Chisos Hedgehog Cactus
Echinocereus chisoensis W.T. Marshall ssp. *chisoensis*

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW

Chisos hedgehog cactus / *Echinocereus chisoensis* W.T. Marshall var. *chisoensis*

1.0 GENERAL INFORMATION.

1.1 Reviewers.

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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Diversity Database (TXNDD), final reports of Section 6-funded projects, monitoring reports, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and Internet web sites.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 Chisos hedgehog cactus as threatened without critical habitat on September 30, 1988. The State of Texas listed Chisos hedgehog cactus as threatened on December 30, 1988.

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 30-34. For convenience, the first uses of scientific units are spelled out, and are also summarized on page 29. Photographic credits are on page 29.

Since this is the first status review since the species was listed, 30 years ago, we include brief summaries under each topic of the conditions at the time of listing.

Recommended citation:

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. 35 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: 53 FR 38453.
Date listed: September 30, 1988.
Entities listed: *Echinocereus chisoensis* var. *chisoensis* (Chisos Mountain hedgehog 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 Chisos hedgehog cactus. Other review documents include:

Status Report on *Echinocereus chisoensis* and Environmental Assessment (Heil and Anderson 1982a, 1982b).

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

Prior to this review, the Recovery Priority Number for Chisos hedgehog cactus was 9. This indicates that the threat level was moderate, the recovery potential was high, the taxon was a subspecies rather than a species, and no conflicts with construction, development projects, or other forms of economic activity were foreseen. However, see the discussion under Section 2.3.1.1 (taxonomy and phylogenetics).

1.3.6 Recovery Plan or Outline.

Name of plan or outline: Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis var. chisoensis*) Recovery Plan.
Date issued: December 8, 1993.
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 (U.S. Fish and Wildlife Service 2017).

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

> *Establish 50 distinct populations, each consisting of at least 100 reproductive individuals, and demonstrate that the populations are demographically stable and reproductively successful over a 10-year monitoring period.*

Section II.A. (pp. 16-17) of the recovery plan describes the criteria in greater detail and includes these additional statements:

- These 50 populations should be distributed across the available habitat in a manner that is designed to minimize losses from catastrophic events.
- Initial estimates of numbers of populations needed to allow delisting may later be reduced if it can be demonstrated that the demand for field-dug plants is no longer a threat to the variety.
- Each population would need to contain enough individuals and genetic variability to assure viability and reproduction.
- The age-class structure and overall vigor and maturity of the plants must enable the populations to survive a variety of conditions (precipitation and temperature extremes, fluctuations in predator and pollinator populations, etc.) and still remain a genetically viable and self-regenerating population.
- A ten-year monitoring period is necessary to demonstrate reproductive success because these plants do not flower until they are 4-6 years old. The ten year monitoring period will also assure that these populations have not been subjected to intolerable collecting pressures.

- These delisting criteria are preliminary. As more information about the variety is accumulated and recovery tasks are accomplished the criteria will be reevaluated and may be revised.

Discussion

The delisting criterion requires no fewer than 5,000 individuals. Heil and Anderson (1982a) judged that the approximate total population size prior to listing Chisos hedgehog cactus was less than 1,000. The most recent surveys document a total of 1,500 individuals (Schmidt 2017), so the criterion has not been met. The numbers of individuals on several monitoring plots has declined substantially, but the data do not indicate whether the total population is increasing, decreasing, or stable.

The criteria indicated in some cactus recovery plans require comparatively smaller numbers of very large populations. The comparatively large number (50) of smaller populations (100 or more individuals) required under this plan is a more realistic and attainable criterion for cactus (and many other plant) species. This wide dispersal throughout the potential habitat is inherently less vulnerable to catastrophic events, as well as illicit collection—one of the most significant threats. However, the recovery plan does not describe how populations should be delimited; the known geographic distribution of Chisos hedgehog cactus could be interpreted as one metapopulation of many dispersed colonies, or many small populations (see Section 2.3.1.3). Furthermore, we expect that through successful recovery, multiple small, adjacent populations may grow until they coalesce into fewer large populations, but this could reduce the number of populations, making it more difficult to attain the delisting criterion.

Numbers of individuals and of populations are simple, measurable recovery criteria, but these numbers alone are not adequate measures of recovery. A species' viability derives not only from its current condition, but also where it is headed. The combination of size and numbers of populations with other measures of viability, such as recruitment, mortality, and population genetics, are meaningful qualifiers of recovery in this plan. However, successful recruitment of Chisos hedgehog cactus is likely to be strongly correlated with years of higher-than-average precipitation, as has been documented with other cylindrical cactus species (Bowers 1997, p. 42; Arroyo-Cosultchi *et al*. 2016, pp. 57, 59). We expect both recruitment and mortality to occur in pulses, and age-class structure to exhibit wide annual variation, driven by longer-term climate cycles such as the El Niño-Southern Oscillation (ENSO). For this reason, a 10-year monitoring period is not long enough to determine demographic trends, since successful recruitment might only occur once or twice during that span. Age-class structure is also difficult to use as a recovery criterion unless tracked over extended periods of time.

Consequently, as suggested in the current recovery plan, the criteria should now be revised to address:

- The delineation of populations;
- The possible coalescence of multiple small populations into fewer large ones;
- An appropriate span of time to track demographic trends;
- Appropriate measures of population genetic diversity.

2.3 Updated Information and Current Species Status.

2.3.1 Biology and Habitat.

2.3.1.1 Taxonomic classification and phylogenetics:

Summary of prior information.

F. Radley collected the type specimens of Chisos hedgehog cactus on April 10, 1939, which were described by W.T. Marshall (1940) as *Echinocereus chisoensis*, a distinct species. Table 1 lists the distinguishing features.

Table 1. Distinguishing features of Chisos hedgehog cactus (Marshall 1940; Heil and Anderson 1982a; Poole *et al*. 2007).

Feature	Description
Ribs	15 to 16 spiraling ribs formed by confluent, dorsally flattened tubercles.
Radial spines	11 to 14 acicular spines, white with dark brown tips becoming white with age.
Central spines	1 to 4, black.
Flowering areoles	Very long wool.
Flowers	3 to 5 per plant, funnel-shaped, apically rose-colored with white throats and deep magenta centers (see Figure 1b); perianth segments (tepals) oblong, apiculate, entire; ovary and floral tube tuberculate with wooly areoles and 10 to 12 bristles per areole.
Fruits	Dehisce by splitting, nearly dry.

In 1940, Oehme described a closely related taxon from the Mexican states of Durango and Coahuila as *Echinocereus fobeanus*. Benson (1982) placed this taxon and Chisos hedgehog cactus as varieties *fobeanus* and *chisosensis*, respectively, of *Echinocereus reichenbachii*; note that he added the "s" to Marshall's *chisoensis* so the species and location would be spelled the same.

New information.

Botanists consistently recognize Chisos hedgehog cactus as a valid, distinct taxon of the genus *Echinocereus*; however, a consistent spelling and infra-taxonomic classification have not emerged. Table 2 summarizes its recent classifications.

Table 2. Recent classifications of Chisos hedgehog cactus.

Echinocereus chisosensis W.T. Marshall	Zimmerman and Parfitt (2004a, b) in the Flora of North America; Royal Botanical Garden 2018.
Echinocereus chisoensis var. *chisoensis* W.T. Marshall.	Anderson 2001; Poole et al. 2007; Powell *et al*. 2008; Tropicos 2018a, b, c.
Echinocereus chisosensis ssp. *chisosensis* W.T. Marshall	Hunt et al. 2006; ITIS 2018 a,b.
Echinocereus chisoensis W.T. Marshall	NRCS 2018; Royal Botanical Garden 2018.

USFWS has to choose the one best-justified classification. Marshall's description spells the species epithet "*chisoensis*" 5 times, so this spelling was clearly intentional. Benson's arbitrary spelling change violates article 51.1 of the International Code of Botanical Nomenclature (McNeill *et al*. 2012), and creates unnecessary confusion. Therefore, the more justifiable choice is to conserve the original published epithet.

Table 3 summarizes the distinguishing features of *E. chisoensis* infra-taxa. These have been described both as subspecies and varieties. These infra-taxa are geographically isolated by a distance of about 400 kilometers (km) (248 miles (mi)), and surveys have failed to detect intervening populations of either one (Figure 2). The combination of geographic isolation and consistent morphological differences justifies recognition as full subspecies, rather than as varieties.

Table 3. Distinguishing features of *Echinocereus chisoensis* subspecies (Anderson, 2001; Hunt et al. 2006).

Feature	Subspecies *chisoensis*	Subspecies *fobeanus*
Stems	Without annual constrictions.	Often constricted in annual sections.
Flowers	6 centimeters (cm) (2.4 inches (in)) long; bases of inner perianth members deep red (see Figure 1b).	Up to 9.5 cm (3.7 in) long; bases of inner perianth members pale green to light brown.
Elevation range	Below 1,000 meters (m) (3,281 feet (ft)).	Above 1,000 m (3,281 ft).

Finally, the common name for ssp. *chisoensis* has been listed as Chisos Mountains hedgehog cactus (Anderson 2001; Zimmerman and Parfit 2004; ITIS 2018b; NRCS 2018), Chisos pitaya (Evans 1986), and Chisos hedgehog cactus (Heil and Anderson 1982; Heil et al. 1985; Anderson 2001; Powell *et al*. 2008). We concur with Joe Sirotnak, a former botanist at Big Bend National Park (BIBE), who preferred the latter common name, since the subspecies' entire range is in view of, but does not actually occur within the Chisos Mountains (see Figure 1c).

The Genus *Echinocereus* ranges from South Dakota to Oaxaca, Mexico. Sánchez *et al*. (2014) constructed a molecular phylogeny of 59 of the 65 species in 8 sections recognized in Hunt et al. (2006), and also included 10 species in related genera. This study used samples of *E. chisoensis*—presumably subspecies *fobeanus*—from Durango, México. The phylogeny, based on 6 coding and non-coding chloroplast genetic markers, confirmed that *Echinocereus sensu stricto* (minus *E. pensilis*) is monophyletic. Within the genus, they identified 9 monophyletic clades that did not conform to the 8 sections mentioned above. *E. chisosensis* was one of 10 species in clade VIII, and is most closely related to *E. primolanatus*, a species ranging from Coahuila to Jalisco, México.

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

Summary of prior information.

Chisos hedgehog cactus stems average 14.1 cm (5.6 in) tall and 3.9 cm (1.5 in) in diameter; 59 percent have a single stem, and 95 percent have 7 or fewer stems (Evans 1986). The species reaches reproductive age at 4 to 6 years (Heil et al. 1985), flowers from March to early June (Evans 1986), requires outcrossing (Heil and Anderson 1982a), and produces an average of 3 to 4 fruits per plant with 200 to 250 seeds per fruit (Heil et al. 1985); fruits mature from May to August (Evans 1986). Seedlings observed within populations provide evidence of recruitment (Heil et al. 1985). The habitat consists of flat, Quaternary alluvial terrace deposits forming a desert pavement (Heil and Anderson 1982a; Evans 1986), and plants occur at elevations ranging from 636 to 717 m (2120 to 2390 ft) (Evans 1986). The soils are aridisols with a pH ranging from 6.8-7.3 (Heil and Anderson 1982a). Formerly, habitats were probably Chihuahuan Desert grasslands, but were degraded by overgrazing during World War I, and now have only 20 to 30 percent total vegetative cover with few grasses; creosote bush (*Larrea tridentata*) comprises 80 to 90 percent of the vegetation (Heil and Anderson 1982a). Individual Chisos hedgehog cactuses are frequently associated with dog cholla (*Cilindropuntia schottii*) or other nurse plants (Heil and Anderson 1982a). Other associated plants include ocotillo (*Fouquieria splendens*), leather stem (*Jatropha dioica*), Torrey yucca (*Yucca torreyana*), cenizo (*Leucophyllum frutescens*), whitethorn acacia (*Vachellia constricta*), *Dalea* species, lechuguilla (*Agave lechuguilla*), blind prickly pear (*Opuntia rufida*), tasajillo (*Cilindropuntia leptocaulis*), long-spined purplish prickly pear (*O. macrocentra*), Texas prickly pear (*O. engelmannii*), strawberry cactus (*Echinocereus stramineus*), Langtry rainbow cactus (*E. pectinatus* var. *wenigeri*), eagle-claw cactus (*Echinocactus horzonthalonius*), Warnock's cactus (*Echinomastus warnockii*), big-needle pincushion cactus (*Coryphantha macromeris*) and sea-urchin cactus (*Coryphantha echinus*) (Heil and Anderson 1982a). Evans (1986) added little-leaf rattany (*Krameria glandulosa*), pitaya (*Echinocereus enneacanthus*), and guayacán (*Guaiacum angustifolium*) to this list.

New information.

Phenology and reproduction.

Amos and Vassiliou (2001, p. 193) reported the following observations of Chisos hedgehog reproduction in the wild: Most flowering occurs between March 12 and April 10, and may continue if it has rained. Flowers open for 1 (or rarely 2) days between 8:00 to 11:00 am and

close between 1:30 to 5:30 pm. Flowers are homogamous (p. 197); anthers are 5 to 12 mm below the stigma, dehisce when flowers open, and spread away from the stigma after the first pollinator visit. Tepals remain cup-shaped at full anthesis. Pollen grains germinate within 2 hours of deposition on the stigma; stigmas remain receptive when flowers are open. Pollen tubes reach ovules in less than 17 hours. From a total of 154 individuals, 129 flowered; the dry fruits mature in about 1 month and dehisce longitudinally. The breeding system is self-incompatible and requires a pollinator, the pollen/ovule ratio is 1416.7, and the outcrossing index is 4 (p. 194). Fruits (n=73) produced an average of 399 seeds, ranging from 0 to 758 seeds (p. 194–195). There was no significant effect of distance (0.3 to 157 m) between pollen donors and recipients on fruit set (pp. 195–196). Flowers produced little detectable nectar, but large amounts of pollen, and the frequency and diversity of visiting insects was low (p. 196). Of three visiting bee species, *Megachile sidalceae* (Megachilidae) was a rare visitor, and a species of *Dialictus* (Halictidae) was frequent, but not an effective pollinator because it did not contact stigmas; both males and females of *Diadasia rinconis* (Anthophoridae) were the most frequent visitors and used the stigma as a landing and take-off platform (p. 196). *D. rinconis* effectively transferred pollen from the flower of one plant to the stigma of another (p. 196–197). *D. rinconis* is oligolectic on several genera of Cactaceae (*Echinomastus*, *Echinocereus*, *Opuntia*, and *Ferocactus*). There was no evidence of pollinator limitation at these two relatively large populations, but most populations have far fewer individuals (p. 197). Heavy seed predation in 2000 was due to drought. In summary, Chisos hedgehog cactus is a predominantly self-incompatible species that is effectively pollinated by a cactus-specialist bee, *Diadasia rinconis*. There was no evidence of pollen limitation in the two relatively large population studies; 84 percent of individuals flowered and the numbers of fruits and seeds produced indicate a healthy level of fecundity.

Considering the relatively small size of *Diadasia rinconis*, a solitary soil-nesting bee, its maximum forage range is probably between 150 and 600 m (492 and 1,968 ft) (Gathmann and Tscharntke 2002, pp. 760–761; Greenleaf et al. 2007; Ritchie and Jha 2016, p. 916). We expect that the reproductive output of populations with few, widely dispersed individuals, or individuals that are too closely related, would decline. Cross pollination between populations separated by a distance greater than the bee's forage range would be rare, so gene flow between geographically isolated populations would occur only through seed dispersal. Currently, we do not know how seeds disperse. Since the fruits are dry at maturity, they probably are not dispersed by birds or mammals; their dispersal could be limited to gravity and rainfall, or perhaps ants attracted to the seed funiculus (González-Espinosa and Quintana-Ascencio 1986, p. 276; Rojas-Aréchiga and Vázquez-Yanes 2000, pp. 86, 88). Therefore, seed dispersal may also be geographically limited and the frequency of gene flow between neighboring populations may be low.

Bruns and Amos (2015, pp. 205-206) investigated the soil seed bank within populations of Chisos hedgehog cactus. They detected 370 Chisos hedgehog cactus seeds in soil samples collected near 60 plants; samples located 10 cm (3.9 in) from plants had an average of 1.42 seeds, and samples located 25 cm (9.8 in) from plants averaged 0.64 seeds each. Seed density was not significantly influenced by nurse plant species, but significantly more seeds were found south and west versus north and east of plants. Although the authors did not determine the viability of the seeds detected, the study provides evidence that populations do establish

persistent seed banks. The greater density of seeds near mature plants also suggests that a large portion of seeds do not disperse far from parent plants.

Habitat.

Schmidt (2017) constructed predictive models for Chisos hedgehog cactus distribution using the geographic coordinates and data from a census conducted in 2010 by personnel of BIBE. The census included 1,490 individuals, and she found 10 new individuals during her study, bringing the total to 1,500 (p. 18). The most frequent nurse plants included creosote bush, prickly pears, and dog cholla (p. 18). The average values for all plants was: 648 m (2,128 ft) elevation, 1.66° slope, 26.64 cm (10.5 in) precipitation, maximum temperature 30.16° C (86° F), and minimum temperature 12.28° C (54° F) (p. 19). Populations occurred over the Aguja geological formation, which is a late Cretaceous sandstone interbedded with clay. Six variables significantly predicted Chisos hedgehog cactus at the individual scale: slope, aspect, percent canopy cover, geology, soil unit, and soil type (p. 19). Elevation and land cover did not significantly predict individual locations, since all plants were in the scrubland landcover (p. 19-20). The variables associated with a greater probability of individual occurrence were: lower percent slopes, 0 to 15% canopy cover (not including nurse plants), alluvial fans and clays, and the Corazones and Chillon soil units (p. 20).

We used Schmidt's predictive variables to create a model to estimate the amount and distribution of potential habitat in the ArcGIS software. Although elevation was not a useful predictor of individual plants within habitats in Schmidt's study, it is useful to model potential habitats, since all known populations lie within a narrow elevation range. We were not able to use percent canopy cover, since this is a very fine-scale predictor of individual plants rather than entire populations. We constructed the potential habitat model by intersecting four available geographic data layers: 1) Elevations between 550 and 800 m (1,804 to 2,625 ft), obtained from USGS Digital Elevation Models; slopes from 0 to 15 percent, also derived from USGS Digital Elevation Models; 3) Corazones and Chillon soils, obtained from NRCS SSURGO web soil survey data sets (NRCS 2017); and 4) vegetation cover described as "Creosote Scrub" in a digital vegetation map of BIBE, provided to us by the park. We then added a 50-m (164-ft) horizontal buffer as an estimate of the combined geographic errors of the data layers. More than 95 percent of the known Chisos hedgehog cactus locations occur within this potential habitat model (see Figure 3), which totals 34,426 hectares (ha) (85,066 acres (ac)). Figure 3 does not show the geographic coordinates of individual Chisos hedgehog cactuses, as this could aid illicit collection; however, all known individuals occur within the red oval on the map. Potential habitats, as defined by the four parameters described here, are not shown, but probably occur outside of BIBE and across the Rio Grande/Bravo in Coahuila, but to date no individuals have been found outside the red oval. Nevertheless, a revised recovery plan should consider the possible benefits of establishing redundant populations in other portions of the potential habitat to reduce the species' vulnerability to catastrophic loss. Finally, as we learn more about the subspecies' ecological requirements, the potential habitat model used here can be improved.

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

Summary of prior information.

Heil and Anderson (1982a) estimated that fewer than 1,000 individuals of Chisos hedgehog cactus occurred within a small area of BIBE. Although similar habitats occur across the Rio Grande/Bravo, near Boquillas, Coahuila, the subspecies had not been found in Mexico. By the early 1980s, anecdotal evidence indicated that the population had declined significantly, possibly due to illicit collection and prior habitat degradation.

Evans (1986) surveyed the known habitat at BIBE (see Figure 1c and Figure 3) from March 13, 1984, to January 18, 1986. He detected 127 individuals of Chisos hedgehog cactus on 13 transects totaling 99.54 km (61.8 mi) in length. The locations of Chisos hedgehog cactus individuals ranged from 636 to 717 m (2,087 to 2,352 ft) elevation.

New Information.

Population, site, location, and other terms are often used interchangeably or ambiguously to describe the geographic distributions of rare plants. NatureServe (2002) defines Element Occurrences (EOs) as "area(s) of land and/or water in which a species or natural community is, or was, present." TXNDD has adopted the EO standard for tracking records of plants, animals, and habitats of conservation concern. TXNDD provided its EO records and shapefiles of Chisos hedgehog cactus to USFWS on February 14, 2017 (Texas Natural Diversity Database 2017). These 12 EO records coincide with the geographic coordinates described in Schmidt (2017). Figure 3 does not show these EO records, due to concerns about illicit collection, but all lie within the red oval indicated.

We searched for records of *Echinocereus chisoensis, E. chisosensis,* and *E. fobeanus*, including their respective infra-taxa (chisoensis and fobeanus), in Mexican herbarium databases through REMIB (*Red Mundial de Información sobre Biodiversidad*; CONABIO 2018). We found no records from any Mexican herbaria for the subspecies or variety *chisosensis* or *chisoensis,* but REMIB found one record for *E. chisosensis* var. *fobeanus* at the Royal Botanic Gardens, Kew, England. We then searched the Royal Botanic Gardens herbarium database, which revealed the aforementioned collection (*Echinocereus chisosensis* var. *fobeanus* (Oehme) N.P. Taylor, Specimen 51651) by H. Kunzler along the Durango-Coahuila border (no date given), and an additional specimen (65066) is listed as *E. chisoensis* var. *fobeanus* (Royal Botanic Garden 2018).

In March, 2016, personnel of BIBE and USFWS collected data from Chisos hedgehog cactus in 3 monitoring plots. The populations within these plots had declined substantially since 2011 (2011 and 2012 were years of exceptional drought at this site), and had not recovered. However, these plots were not representative samples of the entire population. The population decline on the plots is alarming, but it is not possible to extrapolate the plot data to determine an overall demographic trend.

Schmidt (2017, described above) reported a total of 1,500 individual Chisos hedgehog cactuses, including 1,490 individuals detected in a 2010 census, and 10 new individuals she found during her field work. Thus, it might appear that the total population had increased more than 50 percent since the time of Heil and Anderson's status report (1982a). However, the earlier figure was only an approximate figure rather than an actual count.

In summary, the most recent information confirms that Chisos hedgehog cactus is extant in the same areas where it was known when it was listed as threatened. Populations may have declined during recent exceptional droughts, but we have insufficient information to detect any general demographic trends during this 30-year span.

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 Chisos hedgehog cactus, nor do we possess the baseline demographic and life history data needed to perform these calculations. Table 4 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 Chisos hedgehog cactus. Two factors require fewer individuals (perennial lifespan and climax successional status), four are intermediate or unknown (intermediate growth form, moderate fecundity, moderate ramet production, and unknown longevity of seed viability), and three require more individuals (outcrossing, low survivorship (indicated by recent high mortality in monitoring plots), and high environmental variation (wide variation in annual precipitation)), suggesting an estimated MVP for Chisos hedgehog cactus in the intermediate range (roughly 1,000 to 1,500 individuals). 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 seedlings 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 matured and germinated and the proportion of surviving seedlings.

Table 4. Minimum viable population guidelines applied to Chisos hedgehog 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		**Outcrossing**
Growth Form	Woody	**Intermediate**	Herbaceous
Fecundity	High	**Moderate**	Low
Ramet Production	Common	**Moderate**	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 criterion of 100 individuals (in each of 50 populations) may be an order of magnitude too low. As discussed in Section 2.3.3, this criterion is problematic because the recovery plan does not define how populations should be delineated. Like many cactus species, Chisos hedgehog cactus is distributed through its habitat in relatively small, scattered colonies. This distribution pattern may be driven by natural factors, since larger populations may be more vulnerable to decimation by parasites or herbivores (U.S. Fish and Wildlife Service 2017, pp. 27-28, 31, 39-40). For this reason, it may be more practical to apply the estimated MVP to metapopulations that consist of many colonies of varying size spread across an area of contiguous habitat.

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). Considering the narrow endemism and limited geographic range of Chisos hedgehog cactus, its populations—which may constitute a single metapopulation—cannot be completely independent. For example, variation in climate, such as extended drought or catastrophic rainfall, would likely affect all sub-populations similarly. Metapopulation redundancy cannot be achieved for this species unless a) additional geographically independent wild metapopulations are discovered elsewhere, or b) additional metapopulations are successfully reintroduced in distinct areas of potential habitat.

2.3.1.4 Conservation measures:

Protection and conservation at Big Bend National Park.

The entire known global population of Chisos hedgehog cactus lies within BIBE. The National Park Service manages all species on their lands in accordance with the National Park Service Organic Act of 1916. Since the park is federally owned land, it is 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 Chisos hedgehog cactus, including the National Park Services' operations and management of the park, are subject to consultation with USFWS under section 7 of the ESA.

BIBE monitors populations of Chisos hedgehog cactus, and its law enforcement officers discourage illegal collection.

Section 7 consultations.

BIBE consulted with USFWS under section 7 of the ESA in the development of its Exotic Plant Management Plan (2012). We concurred that the actions described in the plan are not likely to jeopardize the continued existence of Chisos hedgehog cactus (U.S. Fish and Wildlife Service 2015). To the contrary, these actions will benefit Chisos hedgehog cactus and other listed threatened cactus species by reducing competition from buffelgrass 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).

No section 6-funded grants have been awarded that address conservation and recovery of Chisos hedgehog cactus. However, 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 Chisos hedgehog cactus and 3 other federally listed plants at BIBE. We have received proposals that address this priority for Fiscal Year 2018; however, grant selections for FY 2018 have not yet been announced.

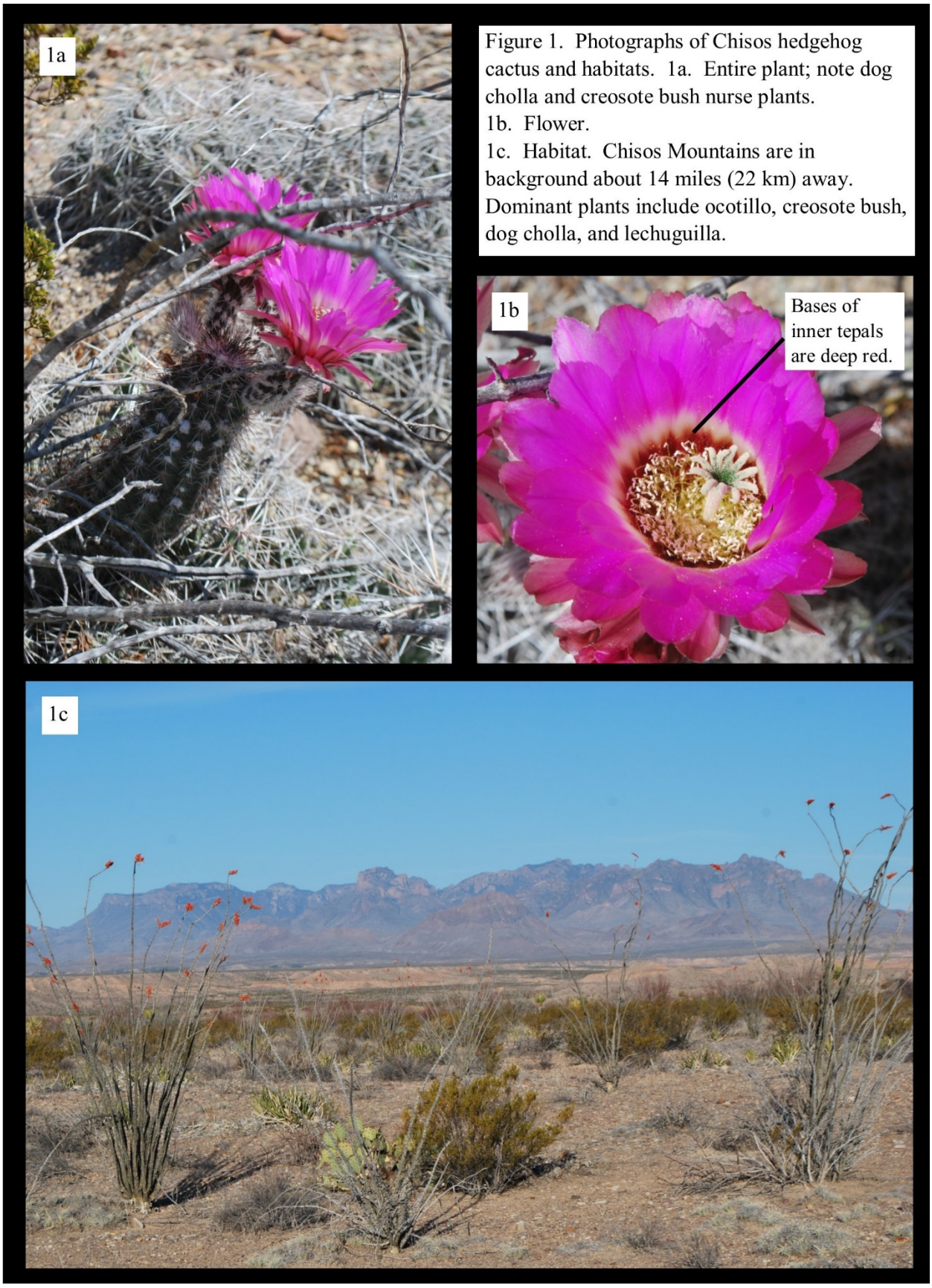
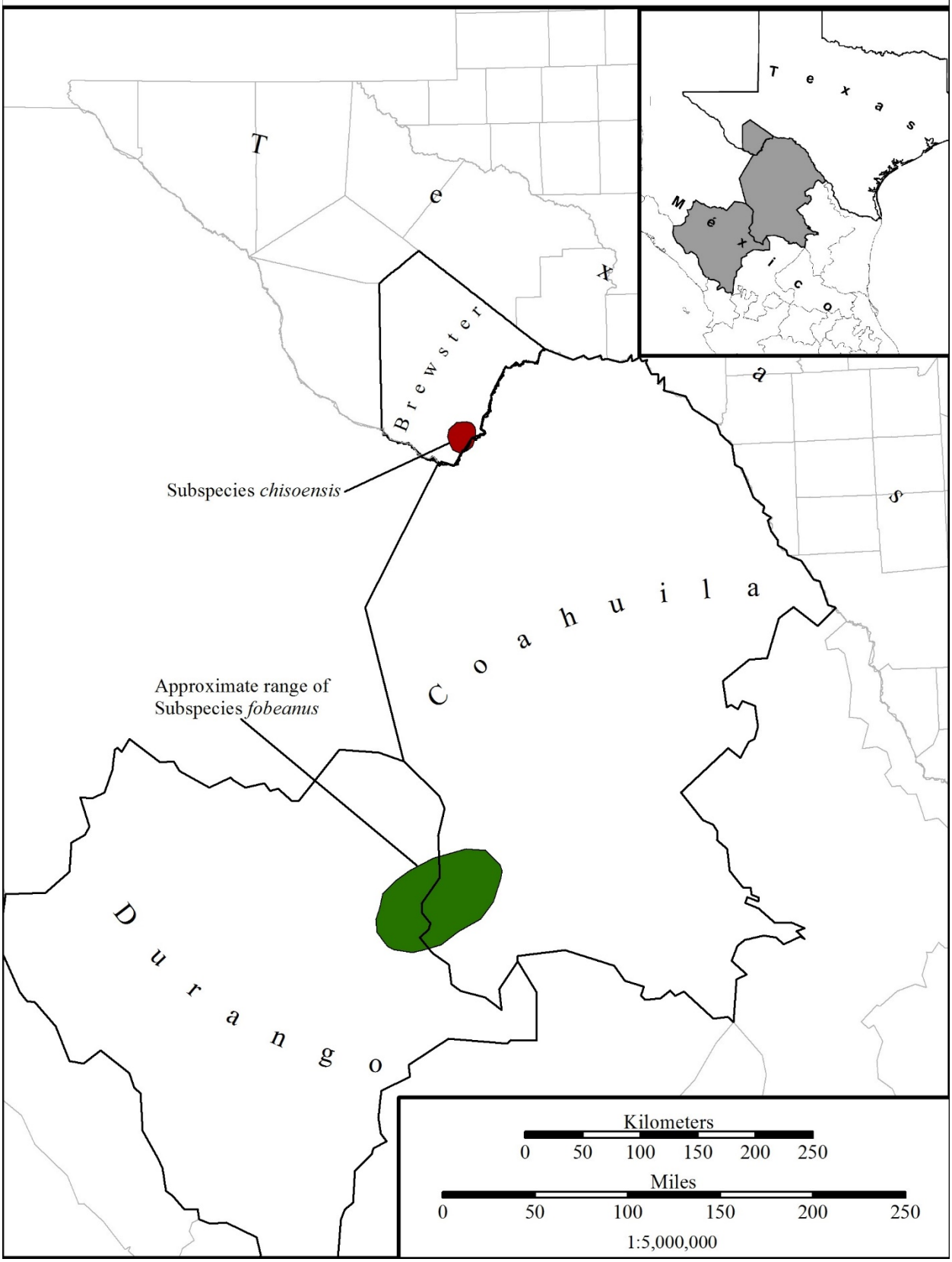


Figure 1. Photographs of Chisos hedgehog cactus and habitats. 1a. Entire plant; note dog cholla and creosote bush nurse plants.
1b. Flower.
1c. Habitat. Chisos Mountains are in background about 14 miles (22 km) away. Dominant plants include ocotillo, creosote bush, dog cholla, and lechuguilla.

Figure 2. Geographic distribution of *Echinocereus chisoensis* subspecies.



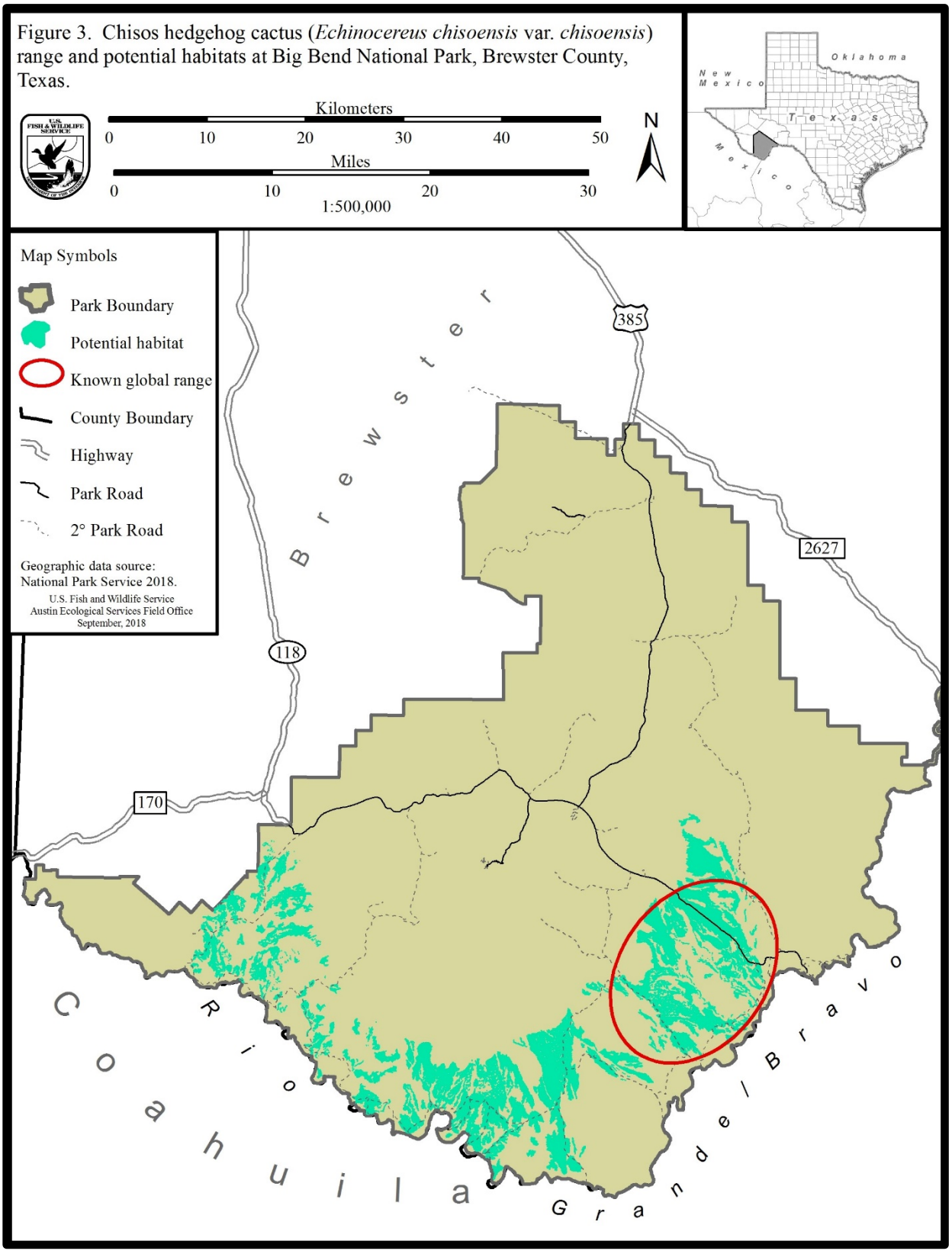


Figure 3. Chisos hedgehog cactus (*Echinocereus chisoensis* var. *chisoensis*) range and potential habitats at Big Bend National Park, Brewster County, Texas.
Kilometers
0 10 20 30 40 50
Miles
0 10 20 30
1:500,000
N
Oklahoma
New Mexico
Texas
Mexico
Map Symbols
Park Boundary
Potential habitat
Known global range
County Boundary
Highway
Park Road
2° Park Road
Geographic data source: National Park Service 2018.
U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
September, 2018
Brewster
385
2627
118
170
Coahuila
Rio Grande/Bravo

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

Table 5 (below) summarizes and compares threats to Chisos hedgehog cactus described in the federal listing and recovery plan, and our current understanding of threats.

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

Overgrazing in the early 20th Century depleted the native grass cover and the seedling establishment substrate (Heil and Anderson 1982a), and may have increased soil erosion and shrub encroachment (U.S. Fish and Wildlife Service 1993). Three quarters of a century after the park was established and livestock were removed, there appears to be little regeneration of native grass cover within the known populations of Chisos hedgehog cactus. This modification of habitat, including soil erosion, continues to threaten the species. We have no information on the current trend of shrub encroachment.

Schmidt (2017) documented the encroachment of the introduced invasive buffelgrass (*Pennisetum ciliare*) near an area of occupied habitat. Buffelgrass threatens to outcompete Chisos hedgehog and its host plants, and also increases the risk of wildfire. Buffelgrass disperses rapidly in the disturbed soils along roads and trails before spreading into adjacent intact habitats; 39.0 km (24.2 mi) of roads and trails pass through the occupied habitats of Chisos hedgehog cactus (U.S. Fish and Wildlife Service 2015, p. 8).

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

Heil and Anderson (1982a) stated that Chisos hedgehog cactus is sold commercially and is probably collected illegally from BIBE. An incidence of poaching occurred in 1990 (U.S. Fish and Wildlife Service 1993, p. 11). Personnel at BIBE do not know the current extent of illegal collection (Schmidt 2017, p. 16); listing as a threatened subspecies has stimulated greater public awareness of the conservation need, and federal protection has probably reduced the incidence of poaching. Nevertheless, poaching will continue to be a potential threat as long as there are avid cactus collectors who seek specimens dug from wild populations. Portions of the population that are nearest roads and trails are at greater risk of poaching.

2.3.2.3 Disease or predation:

The recovery plan (U.S. Fish and Wildlife Service 1993, p. 11) reported that jackrabbits (*Lepus* sp.) or rodents damage Chisos hedgehog cactus plants during periods of dry weather. Personnel of BIBE and USFWS also observed mortality of Chisos hedgehog cactus individuals from herbivory at monitoring sites in March, 2016, following several years of exceptional drought. Thus, herbivory is not only brought on by drought, but exacerbates mortality from other causes 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 entire known range of Chisos hedgehog cactus at BIBE.

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 Chisos hedgehog cactus that occur along the Rio Grande/Bravo.

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. Chisos hedgehog cactus was listed as endangered by the State of Texas on December 30, 1988. 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 without a TPWD permit.

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

Population genetics.

The federal listing states, “Any further reduction in plant numbers could reduce the reproductive capabilities and genetic potential of this cactus.” (53 FR 38455). Small, isolated plant populations are vulnerable to genetic drift, loss of genetic diversity, and inbreeding depression. However, the population genetics of Chisos hedgehog cactus have not been investigated; we have no evidence of the extent of the actual impacts of these potential threats.

Climate change.

The federal listing also states, “Long or short term climatic changes may be creating drier conditions in the area, possibly contributing to a population decline.” The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013) projects the following changes by the end of the 21st 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° Celsius (C) (0.5° to 3.1° Fahrenheit (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, the Fifth Assessment Report does not simulate regional precipitation patterns well. Milly *et al*. (2005) project a 10–30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

We do not know whether the climate changes that have already occurred have affected the populations or distribution of Chisos hedgehog 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, Chisos hedgehog 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 followed by extreme rainfall could damage habitats through erosion. At present, we cannot predict how the infinitely complex aggregation of climate changes will affect the synecology of Chisos hedgehog cactus populations and habitat. Therefore, we will adapt our recovery and management strategies when necessary to address the changing conditions; however, our ability to make sound decisions will depend on periodic, verifiable monitoring of the species' status.

We conclude that Chisos hedgehog cactus populations and habitats are currently threatened by: Continued vegetation changes and soil erosion following a period of overgrazing during the early 20th Century; encroachment of invasive buffelgrass into habitats, resulting in increased competition and the risk of wildfire; poaching from cactus collectors; and increased herbivory during droughts. The species may be threatened by the construction of new border walls and related infrastructure through its habitats. Due to its small population sizes, Chisos hedgehog cactus may be threatened by the loss of genetic integrity, although this has not been investigated. 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 5. Factors affecting the survival of Chisos hedgehog cactus.

53FR 38453 and Recovery Plan	This review
A. The present or threatened destruction, modification, or curtailment of its habitat or range.	
• Former overgrazing reduced native grass cover and may have removed substrate for seedling establishment. • Soil erosion and shrub encroachment are secondary results of overgrazing. • Populations near roads and trails are vulnerable to road maintenance and trail construction.	• Despite 75 years of conservation, the native grass cover has not recovered in Chisos hedgehog habitats. • Soil erosion within the habitat is evident; the extent of shrub encroachment is unknown. • Buffelgrass has now invaded disturbed soils along roads and trails and threatens to spread into habitats.
B. Overutilization for commercial, recreational, scientific, or educational purposes.	
• Greatest immediate threat is commercial and private collection. • Plants adjacent to public road are visible and vulnerable to taking.	• Current extent of poaching is unknown, but is likely to continue.
C. Disease or predation.	
• Rodent or jackrabbit predation during drought.	• Mortality from herbivory increases during drought and exacerbates mortality from other causes. • This threat may become more severe if the incidence of drought increases.
D. The inadequacy of existing regulatory mechanisms.	
• National Park Service regulations prohibit taking of natural resources—including Chisos hedgehog cactus—from park. • Listed in Appendix II 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.	
• Total population size of 1,000 and limited geographic distribution create vulnerability to natural catastrophic events and human impacts. • Long and short-term climate changes may lead to reduced precipitation and population declines.	• Small isolated populations are subject to genetic drift, loss of genetic diversity, and inbreeding. • 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.

A consensus among experts has not emerged to favor any one of multiple scientific and common names. We prefer *Echinocereus chisoensis* subspecies *chisoensis* and Chisos hedgehog cactus, respectively. The known range of Chisos hedgehog cactus has not changed since it was listed as threatened. The available information on its demography suggests opposing trends. On one hand, extensive monitoring in 2010 and 2017 documented 1,500 individuals, so the known population size is much greater than the initial approximations during the 1980s. On the other hand, populations declined substantially in 3 non-representative monitoring plots during the exceptional droughts of 2011 and 2012, and had not recovered by 2016. This data does not indicate whether the total population is increasing, decreasing, or stable. Listing as a threatened subspecies has stimulated greater public awareness of the conservation need, and federal protection has probably reduced the incidence of poaching. Buffelgrass invasion represents a new threat that the park is managing through its draft Exotic Species Management Plan. Border wall construction could impact part of the population. The recovery plan should be revised to incorporate updated guidance and specific, measurable recovery criteria that clarify the delineation of populations; the use of a minimum viable population level as a recovery criterion may be more practically applied to metapopulation. Additionally, the ten-year monitoring period is not long enough to detect demographic trends. We do not recommend changing the ESA classification of Chisos hedgehog cactus.

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:

12C.

Brief Rationale:

The Recovery Priority Number for Chisos hedgehog cactus prior to this review was 9, meaning that it incurred a moderate degree of threat, the recovery potential was high, and it was a variety or subspecies. No conflict with construction, development projects, or other forms of economic activity were foreseen. Our current assessment is that the degree of threat remains moderate: the species will not immediately become extinct if recovery actions are delayed. However, since Chisos hedgehog cactus is endemic to a very restricted range, it has no population redundancy, and therefore the potential for full recovery potential is low. Chisos hedgehog cactus is a subspecies. 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 12C (moderate threat, low recovery potential, subspecies, conflict).

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS.

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 that clarify the delineation of populations; the use of a minimum viable population level as a recovery criterion may be more practically applied to metapopulation. The ten-year monitoring period is not long enough to detect demographic trends.
- The best-justified taxonomic classification is *Echinocereus chisoensis* subspecies *chisoensis*.
- The best-justified common name is Chisos hedgehog cactus.
- Continue to improve the potential habitat model as we learn more about the ecological requirements. Conduct expanded surveys based on this model, using representative sampling and appropriate statistical methods to determine reliable estimates of the total population size. Design an efficient sampling protocol that can be repeated at intervals to determine demographic trends.
- Establish a controlled propagation and reintroduction plan; collect seeds, following Center for Plant Conservation Guidelines, representing the range of the subspecies' ecological and genetic diversity; develop propagation methods; and reintroduce the propagated Chisos hedgehog cactus plants into other portions of the potential habitat range to create redundant populations.
- 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 Chisos hedgehog cactus.

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ABBREVIATIONS OF SCIENTIFIC UNITS

Abbreviation	Scientific Unit
ac	acres
cm	centimeters
° C	degrees Celsius
° F	degrees Fahrenheit
ft	feet
ha	hectares
in	inches
km	kilometers
m	meters
mi	miles

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).
Alluvium	Loose, unconsolidated soil or sediments, eroded, deposited, and reshaped by water in some form in a non-marine setting (Wikipedia 2018).
Anther	The pollen-bearing part of the stamen. (Correll and Johnston 1979).
Anthesis	The period when a flower is receptive to fertilization.
Apiculate	"A shape ending abruptly in a short, protruding point (an apiculation), but not a hard prickly point…" (Powell *et al*. 2008, p. 357).
Areole	Specialized axillary bud or short shoot in cactus species; the spine cushion, producing leaves, spines, and flowers (Anderson 2001, p. 695.)
Aridisol	In U.S. soil taxonomy, soils of arid or semi-arid climates that have very low organic matter, predominant water deficiency, and sub-soil weathering and development; limited leaching often results in subsurface mineral horizons of silicate clays, sodium, calcium carbonate, gypsum, or soluble salts (Wikipedia 2018).
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, p. 695).
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.
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.
Dehiscent	Structure that naturally splits open along lines of mechanical weakness.
Demography	Scientific study of populations.
Desert Pavement	A desert soil surface of tightly packed rock fragments typically occurring in alluvial fans (Wikipedia 2018).
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).
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).
El Niño—Southern Oscillation (ENSO)	Year-to-year variations in sea- surface temperatures, convective rainfall, surface air pressure, and atmospheric circulation that occur across the equatorial Pacific Ocean. El Niño and La Niña refer to above- and below-average sea-surface temperatures (respectively) that periodically develop across the east-central equatorial Pacific (NOAA 2018).
Element Occurrence	An area of land and/or water in which a species or natural community is, or was, present (NatureServe 2002).
Endemic	An organism restricted to a specific habitat or geographic range.
Epithet	The species name in a binomial taxonomic classification.
Funiculus	Attachment or stalk between the ovary wall and the ovule (Anderson 2001, p. 696).
Genetic drift	A change in allele frequencies within a population over time.
Genetic structure	Any pattern in the genetic makeup of individuals within a population (Wikipedia 2018).
Habitat	Ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism (Wikipedia 2018).
Homogamy	Maturation of a plant's male and female sexual organs at the same time (Wikipedia 2018).
Inbreeding depression	The reduction of fitness caused by mating between relatives (Edmands 2007, p. 464).
Infra-taxa	A subdivision of a taxon (e.g., infra-species).
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).

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.
Monophyly	A group of organisms that consists of all the descendants of a single common ancestor.
Nurse Plant	A plant that creates a suitable habitat for the establishment of another plant.
Oligolecty	Bee species that have a narrow, specialized preference for pollen source plants (Wikipedia 2018).
Outcross	In plants, sexual fertilization involving the union of gametes from different individuals.
Perianth	The floral envelopes collectively; usually used when calyx and corolla are not clearly differentiated. (Correll and Johnston 1979).
pH	A measure of the acidity or basicity of a solution approximately equal to p[H], the negative logarithm (base 10) of the molar concentration of dissolved hydronium ions (H3O+). (Wikipedia 2018).
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, p. 697).
Ramet	An individual, genetically-identical plant reproduced as a clone of the parent plant.
Self-incompatible	Incapable of self-fertilization.
Shapefile	A digital geospatial vector data storage format developed by Esri. (Wikipedia 2018).

Soil seed bank	Dormant and non-dormant seeds present in the soil that are able to germinate.
Species	One of the basic units of taxonomic identity (Wikipedia 2018). 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.
Species viability	A species' ability to sustain populations in the wild beyond the end of a specified time period, assessed in terms of its resilience, redundancy, and representation (USFWS 2015).
Stigma	The receptive part of the pistil on which the pollen germinates. (Correll and Johnston 1979).
Sub-population	A distinct portion of a larger population or metapopulation.
Subspecies	A taxonomic group that is a division of a species; usually arises as a consequence of geographical isolation within a species (Biology-online.org 2011).
Synecology	Ecology of groups of coexisting organisms.
Taxon	(Plural, taxa). A natural group of organisms at any rank in the taxonomic hierarchy (Anderson 2001, p. 698).
Taxonomy	Scientific classification of living organisms.
Tepal	Sterile leaflike structure of the flower when the perianth parts are not differentiated into sepals and petals (Anderson 2001, p. 698).
Transect	An ecological sample unit of relatively narrow width and much greater length conducted in a specified direction.
Tubercle	A conical or cylindrical outgrowth or protuberance from a cactus stem, usually bearing all or part of the areole; podarium (Anderson 2001, p.698).
Type specimen	A specimen upon which the description of a new taxon is based.
Variety	A taxonomic rank below subspecies in botany (Biology-online.org 2011).
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.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of
ECHINOCEREUS CHISOENSIS ssp. CHISOENSIS

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