# Lloyd’s Mariposa Cactus
# *Sclerocactus mariposensis* (Hester) N.P. Taylor

## 5-Year Review:
## Summary and Evaluation

**U.S. Fish and Wildlife Service**
**Austin Ecological Services Field Office**
**Austin, Texas**

# 5-YEAR REVIEW
## Lloyd's mariposa cactus / *Sclerocactus mariposensis* (Hester) N.P. Taylor

## 1.0 GENERAL INFORMATION.

### 1.1 Reviewers.

Lead Regional Office: Southwest (Region 2).
Jennifer Smith-Castro, Regional Recovery Biologist, (281) 286-8282 x 234.

Lead Field Office: Austin Ecological Services Field Office.
Chris Best, Texas State Botanist, Austin Ecological Service Field Office.
(512) 490-0057 x 225.

Cooperating Field Office: n/a

### 1.2 Methodology used to complete the review:

This review considers both new and previously existing information from Federal and State agencies, non-governmental organizations, academia, and the general public. Information used in the preparation of the review include the Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (TXNDD), final reports of Section 6-funded projects, monitoring reports, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and Internet web sites. The 5-year review was prepared without peer review by personnel of the Austin Ecological Services Field Office.

### 1.3 Background:

U.S. Fish and Wildlife Service (USFWS) listed Lloyd's mariposa cactus as threatened without critical habitat on November 6, 1979. The State of Texas listed Lloyd's mariposa cactus as threatened on April 29, 1983. The Mexican federal government listed the species as threatened (Secretaría de Medio Ambiente y Recursos Naturales 2010, p. 56).

The first use of technical terms and words with arcane meanings in the lexicons of science and government are underlined, and are defined in the glossary on pages 35-40. For convenience, the first uses of scientific units are spelled out, and are also summarized on page 34. Photographic credits are on page 34. This is the first status review since the species was listed (1979) and the recovery plan was prepared (1989). For convenience, we include brief summaries under each topic of the information known at that time.

Recommended citation:

U.S. Fish and Wildlife Service. 2018. Lloyd's mariposa cactus (*Sclerocactus mariposensis* (Hester) N.P. Taylor) five-year review: Summary and evaluation. Austin Ecological Services Field Office, Austin, Texas. 41 pp.

**1.3.1 FR Notice citation announcing initiation of this review:** February 11, 2009 (74 FR 6917) and May 31, 2018 (83 FR 25034).

**1.3.2 Listing history.**

Original Listing.

Federal Register notice: 44 FR 64247.
Date listed: November 6, 1979.
Entities listed: *Neolloydia mariposensis* (Lloyd's mariposa cactus).
Classification: Threatened; Critical Habitat was not designated.
Critical Habitat Designation: n/a.

**1.3.3 Associated rulemakings**: n/a

**1.3.4. Review History.**

No previous 5-year review has been conducted for Lloyd's mariposa cactus. Other review documents include:

Status Report on *Neolloydia mariposensis* (Weniger 1979).

**1.3.5 Species' Recovery Priority Number at start of 5-year review:**

Prior to this review, the Recovery Priority Number for Lloyd's mariposa cactus was 2. This indicates that the threat level was high, the recovery potential was high, the taxon was a species, and no conflicts with construction, development projects, or other forms of economic activity were foreseen.

**1.3.6 Recovery Plan or Outline.**

Name of plan or outline: Lloyd's mariposa cactus (*Neolloydia mariposensis*) Recovery Plan.
Date issued: April 13, 1990.
Dates of previous revisions, if applicable: n/a

## 2.0 REVIEW ANALYSIS.

### 2.1 Application of the 1996 Distinct Population Segment (DPS) policy.

The Distinct Population Segment policy applies only to vertebrate animals.

### 2.2 Recovery Criteria.

#### 2.2.1 Does this species have a final, approved recovery plan?

Yes.

#### 2.2.1.1 Does the recovery plan contain objective, measurable criteria?

Yes.

#### 2.2.2 Adequacy of recovery criteria.

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

The recovery criteria should be revised, as discussed in Sections 2.2.3 and 2.3.1.3, in accordance with the revised recovery planning guidance (USFWS 2017a).

#### 2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

Recovery Plan Criteria

> *The criteria for delisting the Lloyd's Mariposa cactus will be to identify at least three sites where the species can be protected and then carry out protective management measures. One site should be on private land in northeastern Brewster County, one site should be in Big Bend National Park, and one site should be in Mexico. Each site should initially contain at least 1,000 plants, and should have enough available habitat to permit population expansion and growth. The species can be delisted when monitoring and habitat surveys indicate that a total of at least 20,000 plants is being sustained at the protected and managed sites.*

Section II. (p. 13) of the recovery plan describes "primary actions", also referred to as criteria (p.14) in greater detail:

1. *Develop and implement management measures that will ensure the continued protection of at least three sites where populations occur. The three sites should represent the full geographic range of the species with one site in northeastern Brewster County on private land, one site in Big Bend National Park, and one site in Mexico. Each site should initially contain at least 1,000 plants, and should have adequate suitable habitat to permit population expansion and growth.*

2. *Develop and implement cooperative law enforcement strategies to provide protection against illegal collecting both on public and on private lands.*
3. *Search potential habitat and accurately determine population locations, area occupied, and number of plants.*
4. *Establish permanent monitoring plots to determine population changes. The plots should be censused at least annually.*

*Actions necessary for delisting include:*

1. *Identifying at least three sites (using the criteria on the previous page) where the species will be protected.*
2. *Carrying out management measures that are determined to be necessary for continued protection of the three sites and for the general protection of the species and its habitat.*
3. *Demonstrating long—term stability or increase in population levels and habitat through monitoring and habitat surveys. A total of 20,000 plants at protected and managed sites must be sustained. This figure is higher than might otherwise be needed because of the degree of collecting threat to this species.*

*These criteria will be evaluated for adequacy upon attainment and prior to delisting.*

Discussion

Heil *et al*. (1985, p. 27) estimated that the population at Big Bend National Park could exceed 100,000, but this estimate was not based on censuses or representative samples. A census conducted by personnel of Big Bend National Park in 2005 documented 1,084 individuals, and Schmidt (2017, p. 23) found 10 new individuals in March 2017. Similarly, McKinney (1998, p.14) estimated the size of a single population at Black Gap Wildlife Management Area (BGWMA) at 10,000 individuals, although actual counts had only been conducted on two plots totaling 168 mature individuals. Nevertheless, it is likely that populations at both of these protected sites have reached the criterion of 1,000 individuals. We have no information on the sizes or protected status of populations in Coahuila.

The following factors should be taken into consideration regarding these recovery criteria:

1. The recovery plan does not state whether the criterion of 1,000 individuals per protected site and 20,000 total individuals refers to all individuals or mature individuals of reproductive age. This is an important distinction, because the mortality of Lloyd's mariposa cactus juveniles (and juvenile plants in general) is extremely high and the numbers present during censuses varies greatly, depending on recent weather patterns (see discussion in Section 2.3.1.3).

2. The provisional estimate of minimum viable population size (also in Section 2.3.2.3) is from 1,500 to 2,000 mature individuals. The criterion of 1,000 individuals per population in the current recovery plan may be too low; for the same reason, the total of 20,000 total individuals at 3 sites may be too high.

3. It is unlikely that a total count can be made of individuals widely scattered across rugged habitats of the Chihuahuan Desert. Population sizes can be estimated from samples, but this is challenging due to the patchy distribution pattern of Lloyd's mariposa cactus—a common

characteristic of rare plant populations. To demonstrate fulfillment of population-based recovery criteria, scientifically valid, repeatable sampling and statistical methods must be used.

4. The recovery plan states that the criterion of 20,000 total individuals must be sustained, but does not state for how long. The monitoring period should be long enough to detect trends through multiple lifespans and climatic cycles.

5. If systematic botanists concur that the Coahuilan population is a different species, these populations cannot be used to meet recovery criteria.

## 2.3 Updated Information and Current Species Status

### 2.3.1 Biology and Habitat

#### 2.3.1.1 Description, taxonomic classification and phylogenetics:

Summary of prior information.

Lloyd's mariposa cactus was first collected and described as *Echinomastus mariposensis* by Hester (1940, pp. 59-60), who collected the type specimens on a limestone mountain southeast of the abandoned Mariposa silver mine, at an elevation of 1,036 meters (m) (3,400 feet (ft)). The species epithet derives from the type locality (Heil *et al*. 1985, p. 26). Table 1 lists its distinguishing features. Benson (1969) assigned the species to the genus *Neolloydia*. Glass and Foster (1975, pp. 219, 221, 222) returned the species to *Echinomastus*. Weniger (1979) opted for *Echinocactus*, but that hasn't caught on with any other taxonomists. Anderson's revision of *Neolloydia* concurred with Glass and Foster (Anderson 1986, pp. 3-4). Noting that specimens from Cuatrociénegas and Cuesta de la Muralla, Coahuila, were larger, Glass and Foster speculated that they might represent a distinct variety.

Table 1. Distinguishing features of Lloyd's mariposa cactus (Hester 1945, pp. 59-60; Glass and Foster 1975, p. 222; Heil *et al*. 1985, p. 26; USFWS 1989, pp. 2-3; Poole *et al*. 2007; Powell *et al*. 2008, pp. 258-260).

| Feature | Description |
|---|---|
| Stems | Typically solitary or occasionally branched, blue-green, ovoid to ovoid-cylindroid, to 10 centimeters (cm) (3.9 inches (in)) tall and 6 cm (2.4 in) diameter. |
| Ribs | About 21, divided into short tubercles. |
| Tubercles | 6 millimeters (mm) long. |
| Areoles | Elliptic, elongated into a groove, 3 mm long, with short wool. |
| Central spines | 4-7 per areole, white, gray, or pale yellow, tips light brown or chalky-blue; upper 3-6 are 1.3-2 cm long, directed upward; lower 0.5-1.3 cm, directed outward or downward. |
| Radial spines | 25-36 per areole, white to gray or tipped with light brown, 0.5-1.1 cm long, stiff, straight, and acicular, appressed to and obscuring the stem. |
| Flowers | 2-4 cm long and broad; white or pinkish fading to white, inner perianth |

| Feature | Description |
|---|---|
| | pink, outer perianth with green to purplish mid-rib; styles pale green, 1.5 cm long, with greenish-yellow stigma; filaments grayish white, anthers minute, pale cream. |
| Fruit | Up to 1.0 cm long by 8 mm wide, globose or oblong, yellowish green with whitish scales and persistent perianth. |
| Seeds | 1.8 by 1.2 by 1.0 mm, ovate, black, minutely tuberculate. |

New information.

Chloroplast DNA is often used to study plant phylogenies because, like mitochondria, chloroplasts are maternally inherited and their DNA is not affected by sexual reproduction; changes in chloroplast DNA are due only to mutations and can be used to reconstruct the evolutionary history of taxa. Porter and Prince (2011, pp. 11-18) constructed a molecular phylogeny of a narrowly defined *Sclerocactus* and related taxa based on chloroplast DNA sequences using data from five independent investigations (Porter *et al*. 2000; Butterworth *et al*. 2002; Crozier 2005; Hernandez *et al*. 2011; and Butterworth and Porter (in prep.). Although these studies examined different regions of chloroplast DNA, the results were completely congruent: *Ancistrocactus*, *Echinomastus*, and *Toumeya*, but not *Glandulicactus*, are in a clade with a narrowly defined *Sclerocactus*. *Echinomastus*, as defined in the Flora of North America (Zimmerman and Parfitt 2004a), is paraphyletic (Porter and Prince 2011, p. 176). Porter and Prince (2011, pp. 18-19) recognized a monophyletic, though polymorphic clade, in which *Ancistrocactus*, *Echinomastus*, and *Toumeya* are included in a broadly defined *Sclerocactus* genus. They assign Lloyd's mariposa cactus to *Sclerocactus mariposensis* in Section Andersonianus (pp. 36-37, 58-59). We concur with this classification, which has been accepted by most recent sources (see Table 2).

Porter and Prince (2011, pp. 174, 178), citing their own unpublished data (Butterworth and Porter (in prep.)), concluded that the populations in Cuatrociénegas, Sierra de la Paila, and Cima de la Muralla, Coahuila, are phylogenetically closer to *Sclerocactus warnockii* and should not be included in *S. mariposensis*.

Table 2. Taxonomic classifications of Lloyd's mariposa cactus.

| Classifications | Citations |
|---|---|
| *Echinomastus mariposensis* | Hester 1945; Glass and Foster 1975; Anderson 1986, p. 4; Zimmerman 1985; Anderson 2001, pp. 353-354; Zimmerman and Parfitt 2004; NRCS 2018. |
| *Neolloydia mariposensis* | Benson 1969, p. 188; Benson 1982, p. 957. |
| *Echinocactus mariposensis* | Weniger 1979. |
| *Pediocactus mariposensis* | Halda 1998. |
| *Sclerocactus mariposensis* | Taylor 1987, p. 94; Poole *et al*. 2007, pp. 444-445; Porter and Prince 2011; ITIS 2018; Tropicos 2018. |

Figure 1. Photographic images of Lloyd's mariposa cactus and habitats.




1a. Juvenile, diameter ± 20 mm (0.8 in).

1b. Mature reproductive individual, diameter ± 35 mm (1.4 in).

1c. Detail of flower.

1d. Large individual, height ± 10 cm (4 in).

1e. Habitat at Big Bend National Park.


**2.3.1.2 New information on the species' biology, life history, habitat, and ecosystem**:

Summary of prior information (Weniger 1979, pp. 4,7; Heil *et al*. 1985, p. 27; USFWS 1989, pp. 3-5).

Populations of Lloyd's mariposa cactus consist of scattered individuals growing in cracks and fragments of highly fractured, crumbling limestone in Chihuahuan Desert scrubland; elevations range from 750-1050 m (2,460-3,445 ft), and mean annual precipitation ranges from 25-35 cm (10-14 in). Geological substrates include some Quaternary deposits, the Tertiary Chisos Formation, and Cretaceous limestones of the Santa Elena, Sue Peaks, Del Carmen, Telephone Canyon, Boquillas, Glen Rose, Del Rio Clay, Aguja, and Pen formations. Soils are alkaline, very rocky, crumbling limestone gravels of the Chambarino, Lajitas, Lozier, Mariscal, Pantera, Solis, Tornillo, and Upton-Nickel series. The habitats are very open, and most individuals are exposed to full sunlight and reflected light from the white limestone. Associated plant species are listed in Table 3. Lloyd's mariposa cactuses reproduce sexually, but the pollinators, breeding system (mating system), and seed dispersal were unknown. Flowering occurs mainly from March to April. Flowers open in the afternoon and remain open for 3 to 4 days. The fruits mature about 1 month later; from 5 to 10 fruits per individual produce 20 to 30 seeds each. The abundance of juvenile individuals in the known populations is evidence of recruitment. Individuals reach sexual maturity in 4 to 5 years.

New information.

Phenology and reproduction.

Anderson and Schmalzel (1997) investigated two populations of Lloyd's mariposa cactus at Big Bend National Park for three years (pp. 11-16). Mature plants began flowering in late winter (p. 17). Individuals first became reproductive when stem diameters reached 30-40 mm (1.2-1.6 in) (pp. 11-16). However, the ages of plants could not be determined directly from stem diameters because the plants expand and contract up to 35 percent, depending on their moisture content (p. 18). They used simulations to estimate that the time to reach sexual maturity takes from 5 to 8 years in one population and from 11 to 33 years in the second population (p. 18). Reproductive rates ranged from 19 to 39 percent of individuals at one site and from 22 to 36 percent at the other. Fruits averaged 28.4 seeds during two years when rainfall was well below average; in the first four months of 1997, rainfall was above average, and seed set increased to 33.6 and 48.8 seeds per fruit in the two sites.

Personnel of Big Bend National Park and Jennette Jurado, a graduate student at Sul Ross State University, continued to collect data from the plots established by Anderson and Schmalzel. Jurado analyzed the data collected over more than 15 years in her thesis (Jurado 2010). The expanded data set reveals that mean diameter at first reproduction was 32.9 and 38.5 mm (1.3 and 1.5 in) at the two plots (p. 43). Fruit production had a weak positive correlation with February rainfall, when flower buds typically form, and a weak negative correlation with rainfall during the previous August (pp. 43-46, 66). Jurado speculated that unusually cold weather during the early spring flowering season could inhibit pollinator activity, resulting in pollen limitation (p. 66).

Habitat.

Anderson and Schmalzel (1997, pp. 17-18) observed that Lloyd's mariposa cactus is relatively common in flaky or plate-like limestones of the Boquillas and Santa Elena formations, and noted that similar upper Cretaceous limestones occur in Coahuila; its distribution is similar to living rock cactus (*Ariocarpus fissuratus*).

Schmidt (2017) constructed predictive models for Lloyd's mariposa cactus distribution using the geographic coordinates and data from a census conducted by personnel of Big Bend National Park in 2005. The census documented 1,084 individuals, and Schmidt found 10 new individuals in March 2017 (p. 23). The average parameters for all known individuals at the park are 864 m (2,835 ft) elevation, slope of 5.6°, 30.0 cm ( 11.8 in) of precipitation, and annual maximum and minimum temperatures of 28.32° and 11.82° Celsius (C) (83.0° and 53.3° Fahrenheit (F)), respectively (pp. 24-25). Seven site variables significantly predicted distribution: elevation, slope, aspect, percent canopy cover, geological substrate, soil unit, and soil type (p. 25). Within the currently known range of 750 to 1,150 m (2,461 to 3,773 ft), the probability was higher at lower elevations. Similarly, the probability was higher at lower slopes, and slightly higher at east- and southeast-facing slopes. Individuals were more likely to occur in the lowest canopy cover class (see vegetative cover) of 0 to15 percent. The probability was higher on shale limestones than on gravel, and highest on the Mariscal-Rock outcrop complex, 5-30 percent slopes, and on Geefour silty clay, 10-45 percent slopes; both are classified as Lithic Ustic Torriorthents.

We used some of the variables identified by Schmidt to estimate the amount and distribution of potential habitat using ArcGIS software. We used USGS Digital Elevation Models to create a geographic layer of areas ranging from 750 to 1,150 m (2,461 to 3,773 ft), the known elevation range of Lloyd's mariposa cactus populations. We created another geographic layer consisting of the soil units where Lloyd's Mariposa cactus has been found, obtained from NRCS SSURGO web soil survey data sets (NRCS 2017): Black Gap rock outcrop complex (1-70 percent slopes), Geefour silty clay (3-45 percent slopes), Leyva rock outcrop complex (10-30 percent slopes), Mariscal very channery loam (1-8 percent slopes), Mariscal rock outcrop complex (5-30 percent slopes), and Strawhouse-Stillwell complex (1-30 percent slopes). The intersection of these two layers represents potential habitats in Brewster and Presidio counties, totaling 219,828 hectares (ha) (543,194 acres (ac)) (shown in Figure 3). This estimate was limited to these two counties because the NRCS soil surveys used different names to describe the same or similar soil units in Terrell and Pecos counties; McKinney (1998, p. 6) asserts that Lloyd's mariposa cactus populations extend into Terrell County, but we do not have geographic coordinates for populations in Terrell County or descriptions of the soil units where it occurs. The two parameters we used yield a fairly broad provisional estimate of potential habitats. As we learn more about the species' ecological requirements, this estimate could be refined.

Table 3. Plant species associated with Lloyd's mariposa cactus.

| Family | Genus | Species | Common Name | Anderson & Schmalzel 1997, pp. 9-11 | Heil, Brack, and Porter 1985, p. 28 | Weniger 1979, p. 5 | USFWS 1989, pp. 4-5 | McKinney 1998, p. 5 |
|---|---|---|---|---|---|---|---|---|
| Anacardiaceae | *Rhus* | *microphylla* | Desert sumac | x | | | | |
| Apocynaceae | *Asclepias* | *oenotheroides* | Hierba de zizotes | | | | x | |
| Apocynaceae | *Mandevilla* | *hypoleuca* | Davis Mountains rocktrumpet | | | | x | |
| Apocynaceae | *Mandevilla* | *macrosiphon* | Flor de San Juan | x | | | | |
| Asparagaceae | *Agave* | *lechuguilla* | Lechuguilla | x | x | x | x | x |
| Asparagaceae | *Dasylirion* | *leiophyllum* | Green sotol | | x | | x | |
| Asparagaceae | *Dasylirion* | *texanum* | Sotol | x | | | | x |
| Asparagaceae | *Yucca* | *faxoniana* | Faxon Yucca | x | x | | | |
| Asparagaceae | *Yucca* | sp. | | | | x | | |
| Asparagaceae | *Yucca* | *thompsoniana* | Thompson Yucca | x | x | | | |
| Asparagaceae | *Yucca* | *torreyi* | Torrey Yucca | | x | | x | x |
| Asparagaceae | *Yucca* | *treculeana* | Spanish dagger | x | | | | |
| Asteraceae | *Baileya* | *multiradiata* | Desert Baileya | x | | | | |
| Asteraceae | *Flourensia* | *cernua* | Tarbush | x | | | | |
| Asteraceae | *Thelesperma* | *longipes* | Longstalk greenthread | x | | | | |
| Berberidaceae | *Mahonia* | *trifoliolata* | Agarito | x | | | | |
| Boraginaceae | *Tiquilia* | *gossypina* | | | x | | x | |
| Boraginaceae | *Tiquilia* | *greggii* | Plume Tiquilia | x | | | | |
| Bromeliaceae | *Hechtia* | *texensis* | Texas false agave | x | x | | x | x |
| Buddlejaceae | *Buddleja* | *marrubiifolia* | Woolly butterfly bush | x | | | x | |
| Cactaceae | *Ariocarpus* | *fissuratus* | Living rock cactus | x | x | | x | x |
| Cactaceae | *Cylindropuntia* | *imbricata* | Tree cholla | x | | | | |
| Cactaceae | *Cylindropuntia* | *leptocaulis* | Tasajillo | x | x | x | x | x |
| Cactaceae | *Coryphantha* | *echinus* | Sea urchin cactus | x | x | | x | x |
| Cactaceae | *Coryphantha* | *ramillosa* | Bunched cory cactus | | | | x | |
| Cactaceae | *Echinocactus* | *horizonthalonius* | Eagle claw | x | x | | x | x |
| Cactaceae | *Echinocereus* | *dasyacanthus* | Texas rainbow cactus | x | x | x | x | x |

| Family | Genus | Species | Common Name | Anderson & Schmalzel 1997, pp. 9-11 | Heil, Brack, and Porter 1985, p. 28 | Weniger 1979, p. 5 | USFWS 1989, pp. 4-5 | McKinney 1998, p. 5 |
|---|---|---|---|---|---|---|---|---|
| Cactaceae | *Echinocereus* | *enneacanthus* var. *enneacanthus* | Pitaya | | x | | x | |
| Cactaceae | *Echinocereus* | *stramineus* | Strawberry hedgehog cactus | x | x | x | x | x |
| Cactaceae | *Epithelantha* | *bokei* | Boke's button-cactus | | | | x | |
| Cactaceae | *Escobaria* | *albicolumnaria* | | | | x | x | |
| Cactaceae | *Escobaria* | *duncanii* | Duncan's pincushion | | x | | x | |
| Cactaceae | *Escobaria* | *tuberculosa* | Cob cactus | x | x | | | x |
| Cactaceae | *Ferocactus* | *hamatacanthus* | Turk's-head barrel cactus | x | x | | x | |
| Cactaceae | *Glandulicactus* | *uncinatus* | | | | x | | |
| Cactaceae | *Glandulicactus* | *uncinatus* var. *wrightii* | Chihuahuan fishhook cactus | | x | | | |
| Cactaceae | *Grusonia* | *schottii* | Dog cholla | x | x | | x | x |
| Cactaceae | *Mammillaria* | *lasiacantha* | Golf ball pincushion cactus | x | x | x | x | x |
| Cactaceae | *Mammillaria* | *pottsii* | | | | x | x | |
| Cactaceae | *Neolloydia* | *conoidea* | Lloyd's cactus | x | x | | | |
| Cactaceae | *Opuntia* | *engelmannii* | Engelmann prickly pear | x | x | x | x | x |
| Cactaceae | *Opuntia* | *macrocentra* | Purple prickly pear | x | | | | |
| Cactaceae | *Opuntia* | *phaeacantha* | Brown-spined prickly pear | | x | x | x | |
| Cactaceae | *Opuntia* | *rufida* | Blind prickly pear | x | x | x | x | |
| Cactaceae | *Opuntia* | *x spinosibacca* | Spiny fruited prickly pear | x | x | | | |
| Cactaceae | *Sclerocactus* | *warnockii* | Warnock's fishhook cactus | x | x | | x | x |
| Ebenaceae | *Diospyros* | *texana* | Chapote | x | | | | |
| Ephedraceae | *Ephedra* | *torreyana* | Mormon tea | x | | | | x |
| Ephedraceae | *Ephedra* | *trifurca* | | | x | | | |
| Euphorbiaceae | *Chamaesyce* | sp. | Spurge | x | | | | |
| Euphorbiaceae | *Euphorbia* | *antisyphilitica* | Candelilla | x | x | | x | x |

| Family | Genus | Species | Common Name | Anderson & Schmalzel 1997, pp. 9-11 | Heil, Brack, and Porter 1985, p. 28 | Weniger 1979, p. 5 | USFWS 1989, pp. 4-5 | McKinney 1998, p. 5 |
|---|---|---|---|---|---|---|---|---|
| Euphorbiaceae | *Jatropha* | *dioica* | Leatherstem | | x | | x | |
| Fabaceae | *Acacia* | *constricta* | Whitethorn Acacia | x | x | | x | x |
| Fabaceae | *Acacia* | *farnesiana* | Huisache | x | | | | |
| Fabaceae | *Acacia* | *greggii* | Gregg's Acacia | x | | | | x |
| Fabaceae | *Acacia* | *roemeriana* | Roemer Acacia | x | | | | |
| Fabaceae | *Calliandra* | *conferta* | Feather duster | x | | | x | |
| Fabaceae | *Dalea* | *greggii* | Gregg's prairie clover | x | | | | |
| Fabaceae | *Mimosa* | *aculeaticarpa* var. *biuncifera* | Catclaw Mimosa | x | | | | |
| Fabaceae | *Prosopis* | *glandulosa* | Mesquite | x | | | x | |
| Fouquieriaceae | *Fouquieria* | *splendens* | Ocotillo | x | x | x | x | x |
| Koeberliniaceae | *Koeberlinia* | *spinosa* | Allthorn | x | x | | | |
| Krameriaceae | *Krameria* | *erecta* | Littleleaf rattany | x | x | | x | |
| Malpighiaceae | *Janusia* | *gracilis* | Slender janusia | x | | | | |
| Oleaceae | *Forestiera* | *angustifolia* | Elbow bush | x | | | | |
| Poaceae | *Aristida* | *purpurea* | Purple threeawn | x | | | | x |
| Poaceae | *Bouteloua* | *barbata* | Sixweeks grama | x | | | | |
| Poaceae | *Bouteloua* | *breviseta* | Gypsum grama | | x | | x | |
| Poaceae | *Bouteloua* | *gracilis* | Blue grama | x | | | | x |
| Poaceae | *Erioneuron* | *pulchellum* | Hairy Tridens | x | | | | x |
| Poaceae | *Panicum* | *hallii* | Hall's Panicum | x | | | | |
| Poaceae | *Tridens* | *muticus* | Slim Tridens | x | | | | |
| Pteridaceae | *Notholaena* | sp. | Cloak fern | x | | | | |
| Rhamnaceae | *Condalia* | *ericoides* | Javelina bush | x | | | x | |
| Rosaceae | *Prunus* | *havardii* | Havard plum | x | | | | |
| Scrophulareaceae | *Castilleja* | *rigida* | Rigid Indian paintbrush | | x | | | |
| Scrophulareaceae | *Castilleja* | sp. | | | | | x | |
| Scrophulareaceae | *Leucophyllum* | *candidum* | Barometer bush | x | x | | x | x |
| Scrophulareaceae | *Leucophyllum* | *frutescens* | Cenizo | x | | | | x |
| Selaginellaceae | *Selaginella* | *lepidophylla* | Resurrection plant | x | | | | x |
| Selaginellaceae | *Selaginella* | sp. | Resurrection plant | | x | | x | |
| Solanaceae | *Physalis* | sp. | Ground cherry | x | | | | |
| Ulmaceae | *Celtis* | *ehrenbergiana* | Granjeno | x | | | | |
| Verbenaceae | *Aloysia* | *gratissima* | Whitebrush | x | | | | |

| Family | Genus | Species | Common Name | Anderson & Schmalzel 1997, pp. 9-11 | Heil, Brack, and Porter 1985, p. 28 | Weniger 1979, p. 5 | USFWS 1989, pp. 4-5 | McKinney 1998, p. 5 |
|---|---|---|---|---|---|---|---|---|
| Zygophyllaceae | *Guaiacum* | *angustifolium* | Guayacán | x | | | | x |
| Zygophyllaceae | *Larrea* | *tridentata* | Creosote bush | x | x | x | x | x |

### 2.3.1.3 Trends in abundance, number and spatial distribution of populations, and demographic trends.

Summary of prior information (Weniger 1979, p. 4-8; Heil *et al*. 1985, p. 26-27; U.S Fish and Wildlife Service 1989, pp. 5-7).

Lloyd's mariposa cactus was known from at least 4 areas: 1) from 10 miles west of Terlingua to 15 miles north of Terlingua, in Presidio and Brewster counties; 2) West of Terlingua Creek, near Santa Elena Canyon in the southwest corner of Big Bend National Park; 3) northeast Big Bend National Park, Black Gap Wildlife Management Area, and eastern Brewster County; and 4) central Coahuila, Mexico, near Monclova and Cuatrociénegas. Heil *et al*. (1985, 27) estimated that the population at Big Bend National Park could exceed 100,000, but the recovery plan (USFWS 1989, p. 7), states that population sizes are difficult to estimate due to patchy distribution.

New Information.

Desert Botanical Garden (DBG) staff investigated wild populations and herbarium specimens of Lloyd's mariposa cactus to document the species' distribution and range (Anderson and Schmalzel 1997, pp. 8-9). They observed 12 large populations in Texas where the proportions of juveniles and adults indicated healthy demographic trends. In the Mexican State of Coahuila, the DBG team discovered two populations near Cima de la Muralla; herbarium specimens confirmed two additional populations in the Cuatrociénegas Basin (however, as noted in Section 2.3.1.1, Porter and Prince (2011, p. 174, 178) now believe the Coahuilan populations are a different species). The associated plant species from the Texas populations (Anderson and Schmalzel 1997, pp. 9-11) are listed in Table 3.

The population plots begun by Anderson and Schmalzel (1997) and continued by Big Bend National Park and Jurado (2010) (cited in Section 2.3.1.2) tracked the individual growth rates, reproduction, recruitment, and mortality of two populations of Lloyd's mariposa cactus for 15 years. Anderson and Schmalzel (1997, pp. 16, 19) did not observe germinating seeds or juveniles less than 5 mm (0.20 in) in diameter; they speculate that seeds germinate within a 3-5 cm (1.2-2.0 in) deep mulch of fine rock chips and are not visible until they have grown to the detected size. Although not stated, we assume that enough light reflects between the whitish limestone fragments to sustain the growth of seedlings shallowly buried in gravel. Successful seedling establishment may require consecutive rains, which happen about once every five years (p. 19). Since seed germination was not observed, and because stems expand and contract greatly, depending on water content, it was not possible to determine the age of plants or correlate size with age. The investigators tracked growth rates by painting the spines of the youngest tubercles and observing development at intervals (pp. 16-17). This method revealed that young plants produced new tubercles in late winter, while the vegetative growth of mature plants occurred from November to April, and flower buds were formed in late winter. These investigators estimated that individuals in the wild reach sexual maturity after 20 to 30 years (p. 19). They concluded that Lloyd's mariposa cactus occurs in high densities on late Cretaceous limestone, and does not appear to be threatened (p. 20), and Anderson (2001, p. 254) later reiterated that the species is more abundant than previously known. However, the authors also

shared anecdotal reports of the complete die-off of populations of mature individuals due to parasite larvae, which may indicate a density-dependent relationship (p. 20; see the discussion of cactus parasites in USFWS 2017, pp. 27-28, 35-36, 39-40).

Jurado (2010, pp. 67-68) reported that juveniles were first observed when they reached 9-11 mm (0.35-0.43 in) in diameter. She hypothesized that seeds germinated during the late summer monsoons, not long after fruits matured and seeds dispersed, noting that seeds of other cacti also germinate during this rainiest of seasons in the Chihuahuan Desert. Individuals grew at an average rate of 5 mm (0.2 in) in diameter per year until they reached 50-60 mm, after which the rate slowed, with few individuals reaching 70 mm (pp. 11, 62). Plants often shrank for 1 to 3 years before dying (p. 11); the shrinkage may have been due to parasite infestations (p. 63). Annual mortality was highly variable, ranging from 16-54 percent and 2-16 percent at the two sites (pp. 55-60). Mortality was highest among larger mature plants, possibly because they are more attractive to herbivores (pp. 69-70). However, some plants generated one or more new stems after the initial stem was injured or destroyed by herbivores (p. 60, 61). Both reproduction and mortality rates were consistently higher at the larger population; the increased mortality at that site may have been due to the lower elevation (hotter climate), or to the proximity to a water source (greater herbivore populations) (pp. 64, 69). The higher reproductive rate at the larger population was not explained; we suggest this may have been due to pollen limitation or lack of genetic diversity in the smaller population. Tables (p. 35) indicate the 15-year trends, summarized in Table 4 below. Mortality of juvenile perennial plants is often very high, and the proportion of juveniles in populations varies greatly from year to year. Anderson and Schmalzel (1997, p. 18) estimated that 95 percent of Lloyd's mariposa cactus seedlings less than 5 mm in diameter die within 6 to 10 years; we interpret this to mean that as little as 5 percent of first-year individuals survive long enough to reproduce. The numbers of mature individuals at these two sites increased until the mid-2000s before declining to their previous levels. This would suggest stable demographic trends for these two sites over the 15-year period. Nevertheless, the data from two small samples cannot be extrapolated to determine the demographic trends of entire populations, the global population, or the viability of the species.

Table 4. Fifteen-year population trend at two Lloyd's mariposa cactus plots.

| | Site 1 | | | Site 2 | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Adults | Juveniles | Total | Adults | Juveniles | Total | Adults | Juveniles | Total |
| 1995 | 19 | 31 | 50 | 21 | 58 | 79 | 40 | 89 | 129 |
| Maximum adult population in: | | | | | | | | | |
| 2002 | 32 | 13 | 45 | | | | 164 | 74 | 238 |
| 2006 | | | | 132 | 61 | 193 | | | |
| 2010 | 25 | 25 | 50 | 24 | 48 | 72 | 49 | 73 | 122 |

McKinney (1998, p. 6) stated that populations of Lloyd's mariposa cactus occurred on 3 private ranches north of Black Gap Wildlife Management Area (BGWMA), were abundant at BGWMA, and extended in a band southeast to the Rio Grande and eastward into Terrell County. She established two population plots at BGWMA, both about 700 $m^2$ (7,535 $ft^2$) in area, following the methods of Anderson and Schmalzel (1997). Table 5 summarizes the numbers of individuals

at these two plots. She estimated the size of another population at BGWMA at 10,000 individuals (p. 14), and states that the species was not adequately surveyed prior to listing as threatened (p. 14).

Table 5. Population plot data at Black Gap Wildlife Management Area (McKinney 1998, pp. 8-13).

| Individual Status | Plot 1 | Plot 2 | Totals |
|---|---|---|---|
| Mature reproductive | 37 | 116 | 153 |
| Mature non-reproductive | 3 | 12 | 15 |
| Juvenile | 6 | 22 | 28 |
| Dead or dying | 6 | 6 | 12 |
| Totals | 52 | 156 | 208 |

The anecdotal observations of Heil *et al*. (1985), Anderson and Schmalzel (1997), and McKinney (1998) concur that Lloyd's mariposa cactus is more widespread and abundant than previously known. However, in their biological assessment of this species, Porter and Prince (2011, p. 178) stated, "Data on population trends is very sketchy and difficult to interpret. This is largely because few populations have accurate counts determined and few have been regularly surveyed. In addition, because of the massive increase in the number of known localities, global numbers will appear to increase even if individual populations are declining."

Estimate of minimum viable population size.

Minimum viable population (MVP) refers to the smallest population size that has a high probability of surviving a prescribed period of time. For example, Mace and Lande (1991, p. 151) propose that species or populations be classified as vulnerable when the probability of persisting 100 years is less than 90 percent. Determinations of MVP usually take into account the effective population size ($n_e$), rather than total number of individuals (n); 10 genetically identical individuals (for example, clones) would have an effective population size of 1.

A minimum viable population size (MVP) or Population Viability Analysis has not been calculated for Lloyd's mariposa cactus, nor do we possess all the baseline demographic and life history data needed to perform these calculations. Table 6 is an adaptation of a method for estimating plant MVPs published in Pavlik (1996). Species with traits that all fall under column A would have MVPs of about 50 individuals. Those with traits that all ascribe to column C would have MVPs around 2,500 individuals. We added an intermediate column (B) to Pavlik's table to account for species with intermediate or unknown traits. The bold letters in the table indicate values, if known, for Lloyd's mariposa cactus. Two factors require fewer individuals (perennial lifespan and climax successional status), three are intermediate or unknown (intermediate growth form, moderate fecundity, and unknown longevity of seed viability), and four require more individuals (outcrossing, rare ramet production, low survivorship (indicated by recent high mortality in monitoring plots), and high environmental variation (wide variation in annual precipitation)), suggesting an estimated MVP for Lloyd's mariposa cactus in the intermediate range (roughly 1,500 to 2,000 individuals); although outcrossing has not been documented for this species, most cactus species require outcrossing (Anderson 2001, p. 33)).

This provisional MVP range may be revised in the future if accumulated data permits actual calculation. This estimate of MVP is based only on numbers of mature individuals (those that have flowered at least once or are judged capable of flowering) because most juveniles die before they are able to reproduce and therefore do not contribute to the effective population size. Furthermore, population surveys that do not distinguish mature plants from seedlings would appear to fluctuate wildly, depending on how recently seeds had germinated and the proportion of surviving seedlings.

Table 6. Minimum viable population guidelines applied to Lloyd's mariposa cactus (adapted from Pavlik 1996, p. 137).

| Factor | A. MVP of 50 individuals for species with these traits. | B. Intermediate MVP Range for species with intermediate or unknown traits. | C. MVP of 2,500 individuals for species with these traits. |
|---|---|---|---|
| Longevity | **Perennial** | | Annual |
| Breeding System | Selfing | | **Probably Outcrossing** |
| Growth Form | Woody | **Intermediate** | Herbaceous |
| Fecundity | High | **Moderate** | Low |
| Ramet Production | Common | | **Rare or None** |
| Survivorship | High | | **Low** |
| Longevity of Seed Viability | Long | **Unknown** | Short |
| Environmental Variation | Low | | **High** |
| Successional Status | **Climax** | | Seral or Ruderal |

Hence, the current recovery criterion of 1,000 individuals (in each of 3 protected sites) may be too low. By the same reasoning, the criterion of a total of 20,000 individuals at all 3 protected sites may be too high. Like many cactus species, Lloyd's mariposa cactus is distributed through its habitat in relatively small, scattered colonies. This patchy distribution pattern may be driven by natural factors, since larger populations may be more vulnerable to decimation by parasites or herbivores (USFWS 2017, pp. 27-28, 31, 39-40)—as well as cactus poachers. It may be more practical to apply MVP sizes to metapopulations consisting of multiple colonies or subpopulations.

We are not aware of a scientific method to determine the minimum number of populations or metapopulations needed to assure long-term survival of a species; in general, more populations distributed over a wider geographic range are better. Although greater population redundancy reduces extinction risk, the degree of separation between populations is also important; there are both advantages and disadvantages to population independence (White 1996). If the Coahuilan populations are accepted as a distinct species, the geographic range of Lloyd's mariposa cactus narrows to the point of endemism and its populations cannot be completely independent. For example, variation in climate, such as extended drought or catastrophic rainfall, would likely affect all populations similarly.

**2.3.1.4 Conservation:**

On July 29, 1983, Lloyd's mariposa cactus was placed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (USFWS 1989, p. 10). Porter and Prince (2011, p. 184) recommend that the species remain on Appendix I until it is delisted.

DBD, in Pheonix, Arizona, is a founding member and Southwest regional garden of the Center for Plant Conservation (CPC). Personnel of DBG collected 3,000 seeds of Lloyd's mariposa cactus from BBNP for seed banking (Slauson 1994). However, Lloyd's mariposa cactus is not currently listed in the DBG living plant collection (Desert Botanical Garden 2018).

Two populations or metapopulations of Lloyd's mariposa cactus occur within Big Bend National Park. The National Park Service manages all species on their lands in accordance with the National Park Service Organic Act of 1916. Big Bend National Park monitors populations of Lloyd's mariposa cactus, and its law enforcement officers discourage illegal collection. Since the park is federally owned land, it is also a violation of the Endangered Species Act (ESA) to remove and reduce to possession its threatened and endangered plant species. Federally funded or regulated actions that may affect Lloyd's mariposa cactus, including the National Park Services' operations and management of the park, are subject to consultation with USFWS under section 7 of the ESA.

Texas law protects state-listed plants (including Lloyd's mariposa cactus) on public lands, including both Big Bend National Park and Black Gap Wildlife Management Area.

Section 7 consultations.

Turner (2001, p.2) surveyed a proposed water pipeline construction on February 23-24, 2001. He found two Lloyd's mariposa cactuses near, but not within the pipeline ROW (p.3).

Texas Department of Transportation surveyed a construction zone along FM 170, between Lajitas and Terlingua in Brewster County, prior to improving the existing highway (Clary 2004; USFWS S7 consultation 2-25-F-2003-0469). They found 158 Lloyd's mariposa cactus in two locations. The conservation measures adopted for this project consisted of removing 90 individuals in or near the path of construction, of which half were donated to DBG and half were donated to Sul Ross State University for research purposes (TPWD Scientific Research Permit no. SPR-0204-353). About 50 individuals remained within the ROW outside the construction zone.

Big Bend National Park consulted with USFWS under section 7 of the ESA in the development of its Exotic Plant Management Plan (Big Bend National Park 2012). We concurred that the actions described in the plan are not likely to jeopardize the continued existence of Lloyd's mariposa cactus (USFWS 2015). To the contrary, these actions will benefit this and other listed cactus species by reducing competition from buffelgrass (*Pennisetum ciliare*) and King Ranch bluestem (*Bothriochloa ischaemum*) and by preventing the trampling of cactus by feral livestock.

Section 6-funded grants.

"The Cooperative Endangered Species Conservation Fund (section 6 of the ESA) provides grants to States and Territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to States and Territories for species and habitat conservation actions on non-Federal lands" (USFWS 2009).

One section 6-funded grant has been awarded to address conservation and recovery of Lloyd's mariposa cactus (McKinney 1998, described in Section 2.3.1.3). In 2016 and 2017, TPWD and USFWS announced a priority request for proposals for section 6 funding to conduct habitat modeling and population estimates of Lloyd's mariposa cactus and 3 other federally listed plants at Big Bend National Park. We have received proposals that address this priority for Fiscal Year 2018; however, grant selections for FY 2018 have not yet been announced.

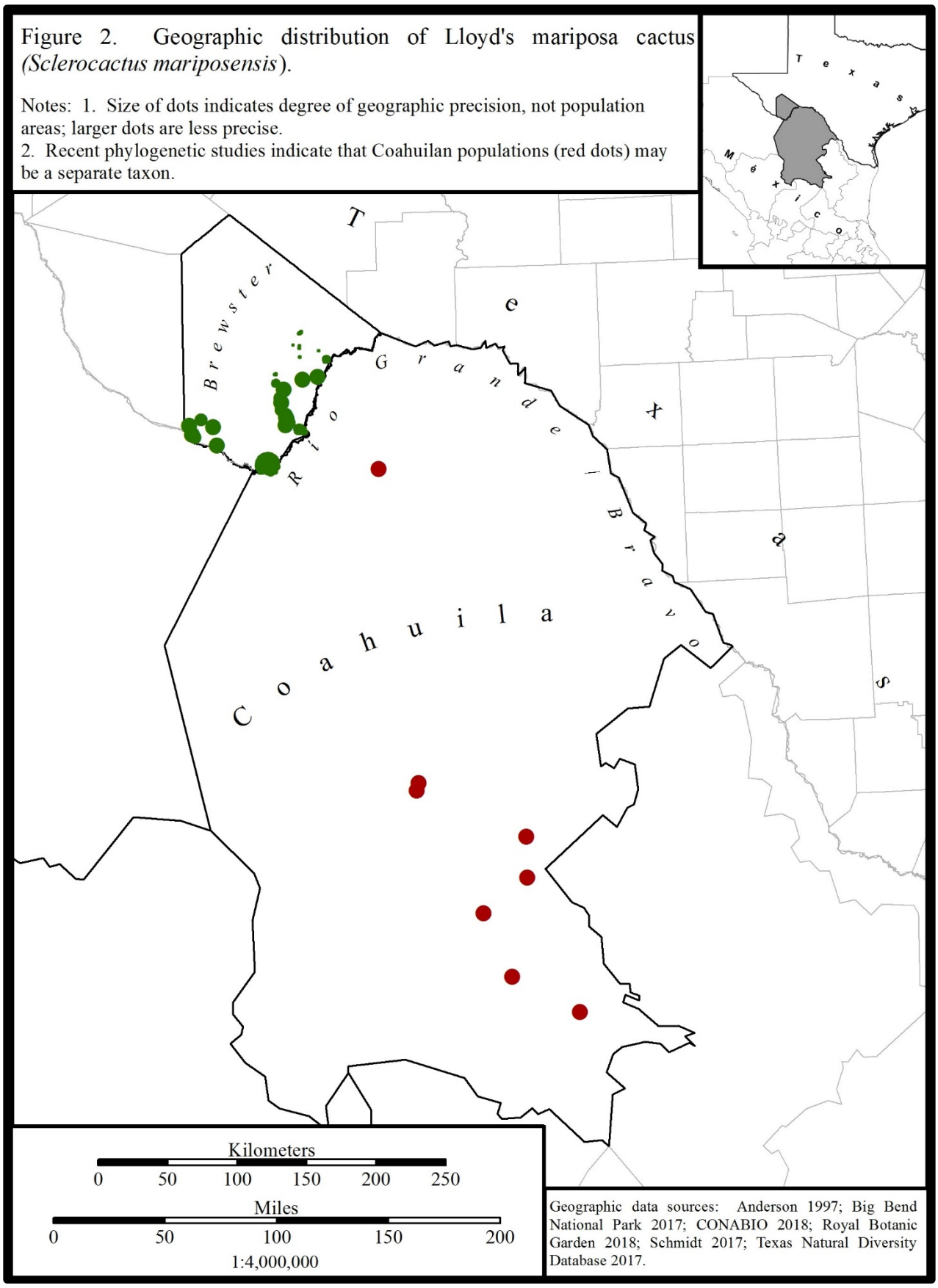


Figure 2. Geographic distribution of Lloyd's mariposa cactus *(Sclerocactus mariposensis)*.

Notes: 1. Size of dots indicates degree of geographic precision, not population areas; larger dots are less precise.
2. Recent phylogenetic studies indicate that Coahuilan populations (red dots) may be a separate taxon.

Geographic data sources: Anderson 1997; Big Bend National Park 2017; CONABIO 2018; Royal Botanic Garden 2018; Schmidt 2017; Texas Natural Diversity Database 2017.

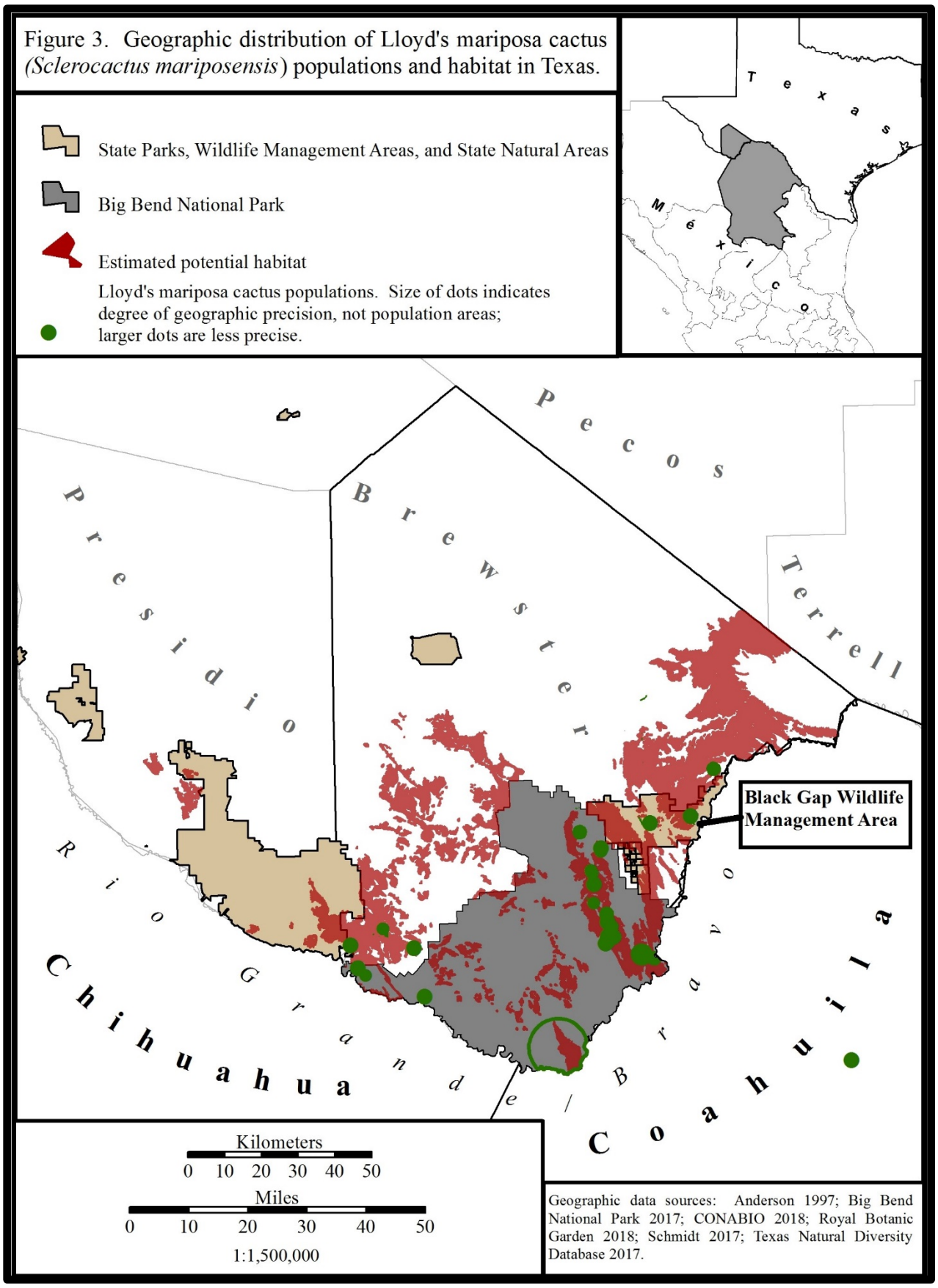
Figure 3. Geographic distribution of Lloyd's mariposa cactus (*Sclerocactus mariposensis*) populations and habitat in Texas.
State Parks, Wildlife Management Areas, and State Natural Areas
Big Bend National Park
Estimated potential habitat
Lloyd's mariposa cactus populations. Size of dots indicates degree of geographic precision, not population areas; larger dots are less precise.
Texas
México
Presidio
Brewster
Pecos
Terrell
Black Gap Wildlife Management Area
Chihuahua
Coahuila
Río Grande / Río Bravo
Kilometers
0 10 20 30 40 50
Miles
0 10 20 30 40 50
1:1,500,000
Geographic data sources: Anderson 1997; Big Bend National Park 2017; CONABIO 2018; Royal Botanic Garden 2018; Schmidt 2017; Texas Natural Diversity Database 2017.

### 2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms).

Table 7 (below) summarizes and compares threats to Lloyd's mariposa cactus described in the federal listing and recovery plan, and our current understanding of threats.

Summary of prior information.

Weniger (1979, pp. 9-11) observed that the known habitats of Lloyd's mariposa cactus occurred mostly on large private ranches, and the human population was very low. Livestock grazing did not appear to threaten the species. Plans to develop resorts in some areas were hindered by the lack of water. The main threat to the species was from repeated, systematic harvest by commercial collectors. Nevertheless, the population decline in harvested areas appeared to be slight. There was no evidence of disease or predation. The species was protected only at BBNP. Recommendations included a) developing a propagated supply as an alternative to wild collection; b) monitoring the impacts of real estate development; and c) investigating the species' demographic trends.

Brack (1983a) observed a population near Lajitas that previously had 50 individuals, but by February 1983 it had been reduced by collection to 1 adult and 2 seedlings. At a different site about 1 mile off the highway that was difficult to access, he found a new population of Lloyd's mariposa cactus in association with other cactus species that had also been over-collected elsewhere (Brack 1983b), suggesting that collection is a significant factor in population declines.

Heil *et al*. (1985, p. 28) stated that only occasional instances of poaching had occurred at BBNP. They recommended delisting the species, due to large protected population at the park.

The recovery plan (USFWS 1989, pp. 8-10) noted that mercury mines at Terlingua and Mariposa ceased operations in 1946 and no longer constituted a threat. Off-road vehicles and heavy grazing around Reagan Canyon were potential threats. Although the protected populations at BBNP showed little impact from collection, the species remained vulnerable to collection due to its limited distribution.

#### 2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

McKinney (1998, p. 7) stated that habitats that were destroyed in the Terlingua-Lajitas area by past as well as current uses, such as development and off-road vehicles (ORVs), may never recover. Other protected habitats, such as BBNP, BGWMA, and large ranches that do not allow trespass, are secure. Some ranches do graze livestock, but due to the harsh terrain the threat of trampling is negligible.

Porter and Prince (2011, p. 179) include commercial and residential development in the Lajitas-Terlingua area as potential threats, but the impacts of development on Lloyd's mariposa cactus have not been assessed. A possible consequence of development is increased use of ORVs, which can cause significant damage to habitats and populations in a single pass. This threat is likely to be limited to habitats closer to developed areas, and is of a limited extent. Livestock

grazing may be a moderate threat in the northeast portion of the range, both from trampling and habitat degradation resulting from overgrazing (p. 180). Pesticides could affect individuals along highway ROWs as well as the species' pollinators. However, most Lloyd's mariposa cactus populations are far from areas of pesticide use, which is at most a moderate threat (pp. 181-182).

#### 2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

McKinney (1998, pp. 6-7) has observed thousands of small Lloyd's mariposa cactus that were dug by poachers and left to die in the sun. However, the threat of collection has now diminished, and the plants are actively protected at BBNP and BGWMA. Populations on large ranches that do not allow trespass are also relatively secure.

Porter and Prince (2011, p. 179) noted recent incidents involving the take of Lloyd's mariposa cactus from a protected area along a highway ROW. They conclude that the species will remain vulnerable to a persistent, low-grade threat of illegal collection.

#### 2.3.2.3 Disease or predation:

Porter and Prince (2011, pp. 180-181) noted that black-tailed jackrabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus auduboni*) may browse the tops of Lloyd's mariposa cactuses, exposing the soft inner tissues to opportunistic attack by snails or insects. Some herbarium specimens were infested with moth larvae or other parasites. Although parasitism of Lloyd's mariposa cactus by the cactus longhorn beetle (*Moneilema armata*) has not been documented, it is possible, but the degree of this threat cannot currently be assessed.

Personnel of Big Bend National Park and USFWS observed increased mortality of Chisos hedgehog cactus (*Echinocereus chisoensis* ssp. *chisoensis*) individuals from herbivory at monitoring sites in March, 2016, following several years of exceptional drought (USFWS 2018, p.15). Both species occur at Big Bend National Park and are affected by the same climate and herbivore populations; therefore, we assume that herbivory of Lloyd's mariposa cactus also increases during drought. If droughts become more frequent as a result of climate changes, the impact of herbivory may also increase.

#### 2.3.2.4 Inadequacy of existing regulatory mechanisms:

The ESA does provide some legal protection for federally-listed plants on land under federal jurisdiction, including the populations of Lloyd's mariposa cactus at Big Bend National Park.

Beginning in 2007, USFWS and the U.S. Department of Homeland Security (DHS) interacted extensively regarding the proposed construction of a border wall along the Rio Grande in south and west Texas. A provision of the REAL ID Act of 2005 gives the Secretary of Homeland Security authority to waive other federal laws, including the ESA, in order to expedite construction of border barriers. Hence, the border wall project was exempt from consultation with USFWS under section 7 of the ESA. Nevertheless, DHS and USFWS have coordinated to establish best management practices for the federally listed plants and animals in the project impact area (U.S. Department of Homeland Security 2008). Additional border wall construction

has been proposed by the current Administration. If implemented, the border wall and related infrastructure may affect populations and habitats of Lloyd's mariposa cactus that occur along the Rio Grande.

Chapter 88 of the Texas Parks and Wildlife Code lists plant species as state-threatened or endangered once they are federally-listed with these statuses. Lloyd's mariposa cactus was listed as threatened by the State of Texas on April 29, 1983. The State prohibits taking and/or possession for commercial sale of all or any part of an endangered, threatened, or protected plant from public land. TPWD requires permits for the commercial use of listed plants collected from private land. Scientific permits are required for collection of endangered plants or plant parts from public lands for scientific or educational purposes. In addition to State endangered species regulations, other State laws may apply. State law prohibits the destruction or removal of any plant species from State lands, including BGWMA, without a TPWD permit.

Lloyd's mariposa cactus is listed (as *Echinomastus mariposensis*) as a threatened species (category A) and subject to protection in Mexico (Secretaría de Medio Ambiente y Recursos Naturales 2010, p. 56).

**2.3.2.5. Other natural or manmade factors affecting its continued existence:**

Demographic and genetic consequences of small population sizes.

The federal listing states, "Low total population levels intensify the adverse effects of threats to the two plants [Lloyd's mariposa cactus and bunched cory cactus] and their habitats." (44 FR 64249). To assess this threat, Porter and Prince (2011, pp. 182-183) considered the scattered distribution, the range of population sizes, and the limited geographic range of Lloyd's mariposa cactus. They note that smaller populations are vulnerable to extirpation from natural and human disturbance and random events, while large, remote populations are less vulnerable. Nevertheless, climate changes could affect the species throughout its range. Since individuals reach sexual maturity slowly, the species could not recovery quickly following losses. They concluded, "At the present time it is questionable whether population size represents a vulnerability for this species," (pp. 182-183).

Small, isolated plant populations are also vulnerable to genetic drift, loss of genetic diversity, and inbreeding depression. However, the population genetics of Lloyd's mariposa cactus has not been investigated; we have no evidence of the extent of the actual impacts of these potential threats.

Climate change.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013) projects the following changes by the end of the 21$^{st}$ century, relative to the 1986 to 2005 averages: It is virtually certain that most land areas will experience warmer and/or fewer cold days and nights; it is virtually certain that most land areas will experience warmer and/or more frequent hot days and nights; it is very likely that the frequency and/or duration of warm spells and heat waves will increase in most land areas; it is very likely that the frequency, intensity,

and/or amount of heavy precipitation will increase in mid-latitude land masses; it is likely that the intensity and/or duration of droughts will increase on a regional to global scale. The magnitude of projected changes varies widely, depending on the assumptions of future greenhouse gas emissions used by different models. For example, the RPC2.6 model projects an increase of global mean surface temperatures of 0.3° to 1.7° C (0.5° to 3.1° F) by the end of the 21st Century. Under the RPC8.5 model the increase would range from 2.6° to 4.8° C (4.7° to 8.6° F). The report also states, "In many mid-latitude and subtropical dry regions, mean precipitation will likely decrease..." However, these models do not simulate well the projected patterns of regional precipitation (IPCC 2013, p. 11).

Porter and Prince (2011, p. 181) stated, "There has been no assessment of the potential long-term effects of climate change on this species. Changes in temperature and rainfall amounts and patterns could alter the species interactions involving Lloyd's mariposa cactus and its microhabitat…The response and abundance of parasitic insects, the abundance of weeds, the distributions of woody plants all represent interspecific interactions, which may change in response to climate change. How these changing interactions affect Lloyd's mariposa cactus are unknown and have not been modeled. While the potential impacts of climate change could be serious, improved projections are needed to better understand this potential threat."

We do not know whether the climate changes that have already occurred have affected the populations or distribution of Lloyd's mariposa cactus, nor can we predict how the species might be affected by the type and degree of climate changes forecast by the range of models. While many species have adapted to previous climate changes by migrating in latitude or elevation, it is unlikely that this species could migrate, without facilitation, fast enough to match the projected rate of climate change. Changes in temperature and rainfall amounts and patterns could have multiple effects that alter the species' fitness in opposing ways. For example, hotter summers could increase mortality from drought, but warmer winters could reduce mortality from freezing. Regardless of how these changes may affect its autecology, the altered synecology may be more significant. For example, Lloyd's mariposa cactus might benefit from more frequent or more severe droughts if it tolerates extended drought better than other plants that compete with it. Conversely, extended drought could reduce pollinator populations, resulting in pollen limitation and reduced reproductive output. At present, we cannot predict how the infinitely complex aggregation of climate changes will affect the synecology of Lloyd's mariposa cactus populations and habitat. Therefore, we will continue to monitor the species' status and will adapt our recovery and management strategies when necessary to address the changing conditions.

We conclude that Lloyd's mariposa cactus populations are currently threatened by illicit collection, although the degree of threat is less than when the species was listed, and a number of large populations occur on protected sites and are relatively secure. Commercial and residential development and ORV use currently damage and destroy habitats in a small portion of the species' range. Livestock grazing is a current minor threat to a relatively small portion of the species' range. Herbivory is a natural cause of mortality than may worsen during extended drought. Parasitic infestations do occur in Lloyd's mariposa cactus populations, but their extent is currently unknown. A portion of the species' habitats and populations along the Rio Grande may be impacted by the construction of new border walls and related infrastructure. The

demographic and genetic consequences of small population sizes are potential threats, but we have no evidence that these are currently affecting the species. The species may also be threatened by climate changes, but we are currently unable to predict how the species will react to projected changes.

Table 7. Factors affecting the survival of Lloyd's mariposa cactus.

| 44 FR 64247 and Recovery Plan | This review |
|---|---|
| A. The present or threatened destruction, modification, or curtailment of its habitat or range. | |
| • Mercury mining had ceased and was no longer a threat.<br>• ORV use is a potential threat.<br>• Livestock grazing is a potential threat in some areas. | • Past and current commercial and residential development and ORV use has damaged or destroyed habitats in a small portion of the range.<br>• Livestock grazing is a current minor threat that affects a small portion of the range. |
| B. Overutilization for commercial, recreational, scientific, or educational purposes. | |
| • Collection from the wild depleted many known populations and the threat to remaining populations may increase as a consequence of development. | • Illicit collection currently threatens populations, but the degree of threat is less than when the species was listed. Many populations are protected. |
| C. Disease or predation. | |
| • Current livestock grazing had not affected the species, but increased grazing and some range management practices potentially threaten populations. | • Mortality from herbivory may increase during drought. This threat may become more severe if the incidence of drought increases.<br>• The extent of mortality from parasites is unknown. |
| D. The inadequacy of existing regulatory mechanisms. | |
| • National Park Service regulations prohibit taking of natural resources—including Lloyd's mariposa cactus—from park.<br>• Listed in Appendix I of CITES, but this applies only to international trade. | • Endangered Species Act provisions can be waived by DHS for construction of border barriers. |
| E. Other natural or man-made factors affecting its continued existence. | |
| • Small population sizes intensify adverse effects of other threats. | • Demographic and genetic factors potentially threaten small isolated populations, but the current or future extent is unknown.<br>• Climate changes may have multiple effects on fitness and survival; however, we are currently unable to project the net change to the species' viability. |

## 2.4 Synthesis.

Lloyd's mariposa cactus has consistently been recognized as a valid species. Most recent classifications based on morphology, as well as phylogenetic research, support inclusion in the genus *Sclerocactus*. However, an unpublished phylogenetic analysis also indicates that the Coahuilan populations should not be included in *S. mariposensis*. If this conclusion is accepted, then *S. mariposensis* is more narrowly endemic to portions of two or three counties in the Big Bend region of Texas. The known populations occur on formations of highly fractured limestone at elevations ranging from 750-1,150 m (2,461-3,773 ft). We provisionally estimate that about 220,000 ha (543,000 ac) of potential habitat occur in Brewster and Presidio counties; potential habitats and populations very likely also extend into Terrell County, but we do not have verifiable records of occurrences there. Demographic studies on two plots observed the following: The populations fluctuated widely, but returned to initial levels after 15 years; estimates of first reproductive age ranged from 5 to 33 years; as much as 95 percent of the youngest class of plants do not reach reproductive maturity; mature plants produced fairly typical numbers of seeds (for a small cactus), but the largest plants also had higher mortality rates; favorable years for recruitment may occur about once every 5 years; and the appearance and growth of juvenile plants indicates that populations are resilient. Anecdotal observations of several experts indicate that the species is much more abundant and widespread than previously known; large populations occur on two protected sites, BIBE and BGWMA; and the most significant threat, the large-scale commercial collection of this species from the wild, appears to have subsided significantly, but will probably continue indefinitely. Several experts suggest that the species could be delisted. However, censuses at BIBE and BGWMA documented only 1,094 and 208 individuals, respectively, and the data from 4 small plots cannot be extrapolated to represent the size and trends of entire populations. Finally, the recovery criterion of 1,000 individuals per protected site is lower than our estimated MVP of 1,500 to 2,000 individuals; this should apply only to mature individuals of reproductive age, and due to the patchy distribution typical of rare cactus species, may best be applied to metapopulations. The recovery plan should be revised to incorporate updated guidance and specific, measurable recovery criteria, including the length of the monitoring period needed to detect demographic trends. We do not recommend changing the ESA classification of Lloyd's mariposa cactus at this time, because: 1) Ascertaining whether the recovery criteria have been met depends on how the phylogenetic identity of the Coahuilan populations is resolved; and 2) we do not have quantitative, verifiable measures of the actual population sizes and trends. However, the use of valid scientific methods to determine population sizes and trends may justify delisting this species in the near future.

## 3.0 RESULTS

### 3.1 Recommended Classification:

**___ Downlist to Threatened**
**___ Uplist to Endangered**
**___ Delist** (*Indicate reasons for delisting per 50 CFR 424.11):*
___ *Extinction*
___ *Recovery*
___ *Original data for classification in error*
**_X_ No change is needed**

### 3.2 New Recovery Priority Numbers:

14C.

**Brief Rationale:**

The Recovery Priority Number for Lloyd's mariposa cactus prior to this review was 2. This indicates that the threat level was high, the recovery potential was high, the taxon was a species, and no conflicts with construction, development projects, or other forms of economic activity were foreseen. Our current assessment is that the degree of threat is low: the species is rare, and the impacts of some threats, such as climate change and small population sizes, are unknown. The recovery potential is high: although the species is endemic to a fairly restricted range, it is more abundant than previously known, and several populations are protected at BIBE and BGWMA. Lloyd's mariposa cactus is a full species. The proposed construction of new border walls through a portion of the range represents a clear conflict with construction. Therefore, the current Recovery Priority Number is 14C (low threat, high recovery potential, full species, conflict).

## 4.0 RECOMMENDATIONS FOR FUTURE ACTIONS.

To ascertain the degree to which the recovery criteria of Lloyd's mariposa cactus have been met, we recommend the following:

- Develop efficient, quantitative, verifiable methods to estimate population sizes and trends using representative samples of potential habitats and valid statistical analyses.
- Resolve the phylogenetic identity of the Coahuilan populations that were previously included in *Sclerocactus mariposensis*.

The most important recovery actions during the next five years include, but are not limited to, the following:

- Revise the recovery plan and recovery criteria to incorporate updated guidance and specific, measurable recovery criteria, including the length of the monitoring period needed to detect demographic trends. Revise the population size criterion to the provisional minimum viable population level of 1,500 to 2,000 mature, reproductive individuals per metapopulation.
- Continue to improve the potential habitat model as we learn more about the ecological requirements.
- Explore the potential to conserve populations of Lloyd's mariposa cactus on private lands in Presidio, Brewster, and Terrell counties, Texas through private landowner agreements or other appropriate measures.
- If at least some populations in Coahuila, Mexico are determined to be *S. mariposensis* (or *Echinomastus mariposensis*), communicate with Mexican agencies, non-profit conservation organizations, and academic institutions to promote their conservation and management.
- Investigate the population genetics to determine the genetic structure, genetic diversity and extent of inbreeding, evidence of gene flow, and other parameters that will be useful in the conservation and recovery of Lloyd's mariposa cactus.

## 5.0 Literature Cited.

Anderson, E.F. 1986. A revision of the genus Neolloydia B. & R. (Cacctaceae). Bradleya 4:1-28.

Anderson, E.F. 2001. The Cactus Family. Timber Press, Portland, Oregon. 776 pp.

Anderson, E.F. and R.J. Schmalzel. 1997. Final report on Lloyd's mariposa cactus survey (Sclerocactus [Neolloydia] mariposensis). Prepared for Joint Task Force Six. Desert Botanical Garden, Pheonix, Arizona. 109 pp. + 2 Appendices.

Benson, L. 1969. The cacti of the United States and Canada—New names and nomenclature combinations. Cactus and Succulent Journal (U.S.) 41:185-190.

Benson, L. 1982. The Cacti of the United States and Canada. Stanford University Press, Stanford, California. 1,044 pp.

Big Bend National Park. 2012. Draft Exotic Plant Management Plan and Environmental Assessment. September 2012. 94 pp. + 6 Appendices.

Brack, S. 1983a. Field trip report – February 1983. 1 page.

Brack, S. 1983b. Field observations – October and November 1983.

Butterworth, C. A., J. H. Cota-Sánchez, and R. S. Wallace. 2002. Molecular systematics of the tribe Cacteae (Cactaceae: Cactoideae): A phylogeny based on rpl16 intron sequence variation. Systematic Botany 27: 257-270.

Butterworth and Porter, in prep. Generic circumscription of *Sclerocactus*: inferences from chloroplast DNA sequences. To be submitted to Cactus and Succulent Journal (Los Angeles).

Clary, K. 2004. FY 2004 ESA Survey Report to Environmental Affairs Division, Texas Department of Transportation. 4 pp.

CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad). 2018. Search of Mexican Herbaria through REMIB (Red Mundial de Información sobre Biodiversidad) for *Sclerocactus mariposensis*, *Echinomastus mariposensis*, and *Neolloydia mariposensis*. http://www.conabio.gob.mx/remib/doctos/remib_esp.html. Accessed April 12 and 25, 2018.

Crozier, B.S. 2005. Systematics of Cactaceae Juss.: Phylogeny, cpDNA evolution, and classification, with emphasis on the Genus Mammillaria Haw. Ph.D. Dissertation. University of Texas at Austin. 154 pp.

Desert Botanical Garden. 2018. Species and habitat conservation. http://www.dbg.org/species-habitat-conservation. Accessed May 21, 2018.

Glass, C. and R. Foster. 1975. The Genus Echinomastus in the Chihuahuan Desert. Cactus and Succulent Journal (U.S.) 47: 218-223.

Halda, J.J. 1998. Acta Mus. Richnov., Sect. Nat. 5: 24.

Heil, K.D., S. Brack, and J.M. Potter. 1985. The rare and sensitive cacti of Big Bend National Park. September 1985. Pp. 26-28.

Hernández-Hernández, T., H.M. Hernández, J.A. De-Nova, R. Puente, L.E. Eguiarte, and S. Magallón. 2011. Phylogenetic relationships and evolution of growth form in Cactaceae (Caryophyllales, Eudicotyledoneae). American Journal of Botany 98: 44-61.

Hester, J.P. 1945. Echinomastus mariposensis sp. nov. Desert Plant Life 17: 59-60.

Integrated Taxonomic Information Service. 2018. *Sclerocactus mariposensis* (Hester) N.P. Taylor. http://www.itis.gov. Accessed April 12, 2018.

Intergovernmental Panel on Climate Change. 2013. Summary for Policymakers. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 29 pp.

Jurado, J. 2010. A study of the growth, reproduction, and mortality of *Echinomastus mariposensis* (Cactaceae) in Big Bend National Park, Texas. Master of Science Thesis, Sul Ross State University, Alpine, Texas. 75 pp.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: Toward re-evaluation of IUCN threatened species categories. Conservation Biology 5: 148-157.

McKinney, B. 1998. Surveying, monitoring and managing select endangered/threatened species of concern in the Trans-Pecos ecoregion of Western Texas. Annual and Final Report. Texas Parks and Wildlife Department. Attachment F: Lloyd's mariposa cactus (*Neolloydia mariposensis*). 15 pp. + 3 maps.

Natural Resources Conservation Service. 2017. United States Department of Agriculture. Web Soil Survey. http://websoilsurvey.nrcs.usda.gov/ Accessed: March 30, 2017.

Natural Resources Conservation Service. 2018. The PLANTS Database. Plants Profile for *Echinomastus mariposensis* (Lloyd's fishhook cactus). http://plants.usda.gov/. Accessed: April 12, 2018. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Pavlik, B.M. 1996. Defining and Measuring Success. Pp. 127-155 in D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Poole, J., W. Carr, D. Price, and J. Singhurst. 2007. The Rare Plants of Texas. Texas A&M University Press. College Station, Texas. 640 pp.

Porter, J. M., M. S. Kinney, and K. D. Heil. 2000. Relationships between *Sclerocactus* and *Toumeya* (Cactaceae) based on chloroplast trnL–trnF sequences. Haseltonia 7: 8–23.

Porter, J.M. and L.M. Prince. 2011. Draft final report on the evidence supporting generic and species circumscriptions in the Genus *Sclerocactus* with recommendations for a biologically justified taxonomy that will be stable into the future; and biological assessments of species of concern. Conducted for the Division of Scientific Authority, U.S. Fish and Wildlife Service, January 26, 2011. Rancho Santa Ana Botanic Garden, Claremont, California. 274 pp.

Powell, A.M., J.F. Weedin, and S.A. Powell. 2008. Cacti of Texas: A field guide. Texas Tech University Press, Lubbock Texas. 383 pp.

Schmidt, O.G. 2017. A report on four rare plant species of Big Bend National Park, Texas Master of Arts Report. University of Texas at Austin. 107 pp.

Secretaría de Medio Ambiente y Recursos Naturales. 2010. NORMA Oficial Mexicana NOM-059-SEMARNAT-2010: Protección ambiental—Especies nativas de México de flora y fauna silvestres—Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—Lista de especies en riesgo. Diario Oficial (Mexican Federal Government). December 30, 2010.

Slauson, L. 1994. *Coryphantha ramillosa*, *Coryphantha robbinsorum*, *Coryphantha viridiflorus* var. *davisii*, and *Neolloydia mariposensis*. Annual report submitted to U.S. Fish and Wildlife Service. Desert Botanical Garden, Phoenix, Arizona.

Taylor, N.P. 1987. Bradleya 5: 94.

Texas Natural Diversity Database. 2017. Element occurrence printouts for *Sclerocactus mariposensis.* Wildlife Diversity Program of Texas Parks and Wildlife Department. February 14, 2017.

Tropicos. 2018. Missouri Botanical Garden. *Sclerocactus mariposensis* (Hester) N.P. Taylor. http://www.tropicos.org/Name/50181307. Accessed April 12, 2018.

Turner, J.S. 2001. A biological and botanical survey for Study Butte Water Supply Corporation. 8 pp. + Appendix and 5 photographs.

U.S. Department of Homeland Security, U.S. Customs and Border Protection, and U.S. Border Patrol Rio Grande Valley Sector. 2008. Biological Resources Plan for Construction, Operation, and Maintenance of Tactical Infrastructure for Rio Grande Valley Sector, Texas. Prepared in July 2008.

U.S. Fish and Wildlife Service. 1989. Lloyd's Mariposa Cactus (*Neolloydia mariposensis*) Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, NM. 47 pp.

U.S. Fish and Wildlife Service. 2009. Cooperative Endangered Species Conservation Fund (Section 6 of the ESA). http://www.fws.gov/endangered/factsheets/Sec6_Factsheet_2009.pdf. Accessed June 20, 2009.

U.S. Fish and Wildlife Service 2015. Biological Opinion on Consultation No. 02ETAU00-2015-F-0333 on Big Bend National Park Exotic Species Management Plan. December 15, 2015.

U.S. Fish and Wildlife Service. 2017a. Recovery Planning and Implementation User Guide, Version 2.0. U.S. Fish and Wildlife Service, Arlington, VA. 32 pp. + 2 appendices.

U.S. Fish and Wildlife Service. 2017b**.** Species status assessment of Tobusch Fishhook Cactus (*Sclerocactus brevihamatus* ssp. *tobuschii* (W.T. Marshall) N.P. Taylor). U.S. Fish and Wildlife Service Southwest Region, Albuquerque, New Mexico. 64 pp. + 2 appendices.

U.S. Fish and Wildlife Service. 2018. Chisos hedgehog cactus (*Echinocereus chisoensis* ssp. *chisoensis*). Five-year review: Summary and evaluation. Austin Ecological Services Field Office, Austin, Texas. 49 pp.

Weniger, D. 1979. Status report on Neolloydia mariposensis. Prepared for U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 15 pp.

White, P.S. 1996. Spatial and Biological Scales in Reintroduction. Pp. 49-86 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Zimmerman, A.D., and B. Parfitt. 2004a. *Echinomastus* Britton & Rose.. *In*: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. New York and Oxford. Vol. 4, p. 192. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=111238. Accessed April 12, 2018.

Zimmerman, A.D., and B. Parfitt. 2004b. *Echinomastus mariposensis* Hester. *In*: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. New York and Oxford. Vol. 4, p. 195. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242415278. Accessed April 12, 2018.

## PHOTOGRAPHIC CREDITS

Cover photograph and Figure 1.c copyright by Olivia Grace Schmidt. All other photographs may be used without permission, with credit to: Chris Best, USFWS.

## ABBREVIATIONS OF SCIENTIFIC UNITS

| Abbreviation | Scientific Unit |
|---|---|
| ac | acres |
| cm | centimeters |
| ° C | degrees Celsius |
| ° F | degrees Fahrenheit |
| ft | feet |
| ha | hectares |
| in | inches |
| m | meters |
| mm | millimeters |

## GLOSSARY OF TECHNICAL TERMS.

| Term | Definition |
|---|---|
| Acicular | "Needlelike; slender, elongate, circular in cross section, and tapering to a pointed apex." (Powell *et al*. 2008, p. 357). |
| Alkaline (Soil) | Soil having a basic (pH > 7) soil solution due to a high content of alkaline minerals, such as calcium carbonate. |
| Anther | The pollen-bearing part of the stamen. (Correll and Johnston 1979). |
| Areole | Specialized axillary bud or short shoot in cactus species; the spine cushion, producing leaves, spines, and flowers (Anderson 2001) |
| Autecology | Ecology of individual species. |
| Breeding System | The ability of a plant species to reproduce via outcrossing, self-fertilization, apomixis, or a combination (Wikipedia 2018). |
| Central spines | One of the innermost spines of an areole (Anderson 2001). |
| Chihuahuan Desert | Arid region between the Sierra Madre Oriental and Sierra Madre Occidental of northern Mexico, extending into southwest Texas and southern New Mexico of the U.S. |
| Chloroplast | A double-membrane organelle found in higher plants in which photosynthesis takes place. |
| Clade | The scientific classification of living and fossil organisms to describe a monophyletic group, defined as a group consisting of a single common ancestor and all its descendants (Wikipedia 2018). |
| Climax Succession | Late, relatively stable stage of ecological succession. |
| Clone | Asexually reproduced progeny that are genetically identical to parent organism. |
| Conservation Measures | Actions to benefit or promote the recovery of listed species that are included by the Federal agency as an integral part of the proposed action. These actions will be taken by the Federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or actions which the Federal agency or applicant have committed to complete in a biological assessment or similar document (USFWS and NMFS 1998, p. xii). |
| Correlation | A statistically dependent relationship between two random variables or sets of data (Wikipedia 2018). |
| Cretaceous | Geologic period and system from 145 ± 4 to 66 million years (Ma) ago (Wikipedia 2018). |

| | |
|---|---|
| Critical habitat | "…(i) the specific areas within the geographical area occupied by the [threatened or endangered] species, at the time it is listed in accordance with the provisions of section 4 of [the ESA], on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of [the ESA], upon a determination by the Secretary that such areas are essential for the conservation of the species." U.S. Congress 1988. |
| Delist | Remove a species from the list of threatened and endangered species. |
| Demography | Scientific study of populations. |
| Digital Elevation Model | Digital model or 3D representation of a terrain's surface — commonly for a planet (including Earth), moon, or asteroid — created from terrain elevation data (Wikipedia 2018). |
| DNA Sequence | The sequence of nucleotide bases in a DNA molecule (or portion of a molecule). |
| Effective population size | The size of an idealized population in which individuals contribute equally to the gamete pool and have the same variation in allele frequencies and levels of inbreeding as the observed population (Barrett and Kohn 1991). |
| Element Occurrence | An area of land and/or water in which a species or natural community is, or was, present (NatureServe 2002). |
| Endangered | "…any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." U.S. Congress 1988. |
| Endemic | An organism restricted to a specific habitat or geographic range. |
| Entisol | A young soil high in mineral content and without distinct horizons (Wiktionary 2018). |
| Epithet | The species name in a binomial taxonomic classification. |
| Filament | The stalk of an anther (Correll and Johnston 1979, p. 1752). |
| Genetic drift | A change in allele frequencies within a population over time. |
| GIS | Geographic Information System; computer software used to store, analyze, and create maps using geographic data. |
| Habitat | Ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism (Wikipedia 2018). |
| Inbreeding depression | The reduction of fitness caused by mating between relatives (Edmands 2007, p. 464). |
| Invasive | Species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Clinton 1999; 64 FR:6183-6186, February 3, 1999). |
| Lithic | Composed of sedimentary rock fragments. |

| | |
|---|---|
| Metapopulation | A group of spatially separated populations of the same species that interact at some level (Wikipedia 2018). |
| Minimum viable population | The fewest individuals required for a specified probability of survival over a specified period of time (Pavlik 1996; Mace and Lande 1991); see Population Viability Analysis. |
| Mitochondrion | A double-membraned organelle present within the cells of all eukaryotes in which respiration takes place. |
| Monophyly | A group of organisms that consists of all the descendants of a single common ancestor (Wikipedia 2018). |
| Outcross | In plants, sexual fertilization involving the union of gametes from different individuals. |
| Paraphyly | A group consisting of all the descendants of the group's last common ancestor minus a (small) number—typically just one or two—of monophyletic subgroups (Wikipedia 2018). |
| Perianth | The floral envelopes collectively; usually used when calyx and corolla are not clearly differentiated. (Correll and Johnston 1979). |
| Phenology | Seasonal pattern of plant growth, development and reproduction. |
| Phylogeny | The study of evolutionary relatedness among various groups of organisms (e.g., species, populations), which is discovered through molecular sequencing data and morphological data matrices (Wikipedia 2018). |
| Pollen Limitation | Reduced reproductive output of a plant due either to insufficent pollen sources or a lack of pollinators. |
| Population | Collection of inter-breeding organisms of a particular species (Wikipedia 2018). |
| Population Viability Analysis | Statistical models used to predict the probability of extinction of a population after a specified period of time. |
| Quaternary | Geologic Period beginning 2.588 million years ago until the present; includes the Pleistocene and Holocene Epochs (Wikipedia 2018). |
| Radial spines | One of the outermost spines of an areole, often radiating or appressed (Anderson 2001). |
| Ramet | An individual, genetically-identical plant reproduced as a clone of the parent plant. |
| Recruitment | Addition of new individuals to a population. |
| Redundancy | The number of populations or sites necessary to endure catastrophic losses (Shaffer and Stein 2000, pp. 308-310). |
| Section | In botany, a section is a taxonomic rank below the genus and subgenus, but above series and species (Wikipedia 2013). |
| Section 6 | Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) (USFWS 2009). |

| | |
|---|---|
| Section 7 | The section of the Endangered Species Act of 1973, as amended, outlining procedures for interagency cooperation to conserve Federally listed species and designated critical habitats (USFWS and NMFS 1998, p. xviii). |
| Seed banking | Storage of plant seeds, under conditions that extend viability, for species conservation and restoration. |
| Species | One of the basic units of taxonomic identity (Wikipedia 2013). Multiple species definitions exist, including the biological, phylogenetic, evolutionary, etc. The biological definition ("... groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups" (Mayr 1942)) is adopted in the ESA but does not apply well to all organisms. |
| Stigma | The receptive part of the pistil on which the pollen germinates. (Correll and Johnston 1979). |
| Style | A narrowed, often elongate portion of a pistil between the stigma and ovary (Correll and Johnston 1979). |
| Subpopulation | A distinct portion of a larger population or metapopulation. |
| Synecology | Ecology of groups of coexisting organisms. |
| Taxon | (Plural, taxa). A natural group of organisms at any rank in the taxonomic hierarchy (Anderson 2001). |
| Taxonomy | Scientific classification of living organisms. |
| Tertiary | The geologic period from 65 million to 2.58 million years ago (Wikipedia 2018). |
| Threatened | "…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." United States Congress 1988. |
| Torriorthents | A course, silty entisol (Wiktionary 2018). |
| Tubercle | A conical or cylindrical outgrowth or protuberance from a cactus stem, usually bearing all or part of the areole; podarium (Anderson 2001). |
| Type locality | The location where a type specimen was collected. |
| Type specimen | A specimen upon which the description of a new taxon is based. |
| Ustic | A soil mosture regime in which limited moisture is present when conditions are suitable for plant growth (Soil Science Society of America 2018). |
| Vegetative cover | The proportion of an area that is intercepted vertically by tissues of a specified taxon or type of plants; total cover may exceed 1 due to multiple layers. |

Literature cited in glossary.

Anderson, E.F. 2001. The Cactus Family. Timber Press, Portland, OR. 776 pp.

Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: Implications for conservation. Pp. 3-30 *in* Falk, D.A. and K.E.

Holsinger (eds.), Genetics and Conservation of Rare Plants. Oxford University Press, New York, New York.

Clinton, President William J. 1999. Executive Order 13112 on invasive species. 64 FR: 6183-6186. February 3, 1999.

Correll, D.S. and M.C. Johnston. 1979. Manual of the vascular plants of Texas. University of Texas at Dallas, Richardson, Texas. 1881 pp.

Edmands, S. 2007. Between a rock and a hard place: evaluating the relative risks of inbreeding and outbreeding for conservation and management. Molecular Ecology 16: 463-475.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: Toward re-evaluation of IUCN Threatened Species Categories. Conservation Biology 5:148-157.

NatureServe. 2002. NatureServe Element Occurrence Standard. http://www.natureserve.org/prodServices/eodata.jsp. Accessed June 26, 2009.

Pavlik, B.M. 1996. Defining and measuring success. Pp. 127-155 *in* Falk, D.A., C.I. Millar, and M. Olwell, (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Powell, A.M., J.F. Weedin, and S.A. Powell. 2008. Cacti of Texas: A field guide. Texas Tech University Press, Lubbock, Texas. 383 pp.

Shaffer, M.L. and B.A. Stein. 2000. Safeguarding our Precious Heritage. Pp. 301-321 *in* B.A. Stein, L.S. Kutner, and J.S. Adams (eds.), Precious Heritage: The status of biodiversity in the United States. Oxford University Press. 399 pp.

Soil Science Society of America. 2018. Glossary of Soil Science Terms. https://www.soils.org/publications/soils-glossary. Accessed May 23, 2018.

U.S. Congress. 1988. Endangered Species Act of 1973, as amended through the 100th Congress. U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. 2009. Cooperative Endangered Species Conservation Fund (Section 6 of the ESA). http://www.fws.gov/endangered/factsheets/Sec6_Factsheet_2009.pdf. Accessed June 20, 2009.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook: Procedures for conducting section 7 consultations and conferences. https://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF. Accessed September 12, 2016.

Wikipedia.org. 2018. http://en.wikipedia.org/. Articles on clade, correlation and dependence, Cretaceous, digital elevation model, habitat, mating system, metapopulation, monophyly, paraphyly, phylogenetic tree, population, Quaternary, series (botany), species, and Tertiary. Accessed May 23, 2018.

Wiktionary.org. 2018. Definitions of entisol and torriorthent. https://en.wiktionary.org/wiki/. Accessed: May 23, 2018.

**U.S. FISH AND WILDLIFE SERVICE**
**5-YEAR REVIEW of**
***Sclerocactus mariposensis***

**Current Classification**: Threatened.

**Recommendation resulting from the 5-Year Review**:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed.

**Review Conducted By**: Chris Best, State Botanist, Austin Ecological Services Field Office.

**FIELD OFFICE APPROVAL**:

**Lead Field Supervisor, U.S. Fish and Wildlife Service**

Approved _____ Date July 6, 2018