Interim Core Map Documentation for *Geocarpon minimum*

Version 1

Review Completed: April 2026

Core Map Developer: U.S. Environmental Protection Agency (EPA) Office of Pesticide Programs (OPP)

Species Summary

*Geocarpon minimum (*no common name, Entity ID 716) is a threatened terrestrial plant (dicot). The U.S. Fish and Wildlife Service (FWS) has not designated a critical habitat for *Geocarpon minimum*. All populations outside Missouri are associated with "slick spots" within saline soil barrens. In Missouri's sandstone glades, *Geocarpon minimum* colonizes shallow depressions within rocks that provide poor habitat for most other herbaceous species. However, no other populations have been found in sandstone glades outside of Missouri. The flowering and fruiting period when the plant ranges from late February to early June. *Geocarpon minimum* has a predominately self-mating system with virtually no cross pollination among individuals. Seed dispersal is primarily highly localized, likely by water and gravity. *Geocarpon minimum* is found in four states: Arkansas, Louisiana, Missouri and Texas. Since the 2016 5-Year Review conducted for this species, additional populations have been found in Oklahoma. Additional information on the species is provided in **Appendix 1**.

Description of Core Map

The core map for *Geocarpon minimum* is biological information type, based on the range and expanded to include additional populations in Oklahoma. The species range is refined and has a limited distribution. However, using the range on its own would exclude the Oklahoma populations of this species. There is no designated critical habitat.

Figure 1 depicts the resulting interim core map for *Geocarpon minimum*. The size of this core map is approximately 134,054 acres. The range encompasses 127,069 acres, and the additional Oklahoma populations encompass 6,985 acres. Landcover categories within the core map area are included in **Table 1**. Landcover is predominantly forest, woody wetlands and pasture/hay fields.

The core map developed for *Geocarpon minimum* is considered interim. This core map will be used to develop pesticide use limitation areas (PULAs) that include *Geocarpon minimum*. This core map incorporates information developed by FWS and made available to the public; however, the core map has not been formally reviewed by FWS. This interim core map may be revised in the future to incorporate species expert feedback from FWS. This interim core map has an "limited" best professional judgment classification as it consists of the species' range with additional populations added in Oklahoma.

This core map does not replace or revise any range or designated critical habitat developed by FWS for this species.

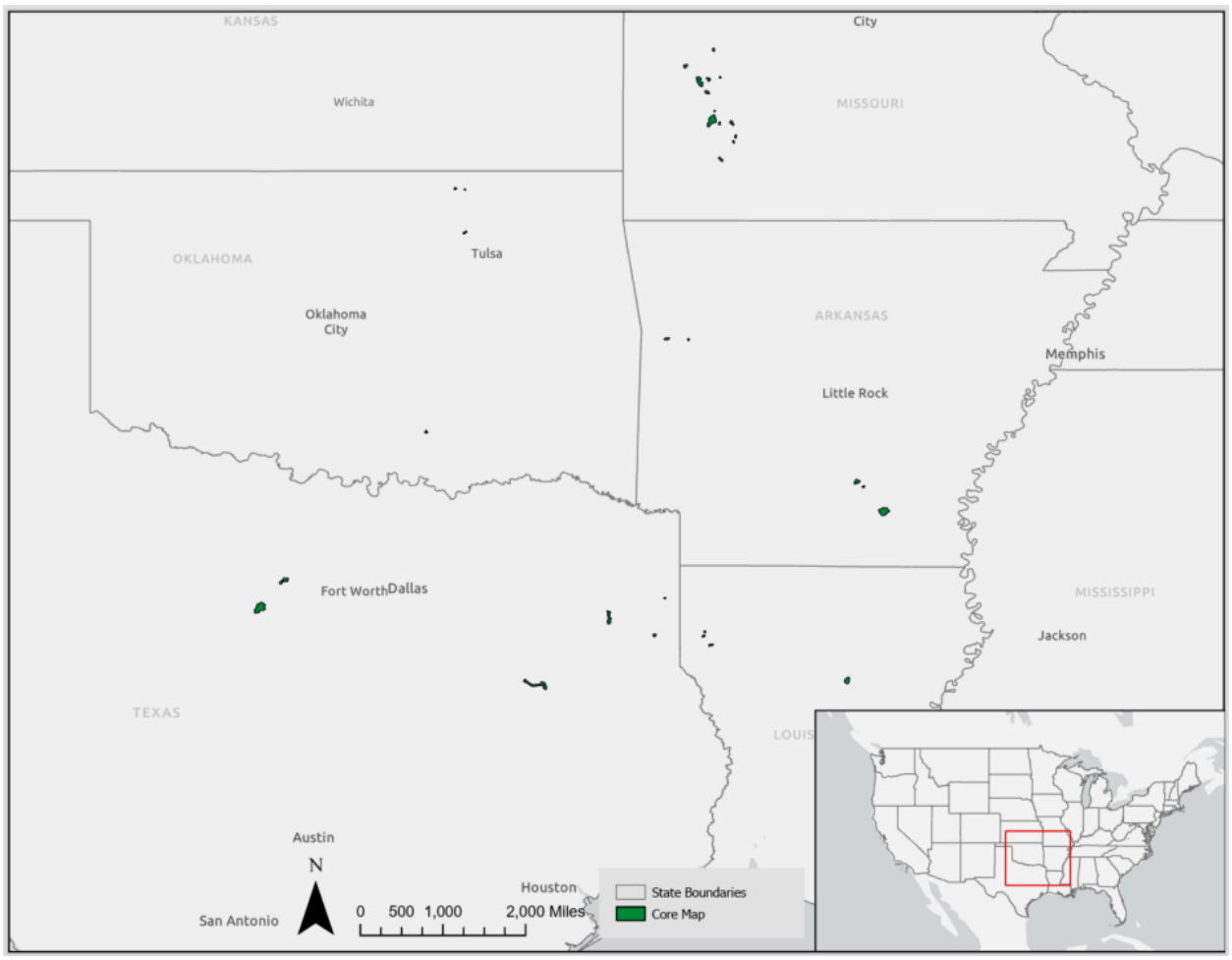

Figure 1. Interim core map for *Geocarpon minimum*. The total acreage of the interim core map is approximately 134,054 acres.

Table 1. Percentage of Interim Core Map Represented by NLCD[1] Land Covers and Associated Example Pesticide Use Sites/Types.

Example pesticide use sites/types	NLCD Landcover (Value)	% of core map represented by landcover
Forestry	Deciduous Forest (41)	22
Forestry	Evergreen Forest (42)	15
Forestry	Mixed Forest (43)	3
Agriculture	Pasture/Hay (81)	19
Agriculture	Cultivated Crops (82)	1
Mosquito adulticide, residential	Open space, developed (21)	2
Mosquito adulticide, residential	Developed, Low intensity (22)	2
Mosquito adulticide, residential	Developed, Medium intensity (23)	1
Mosquito adulticide, residential	Developed, High intensity (24)	1
Invasive species control	Woody Wetlands (90)	19
Invasive species control	Emergent Herbaceous Wetlands (95)	1
Invasive species control	Open water (11)	2
Invasive species control	Grassland/herbaceous (71)	9
Invasive species control	Scrub/shrub (52)	2
Invasive species control	Barren land (rock/sand/clay; 31)	0
Total Acres	**Interim Core Map Acres**	**~ 134,054**

Evaluation of Known Location Information

There are four datasets with known location information:

- Descriptions of locations provided by FWS
- Occurrence locations in iNaturalist
- Occurrence locations in NatureServe
- Occurrence locations in the Global Biodiversity Information Facility (GBIF)

EPA evaluated these sets of data before selecting the type of and developing the core map. FWS appeared to have the finest resolution of the location information, providing a map that depicted the current known locations within Missouri, Arkansas, Louisiana and Texas (**Figure A1-2 in Appendix 1**). Occurrences in iNaturalist, GBIF, and NatureServe were generally consistent with the locations of the range, with several exceptions. One 2023 observation in iNaturalist occurred near Morvin, OK, and one 2016 observation in GBIF occurred near Austin, TX. Both were well outside the FWS-defined range for this species. Upon further review, the 2016 Austin, TX observation was that of a preserved specimen whose description indicates it was collected in Missouri. Six observations in GBIF that occurred prior to

[1] Dewitz, J., 2023, National Land Cover Database (NLCD) 2021 Products: U.S. Geological Survey data release, https://doi.org/10.5066/P9JZ7AO3

1950 northwest of Carthage, MO, are well outside the FWS-defined range for this species. Because these observations are very old and there is no evidence that the species still exists in this area, this area was not considered further for the core map. Occurrences near Morvin, OK, from a 2023 Oklahoma Biological Survey near Morvin, OK, that were validated were added to the core map. **Appendix 1** includes more information on the available known location information.

Approach Used to Create Core Map

The core map was developed using the "Process EPA Uses to Develop Core Maps for Draft Pesticide Use Limitation Areas for Species Listed by the U.S. Fish & Wildlife Service (FWS) and their Designated Critical Habitats"[2] (referred to as "the process"). EPA developed the core map using the 4 steps described in the process document:

1. Compile available information for a species
2. Identify core map type
3. Develop the core map for the species
4. Document the core map

For step 1, EPA compiled available information for *Geocarpon minimum* from FWS, as well as observation information available from various publicly available sources (including iNaturalist, NatureServe, and GBIF). The information compiled for *Geocarpon minimum* is included in **Appendix 1**. Influential information that impacted the development of the core map included:

- Occurrences and known locations of the *Geocarpon minimum* in Oklahoma provided by the University of Oklahoma Biological Survey
- FWS provided range for this species

For step 2, EPA used the compiled information to identify the core map type including species range and known location information. The extant populations are included in the range map provided by FWS. Additional populations located in Oklahoma were added to the core map based on the iNaturalist Morvin, OK, observation which was verified to contain the species. The range alone was not used as the core map because additional known locations occurred were discovered outside of the range.

For step 3, EPA used the best available data sources to generate the core map. Data sources are discussed in the process document. For this core map, EPA used the FWS range map, and the CSV file of all Oklahoma observations provided by the University of Oklahoma Biological Survey. EPA added a 500-meter buffer around the Oklahoma observations as recommended by FWS. **Appendix 2** includes more details on the GIS analysis and data used to generate the core map.

Discussion of Approaches and Data that were Considered but not Included in Core Map

EPA explored using GIS datasets that describe the species' habitat to further refine the core map, however the existing species range already appears to reflect some degree refinement based on habitat

[2] Dated 2024, available online at: https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas

information. Consequently, further habitat-based refinement was deemed unlikely to yield a significant reduction in core map acreage.

Appendix 1. Information Compiled for Species

Recent FWS documents/links

1. FWS ECOS link: https://ecos.fws.gov/ecp/species/7699
2. Federal Register Notice (52 FR 22930 22933): 50 CFR Part 17 Endangered and Threatened Wildlife and Plants: Threatened Status for *Geocarpon minimum*
    a. June 16, 1987
    b. https://www.govinfo.gov/content/pkg/FR-1987-06-16/pdf/FR-1987-06-16.pdf
3. *Geocarpon minimum* (Geocarpon) 5-Year Review: Summary and Evaluation
    a. July 20, 2016
    b. https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/2360.pdf
4. *Geocarpon minimum* (no common name) 5-Year Review: Summary and Evaluation
    a. July 1, 2009
    b. https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/1415.pdf
5. *Geocarpon minimum* MacKenzie: Recovery Plan
    a. July 26, 1993
    b. https://ecos.fws.gov/docs/recovery_plan/930726.pdf

Background information

- **Status**
    - Federally listed as threatened in 1987
- **Resiliency, redundancy, and representation (the 3Rs)**
    - No Species Status Assessment available for this species, which is the document that often outlines the 3Rs.
    - Resiliency per the 2009 and 2016 5-Year Reviews: "Long-term monitoring of known sites indicates that aside from annual variations due to weather, **populations appear resilient if the appropriate microhabitats (shallow, sandy soil within sandstone glades or the margins of slick spots within saline prairies) are maintained at the site**. The only extirpation of an entire population at a known site involved intensive disturbance of a sandstone glade (Smith in litt. 2006a). Some subpopulations have been extirpated or migrated around a known site due to natural shifts in the location of shallow soils within sandstone glades (Smith and Ely 2006), competition with other plants due presumably to a lack of periodic disturbance (Witsell 2004), and anthropogenic changes in microhydrology (TNC 2004; Witsell pers. comm. 2006)."
    - Per the FWS's 2022 Biological Opinion for Malathion (Appendix C[3]), the species' resiliency is moderate to high, representation is high, and redundancy is high.

[3] Available at: https://www.fws.gov/media/biological-and-conference-opinion-registration-malathion

Habitat, life history and ecology

- **Habitat:**
    - "In Missouri, it occurs only on Pennsylvanian-age sandstone glades or outcrops in upland prairies. Elsewhere it occurs in habitats known as "slick spots" which are sparsely vegetated soils with high concentrations of magnesium and sodium (USFWS 1993). The later habitats are often referred to as "saline prairies" or "barrens"." (5-Year Review, 2016)
    - "All populations but one outside of Missouri are associated with "slick spots" within saline soil prairies. In Missouri sandstone glades it colonizes shallow depressions within rocks that provide poor habitat for most other herbaceous species. The only population found in sandstone glades outside of Missouri is one recently discovered west of Fort Worth, Texas." (ECOS)
    - "Because of their close association with the known occurrences of Geocarpon in Arkansas and Louisiana, the chemical properties, morphological description and characteristic vegetation of these soils will be discussed in some detail below..." (Recovery Plan, 1993)
        - "Diagnostic horizon is most commonly a silt loam in texture (e.g., the Lafe, Foley, and Bonn Series) but also can be composed of silty clays (e.g., the Wing, Bonn, Carytown, and Grubbs series). The exchangeable sodium may reach 20 to 40 percent at about 3 feet (Horn et al. 1962). These figures are often doubled for magnesium. Such high salt concentrations are correlated with columnar and prismatic subsurface soil structure, which in turn are correlated with arid-region soils." (Recovery Plan, 1993)
        - "The soil pH can be extremely high in the sodic horizon (pH 8 to 10) and is caused by the hydrolysis of sodium salts forming hydroxyl ions (Brady 1974). Acid phases of Lafe and Foley soils exist in which the entire solum is acidic. Here, magnesium is the dominant exchangeable cation (Horn et ii. 1964). Water-soluble salts dramatically affect drainage by causing electrostatic dispersion of the clay micelles present in the subsurface (Horn 1962). This deflocculation produces a soil that is extremely slippery when wet and dense, compact, and only slowly permeable to soil water and gases when dry. Thus, soil water capacity is low; soil aeration negligible; root toxicity high; and soil organic matter minimal.... In summary, a combination of high run-off, low field capacity, little organic matter, root toxicity, poor aeration, and low osmotic potentials produce soils with very poor biophysical conditions for plant growth." (Recovery Plan, 1993)
        - "Woody vegetation is sparse and limited to low mounds producing a savannah-like community structure. With the grassy, treeless area covering several acres, they are reminiscent of the better known prairies of the Midwest- hence the name saline soil 'prairie." It is here that Geocarpon can be found, but only in highly localized areas known as slick spots." (Recovery Plan, 1993)
        - "Microtopographic relationships within the slick spots seem to be critical to the spatial distribution of Geocarpon. Only a few scattered individuals can be observed in the totally bare areas at the center of a slick spot. Here, the salt concentrations can become so high that white patches of salt crystals are readily visible on the soil surface during the warm-season months." (Recovery Plan, 1993)
    - Missouri

        - "The Missouri Department of Conservation (MDC) currently recognizes 22 extant naturally occurring Geocarpon populations and three plantings." (5-Year Review, 2016)
        - "In Missouri, Geocarpon is limited to shallow depressions in slightly tilted sandstone strata within sandstone glade plant communities." (Recovery Plan, 1993)
        - "In Missouri sandstone glades it colonizes shallow depressions within rocks that provide poor habitat for most other herbaceous species." (5-Year Review, 2016)
        - "All sites in Missouri are located either in or near contact zones between rocks of Mississippian and Pennsylvanian Age or on the Pennsylvanian Age (Smith 1990) Channel Sands." (Recovery Plan, 1993)
    - Texas
        - "The Texas Parks and Wildlife Department (TPWD) recognizes four populations of Geocarpon. Three occur on private property, although one of these is within the acquisition boundary of the Neches River National Wildlife Refuge (Singhurst in litt. 2015)." (5-Year Review, 2016)
    - Arkansas
        - "The Arkansas Natural Heritage Commission (ANHC) recognizes five Geocarpon populations containing dozens of subpopulations. The site containing the largest known population (Warren Prairie) is owned and managed by the ANHC." (5-Year Review, 2016)
        - "Occurs in saline-alkali soils at the edges of highly localized, surficial concentrations of sodium and magnesium salts. Locally known as 'slick spots,' these austere and nearly barren patches of mineral soil are scattered across savannah-like formations classified as saline soil prairies." (Recovery Plan, 1993)
        - "To date, no Geocarpon populations have been found on Arkansas sandstones. Many of the species associated with *Geocarpon* sites in Missouri also occur on many of Arkansas' glades. These associate species include *Hypericum gentianoides (*L.) BSP.; *Plantago pusilla* Nutt.; *Saxifraga texana* Buckl.; *Selaginella rupestris* (L.) Spring; and *Selenia aurea* Nutt., all of which inhabit the shallow, seasonally-wet, lichen/moss-lined depressions typical of Geocarpon habitat. Also, the blue-green alga, *Nostoc* sp., was noted at some sites." (Recovery Plan, 1993)
        - "All populations of Geocarpon known to occur in Arkansas and Louisiana are restricted to saline or natric soils in plant communities classified as 'saline soil prairies'. The soils are classified as fine silty, mixed, thermic Aquic and Glossic, Natrudalfs." (Recovery Plan, 1993)
        - "Three of the four Arkansas sites have soils classified as belonging to the Lafe series." (Recovery Plan, 1993)
    - Louisiana
        - "The Louisiana Natural Heritage Program (LNHP) recognizes six Geocarpon populations. All populations occur on private property. Two are owned by a large timber company and are managed cooperatively with the LNHP as registered natural areas." (5-Year Review, 2016)
        - "Occurs in saline-alkali soils at the edges of highly localized, surficial concentrations of sodium and magnesium salts. Locally known as 'slick spots,' these austere and nearly barren patches of mineral soil are scattered across savannah-like formations classified as saline soil prairies." (Recovery Plan, 1993)

        - "All populations of Geocarpon known to occur in Arkansas and Louisiana are restricted to saline or natric soils in plant communities classified as 'saline soil prairies'. The soils are classified as fine silty, mixed, thermic Aquic and Glossic, Natrudalfs." (Recovery Plan, 1993)
        - "In Louisiana, the only known site for the species occurs in slick spots over the Brimstone soil series. The natric horizon is within 16 inches of the soil surface and exchangeable sodium capacity ranges from 15 to 30 percent (Smith and Mclnnis 1990)." (Recovery Plan, 1993)

- **Diet:** N/A; autotrophic plant

- **Reproduction:**
    - "Geocarpon is an annual usually easily visible for only three to six weeks during the spring. The flowering and fruiting period when the plant is usually most visible ranges from late February to early June (Bates 1994; McInnis and Larke 1997; Smith in litt. 1998; MDC 2000; TNC 2004, 2005). The flowering date appears to be earlier in the southern range presumably due to milder temperatures. March and April are the most common survey dates reported throughout the range and this likely corresponds to the peak flowering period. The factors affecting the timing and success of germination are not fully understood, although many researchers suggest that temperature and weather conditions are the two primary factors (Bates 1994; Logan 1998; TNC 2004; Witsell 2003; Singhurst in litt. 2006). During dry years, the number of observed plants often plummets to few or none only to return to previous numbers in subsequent wet years. This indicates that seeds remain viable for several years or more. The factor that appears to most affect the long-term reproductive success and persistence of Geocarpon populations is competition with and shading by other native or invasive plants (Baker and Witsell 2015)." (206 5-year Review)
    - "Recent genetics work indicates that *G. minimum*has a predominately self-mating system with virtually no cross pollination among individuals. This is supported by the fact that several populations contained individuals that were 100% genetically identical to each other and completely homozygous. This is consistent with the floral attributes of this species which lacks any obvious adaptations for attraction of pollinators. It also indicates that seed dispersal is primarily highly localized, likely by water and gravity." (ECOS)
    - "The pollination and seed dispersal mechanisms and vectors are unknown. However, surface flow of rainwater is perhaps a factor in local dispersal on the glades in Missouri." (Recovery Plan, 1993)
        - The FWS's 2022 Biological Opinion for Malathion (Appendix C), suggests that centipedes and ants may have a role in seed dispersal/pollination.

Taxonomy

- Monotypic genus, Caryophyllaceae family (Caryophyllales)
- Dicot, terrestrial plant
- "Recent phylogenetic work suggests that it should be placed in the genus *Mononeuria* and it is now known as *Mononeuria minima*. This new scientific classification has not been updated in the Federal Register, so for regulatory purposes this species retains its original scientific name (*Geocarpon minimum*) and is still referred to commonly as Geocarpon." (ECOS)

Relevant pesticide use sites

- No information about relevant use sites in existing documents

Relevant recovery criteria and actions

- Recovery Criteria from the 1993 Recovery Plan:
    - *Geocarpon minimum* will be considered for delisting when:
        - A total of 15 viable populations, representing the diversity of habitats and the geographic range of the species, are protected as necessary to ensure their continued existence.
        - Populations should also include the wide spectrum of current genetic variation found in the species.
        - Population viability should be confirmed through periodic monitoring for at least a 15-year period.
- Recovery Actions/Tasks from the 1993 Recovery Plan:
    - Protect viable populations of *Geocarpon minimum* to include all variations in habitat across its known geographic range.
        - Protect existing populations in Missouri, Arkansas, and Louisiana.
        - Search for additional populations in Arkansas, Mississippi, Oklahoma, and Texas.
    - Study the ecology and species biology.
        - Characterize the chemical, physical, and biological micro-environment immediately supporting *Geocarpon minimum*.
            - Analyze the physical habitat.
            - Determine the soil chemical profiles of saline soil prairies and the origin of slick spots.
            - Describe the cryptogamic flora that forms the micro-ecotone which glues soil particles into place around slick spots and in sandstone depressions.
            - Determine those factors that apparently restrict *Geocarpon minimum* to a very limited set of flatrock sandstone glades.
            - Determine those factors that control seed germination and phenology.
            - Conduct genetic analyses of the sandstone versus the slick spot populations.
            - Further investigate breeding biology, seed set, and seed banking.
    - Continue species monitoring and demographic studies at designated natural areas.
        - Design experimental sampling procedures across *Geocarpon minimum*-bearing slick spots and glades to monitor long-term successional relationships.
    - Preserve genetic stock.
    - Establish additional populations in the Arkansas Valley Natural Division, if deemed necessary.
- Recommendations for Future Actions from the 2016 5-Year Review:
    - Complete the investigation into the genetic variability of *Geocarpon minimum* throughout the plant's range (funded in 2015 with completion expected in 2017) to get a better understanding on possible completion of recovery criteria #2.
    - Continue to investigate the role of disturbance in the distribution and success of *Geocarpon minimum* in sandstone glades and saline prairies. The impacts of extreme disturbance due to feral hogs should be incorporated into these studies. As an understanding develops regarding the role of disturbance, a threats assessment should

be conducted to determine which threats should be addressed first.
    - Develop standardized monitoring protocols and reach consensus among states regarding the delimitation of populations and sub-populations.
    - Continue to search for new populations in suitable sandstone glade habitats in Missouri and Arkansas and saline prairie habitats in the Arkansas River Valley of Arkansas and Oklahoma and other saline prairie sites in Arkansas, Louisiana, and Texas.
    - Select sites throughout the range to be demographically monitored. Where it is already occurring this should continue, and it should be instituted at other representative sites throughout the range that are currently only monitored opportunistically for presence/absence or rough estimations of population.
    - Develop a long-term management plan based on the results of studies on genetics, the role of disturbance, and other life history studies. Specific recovery criteria that address the long-term protection and viability of *Geocarpon minimum* should be developed as new information becomes available.
    - Work cooperatively with landowners to conserve privately owned sites through fee title or easement purchases or development of management agreements.

Range

- Last updated on 12/17/2021 (ECOS)
    - States/US Territories in which this population is known to or is believed to occur: Arkansas, Louisiana, Missouri, Texas
    - US Counties/Parishes in which this population is known to or is believed to occur: Bradley (AR), Cleveland (AR), Drew (AR), Franklin (AR), Sebastian (AR), Caddo (LA), De Soto (LA), LaSalle (LA), Winn (LA), Cedar (MO), Dade (MO), Greene (MO), Henry (MO), Lawrence (MO), Polk (MO), St. Clair (MO), Anderson (TX), Cherokee (TX), Gregg (TX), Harrison (TX), Marion (TX), Palo Pinto (TX), Panola (TX), Parker (TX)
- "No comprehensive range-wide surveys have been conducted for the species." (5-Year Review, 2016)
    - "Personnel from the Missouri Department of Conservation (MDC) periodically survey some of the 25 documented sites in Missouri, but this occurs irregularly. The species is considered stable in Missouri." (5-Year Review, 2016)
    - "Personnel from the Arkansas Natural Heritage Commission (ANHC) also periodically survey the known populations of Geocarpon. The larger populations (Warren Prairie and Kingsland Prairie) have been surveyed on a frequent basis since the mid-1980s. The number of individual plants in these populations fluctuates greatly between years, but overall, these populations are classified as stable. Other sites in south Arkansas and the Arkansas River Valley are monitored less frequently and appear less stable." (5-Year Review, 2016)
    - "Additionally, a new population was discovered in 2014 near the Oklahoma border at Ft. Chaffee in Sebastian County. The historic sites in Louisiana continue to persist. Texas Parks and Wildlife Department (TPWD) recently discovered a new site in Gregg County. They plan to continue surveying known and potential sites within Texas." (5-Year Review, 2016)

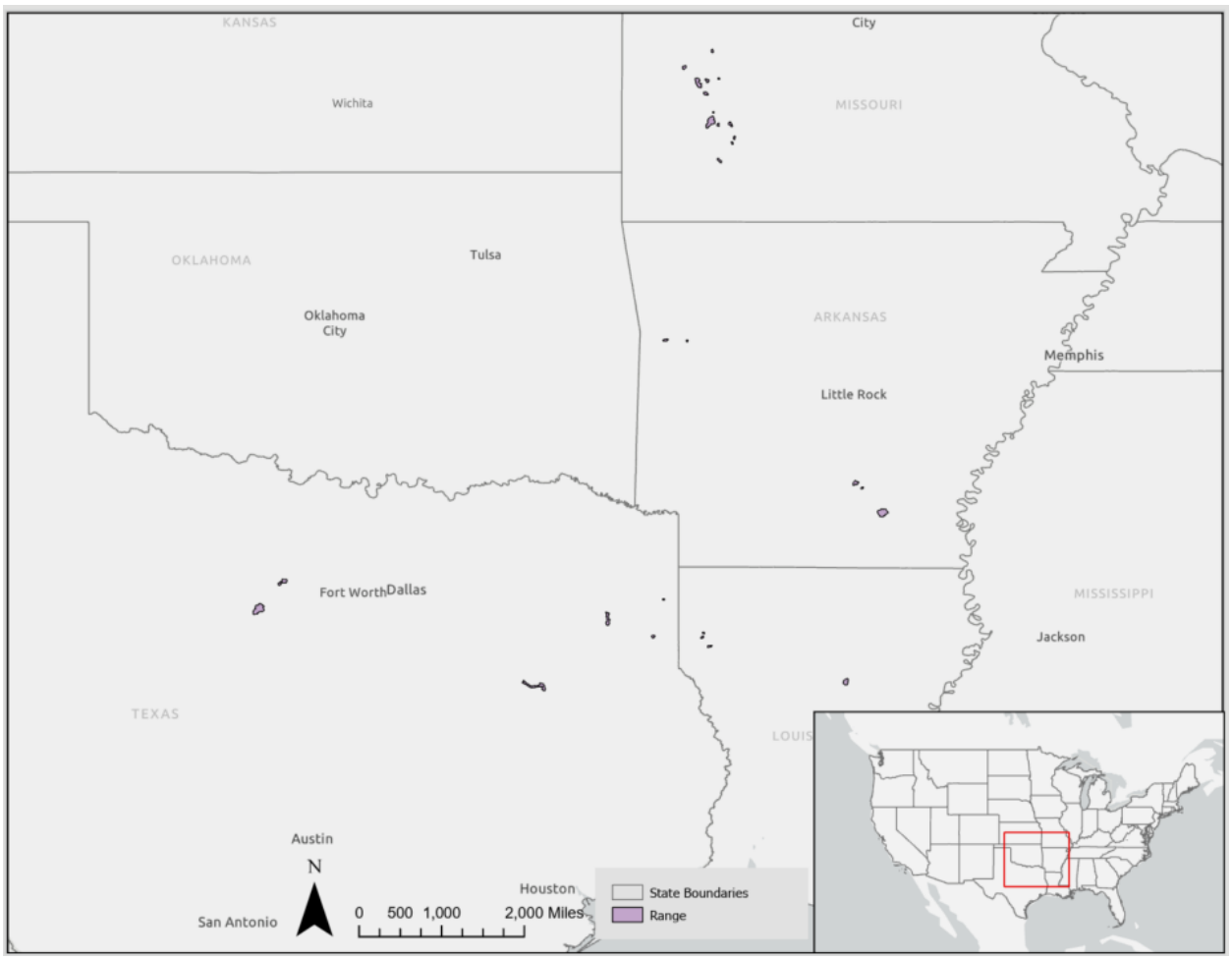

Figure A1-2. Map of *Geocarpon minimum* range (Source: FWS ECOS, https://ecos.fws.gov/ecp/species/7699). Range last updated December 17, 2021

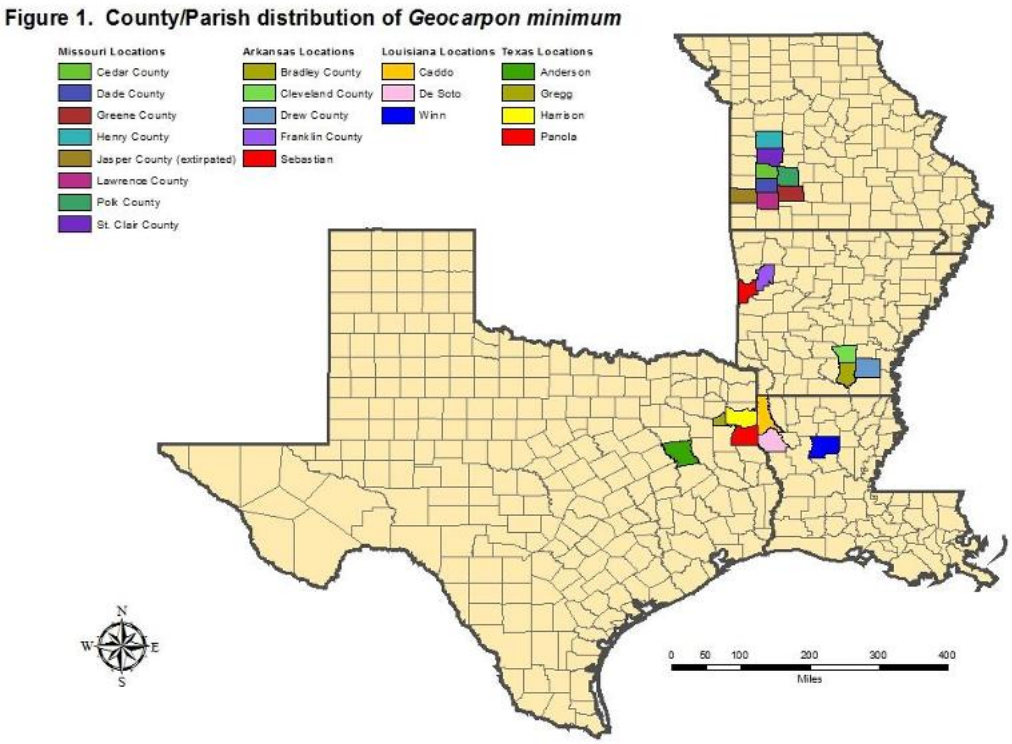

Figure A1-2. County Map of *Geocarpon minimum* (Source: 5-Year Review, 2016).

Critical habitat

- No critical habitat has been designated for this species.

Known Locations

- "Even though there appear to be extensive and numerous habitats available for *Geocarpon* in the form of 600,000+ acres of sodic soils, the number of actual occurrences is quite small" (Recovery Plan, 1993).
    - "Geocarpon minimum is known to have occurred at a total of only 28 locations in Arkansas, Louisiana, and Missouri" (Recovery Plan, 1993).
- Known locations from the 2016 5-Year Review:

Table 2. Site records of *Geocarpon minimum*

Missouri				
County	**Site Name/Quad**	**Natural Division**	**Collection/Observation Data**	**Ownership/Comments**
Cedar	Bluff Springs CA / Caplinger Mills	Ozark	First observed in 2004 Last observed in April 2015 60 plants	MDC / Soil containing seeds from nearby Coal Bank Hills was moved to suitable habitat within the conservation area to secure a protected population. Occurs in four plots. Surveys in 2008 revealed 135 plants. Additional surveys are needed to determine long-term viability. EO rank = D*
Cedar	Cave Branch Glades / Roscoe	Ozark	First observed in 1984 Last observed in April 1995 12 plants	Private / Not protected. Earlier observations indicated large populations up to 4,000 plants, although numbers show great annual variation. Last observation was well past flowering. Lacked permission to survey in 2005. Owner historically recognized population and protected, but unwilling to sell or register with conservation organizations. EO rank = A
Cedar	Coal Bank Hills / Caplinger Mills	Ozark	First observed in 1989 Last observed in April 2005 1,107 plants	Private / Not protected. Contains an "east" and "west" population. Both populations surveyed in 2005. Large annual variation in number of plants. Served as source of seeds for Bluff Springs CA. EO rank = C
Cedar	Leila Store Glade / Caplinger Mills	Ozark	First and last observed in February 1984 230 plants	Private / Not protected. Occurred in two "patches" of 30 and 200 plants. Lacked permission to survey in 2005. EO rank = C
Cedar	Tara Glade / Bona	Ozark	First observed in 1989 Last observed in April 2005 1,700 plants	USCOE / Occurred at two rock outcroppings with 850 plants each. EO rank = C
Dade	Bona Glade NA / Bona	Ozark	First observed in 1973 Last observed in April 2015 1,369 plants	USCOE / Widely distributed throughout the northern and western portions of the area. EO rank = B
Dade	Carmack Branch Glade / Bona	Ozark	First observed in 1984 Last observed in April 2005 903 plants	Private / Not protected. Past surveys showed large populations estimated at 10,000 plants. Cedars were noted as encroaching on portions of the glade. EO rank = A
Dade	Corry Flatrocks / Dadeville	Ozark	First observed in 1984 Last observed in April 2005 Estimated over 1,000 plants	TNC / Private. TNC owns the northern half of glade and owner of south portion has registered the site with TNC. Last population estimate was in 1997. EO rank = A
Dade	Corry Flatrocks – Mayer Introduction Site / Dadeville	Ozark	First and last observed in April 2005 31 plants	Private / Not protected. Soil containing seeds from a nearby glade was placed in suitable habitat here by a private landowner. EO rank = D

Dade	Flint Hill Glades / Bona	Ozark	First observed in 1989 Last observed in April 2015 4,410 plants	USCOE & Private / Site of long-term monitoring to observe effects of succession on *Geocarpon* distribution and density. Majority of plants occur on Corps property. Significant population on adjacent private property not surveyed in 2015. EO rank = A
Dade	Maze Creek / Bona	Ozark	First observed in 1988 Last observed in April 2015 2,675 plants	USCOE / Plants primarily in two sites. Rocky outcrops to the south support most plants. Northern sites have fewer plants and suffer from cedar encroachment. EO rank = A
Dade	Maze Creek Outcrops / Dadeville	Ozark	First observed in 1984 Last visited in April 2005 No plants	Private / No protection. Several hundred plants historically occurred within small rock outcrops north and south of a road at this site. It is a heavily grazed pasture. Only the north site was surveyed in 2005. The site should be revisited in future wet years favorable to germination in order to determine the status of this site. EO rank = unknown
Dade	Rice Glade / Dadeville	Ozark	First and last observed in 1989 1,000 or less plants	Private / Not protected. Lacked permission to survey in 2005. EO rank = B
Dade	Stockton Lake – Corry Branch Glade / Greenfield	Ozark	First observed in 1978 Last observed in April 2015 687 plants	USCOE / Plants scattered throughout four subpopulations around east arm and west side of lake. EO rank = B
Greene	Bois D'Arc CA/ Ash Grove	Ozark	First observed in 2006 Last observed in April 2014 4 plants	MDC / In October 2005 soil containing viable seeds was removed from Pearl Glade and placed within six sandstone outcroppings. Surveys in 2005 revealed 72 plants. Additional surveys are needed to determine if more recent observations represent a long-term decline or poor germination due to climatic conditions. EO rank = D
Greene	Pearl Glade / Willard	Ozark	First observed in 2000 Last observed in March 2005 750 plants	Private / No protection. Site used as a source for soil/seed for introduction at Bois D'Arc CA. EO rank = C
Henry	Otter Creek Glade / Lowry City	Osage Plains	First observed in 2000 Last observed in April 2005 5,118 plants	USCOE & Private / Found scattered in 4-5 subpopulations throughout glade. Approximately half of population occurs on Corps property. Portion on private land not protected. EO rank = B
Henry	Truman Lake / Lowry City	Osage Plains	First observed in 1997 Last observed in April 2006 3,265 plants (2005)	USCOE / Last comprehensive survey was in April 2005. Over 3,000 plants observed scattered widely throughout the glade. Observers in 2006 noted "hundreds" of plants but did not conduct a thorough quantitative survey. EO rank = C
Lawrence	Halltown Glade / Halltown	Ozark	First observed in 1980 Last observed in April 2005 2,215 plants	Private / Not protected. Plants scattered on south side of road. EO rank = C

Polk	Eudora Glades / Walnut Grove	Ozark	First observed in 1970 Last observed in 1984 1,000 plants or less	Private / Registered by TNC in 1980s but no enforceable protection. May have changed owners since registration. Lacked permission to survey in 2005. EO rank = B
Polk	Graydon Springs Glade / Walnut Grove	Ozark	First observed in 1958 Last observed in April 2005 750 plants	Private / Not protected. Plants located in three subpopulations. EO rank = C
St. Clair	Buzzard's Bluff / Vista	Ozark	First observed in 1957 Last observed in April 2005 355 plants	Private / Not protected. EO rank = BC
St. Clair	Collins Glade / Vista	Ozark	First observed in 1986 Last observed in April 2015 1,270 plants	Missouri Department of Transportation (MODOT) / This site was impacted by a road expansion project. Soil containing seeds from the impacted portion were transferred to suitable habitat across the highway and have successfully germinated since 1997. The majority of plants in 2015 were found in a few concentrated areas. EO rank = C
St. Clair	Schwarz Prairie / Roscoe	Ozark	First observed in 1990 Last surveyed in April 2015 568 plants	Private / Area is owned by the Missouri Prairie Foundation and is managed to maintain native plants. EO rank = C
St. Clair	Taberville Prairie NA and vicinity	Osage Plains	First observed in 1985 Last observed in April 2014 4 plants	MDC & Private / Approximately half of population occurs on Natural Area. Remainder is on unprotected private property. Surveys in 2005 revealed 500-1,000 plants. Additional surveys needed to determine if more recent observations represent a long-term decline or poor germination due to climatic conditions. EO rank = C
Arkansas				
County	**Site Name/Quad**	**Natural Division**	**Collection/Observation Data**	**Ownership/Comments**
Bradley & Drew	Warren Prairie Natural Area / Wilmar South	West Gulf Coastal Plain	First observed in 1958 Observed March 2012 Comprehensive survey revealed an estimate of between 7,567-8,767 plants Limited surveys in 2013 revealed two potentially new patches containing nearly 200 plants total	ANHC / The Warren Prairie Natural Area represents the largest population in both number and area. The majority of the population is on protected land, although five patches occur on adjacent private property. The biggest threats are lack of appropriate disturbance and associated vegetation succession, and severe disturbance by feral hogs. EO rank = A

Cleveland	Kingsland Prairie / New Edinburg	West Gulf Coastal Plain	First observed in 1982 Eastern cluster last observed in March 2012 900+ plants Western cluster last observed in March 2013 925 plants Limited surveys in 2014 revealed two new patches containing 250-300 plants total	ANHC / The Kingsland Prairie Natural Area contains a relatively large population but covers much less area than Warren Prairie NA. The majority of the population is on protected land, although one historic patch occurs on adjacent private property. The biggest threats are lack of appropriate disturbance and associated vegetation succession, and severe disturbance by feral hogs. EO rank = A.
Cleveland	Hall Creek Barrens (formally New Edinburg Prairie / New Edinburg)	West Gulf Coastal Plain	First observed in 1984 Last observed in 2012 80+ plants Last surveyed in 2013 Zero plants	ANHC / Acquired recently by ANHC and designated as Hall Creek Barrens Natural Area. Several historic and likely sites were surveyed in 2013 with no plants observed. One small site is still extant. Much of the habitat at this site is marginal and may benefit from management to favor Geocarpon. EO rank = CD.
Franklin	Branch Saline Barrens / Branch	Arkansas River Valley	Firsts observed in 1986 Last observed in March 2012 74 plants Last surveyed in spring 2014 Zero plants	Private / Used as a cattle pasture. The most recent survey revealed no plants at the site. It had been altered significantly by efforts to improve pasture in the area (fertilization and disturbance from adjacent tree removals). AHNC noted that these activities and declines had been noted in the past and in subsequent years Geocarpon was again observed. Continued surveys are needed to determine if this is a normal decline or a long-term trend. Only one population occurs at this site and it has an EO rank of D.
Sebastian	Ft. Chaffee / Fort Smith	Arkansas River Valley	First and last observed in April 2014 450-500 plants	DOD / This site was discovered within wing soils on a small, cedar-encroached saline slick area just inside the permanent plowed fireline. Other potentially suitable sites nearby were surveyed with no plants observed. EO rank = C.
Louisiana				
Parish	**Site Name/Quad**	**Natural Division**	**Collection/Observation Data**	**Ownership/Comments**
Winn	Saline Creek Prairie / Tullos	West Gulf Coastal Plain	First observed in 1990 Last observed in 2014 Plants casually observed in good numbers	Private / Recognized by owner as "unique site" and registered as a natural area with LNHP. During better years (1991) over 300 plants observed. EO rank = BC
Winn	Castor Creek Saline Prairie / Tullos	West Gulf Coastal Plain	First observed in 1991 Last observed in 2014 Plants casually observed in good numbers	Private / Recognized by owner as "unique site" and registered as a natural area with LNHP. During better years (1991) over 600 plants observed. EO rank = B
Caddo	Barren Road Prairie / Stonewall	West Gulf Coastal Plain	First observed in March 2006 Last observed in 2008 zero plants	Private / Impacts from ATV use and dirt moving activities, although it is unclear if these activities are affecting Geocarpon. Landowner has shown little interest in modifying these activities and recent access is questionable. EO rank = D
De Soto	Rambin Bayou Saline Prairie / Holly	West Gulf Coastal Plain	First observed in March 2007 Last observed in 2015 Plants casually observed in good numbers	Private / Some rutting from vehicle and ATV use but otherwise in good condition. No special protection by landowner. EO rank = AB

DeSoto	Dalton Prairie / Stonewall	West Gulf Coastal Plain	First and last observed in 2007 418 plants	Private / Some damage by ATV use. No special protection in place. EO rank = A
DeSoto	Dickson Prairie / Stonewall	West Gulf Coastal Plain	First observed in 2007 Last observed in 2015 Plants casually observed in good numbers	Private / Characterized as the "best quality" saline prairie (similar to Castor Creek) surveyed. No special protection in place. EO rank = A
Texas				
County	**Site Name/Quad**	**Natural Division**	**Collection/Observation Data**	**Ownership/Comments**
Anderson	Neches River Site / Neches	West Gulf Coastal Plain	First observed in 2004 Last observed in March 2005 360 plants	Private / Recognized by owner as "unique site" and managed to avoid impacts. Located in acquisition boundary of recently approved Neches River NWR. EO rank = Not ranked.
Gregg	Jay Global Prairie / Currently Undisclosed	West Gulf Coastal Plain	First and last observed in 2012 4,000 plants	Private / Corporate land used for hunting. EO rank = Not ranked.
Harrison	Bayou Saline Prairie / Karnack	West Gulf Coastal Plain	First and last observed in 2009 1,806 plants	TPWD and Private / A portion of this population extends into the Caddo Lake State Park. The remainder is on unprotected private land. EO rank = Not ranked.
Panola	Horton Saline Prairie / Currently Undisclosed	West Gulf Coastal Plain	First observed in 2009 Last observed in 2013 200 plants	Private / No special protection in place. EO rank = Not ranked.

* EO rank is a general ranking of the site assigned by MDC, ANHC, and LNHP biologists. Ranges from: A (excellent) – D (poor) (e.g., a large population of mature reproducing individuals occurring in an undisturbed area with no prospective human interference would receive the highest rank, A) (Butler in litt. 2006). These ranks have some subjectivity but are generally based on long-term trends rather than individual surveys. This is especially important for a species such as *Geocarpon* that exhibits high annual population variability (Smith in litt. 2006b).

Data for this table was provided by heritage data managers and botanists from each state (Baker in litt. 2015; Baker and Witsell 2015; Briggler in litt. 2015; Reid in litt. 2015; Singhurst in litt. 2015).

- 64 Research Grade occurrences in iNaturalist (https://www.inaturalist.org/observations?taxon_id=791506)
- 256 occurrences in the GBIF database (https://www.gbif.org/species/3085364)
    - 120 have coordinates (excluding those flagged as suspicious)
    - 53 are from iNaturalist
- Generally, the iNaturalist and GBIF observations are within or near to the range with a few exceptions as described below.
    - One 2023 observation in iNaturalist near Morvin, OK, and one 2016 observation in GBIF near Austin, TX, are well outside the FWS-defined range for this species.
        - The accuracy of the 2023 observation is >300 km (https://www.inaturalist.org/observations/153938506); however, it appears to be a valid observation. EPA received additional information from the University of Oklahoma Biological Survey to confirm and refine this occurrence.
        - Because the 2016 observation that appears near Austin, TX is a preserved specimen whose description indicates collection in Missouri (https://www.gbif.org/occurrence/2807471759; https://was.tacc.utexas.edu/fileget?coll=TEX-LL&type=O&filename=sp6820213674524177556 8.att.jpg) and because this area in Missouri (near Brownington) is already represented by the FWS-defined range, the area in Texas is not considered further for the core map.
    - Six observations in GBIF that occurred prior to 1950 northwest of Carthage, MO, are well outside the FWS-defined range for this species. Because these observations are very old and there is no evidence that the species still exists in this area, this area is not considered further for the core map.

Appendix 2. GIS Data Review and Method to Develop Core Map

This core map was created using the FWS provided range map with an addition of the Oklahoma observations provided by University of Oklahoma Biological Survey (OUBS) buffered by 500 meters to account for data uncertainties.

1. **Data References and Software**
    a. FWS Species Range – last updated on 12/17/2021
    b. CSV file of Oklahoma observations provided by OUBS.
2. **Datasets Used in Core Map Development**
    a. The FWS Species Range dataset is described in EPA's process document.
    b. The CVS file included longitude and latitude points of the Oklahoma *Geocarpon minimum* observations.
3. **Core Map Development**
    a. EPA used the range map provided by FWS as the starting point for developing this core map.
    b. The range map did not include the Oklahoma observations included in iNaturalist. Upon verification of those sites, the species range was expanded by adding the CVS file provided by OUBS.
    c. Based on discussions with FWS, a buffer of 500-meters was added to the Oklahoma observations.