sites occur, the best indicator of population viability likely is the landscape above and the threats posed by land management activities. Environmental water quality sampling of Bear Hollow and Logan Cave streams produced evidence of fecal coliform bacteria contamination and elevated levels of dissolved nutrients and metals in water, cave sediment, and tissues of cave animals. The study however failed to document any direct effects of these pollutants upon the ecosystems, but the pollutants are present and remain a constant stress upon *C. aculabrum*, which is adapted to oligotrophic, pristine groundwater habitats. Fine benthic organic matter in sediments appears to sustain crustacean detritivores such as *C. aculabrum* (Graening 2005). In 1968, 59%of the Logan Cave recharge area was forested; this had decreased to 43 percent by 1987. By 2008, the only forested areas are along creek bottoms or ridge tops where it is too steep for livestock or poultry

operations (Aley and Aley 1987; USFWS 2008). Two major land use activities occur in the Logan Cave recharge area: residential and commercial development and agriculture. Problems associated with these land uses include elevated nutrient concentrations, pesticides, and varied contaminants yielded from storm water runoff (Aley and Aley 1987; USFWS 2008). Numerous cattle, swine, and poultry farms operate within the recharge area and produce substantial quantities of animal waste. Land application of animal waste is commonly used as fertilizer to enhance pasture production. Leaks and spills associated with increased road density in the recharge area increases the likelihood of water quality contaminants entering the cave system. A substantial amount of groundwater contamination from residential and commercial development occurs from inadequate sewage disposal systems. A large golf course exists on high vulnerability lands in Gordon Hollow that are within the delineated recharge area for Old Pendergrass Cave. Potential water quality issues associated with management of the golf course include increased nutrients and pesticides. In general, regulations are not specific enough to provide adequate protection to *C. aculabrum*, and enforcement of existing regulations is understaffed. Threats associated with development and nonpoint source pollution within the delineated recharge areas have increased since listing and development of the recovery plan. Vandalism and trespass at some cave locations continue to be a problem affecting this species.

EB/CE Source: U. S. Fish and Wildlife Service. Benton County Cave Crayfish (*Cambarus aculabrum*) 5-Year Review: Summary and Evaluation. Southeast Region, Arkansas Ecological Services Field Office, Conway, Arkansas. May 2013. 16 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Benton County Cave crayfish will experience direct mortality for most uses of malathion at maximum rates for all bins (2, 6, and 7). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 3.19% of Benton County cave crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 2.47% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	3.19%
MOSQUITO CONTROL	
Mortality effects	2.47%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	37,210	2.47	0	0	2,6,7	2H 6H 7H
Developed	D	44,676	2.97	2,234	0.15	2,6,7	2H 6H 7H
Corn	D	1,507	0.1	1,475	0.1	2,6,7	2H 6H 7H
Wheat	D	573	0.04	522	0.03	2,6,7	2H 6H 7H
Other Grains	D	92	<0.01	92	<0.01	2,6,7	2H 6H 7H
Other Crops	D	74	<0.01	0	<0.01	2,6,7	2H 6H 7H
Nurseries	D	68	<0.01	68	<0.01	2,6,7	2H 6H 7H
Pasture	D	54	<0.01	48	<0.01	2,6,7	2H 6H 7H
Vegetables and Ground Fruit	D	16	<0.01	16	<0.01	2,6,7	2H 6H 7H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Other Row Crops	D	3	<0.01	0	<0.01	2,6,7	2H 6H 7H
Orchards and Vineyards	D	2	<0.01	1	<0.01	2,6,7	2H 6H 7H
Cotton	D	1	<0.01	0	<0.01	2,6,7	2H 6H 7H
Sub-TOTAL (D): *Other uses with effects*[3]		47,066	3.19	4,456	0.33		
TOTAL[4]:		84,276	5.66	4,456	0.33		

 # acres in species range: 1,504,944 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 64,909 acres, 4.313%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases,

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Benton County Cave crayfish. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Benton County Cave crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

The karst habitats occupied by this species are susceptible to groundwater contamination from surface runoff because of the rapid penetration of karst rock and little natural filtration. While insecticides were not specifically noted as threats for this species, it is reasonable to assume the species would be vulnerable to pesticide exposure like similar species. We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 3.19% mortality of individuals and 2.47% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The

waterbodies used by this species (bin 2, specifically) would result in a high concentration of toxins, including malathion, if exposed due to their small size and low water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.33% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the species. Even though the vulnerability and risk are high and pesticides have been listed as a potential threat to this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Benton County Cave crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Branchinecta conservatio	Conservancy fairy shrimp	490

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: All populations stable, with none known to be increasing or decreasing
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The Service is aware of 10 populations of Conservancy fairy shrimp, which include (from north to south): (1) Vina Plains, Butte and Tehama counties; (2) Sacramento National Wildlife Refuge (NWR), Glenn County; (3) Mariner Ranch, Placer County; (4) Yolo Bypass Wildlife Area, Yolo County; (5) Jepson Prairie, Solano County; (6) Mapes Ranch, Stanislaus County; (7) University of California (U.C.) Merced area, Merced County; (8) the Highway 165 area, Merced County; (9) Sandy Mush Road, Merced County; and (10) Los Padres National Forest, Ventura County. Although substantial progress with regard to protecting Conservancy fairy shrimp habitat has been made, many unprotected localities remain.

Two of four localities in the U.C. Merced population are not protected from habitat loss or modification and are threatened by habitat fragmentation and degradation from increased development pressures in the region. There is also a threat of direct habitat loss; however, this appears less severe than the threats of fragmentation and degradation. As of 2012, 14 of the known localities within the U.C. Merced population are zoned by the City of Merced as exclusive agriculture, and are not managed for vernal pool species (Jones and Stokes 2008). Current land-use plans for U.C. Merced have designated the Virginia Smith Trust parcel as conservation land, but the remaining localities (Ichord Ranch and Flying M Ranch) are not designated as conservation lands (Jones and Stokes 2008). The Ichord Ranch locality is now surrounded by lands protected by conservation easements, and the Service expects that the vernal pool known to harbor Conservancy fairy shrimp at this location will be protected in the future. The historic range of the Conservancy fairy shrimp is not known, and the loss and modification of vernal pool habitat statewide continues to be the primary threat to the Conservancy fairy shrimp. Loss of habitat due to urbanization reduces the ability of the Conservancy fairy shrimp to recover. Even in areas where habitat is protected, the urbanization of surrounding lands can reduce the suitability of protected habitats, and hinders the dispersal of the Conservancy fairy shrimp within and between populations, as well as causes increased edge effects to pool complexes. Other natural or anthropogenic threats cited in the 1994 final rule include stochastic extinction due to the high degree of isolation and small numbers of populations of this species

(Service 1994). Stochastic extinction as a result of random or unpredictable disturbances is a continued threat to the species. Additional threats not discussed in the 1994 listing rule include climate change, invasive plant species, inappropriate grazing regimes, and contaminants (e.g., pesticide use). In addition, pesticides applied to agricultural fields and orchards in the Central Valley can volatize to the atmosphere, which can be transported by bulk air movement and directly enter the vernal pool system from rainfall (Johnson 2005). Little is known about the relative sensitivity of vernal pool invertebrates to commonly used agricultural pesticides and chemical concentrations. However, research has shown that many commonly used pesticides may result in adverse effects to aquatic invertebrate species (Weston et al. 2005). Johnson (2005) found that 11 of 18 vernal pools sampled within the Sacramento NWR contained pesticides, although this study did not include the single vernal pool with a known occurrence of Conservancy fairy shrimp. However, pesticides are known to be used within close proximity of known Conservancy fairy shrimp localities.

EB/CE Source: U. S. Fish and Wildlife Service. Conservancy Fairy Shrimp (*Branchinecta conservation*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. June 2012. 35 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Conservancy fairy shrimp will experience direct mortality from most uses of malathion at maximum rates for all bins (5 and 6). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 29.11% of Conservancy Fairy Shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 74.00% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	29.11%
MOSQUITO CONTROL	
Mortality effects	74.00%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	8,649,668	74	188,788	1.62	5,6	5H 6H
Orchards and Vineyard	D	1,129,949	9.67	7,497	0.1	5,6	5H 6H
Developed	D	657,443	5.62	32,872	0.28	5,6	5H 6H
Pasture	D	241,697	2.07	12,428	0.11	5,6	5H 6H
Christmas Trees	D	<1	<0.01	<1	0	5,6	5H 6H
Corn	D	77,378	0.66	1,070	<0.01	5,6	5H 6H
Cotton	D	56,561	0.48	602	<0.01	5,6	5H 6H
Nurseries	D	4,246	0.04	1,756	0.02	5,6	5H 6H
Other Crops	D	477,645	4.09	39	<0.01	5,6	5H 6H
Other Grains	D	142,723	1.22	1,139	0.01	5,6	5H 6H
Rice	D	257,306	2.20	530	<0.01	5,6	**
Vegetables and Ground Fruit	D	119,128	1.02	69,861	0.60	5,6	5H 6H
Wheat	D	237,415	2.03	2,600	0.02	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		3,401,491	29.11	130,394	1.11		
TOTAL[4]:		12,051,159	100.00 [§]	319,182	2.73		

[§]Use overlaps with range are additive and cannot be greater than 100%.

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

**This use not in R-Plot.

 # acres in species range: 11,688,357 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 1,794,904 acres, 15.356%

Overall Usage: ☐ High ☐ Medium ☒ Low

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this

measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Conservancy fairy shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Conservancy fairy shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 29.11% mortality of individuals and 74.00% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 5, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations. Populations may be exposed from upland and non-point sources of malathion runoff from use sites. Where exposure occurs, malathion uses may result in a disproportionate number of individuals being killed because of the species' clumped distribution.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 2.80% of the non-Federal portion of the species range annually based on standard past usage data, and we anticipate similar levels of usage in the future. We anticipate a loss of individuals may occur if malathion is used within or adjacent to the non-Federal range of the species. Though the species is sensitive to groundwater contaminants that underlay the larger geographic area and pesticides have been

noted as a concern for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range. The 2012 5-Year Review mentions that pesticides are used in close proximity to areas occupied by conservancy fairy shrimp, but malathion was not specifically mentioned.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Conservancy fairy shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Branchinecta longiantenna	Longhorn fairy shrimp	491

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
When the longhorn fairy shrimp was listed as endangered in 1994, the primary threats to its survival and recovery were stochastic (random) extinction by virtue of the small isolated nature of the remaining populations, and loss of habitat due to urban development and conversion to agriculture. Longhorn fairy shrimp are extremely rare and were only known to occur in four disjunct populations as of the last review. The species has since been detected at a new location at Alkali Sink in Fresno County, thereby increasing the known distribution, although not appreciably expanding the range. Additional localities have also been detected at the Carrizo Plain population since the last review. Despite these positive indications, the populations at Brushy Peak, Vasco Caves and the San Luis NWR seem to have declined, with only a single pool supporting longhorn fairy shrimp in each population, despite more systematic annual surveys beginning in 2010 at both Brushy Peak and Vasco Caves. While these apparent reductions may be due to the timing of surveys, or to natural fluctuations in longhorn fairy shrimp dynamics, they are noteworthy. In most cases, we have no information to indicate that observed localities represent demographically independent units that contribute to species viability, and the long-term viability of the species at most sites is unknown regardless of the number of localities. The potential reduction to a single locality in three sites, however, raises serious concerns about the continued persistence of those populations. This species is highly susceptible to extirpation at any locality due to chance events or additional environmental disturbance as described above. If a catastrophic extirpation event occurs in any locality, the opportunities for re-colonization from other source localities within that population may be reduced, with long-term impacts to the abundance and sustainability of longhorn fairy shrimp in that population.

We consider the loss of long-term viability in any one of the five extant populations a serious threat the species' recovery. The majority of the five known populations of longhorn fairy shrimp are found on public lands, so many of the known localities are protected from land-use conversion; however the localities near Livermore, in Alameda County, are potentially threatened by wind energy leases. As of 2012, the Alkali Sink population was unprotected and its

designation as a conservation bank was pending, which was expected to lead to its protection under a conservation easement. Additionally, roughly half of the localities in the Carrizo Plain population remain unprotected on private lands. Given the overall rarity of the longhorn fairy shrimp, we anticipate protection of all localities would best ensure the long-term viability of the Carrizo Plain population and its contribution to the overall survival and recovery of the species. Potential threats such as habitat degradation due to inappropriate grazing regimes, altered hydrology due to drought and climate change, and non-native invasive weedy species remain for longhorn fairy shrimp whether they are on protected lands or not.

EB/CE Source: U. S. Fish and Wildlife Service. Longhorn Fairy Shrimp (*Branchinecta longiantenna*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. June 2012. 32 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the longhorn fairy shrimp will experience direct mortality for all malathion uses at maximum rates for all bins (5 and 6), except for developed uses in bin 6, where the risk of effects are expected to be low. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 9.28% of longhorn fairy shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 68.46% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	9.28%
MOSQUITO CONTROL	
Mortality effects	68.46%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	254,771	68.46	16,000	4.3	5,6	5H 6H
Developed	D	9,296	2.5	465	0.12	5,6	5H 6M
Pasture	D	13,921	3.74	217	0.06	5,6	5H 6H
Orchards and Vineyards	D	5,963	1.6	67	0.02	5,6	5H 6H
Vegetables and Ground Fruit	D	5,364	1.44	535	0.14	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		34,544	9.28	1284	0.34		
TOTAL[4]:		289,315	77.74	17,284	4.64		

 # acres in species range: 372,133 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 117,014 acres, 31.444%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Longhorn fairy shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Longhorn fairy shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but

we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 9.28% mortality of individuals and 68.46% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 5, specifically) would result in a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to isolated nature of species locations. Populations may be exposed from upland and non-point sources of malathion runoff from use sites. Where exposure occurs, malathion uses may result in a disproportionate number of individuals being killed because of the species' clumped distribution.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 4.64% of the non-Federal portion of the species range annually based on standard past usage data and we anticipate similar levels of usage in the future. The 2012 5-Year Review did not mention effects of pesticides or, specifically, insecticides, to this species.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct Exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Longhorn fairy shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Streptocephalus woottoni	Riverside fairy shrimp	492

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (numerous)
Species Trends: All populations stable, with none known to be increasing or decreasing
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
Since listing, as many as 52 additional occupied complexes have been identified, including one anthropogenic complex at Johnson Ranch. Additionally, there is one complex (Banning) in which Streptocephalus species cysts have been found. Although these may be Riverside fairy shrimp cysts, it is more likely they are cysts of the common New Mexico fairy shrimp (*S. dorothae*), which is known to occur in Banning less than 1 mi (1.6 km) from this site (Eriksen and Belk 1999). Since listing, about 9 of the total 57 complexes are known to have been extirpated, and we are unsure whether the species persists in 3 other complexes; hence, at the time of the last review in 2008, there were 45 known occupied vernal pool complexes (approximately 200 occupied pools), which include the anthropogenic complex at Johnson Ranch. More than half of all extant complexes known to contain Riverside fairy shrimp are in San Diego County, including 8 complexes on Marine Corps Base (MCB) Camp Pendleton.

All remaining Riverside fairy shrimp habitat is threatened to some degree by indirect effects of development (including off-highway vehicle use and other human access and disturbance impacts, runoff, dumping of trash and litter, and water and air pollution) resulting from the proximity of Riverside fairy shrimp habitat to development. Non-native plants also threaten Riverside fairy shrimp throughout the range of the species. Off-highway vehicle use by recreators, law enforcement (including Border Patrol), and the military threatens this species throughout much of its range. Riverside fairy shrimp habitat is naturally fragmented, but development projects continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species. Pesticide applications for the control of mosquito larvae have become more common to combat West Nile Virus. Although at this time the degree of this threat to Riverside fairy shrimp is unknown, the fact that some pesticides are designed specifically for the purpose of killing certain invertebrates adds strength to the argument that they may be a significant threat to Riverside fairy shrimp in areas where they are used.

EB/CE Source: U. S. Fish and Wildlife Service. Riverside Fairy Shrimp (*Streptocephalus woottoni*) 5-Year Review: Summary and Evaluation. Carlsbad Ecological Services Field Office, Carlsbad, California. September 2008. 86 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Riverside fairy shrimp will experience direct mortality for most uses of malathion at maximum rates for all bins (5 and 6). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 15.57% of riverside fairy shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 62.21% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	15.57%
MOSQUITO CONTROL	
Mortality effects	62.21%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage based on CalPUR data

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	1,103,621	62.21	0	0	5,6	5H 6H
Developed	D	272,228	15.35	13,611	0.77	5,6	5H 6H
Orchards and Vineyards	D	986	0.06	7	<0.01	5,6	5H 6H
Corn	D	8	<0.01	8	0.02	5,6	5H 6H
Nurseries	D	1,143	0.06	180	0.01	5,6	5H 6H
Pasture	D	1,150	0.06	89	<0.01	5,6	5H 6H
Vegetables and Ground Fruit	D	612	0.03	612	0.04	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		276,126	15.57	14,507	0.82		
TOTAL[4]:		1,379,747	7	14,507	0.82		

 # acres in species range: 1,773,966 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 563,779 acres, 31.781%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Riverside fairy shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Riverside fairy shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 15.57% mortality of individuals and 62.21% mortality of individuals from mosquito control efforts. We

anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are not considered in our analysis for crustaceans. The waterbodies used by this species (bin 5, specifically) would maintain a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.82% of the non-Federal portion of the species range annually based on standard past usage data. Pesticides are not a known threat to this species, though the possibility that pesticides likely pose a threat to this species has been realized since its listing. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Riverside fairy shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Branchinecta lynchi	Vernal pool fairy shrimp	493

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Threatened
Distribution: Species/Populations neither constrained nor widespread
Number of Populations: Multiple populations (numerous)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The loss and modification of vernal pool habitat continues to be the primary threat to the vernal pool fairy shrimp. In areas with extant habitat, loss of vernal pool habitat is expected to continue as urban boundaries expand further, especially through high and low terrace formations on the eastern side of the valley. Even in areas where habitat is protected, the urbanization of lands surrounding conserved areas results in the fragmentation of protected habitats, likely preventing dispersal of the shrimp within and between populations, as well as causing increased edge effects to pool complexes. Protection of vernal pool habitat through the purchase of land and conservation easements has resulted in the preservation of habitat for the shrimp, but the trend of loss of vernal pool habitat has continued. Remnant habitat that has been protected in small parcels is often subject to changed hydrological conditions, invasion by non-native plants and other species, increased vegetation growth, and other conditions (such as cessation of grazing or overgrazing) that serve to make habitat less suitable for the shrimp. This threat is expected to continue as expected population increases result in urban growth in areas of remaining vernal pool habitat. Studies have not been conducted to determine the minimum area (upland and wetland) needed to sustain vernal pool species in the long term. Of the total 400 records present in the CNDDB (2007), approximately 53% are located on private lands. About 15% of recorded occurrences are on Federal lands, including 13% on Department of Defense installations and 2% on public lands managed by the U.S. Forest Service, the U.S. Bureau of Reclamation, the U.S. Bureau of Land Management, and the Western Area Power Administration.

Water quality in vernal pools may also be degraded over large portions of the Central Valley due to pesticide overspray and residues. There are several examples of pesticides issues that have been recognized. For instance, the runoff and precipitation that fill the pools can include pesticides (i.e., herbicides, insecticides, fungicides). In addition, toxic levels of some compounds accumulate in aquatic stream sediments within the Central Valley (Weston et al. 43 2004; Amweg et al. 2005), so may also be a problem in vernal pools. In 2005, 194,310,983 pounds of pesticides (i.e., the active ingredient) were applied in California. The following counties with habitat for the vernal pool fairy shrimp were among the 10 counties with the highest commercial

pesticide application: Fresno, Tulare, San Joaquin, Madera, Monterey, Merced, Ventura, and Kings Counties (California Department of Pesticide Regulation 2005). Although little information exists on the effects of pesticides to the vernal pool fairy shrimp, studies have considered the effects on other crustaceans, including other fairy shrimp species. Tests of lethal pesticide effects to the congeneric San Diego fairy shrimp (*Branchinecta sandiegonensis*) have indicated that it is not particularly sensitive to the insecticide Malathion at likely concentrations in the Sacramento River, a large water body with consistently flowing water. However, the environmental concentrations of an herbicide (glyphosate - Roundup), do pose a potential direct risk to survival of the San Diego fairy shrimp, while indirect effects of these two pesticides could also negatively affect it (Ripley et al. 2002/2003). However, herbicide formulations, although less toxic to invertebrates than insecticides, may lead to retarded growth and concomitant reductions in fecundity for exposed fairy shrimp (Brausch et al. 2006). Herbicides may be used on some preserved vernal pool habitats to control invasive plant species (e.g., CNLM 2004a). Several commonly used pesticide formulations, including herbicides (Karmex [diuron] and Round-up), have been found to be toxic to *Thamnocephalus platyurus*, a fairy shrimp easily hatched in lab beakers and commonly used to test water quality and toxicity (Brausch et al. 2006). Pesticide effects can include the effects of the surfactants formulated with the active ingredient. For example, polyethoxylated tallowamine (POEA) is a surfactant that is commonly used in herbicide formulations to increase the efficacy of active ingredients. It is also known to cause alterations in respiratory surfaces of animals. POEA use has increased with the advent of "Roundup-Ready" crops; however, its potential effects on aquatic invertebrates are relatively unknown. Brausch and Smith (2007) used *T. platyurus* to assess the acute toxicity of POEA and found it to be extremely toxic at low concentrations. Pesticides that are found in vernal pools due to atmospheric deposition have been found to be toxic to another vernal pool crustacean, the cladoceran *Ceriodaphnia dubia*. A complex mixture of pesticides (bromoxynil, dicamba, 2,4-D, MCPA, triallate, trifluralin, pentachlorophenol, lindane, and 4,4′-DDT) has been detected in appreciable quantities in dry atmospheric deposits in vernal pools. The toxicity of this pesticide mixture has been determined to be due to the DDT component, which is commonly detected in surface waters (George et al. 2003). Concentrations of the pesticide Diazinon found in vernal pools on NWR complexes in the Sacramento and San Joaquin Valleys occur at levels that could have adverse effects on vernal pool species, including the vernal pool fairy shrimp.

EB/CE Source: U. S. Fish and Wildlife Service. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. September 2007. 76 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the vernal pool fairy shrimp will experience direct mortality from most uses of malathion in all bins (5 and 6). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 27.56% of vernal pool fairy shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 66.17% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality	22.77% (California only, CalPUR data for agricultural uses) 53.91% (All areas, standard data)
MOSQUITO CONTROL	
Mortality effects	66.17% (All areas, standard data)

Risk modifiers:
Bins 5, 6

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Usage data for the whole range based on data from EPA's SUUM.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	21,349,999	66.17	243,733	0.76	5,6	5H 6H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Developed	D	1,544,181	4.79	77,209.05	0.24	5,6	5H 6H
Christmas Trees	D	1	<0.01	1	<0.01	5,6	5H 6H
Orchards and Vineyards	D	2,913,097	9.03	159,179	0.49	5,6	5H 6H
Corn	D	176,502	0.55	510	<0.01	5,6	5H 6H
Cotton	D	215,863	0.67	31,842	0.1	5,6	5H 6H
Nurseries	D	9,635	0.03	9,635	0.03	5,6	5H 6H
Other Crops	D	1,463,013	4.53	0	<0.01	5,6	5H 6H
Other Grains	D	326,210	1.01	12,594	0.04	5,6	5H 6H
Other Row Crops	D	50,085	0.16	1,905	<0.01		
Pasture	D	675,993	2.09	112,837	0.35	5,6	5H 6H
Vegetables and Ground fruit	D	422,868	1.31	86,539	0.27	5,6	5H 6H
Wheat	D	701,351	2.17	19,561	0.06	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		8,889,442	27.56	290,586	0.99		
TOTAL[4]:		30,239,441	93.73	534,319	1.75		

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Agricultural usage based on CalPUR data

Use type	Risk to species[5]	Use overlap with range		Estimated usage in range[6]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Christmas Trees	D	1	<0.01	1	0	5,6	5H 6H
Orchards and Vineyards	D	2,913,097	9.03	30,840	0.1	5,6	5H 6H
Corn	D	176,502	0.55	1,070	<0.01	5,6	5H 6H
Cotton	D	215,863	0.67	14,905	0.05	5,6	5H 6H
Nurseries	D	9,635	0.03	2,143	0.01	5,6	5H 6H
Other Crops	D	1,463,013	4.53	41	<0.01	5,6	5H 6H
Other Grains	D	326,210	1.01	2,597	<0.01	5,6	5H 6H
Pasture	D	675,993	2.09	47,503	0.2	5,6	5H 6H
Rice	D	440,727	1.37	747	<0.01	5,6	**
Vegetables and Ground fruit	D	422,868	1.31	106,498	0.33	5,6	5H 6H
Wheat	D	701,352	2.17	7,033	0.02	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[7]		7,345,261	22.77	213,377	0.75		
TOTAL[8]:		7,345,261	22.77	213,377	0.75		

**This use not in R-Plot.

 # acres in species range: 32,267,287 acres
% of range in California (i.e., where CalPUR data is available): 97%
Range overlap with Federal lands: 6,950,487 acres, 21.540%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

[5] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[6] Estimated usage in the range is based on information about annual past usage.
[7] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[8] TOTAL includes usage on all use sites with effects, including mosquito control.

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the

Action is not likely to jeopardize the continued existence of the Vernal pool fairy shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Vernal pool fairy shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on mostly CalPUR (97%) usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 22.77% mortality of individuals in California and 53.91% mortality of individuals in all other areas of the species range. We estimate that annual malathion use for mosquito control efforts would result in about 66.17% mortality of individuals in all areas of the species range. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans. The waterbodies used by this species (bin 5, specifically) would maintain a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Though Ripley et al. 2002/2003 suggested that the closely-related San Diego fairy shrimp was not particularly sensitive to malathion at likely concentrations in the Sacramento River, effects of malathion to fairy shrimp in vernal pools were not assessed in this study and we expect greater concentrations of malathion to occur in vernal pools than in the Sacramento River due to differences in volume and water flow. We do not have sufficient information to determine what concentrations of malathion would occur in vernal pools. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 2.50% of the non-Federal portion of the species range annually based on standard past usage data and we anticipate similar levels of usage in the future. We anticipate a loss of individuals may occur if malathion is used within the non-Federal range of the species or adjacent to the range of the species. Though the species is sensitive to groundwater contaminants that underlay the larger geographic area and pesticides have been noted as a concern, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the vernal pool fairy shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Lepidurus packardi	Vernal pool tadpole shrimp	494

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (numerous)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
Vernal pool tadpole shrimp generally take between 3 and 4 weeks to mature (Ahl 1991, King et al.1996). Large females can deposit as many as 6 clutches, ranging from 32 to 61 eggs per clutch, in a single wet season (Ahl 1991). Vernal pool tadpole shrimp may be hermaphroditic (individuals have both male and female reproductive organs) (Longhurst 1955, Lynch 1966, C. Rogers in litt. 2001). Although vernal pool tadpole shrimp are spread over a wide geographic range, their habitat is highly fragmented and they are uncommon where they are found (Helm 1998; Service 2005a). As of 2007, the California Natural Diversity Database reported 226 occurrences of vernal pool tadpole shrimp in the following 19 counties: Alameda, Butte, Colusa, Contra Costa, Fresno, Glenn, Kings, Merced, Placer, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo, and Yuba. Sacramento County contains 28 percent, the greatest amount, of the known occurrences (CNDDB 2007).

The modification and destruction of occupied habitat caused largely by urban development and conversion of natural lands to agriculture and the resulting habitat fragmentation over the landscape were the primary threats to the vernal pool tadpole shrimp at the time of listing and continue to be the primary threats to the species today. Additionally, altered site hydrology, inappropriate levels of grazing, contaminant runoff into vernal pools, stochastic extirpation, and prolonged drought are also major threats which were known at the time of listing and remain as threats today. Since the time of listing, however, several new threats have become known, including invasive plants, mosquito fish (*Gambusia affinis*), and climate change. The CNDDB (2007) reports occurrences being threatened by biocides in the Solano-Colusa and Southeastern Sacramento Valley Vernal Pool Regions, although the magnitude of this threat is not known at this time.

Petroleum products, pesticides, herbicides, and other chemicals can be conveyed into the vernal pool habitats by overland runoff during the rainy season, thereby adversely affecting water quality and altering the water chemistry of vernal pools (e.g., pH), which may make conditions unsuitable for vernal pool crustaceans (Johnson 2005; C. Johnson, in litt., 2007; Weston et al.,

2005; Weston et al. 2006). Many of these chemical compounds are thought to have adverse effects on all of the listed vernal pool crustaceans and/or their cysts, with individuals being killed directly or suffering reduced fitness through physiological stress or a reduction in their food base due to the presence of these chemicals (Sheldon et al. 2003). Fertilizer contamination can lead to the eutrophication of vernal pools, which can kill vernal pool crustaceans by reducing the concentration of dissolved oxygen (Rogers 1998).

The introduction of pesticides and other contaminants into vernal pool waters may threaten occurrences of the vernal pool tadpole shrimp. Vernal pools are hydrated by winter precipitation, which often includes pesticides (e.g., herbicides, insecticides, fungicides) that have volatized and are atmospherically transported. In 2003, approximately 175,127,171 pounds of pesticides were applied in California and the greatest use was in Central Valley counties with extensive vernal pool habitat (Johnson 2005). Concentrations of the pesticide Diazinon, found in vernal pools on NWR complexes in the Sacramento and San Joaquin Valleys, occur at levels that could have adverse effects on vernal pool species, including the vernal pool tadpole shrimp. Detectable levels of Endosulfane, Hexazinone, Trifluralin, and Simazine were also present in sampled pools at levels which could be also be toxic to the shrimp, although their effects on listed vernal pool species have not been studied (Johnson 2005).

EB/CE Source: U. S. Fish and Wildlife Service. Vernal Pool Tadpole Shrimp (*Lepidurus packardi*) 5-Year Review: Summary and Evaluation. Sacramento Fish and Wildlife Office, Sacramento, California. September 2007. 50 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the vernal pool tadpole shrimp will experience direct mortality from most malathion uses at maximum rates for all bins (5 and 6). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 35.10% of vernal pool tadpole shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 60.51% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	35.10%
MOSQUITO CONTROL	
Mortality effects	60.51%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	9,744,958	60.51	243,733	1.51	5,6	5H 6H
Developed	D	661,732	4.11	33,087	0.21	5,6	5H 6H
Orchards and Vineyards	D	1,397,660	8.68	15,820	0.1	5,6	5H 6H
Corn	D	131,786	0.82	409	<0.01	5,6	5H 6H
Cotton	D	90,597	0.56	1,124	0.01	5,6	5H 6H
Nurseries	D	5,358	0.03	768	<0.01	5,6	5H 6H
Other Crops	D	585,935	3.64	41	<0.01	5,6	5H 6H
Other Grains	D	178,990	1.11	1,399	0.01	5,6	5H 6H
Pasture	D	437,608	2.72	29,840	0.3	5,6	5H 6H
Rice	D	380,376	2.36	747	<0.01	5,6	**
Vegetables and Ground Fruit	D	202,191	8.68	4,957	0.03	5,6	5H 6H
Wheat	D	385,306	2.39	2,999	0.36	5,6	5H 6H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species [1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Sub-TOTAL (D): *Other uses with effects*[3]		4,457,539	35.10	91,191	1.06		
TOTAL[4]:		14,2020,497	95.61	334,924	2.57		

**This use not in R-Plot.

 # acres in species range: 16,105,788 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 4,833,903 acres, 30.013%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Vernal pool tadpole shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Vernal pool tadpole shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage, per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 35.10% mortality of individuals and 60.15% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans. The waterbodies used by this species (bin 5, specifically) would maintain a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental

losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 2.57% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of individuals may occur if malathion is used within the non-Federal range of the species. Though the species is sensitive to groundwater contaminants that underlay the larger geographic area and pesticides have been noted as a concern, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range. The 2007 5-Year Review discusses potential negative effects of pesticides, including insecticides, on this species, though malathion was not specifically mentioned and general effects of pesticides to this species were surmised from studies of other crustaceans.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the vernal pool tadpole shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Branchinecta sandiegonensis	San Diego fairy shrimp	495

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (numerous)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The overall distribution of complexes known to be occupied by San Diego fairy shrimp has increased since listing from an estimated 25 occupied complexes to approximately 137 known today. Approximately 38% of known occupied complexes occur on military lands, including 9 complexes on Marine Corps Base (MCB) Camp Pendleton and 39 complexes on Marine Corps Air Station (MCAS) Miramar, which supports the largest contiguous block of habitat and highest number of occupied vernal pools within the range of the San Diego fairy shrimp.

Vernal pool sites on military lands are not considered completely protected because many pools on MCB Camp Pendleton occur in active training areas. Approximately 25% of occupied vernal pool complexes have been conserved and are protected from land-use conversion. All remaining San Diego fairy shrimp habitat is threatened to some degree by indirect impacts of development (including off-highway vehicle (OHV) use and other human access and disturbance impacts, runoff, dumping of trash and litter, and water and air pollution) resulting from the proximity of San Diego fairy shrimp habitat to development. Off-highway vehicle use by recreators, law enforcement (including Border Patrol), and the military threatens this species throughout much of its range. In addition to crushing fairy shrimp cysts, this type of off-road activity (including motorcycles and bicycles) can generally degrade San Diego fairy shrimp habitat, altering pool shape and compacting soil, potentially impacting pool hydrology. The Department of Defense is undertaking a study on the effects of OHV use on San Diego fairy shrimp habitat at MCB Camp Pendleton, which should provide further insight into the nature of OHV impacts on the species and its habitat.

Pesticide use was identified in the listing rule as a threat to San Diego fairy shrimp in the Fairview complex in Orange County (insecticide use) and generally (herbicide use). Herbicides are commonly used to control weeds outside of vernal pools (e.g., along roads, farms, and residential landscaping) and within vernal pools themselves (e.g., for enhancement/restoration projects). One study showed that the commonly used herbicide Roundup® may pose a risk to San Diego fairy shrimp (Ripley et al. 2002). Additionally, pesticide applications for mosquito

larvae control have become increasingly common to combat West Nile Virus. As of 2008, the Service was undertaking research to determine the effects of some pesticides on the species. The final listing rule identified altered vernal pool hydrology as a significant threat to this species throughout its range. Development within a vernal pool watershed can alter the timing, temperature, frequency, and duration of inundation of nearby vernal pools. Non-native plants also threaten San Diego fairy shrimp habitat throughout the range of the species. San Diego fairy shrimp habitat is naturally fragmented, but development projects continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species.

EB/CE Source: U. S. Fish and Wildlife Service. San Diego Fairy Shrimp (*Branchinecta sandiagonensis*) 5-Year Review: Summary and Evaluation. Carlsbad Office, Carlsbad, California. September 2008. 82 pp.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the San Diego fairy shrimp will experience direct mortality from most malathion uses at maximum rates for all bins (5 and 6), except for developed uses in bin 6 where the risk of effects are expected to be low. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 32.14% of San Diego fairy shrimp exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 78.04% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	32.14%
MOSQUITO CONTROL	
Mortality effects	78.04%

Risk modifiers:
Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Agricultural usage (except Developed) based on CalPUR data

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	490,620	78.04	0	0	5,6	5H 6H
Developed	D	200,871	31.95	10,044	1.6	5,6	5H 6M
Vegetables & Ground Fruit	D	140	<0.01	11	<0.01	5,6	5H 6H
Nurseries	D	1,149	0.18	116	0.02	5,6	5H 6H
Sub-TOTAL (D): *Other uses with effects*[3]		202,160	32.14	10,171	1.63		
TOTAL[4]:		692,780	100.00 [§]	10,171	1.63		

[§]Use overlaps with range are additive and cannot be greater than 100%.

 # acres in species range: 628,692 acres
% of range in California (i.e., where CalPUR data is available): 100%
Range overlap with Federal lands: 134,238 acres, 21.352%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the San Diego fairy shrimp. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The San Diego fairy shrimp has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on CalPUR usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage, per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 32.14%

mortality of individuals and 78.04% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans. The waterbodies used by this species (bin 5, specifically) would maintain a high concentration of toxins, including malathion, if it reached these waterbodies, due to their low volume and lack of water flow. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 1.63% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes, will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the San Diego fairy shrimp in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Gammarus desperatus	Noel's amphipod	1261

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The Noel's amphipod is a rare species that survives in only isolated locations in Chaves County, New Mexico, and Pecos and Reeves counties, Texas. Population numbers are unknown, although the species has remained stable at occupied sites. The effects of climate change, including widespread drought, decreased spring discharge, or a change in water chemistry could eliminate the species. Water contamination, particularly from oil and gas activities, catastrophic wildfire, and competition and predation from introduced species are additional threats to the species. A recovery plan has not yet been developed for this species. This species only occurs in isolated locations where it could easily be extirpated by biological or environmental threats. The final listing rule (67 FR 6459) states that the species is vulnerable to habitat degradation and local extinctions due to local and regional groundwater depletion (Hennighausen 1969, Quarles 1993, Jones and Balleau 1996); direct manipulation of flowing water and habitat conditions, such as damming or piping of water flow, pooling, or diverting flow (Cole 1981, NMDGF 1988); and surface and groundwater contamination from residential, agricultural, and industrial runoff (e.g., herbicides, pesticides) (Eisler 1987, Rail 1989).

EB/CE Source: U. S. Fish and Wildlife Service. Noel's amphipod (*Gammarus desperatus*) 5-Year Review: Summary and Evaluation. New Mexico Ecological Services Field Office, Albuquerque, New Mexico. December 2010. 25 pp.U. S. Fish and Wildlife Service. Noel's amphipod (*Gammarus desperatus*), Koster's springsnail (*Juturnia kosteri*), Roswell springsnail (*Pyrgulopsis roswellensis*), and Pecos assiminea (*Assiminea pecos*) 5-Year Review: Summary and Evaluation. New Mexico Ecological Services Field Office, Albuquerque, New Mexico. December 2020. 13 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Noel's amphipod will experience direct mortality from most malathion uses at maximum rates for bin 3. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 1.92% of Noel's amphipod exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 56.24% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	1.92%
MOSQUITO CONTROL	
Mortality effects	56.24%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	2,186,760	56.24	0	0	3	H
Other Crops	D	28,932	0.74	0	<0.01	3	H
Pasture	D	15,604	0.4	353	0.07	3	H
Wheat	D	9,960	0.26	9,122	0.23	3	H
Developed	D	7,067	0.18	353	<0.01	3	H
Other Grains	D	5,375	0.14	2,272	0.06	3	H
Corn	D	3,699	0.1	75	<0.01	3	H
Orchard and Vineyards	D	1,516	0.04	486	0.01	3	H
Cotton	D	1,014	0.03	1,107	0.03	3	H
Vegetables and Ground Fruit	D	22	<0.01	22	<0.01	3	H
Other Row Crops	D	15	<0.01	12	<0.01	3	H
Nurseries	D	9	<0.01	9	<0.01	3	H
Sub-TOTAL (D): *Other uses with effects*[3]		73,213	1.92	13,811	0.45		
TOTAL[4]:		2,259,973	58.12	13,811	0.45		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 3,888,329 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 1,205,062 acres, 30.992%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Noel's amphipod. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Actionduration of the Action, we do not expect species-level effects to occur.

The Noel's amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage, per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 1.92%

mortality of individuals and 56.24% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans. Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.45% of the non-Federal portion of the species range annually based on standard past usage data. The species is most commonly found on National Wildlife Refuge lands (30.99% of the range), though presence on other lands has been documented. We do not necessarily anticipate high levels of malathion use within refuge boundaries. We anticipate a loss of individuals may occur if malathion is used within the non-Federal range of the species or in areas adjacent to the range of the species. Though the species is sensitive to groundwater contaminants that underlay the larger geographic area and pesticides have been noted as a concern for this species, the 2010 5-Year Review mentions that water contamination is particularly from oil and gas operations. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. Thus, while direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Noel's amphipod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Cambarus callainus	Big Sandy Crayfish	5153

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The Big Sandy crayfish is known from 21 stream systems in the 4 larger subwatersheds in the upper Big Sandy River watershed: Tug Fork, Levisa Fork, Upper Levisa Fork, and Russell Fork. During 2006 to 2015 surveys, a total of 276 sites (including all historical locations and additional "semi-random" locations (e.g., appropriately-sized streams for the species)) were surveyed throughout the Tug Fork, Levisa Fork, Upper Levisa Fork, and Russell Fork watersheds. The Big Sandy crayfish was confirmed at 86 of the surveyed sites (31%) and in 21 of the 55 surveyed stream systems (38%). As detailed in the final rule and in the April 7, 2015 proposed rule (80 FR 18710), the Big Sandy crayfish is known to exist only in the Appalachian Plateaus physiographic province and are limited to certain stream classes and habitat types within their respective river basins. Furthermore, the extant populations of the species are limited to certain subwatersheds, which are physically isolated from the others by steep topography, stream distance, human-induced inhospitable intervening habitat conditions, and/or physical barriers (e.g., dams and reservoirs). Based on habitat connectedness (or lack thereof), we consider there to be six existing Big Sandy crayfish subpopulations: lower Tug Fork population (Pigeon Creek), upper Tug Fork population, the Upper Levisa Fork population (Dismal Creek), the Russell Fork/Levisa Fork population (including Shelby Creek), the Pound River population, and the Cranes Nest River population. While the Pound River and Cranes Nest River are in the same subwatershed, they both flow into the Flannagan Reservoir, which is unsuitable habitat for the species. Therefore, the Big Sandy crayfish populations in these streams are not only isolated from other populations by the dam and reservoir, but also most likely isolated from each other by the inhospitable habitat in the reservoir itself (Loughman, pers. comm., December 1, 2014). Also, because the Fishtrap Dam physically isolates the upper Levisa Fork (Dismal Creek) population from the remainder of the species' range, only the Tug Fork and the Russell Fork/Levisa Fork subpopulations still maintain any possible connection.

Within the historical range of the Big Sandy crayfish, the aquatic habitat has been severely degraded by past and ongoing human activities (Hunt et al. 1937, p. 7; Eller 1982, pp. 162, 184–186; Jezerinac et al. 1995, p. 171; Channell 2004, pp. 16–23; Thoma 2009b, p. 7; Thoma 2010,

pp. 3–4; Loughman 2013, p. 6; Loughman and Welsh 2013, p. 23; Loughman 2014, pp. 10–11). Visual evidence of habitat degradation, such as excessive bottom sedimentation, discolored sediments, or stream channelization and dredging, is often obvious, while other water quality issues such as changes in pH, low dissolved oxygen levels, high dissolved solids, high conductivity, high metals concentrations, and changes in other chemical parameters are less visible. Within the range of each species, water quality monitoring reports, most recently from the Kentucky Division of Water (KDOW) (2013, entire), the U.S. Environmental Protection Agency (USEPA) (2004, entire), the Virginia Department of Environmental Quality (VADEQ 2012, entire), and the West Virginia Department of Environmental Protection (WVDEP 2014, entire), have linked these widespread and often interrelated direct and indirect stressors to coal mining and abandoned mine land (AML), commercial timber harvesting, residential and commercial development, roads, and sewage discharges. The best available data indicate that the primary threats to the Big Sandy crayfish throughout its range are land-disturbing activities that increase erosion and sedimentation, which degrades the stream habitat required by both species. Identified sources of ongoing erosion and sedimentation that occur throughout the ranges of the species include active surface coal mining, commercial forestry, unpaved roads, gas and oil development, road construction, and stream modifications that cause channel instability. These activities are ongoing (e.g., imminent) and expected to continue at variable rates into the future. For example, while active coal mining may decline, the legacy effects will continue, and oil and gas activities and road construction are expected to increase.

EB/CE Source:
U. S. Fish and Wildlife Service. 2016. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Big Sandy Crayfish and Endangered Species Status for the Guyandotte River Crayfish. Final Rule. Federal Register 81:20449-20481.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Big Sandy crayfish will experience direct mortality from most uses of malathion at maximum rates for all bins (3 and 4). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 2.90% of Big Sandy crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 1.86% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	2.90%
MOSQUITO CONTROL	
Mortality effects	1.86%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☒ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	55,272	1.86	0	0	3,4	3H 4H
Developed	D	82,920	2.79	4146	0.14	3,4	3H 4H
Pasture	D	4,630	0.02	407	0.01	3,4	3H 4H
Corn	D	276	<0.01	178	<0.01	3,4	3H 4H
Nurseries	D	46	<0.01	46	<0.01	3,4	3H 4H
Other Crops	D	40	<0.01	0	<0.01	3,4	3H 4H
Orchards and Vineyards	D	22	<0.01	21	<0.01	3,4	3H 4H
Christmas Trees	D	20	<0.01	13	<0.01	3,4	3H 4H
Other Grains	D	14	<0.01	14	<0.01	3,4	3H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
							4H
Wheat	D	3	<0.01	<	<0.01	3,4	3H 4H
Vegetables and Ground Fruit	D	2	<0.01	2	<0.01	3,4	3H 4H
Other Row Crops	D	2	<0.01	2	<0.01	3,4	3H 4H
Sub-TOTAL (D): *Other uses with effects*[3]		87,975	2.96	4,829	0.23		
TOTAL[4]:		143,247	4.82	4,828.97	0.23		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 2,970,284 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 298,104 acres, 10.036%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Big Sandy Crayfish. As discussed below, even though the vulnerability is high and risk is medium for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Big Sandy Crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is medium. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage, per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 2.09% mortality of individuals and 1.86% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.23% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the non-Federal range of the

species. Even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Big Sandy Crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Gammarus pecos	Pecos amphipod	6596

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The primary threat to the continued existence of the Diamond Y Spring species is the degradation and potential future loss of aquatic habitat (flowing water from the spring outlets) due to the decline of groundwater levels in the aquifers that support spring surface flows. Habitat for these species is exclusively aquatic and completely dependent upon spring outflows. Spring flows in the Diamond Y Spring system appear to have declined in flow rate over time, and as spring flows decline, available aquatic habitat is reduced and altered. Other threats to the continued existence of the Pecos amphipod includes: oil and gas activities and pipelines that run close to the spring, inadequate regulatory protections on groundwater overabstraction, non-native snails in the habitat that are thought to be competing with resources, and future droughts related to climate change. Agricultural activities are far removed from the spring system and are not thought to pose a contaminant threat to the springs, although groundwater overabstraction for irrigation is contributing to diminshed spring flows to some extent.

EB/CE Source:
U. S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates. Final Rule. Federal Register 78:41227-41258.

Overall Vulnerability: ☒ **High** ☐ **Medium** ☐ **Low**

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Pecos amphipod will experience direct mortality from most uses of malathion at maximum rates for all bins (2, 3, and 5). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 0.73% of Pecos amphipods exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site.

ALL USES except mosquito control	
Mortality effects	0.73%
MOSQUITO CONTROL	
Mortality effects	0%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☐ Medium ☒ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	0	0	0	0	2,3,5	2H 3 5H
Other Crops	D	8,999	0.3	0	<0.01	2,3,5	2H 3 5H
Developed	D	4,378	0.14	219	<0.01	2,3,5	2H 3 5H
Cotton	D	2,467	0.08	2,476	0.08	2,3,5	2H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
							3 5H
Wheat	D	2,008	0.07	1,583	0.05	2,3,5	2H 3 5H
Pasture	D	1,860	0.06	1,045	0.03	2,3,5	2H 3 5H
Orchards and Vineyard	D	555	0.02	555	0.02	2,3,5	2H 3 5H
Other Grains	D	484	0.02	487	0.02	2,3,5	2H 3 5H
Vegetables and Ground Fruit	D	145	<0.01	143	<0.01	2,3,5	2H 3 5H
Corn	D	83	<0.01	0	<0.01	2,3,5	2H 3 5H
Other Row Crops	D	67	<0.01	64	<0.01	2,3,5	2H 3 5H
Nurseries	D	3	<0.01	3	<0.01	2,3,5	2H 3 5H
Sub-TOTAL (D): *Other uses with effects*[3]		21,049	0.73	6,575	0.24		
TOTAL[4]:		21,049	0.73	6,575	0.24		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 3,049,436 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 3 acres, 0.000%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action not likely to jeopardize the continued existence of the Pecos amphipod. As discussed below, even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Pecos amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is low. The estimated usage within the range is low based on standard usage data. Only 3 acres (~0%) of the species range overlaps Federal lands and we did not quantitatively evaluate use or usage on Federal lands that overlap with the species range.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 0.73% mortality of individuals and no mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans. The waterbodies used by this species would maintain a high concentration of toxins, including malathion, if it reached these waterbodies, due to their small size and low water flow (bin 2) or low volume and lack of

water flow (bin 5). Where exposure occurs and all individuals of a population are lost, or large proportions of those populations are lost, in any given year or due to incremental losses over time, the area of suitable habitat will likely not be recolonized due to the isolated nature of species locations.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.24% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability is high for this species, the likelihood of exposure to malathion is low because risk is low and past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future over the duration of the Action. Pesticides are not a known threat to this species; agricultural activities are currently far removed from the spring system and are not thought to pose a contaminant threat to the springs, although groundwater over-extraction for irrigation is contributing to diminished spring flows to some extent.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions and aquatic habitat buffers will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. Thus, while direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not anticipate species level effects.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Pecos amphipod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Gammarus hyalleloides	Diminutive Amphipod	8172

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The three species in the San Solomon Spring system, including this one, are threatened by the past and future destruction of their habitat and reduction in their range. The stressors include: (1) spring flow declines; (2) water quality changes and contamination; and (3) modification of spring channels. For example, degradation of water quality from point and nonpoint pollutant sources is of concern. This pollution can occur either directly into surface water or indirectly through contamination of groundwater that discharges into spring run habitats used by the species. The main source for contamination in these springs comes from herbicide and pesticide use in nearby agricultural areas. There are no oil and gas operations in the area around the San Solomon Spring system.

EB/CE Source:
U. S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates. Final Rule. Federal Register 78:41227-41258.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the diminutive amphipod will experience direct mortality from most uses of malathion at maximum rates in bin 3. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 3.16% of diminutive amphipods exposed to malathion via all uses except

mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 0.08% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	3.16%
MOSQUITO CONTROL	
Mortality effects	0.08%

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☐ High ☒ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	2,418	0.08	0	0	3	H
Other Crops	D	83,270	2.63	22	<0.01	3	H
Cotton	D	7,386	0.23	7,054	0.22	3	H
Pasture	D	5,612	0.18	1,704	0.05	3	H
Wheat	D	1,706	0.05	1,531	0.05	3	H
Other Grains	D	1,105	0.03	1,105	0.04	3	H
Orchards and Vineyard	D	309	<0.01	226	<0.01	3	H
Other Row Crops	D	124	<0.01	123	<0.01	3	H
Vegetables and Ground Fruit	D	102	<0.01	102	<0.01	3	H
Corn	D	17	<0.01	0	<0.01	3	H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Sub-TOTAL (D): *Other uses with effects*[3]		99,631	3.16	11,867	0.38		
TOTAL[4]:		102,049	3.24	11,867	0.38		

 # acres in species range: 3,163,209 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 820 acres, 0.026%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Diminutive Amphipod. As discussed below, even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Diminutive Amphipod has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is medium. The estimated usage within the range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage, per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 3.16% mortality of individuals and 0.08% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.40% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability is high and risk is medium for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low

levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Diminutive Amphipod in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Procambarus econfinae	Panama City Crayfish	9386

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Proposed Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (numerous)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The Panama City crayfish (*Procambarus econfinae*) (PCC) is a semi-terrestrial crayfish that inhabits wet pine flatwoods and prairie-marsh communities. Historically, the PCC inhabited natural and often temporary bodies of shallow fresh water within open pine flatwoods (Hobbs 1942) and wet prairie-marsh communities. However, most of these communities have been cleared for residential or commercial development or replaced with slash pine plantations. Thus, the PCC is known to inhabit the waters of grassy, gently-sloped ditches and swales, slash pine plantations, utility rights-of-way (Keppner and Keppner 2001) and a few remnant parcels protected under wetland and private easements.

Potential threats to PCC include habitat loss and degradation, habitat fragmentation, and subpopulation isolation due to residential development. We also consider other possible factors including direct mortality related to construction activities, inappropriate application of pesticides and other toxic substances, chemical spills, off- road vehicle use, illegal harvest, and direct competition with indigenous and/or nonindigenous species. Declines in water quality are known to present a significant threat to other species of crayfish (and presumably to PCC). These declines can range from oxygen-deficient conditions resulting from algal blooms, sewage spills, or localized leaks to pollution originating from roadway runoff or chemical spills (Acosta and Perry 2001). Many substances commonly used around the home or business can be toxic to PCC and other wildlife if used or disposed of improperly. PCC often inhabit ditches and swales close or adjacent to commercial and private properties, which may affect the water quality at these sites.

EB/CE Source: U. S. Fish and Wildlife Service. 2017. Species Status Assessment Report for the Panama City Crayfish (*Procambarus econfinae*), Version 1.1, Atlanta, GA.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK

(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: Effects for this species were estimated based on overlap and estimated risk to a similar species (Nashville crayfish). We assume that risks may be overestimated. We did not have aquatic habitat bins identified for this species for the draft biological opinion.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses.

ALL USES except mosquito control	
Mortality effects	High based on overlap (15.08%)
MOSQUITO CONTROL	
Mortality effects	High based on overlap (95.55%)

Risk modifiers:

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ **High** ☐ **Medium** ☐ **Low**

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	631,430	95.55	136	0.02	NA	NA
Other Crops	D	2,836	0.26	0	0	NA	NA
Open Space Developed	D	38,811	5.69	1,941	0.29	NA	NA
Other Grains	D	314	0.03	234	0.04	NA	NA
Corn	D	177	2.16	114	0.02	NA	NA
Cotton	D	1,110	0.10	615	0.09	NA	NA
Developed	D	27,060	3.81	1,353	0.20	NA	NA
Wheat	D	82	0.03	25	0.01	NA	NA

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Vegetables & Ground Fruit	D	49	0.05	25	0.03	NA	NA
Orchards & Vineyards	D	15	<0.01	14	<0.01	NA	NA
Pasture	D	1	<0.01	1	<0.01	NA	NA
Other Row Crops	D	851	0.01	772	0.11	NA	NA
Nurseries	D	30	0.01	30	0.01	NA	NA
Pine Seed Orchards	D	28,336	4.29	10,281	1.56	NA	NA
Sub-TOTAL (D): *Other uses with effects*[3]		99,672	15.08	15,405	2.33	NA	NA
TOTAL[4]:		731,102	100[δ]	15,541	2.35	NA	NA

[δ]Use overlaps with range are additive and cannot be greater than 100%.

 # acres in species range: 660,828 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 28,118 acres, 4.255%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Panama City Crayfish. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be adversely affected over the duration of the Action, we do not expect species-level effects to occur.

The Panama City Crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the non-Federal portion of the species range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 15.08% mortality of individuals and 95.55% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 2.35% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Panama City Crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Cambarus cracens	Slenderclaw Crayfish	10757

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☒

Environmental Baseline/Cumulative Effects (EB/CE) Summary:
The slenderclaw crayfish is a relatively small, freshwater crustacean with a comparatively elongate, slender front claw (Bouchard and Hobbs 1976, p. 2). This species is a cryptic, stream-dwelling crayfish and is endemic to Sand Mountain in DeKalb and Marshall counties, Alabama on the Cumberland Plateau in the Tennessee River Basin. Hydrologic alteration (precipitation change), land-use change, and non-native virile crayfish were the factors identified as affecting slenderclaw crayfish in the future. Non-native and invasive virile crayfish, low abundance, and water quality put the slenderclaw crayfish at risk of being in danger of extinction within the next 10 to 20 years. The invasive virile crayfish is the biggest threat against the species. It has been documented to occur in Guntersville Lake (a Tennessee Valley Authority reservoir constructed in 1939 on the Tennessee River mainstem). Overall, there will be a reduction in the occupied range of the species through the loss of the Short Creek population, and at a minimum, its range within the Town Creek population will be highly restricted to the headwaters due to the expansion of virile crayfish and urban areas. In addition, the slenderclaw crayfish exhibits low natural redundancy given its narrow range, and in the future, the presence of virile crayfish is expected to reduce redundancy further. Within both populations of the slenderclaw crayfish, there are historical sites that were considered extirpated in 2018; in the future, additional sites (and possibly both populations) are expected to become extirpated.

EB/CE Source: U.S. Fish and Wildlife Service. 2018. Species Status Assessment Report for the Slenderclaw Crayfish (*Cambarus cracens*), Version 1.3. Atlanta, GA.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: Effects for this species were estimated based on overlap and estimated risk to a similar species (Nashville crayfish). We assume that risks may be

overestimated. We did not have aquatic habitat bins identified for this species for the draft biological opinion.

Risk to the species from labeled uses across the range:
The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses.

ALL USES except mosquito control	
Mortality effects	High based on overlap (12.15%)
MOSQUITO CONTROL	
Mortality effects	High based on overlap (3.74%)

Risk modifiers:

As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control	D	8,188	3.74	0	0	NA	NA
Other Crops	D	567	0.26	0	0	NA	NA
Open Space Developed	D	12,475	5.69	624	0.28	NA	NA
Other Grains	D	60	0.03	43	0.02	NA	NA
Corn	D	4,727	2.16	215	0.10	NA	NA
Cotton	D	229	0.10	141	0.06	NA	NA
Developed	D	8,348	3.81	417	0.19	NA	NA
Wheat	D	60	0.03	25	0.01	NA	NA

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Vegetables & Ground Fruit	D	110	0.05	60	0.03	NA	NA
Orchards & Vineyards	D	1	<0.01	1	<0.01	NA	NA
Pasture	D	<1	<0.01	<1	<0.01	NA	NA
Other Row Crops	D	12	<0.01	8	<0.01	NA	NA
Nurseries	D	30	0.01	30	0.01	NA	NA
Christmas trees	D	5	<0.01	2	<0.01	NA	NA
Sub-TOTAL (D): *Other uses with effects*[3]		26,626	12.15	1,566	0.72	NA	NA
TOTAL[4]:		34,813	15.89	1,566	0.72	NA	NA

 # acres in species range: 219,112 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 1,102 acres, 0.503%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases,

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from "repeat as necessary" to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

Reduced application number and rate: New restrictions on corn, cotton, orchards and vineyards, pasture, other crops, and vegetables and groundfruit lower the maximum allowable number of applications to 2-4 per year (depending on the specific crop, previous allowable numbers of applications ranged from 3 to 13 applications per year). We anticipate that this measure will reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service's biological opinion that the Action is not likely to jeopardize the continued existence of the Slenderclaw Crayfish. As discussed below, even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be adversely affected over the duration of the Action, we do not expect species-level effects to occur.

The Slenderclaw Crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the range is low based on standard usage data. For the portion of the species range that is on Federal lands, we did not quantitatively evaluate use or usage, but we assume only low levels of usage per the rationale related to usage on Federal lands as described in the Biological Opinion.

We estimate that across the non-Federal portion of the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 12.15% mortality of individuals and 3.74% mortality of individuals from mosquito control efforts. We

anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.72% of the non-Federal portion of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the non-Federal species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, residential use label changes, and reduced numbers of applications and application rates will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. The reduced application numbers and rate is expected to reduce the amount of malathion used and decrease potential exposure to the species, thus decreasing the risk of both indirect and direct effects to the species. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Slenderclaw Crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Cambarus veteranus	Guyandotte River crayfish	11201

VULNERABILITY
(Summary of status, environmental baseline and cumulative effects)

Status: Endangered
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Declining population(s) – one or more populations declining
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary: The best available data indicate that the historical range of the Guyandotte River crayfish is limited to the Upper Guyandotte River basin in West Virginia. Within the historical range of the Guyandotte River crayfish, the aquatic habitat has been severely degraded by past and ongoing human activities (Hunt et al. 1937, p. 7; Eller 1982, pp. 162, 184–186; Jezerinac et al. 1995, p. 171; Channell 2004, pp. 16–23; Thoma 2009b, p. 7; Thoma 2010, pp. 3–4; Loughman 2013, p. 6; Loughman and Welsh 2013, p. 23; Loughman 2014, pp. 10–11). Visual evidence of habitat degradation, such as excessive bottom sedimentation, discolored sediments, or stream channelization and dredging, is often obvious, while other water quality issues such as changes in pH, low dissolved oxygen levels, high dissolved solids, high conductivity, high metals concentrations, and changes in other chemical parameters are less visibly obvious. Within the range of the species, water quality monitoring reports, most recently from the Kentucky Division of Water (KDOW) (2013, entire), the U.S. Environmental Protection Agency (USEPA) (2004, entire), the Virginia Department of Environmental Quality (VADEQ 2012, entire), and the West Virginia Department of Environmental Protection (WVDEP 2014, entire), have linked these widespread and often interrelated direct and indirect stressors to coal mining and abandoned mine land, commercial timber harvesting, residential and commercial development, roads, and sewage discharges.

The best available data indicate that the primary threats to the Guyandotte River crayfish throughout its range are land-disturbing activities that increase erosion and sedimentation, which degrades the stream habitat required by both species. Identified sources of ongoing erosion and sedimentation that occur throughout the ranges of the species include active surface coal mining, commercial forestry, unpaved roads, gas and oil development, road construction, and stream modifications that cause channel instability. These activities are ongoing (e.g., imminent) and expected to continue at variable rates into the future. For example, while active coal mining may decline, the legacy effects will continue, and oil and gas activities and road construction are expected to increase. As detailed in this final rule and in the April 7, 2015, proposed rule (80 FR 18710), the Guyandotte River crayfish is known to exist only in the Appalachian Plateaus physiographic province and is limited to certain stream classes and habitat types within their

respective river basins. Furthermore, the extant populations of the species are limited to certain subwatersheds, which are physically isolated from the others by steep topography, stream distance, human-induced inhospitable intervening habitat conditions, and/or physical barriers (e.g., dams and reservoirs).

EB/CE Source:
U. S. Fish and Wildlife Service. 2016. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Big Sandy Crayfish and Endangered Species Status for the Guyandotte River Crayfish. Final Rule. Federal Register 81:20449-20481.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK
(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Guyandotte River crayfish will experience direct mortality for most uses of malathion at maximum rates for all bins (3 and 4). We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range: The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 2.69% of Guyandotte River crayfish exposed to malathion via all uses except mosquito adulticide at maximum rates on use sites will die, depending on the use site. For mosquito adulticide, we anticipate 39.14% of individuals exposed to malathion will die.

ALL USES except mosquito control	
Mortality effects	2.69%
MOSQUITO CONTROL	
Mortality effects	39.14%

Risk modifiers: As described in the *Approach to the Effects Analysis* section of the main body of the Opinion, we made specific considerations for species that occur in bins 3 and 4 and they were modeled in such a way that likely resulted in overestimation of estimated environmental concentrations, thus overestimating potential exposure.

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		^
Mosquito Control	D	235,711	39.14	0	NA	3,4	3H 4H
Developed	D	15,670	2.6	783	0.13	3,4	3H 4H
Nurseries	D	21	<0.01	21	<0.01	3,4	3H 4H
Corn	D	15	<0.01	6	<0.01	3,4	3H 4H
Orchards and Vineyards	D	5	<0.01	3	<0.01	3,4	3H 4H
Other Crops	D	5	<0.01	0	<0.01	3,4	3H 4H
Pasture	D	4	<0.01	4	<0.01	3,4	3H 4H
Christmas Trees	D	2	<0.01	2	<0.01	3,4	3H 4H
Other Grains	D	1	<0.01	1	<0.01	3,4	3H 4H
Vegetables and Ground Fruit	D	1	<0.01	1	<0.01	3,4	3H 4H
Wheat	D	<1	<0.01	<1	<0.01	3,4	3H 4H
Sub-TOTAL (D): *Other uses with effects*[3]		15,724	2.69	821	0.20		
TOTAL[4]:		251,435	41.83	821	0.20		

^We consider the bin 2 estimates as an upper bound of bin 3 & 4 exposures.

 # acres in species range: 602,162 acres
% of range in California (i.e., where CalPUR data is available): 0%
Range overlap with Federal lands: 1 acre, 0.000%

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

CONSERVATION MEASURES

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.
[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted for at least 48 hours or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers, which specify on the label a distance from water bodies where pesticides are not to be applied, are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. We anticipate that, in many cases, these buffers will significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to substantially reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways, which specify on the label a distance from water bodies where pesticides are not to be applied, and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Guyandotte River crayfish. As discussed below, even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Guyandotte River crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated

usage within the range is low based on standard usage data. Only 1 acre (~0%) of the species range overlaps Federal lands and we did not quantitatively evaluate use or usage on Federal lands that overlap with the species range.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 2.69% mortality of individuals and 39.14% mortality of individuals from mosquito control efforts. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.20% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur. Pesticides are not a known threat to this species.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Guyandotte River crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Faxonius peruncus	Big Creek Crayfish	11563

VULNERABILITY

(Summary of status, environmental baseline and cumulative effects)

Status: Proposed Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary:

The Big Creek Crayfish (*Faxonius peruncus*) is a small, olive-tan crayfish with blackish blotches

and specks over the upper surface of pincers, carapace and abdomen. The species was first described as *Cambarus peruncus* from specimens collected in Little Creek, a tributary to Big Creek in the Upper St. Francis River watershed in southeastern Missouri. The Big Creek Crayfish require pools, runs, or riffles with relatively low water velocity, shallow water depth, and low turbidity. The species also require rock substrate to use as refuge from predators and to harbor prey resources, likely consisting of invertebrates, periphyton, and plant detritus. The Big Creek Crayfish appears to consist of two populations, the Twelvemile Creek and Main populations. On September 17, 2020, the species was proposed to be listed as threatened with designated critical habitat (Federal Register, Vol. 85, No. 181, 58192-58222).

The primary factor influencing viability of the Big Creek Crayfish is invasion by the Woodland Crayfish (*Faxonius hylas*). The Woodland Crayfish was first documented in the Upper St. Francis River watershed in 1984 and is now known to occur in 11 streams in the watershed. The invasion resulted in reduced abundance of this native species, and in some areas, complete displacement. There are currently no known mechanisms to stop or reverse the Woodland Crayfish invasion. Results of the future conditions models predict that within 50 years Big Creek Crayfish abundance may be reduced 50-100% in 49-90% of the Main population and 0-100% in the Twelvemile Creek population (constituting 46-91% of the species' total range) due to the Woodland Crayfish invasion. The only other major factor likely impacting the Big Creek Crayfish is contamination by lead mining. Several studies investigating effects from heavy metal contamination in Southeastern Missouri and the Tri-State Mining District indicate that heavy metals and mining-related tailings adversely affect riffle-dwelling crayfish.

EB/CE Source: U. S. Fish and Wildlife Service. 2018. Species Status Assessment Report for the Big Creek Crayfish (*Faxonius perunus*) and St. Francis River Crafish (*Faxonius quandruncus*), Version 1.0, Bloomington, Minnesota. 69 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK

(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the Big Creek crayfish will experience direct mortality for most uses of malathion at maximum rates for all bins (2 and 5), except for developed and open space developed uses for bin 5, where the risk of effects will be low. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 3.75 % of Big Creek crayfish exposed to malathion via all uses at maximum rates on use sites will die, depending on the use site.

ALL USES except mosquito control	
Mortality and indirect effects	3.75%
MOSQUITO CONTROL	
Mortality and indirect effects	NA

Risk modifiers:

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE
(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control		0	0	0	0	2, 5	-
Other Crops	D	844	0.05	0	0	2, 5	2H

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
							5H
Open Space Developed	D	38,787	2.49	1,939	0.12	2, 5	2H 5L
Other Grains	D	151	0.01	151	0.01	2, 5	2H 5H
Other Row Crops	D	0.6	<0.01	0.5	<0.01	2, 5	2H 5H
Corn	D	3261	0.21	3,209	0.21	2, 5	2H 5H
Cotton	D	110	0.01	109	0.01	2, 5	2H 5H
Developed	D	13892	0.89	695	0.04	2, 5	2H 5L
Nurseries	D	21	<0.01	21	<0.01	2, 5	2H 5H
Rice	D	483	0.03	427	0.03	2, 5	-
Wheat***	D	448	0.02	296	0.02	2, 5	2H 5H
Vegetables & Ground Fruit	D	1.4	<0.01	1.4	<0.01	2, 5	2H 5H
Orchards & Vineyards	D	0.5	<0.01	0.4	<0.01	2, 5	2H 5H
Pasture	D	171	0.01	171	0.01	2, 5	2H 5H
Sub-TOTAL (D and I): *Other uses with effects*[3]		58,171	3.75	7,020	0.49		
TOTAL[4]:		58,171	3.75	7,020	0.49		

***Use acres values for wheat are slightly off from R-Plot values for this species

 # acres in species range: 1,556,380 acres
% of range in California (i.e., where CalPUR data is available): 0 %
Range overlap with Federal lands: 475,634 acres, 30.56 %
Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. In many cases, these buffers significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to significantly reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated. Changes to the general labels (e.g., reduction in number of applications allowed per year, timing restrictions, habitat buffers, etc.) would further reduce potential impacts to the Hay’s Spring amphipod and reduce take of the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the Big Creek crayfish. As discussed below, even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The Big Creek crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the range is low based on standard usage data. Approximately 30% of the species range overlaps Federal lands and we did not quantitatively evaluate use or usage on Federal lands that overlap with the species range.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 3.75% mortality of individuals. Mosquito control efforts are no expected to be a driver for effects to the species. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.49% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur. Pesticides are not a known threat to this species.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the Big Creek crayfish in the wild.

Conclusion: Is not likely to jeopardize

Integration and Synthesis Summary: Crustaceans

Scientific Name:	Common Name:	Entity ID:
Faxonius quadruncus	St. Francis River Crayfish	11564

VULNERABILITY

(Summary of status, environmental baseline and cumulative effects)

Status: Proposed Threatened
Distribution: Small, endemic, constrained, and/or isolated population(s)
Number of Populations: Multiple populations (few)
Species Trends: Unknown population trends
Pesticides noted ☐

Environmental Baseline/Cumulative Effects (EB/CE) Summary: The St. Francis River Crayfish (*Faxonius quadruncus*) is a rather small, dark brown crayfish with blackish blotches or specks over the upper surfaces of the pincers, carapace, and abdomen. Length of adult individuals also ranges from 2.8 to 5.6 centimeters (cm)(1.1 to 2.2 inches)(in). The St. Francis River Crayfish mainly inhabits the upper St. Francis River tributaries on the upper end of the Upper St. Francis River watershed in southeastern Missouri. The St. Francis River Crayfish require pools, runs, or riffles with relatively low water velocity, shallow water depth, and low turbidity. The species also require rock substrate to use as refuge from predators and to harbor prey resources, likely consisting of invertebrates, periphyton, and plant detritus. On September 17, 2020, the species was proposed to be listed as threatened with designated critical habitat (Federal Register, Vol. 85, No. 181, 58192-58222).

The primary factor influencing viability of the St. Francis River Crayfish is invasion by the Woodland Crayfish (*Faxonius hylas*). The Woodland Crayfish was first documented in the Upper St. Francis River watershed in 1984 and is now known to occur in 11 streams in the watershed. The range of the St. Francis River Crayfish has also contracted due to the Woodland Crayfish invasion in portions of at least three streams (Stouts Creek, Orr Hollow Creek, and Marble Creek), with St. Francis River Crayfish in two-thirds of the length of Stout's Creek presumably now extirpated. The invasion resulted in reduced abundance of this native species, and in some areas, complete displacement. There are currently no known mechanisms to stop or reverse the Woodland Crayfish invasion. Results of the future conditions models predict that within 50 years St. Francis River Crayfish abundance may be reduced 10-100% in 38-82% of the species' range within 50 years due to the Woodland Crayfish invasion. The only other major factor likely impacting the St. Francis River Crayfish is contamination by lead mining. Several studies investigating effects from heavy metal contamination in Southeastern Missouri and the Tri-State Mining District indicate that heavy metals and mining-related tailings adversely affect riffle-dwelling crayfish.

EB/CE Source: U. S. Fish and Wildlife Service. 2018. Species Status Assessment Report for the Big Creek Crayfish (*Faxonius perunus*) and St. Francis River Crafish (*Faxonius quandruncus*), Version 1.0, Bloomington, Minnesota. 69 pp.

Overall Vulnerability: ☒ High ☐ Medium ☐ Low

RISK

(Risk is based on species exposure and response from labeled uses across the range)

Risk to individuals if exposed: We anticipate the St. Francis River crayfish will experience direct mortality for all uses of malathion at maximum rates for all bins (2 and 5), except for developed and open space developed uses in bin 5, where the risk of effects will be low. We expect individuals to be at greater risk of lethal effects than sublethal effects.

Risk to the species from labeled uses across the range:

The table below summarizes the risk to the species from labeled uses across the range based on range overlaps with use sites and anticipated effects associated with the particular uses. We anticipate that 3.76 % of St. Francis River crayfish exposed to malathion via all uses at maximum rates on use sites will die, depending on the use site.

ALL USES except mosquito control	
Mortality and indirect effects	3.76%
MOSQUITO CONTROL	
Mortality and indirect effects	NA

Risk modifiers:

Allowable uses driving effects/other considerations: Crustaceans are algae or plankton eaters. Pesticides may impact the forage base in exposed areas.

Overall Risk: ☒ High ☐ Medium ☐ Low

USAGE

(Anticipated usage within the range based on past usage data)

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Mosquito Control		0	0	0	0	2, 5	-

[1] Direct effects (D), No effects expected (N), Use site not utilized by the species (*)
[2] Estimated usage in the range is based on information about annual past usage.

Use type	Risk to species[1]	Use overlap with range		Estimated usage in range[2]		Bins associated with use type	Effect associated with bin (H, M, L)
		Acres	%	Acres	%		
Corn	D	3,261	0.21	3209	0.21	2, 5	2H 5H
Cotton	D	110	0.01	109	0.01	2, 5	2H 5H
Developed	D	13,892	0.89	695	0.04	2, 5	2H 5L
Nurseries	D	21	<0.01	21	<0.01	2, 5	2H 5H
Open Spaced Developed	D	38,787	2.49	1939	0.12	2, 5	2H 5L
Orchards and Vineyards	D	0.41	<0.01	0.37	<0.01	2, 5	2H 5H
Other Crops	D	844	0.05	0	0	2, 5	2H 5H
Other Grains	D	151	0.01	151	0.01	2, 5	2H 5H
Pasture	D	171	0.01	171	0.01	2, 5	2H 5H
Pine Seed Orchards	D	0	0	0	0	2, 5	2H 5H
Rice	D	2	0.03	427	0.03	2, 5	-
Vegetables and Ground Fruit	D	1	<0.01	1.37	<0.01	2, 5	2H 5H
Wheat***	D	1639	0.02	296	0.02	2, 5	2H 5H
Sub-TOTAL (D and I): *Other uses with effects*[3]		58,879	3.76	7,020	0.48		
TOTAL[4]:		58,879	3.76	7,020	0.48		

***Use acres values for wheat are off from R-Plot values for this species

 # acres in species range: 1,556,380 acres
% of range in California (i.e., where CalPUR data is available): 0 %
Range overlap with Federal lands: 475,634 acres, 30.56 %

Overall Usage: ☐ **High** ☐ **Medium** ☒ **Low**

[3] Mosquito control has the potential to overlap with other uses. It is not included in the Sub-TOTALs.
[4] TOTAL includes usage on all use sites with effects, including mosquito control.

CONSERVATION MEASURES

Rain restriction: Given the relatively short half-life of malathion and rapid degradation via hydrolysis and other processes, persistence of malathion in storm run-off into most aquatic habitats is not anticipated to last longer than 48 hours under typical pH values, (i.e., 6.5-8.5) and water temperatures corresponding to growing season. Restricting malathion application to periods where rain is not forecasted or when the soil is not saturated will provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk.

Aquatic habitat buffers: Application buffers are designed to reduce spray drift from entering sensitive non-target areas, thereby providing protection to aquatic species. While the exact amount of spray drift reduction depends on the physical traits of the aquatic ecosystem (e.g. flow rate, volume, etc.) as well as the application method, we can expect (based on AgDRIFT modeling) spray drift reductions ranging from 40 to 91%, with low flow and low volume aquatic habitats receiving the most reduction in spray drift deposition. In many cases, these buffers significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects.

Residential use label changes: New restrictions to the method and frequency of application for residential use of malathion are expected to significantly reduce exposure to species that overlap with developed and open space developed areas. Label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing initial residues to degrade prior to the next application. In addition, exposure to aquatic organisms is reduced due to buffers from waterways and restrictions to application during periods where rain is not forecasted within 24 hours or when the soil is not saturated. Changes to the general labels (e.g., reduction in number of applications allowed per year, timing restrictions, habitat buffers, etc.) would further reduce potential impacts to the Hay’s Spring amphipod and reduce take of the species.

CONCLUSION

After reviewing the current status of the species, the environmental baseline for the action area, the effects of the Action, and the cumulative effects, it is the Service’s biological opinion that the Action is not likely to jeopardize the continued existence of the St. Francis River crayfish. As discussed below, even though the vulnerability and risk are high for this species, pesticides are not a known threat to this species and the likelihood of exposure to malathion is low, and the implementation of the general conservation measures described above is expected to further reduce the likelihood of exposure. While we anticipate that small numbers of individuals will be affected over the duration of the Action, we do not expect species-level effects to occur.

The St. Francis River crayfish has a high vulnerability based on its status, distribution, and trends. The risk to the species posed by labeled uses across the range is high. The estimated usage within the range is low based on standard usage data. Approximately 30% of the species range overlaps Federal lands and we did not quantitatively evaluate use or usage on Federal lands that overlap with the species range.

We estimate that across the species range, annual malathion uses pursuant to the labels for purposes other than mosquito control would result in about 3.76% mortality of individuals. Mosquito control efforts are no expected to be a driver for effects to the species. We anticipate effects of malathion on crustaceans to be lethal where exposure occurs, therefore sublethal effects from spray drift and indirect effects to prey items are considered not applicable for crustaceans.

However, we do not expect usage on all use sites nor at the maximum rates allowed by the labels wherever used each year. We anticipate that usage will occur in up to 0.48% of the species range annually based on standard past usage data. We anticipate a loss of a small number of individuals may occur if malathion is used within the range of the species. Even though the vulnerability and risk are high for this species, the likelihood of exposure to malathion is low because past malathion usage overlaps a small portion of the species range, and we anticipate similar levels of usage in the future.

Furthermore, we anticipate the additional conservation measures above, including rain restrictions, aquatic habitat buffers, and residential use label changes will further reduce the likelihood of exposure of the species, their prey, and their habitat. The rain restriction is expected to provide time for the pesticide to degrade before runoff into aquatic habitats can occur, decreasing exposure and risk. The aquatic habitat buffers are expected to significantly reduce exposure to aquatic organisms and subsequent risk of direct and indirect effects. The residential use label changes will ensure that residential use is limited to spot treatments only (rendering spray drift offsite unlikely) and reducing the extent of area which can be treated in the developed and open space developed areas by as much as 75% or more from modeled values. In addition, we expect the frequency of exposure to decrease as the number of allowable applications is reduced from “repeat as necessary” to a maximum of 2–4 applications per year (depending on the specific residential use). Retreatment intervals of 7-10 days between any repeated applications are expected to reduce environmental concentrations by allowing any initial residues to degrade prior to the next application. While direct exposure from use sites is anticipated to result in low levels of mortality (small numbers of individuals) over the duration of the Action, we do not expect species-level effects to occur. Pesticides are not a known threat to this species.

Therefore, we do not anticipate that the Action would appreciably reduce survival and recovery of the St. Francis River crayfish in the wild.

Conclusion: **Is not likely to jeopardize**