Geocarpon minimum
(no common name)

Photo by: Theo Witsell / Arkansas Natural Heritage Commission

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Arkansas Ecological Services Field Office
Conway, Arkansas

5-YEAR REVIEW
Geocarpon minimum (no common name)

I. GENERAL INFORMATION

A. Methodology

This review was completed by the U. S. Fish and Wildlife Service's (Service) Arkansas Field Office. No part of the review was contracted to an outside party. All literature and documents used for this review are on file at the Arkansas Field Office. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on *Geocarpon minimum*. A notice of the initiation of this five-year review was published by the Service in the *Federal Register* (70 FR 43171), and a 60-day comment period was opened. Comments and suggestions regarding the review were received from botanical experts from Service field offices and state agencies within the known range. Comments received were evaluated and addressed, as appropriate (see Appendix A).

B. Reviewers

Lead Region: Kelly Bibb, Southeast Region, 404-679-7132

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C. Background

1. Federal Register Notice announcing initiation of this review

July 26, 2005. 70 FR 43171.

2. Species Status

Stable 2008 Recovery Data Call
No comprehensive rangewide surveys have been conducted for the species. Personnel from the Missouri Department of Conservation (MDC) periodically survey some of the 23 documented sites in Missouri, but this occurs irregularly. The species is considered stable in Missouri. In Arkansas, 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 an annual or semi-annual 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. The historic sites in Louisiana continue to persist and additional populations have also been found in the northwestern part of the State. Texas Parks and Wildlife Department (TPWD) personnel conducted surveys in 2004-2009 and found *Geocarpon* at one site in 2004 and two additional sites in 2009. They plan to continue surveying known and potential sites within Texas.

3. Recovery Achieved

4 (76-100% recovery objectives achieved)
Although the recovery achieved was listed as 2 (26-50% recovery objectives achieved) in the 2007 Recovery Data Call, information and data synthesized subsequently indicate that this ranking is not accurate regarding the current status of the species. A recovery achieved ranking of "4" is most appropriate at this time.

4. Listing History

a. Original Listing

FR notice: 52 FR 22930
Date listed: July 16, 1987
Entity listed: species
Classification: threatened

5. Review History

5-year review November 6, 1991 (56 FR 56882) - In this review, different species were simultaneously evaluated with no in-depth assessment of the five factors, threats, etc. as they pertained to the different species' recovery. In particular, no changes in status were proposed for this plant.

Final Recovery Plan – 1993
Recovery Data Call – 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, 1998

6. Species' Recovery Priority Number at start of review (48 FR 43098): 13. This number indicates *Geocarpon minimum* has a low degree of threat and high recovery potential.

7. Recovery Plan

Name of plan: Recovery Plan for *Geocarpon minimum* MacKenzie
Date issued: July 26, 1993

REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy:
Geocarpon minimum is a plant and, therefore, not covered by the DPS policy. The other DPS questions will not be addressed further in this review.

B. Recovery Criteria
1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes

3. List the recovery criteria and discuss how each has or has not been achieved?
The *Geocarpon minimum* recovery plan was approved in 1993.

The objective of this recovery plan is to delist *Geocarpon minimum*. Delisting can be considered when:

1. 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;

2. Populations include the wide spectrum of current genetic variation; and

3. Population viability is confirmed through periodic monitoring for at least a 15-year period.

A summary of achievement toward delisting criteria is presented here. First, a breakdown by State is provided of populations and their protective status.

Missouri

The MDC currently recognizes 22 extant naturally occurring *Geocarpon* populations and three plantings (Smith in litt. 2006a, 2006c) (Figure 1 and Table 1). The plantings on public lands were an attempt to establish protected populations using seed sources from nearby unprotected populations on private land. These populations remain and appear to be increasing (Smith 2008). The

one planting on private property was conducted by a private landowner wishing to expand *Geocarpon* to uninhabited suitable habitat near existing sites. All or a significant portion of the population at 11 of the 22 naturally occurring sites are protected on public lands or lands belonging to private conservation groups. The remaining 11 sites occur on private property and have no formal protective agreements.

Arkansas

The ANHC recognizes four *Geocarpon* populations containing 33 subpopulations (Osborne 2006 in litt.) (Figure 1 and Table 1). The site containing the largest known population (Warren Prairie) is owned and managed by the ANHC in cooperation with The Nature Conservancy (TNC). The ANHC recently purchased an additional 240 acres adjacent to these known sites that will provide a buffer and may contain suitable Geocarpon habitat (Witsell 2009). A population at the Kingsland Prairie site is owned and managed by TNC (TNC 2004, 2005). The two remaining populations are located on private property. One is owned by a large timber products company. The ANHC is currently working with this landowner to protect and manage the site as part of the company's Sustainable Forestry Initiative. The remaining population on private property is currently unmanaged for *Geocarpon* and the site has been used as a cattle pasture in the past. A total of 23 out of 33 subpopulations in Arkansas are on public land or land owned by a private conservation group.

Louisiana

The Louisiana Natural Heritage Program (LNHP) recognizes five *Geocarpon* populations (MacRoberts and MacRoberts 2007; Reid and Faulkner 2007; MacRoberts and MacRoberts 2008; Reid et al. 2008) (Figure 1 and Table 1). 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. The other three are owned by individuals or timber companies and currently have no protective agreements. Portions of these sites are heavily impacted by all terrain vehicle (ATV) traffic and use of dirt-moving equipment.

Texas

The TPWD recognizes three populations of *Geocarpon*. Two occur on private property, although one of these is within the acquisition boundary of the Neches River National Wildlife Refuge (Neal in litt. 2006; Singhurst in litt. 2009). There was recent unsuccessful litigation to prevent the establishment of this refuge in favor of impounding the river to provide water supplies (Singhurst in litt. 2009). Barring a successful appeal to the U.S. Supreme Court, the acquisition phase of the refuge should proceed in the near future. This site will be a priority for purchase if funding becomes available. The third site occurs mostly on private property but also extends into the Caddo Lake State Park.

Range-wide

This review indicates that *Geocarpon minimum* is very close to meeting all of the criteria required for delisting. Two of the criteria have been met. Although all populations are not officially protected, twenty populations representing both sandstone glades and saline prairies/barrens and at least one site from each state occur on protected properties. Many of the sites that are not officially protected appear to be stable and in no immediate danger of conversion.

Additionally, at least 15 viable (EO rank of C or higher; see Table 1 for explanation) protected populations have been monitored for a minimum of 15 years and as long as 48 years. On average, the protected populations (14 including planted sites) in Missouri have been monitored for a period of 16.2 years and have an EO rank ranging from "A" to "D" (A=4, B=2, C=6, D=2). It should be noted that two unprotected sites also have EO ranks of "A", indicating that they are large, vigorous populations with few threats. The only protected sites with ranks of "D" are those planted by the MDC. They were ranked low due to their small initial size and the uncertainty of long-term success. The protected populations in Arkansas (3) have been monitored for an average of 31.3 years and have an EO rank ranging from "A" to "AB", with some sub-populations ranking "C" (A=1, AB=2). The remaining unprotected population ranks "AB". In Louisiana the two officially protected sites have been monitored for an average 16.5 years and have ranks of "BC" and "B". The remaining sites in Louisiana and all sites in Texas are recently discovered, have only been monitored for several years, and have not been assigned EO ranks. However, researchers note that several of these new populations appear to be vigorous.

Although criteria 1 and 3 have been met, criteria 2 dictates that we gather information regarding the genetic variability of geographically isolated populations and populations that occur in differing habitats (sandstone glades vs. saline prairies/barrens). Currently, no investigators have addressed this deficiency. Researchers at the Missouri Botanical Gardens (MBG) have begun the process of extracting DNA and developing protocols for genetic analysis using existing material in their collection (Albrecht in litt. 2009). They recently submitted proposals to the Service to gather material from throughout the range for the purpose of determining genetic variability among populations. Such work will be necessary to fulfill delisting criterion 2 and move towards delisting of this species. If the genetic variability studies are undertaken and show that criteria 2 has been met, we could move forward on a possible delisting proposed rule quickly. Any formal rulemaking process would include an opportunity for public review and comment.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Spatial distribution, abundance and population trends

Once widespread in North America, *Geocarpon* is now considered a relict species with a reduced distribution due to changes in climate and habitat (Rabeler and Hartman 2005). At the time of the recovery plan publishing, 27 *Geocarpon* populations (many with subpopulations) were known to occur within 12 counties/parishes in three states (USFWS 1993). Populations are currently documented to occur at a total of 37 sites (including three plantings in Missouri) within 17 counties in four states (Osborne in litt. 2005; Smith in litt. 2006a, 2006c; Reid in litt. 2009; Singhurst in litt. 2009). 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 latter habitats are often referred to as "saline prairies" or "barrens".

The number and location of subpopulations and individual plants within each population varies widely between years due to variations in winter and spring rainfall as well as competition with native and/or invasive plants (McInnis and Large 1997; Witsell 2004a; Singhurst in litt. 2006). Some sites have no plants during dry years and may contain hundreds or thousands of individuals during wetter years. Some subpopulations have disappeared over the years apparently due to succession of lichens, non-native grasses, and other salt tolerant plants into slick spots (Witsell 2004a). Previously unknown subpopulations within known populations have also been noted. Population changes associated with weather tend to be dramatic and temporary while those associated with succession of competitors tend to occur at a slower rate and may be more permanent (Witsell 2004a; Smith and Ely 2007). 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 2004a), and anthropogenic changes in microhydrology (TNC 2004; Witsell pers. comm.. 2006).

b. Demographic characteristics

Geocarpon is an annual that is 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 (Witsell 2004a). This is attributed by some researchers to a lack of slick spot or sandstone glade disturbance by fire, large mammals, or other erosive forces (Thurman and Hickey 1990; Logan 1998; TNC 2002; Witsell 2002, 2003, 2004a). The amount of disturbance required to maintain suitable *Geocarpon* habitat without negatively impacting the long-term viability of populations is unclear.

c. Taxonomy and Genetics

Geocarpon MacKenzie is a monotypic genus originally described by K.K. MacKenzie (1914). It is placed in the family Caryophyllaceae (USFWS 1993). Currently no studies describe the genetic variability among geographically isolated populations and populations that occur in differing habitats (sandstone glades vs. saline prairies/barrens). Researchers at the Missouri Botanical Gardens have begun the process of extracting DNA and developing protocols for genetic analysis using existing material in their collection (Albrecht in litt. 2009). Additional tissue samples and analysis are needed to characterize the genetic variability among distinct populations.

d. Habitat

The range of *Geocarpon* has been extended into northwestern Louisiana and eastern Texas and the habitat at these sites appears similar to that described in the recovery plan for known sites in Arkansas and northcentral Louisiana. All populations outside Missouri are associated with “slick spots” within saline soil prairies (Keith *et al*. 2004; Reid in litt. 2006; Singhurst in litt. 2009). In Missouri sandstone glades it colonizes shallow depressions within rocks that provide poor habitat for most other herbaceous species (USFWS 1993, Smith and Ely 2006). No populations have been found in sandstone glades outside of Missouri (Witsell 2002).

2. Five Factor Analysis

a. Present or threatened destruction, modification or curtailment of its habitat or range:

No new habitat related threats have been identified since the 1991 5-year review and publication of the recovery plan. Specific threats to habitats for known populations are detailed in Table 1. The primary threat continues to be soil development on suitable sites within saline prairies (slick spots) and sandstone glades (shallow sandy soils) (Logan 1998; Witsell 2004a; Smith and Ely 2006). *Geocarpon* thrives in these harsh conditions that exclude competing plant species. Accumulation of more suitable soils quickly leads to an invasion of other plants that shade *Geocarpon*. Such soil development may be facilitated by lack of disturbances such as fire and use by large mammals (Witsell 2004a; Smith and Ely 2006).

Excessive soil development and subsequent colonization by competitive plants may also occur when excessive soil movement occurs due to dense cattle use, ATV use, or other factors. Movement of dirt can also alter the microhydrology of sites which may lead to localized extirpation of subpopulations (TNC 2004; Witsell pers. comm. 2006). Although ATV and other off-road vehicle damage has been cited at some sites (TNC 2004; Reid in litt. 2006), some authors have suggested that limited erosion from ATV traffic or other anthropogenic disturbances may play a role in maintaining slick spots that are otherwise susceptible to rapid succession (TNC 2004; Witsell 2004a; Smith pers. comm. 2006). Witsell (2003) suggested that due to intensive grazing by cattle the one *Geocarpon* population in the Arkansas River Valley was able to thrive among grasses that would normally outcompete it. When cattle were removed from the site *Geocarpon* was restricted to areas only along the margins of the remaining slicks.

The current understanding of the role of disturbance in maintenance of *Geocarpon* populations is contradictory. It is likely that some level of disturbance is required to maintain the required microhabitat. It is also likely that intensive use by livestock or off road vehicles may be detrimental. The impact of such activities may be better assessed on a case-by-case basis depending on the amount of natural disturbance at the site.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Taking for these purposes could pose a risk to *Geocarpon* due to the ease of access at many sites and its desirability due to its taxonomic uniqueness (monotypic genus). However, at this time there is no indication that this is a likely threat.

c. Disease or predation:

There is no evidence to suggest that this factor is a threat.

d. Inadequacy of existing regulatory mechanisms:

Thirteen of the 25 known populations in the Ozark and Osage Plains region of Missouri are partially or fully owned by the MDC, U.S. Army Corps of Engineers (USCOE), Missouri Department of Transportation (MODOT), or private conservation organizations. The two largest populations in the West Gulf Coastal Plain of Arkansas are owned by the ANHC and TNC. Another population in this region is owned by a large timber products company. They have consulted with the ANHC to develop protective measures and consider the location of the population a "unique site" (Witsell pers. comm. 2006). The other population in Arkansas is on private property within the Arkansas River Valley and is used as a cattle pasture. Two of the Louisiana populations are owned by a timber products company. The owners have worked with the LNHP to develop protective measures and have registered the sites as natural areas. The remaining 3 populations were only recently discovered on private lands in the northwestern section of the State near the Texas border. One of these populations occurs in an area with heavy ATV and dirt moving activities (MacRoberts and MacRoberts 2007). The 3 populations in Texas occur mostly on private land, although one site is within the acquisition boundary of a proposed national wildlife refuge and is currently under management by the owner to limit impacts from off-road vehicles and silvicultural activities. Another site occurs partially on Caddo Lake State Park.

None of the inhabited states have laws that protect *Geocarpon* habitat within private property. A permit is required for individuals wishing to survey or collect *Geocarpon* or modify habitat within Federal or State lands. Enforcement of these regulations is difficult, but there are no indications that illegal activities have occurred at any of these sites. The listing of *Geocarpon* as threatened provides some protection through section 7 (requires interagency consultation on federally funded or permitted activities) and section 9 (prohibits removal and reduction to

possession from federal lands and restricts interstate commercial activity) of the ESA.

e. Other natural or manmade factors affecting its continued existence:

Geocarpon is vulnerable to local extirpations because it occurs in isolated populations and depends on the presence of specific microhabitats in order to compete with other plants. Although extirpations of subpopulations due to encroachment of other vegetation have been observed (Witsell 2004), no known populations have disappeared due to this factor. Loss of microhabitats such as thin soils within sandstone glades and the margins of slick spots within saline prairies appear to be the biggest threat to the long-term survival of *Geocarpon*. The presence of natural disturbances such as fire, movement of sheet water, and periodic use by large mammals may play a key factor in the maintenance of these microhabitats (Smith and Ely 2006; Witsell pers. comm. 2006). Fire suppression, alteration of microhydrology, and extirpation of large mammals such as elk and bison may result in the long-term loss of microhabitats that support *Geocarpon*. Active management even within protected sites may be necessary to ensure the long-term viability of this species.

3. Conservation Measures

In 1997, the MDC and the Service worked with the MODOT to develop a plan for the relocation of a *Geocarpon* population in the path of a proposed highway expansion project (Smith and Gardner 1999). In the late summers of 1997-1999, researchers removed sandy soil containing seeds from the impacted site to a total of nine protected glade sites on the opposite side of the road. Soil was disturbed at each site in an attempt to allow the development of suitable microhabitat. All of the plots, including the source location, continue to support *Geocarpon* (MDC 2005, Smith in litt. 2008).

In 2003 and 2004, the MDC removed soil from a *Geocarpon* population on private property and placed it within plots in the nearby Bluff Springs Conservation Area in Cedar County (MDC 2005). *Geocarpon* has been observed in all of four plots, although not all in the same year. The population has ranged from a high of 135 plants in 2008 to a low of 3 plants in 2006 (Smith in litt. 2008). The low numbers in 2006 were likely due to dry weather. In 2005, soil from a site on private property in Greene County was moved to suitable habitat at the nearby Bois D'Arc Conservation Area. A survey of this site in March of 2006 revealed 72 plants (Smith in litt. 2006c). The purpose of these projects was to establish protected populations on public property. No eminent threat was noted at either of the seed sources.

In 2005, the MDC initiated a survey funded through section 6 of the ESA of *Geocarpon* throughout the assumed range in Missouri (MDC 2005). Searchers

visited 28 known and potential sites and observed 20 populations, including one new subpopulation of 200 plants.

MDC monitored permanent plots established at Flint Hill Glades in Dade County from 1994-2003 (MDC 2005). These plots were monitored in an attempt to assess the role that succession and competition plays in the distribution and success of *Geocarpon* and to better define the distribution of the plant in relation to soil depth (Smith and Ely 2006). This study revealed that plants were found in shallow sandy soil (mean of 19 mm) and increased in density as depth increased to about 20 mm with declines thereafter. An examination of bare rock distribution in the glade revealed that the distribution of shallow soils moved dynamically within the glade due to water transport. Researchers observed a negative association between cryptograms (combined category including bryophytes and lichens) and *Geocarpon* numbers. This suggests the possibility that these plants and lichens may depress *Geocarpon* numbers in sandstone glades. However, the population of *Geocarpon* within the glade was highly variable and may have been more affected by weather patterns and the shifting distribution of shallow sandy soils. The last year of surveying revealed a larger population of plants than observed in any of the previous nine years.

The ANHC monitors most known *Geocarpon* sites and searches for new sites in areas containing appropriate habitat and associate plant species (Logan 1998; Witsell 2002, 2003, 2004a). Warren Prairie Natural Area contains the largest population in Arkansas. Long-term monitoring has taken place at this site since 1986 and permanent nested plots were identified in 1995 and are typically monitored on an annual basis. This monitoring has been an important aid to begin understanding the plant succession and disturbance factors that influence the distribution and success of *Geocarpon*. Based on observations at this site, researchers currently theorize that some level of disturbance is necessary to maintain optimum habitat along the edge of slick spots (Witsell 2004a). Some of the subpopulations noted in the 1980s are now dominated by lichens, bryophytes, and other competitive plants.

TNC owns and manages Kingsland Prairie in Cleveland County, Arkansas. They developed a conservation plan for the area and using funding from the Service's endangered species Private Stewardship Grants have begun to implement conservation measures including monitoring of permanent *Geocarpon* plots, establishment of fire management, use of timber management to restore historic plant communities, and removal of invasive/exotic herbaceous and woody plants (Fox in litt. 2005). They are also in negotiations with several bordering private landowners to purchase property with prairie soils that may contain additional *Geocarpon* populations.

The populations in Winn Parish, Louisiana are owned by a private timber products company. The LNHP has worked with the company to monitor and protect the sites. The saline prairies that include the populations are now

registered natural areas with the heritage program (Reid in litt. 2006). LNHP has been less successful in securing protective agreements with a small landowner who owns the recently discovered population in Caddo Parish. However, several nearby landowners at sites in DeSoto Parish have expressed interest in conserving prairie habitats on their property. Researchers are hopeful that future surveys will reveal additional *Geocarpon* populations in suitable habitat within nearby Parishes as well.

The *Geocarpon* population in Anderson County, Texas is on property owned by a private timber products company. Botanists from the TPWD have cooperated with the company to monitor and protect the site (Singhurst in litt. 2006). Although no formal agreements are in place, the company considers the area a unique conservation site and has taken steps to exclude the primary threat which was overuse by ATVs. Additionally, the site is within the acquisition boundary of the recently approved Neches River National Wildlife Refuge (Neal in litt. 2006). It is considered an ideal tract for purchase contingent on funding availability and the willingness of the landowner. In spring 2007, researchers discovered two new populations in Harrison and Panola counties near the newly discovered population in Caddo and DeSoto Parishes, Louisiana (Singhurst in litt. 2009). Researchers in Texas have expressed interest in partnering with Louisiana to submit grants to fund the purchase of these sites. They are also hopeful that future surveys will document additional populations in nearby counties containing similar habitats as identified by aerial photography.

3. Synthesis

When the recovery plan was published for *Geocarpon minimum* in 1993, 27 populations (many with subpopulations) were known within 12 counties in three states. Today, 37 populations (including 3 plantings in Missouri) are recognized within 17 counties in four states. Twenty of the 37 populations are at least partially on public land, owned by private conservation groups such as TNC, or are recognized in a private conservation plan. The remaining 14 sites are not protected by any official measures. The status of sites on private land ranges from stable with no immediate threats to degraded sites impacted by off-road traffic, livestock, and silvicultural activities (Table 1). However, many sites on private land appear to be stable and some may even depend on occasional disturbance from off-road use and cattle grazing to maintain suitable habitats (Witsell 2004a; Smith pers. comm. 2006). The status of the species is variable even in protected areas. Many subpopulations that were noted in the 1980s have succumbed to competition with competitive native or invasive plant species. The number of individual plants in a population varies widely on an annual basis due largely to the amount of spring and winter rainfall.

Both government and privately funded monitoring programs of varying intensity and scope are in place in all states where *Geocarpon* occurs. Most of these efforts

are focused on documenting occurrence and density. Some efforts in Missouri, Arkansas, and Louisiana have focused on establishing permanent survey plots to identify the role of vegetative succession and disturbance on the distribution, movement, and success of *Geocarpon* populations. Preliminary hypotheses indicate that some level of disturbance in the form of fire or erosion is necessary to maintain the thin and/or highly saline soils where *Geocarpon* thrives and to suppress competitive plant growth. There is some contradiction regarding the role of erosion in maintenance of populations. Grazing and trampling by cattle has been listed as both a negative impact and a mechanism for maintenance of slick spots. Excessive erosion from off -road vehicle use has been cited as a risk to several populations. It is likely that too much disturbance can physically destroy the plants or result in soil development that supports competitive plant species. However, some periodic disturbance within saline prairies, such as that resulting from large mammal use for grazing and mineral licks, may be necessary to maintain the slick spots within the prairie.

Although several new populations have been discovered since 1993, the delisting criteria required for *Geocarpon* have yet to be fully accomplished. The recovery plan states that 15 populations representing the full geographic and genetic variability should be protected and that population viability at these sites should be demonstrated by 15 years of monitoring. Although monitoring throughout the geographic range indicates that the species appears viable throughout its range, currently there is little understanding of the genetic variability of the species. At this time *Geocarpon minimum* should remain listed as threatened and efforts to accomplish the delisting criteria regarding genetics should continue.

III. RESULTS

A. Recommended Classification:

Geocarpon should remain listed as threatened. No change in status is recommended.

Also, no change in Recovery Priority Number is recommended at this time. The degree of threat to *Geocarpon* is low because about half of the known populations, including many with the largest populations, are protected by public ownership or private protective agreements. The recovery potential is high despite the fact that its biology and ecology are not fully understood. Researchers have identified the preferred microhabitats at known locations and the species appears to thrive in such sites. There are active efforts to determine what actions may be necessary to maintain these microhabitats. Preliminary results indicate that a light level of disturbance may be important for maintenance of thin, sandy soils characteristic of the sandstone glade sites in Missouri and the slick spots within saline prairies elsewhere in the range. Work conducted by the MDC has

shown that relocation and augmentation of threatened populations is possible without intensive effort.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Seek funding to complete an investigation into the genetic variability of *Geocarpon* throughout the range, including the newly discovered populations in Texas and Louisiana.

2. Continue to investigate the role of disturbance in the distribution and success of *Geocarpon* in sandstone glades and saline prairies.

3. Initiate studies to determine the mode of seed dispersal. Promising theories include movement by water, insects, and large mammals.

4. 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.

5. Continue to monitor known sites.

6. Work cooperatively with landowners to conserve privately owned sites through fee title or easement purchases or development of management agreements.

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All references and documents pertaining to this five year review can be obtained from the U. S. Fish and Wildlife Service's Arkansas Ecological Services Field Office.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Geocarpon minimum (no common name)

Current Classification _Threatened__

Recommendation resulting from the 5-Year Review

_ X __ **No change is needed**

Review Conducted By _Jason W. Phillips, U.S. Fish and Wildlife Service Arkansas Field Office, Delta Suboffice

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date _____

Cooperating Field Supervisor, Fish and Wildlife Service

Missouri Field Office

Approve _____ Date 6/30/09

Louisiana Field Office

Approve _____ Date 5/19/09

Arlington, Texas Field Office

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service, *Acting*
Southeast Region

Approve _____ Date 5-11-09

Cooperating Regional Director, Fish and Wildlife Service

Southwest Region

Approve_____ _____ _____ _____Date_____ _____

Cooperating Assistant Regional Director, ES, Fish and Wildlife Service

Midwest Region

Approve _____ _____ Date 7/1/09

Acting ARD

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Geocarpon minimum (no common name)

Current Classification Threatened

Recommendation resulting from the 5-Year Review

X **No change is needed**

Review Conducted By Jason W. Phillips, U.S. Fish and Wildlife Service Arkansas Field Office, Delta Suboffice

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 5 19 09

Cooperating Field Supervisor, Fish and Wildlife Service

Missouri Field Office

Approve _____ Date _____

Louisiana Field Office

Approve _____ Date 5/19/09

Arlington, Texas Field Office

Approve _____ Date 6/12/09

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service, Acting
Southeast Region

Approve _____ Date 5-11-09

Cooperating Regional Director, Fish and Wildlife Service

Southwest Region

Approve_____ Date 6/30/09

Cooperating Regional Director, Fish and Wildlife Service

Great Lakes – Big Rivers Region

Approve_____ Date_____

Appendix A

Summary of peer review for the 5-year review of *Geocarpon minimum*

A. Peer Review Method: The Service conducted peer review. We selected one reviewer from each state within the range (Arkansas, Missouri, Louisiana, and Texas). These four individuals represented state agencies with responsibilities for the management and/or monitoring of *Geocarpon*. Two state representatives responded with comments on the completed draft, although representatives from other states provided input and data during the early development of the review. We also requested comments from Service biologists assigned to field offices within each state. Two Service Field Offices responded with comments on the draft.

B. Peer Review Charge: Reviewers were asked to provide comments on the draft as they pertained to *Geocarpon* in both their respective state and range wide.

C. Summary of Peer Review Comments/Reports: Our response to each reviewer comment is provided in parenthesis.

Tim E. Smith
Botanist
Missouri Department of Conservation

This looks good overall. I think you have accurately represented the current status and I support no change in federal status at this time.

A couple of minor changes/updates re. MO sites:

Page 6 - The Bois D'Arc MO site was visited on 2006-03-29 and 72 plants were observed.

Page 20 – 2nd paragraph – Geocarpon has been observed at all 4 of the relocation plots, although not all in the same year. The total no. of plants in the four plots declined to 3 in the spring of 2006, but drought conditions may have limited plant nos. Also, the Bois D'Arc site in the same paragraph should be updated to reflect current information given above. (The new data was incorporated into the report.)

Omar Bocanegra
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Arlington, Texas Field Office

I briefly looked over the draft 5-year review for Geocarpon minimum from R4. As far as I can tell, your information on the Texas population looks correct. There are a couple of places (page 10-11) where "Neches NWR" should be changed to "Neches River NWR." Also, since there are four ES offices in Texas, references to the "Texas Field Office" should be changed to "Arlington, Texas Field Office." Let me know if you need anything else. (We incorporated the recommended changes into the report.)

Deborah Fuller
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Louisiana Field Office

Brigette Firmin and I have reviewed the draft geocarpon minimum 5-yr review. We are not aware of any information for this species in addition to that discussed in the draft review. In addition, we believe the species data (including status) for Louisiana are accurately presented in this report. Thanks for the opportunity to review this and please call or email me or Brigette should you have any questions. (No changes were recommended.)

Jason Singhurst
Botanist/Plant Community Ecologist
Science, Research and Diversity Program
Texas Parks and Wildlife Department

I apologize that I am several days late with my review. My wife and I got back from a two week vacation on Sunday and I am just now catching up. I went through the whole document this afternoon and it reads very clean. I could not locate any major changes that needed attending. You have correctly interpreted the information from Texas, that is what little we know about the taxa. I will be working with Chris Reid this spring to survey some of the Caddo and De Soto Parish sites in Louisiana in exchange for having Chris assist me on some potential areas in Harrison and Panola Counties. I will send you a summary of any finding that we come across. (No changes were recommended.)

D. Response to Peer Review: Each comment provided by reviewers was taken into consideration when revising the draft.

Figure 1. County/Parish distribution of *Geocarpon minimum*

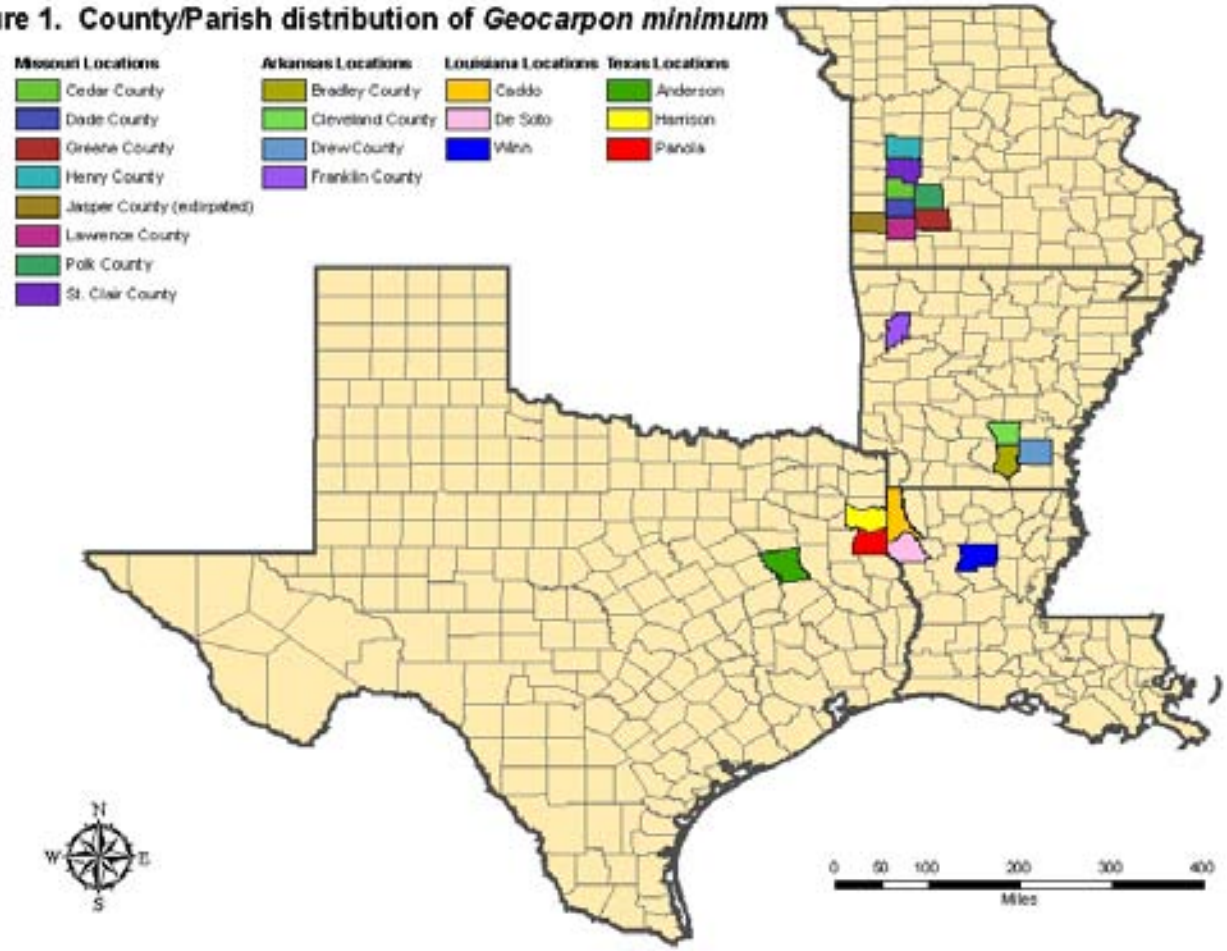

Table 1. Site records of *Geocarpon minimum*

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 2008 135 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. Last count was highest on record likely due to wet spring conditions. 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 2005 2,800 plants	USCOE / Widely distributed throughout the northern and western portions of the area. EO rank = C
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 2005 5,500 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. EO rank = A
Dade	Maze Creek / Bona	Ozark	First observed in 1988 Last observed in April 2005 1,010 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.
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 2005 600 plants	USCOE / Plants scattered throughout four subpopulations around east arm and west side of lake. EO rank = A

Greene	Bois D'Arc CA/ Ash Grove	Ozark	First and last observed in March 2006 72 plants	MDC / In October 2005 soil containing viable seeds was removed from Pearl Glade and placed within six sandstone outcroppings. 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 2005 2,360 plants	Missouri Department of Transportation (MODOT) / Plants observed throughout western portion of glade including in roadcut and ATV trail. This site was recently 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. EO rank = C
St. Clair	Schwarz Prairie / Roscoe	Ozark	First observed in 1990 Last observed in April 2005 300-500 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 2005 500-1,000 plants	MDC & Private / Approximately half of population occurs on Natural Area. Remainder is on unprotected private property. 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 Last observed in 2006 1,548 plants (2003)	ANHC / Most subpopulations observed casually in 2006. In 2003 plants were counted from the "north" and "south" monitoring grids. Numbers were less than in 2001 but much higher than those documented in 1999. This follows the pattern of high annual variation in populations. The biggest threat at the site is lack of disturbance and associated vegetation succession. The ANHC has lumped subpopulations that occur within contiguous habitat. Each of these "groups" was given an EO rank. There are four groups at Warren Prairie with ranks of A, C, C, and B.
Cleveland	Kingsland Prairie / New Edinburg	West Gulf Coastal Plain	First observed in 1982 Last observed in 2006 962 plants (2005)	TNC and private / All known plants occur on TNC-owned portion of prairie. Only casually observed in 2006. In 2005 plants were counted in three permanent plots. Researchers estimate that a minimum of 1,000 plants and up to 5,000 plants are present in entire prairie complex. Past silvecultural practices (bedding for trees and road building) have altered the microhydrology in portions of the site. This has reduced the suitability for *Geocarpon* in part of the prairie. The subpopulations at Kingsland Prairie are lumped into two groups. One group is extirpated due to dramatic habitat alteration from silvecultural activities and the other group has an EO rank of AB.

Cleveland	New Edinburg Prairie / New Edinburg	West Gulf Coastal Plain	First observed in 1984 Last observed in 2006 300+ plants	Private / Recognized by owner as "unique site" and managed to avoid impacts. Surveys in the late 1980s and 1990s revealed no plants. Recent observations in 2004 were first since 1984. Subpopulations here are lumped into two groups. One group has suitable habitat but no plants and the other has an EO rank of AB.
Franklin	Branch Site / Branch	Arkansas River Valley	Firsts observed in 1986 Last observed in March 2002 650 plants	Private / Used as a cattle pasture. Plants occurred in six patches within three slicks. Heavy grazing at this site aided in the maintenance of suitable habitat and reduced competition from grasses during the previous year (1,167 plants observed). Removal of grazing led to a decrease in slick size and number of plants. Only one population occurs at this site and it has an EO rank of AB.
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 2007 90 plants	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 2007 100 plants	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 2007 29 plants	Private / Heavy impacts from ATV use and dirt moving activities. Landowner has shown little interest in modifying these activities. EO rank = unknown
De Soto	Rambin Bayou Saline Prairie / Holly	West Gulf Coastal Plain	First and last observed in March 2007 271 plants	Private / Some rutting from vehicle and ATV use but otherwise in good condition. No special protection by landowner. EO rank = unknown
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 = unknown
DeSoto	Dickson Prairie / Stonewall	West Gulf Coastal Plain	First and last observed in 2007 782 plants	Private / Characterized as the “best quality” saline prairie (similar to Castor Creek) surveyed. No special protection in place. EO rank = unknown
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 = unknown

Harrison	Bayou Saline Prairie / Karnack	West Gulf Coastal Plain	First and last observed in 2009 1806 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 = unknown
Panola	Horton Saline Prairie / Currently Undisclosed	West Gulf Coastal Plain	First and last observed in 2009 73 plants	Private / No special protection in place. EO rank = unknown

***** 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 (Butler in litt. 2006; Osborne in litt. 2006; Reid in litt. 2006; Reid in litt. 2009; Singhurst in litt. 2006; Singhurst in litt. 2009).