Cochise pincushion cactus
(*Coryphantha robbinsorum*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Arizona Ecological Services Office
Tucson, Arizona
August 2020

5-YEAR REVIEW
Cochise pincushion cactus
(*Coryphantha robbinsorum*)

1.0 GENERAL INFORMATION

1.1 Reviewers:

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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 Act (Act) 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 Act. 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's Arizona Ecological Services Plant Ecologist, who is species lead for Cochise pincushion cactus (*Coryphantha robbinsorum*), was the primary author of this document. A great deal of new information is available on this species since the completion of the last 5-year review in 2007. We conducted a review of past and recent literature and data, the listing rule, and the recovery plan. Interviews with individuals were conducted as needed to clarify or obtain specific information. In addition, we also solicited public comments and

information in the Federal Register (85 FR 15795). We prepared a preliminary draft that was reviewed by biologists within the Arizona Ecological Services Office, a retired botanist who has a history working with this species, as well as, biologists with the San Bernardino National Wildlife Refuge, who are critically involved with the monitoring of this species.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review: 85 FR 15795

1.4.2 Listing history: Cochise pincushion cactus was listed threatened on January 9, 1986 (51 FR 952).

1.4.3 Review History: A Cochise pincushion cactus 5-year Review was signed on April 6, 2007.

1.4.4 Species' Recovery Priority Number at start of 5-year review: 8

1.4.5 Recovery Plan or Outline

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review a vertebrate?

_____Yes, *go to section 2.1.2.*
__X__No, *go to section 2.2.*

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan[1]?

__X_***Yes****, continue to section 2.2.1.1.*
____ ***No****, consider recommending development of a recovery plan in section IV, Recommendations for Future Actions, and go to section 2.3., Updated Information and Current Species Status.*

2.2.1.1 Does the recovery plan contain objective, measurable criteria?

__X_ Yes, *continue to section 2.2.2.*
____ No, *consider recommending development of objective, measureable, threats based recovery criteria in section IV, Recommendations for Future Actions, and go to section 2.3., Updated Information and Current Species Status.*

[1] Although the guidance generally directs the reviewer to consider criteria from final approved recovery plans, criteria in published draft recovery plans may be considered at the reviewer's discretion.

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?

____ Yes, go to section 2.2.2.2.
__X_ ***No****, go to section 2.2.3, and note why these criteria do not reflect the best available information. Consider developing recommendations for revising recovery criteria in section 4.0.*

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:

1. Develop landowner or public land management agency agreements that will ensure permanent protection and management.
   - As of 2020, there are no land management agency agreements in place to provide permanent protection or management of Cochise pincushion cactus or its habitat. This would include management of livestock grazing, predator prey relationships, trampling, vandalism, illegal collection, and other threats. There has been little done regarding the threat of continuing drought, with the exception of seed collection and, as of March 2020, there are 113 individuals growing in captivity between two botanical gardens in Arizona.
2. Implement management measures that research studies indicate are needed to maintain habitat condition suitable for sustaining 50 high density, viable populations with 300 plants in each population that are linked with habitat maintaining low-density populations.
   - The entirety of the species resides on non-federal lands and there are no management measures in place for maintaining or improving habitat or increasing population size or numbers of populations.
   - At the present time, we are unaware of additional populations which could be managed to meet this criteria and therefor this criteria is at present unlikely to be met.
3. Map and quantify the number of high-density populations of Cochise pincushion cactus in the United States.
   - Surveys for the species have been conducted and known populations have been mapped. Between 1989 and 2006, plants within plots were repeatedly measured and a decreasing trend was noted. Between 2009 and 2019, random diameter measures from within the population suggest the population is stable, though predation has occurred and no complete census has been conducted.
4. Eliminate or minimize the threat of surface-disturbing activities, particularly oil and gas drilling and mineral entry.
   - In 2014, the Arizona State Land Department notified landowners that oil and gas exploration and development lease numbers 13-117705 through 13-117708 had been issued to B & N Land and Cattle Company of McPherson, Kansas for the state-owned lands that are a part of the private landowner's state grazing lease, including Cochise pincushion cactus habitat. According to the Cochise pincushion cactus Recovery Plan, the Federal government owns the mineral

rights, which are administered by the Bureau of Land Management for some of the occupied habitat. The present private landowners do not own the subsurface rights to the area.

- The use of the limestone hills habitat by illegal immigrants and drug smugglers is ongoing, resulting in obvious trailing and litter in some areas (Walker 2019, p. 3). In addition, in 2006, plots were reported vandalized with many nails and tags removed, trash and other evidence of human visitation was also present (Rutman pers. comm. January 22, 2020; Rutman pers. comm. January 9, 2020).
- Livestock grazing in the limestone habitat has increased since 2014 when ranch ownership changed, and is evident by the increased grass consumption, increased abundance of cow manure, and increased disturbance to some vegetation and to the rocky limestone slopes (Walker 2019, p. 3).

5. Commercial trade protection provided by the Arizona Native Plant Law and the Convention on International Trade in Endangered Species remain in place following removal from the Federal list of endangered and threatened species.

- While the Arizona Native Plant Law provides protection to these plants, law enforcement personnel are unable to keep constant lookout for removal of plants or seeds of this species. In 2019, following a tip from a Cochise County Sheriff's Deputy, U.S. Fish and Wildlife Service law enforcement were able to arrest one individual who had illegally collected 111 bags of cactus seed from southern Arizona, including that of Cochise pincushion cactus.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

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

Adequate winter precipitation is required for the Cochise pincushion cactus flowering in March (Radke and Minckley 2012, pp. 4-5; San Bernardino National Wildlife Refuge and Minckley 2010, p. 4). Radke and Minckley 2014 (p. 2) noted that individual Cochise pincushion cactus are more robust and larger in diameter following a wet period. Additionally, if moisture conditions are favorable, an individual Cochise pincushion cactus is capable of producing multiple flowers (Radke and Minckley 2014, p. 4). Some projections for the future climate of the Southwestern United States indicate that temperature will increase and precipitation will be less certain, likely decreasing in winter and increasing in summer (Overpeck *et al.* 2013, p. 3; Karl *et al.* 2009, pp. 24, 33; Seager *et al.* 2007, p. 1181). These changes in climate may affect flowering, seed development, and seedling establishment.

Monitoring conducted at the Cochise pincushion cactus site by San Bernardino National Wildlife Refuge staff has shown that both flowering and fruiting are staggered in time within the population and on individual plants, indicating an adaptation to maximize pollinator presence (Radke and Minckley 2016, p. 1). The Cochise pincushion cactus has been determined to be an obligate outcrosser,(requires pollen from a separate plant to create offspring) per a

bagging pollination experiment conducted in 2012 (Radke and Minckley 2012, p. 4). Through a multiple year study of Cochise pincushion cactus pollinators, it was found that at least 100 species of bees are using the Cochise pincushion cactus habitat and 4 species were detected on the flowers of Cochise pincushion cactus (Minckley per. comm. January 28, 2020). It is believed that the widespread, but rare, cactus specialist bee, *Macrotera parkeri* (no common name), is the primary (but not the only) pollinator of *C. robbinsorum* (Radke pers. comm. January 27, 2020; Walker 2019, p. 2).

Fruits of the Cochise pincushion cactus are small (3 to 4.5 millimeters by 6 to 8.5 millimeters [0.12 to 0.18 inches by 0.24 to 0.34 inches]) and orange to reddish in color, hidden underneath the protective enclosure of radial spines (Phillips and Brian, 1982, p. 7; Zimmerman 1978, p. 293). Fruits may contain up to 48 seeds, with an average of 26.16 seeds per fruit (Fehlberg and Nidley 2015, p. 2; Radke and Minckley 2014, pp. 2-3). Despite speculation that these fruits attract mammalian and bird predators, trail cameras placed within one group of plants in 2013 failed to detect any vertebrate visitors (Radke and Minckley 2014, p. 2). It is possible that ants may help disseminate the seeds of the Cochise pincushion cactus, as in 2012, they were seen attempting to carry away seed (Radke and Minckley 2013, p. 2). It appears, however, that fruits are rarely removed from the plant by other organisms (*e.g.*, ants) seeking food, but rather the fruits simply ripen, mature, and seeds fall from the plant onto the ground, with a limited distribution distance (Radke and Minckley 2014, p. 2).

In 1976, when the plant was first discovered and named, Keil (1976, p. 66) noted that Cochise pincushion cactus seed is distributed by gravity, falling to the base of the plant where seeds will germinate giving the appearance of many pups. Keil also noted that Cochise pincushion cactus is a single-stemmed plant, but that damage to the apical meristem may cause it to form auxiliary stems. Differentiating seedling from pup is difficult without genetic testing or digging up plants to look at roots. Recently documented extensive herbivory by small mammals has led to the removal of many adult plants (Walker 2019, p. 2), however small plants have appeared around the perimeter of missing plants (Radke pers. comm. December 13, 2019; Radke *et al.* 2018, p. 2). Research to verify the origins of these small plants is needed to determine if plants are regenerating from damage (vegetative pupping) or growing from a seedbank, or both.

Adequate winter precipitation is also required for germination and seedling growth. The seedling stage of small cacti is the most vulnerable life stage due to the likelihood of desiccation (Aragon and Lasso, p. 1-2; Rice pers. comm. June 4, 2001; Nobel 1984, pp. 310, 316). For succulents, water-storing tissue developed in the first growing season following germination may determine the plants ability to survive drought (Jordan and Nobel 1981, p. 901). In addition, many seedling cacti have very small roots, and, therefore, limited ability to access deeper water sources (Aragon and Lasso 2018, p. 2). Cacti, in general, are very slow growing, and it has been suggested that Cochise pincushion cactus

may require 30 years before reaching reproductive age (Schmalzel *et al.* 1995, pp. 33-34). If this is true, the period of vulnerability may be lengthy in this species. It is possible, however, that this is a shorter lived species, due to the evidence that individual cacti had died and disappeared between the 2006 end of the Rutman / Falk monitoring period and the Radke *et al.* monitoring which resumed near the Rutman plots in 2009. Additionally, of the 31 tagged cacti Radke *et al.* have tracked since 2009, 25 of these have died and only 6 remain through April 2020. Projections of continuing drought, reduction in winter precipitation, and increases in evapotranspiration make continued annual monitoring necessary to ensure the population continues to produce young plants to counteract those lost to age, drought, herbivory, or other causes.

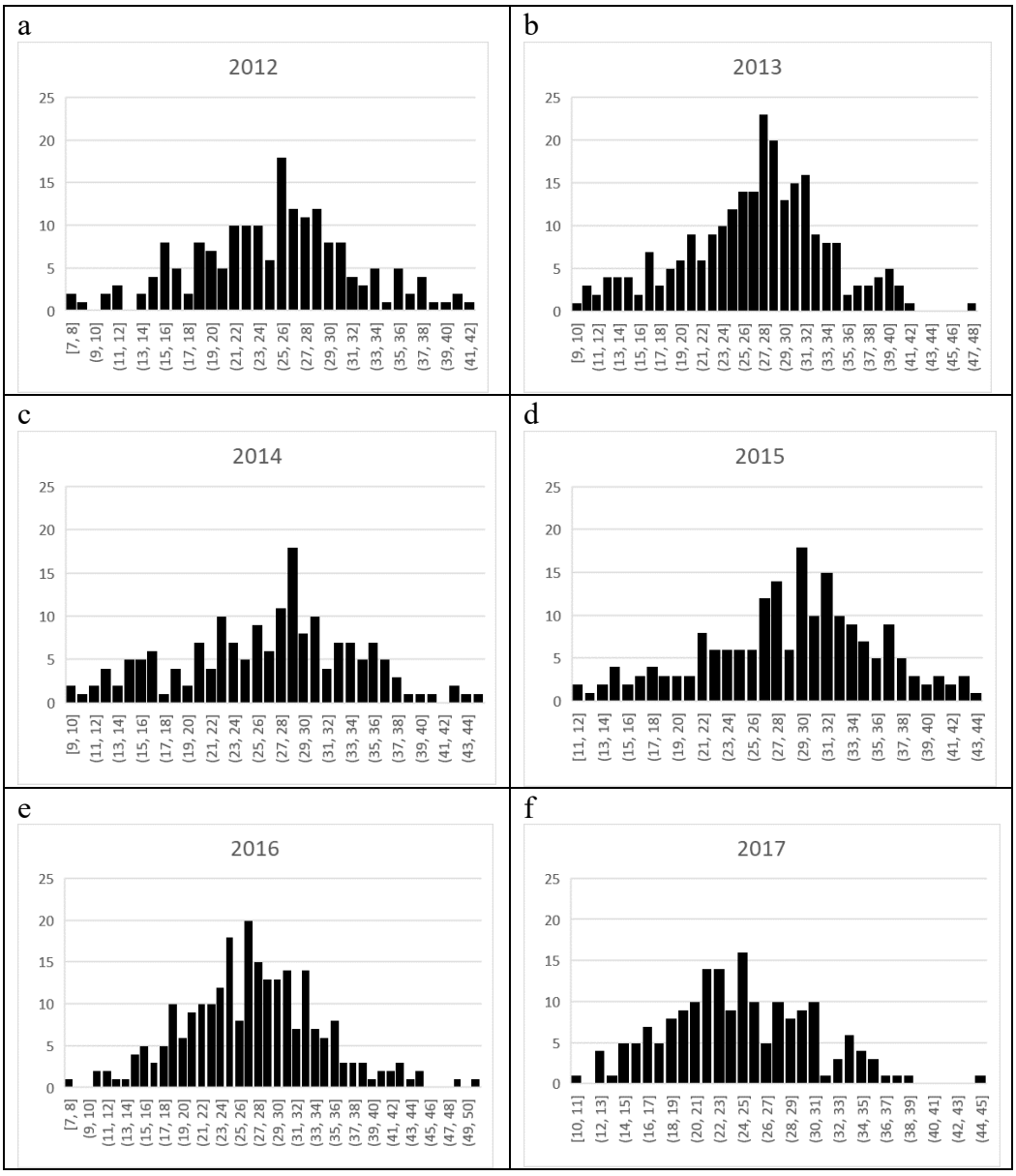
2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

The Cochise pincushion cactus is known from among several Permian limestone hills in southeastern Cochise County, Arizona. Once thought to have occurred in northern Sonora, Mexico, the species has never been found in that country (Van Devender pers. comm. March 22, 2020; Van Devender *et al.* 2013, p. 1). There has been no census of the complete population, however, a 1985 report by Zimmerman (p. 48) indicates there are three distinct populations with 18,000, 11,000, 1,300 plants, respectively. By contrast, the 2007 5-year review noted the plants occurred in a few scattered dense clumps ranging from 100-1,000 individuals.

Between 1989 and 2006, Cochise pincushion cactus individuals in 3 circular plots (A, B, and C) were monitored 14 times and all 3 plots had an overall declining trend. The placement of Rutman;s plots A, B, and C each center within a group of cacti marked with an iron bolt anchored in the ground, from which a tape was extended some given distance and then rotated in a circular pattern to monitor and measure change over time. Cacti intersected by that tape were tagged and tracked as individuals. Undeniably, the 2007 5-year review stated: “Overall, from 1988 through 2006, there has been a continuing decline of the number of individual cacti within the plots. There has been little or no recruitment of juveniles over the past five years.”

In 2009, Robert Minckley established a simple linear transect of 31 plants, each with an aluminum tag, that essentially ran uphill on a characteristic limestone ridge. By chance, the Minckley transect intersected the edge of Rutman and Falk’s plot B. Beginning in 2012 and continuing through 2019, the diameter of a random selection of over 100 individuals were measured annually at this location (Figure 1a-h). These measurements include every live plant that can be found on the hill where Rutman and Falk’s plots B and C were located. Care is taken during monitoring not to double count individuals, and it is expected that at least some (perhaps up to 30 percent) of the individuals are missed in the measurements.

The work since 2009 paints a different picture than the Rutman / Falk plots of 1989-2006. In general, there appears to be a good distribution of Cochise pincushion cactus size classes, including some smaller and larger individuals, though most were intermediate sized individuals; the population is therefore thought to be stable (Walker 2019, p. 2; Cajero *et al.* 2017, p. 2; Radke and Minckley 2016, p. 2). In each of the 8 years where random measurements were collected, at least one small (6-12 millimeter diameter) individual was counted. It is presumed these small plants replace a proportionate number of individuals that died, such as the at least one 42-50 millimeter diameter individuals recorded during these same years.



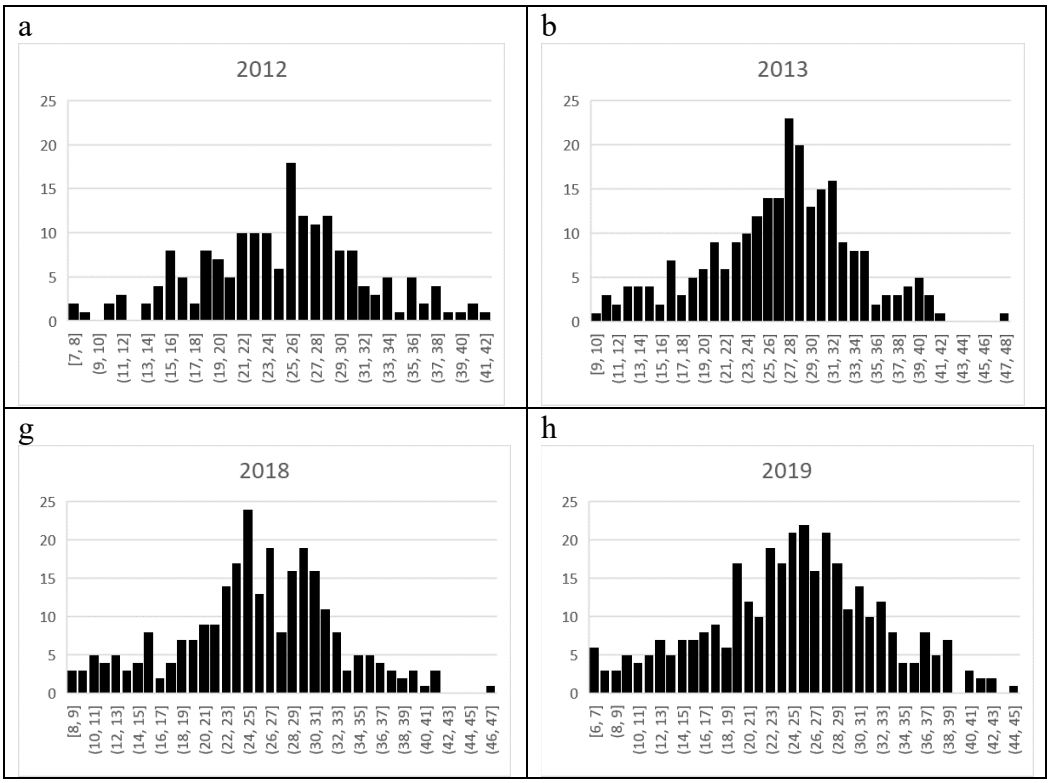


Figure 1 a-h. Size distribution, in milimeters, of randomly measured Cochise pincushion cacti from 2012 (a) through 2019 (h).

Rodents consume cacti for water, especially in times of drought (Riegel 1941, p. 96; Orr *et al.* 2015, p. 1058). Another sample plot containing 31 tagged Cochise pincushion cactus individuals were measured between 2009-2019. In 2017, 11 of the original 31-tagged individuals within a monitored group were removed by small mammal herbivory (Cajero *et al.* 2017, p. 2). By 2019, 25 of the 31 plants were removed by small mammals (Walker 2019, p. 2). Some of the severely damaged plants perished, while others have been found with small plants encircling the missing tagged individual. It is believed by researchers involved with the project that the new small plants were produced vegetatively through pupping rather than through the seedbank, though only genetic research or digging up plants can confirm this. In captivity, there is evidence that seedlings germinate readily from a seedbank in pots following the death of adults (Wiens pers. comm. Jan 15, 2020).

In 2019, a person was apprehended and convicted of illegally collecting 111 bags of seed from Cochise pincushion cactus and multiple other cactus species throughout the Southwest United States (Rohrlich and Schlanger 2019, entire). Although no Cochise pincushion cactus plants were removed, the loss of the year's seed production can have serious implications for seedbank storage, genetic diversity, and recruitment.

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

Scientists from the Desert Botanical Garden and the San Bernardino National Wildlife Refuge collected floral tissue from 198 individuals distributed across six Cochise pincushion cactus groups, with DNA extracted from all samples, and genetic diversity data gathered for 8 newly developed, species-specific microsatellite loci (Fehlberg and Nidley 2015, entire). Results indicate the six groups of Cochise pincushion cactus are genetically very similar to one another, with low genetic differentiation values ranging from 0.009 to 0.10, suggesting a high level of gene flow between these groups (Table 1; Fehlberg and Nidley 2015, p. 7). Cochise pincushion cactus has overall high genetic diversity, with the 6 of 15 most geographically separated groups being the most genetically differentiated from other sites (Table 1; Fehlberg and Nidley 2015, p. 8). Much of the observed genetic variation was attributable to differences within groups (96%) rather than differences among groups (4%; Fehlberg and Nidley 2015, p. 6). It is unknown if these groups represent a metapopulation (*e.g.* expansion) or a single population that has been fragmented (*e.g.* contraction). In addition, one of the groups may have undergone a recent bottleneck (Fehlberg and Nidley, 2015, p. 1).

Table 1. Approximate distance between Cochise pincushion cactus sites and level of gene flow as determined by Fehlberg and Nidley 2015.

Site 1 to Site 2	**Level of Gene Flow (F_{ST})**	**Approximate Distance (meters)**
D to F	0.009	910
A to F	0.016	450
A to D	0.025	910
B/C to F	0.031	890
B/C to D	0.032	405
A to B/C	0.033	690
D to G	0.039	900
D to E	0.050	750
E to G	0.057	330
E to F	0.072	1,600
F to G	0.074	1,650
A to E	0.081	1,645
A to G	0.082	1,780
B/C to E	0.086	1,076
B/C to G	0.100	1,300

Why the groups are genetically very similar is unknown. Pollinator research from 2009 to 2012 has shown there are a minimum of 100 bee species visiting the area, including 4 small bee species that have been captured on Cochise pincushion cacti (Minckley pers. comm. January 28, 2020; Radke and Minckley 2014, p. 2). Although most bee foraging ranges are unknown, it is generally thought that small, solitary bees are able to travel only short distances (*i.e.* <450 meters; Gathmann and Tscharntke 2002, p. 760). The cacti groups are

separated by 330 meters to 1,650 meters (Table 1). Bee expert Robert Minckley (pers. comm. January 13, 2020) suggests it does not take much gene flow to homogenize these groups of cacti. It is possible that additional Cochise pincushion cactus plants exist within the area that have yet to be discovered, thus providing opportunity for movement between patches via small bees. It is also possible that the small bees are able to travel between the known patches or that another undiscovered larger pollinator is enabling gene flow between populations.

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

Not previously reported in a 5-year Review, Bill Radke noted in both 2006 and 2008 finding scattered Cochise pincushion cacti in southern Arizona on the south-facing slope of a local limestone hill outside of the known groupings of plants. The elevation of the occurrence is 4,884 to 4,973 feet, thus extending the known elevational range of the species. While this was not a large group of plants, but instead a few widely scattered plants, it opens the possibility of future Arizona surveys locating additional Cochise pincushion cactus populations. Such surveys are highly recommended.

Recently, botanists in New Mexico were consulted to determine if any Cochise pincushion cacti could occur in that state, on limestone soils near the current distribution of the plant in Arizona. It was determined that suitable limestone habitat is largely absent from the southwest corner of New Mexico. Although no surveys specifically for Cochise pincushion cactus have been conducted in the fragments of limestone in New Mexico and within 50 miles of the Arizona Cochise pincushion cactus site, the species would likely have been detected if present during other botanical surveys of these areas (Bob Sivinski pers. comm. December 31, 2019; Patrick Alexander, pers. comm. January 2, 2020). Never the less, additional surveys in suitable New Mexico habitat are recommended.

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

Pollinators

Between 2009 and 2012, the San Bernardino National Wildlife Refuge has worked to identify the floral community that overlaps Cochise pincushion cactus plants, as well as documenting species richness of potential cactus pollinators. It was determined that at least 100 species of bees are using the Cochise pincushion cactus habitat and that the rare cactus specialist bee, *Macrotera parkeri*, is the primary (but not the only) pollinator of Cochise pincushion cactus (Radke and Minckley 2014, p. 2). This bee is uncommonly found in Arizona and is on the list of species of greatest conservation need in Texas (g1/g2 s1/s2; Texas Parks and Wildlife 2011, entire). Bee expert Robert

Minckley (pers. comm. January 13, 2020) noted that until a few years ago he was only aware of three *M. parkeri* specimens: one taken from Puebla, Mexico, and two from near Austin, Texas. Since that time, additional records from Mexico and from the Cochise pincushion cactus site in Arizona have been added. Minckley concludes this is a widespread, albeit, rare, species of bee.

Livestock grazing

In 2014, the ownership of the private land where some Cochise pincushion cactus plants occur changed. The new owner has intensified livestock grazing within private and State trust (leased) lands in occupied habitat, with increasing grass consumption, habitat disturbance, and presence of cow manure (Walker 2019, p. 2). In 2019, one individual Cochise pincushion cactus was discovered dead underneath a cow pie (Walker 2019, p. 3). Although this grazing could reduce fire risk (Walker 2019, p. 3), Phillips and Brian (1982, p. 8) indicate that increased grazing of the habitat might pose a serious threat to the species through trampling, and micro-habitat loss to disturbance and erosion.

Cross-border violators

Over the past several decades, tens of thousands of people illegally attempt crossings of the United States – Mexico border into Arizona annually; these people are often termed cross-border violators. Cross-border violator and law enforcement activity in the area may degrade Cochise pincushion cactus habitat by creating new roads and trails, depositing litter, disturbing vegetation and soils, altering hydrology, and moving exotic plant seeds or plant parts, leading to their spread into unoccupied areas (Rutman pers. comm. January 9, 2020; Duncan *et al.* 2010, pp. 124-125). In 2006, Cochise pincushion cactus plots were reported vandalized with many nails and tags removed; trash and other evidence of human visitation was also present (Rutman pers. comm. January 22, 2020; Rutman pers. comm. January 9, 2020). Cochise pincushion cactus habitat continues to be used by cross-border violators, as evidenced by trails and litter in some areas (Walker 2019, p. 2). This illegal use, however, has decreased with Department of Homeland Security installed Integrated Fixed Tower surveillance sites on the north and east edges of the limestone hills. In 2019, construction of a new border barrier was initiated along the United States – Mexico Border throughout much of Arizona. This construction plan included ending the barrier near Guadalupe Canyon, thus having the potential to funnel cross-border violators into Cochise pincushion cactus habitat. In March of 2020, a contract modification was signed and a 30-foot tall steel bollard barrier will now be built all the way to the New Mexico State line. This barrier may directly affect occupied Cochise pincushion cactus habitat for a short distance, but does not have the potential result of funneling cross-border violators into Cochise pincushion cactus habitat.

2.3.1.6 Other:

Climate

Southeastern Arizona and much of the American Southwest have experienced serious drought in recent decades (Bowers 2005, p. 421; Overpeck *et al.* 2013, p. 3; CLIMAS 2015, entire). The current trend in the Southwest of less frequent, but more intense, precipitation events leading to overall drier conditions is also predicted to continue (Karl *et al.* 2009, pp. 24, 33; Archer and Predick 2008, pp. 23–24; Seager *et al.* 2007, p. 1181). Drought is directly related to Cochise pincushion cactus population health with regard to reproduction and establishment, as well as herbivory. Over the next century, the conservation of rare plants will need to consider not only the effect of climate change on species and ecosystems, but also on understanding how other factors interact with climate change to influence species viability (Souther and McGraw 2014, p. 1463).

Souther and McGraw (2014, p. 1472) performed projections of viability for a rare northeastern plant with increase in temperature over the next 70 years, with stress from illegal collection of the plant and with the two stressors combined. They found the extinction risk was 65 percent for the combined stressors, but just 6 percent and 8 percent for these 2 stressors independently. It is expected that climate change coupled with any additional stressor could more severely affect rare plant species. For example, because cacti are vulnerable to disturbance due to slow growth, low frequency of germination and establishment, and little capability to recover from disturbance (Portilla-Alonso and Martorell 2011, p. 509), we anticipate small mammal herbivory or habitat disturbance from livestock grazing or other causes could more severely affect Cochise pincushion cactus when coupled with the impacts of drought stress.

Limited Access
Limited access to the private and State owned lands occupied by Cochise pincushion cactus affects our ability to monitor and manage the species and its habitat. Without access to locate additional populations, monitor known populations, or manage threats, the required delisting criteria will be extremely difficult to achieve.

2.3.1.7 Conservation Measures:

In 2014, 15 Cochise pincushion cactus fruits were collected; seeds per fruit ranged from 13 to 48 (Radke and Minckley 2014, p. 2). These seeds were provided to the Desert Botanical Garden and the Arizona Sonora Desert Museum to determine and document optimal propagation techniques for the species. The Desert Botanical Gardens reported a 51.5 percent germination rate, however all of these individuals ultimately perished (Blackwell pers. comm. January 3, 2020). Additional seeds were supplied in 2018, and 85 percent germinated, with 75 seedlings currently growing in captivity. The Arizona Sonora Desert Museum reported a germination ranging from 60-100 percent on 101 seed they sewed. They have 38 seedlings growing in captivity as of March 2020. The Desert Botanical Gardens and the Arizona Sonora

Desert Museum have determined a good germination and growing methodology that will be useful for future conservation actions.

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

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

In 2014, the previous land owners of the private land where Cochise pincushion cactus occur were notified by the Arizona State Land Department that oil and gas exploration/development lease numbers 13-117705 through 13-117708 had been issued to B & N Land and Cattle Company of McPherson, Kansas for the state-owned lands that are a part rancher's state grazing lease, including the Cochise pincushion cactus population (Radke and Minckley 2014, p. 4). To date, no oil and gas exploration or development have occurred, although this remains possible.

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

In 2019, a Cochise County Sheriff's Deputy provided a tip to U.S. Fish and Wildlife Service refuge law enforcement that a German national would be in the area to see and photograph Cochise pincushion cactus. Further investigation ultimately led to the man's arrest at the Denver Airport as he was attempting to smuggle Cochise pincushion cactus seeds out of the country. The man was found with 111 bags of cactus seed, including a purposefully mislabeled collection of Cochise pincushion cactus. The suspect admitted to collecting the seed from public lands and was arrested, released on $5,000 bond, and returned to Germany. Collection of this and other rare cacti and succulents remains a threat to this species.

2.3.2.3 Disease or predation:

Although herbivory of individual Cochise pincushion cactus have been documented historically, the drought, perhaps coupled with changes in land management since 2014, has resulted in a shift in rodent dominance and resultant herbivory. Researchers noted that between 2016 and 2019 herbivory was much increased and associated flowering forbs were much decreased. These observations were believed to be associated with ongoing drought in the region (Radke pers. comm. 12-16-2019). Historically, pocket mice were the primary small mammal herbivore within the Cochise pincushion cactus populations. Following the intensive herbivory on Cochise pincushion cacti observed during 2017, small mammals were monitored at the site during March and July 2018, resulting in the capture of nine white footed mice (*Peromyscus leucopus*), two Bailey's pocket mice (*Chaetodipus baileyi)*, and one hispid pocket mouse (*Chaetodipus hispidus)* (2018 SBNWR Annual Narrative Report

p.47). This is significant because the pocket mice are desert adapted, seed-eating rodents that require little or no moisture to survive, while white footed mice are more dependent on water availability and, therefore, more likely to require cacti consumption to meet that need in times of drought.

Recently documented extensive herbivory by small mammals has led to the removal of many adult plants (Walker 2019, p. 2). In 2019, Walker (p. 2) reported 25 of 31 individuals monitored over time were removed by recent herbivory. Despite this, small plants have appeared around the perimeter of missing plants (Radke pers. comm. December 13, 2019). In addition to small mammal herbivory, mortality of plants was reported in 1994 due to insect herbivory (USFWS 2007, p. 5).

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Regarding the threat of unauthorized collection, Cochise pincushion cacti are protected by the Arizona Native Plants Law, which prohibits collection without obtaining a permit on all public lands, and directs that plants may not be moved off of private property without contacting the Arizona Department of Agriculture. Due to the difficulty in implementing this law, it has not been effective in reducing impacts from collection, nor does it protect habitat.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Over the next century, the conservation of rare plants will need to consider not only the effect of climate change on species and ecosystems, but also on understanding how other factors, such as small population size, herbivory, and illegal collection, interact with climate change to influence species viability (Souther and McGraw 2014, p. 1463). Not only does climate affect plants directly, it has been shown that climate coupled with other stressors, can have a cumulative impact resulting in greater than anticipated decline in rare species. For example, Souther and McGraw (2014, p. 1472) performed projections of viability for a rare northeastern plant with increase in temperature over the next 70 years, with stress from illegal collection of the plant and with the two stressors combined. They found the extinction risk was 65 percent for the combined stressors, but just 6 percent and 8 percent for these two stressors independently.

Climate models indicate that the transition to a more arid climate is already underway and predict that in this century the arid regions of the southwestern U.S. will become drier (*i.e.*, decreased precipitation) and warmer (*i.e.*, increased surface temperatures), and have fewer frost days, decreased snow pack, increased frequency of extreme weather events (heat waves, droughts, and floods), declines in river slow and soil moisture, and greater water demand by plants, animals and humans (Garfin *et al.* 2013, pp. 5-6; Archer and Predick

2008, p. 23). Increasing dryness in the southwestern U.S. and northern Mexico is predicted to occur as early as 2021-2040 (Seager *et al.* 2007, p. 1181).

2.4 Synthesis

The Cochise pincushion cactus is a small cacti of southeastern Arizona with a very limited distribution. Threats and stressors to the species have increased since the last 5-year review of 2007. Annual random diameter measurements of the populations indicate a range of plant sizes, signifying reproduction is occurring. Despite intensified herbivory in recent years, plants, in some cases, are able to respond to this disturbance through either pupping or seed bank germination. Continued survey in areas outside the known Arizona plants, in New Mexico and Mexico is needed. Research to understand the impacts of herbivory, livestock grazing, border activity, drought, and other threats are also essential. Land uses such as oil and gas development must be monitored and tracked and the species and its limestone habitat protected. This includes attaining legal access to sites for monitoring and management of individuals and their habitats. For the time being, no change in status is suggested, however, should any threats increase, there is little room for loss in this very rare species and uplisting to endangered may be required.

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**

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The following are recommendations for future actions to conserve Cochise pincushion cactus and its habitat:

1) Work toward the purchase of some portion of Cochise pincushion cactus populations by a Federal entity (such as the expansion of the Buenos Aires National Wildlife Refuge). This would enable land management to benefit the species, and enable easy access to populations for monitoring, scientific study, and augmentation efforts.
2) Work toward building relationships with current landowners that would enable ease of access by researchers and land managers to survey, monitor, manage, and protect Cochise pincushion cactus.
3) Survey for additional Cochise pincushion cactus populations in appropriate limestone habitats in Arizona, New Mexico, and Mexico.
4) Continue annual monitoring of all accessible Cochise pincushion cactus populations, including attempting to relocate historical plots for re-measurement.

5) Work toward an understanding of stressor, threats, and conservation measures needed to help protect Cochise pincushion cactus.
6) Continue work at botanical gardens both developing plants for potential outplanting and periodically collecting seeds from a genetically diverse group of individuals for long-term storage.
7) Work toward public and partner education of the rarity and importance of Cochise pincushion cactus and the need for teamwork to conserve the species.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Cochise pincushion cactus (*Coryphantha robbinsorum*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X_ No change needed

Review Conducted By: Arizona Ecological Services

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service, [Arizona Ecological Services, Jeff Humphrey]

Approve JEFFREY HUMPHREY Digitally signed by JEFFREY HUMPHREY Date: 2020.09.02 13:39:34 -07'00'