Lee Pincushion Cactus (*Coryphantha sneedii* var. *leei*)

5-Year Status Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
Albuquerque, New Mexico
August 2023

5-YEAR REVIEW

Species reviewed: Lee Pincushion Cactus (*Coryphantha sneedii* var. *leei*)

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5-YEAR REVIEW

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1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office:
Janess Vartanian, Recovery Biologist, Recovery and Restoration, Ecological Services, Southwest Region Headquarters Office, (505) 248-6657

Lead Field Office:
Chuck Hayes, Supervisory Fish and Wildlife Biologist, New Mexico Ecological Services Field Office (NMESFO), (505) 761-4754

Katie Sandbom, Fish and Wildlife Biologist, NMESFO, (505) 761-4709

Cooperating Field Office(s):
Not Applicable

Cooperating Regional Office(s):
Not Applicable

1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species ESA (ESA) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.3 Methodology used to complete the review:

The Service conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the Act. We provided notice of this status review via the Federal Register (88 FR 1602), requesting information on the status of *Coryphantha sneedii* var. *leei* (Lee pincushion cactus). In addition, we contacted Carlsbad Caverns National Park, Bureau of Land Management

(Carlsbad Field Office and New Mexico State Office), and California Botanic Garden (Rancho Santa Ana Botanic Garden) and submitted an information request via Botanic Gardens Conservation International's PlantSearch application. We received responsive information from the Bureau of Land Management, Carlsbad Caverns National Park, and California Botanic Garden. Our review is based on this information, existing information in our records, and new information discovered during searches of online information databases, such as SEINet, Natural Heritage New Mexico's New Mexico Conservation Information System, Center for Plant Conservation's National Collection of Rare and Endangered Plants, Bureau of Land Management's Mineral and Land Records System, Data.gov (U.S. government open data), the Federal Register, Google Search, and Google Scholar. This review was conducted by Katie Sandbom and Chuck Hayes (NMESFO).

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

88 FR 1602–1604, January 11, 2023

1.4.2 Listing history:

Original Listing
FR notice: 44 FR 61554
Date listed: October 25, 1979
Entity listed: Subpecies, Coryphantha sneedii var. leei
Classification: Threatened, without critical habitat

1.4.3 Associated Rulemakings:

None

1.4.4 Review History:

U.S. Fish and Wildlife Service (Service). 2015. Lee pincushion cactus (*Coryphantha sneedii* var. *leei*) and Sneed pincushion cactus (*Coryphantha sneedii* var. *sneedi*) 5-year review: Summary and evaluation. Albuquerque, New Mexico: U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office: No change in classification recommended.

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

Coryphantha sneedii var. *leei*: 3

The recovery priority number (3) indicates a subspecies with high threats and high recovery potential.

1.4.6 Recovery Plan or Outline

Name of plan or outline: Recovery Plan for Coryphantha sneedii var. sneedii (Sneed pincushion cactus) and Coryphantha sneedii var. leei (Lee pincushion cactus): Amendment 1
Date issued: August 28, 2018
Dates of previous plans/amendment or outline, if applicable: Sneed and Lee Pincushion Cacti Recovery Plan, approved March 21, 1986.

2.0 REVIEW ANALYSIS

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The ESA defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The ESA requires that we determine whether a species meets the definition of "endangered species" or "threatened species" due to any of the five factors described below.

Section 4(a) of the Act describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Service recommends whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

2.1 Distinct Population Segment (DPS) policy (1996):

Lee pincushion cactus is a plant that would not be subject to the Distinct Population Segment policy, which applies to vertebrate animals.

2.2 Updated Information and Current Species Status

2.2.1 Biology and Habitat

2.2.1.1 New information on the species' biology and life history:

The 1986 recovery plan (Service 1986, pp. 8–13) provides a baseline for our understanding of Lee pincushion cactus' (hence forward, Lee's) biology, life history, and species' needs. Updates to the information contained in the 1986 recovery plan include observations about geological substrate specificity (Horton et al. 2017, unpaginated; Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture 2022, unpaginated), microhabitat types (National Park Service 1996b, p. 1), elevation range (Zimmerman 1985, p. 355), associated species (Pierce and Castetter 1962, 1379; Burgess 1979, pers. comm. Sivinski and Lightfoot 1991, 1796; Chauvin et al. 1999, p. 3; Chauvin and Milford 1999, YDC-136; Tonne 2002, Appendix 1; Tonne 2003, Appendix 2; Tonne 2005 Appendix 2), plant size ranges, growth, and time to maturity (National Park Service 1996b, p. 1), flowering period (Zimmerman 1985, pp. 354–355), fruiting period (Zimmerman 1985, pp. 354–355), and lack of seed dormancy (Cactus Art Nursery n.d., unpaginated).

2.2.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, birth rate, seed set, germination rate, age at mortality, mortality rate, etc.), or demographic trends:

Our understanding of Lee's abundance and distribution is confounded by uncertainty about the taxonomic identity of *Escobaria sneedii* individuals in the Guadalupe Mountains. Historically, we considered Lee's and Sneed pincushion cactus (*Escobaria sneedii* var. *sneedii*) as being sympatric within the Guadalupe Mountains, with the subspecific identity of Lee's and Sneed pincushion cactus determined by morphological characteristics of individual plants (Service 1986, p. 5). Sneed's pincushion cactus is now understood to be restricted to areas farther west, in the Franklin and Organ mountains and adjacent foothills (Porter 2023b, pers. comm.). Therefore, we consider *Escobaria sneedii* individuals within the Guadalupe Mountains previously identified as Sneed pincushion cactus (hence forward, Sneed's-form) to be Lee's, consistent with Lee's previous five-year review (Service 2015, p. 10).

Under this approach, we consider all plants with dominantly Lee's-like morphology (having several, tiny, immature stems with numerous, relatively short, stem-obscuring spines) to be Lee's (Barlow-Irick 1995, p. 7). However, Sneed's-form plants have traits intermediate between Lee's and Guadalupe pincushion cushion cactus (*Coryphantha sneedii* var. *guadalupensis*; hence forward, Guadalupensis), and some taxonomists assign Sneed's-form individuals to the dominant "parent" taxon (Lee's or Guadalupensis) in the geographic area (Zimmerman 1993, pers. comm. Baker and Johnson 2000, p. 580; Porter 2023a, pers. comm.). Therefore, the taxonomic identity of Sneed's-form plants in Guadalupensis occurrence areas is uncertain. Resolution of this uncertainty could potentially alter our understanding of Lee's abundance and distribution.

In this review, we assign Sneed's-form plants within the geographic range of plants exhibiting classic Lee's morphology (appressed spines) to one core population and representation area (consisting of the Serpentine Bends/Dark Canyon/Crooked Creek, Walnut Canyon, Rattlesnake Canyon, North Slaughter Canyon/Middle Slaughter Canyon, Bear Canyon, Midnight Canyon, Putnam Canyon, West Slaughter Canyon, and Yucca Canyon occurrences) and Sneed's-form plants beyond the geographic range of plants exhibiting classic Lee's morphology to another (consisting of the Lefthook Canyon, Double Canyon, Cottonwood Canyon, Gunsight Canyon, and Big Canyon occurrences). This distinction is supported by preliminary phylogenetic evidence (Porter 2023b, pers. comm.). Therefore, we report on all observations of Sneed's-form plants within the Guadalupe Mountains and distinguish between those found within occurrences assigned to Lee's, those found within occurrences assigned to Guadalupensis, and those that are found within unassigned occurrence areas (Porter 2020, unpublished data; Porter 2023a, pers. comm.) to help elucidate current and future demographic trends.

In 2015, we understood Lee's to include individuals from six canyons (Service 2015, p. 7). We now understand Lee's to occur within 10–15 canyons or canyon complexes, depending on the taxonomic identity of Sneed's-form plants within Guadalupensis occurrence areas (Table 1; see, also, section 2.2.1.5). Sneed's-form plants in the five southmost canyons (Big Canyon to Lefthook Canyon) aren't known to co-occur with plants exhibiting classic Lee's traits. Given our 2015 Lee's range extent estimate of 22 km (Service 2015, p. 7), we likely did not consider plants within these canyons in our last analysis of Lee's status. Except for the addition of Sargent Canyon, which was discovered in 2022, this increase in occurrence areas doesn't represent new detections or range expansion because the remaining occurrence areas have been documented since at least 2001.

Table 1. Lee's and Sneed's-form occurrence areas. Occurrence areas are listed by relative geographic location, approximately southwest to northeast. These occurrence areas include plants in smaller side canyons, surrounding ridges, and smaller, adjacent canyons. The putative taxon value is the accepted taxon that Lee's and/or Sneed's-form occurrence areas have been historically assigned to. N = no, Y = yes, blue cell colors highlight Y values, lighter cell hues highlight occurrences that we consider to constitute one core population and darker cell hues highlight occurrences that we consider to constitute the other. *Under the operational classification used in this review, we consider the Sneed's-form plants within the Bear Canyon occurrence area to be within the geographic range of plants exhibiting classic Lee's morphology.

Occurrence Area	Putative Taxon	Lee's Documented	Sneed's-form Documented	Guadalupensis Documented
Big Canyon	Guadalupensis	N	Y	Y
Gunsight Canyon	Undetermined	N	Y	N
Cottonwood Canyon	Guadalupensis	N	Y	Y
Double Canyon	Undetermined	N	Y	N
Lefthook Canyon	Undetermined	N	Y	N
West Slaughter Canyon	Lee's	Y	Y	N
Yucca Canyon	Lee's	Y	Y	N
Putnam Canyon	Lee's	Y	Y	N
Midnight Canyon	Lee's	Y	Y	N
Middle Slaughter Canyon and North Slaughter Canyon	Lee's	Y	N	N
Bear Canyon*	Undetermined	N	Y	N
Rattlesnake Canyon	Lee's	Y	Y	N
Walnut Canyon	Lee's	Y	N	N
Serpentine Bends, Dark Canyon, and Crooked Creek	Lee's	Y	Y	N
Sargent Canyon	Lee's	Y	N	N

Census surveys (or occurrence area boundaries and random density plots) are needed to quantify abundance within all occurrence areas, pending resolution of the taxonomic identity of Sneed's-form individuals. Lee's has been inconsistently monitored through space and time; therefore, abundance and trend estimation is speculative. Further, most of the available information about Lee's abundance is from over 20 years ago. Available historic trend information is derived from targeted plots (plots placed in high density areas rather than at randomly or systematically located points). Therefore, we can't reliably estimate population parameters (such as population abundance and population growth rate) from the available data because targeted plots are more likely to experience density-dependent effects that result in plot abundance declines that may not be representative of overall population trends (Buckley et al. 2010, p. 1193). Further, targeted plots are established based on occupancy, and initially unoccupied plots are needed to detect recruitment in available habitat outside of historically occupied areas. Additionally, plot census count and abundance trend results are somewhat confounded by detectability, taxonomic uncertainty, and misidentification. Overall, targeted plots may bias growth rates low (based on density-dependent effects and inability to detect recruitment outside of historically occupied areas), low detectability may bias growth rates high (as pre-existing individuals are discovered during subsequent surveys; it can take at least six passes through a survey area to detect all individuals present (Roller 1996, p. 27)), and taxonomic uncertainty and/or misidentification may bias growth rates low (as plants initially identified as Lee's mature and are identified as belonging to an alternate taxon). Further, Lee's occupies steep, rugged, remote terrain, so there has been limited survey effort for this species relative to the extent of potential habitat for this species (Sivinski and Lightfoot 1991, p. 129).

In 1984, Ken Heil speculated that there were approximately 2,000 Lee's plants and several thousand Sneed's-form plants in Carlsbad Cavern National Park (Ecosphere Environmental Services 1984, pp. 2–3). In 1977, based on information from Burgess, Zimmerman (1985, p. 359) roughly estimated that there were 10,000 or fewer Lee's, including populations transitional to "var. *sneedii*." Heil and Brack (1985a, p. 9; 1985b, pp. 128–129) speculated that there were 1,000–2,000 Lee's and at least 100,000 Sneed's-form plants in Carlsbad Caverns National Park. However, their estimate of the abundance of Sneed's-form plants is confounded by also including Guadalupensis individuals, which they didn't distinguish as a separate taxon until the following year (Heil and Brack 1986, p. 165). Sivinski (1991, p. 129) observed that Sneed's-form plants were common within their occupied habitats. These estimates are based on extrapolation of observed habitat areas. To date, approximately 1,450 Lee's and/or Sneed's-form plants have been counted (including potential duplicate counts) since 1977 in the Guadalupe Mountains and adjacent foothills. Abundance observations by occurrence area are documented below.

Big Canyon

Dunmire (1990b, pp. 2–4) documented three Sneed's-form plants near the mouth of Big Canyon, noting that identification may be in error. Sivinki (1991, p. 128) noted that Sneed's-form plants were present on a ridge northeast of Calamity Cove. Bureau of Land Management (BLM) (2020, unpublished data) documented seven Sneed's-form points during presence/absence surveys along Big Canyon Ridge.

Gunsight Canyon

Sivinski (1991, p. 128) observed that Sneed's-form plants were present on the ridge south of lower Gunsight Canyon.

Cottonwood Canyon (putative Guadalupe pincushion cactus area)

Sivinski (1991, p. 128) observed few, scattered Sneed's-form plants in upper Cottonwood Canyon. Baker (2001c, 14111) noted that he saw approximately 15 Sneed's-form plants on Guadalupe Ridge in the vicinity of an herbarium specimen collection site. BLM (2020, unpublished data) documented 12 Sneed's-form points during presence/absence surveys through a known occupied portion of Guadalupe Ridge.

Double Canyon

Sivinski (1991, p. 128) observed 10 Sneed's-form plants on a ridge on the middle fork of Double Canyon and several dozen Sneed's-form plants on a ridge on the upper north fork of Double Canyon. Baker (2001e, 14119) noted that he saw approximately 50 Sneed's-form plants near the mouth of Double Canyon in the vicinity of an herbarium specimen collection site but observed that many plants looked unhealthy, especially at lower elevations.

Lefthook Canyon

Ecosphere Environmental Services (1984, p. 2) observed that Sneed's-form plants were present in Lefthook Canyon.

West Slaughter Canyon

In 1977, Burgess (1979, pers. comm.) noted three Lee's in a side canyon off West Slaughter Canyon near the terminus of Midnight Canyon and six Lee's on a steep slope about three-fourths of the way up West Slaughter Canyon. He also observed that Lee's was locally uncommon at a saddle on a ridge between West Slaughter Canyon and a small canyon in a reef escarpment about three quarters of the way up West Slaughter Canyon and that Lee's was present on the south rim of West Slaughter Canyon. Baker (2001d, 14115) noted that he saw approximately 50 Sneed's-form plants near the mouth of Slaughter Canyon in the vicinity of an herbarium specimen collection site. Tonne (2002, Appendix 1) observed 22 Lee's along (within 50 ft of either side of) the Slaughter Canyon

Cave Trail. BLM (2020, unpublished data) documented 15 points for Sneed's-form plants during a hasty presence/absence survey in the Slaughter Canyon Cave Trail area.

Yucca Canyon

In 1977, Burgess (1979, pers. comm.) observed a solitary Lee's near the mouth of Yucca canyon and several Lee's along the ridge west-southwest of the top of Yucca Canyon Trail. He noted that Lee's was never really common but that plants were more frequent along the top of the cliff and less common toward the center of the ridge. Tonne (2002, Appendix 1) noted 15 Lee's along (within 50 feet (ft) of either side of) the Yucca Canyon access road and 35 plants at 26 locations along (within 50 ft of either side of) Yucca Canyon Trail. BLM (2020, unpublished data) documented five Lee's points and one Sneed's-form point during a hasty presence/absence survey up the north ridge at the mouth of Yucca Canyon.

Putnam Canyon

This occurrence has been documented twice. Burgess (1979, pers. comm.) noted that Lee's was present in Putnam Canyon on a slope below Putnam Cabin. Baker (2001b, 14107) noted approximately 25 Sneed's-form plants in the upper reaches of Putman Canyon in the vicinity of an herbarium specimen collection site.

Midnight Canyon

This occurrence has only been documented once, by Burgess (1979, pers. comm.), who noted four plants in Midnight Canyon. Only one of these plants was noted as definitively Lee's. The other three plants may have been Sneed's-form plants.

Middle Slaughter Canyon/North Slaughter Canyon

This occurrence area is along the ridge separating Middle Slaughter Canyon and North Slaughter Canyon. Burgess (1979, pers. comm.) noted a single Lee's in North Slaughter Canyon on a north-facing slope along a trail to Putman Cabin. In 1995, no Lee's were observed along Ogle Cave Trail (north side of the mouth of Slaughter Canyon), and one Sneed's-form plant was observed in the vicinity of the cave entrance (Barlow-Irick 1995, p. 6). Tonne (2002, Appendix 1) observed 31 Lee's along (within 50 ft of either side of) Middle Slaughter Canyon Trail.

Bear Canyon

This occurrence has only been documented once, by Baker (2001a, 14106), who noted approximately 20 Sneed's-form plants on Guadalupe Ridge above Bear Canyon in the vicinity of an herbarium specimen collection site.

Rattlesnake Canyon

In 1977, Wagner and Sabo (1977, p. 1) noted that Lee's was fairly common on the tops of ridges overlooking tributaries to Rattlesnake Canyon, and Burgess (1979, pers. comm.) noted that it was widely scattered over a slope in Rattlesnake Canyon. In 1989, there were 42 live Lee's individuals (with one not relocated and two new individuals since 1985) in targeted recreation effects monitoring plots along Rattlesnake Canyon Trail (National Park Service 1989, p. 5). In 1995, there were still 42 live individuals in these plots (Dobos Bubno et al. 1997, p. 2). Dobos Bubno et al. (1997, p. 4) provisionally estimated Lee's density in Rattlesnake Canyon as 36.4 (95% CI: 19.75–87.87) plants per hectare in primary habitat, based on density in these plots. In 2005, Tonne (2005, p. 3) observed 151 plants in 70 patches along (within 50 ft of either side of) Rattlesnake Canyon Trail. In 2012, Gulf South Research Corporation (Gulf South Research Corporation, p. 7) noted 61 flowering individuals while collecting samples in Rattlesnake Canyon for a genetics study.

Walnut Canyon

Observations within Walnut Canyon are concentrated along the western half of Walnut Canyon Desert Drive. In 1997, Burgess (1979, pers. comm.) observed that there were several Lee's along limestone ledges on a northeast-facing slope at the east end of the main occupied ridge but that Lee's was generally uncommon there. Brack (1983, p. 1) observed that Lee's was rather widespread in Walnut Canyon. Baker (1998, 13076) observed numerous individuals locally along upper Walnut Canyon Drive. In 2003, Tonne (2003, Appendix 2) observed 86 Lee's at 41 points along (within 50 ft of either side of) Walnut Canyon Desert Drive.

In 1984, 1988, and 1992, the National Park Service (NPS) observed 28, 150-meter (m) radius, recreation effects monitoring plots along two targeted transects downslope of, and parallel to, Walnut Canyon Desert Drive (National Park Service 1984, entire; National Park Service 1988, entire; National Park Service 1992, entire). In 1984, 234 plants were documented within plots (National Park Service 1984, pp. 11–15). In 1988, 254 plants were documented in plots, and 236 of those were alive (National Park Service 1988, pp. 4, 7–19). In 1992, 318 plants were documented within plots, and 309 of those were alive (National Park Service 1992, entire). This gives us a deterministic annual plot growth rate of 1.0401 (average annual plot abundance increase of 4.01%). Given the available information, however, we can't discern what proportion of new individuals were overlooked in previous monitoring events versus what proportion represent new recruitment. For example, most "new" plants documented in 1988 appeared too large to represent new recruitment within 4 years (National Park Service 1988, p. 4 (annotated)), and 14–27 plants not relocated in 1988 were relocated in 1992 (National Park Service 1988, pp. 4 (annotated), 7–19; National Park Service 1992, entire), suggesting detection difficulties. Therefore, while abundance within Walnut Canyon plots appears to

have been increasing between 1984 and 1992, we're unsure if the data represents an increasing population growth rate or an increase in detections. In 1992, NPS estimated density in Walnut Canyon as 91.9 plants per hectare in primary habitat, based on N = 112 in these targeted plots (National Park Service 1992, p. 6 (annotation)).

Following the 2011 Loop wildfire, survival in burned areas was estimated at 59.5% in 2013 (Muldavin et al. 2013, p. 8). Between 2014 and 2018, within 1 m radius, fire effects monitoring plots, deterministic annual plot growth rates were 0.9932 (average annual plot abundance decline of 0.68%) in unburned plots, 0.9833 (average annual plot abundance decline of 1.67%) in burned plots, and 0.9889 (average annual plot abundance decline of 1.11%) in all (burned and unburned) plots (Roth 2018, unpublished data). In 2018, there were 128 live plants in these plots. While detection is more reliable in these smaller plots, these plots are highly targeted and, therefore, likely to bias growth rates low, exhibiting decline that's not representative of trends within the occurrence area as a whole.

Serpentine Bends/Dark Canyon/Crooked Creek

Two Lee's were discovered around Crooked Creek in 1989 (Dunmire 1990a, unpublished data). One additional Lee's was discovered in Dark Canyon in 1998 (Ladyman et al. 1998, p. 3). Follow-up surveys in 1999 identified 80 Lee's in the local area of the 1998 Dark Canyon occurrence (Chauvin et al. 1999, p. 2). Presence/absence surveys in 2020 documented 162 Lee's and four Sneed's-form (166) points throughout BLM lands in the Dark Canyon/Serpentine Bends area.

Sargent Canyon

BLM (Goss 2022, pers. comm.) observed one individual here. Presence/absence surveys are needed to identify the extent of this occurrence before quantifying abundance via census surveys or plot sampling.

2.2.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The taxonomic identity of Sneed's-form plants in the Guadalupe Mountains is uncertain. Assuming that Sneed's-form individuals don't represent their own, unique taxon and that they aren't hybrids, Sneed's-form individuals demonstrate phenotypic plasticity and/or genetic variation within Lee's.

No studies have investigated population genetics for Lee's, so the status of, and trends in, Lee's genetic diversity within and between populations is unknown. Preliminary phylogenetic results suggest the presence of some gene flow between West Slaughter Canyon and Yucca Canyon, between Big Canyon and Cottonwood Canyon (based on a phylogenetic tree), and between these sets of

canyons (based on STRUCTURE groupings) (Porter 2023b, pers. comm.). Additional sequencing and analysis are needed to evaluate if gene flow exists among other occurrence areas within Lee's range.

Loss of genetic diversity from inbreeding and/or genetic drift can be speculated from self-compatibility and effective population sizes. Lee's self-compatibility is unknown. Effective population sizes below 50 are associated with deleterious consequences from inbreeding, and effective population sizes of at least 500 are needed to maintain adaptive potential (sustain allelic diversity against genetic drift) (Mace and Lande 1991, pp. 151–154; Jamieson and Allendorf 2012, p. 578). Lee's range-wide "census" abundance has historically been speculated as between 1,000–2,000 or 10,000, excluding Heil and Brack's (1985b, p. 129) Sneed's-form abundance estimate of 100,000, which is confounded by inclusion of Guadalupensis individuals (Zimmerman 1985, p. 359; 1985a, p. 9; 1985b, p. 128). The average effective population size to census population size ratio is 0.10 (Jamieson and Allendorf 2012, p. 578). Applying this ratio to our ranges of historic population size estimates, we estimate that historic effective population sizes may have been somewhere between 100–200 or 1,000 (median = 200, average = 433). This estimate assumes that all known Lee's and Sneed's-form occurrences within the Guadalupe Mountains (excluding the Sargent Canyon occurrence) are a single biological population because it's based on range-wide abundance estimates. However, we consider Lee's to consist of two core populations. Therefore, we suspect that Lee's may be experiencing a loss of evolutionary potential from loss of diversity through genetic drift. Populations with effective populations sizes less than 500 have a compromised capacity to adapt to changing environmental conditions.

2.2.1.4 Taxonomic classification or changes in nomenclature:

Lee's remains a valid taxon. It can more reliably be distinguished from closely related taxa by location than morphology. We maintain the understanding that Lee's is restricted to the Guadalupe Mountains and adjacent foothills (Service 2015, p. 10). In 2015, we described Lee's as including plants in the Guadalupe Mountains previously identified as Sneed's-form plants (Service 2015, p. 10). Sneed's-form plants have several, tiny, immature stems with numerous, relatively short, stem-obscuring spines (like Lee's) that are exerted, rather than appressed (like Guadalupensis) (see figures 1–4) (Ecosphere Environmental Services 1984, p. 2; Zimmerman 1985, p. 357; Zimmerman 1993, pers. comm.; Barlow-Irick 1995, p. 7; Baker and Johnson 2000, p. 583; Service 2015, p. 10; Porter 2023b, pers. comm.).

Figure 1. Example of *Escobaria sneedii* individuals from the Serpentine Bends occurrence area (accepted Lee's occurrence area) that were identified as Lee pincushion cactus (Bureau of Land Management 2020, unpublished data; Porter 2020, unpublished data). Upper ruler numbers are in centimeters.

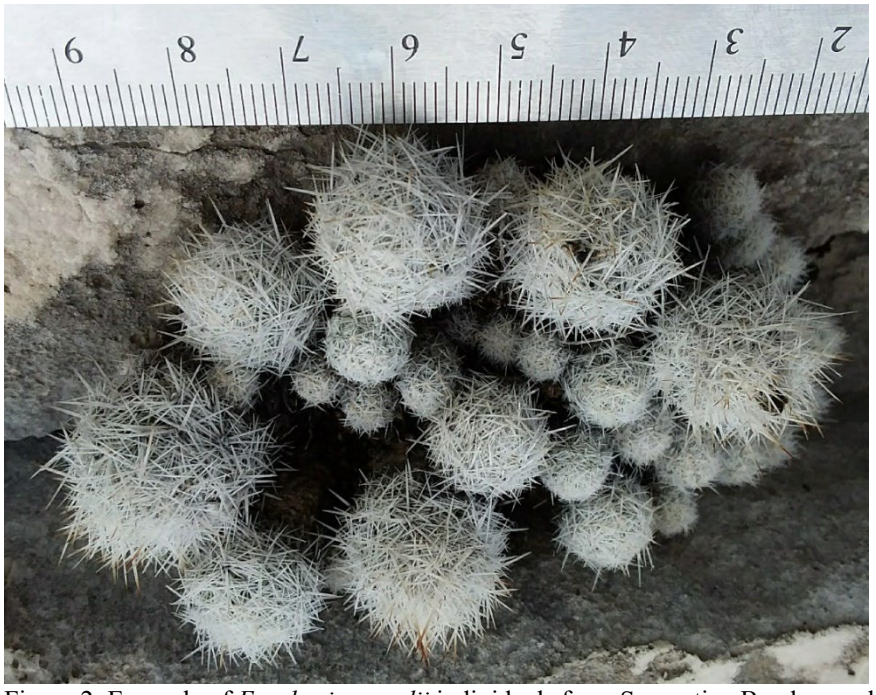

Figure 2. Example of *Escobaria sneedii* individuals from Serpentine Bends population occurrence area (accepted Lee's occurrence area) that were previously identified as Sneed pincushion cactus (Bureau of Land Management 2020, unpublished data; Porter 2020, unpublished data). Ruler numbers are in centimeters.

Figure 3. Example of *Escobaria sneedii* individuals from the Big Canyon and Cottonwood Canyon occurrence areas (putative Guadalupensis occurrence areas) that were previously identified as Sneed pincushion cactus (Bureau of Land Management 2020, unpublished data; Porter 2020, unpublished data). Ruler numbers are in centimeters.

Figure 4. Example of *Escobaria sneedii* individuals from the Tejas Trail occurrence area (accepted Guadalupensis occurrence area) in Guadalupe National Park (Bureau of Land Management 2020, unpublished data; Porter 2020, unpublished data). Ruler numbers are in centimeters.

The taxonomy of *Coryphantha* has undergone revisions since Lee's was listed under the Act. *Coryphantha sneedii*, previously considered a synonym for *Escobaria sneedii* (Missouri Botanical Garden 2023, unpaginated; Integrated Taxonomic Information System (ITIS) n.d., unpaginated), is now also considered a synonym for *Pelecyphora sneedii* (Boyle et al. 2013, unpaginated;

World Flora Online 2023, unpaginated). A recent phylogenetic study of taxa within the genus *Coryphantha* supports the traditional recognition of *Coryphantha* and *Escobaria* as separate genera, but proposes to merge the *Escobaria* genus (Britton and Rose 1923, pp. 53–57) into the *Pelecyphora* genus (Ehrenberg 1843, Col. 737–738; Turland et al. 2018, Art. 11.3; Sánchez et al. 2022, pp. 122–125). Currently, both *Escobaria sneedii* and *Pelecyphora sneedii* are accepted names by different sources (Boyle et al. 2013, unpaginated; Missouri Botanical Garden 2023, unpaginated; World Flora Online 2023, unpaginated; ITIS n.d., unpaginated).

Some authorities recognize several varieties or subspecies within an *Escobaria* (or *Coryphantha*) *sneedii* complex (hence forward, the Sneedii complex) (Zimmerman 1985 pp. 179–180, 186–189; Lüthy 1999, p. 278; Powell and Worthington 2018, pp. 363–365). Based on a phylogenetic study of taxa within the Sneedii complex, these taxa fall within four major, geographically isolated evolutionary lineages (major branches in the *Pelecyphora* phylogenetic tree). Some or all of these major lineages may meet the definition of a species, but for consistency with existing, accepted taxonomy, we assume that all of these lineages fall under, and contain one or more taxonomically valid subspecies or varieties of, *Pelecyphora sneedii*. We call these lineages (east to west) (Porter 2023b, pers. comm.):

- **Albicolumnaria**, including
    - *Escobaria sneedii* subsp. *albicolumnaria* (Hester) Lüthy;
- **Leei**, including
    - *Escobaria sneedii* Britton & Rose var. *leei* (Rose ex Boed.) D.R.Hunt,
    - *Coryphantha sneedii* var. *guadalupensis* (S.Brack & K.D.Heil) A.D.Zimmerman, and
    - *Escobaria sneedii* subsp. *villardii* (Castetter & al.) Lüthy);
- **Sneedii**, including
    - *Escobaria sneedii* Britton & Rose var. *sneedii*,
    - *Escobaria sneedii* subsp. *organensis* (D. Zimmerman) Lüthy, and
    - *Escobaria sneedii* subsp. *sandbergii* (Castetter & al.) Lüthy).
- **Orcutii**, including
    - *Escobaria sneedii* subsp. *orcuttii* (Boed.) Lüthy and

- *Escobaria sneedii* var. *macraxina* (name adapted here from *Escobaria orcuttii* var. *macraxina* Castetter, P. Pierce & K.H. Schwer.).

Each of the taxa listed within these major lineages is genetically, geographically, and—for the most part—morphologically distinct. Therefore, we consider Lee pincushion cactus (*Pelecyphora sneedii* var. *leeii,* the taxon listed as *Coryphantha sneedii* var. *leeii*) to be a taxonomically valid infraspecific taxon that is distinct from *Pelecyphora sneedii* var. *guadalupensis*. Sneed pincushion cactus is now understood to be restricted to the Franklin and Organ mountains and adjacent foothills. Therefore, we consider *Pelecyphora sneedii* individuals within the Guadalupe Mountains previously identified as Sneed pincushion cactus to be Lee pincushion cactus, consistent with Lee's previous five-year review (Service 2015, p. 10).

2.2.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, pollinator availability, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

Due to increased survey effort, the extent of Lee's range has expanded since the time of listing, when it was only known to occur in Carlsbad Caverns National Park. Lee's and/or Sneed's-form individuals are now known to occur on U.S. Forest Service (USFS), NPS, and BLM lands, and there is potential for Lee's to also occur on State and private lands.

Lee's relatively continuous known range (excluding the Sargent Canyon occurrence) extends approximately 30 kilometers (km) (19 miles (mi)) southwest to northeast (including Sneed's-form individuals within putative Guadalupensis occurrence areas) or approximately 15 km (9 mi) southwest to northeast (excluding those populations). In 2015, we documented Lee's range as approximately 22 km. The discrepancy between our 22 km 2015 estimate and our 15 km current estimate does not represent range contraction; rather, it's a product of omitting inaccurately geolocated historic records from the current analysis.

Lee's occupies steep, rugged, remote terrain, so there has been limited survey effort for this species relative to the extent of potential habitat for this species. However, in 2020, BLM (2020, unpublished data) conducted extensive presence/absence surveys through areas on BLM lands identified as high potential habitat in both of two, independently generated distribution models. These surveys significantly expanded the known extent of the Serpentine Bends occurrence area (discovered in 1998), but no new occurrence areas were identified.

The BLM Carlsbad Field Office and NPS Carlsbad Caverns National Park continue to conduct project clearance surveys in Lee's potential habitat. In

2022, a single, disjunct Lee's individual was located during a BLM project clearance survey in atypical habitat (along the crest of a low, limestone ridge with gravelly loam soils in the north Guadalupe Mountains foothills) (Goss 2022, pers. comm.). This disjunct individual (the Sargent Canyon occurrence) is approximately 58 km (36 mi) northwest of the north-most Lee's in the Serpentine Bends area. No additional Lee's individuals have yet been located in the Sargent Canyon area, but survey effort has been limited. When the Serpentine Bends occurrence area was first discovered, which is now known to be at least 6 km (4 mi) in extent, a single Lee's plant was observed during surveys (Ladyman et al. 1998, pp. 2–3). A year later, 80 plants were documented near the only plant observed in 1998 (Chauvin et al. 1999, p. 2). Approximately 20 years later, in 2020, 122 points were documented during hasty presence/absence surveys. Therefore, there's potential that a significant, undiscovered, Lee's population exists in the Sargent Canyon area. Further, vast areas of potential habitat between Sargent Canyon and Serpentine Bends remain unsurveyed, so there's potential for future discovery of additional, intervening Lee's populations as well.

2.2.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Lee's occupies steep, rugged, remote terrain, so there has been limited survey effort relative to the extent of potential habitat for this species. Therefore, habitat and ecosystem conditions are largely unknown. Zimmerman (1985, p. 360) and Baker (2001e, 14119) observed that Lee's and Sneed's-form plants appeared to be stressed by the more arid conditions in lower elevation areas; plant appeared unhealthy, patches were confined to moister microhabitats, and/or recruitment of seedlings appeared to be limited. Therefore, habitat suitability and availability may be decreasing with increasing temperatures (Zimmerman 1985, p. 360; Baker 2001e, 14119).

2.2.1.7 Other:

None.

2.2.1.8 Conservation Measures:

Efforts to ameliorate threats to Lee's include endangered plant protections, special land use designations and management prescriptions, research and monitoring, and outreach and education.

Endangered Plant Law, Regulation, and Policy

Lee's is currently listed as a Federally threatened species without designated critical habitat, a BLM special status species, and a New Mexico endangered species. Each of these statuses confers some level of protection for Lee's plants.

Overall, harm to Lee's plants without a valid permit is prohibited across the species' range, except for incidental take associated with agricultural activities.

The Act prohibits unpermitted import, export, removal and reduction to possession from lands under Federal jurisdiction, commercial transport, and sale or offer for sale of endangered plant species (50 CFR § 17.61); requires Federal agencies, in consultation with the Service, to ensure that Federally authorized, funded, or implemented actions are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat; and directs Federal agencies to use their authorities to carry out conservation programs for the recovery of listed species (16 U.S.C § 1536(a)(1)).

BLM special status species are managed for conservation and/or recovery on BLM-administered lands, in accordance with BLM Manual 6840 (Special Status Species Management), by minimizing and eliminating factors that limit species viability and/or enhancing habitat quality (MS 6840.2.C). While listed as a BLM special status species, project clearance surveys are conducted and potential effects to Lee's within potential habitat areas are analyzed during environmental reviews of proposed projects, even if the species is delisted under the Act. Federally listed plants are retained as BLM special status species for at least 5 years post-delisting. This manual is currently under revision (Goss 2023, pers. comm.), so the extent of future policy protections under this manual could increase, decrease, or remain static.

Under New Mexico endangered plant rules (19.21.2 NMAC), the taking of endangered plants, other than pursuant to a permit issued by the state forester, is prohibited in New Mexico. Therefore, it is illegal to remove, harm, kill, destroy, possess, transport, export, sell, or offer for sale any New Mexico endangered plants, or parts thereof, from the places in the State of New Mexico where they naturally grow—including lands under any Federal, State, private, or other non-tribal jurisdiction—other than by Tribal members for religious purposes, as an incidental result of agricultural practices, or by Federal employees working within their lands of jurisdiction for the purposes of scientific study or propagation. This prohibition of take of State endangered plant species is new in 2023, so the effectiveness of regulatory protections for Lee's plants at the state level in New Mexico are currently uncertain.

Special Land Use Designations and Management Prescriptions

A significant portion of Lee's range is afforded protections via special designations. Exceptions include the recently discovered Sargent Canyon Lee's occurrence and, possibly, the Big Canyon and Cottonwood Canyon Sneed's-form occurrences, which are only afforded incidental habitat protections via the Guadalupe Cave Resource Protection Area. However, because some mineral withdrawal areas on BLM and USFS lands are currently expired and because

Lincoln National Forest and BLM Carlsbad Field Office are currently revising their land use plans, the extent of future protections on USFS and BLM lands could increase, decrease, or remain static.

USDA Forest Service

Lincoln National Forest was permanently withdrawn from mineral entry in 1902, subject to prior rights (Serial Case Number NMNM106272159) (Bureau of Land Management n.d., unpaginated; Bureau of Land Management n.d.f, entire). A second 20-year withdrawal for Guadalupe Cave Resource Protection Area located on the Guadalupe Ranger District (Serial Case Number NMNM105956009) expired in 2021 and is pending renewal (87 FR 3580). Guadalupe Cave Resource Protection Area is managed for cave resources and dispersed recreation activities. There are no management prescriptions for this area, excepting the mineral withdrawal, that directly benefit Lee's (USDA Forest Service 1986, pp. 111–112). The Guadalupe Cave Resource Protection Area is proposed for continuation in the new Lincoln National Forest land management plan, which is pending finalization (USDA Forest Service 2021, pp. 145, 152–154).

National Park Service

Carlsbad Caverns National Park was permanently withdrawn from mineral entry in 1978, subject to prior rights (Serial Case Number NMNM105911041) (Bureau of Land Management n.d., unpaginated; Bureau of Land Management n.d.g, entire). The biodiversity of Carlsbad National Park's Chihuahuan Desert and other ecosystems, including Lee's pincushion cactus, is a fundamental resource and value of this park (National Park Service 2017, pp. 6, 14–15). Current resource and general management plans contain the following conservation and recovery actions for Lee's.

- Control release of information concerning sensitive resources, internally and externally (National Park Service 2006, SOP No. 04-16).

- Restrict permitted cave access to existing trails (National Park Service 2006, p. 28).

- Document locations of listed cactus species during the course of cave inventory and documentation efforts (National Park Service 2006, p. 28).

- Conduct parkwide surveys of threatened or endangered species and their critical habitat (National Park Service 1974, p. 12; National Park Service 1996a, p. 17).

- Conduct a photo-monitoring program for all threatened and endangered cacti (National Park Service 1996a, p. 17).

- Implement Lee's 1986 recovery plan (National Park Service 1996a, p. 17).

- Exclude livestock from, and restore natural systems in, the park (National Park Service 1974, pp. 52, 61–61, 86; National Park Service 1996a, p. 17).

- Control nonnative plant species in the park (National Park Service 1996a, p. 17).

Bureau of Land Management

Portions of the Serpentine Bends/Dark Canyon/Crooked Creek occurrence area are permanently withdrawn under The Lechuguilla Cave Protection Act of 1993 (Public Law 103-169; 59 FR Docket Number 94-3260) but not yet registered within BLM's Mineral and Land Records System (Bureau of Land Management n.d. unpaginated). Other portions of this occurrence area were temporarily withdrawn from mineral entry in 2000, subject to prior rights (Serial Case Number NMNM106102589), to provide additional protection to the Lechuguilla Cave system (Bureau of Land Management n.d., unpaginated; Bureau of Land Management n.d.h, entire). This withdrawal expired in 2020, and its renewal status is unknown.

On BLM lands, Lee's and Sneed's-form plants are also currently provided protections by the following special designations: Dark Canyon Area of Critical Environmental Concern (ACEC), Dark Canyon Scenic Area, Lonesome Ridge ACEC, and—to a lesser extent—by the Guadalupe Escarpment Scenic Area, which contains some unsurveyed habitat within this species' range (Bureau of Land Management 1988, pp. 34–35, 39, C-10–C-13 C33–C34). The Dark Canyon ACEC and Dark Canyon Scenic Area are collectively referred to as the Dark Canyon Special Management Area (SMA) (Bureau of Land Management 1988, p. C-10). All documented Lee's and Sneed's-form plants on BLM lands in the Serpentine Bends/Dark Canyon/Crooked Creek and Big Canyon occurrence areas are within areas proposed to remain or become ACECs under BLM's new resource management plan (RMP), which is currently pending finalization (Bureau of Land Management 2018, pp. 2-52, Appendix A Map 2-55). In the draft new RMP, Lonesome Ridge ACEC is expanded slightly and the portions of the Dark Canyon SMA that contain documented Lee's and Sneed's-form occurrences are contained within a new proposed Serpentine Bends ACEC.

These areas are managed to protect natural resource values and are closed for future mineral leasing, recommended for withdrawal for locatable minerals, closed to salable minerals, avoided or excluded for rights-of-ways (ROWs), closed for geothermal renewable energy, excluded for solar and wind renewable energy, and open for grazing (Bureau of Land Management 1988, pp. C-10–C-13; Bureau of Land Management 2018, Appendix A). The Dark Canyon SMA/Serpentine Bends ACEC is currently designated as open for (but proposed

to be managed as limited to existing roads and vehicle trails for) vehicle travel, and the Lonesome Ridge ACEC is closed to vehicle travel. Currently, fire suppression and geophysical activities are restricted to be consistent with travel designations (Bureau of Land Management 1988, pp. C-10–C-13).

Research and Monitoring

NPS, BLM, USFS, New Mexico's Forestry Division, the National Fish and Wildlife Foundation, and/or the Service have been conducting or funding inventories and/or studies that enhance our understanding of Lee's distribution, abundance, life history, and stressor resilience since before Lee's was listed. Such efforts include conducting presence/absence inventory surveys throughout the species' range, monitoring density and demography in recreation and fire effects plots, conducting project clearance surveys in known occupied areas and unsurveyed habitat, and conducting morphometric and phylogenetic analyses to address taxonomic uncertainties.

Difficultly differentiating this species from other *Pelecyphora*/*Escobaria* taxa and the resulting uncertainty about the taxonomic identity of this species have complicated research and monitoring. A new phylogenetic study of the Sneedii complex is underway, and final findings are pending additional sample sequencing and analysis. Once the taxonomic controversies surrounding these taxa are resolved, research and monitoring should be able to continue more confidently and effectively.

Ex-situ Collections

There are an unknown number of Lee's individuals from wild and cultivated sources in ex-situ conservation and private plant collections. A search of botanical garden records returned six collections searching for Lee's under *Coryphantha* and nine collections searching for Lee's under *Escobaria* (Botanic Gardens Conservation International n.d., unpaginated). It is unknown if these are redundant or additive records. There are no ex-situ conservation seed or other germplasm collections documented in the Center for Plant Conservation's records (Center for Plant Conservation n.d., unpaginated).

Outreach and Education

Nationally, the Service and NatureServe maintain websites that provide public conservation information about Lee's. At the state level, Natural Heritage New Mexico and New Mexico's Forestry Division partner to maintain a website that provides public conservation information about Lee's. Globally, the IUCN's Red List's public conservation information doesn't address the listed varieties of *Escobaria sneedii*.

2.2.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

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

Lee's 1986 recovery plan lists the construction, use, and maintenance of recreation attractant features (such as roads, trails, picnic areas, and campsites) and ungulate trampling as potential threats to habitat (Service 1986, pp. 16–17). In addition to these, fire suppression activities; range improvement construction, use and maintenance; pesticide applications; and, potentially, decreases in air quality are documented habitat threats (New Mexico Rare Plant Technical Council 1999b, unpaginated; Service n.d., unpaginated).

When initially listed, Lee's was only known from Carlsbad Caverns National Park (Service 1986, p. 5). Since then, additional Lee's occurrences have been documented on BLM lands and additional Sneed's-form occurrences have been documented on BLM and USFS lands (Dunmire 1990b, pp. 15–16; Dunmire 1990a, unpublished data; Ladyman et al. 1998, entire; Chauvin et al. 1999, entire; Bureau of Land Management 2020, unpublished data; Goss 2022, pers. comm.). Currently, all documented Lee's occurrences are on public lands and most of these are managed for conservation via special land use designations: Dark Canyon SMA, Carlsbad Caverns National Park, Guadalupe Caves Resource Protection Area, and Lonesome Ridge ACEC (see section 2.2.1.8 Special Land Use Designations and Management Prescriptions). The Sargent Canyon Lee's occurrence is not covered by special designations, and the Big Canyon and Cottonwood Canyon Sneed's-form occurrences have only incidental habitat protections within the Guadalupe Caves Resource Protection Area. While these special designations don't inherently protect Lee's from any of the threats listed above, except decreased air quality, they do limit potential future emerging threats from off-road vehicle use, mineral materials development, and renewable energy development. Of Lee's documented threats, known impacts to Lee's have occurred from road maintenance (Roth 2018, p. 11), trail use (Tonne 2005, p. 10), and ungulate trampling (National Park Service 1992, p. 9; National Park Service 2013, unpublished data; Roth 2018, p. 11).

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

In 1979, at the time of listing, overutilization was a risk but not necessarily a documented threat (Service 1986, pp. 14–15). No impacts had been observed in the wild, but Lee's plants, presumably sourced at some point from the wild, were commercially available. These commercially available plants alleviate the need for cactus hobbyists to collect Lee's germplasm from the wild (44 FR 61555). Collection is prohibited within Carlsbad Caverns National Park, and New Mexico (NMAC 19.21.2) has prohibited unpermitted collection of Lee's (as a State endangered species) since 1985.

Two collection events for scientific purposes are documented (Porter 2020, pp. 21–33; Gulf South Research Corporation, p. 3). Terms and conditions on State and Federal collection permits minimize adverse effects to both plants and populations from scientific collections. Therefore, overutilization for scientific purposes is no longer a threat.

Overutilization via illegal collection for recreational or spiritual purposes is a potential emerging future risk. Recent taxonomic revisions have placed Lee's in the *Pelecyphora* (peyotillo) genus (see section 2.2.1.4), which is known for having psychoactive properties similar to the *Lophophora* (peyote) genus (Neal et al. 1972, entire). This association could result in illegal collection for ethnobotanical exploration, but there is no evidence of renewed collection pressure to date. Lee's is not known or thought to be psychoactive.

2.2.2.3 Disease or predation:

Fungi, bacteria, insects, small mammals, and ungulates are known to prey on cacti (Kelly and Olsen 2011, entire). While Lee's dense spination provides some defense against vegetative herbivory (Kelly and Olsen 2011, p. 7), its reproductive structures remain vulnerable. There has been one observation of an adult *Moneilema armatum* (longhorn cactus beetle) eating portions of a Lee's individual (Service 2015, p. 11). We lack enough information to assess what impact, if any, longhorn beetles have on Lee's or its close relatives. Insect and mammal herbivory on cacti increases during drought (Russell and Felker 1987, p. 440; Kelly and Olsen 2011, pp. 8–9; Hayes et al. 2013, p. 110; Shryock et al. 2014, p. 1951), so herbivory may increase in response to climate change.

2.2.2.4 Inadequacy of existing regulatory mechanisms:

A significant portion of Lee's range is afforded protections via special designations. Exceptions include the recently discovered Sargent Canyon Lee's occurrence and, possibly, the Big Canyon and Cottonwood Canyon Sneed's-form occurrences, which are only afforded incidental habitat protections via the Guadalupe Cave Resource Protection Area (see section 2.2.1.8). However, future protections for Lee's plants on USFS and BLM lands are uncertain because mineral withdrawal areas that previously protected the Cottonwood Canyon Sneed's-form occurrence and significant portions of the Big Canyon Sneed's-form and the Serpentine Bends/Dark Canyon/Crooked Creek Lee's occurrences are currently expired and because Lincoln National Forest and BLM Carlsbad Field Office are currently revising their land use plans. While these protections could decrease in the new land use plans, protections are likely to be continued or increased under the new land use plans, given the content of the draft land use plans (Bureau of Land Management 2018, pp. 2-52, Appendix A Map 2-55; USDA Forest Service 2021, pp. 145, 152–154).

Lee's is currently listed as a Federally endangered species without designated critical habitat. It is also a BLM special status species and a New Mexico endangered species. Each of these statuses confers some level of protection for Lee's plants (see section 2.2.1.8). In New Mexico, the State endangered plant rule (prohibiting unpermitted take) is new, and, therefore, effectiveness of regulatory protections for Lee's plants at the state level is currently uncertain.

2.2.2.5 Other natural or manmade factors affecting its continued existence:

Other natural factors affecting Lee's viability include drought, climate change, fire, and, potentially, hybridization.

Drought and Climate Change

Anthropogenic climate change is increasing the severity and duration of droughts in the Southwest (Williams et al. 2022, p. 234). 2000–2021 was the driest 22-year period since at least 800. Between 2000 and 2021, the Southwest experienced 18 negative soil moisture anomalies, and multi-year droughts within Lee's range spanned 2002–2004, 2011–2014, and 2020–2022 (Williams et al. 2022, p. 232; National Integrated Drought Information System n.d., unpaginated). 2002 was the driest year on record (since 1901), and 2021 was nearly as dry as 2002 (Williams et al. 2022, p. 232). Between 2040 and 2069, projected temperatures across Lee's range substantially increase without a corresponding substantial increase in precipitation. Projections for mean spring maximum temperatures increase by 2.7–3.5 °C (4.8–6.3 °F) while mean spring precipitation either increases or decreases by a projected 1–-2 millimeters (mm) (0.037–-0.066 inches (in)) under RCP 4.5 and 8.5 scenarios, respectively. Projections for mean summer maximum temperatures increase by 2.7–3.3 °C (4.8–5.9 °F) across Lee's range while mean summer precipitation only increases by a projected 1–5 mm (0.043–0.213 in) (MACA n.d., 32.5590 to 32.1850 N x -104.9560 to -104.7330 E). Therefore, we expect growing season drought severity, frequency, and/or duration to increase into the future. Zimmerman (1985, p. 360) and Baker (2001e, 14119) observed that Lee's and Sneed's-form plants appeared to be stressed by the more arid conditions in lower elevation areas; plants appeared unhealthy, patches were confined to moister microhabitats, and/or recruitment of seedlings appeared to be limited. Drought is suspected to increase mortality rates (Roth 2018, pp. 5, 10) and may also reduce reproductive effort and/or success (Konings 2008, p. 1), but no reproductive drought responses are documented for this species. Therefore, it appears reasonable to assume that projected changes in temperature and precipitation may reduce the extent and density of Lee's and Sneed's-form occurrences via decreased recruitment and survival, both directly (via inadequate soil moisture) and indirectly (via increased herbivory, altered disturbance regimes, and phenological mis-matches) (Zimmerman 1985, p. 360;

Baker 2001e, 14119; Kelly and Olsen 2011, pp. 8–9; Roth 2018, pp. 5, 10; Wrobleski et al. 2023, pp. 7, 9, S2).

Fire

Semi-arid grassland wildfires typically occur in dry seasons following a year of exceptional growing season precipitation and plant production (Roth 2018, p. 2; Dewar et al. 2021, p. 334). While Sivinski (1991, p. 129) observed that wildfire does not appear to be a significant threat to Sneed's-form plants, fire is a documented threat to Lee's.

The National Park Service (1994, pp. 4–5) monitored 66 Lee's plants in two plots before and after a prescribed burn. Post-burn, 62.12% of plants showed no signs of direct fire effects (scorching or burning of stems), 30.30% were slightly to severely scorched, and 7.58% were moderately to severely burned. In the year following the burn, 18.18% of plants were in deteriorated condition, including one plant that died: 7.58% were in deteriorated condition without direct, observable fire effects, and 10.61% were in deteriorated condition following direct, observed fire effects. Pre-burn reproductive effort wasn't documented. Post-burn, 33.33% of plants produced flower buds. For the most part (excepting a single, severely scorched plant), moderately scorched to severely burned plants did not produce buds. Budding was higher (41.46%) in plants that showed no signs of scorching than in plants that were slightly scorched (30.00%). Therefore, in the short term, prescribed fire appears to reduce the health and fecundity of Lee's populations.

Fire effects were more severe in response to wildfire, though Lee's response was confounded by multi-year drought (Muldavin et al. 2013, p. 8; Roth 2018, p. 11). In 2011, the National Park Service relocated 61 plants post-burn, of which 26.23–44.26% plants were dead (18.03% plants were in unknown condition). In 2013, two years post-burn, Muldavin et al. (2013, p. 8) relocated 131 plants, 40.5% of which were dead. In 2014–2018, Roth (2018, entire) continued to monitor 85 plants (60 live and 25 dead) and the immediate area (1 m) around each, post-burn. Some of these plants, but not all of them, were also documented in the 2011 and/or 2013 monitoring efforts. In 2014, 29.41% of plants in plots were dead, and by 2018, mortality increased by 9.05% to 38.46% of plants in plots. Both initial and final mortality were approximately twice as high (210.78% and 211.54%, respectively) in burned plots that in control (unburned) plots (Roth 2018, unpublished data). Fecundity was also lower in burned plots, and—while gradually increasing through time—remained lower at seven years post-burn (Roth 2018, p. 8). Therefore, wildfire fire appears to reduce the health and fecundity of Lee's populations for greater than seven years post-burn.

Hybridization

Hybridization is a documented potential threat to Lee's (Roth 2013, unpaginated). Hybridization with Guadalupensis (Lee's closest relative) is possible because these taxa's ranges and flowering periods overlap (New Mexico Rare Plant Technical Council 1999a, unpaginated; New Mexico Rare Plant Technical Council 1999b, unpaginated). The genetic status of Sneed's-form individuals (which have traits intermediate between Lee's and Guadalupensis) is currently pending resolution. Hybridization can promote extinction of rare species by decreasing recruitment and potentially adversely affecting health and/or survival, which results in decreased population growth rates. Hybridization decreases recruitment because it results in production of hybrid seed at the expense of conspecific (true parent species) seed and successful hybrid recruitment decreases microsites available for recruitment of the rare parent species. Hybridization may adversely affect health and survival by promoting pest populations. Hybrid species may be more vulnerable to pests, increasing pest abundance in rare plant populations (Levin et al. 1996, p. 11). Conversely, genetic and morphological diversity within hybrid populations could increase genetic and morphological diversity, and, therefore, adaptive capacity, within the rare parent species through introgression (Thompson et al. 2010, p. 244).

2.3 Synthesis

Recovery Progress

Delisting recovery criteria are outlined in Lee's recovery plan amendment (Service 2019, p. 4–7). Land managers have made significant progress toward achieving Lee's recovery in terms of regulatory mechanisms that conserve Lee's populations and, hence, species redundancy. The current status and/or long-term trends of resiliency (stable to increasing population growth rates) and representation (the maintenance of relatively normal inbreeding coefficients and persistence of multiple subpopulations) within Lee's populations, however, are unknown. While significant portions of Lee's range fall within protected areas, there are no coordinated or agency-specific habitat management plans for Lee's.

Delisting Criteria 1: All core populations demonstrate stable or increasing trends in abundance over a 20-year period.

Trend data representing an approximately 12-year stretch was last collected in 1995 in Rattlesnake Canyon Trail plots and in 1996 in Walnut Canyon Desert Drive plots. Therefore, current population trends are unknown. When trend data was last collected, plots in both the Rattlesnake Canyon and Walnut Canyon occurrence areas had stable or increasing trends, respectively. However, fire effects monitoring plots in the Walnut Canyon occurrence area were exhibiting declining abundance trends when last monitored in 2018.

Delisting Criteria 2a: Maintain a minimum of three geographically separated core populations for each species over a 20-year period.

We define geographically separated core populations as biological populations (occurrence complexes experiencing regular gene flow between them) that are sufficiently robust (in terms of abundance and density) to limit risk of extirpation from stochastic adverse environmental conditions (such as periodic characteristic droughts and wildfires) and that are sufficiently geographically independent (see the Redundancy discussion below) to limit risk of extinction following catastrophic events (such as uncharacteristic, more intensive and/or extensive, droughts and wildfires). In the absence of information about gene flow, delineation of biological plant populations is estimated using a separation distance that approximates the maximum distance that pollination and/or dispersal agents can typically facilitate gene flow between individuals of a species.

Lee's was previously understood to consist of two populations, grouped by proximity and based on a population separation distance of 3 km (1.86 mi) (U.S. Fish and Wildlife Service (Service) 2019, p. 3; NatureServe 2020, p. 13). Lee's occupies steep, rugged, remote terrain, so there has been limited survey effort for this species relative to the extent of potential habitat for this species. If we assume that all canyons with documented Lee's and/or Sneed's-form occurrences are occupied throughout, the area historically known to be occupied by Lee's and/or Sneed's-form plants would, by this method, constitute a single population. Despite the existence or lack of separation distance, there are no documented definitively Lee's plants southwest of the terminus of West Slaughter Canyon (all documented observations from Lefthook Canyon southwest are of Sneed's-form individuals) and samples from Slaughter Canyon northeast are collectively monophyletic but polyphyletic at the occurrence area level (Porter 2023b, pers. comm.). Therefore, for the purposes of this review, we consider there to be one core Lee's population (consisting of the Serpentine Bends/Dark Canyon/CrookedCreek, Walnut Canyon, Rattlesnake Canyon, North Slaughter Canyon/Middle Slaughter Canyon, Bear Canyon, Midnight Canyon, Putnam Canyon, West Slaughter Canyon, and Yucca Canyon occurrences) and one core Sneed's-form population (consisting of the Lefthook Canyon, Double Canyon, Cottonwood Canyon, Gunsight Canyon, and Big Canyon occurrences), as well as a third, isolated, Lee's individual (Sargent Canyon). All three of these populations have been confirmed extant at some point within the last few years. Therefore, both population core areas remain extant for greater than 20 years.

2b. A minimum of one new core population will be discovered (use Criterion 1) or established outside the current range and wholly separated geographically from the other core populations, and remain occupied for 10 years out of the 20-year survey period.

In 2022, a new "population" consisting of a single Lee's individual was discovered in the vicinity of Sargent Canyon, 58 km (36 mi) northwest of the north-most Lee's in the Serpentine Bends area. Additional survey effort is needed to determine if this individual represents a recent rare, random, long-distance dispersal event or if there are more Lee's individuals in the area and/or between Sargent Canyon and Serpentine Bends.

Delisting Criteria 3a. Maintain genetic diversity within all core populations as measured by the fixation indices inbreeding coefficient (F_{IS}) at or within one standard deviation of the F_{IS} of a closely related species with similar reproductive strategies and demonstrated acceptable viability.

While a phylogenetic study of Lee's and Sneed's-form populations and populations of closely related species is underway, inbreeding coefficients for Lee's populations or populations of closely related species aren't part of the study's proposal and haven't been calculated.

Delisting Criteria 3b: Maintain presence in 80 percent of subpopulations over 20-year monitoring period and outside of the core populations, with any subpopulation extirpations compensated by a newly identified or colonized subpopulation.

While all historically documented subpopulations may remain extant, the current statuses of all historically documented subpopulations are unknown.

Delisting Criteria 4: Develop and implement a Habitat Management Plan (HMP) for Sneed and Lee pincushion cacti conservation.

There is currently no habitat management plan for Lee's.

Representation

Lee's currently occupies 2–3, geographically isolated and genetically distinct representation areas, depending on phylogenetic analysis results: one core Lee's population (consisting of the Serpentine Bends/Dark Canyon/CrookedCreek, Walnut Canyon, Rattlesnake Canyon, North Slaughter Canyon/Middle Slaughter Canyon, Bear Canyon, Midnight Canyon, Putnam Canyon, West Slaughter Canyon, and Yucca Canyon occurrences) and one core Sneed's-form population (consisting of the Lefthook Canyon, Double Canyon, Cottonwood Canyon, Gunsight Canyon, and Big Canyon occurrences), as well as a third, isolated, Lee's individual (Sargent Canyon). Genetic diversity within and between occurrence areas and/or populations is unknown, but there's evidence of gene flow between West Slaughter Canyon and Yucca Canyon, between Big Canyon and Cottonwood Canyon, and between these sets of canyons. However, based on small population size(s), we suspect that Sneed's is experiencing a loss of evolutionary potential from loss of diversity through genetic drift, except, potentially, under Zimmerman's (1985, p. 359) rough range-wide abundance estimate, which includes Sneed's-form occurrences. Therefore, while evolutionary processes appear functional, Lee's may have a compromised capacity to adapt to changing environmental conditions.

Redundancy

Lee's relatively continuous known range (excluding the Sargent Canyon occurrence) extends approximately 30 km (19 mi) southwest to northeast (including Sneed's-form individuals within putative Guadalupensis occurrences) or approximately 15 km (9 mi) southwest to northeast (excluding that core population). This range is not extensive enough

to ensure geographic independence of the two core population areas that constitute this range given the potential extent of regional extended droughts (National Integrated Drought Information System n.d., unpaginated) and other destructive, broad-scale severe weather events, which can span several states. However, this range is extensive enough to ensure that wildfires and vegetation treatments wouldn't affect all occurrences simultaneously (Bureau of Land Management 2023, unpaginated), given that recent fires in comparable habitats (such as the Dog, Cottonwood, Potrillo, Brushy, Foster, and San Luis fires of 2021–2023) ranged from 3–11 km (2–7 mi) in extent (National Interagency Fire Center 2023, unpaginated).

Given the contiguity of occurrence areas and evidence of gene flow within this range, there's potential for populations to rescue one another following more localized catastrophic events. Note, however, that the 'Sneed's" core population area doesn't include plants with classic Lee's traits. While there are Lee's plants in ex-situ collections, the quality and diversity of ex-situ germplasm is likely inappropriate and inadequate for successful reintroduction.

There is also a single known disjunct individual (the Sargent Canyon occurrence) approximately 58 km (36 mi) northwest of the north-most Lee's in the Serpentine Bends area. As a single individual, it's unlikely to provide redundancy to Lee's at the species level. However, if this individual represents an additional core population area and/or a continuous range extension, that population would confer considerable redundancy in terms of threats from fire (but not necessarily from regional droughts and other destructive, broad-scale severe weather events).

Resiliency

Initial species abundance estimates were made in 1984–1985, so the current abundance of Lee's populations are unknown. Trend data last collected in 1992–1995 documented that monitored recreation effects plots were stable to increasing. This historic information is unlikely to be a reliable estimate of current abundance and/or trends given the extended droughts of 2002–2004, 2011–2014, and 2020–2022 (National Integrated Drought Information System n.d., unpaginated). Trend data last collected in 2018 from fire effects monitoring plots documented that both monitored burned and unburned fire effects plots were declining. However, these were targeted plots, which are known to be biased toward detecting declining trends that may not represent actual population-level trends. Trends for most occurrence areas have never been monitored. Habitat suitability and availability may be decreasing with increasing temperatures (Zimmerman 1985, p. 360; Baker 2001e, 14119).

Viability

Lee pincushion cactus consists of a single "definitively Lee's" core population with unknown population trends (plot trends were stable to increasing in historically monitored recreation effects plots and declining in recently monitored fire effects plots); one other Sneed's-form population with unknown population trends; and one additional, recently

discovered “definitively Lee’s” “population” that is currently known to consist of a single plant. For all populations, we lack current abundance and trend data (Factor A) and exposure to risks from hybridization is unknown (Factor D). At the species level, collection pressure is a potential emerging future risk (Factor B), neither disease or predation are a known issue, but exposure to pests may increase with hybridization, and herbivory pressure may increase in response to climate change (Factor C), climate change is likely to increase exposure to fire and drought, which decrease survival and recruitment (Factor D), and special land use designations significantly limit incompatible land use activities in both core population areas (Factors A and D). However, the future mineral withdrawal status and management prescriptions for some of these special designation areas are uncertain (Factors A and D). Therefore, we conclude that Lee pincushion cactus remains threatened within the foreseeable future throughout its range. We recommend reviewing the status of Lee pincushion cactus relative to these factors following completion of the ongoing phylogenetic study of the Sneedii complex, collection of more recent and representative population abundance and trend data, and finalization of habitat management prescriptions for Lee’s occurrence areas in BLM Carlsbad Field Office, Carlsbad Caverns National Park, and Lincoln National Forest.

3.0 RESULTS

3.1 Recommended Classification:

No change is needed.

3.2 New Recovery Priority Number (indicate if no change; see 48 FR 43098):

No change is recommended.

Brief Rationale:

Due to the lack of current quantitative scientific data specific to Lee pincushion cactus, it is difficult to ascertain any trends that could recommend a change in classification. The recovery priority number (3) remains appropriate because Lee pincushion cactus is still a subspecies with high threats and high recovery potential.

3.3 Listing and Reclassification Priority Number, if reclassification is recommended (see 48 FR 43098):

Reclassification (from Threatened to Endangered) Priority Number: Not applicable.
Reclassification (from Endangered to Threatened) Priority Number: Not applicable.
Delisting (Removal from list regardless of current classification) Priority Number: Not applicable.

Brief Rationale:

No change in classification recommended.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Resolve the taxonomic identity of Sneed's-form plants range-wide and in the Sneed's-form core population area.

- Survey suitable habitats as predicted by probabilistic models for the presence/absence and extent of Lee's occurrences, starting with the Sargent Canyon occurrence area. Consider evaluating the feasibility of using aerially assisted remote sensing and artificial intelligence assisted object detection techniques to identify potentially occupied areas for on-the-ground presence/absence survey efforts.

- Map the bounds of Lee's occurrences within occupied areas, using standardized and repeatable methods.

- Install randomly or systematically located demographic and density monitoring plots throughout the species' range. Determine the plot specifications and sample sizes needed to achieve the desired statistical power experimentally.

- Assess the probability of wildfire exposure in occurrence areas.

- Assess microclimate refugia in and adjacent to occurrence areas.

- Assess Lee's resiliency to, and capacity to adapt to, projected future climate changes. If resiliency and adaptive capacity are low, identify future suitable habitat areas using probabilistic models that incorporate the range of available future climate scenarios and time periods.

- Collect seeds along >50 maternal lines per occurrence area for ex-situ, long-term conservation storage. Consider what germplasm may be needed for successful reintroductions when planning collections (Maschinski et al. 2012, entire).

- Finalize protections for Lee's occupied and adjacent and intervening habitats, including future habitats, via special designations and associated mineral withdrawals and management prescriptions for the purpose of conserving Lee's.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Lee Pincushion Cactus (*Coryphantha sneedii* var. *leei*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service, New Mexico Ecological Services Field Office

Approve SHAWN SARTORIUS Digitally signed by SHAWN SARTORIUS Date: 2023.08.31 13:44:31 -06'00'