

Peebles Navajo Cactus
(*Pediocactus peeblesianus* ssp. *peeblesianus*)
5-Year Review:
Summary and Evaluation



Photo by Ian Tackett, Logan Simpson Design, Inc.

U.S. Fish and Wildlife Service
Arizona Ecological Services Office
Phoenix, Arizona
August 2022

5-YEAR REVIEW

Peebles Navajo Cactus (*Pediocactus peeblesianus* ssp. *peeblesianus*)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office:

Southwest Region, Albuquerque, New Mexico
Sarah Rinkevich, Tucson Sub-office, (520) 670-6150, ext. 237

Lead Field Office:

Arizona Ecological Services Field Office
Kathy Robertson, Fish and Wildlife Biologist, (602) 889-5957
Julie Crawford, Plant Ecologist, (928) 556-2021
Mary Richardson, Assistant Field Supervisor, (602) 242-0210
Heather Whitlaw, Field Supervisor, (806) 773-5932

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 (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 USFWS provides notice of status reviews in the Federal Register and requests new information on the status of the species (e.g., life history, habitat conditions, and threats). Data for this status review were solicited from interested parties through a Federal Register notice announcing the review on February 2, 2022 (87 FR 5834). No comments from the public were received. The Arizona Ecological Services Field Office conducted this review

and considered both new and previously existing information from federal and state agencies, municipal and county governments, non-governmental organizations, academia, and the public. The primary sources of information used in this analysis are the Peebles Navajo cactus recovery plan (USFWS 1984, entire), research published in scientific journals, survey or monitoring reports compiled since the previous status review, and unpublished technical reports and data. We used this information to examine whether the new information would alter or affect analyses and conclusions made in the previous status review.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

87 FR 5834, Initiation of 5-Year Status Reviews of 35 Species in the Southwest, February 2, 2022

1.4.2 Listing history:

Original Listing

FR notice: 44 FR 61922

Date listed: November 28, 1979

Entity listed: Peebles Navajo cactus (*Pediocactus peeblesianus* var. *peeblesianus*)

Classification: Endangered

1.4.3 Associated Rulemakings: Not Applicable

1.4.4 Review History:

A 5-year review was initiated on July 22, 1985 (50 FR 29901) for all species listed before 1976 or between 1979 and 1980. A notice of completion with no change in status was published on July 7, 1987 (52 FR 25522). Another 5-year review was initiated on November 6, 1991 (56 FR 56882) for all species listed before 1991, but no document was prepared for this species. A 5-year review was completed on August 28, 2008. No change in status was recommended. Status review documents for this species are available online at: [USFWS Environmental Conservation On-line System](#).

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

The Peebles Navajo cactus Recovery Priority Number is 6, indicating the listed entity is a subspecies, and the degree of threat and recovery potential is high.

1.4.6 Recovery Plan or Outline

Name of plan or outline:

Peebles Navajo Cactus (*Pediocactus peeblesianus* var. *peeblesianus*) Recovery Plan

Date issued: March 30, 1984

Dates of previous plans or outline, if applicable: Not applicable

2.0 REVIEW ANALYSIS

Section 4 of the Act (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 Act 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 Act 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.

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): Not applicable

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:

Peebles Navajo cactus is a very small, solitary globose cactus. Mature stems range from 13 to 35 millimeters (mm) in diameter and up to 29 mm in height above ground (Butterwick 1986; Phillips et al. 1985). Individual plants have 3 to 5 (commonly 4) spongy or corky radial spines that are 2 to 9 mm long, 0.5 to 1 mm wide, white to pale gray in color (Heil et al. 1981) and may appear as a twisted cross (AZGFD 2009) (Figure 1). The upper radial spine is often longer than the other radial spines, extending up to 7.5 mm in length (AZGFD 2009). Peebles Navajo cactus lacks a central spine which distinguishes this subspecies from its closest relative, Fickeisen plains cactus (*Pediocactus peeblesianus* ssp. *fickeiseniae*).



Figure 1. Peebles Navajo cactus. Photo taken by USFWS, 2004.

Similar to other species in the genus *Pediocactus*, the Peebles Navajo cactus is able to retract underground during the winter months and periods of drought (Figure 2). Although the plant is referred to as having contractile roots, it is unknown whether the roots contract creating a downward pulling effect or tissue desiccation is the mechanism for retraction (Phillips et al. 2001; Shryock et al. 2014).



Figure 2. Herbarium specimen of a Peebles Navajo cactus showing the top portion of the plant that was above the soil surface and darker bottom portion that was below ground. Collected in 1982 from Navajo County. Photo courtesy of the Museum of Northern Arizona.

Reproductive potential varies among individual Peebles Navajo cacti. Based on monitoring data, most plants become reproductive when they reach a diameter

of 13 to 14 mm (Butterwick 1986). The smallest reproductive plant documented was 7 mm in diameter and produced a single flower bud (Phillips et al. 2018) (Table 1).

Table 1. Observed flowering and fruiting among individual Peebles Navajo cacti classified as juveniles (7 to-13 mm) to young reproductive adults (14 to 20 mm) from 1985 to 2018 (Phillips et al. 2022). No fruit may indicate buds aborted or plant died before fruiting.

Plant Diameter	Instance of Flowering	Instance of Fruiting
7 mm	1	None
9 mm	1	None
11 mm	2	None
12 mm	4	1
13 mm	11	1
14 mm	16	5

Seedlings (plants measuring 0 to 6 mm in stem diameter) are very tiny and difficult to locate (Phillips and Phillips 1988) (Figure 3). Seedlings and young immature plants are often observed near the parent plant. This may be due to its dispersal response but dispersal of this taxon has not been studied.

Alternatively, seedlings may benefit from shade offered by the parent plant or another “nurse” plant for their establishment and survival (Butterwick 1986).



Figure 3. Peebles Navajo cactus seedling. A penny, 19 mm-wide, is used for size comparison. Photo by Kirstin Phillips, Museum of Northern Arizona, 2019.

Flowers are yellow to yellow-green, and average 2.5 cm in diameter, often larger than the entire plant (USFWS 1984) (Figure 4). Fruit development begins in mid-May to early June, approximately one month after flowering (Butterwick

1986) (Figure 5). The fruits are turbinate (top-shaped) and green colored, turning reddish brown at maturity, and then becoming dry and dehiscent (i.e., splitting open along a vertical seam to release seeds) (Heil et al. 1981). Fruits are 7 to 11 mm long and 6 to 11 mm wide, with scales on the upper portion and basally constricted. Plants can produce one to four fruits with one to two fruits the most common (Phillips et al. 1985; Philips et al. 2018).



Figure 4. Peebles Navajo cactus with two flowers and one bud. Photo by Kirstin Phillips, Museum of Northern Arizona, 2019.



Figure 5. Partially retracted Peebles Navajo cactus in fruit. Photo by Kirstin Phillips, Museum of Northern Arizona, 2021.

Seeds are released after dehiscence of mature fruit (Figure 6). The number of seeds per fruit varies, and has been reported from 17 to 24 seeds (Phillips et al. 1985), one to 27 seeds (Butterwick 1986), or 6 to 15 seeds (Murray 2021) (Figure 7). Seeds are dark brown to black, 2.5 mm long, 1.5 to 2.0 mm broad, and 1 mm thick, papillate and rugose (wrinkled surface) (Phillips et. al 1979; Heil and Porter 2001).



Figure 6. Closeup of dehiscent fruit showing vertical line that splits open to release seeds. Photo by Kirstin Phillips, Museum of Northern Arizona, 2021.



Figure 7. Closeup of large seeds inside the opened fruit of a Peebles Navajo cactus. Photo by Kirstin Phillips, Museum of Northern Arizona, 2021.

Seeds may germinate the following spring or persist in the soil for two to three years (Phillips et al. 1985). Seedlings are taller than wide, about 2 mm in diameter and 3 mm tall. Seedlings are often found within 2 cm from the parent plant but a few may occur up to 1.5 meters away (Phillips and Phillips 1988). Seedling germination and establishment are episodic, correlating with favorable amounts of precipitation (Phillips and Phillips 1995).

Pollinators of *Pediocactus* species are solitary native bees from the genera *Agapostemon* (metallic sweat bees) and *Ashmeadiella*, as well as *Dialictus*, a subgenus of sweat bees from the genus *Lasioglossum* (Peach et al. 1993; Tepedino et al. 1996; Tepedino 2000). The primary pollinators of the Peebles Navajo cactus have not been identified. Insects observed visiting open flowers have included a single, native bee of *Lasioglossum*, thrips (Order Thysanoptera), and ants (*Forelius pruinosus*) (Butterwick 1986). In 2021, the Museum of Northern Arizona placed insect traps near the Joseph City plots during the flowering period to document the arthropod diversity in association with Peebles Navajo cactus (Phillips 2021). This will help identify or elaborate on insects observed visiting its flowers. Approximately 80 to 120 arthropod specimens were collected and data will be analyzed in the near future.

The life span of a Peebles Navajo cactus is estimated to be at least 30 years. The Museum of Northern Arizona monitored two plants that were considered to be reproducing adults (16 and 21 mm in diameter, respectively) when they were first recorded in 1985. These two plants continued to survive for the next 23 years and were last measured in 2008. Additionally, Phillips and Phillips (1995) determined that Peebles Navajo cactus reaches reproductive maturity at 8 to 12 years, which suggests that the two plants may be at least 30 years old. This approximated life span is similar to other *Pediocactus* species with individual plants found to live between 20 and 30 years of age (Shryock et al.

2014; Roth 2021). Mortality, growth rates, and the period of time a plant survives while retracted are not well understood.

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:

Approximately 34-years of monitoring data have been collected on the Peebles Navajo cactus, primarily by the Museum of Northern Arizona. Their monitoring results from 1985 to 2004 are described in the 2008 status review and referenced herein (USFWS 2008). A summary of their demographic data from the 2017 to 2018 monitoring period, and abundance data from 2019, 2021, and 2022 are provided below (Phillips et al. 2018; Phillips et al. 2022). We also provide updates on actions taken by the Bureau of Land Management (BLM) to search for additional plants and protect existing populations, also described in the 2008 status review.

Peebles Navajo cactus is known from two core populations in Navajo County, Arizona (USFWS 2008). One population occurs on BLM-administered land near Joseph City and the second on private land near Holbrook (Figure 8). Both populations are within the Tanner Wash Area of Critical Environmental Concern (ACEC), which encompasses 4,650 acres of federal (950 acres), state trust (1,280 acres) and private (2,420 acres) lands (USFWS 2008).

Current Abundance

We compiled count information on the Peebles Navajo cactus between 2021 and 2022. There are at least 150 Peebles Navajo cacti (Phillips 2021; Phillips et al. 2022) (Table 2). Some additional plants were found in 2022 but no numbers were provided so we assume it was a few individuals. Not all areas where the taxon has been found are searched annually. Many years may pass before an area is re-surveyed making it difficult to verify continued occupancy of an area.

Earlier population estimates of approximately 1,000 individual plants rangewide cannot be substantiated with available information (Phillips et al. 1979; USFWS 1984). Based on abundance data from 1985 to 2022, the highest number of reported cacti among three monitoring plots peaked at 522 individuals in 1995, with 498 alive and 24 dead. Numbers of live cacti thereafter have continuously declined to 42 individuals presently (USFWS 2008; Phillips et al. 2022).

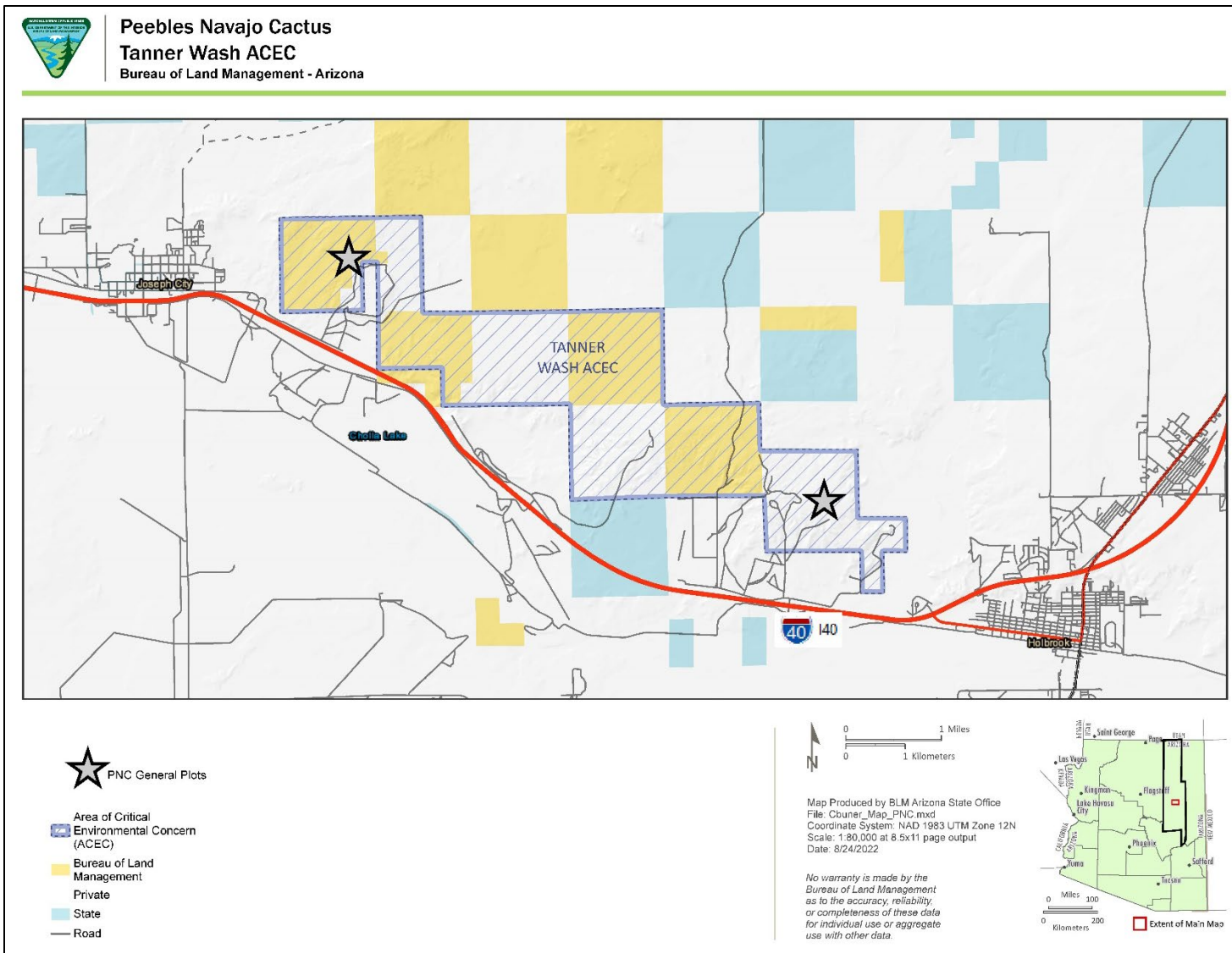


Figure 8. Map showing the generalized locations of the Peebles Navajo cactus populations near Joseph City and Holbrook that are located within the Tanner Wash Areas of Critical Environmental Concern (ACEC). Map provided by the BLM, Safford District Office.

Declines in the Peebles Navajo cactus are largely attributed to fewer individuals found during annual monitoring, poor seedling establishment, low flowering and fruiting rates resulting in little to no recruitment, and spikes in high mortalities. Other contributing factors for changes to observed abundance include the inability to access the Peebles Navajo cactus population in Holbrook after 2008 and not counting or managing those plants; various years when plants from two of three permanent monitoring plots were visited; and difficulty locating plants because of their small stature, retraction, or possible mortality.

Table 2. Summary of Peebles Navajo cactus abundance from eight locations within two populations. Monitoring of the Holbrook Plot ceased in 2008. Except for Joseph City plots, other occupied areas are not searched regularly.

Plot or Site Name	Begin Estimate	High Estimate	High Estimate Date	Low Estimate	Low Estimate Date	2021 Estimate	Source Citation
Joseph City (All plots)	127	415	1995	42	2018	55 (42 as of 2022)	Phillips et al. 2018, Phillips 2021
BLM 40-acres (Near Joseph City plots)	Unknown			29	2017	48	Phillips et al. 2018, Phillips et al. 2022
BLM 40-acres (1980 plot)	55	116	1981-1982	3	2014	32	Butterwick 1986, Cockman 2014, Phillips et al. 2022
BLM 250-acres	Unknown	118	2005	40 (partial count)	2014		Cockman 2014
BLM 250-acres (Historic plot)	Unknown					23	Phillips 2021
BLM 10-acres	41	41	1996	0	2006	Extirpated	Cockman 2014
Holbrook 1	43	83	1995	56	2008	Unknown	USFWS 2008
NW of Holbrook						5	Phillips et al. 2022

Summary of Various Demographic Monitoring Efforts

Joseph City Population (BLM-Administered Land)

BLM established a monitoring plot in 1980 and tracked the demographics of the Peebles Navajo cactus until 1986. The plot (50 by 20 meters [m]) originally

contained about 55 plants, with an additional 115 plants recorded in subsequent years. By 1986, plants numbers declined with 89 plants remaining (Butterwick 1986). This was the last year the plot was monitored for demographic data. It was censused in 2014 by a BLM biologist who located three live plants (Cockman 2014). In April 2021, researchers with the Museum of Northern Arizona and Arboretum at Flagstaff found 32 plants in the plot. Fourteen individuals were flowering or had flower buds and 10 individuals had fruit. Two individuals were identified as juvenile plants. They returned in May and located 31 plants, of which ten plants had fruits. In May 2022, the researchers located 13 plants. Three plants had aborted flowers, two had mature fruit, and eight plants were vegetative (Phillips et al. 2022; Murray 2022). No seedlings were documented. If resources become available in the future, monitoring of this plot may resume.

Researchers with the Museum of Northern Arizona established the Joseph City plots (JC1, JC2, and JC3) and collect long-term demographic data. They have been monitored from 1985 to 2022. No monitoring occurred in any plot from 2009 to 2013, 2015, and 2020, and the JC3 plot was not monitored in 1985, 2006, and 2014. Sampling occurs in April to correspond with flowering and again in May to check for fruit production. Researchers divide each plot into 1-m squares. On hands and knees, they slowly examine each square meter, flagging a Peebles Navajo cactus when found, and recording its locations based on a gridded transect. Data collection consists of documenting live and dead plants, collecting diameter and height measurements to the nearest mm, and recording reproductive structures such as buds, flowers or fruits per plant. The number of missing plants are not recorded. Specific monitoring data for the JC1, JC2, and JC3 plots from 2017 to 2018 is provided below. The monitoring report for 2019, 2021, and 2022 was received, however additional analysis is needed before we can report on the data. We include total plant counts from these years in Table 3 below.

JC1 Plot

The JC1 Plot is 15m long and 4 m wide. In April 2017, 19 plants including one seedling were found. Plant diameters ranged from 5 mm to 34 mm (average diameter 16.9 mm) and plant heights ranged from 3 mm to 22 mm (average height 7.7 mm). The size of the seedling was 5 mm wide and 3 mm tall. Seven plants were in flower; two plants had two flowers each, and five plants had one flower each. In May, seven plants were in fruit; 4 plants had a total of 5 mature fruits and 3 plants had a total of 5 aborted fruit.

In April 2018, 16 plants and no new seedlings were found. Many plants were retracted into the soil with 1 to 3 mm of their height above the surface. Plant diameters ranged from 7 mm (e.g., 2017 seedling) to 31 mm (average diameter 17 mm). One plant that was 22 mm wide and 22 mm tall in 2017 was 25 mm wide and 19 mm tall in 2018. No plants were flowering therefore, the researchers did not check for fruits in May.

JC2 Plot

The JC2 plot is 13 m long and 4 m wide. In April 2017, 22 plants and no new seedlings were found. Plant diameters ranged from 6 to 29 mm (average diameter 15.5 mm) and heights ranged from 3 to 20 mm (average height 8.6 mm). Three plants were in flower but none produced fruit in May.

In April 2018, 24 adult plants and no new seedlings were found. The researchers also found eight plants previously recorded in past surveys but believed to have been retracted during the 2017 survey. Plant diameters were the same as 2017, from 6 to 29 mm (average of 15.2 mm) and heights varied from 1 to 21 mm (average 5.4 mm) with many plants contracted near the soil surface. No plants were flowering therefore, the researchers did not check for fruits in May.

JC3 Plot

The JC3 Plot is 13 m long and 4 m wide. In April 2017, three adult plants and no new seedlings were found. Plants were 8 mm wide and 4 mm tall, 15 mm wide and 8 mm tall, and 19 mm wide and 5 mm tall. None of the plants had flowers. In April 2018, two adult plants and no new seedlings were found. Plants were 15 mm wide and 4 mm tall and 12 mm wide and 3 mm tall. Neither plant had flowers.

Table 3. Summary of the total number of live plants, individuals in flower and with fruits, and seedlings found in the Joseph City plots from 2017 to 2022. No monitoring occurred in 2020. Total number of dead plants were not recorded. “Not counted” refers to fruit production not checked in 2019 and 2021.

Year	Total Plants	Plants in Flower	Plants with Fruits	Total Seedlings
2017	52	10	7	1
2018	42	0	0	0
2019	56	27	Not counted	0
2021	56	5	Not counted	1
2022	42	15	4	0

Holbrook Population

In 1985, the Museum of Northern Arizona established a fourth monitoring plot on private land in Holbrook. They monitored this plot from 1985 to 2008 and reported data through 2004 (USFWS 2008). Data from 2005 to 2008 has not been analyzed (Phillips et al. 2018). Monitoring of the plot ceased in 2008 due to landowner changes affecting access to the site. Some attempts to re-establish contact were made in the past without success. The status of the Peebles Navajo cactus remains unknown at this site, leaving only one population being managed.

Searches for New Peebles Navajo Cacti within BLM Enclosures

The BLM fenced occupied Peebles Navajo cactus habitat in the Tanner Wash ACEC to protect the plant from authorized activities (BLM 2010). Guided by their 1984 Habitat Management Plan (HMP) for the taxon, the HMP originally committed to fencing 30 acres but over time additional occupied areas were fenced (BLM 1984; USFWS 2008). The limited information we have on the three exclosures are reported below.

In 1998, BLM acquired 10 acres previously owned by the Arizona Public Service (APS) Cholla Power Plant (BLM 1998). The parcel is located across from APS's bottom ash pond and had 41 plants when it was inventoried in 1996 (Ecosphere 1996). Plants were distributed among four sites and ranged from 5 to 35 mm in height with most plants retracted and barely protruding above ground (EcoSphere 1996). BLM fenced the parcel in 2003 and inventories in 2004 and 2005 located 4 and 43 plants, respectively (Cockman 2014). No plants have been found after 2006 and BLM believes the site is extirpated primarily from deposition of bottom ash associated with the APS bottom ash pond (discussed in Threats below).

At a second site, BLM fenced 250-acres in 2012 to protect the Peebles Navajo cacti from livestock grazing and off-highway vehicle (OHV) use in the Tanner Wash ACEC, (Cockman 2014; BLM 2010) (Table 3). A full census of the 250-acre exclosure has not been completed. Approximately 118 cacti were found in 2005 prior to fence construction. In 2014, the BLM searched a part of the exclosure and located 40 plants. Many plants appeared severely "stressed" and many dead plant carcasses were observed (Cockman 2014). Due to drought conditions and the difficulty locating plants, BLM surveys covered only a portion of the exclosure before being discontinued. In 2021, researchers with the Museum of Northern Arizona searched suitable habitat near the exclosure perimeter. They located 23 plants, including six small plants with diameters ranging from 5 to 9 mm. These plants appeared to be in an historic BLM plot whose history is unknown (Phillips 2021). In 2022, the researchers searched an area in the center of the exclosure and another in the southeastern corner. They found "several" Peebles Navajo cacti at both areas, including one plant with eaten flower petals, another with an eaten flower bud, and a third with four flower buds (Phillips et al. 2022).

At the third site, BLM fenced 40 acres, creating an exclosure that contains all of the Joseph City plots and the 1980 BLM plot (USFWS 2008). It is not known exactly when the fence was erected but it potentially occurred after 2010 (USFWS 2010). Searches of suitable habitat within the 40-acre exclosure but outside of the established long-term monitoring plots were conducted in 2017, 2021, and 2022 by the Museum of Northern Arizona. In 2017, the researchers found 29 plants in areas south of their monitoring plots. Thirteen plants had characteristics of subspecies *peeblesianus* and 16 plants had characteristics of subspecies *fickeiseniae* – a long central spine and more than four radial spines per areole. No Peebles Navajo cacti were found on the nearby buttes. These

sites lacked soils derived from the Shinarump Member of the Chinle Formation, a type of geologic formation typically associated with Peebles Navajo cacti. In 2021, researchers searched hills located in areas surrounding their plots and found 48 Peebles Navajo cacti, including four seedlings (Phillips et al. 2022). Among those plants, eight were in fruit with one that looked to abort and two with mature fruit.

The Museum of Northern Arizona also conducted a search on BLM land in the east end of the ACEC northwest of Holbrook. Where suitable habitat occurs, they located five non-reproductive Peebles Navajo cactus. The plants are in an unfenced area that is heavily used for recreation; however, the 2022 Peebles Navajo cactus monitoring report did not indicate that the plants were impacted by recreation (Phillips et al. 2022).

General Population Trends from 1986 to 2022

Population trends are based on long-term monitoring data from the three Joseph City plots (USFWS 2008). Over the past 26.5 years, the monitored population continues to decline. From 1986 to 1995 the populations had increased from 185 to 415 plants (Figure 9). The increase was attributed to favorable climatic conditions resulting in high numbers of seedlings and low rates of mortality. After 1995, several large mortalities occurred leading to significant decreases in plant numbers: 119 deaths in 1996, 88 deaths in 1999, and 157 deaths in 2001 (Phillips et al. 2018) (Figure 10). As described in the 2008 status review, the persistent drought and resultant increases in herbivory were likely responsible for the high mortalities (USFWS 2008). Where dead plants were observed in place, drought was presumed as the source of mortality. In most cases; small depressions remained where the plant was missing. Spine clusters or individual spines were observed at many sites where plants had been removed leading the researchers to conclude that rodent or rabbit herbivory rather than collection by humans was the cause (USFWS 2008).

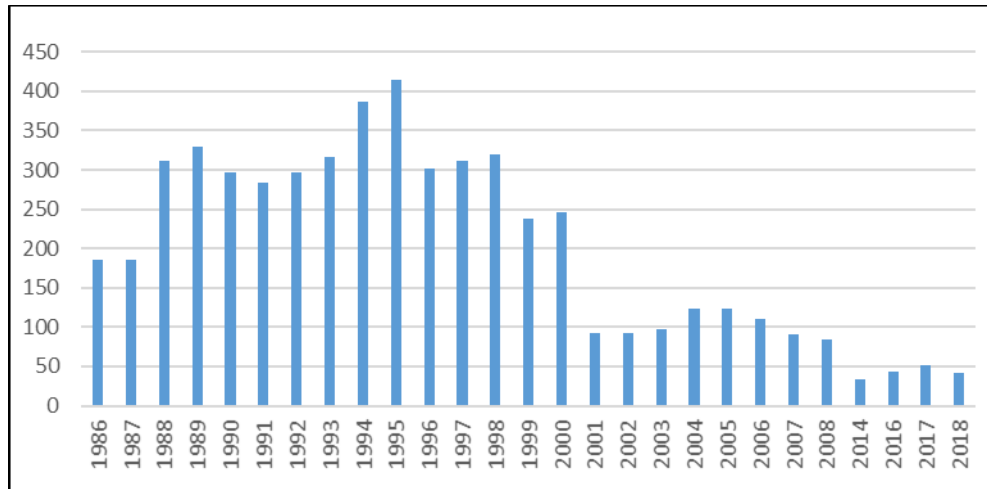


Figure 9. Number of live Peebles Navajo cacti in the Joseph City monitoring plots from 1986 to 2018. No monitoring in JC3 plot occurred in 2006 and 2014.

The number of seedlings has also declined during the past 26.5 years. Recorded seedlings increased from 65 in 1986 to a high of 195 plants in 1995. Seedling numbers dropped to 70 plants in 1996, representing a loss of 125 individuals in one year. After 1996, seedling numbers continued to decline from 53 in 1997 to one in 2021 (Phillips et al. 2022). Although, some flowering is documented annually, very few to no fruits are produced or the fruit aborts before maturing. Seedling establishment remains very low with little to no recruitment, suggesting that the reproductive potential of Peebles Navajo cactus has declined.

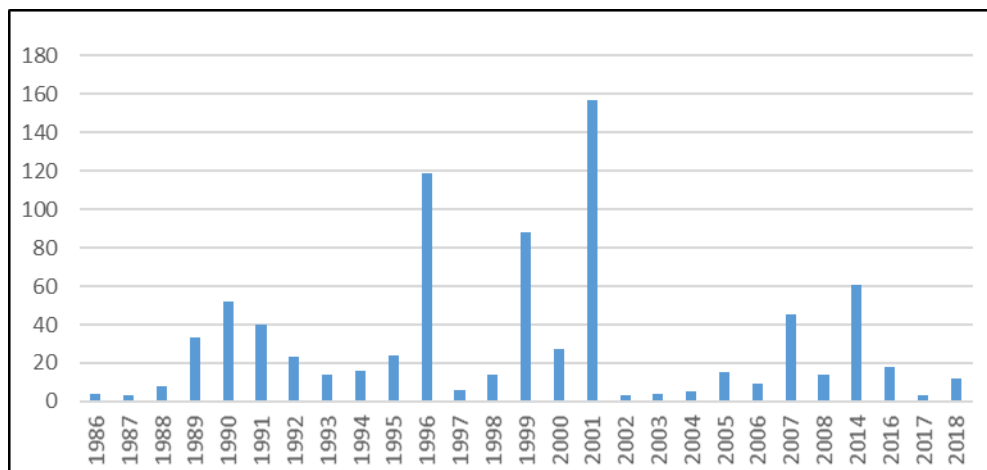


Figure 10. Number of dead Peebles Navajo cacti in the Joseph City monitoring plots from 1986 to 2018. No monitoring in the JC3 plot occurred in 2006 and 2014.

Summary

Preliminary information from the 2022 monitoring season in the three JC monitoring plots showed a decrease among all monitored plants with very low

recruitment. Searches for Peebles Navajo cacti outside of established monitoring plots located 103 additional plants. Peebles Navajo cacti may also be present in the Holbrook plot, but it is difficult to estimate their status given the lapse in time since monitoring concluded. Because of lack of access to the Holbrook Plot, data for this second population cannot be considered in assessing the status of the species and therefore, is considered a loss to long-term monitoring.

Based on a conservative estimate, there are at least 150 known Peebles Navajo cacti mostly occurring in a single population near Joseph City, with five new plants near Holbrook. As fewer plants are found annually without significant recruitment, there is a growing concern that further reductions in the population will place it at risk of extinction (Phillips et al. 2018).

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

Baker (2014) reassessed morphological variations of stem characters within and among populations of *Pediocactus peeblesianus* (ssp. *fickeiseniae* and ssp. *peeblesianus*), reaching a conclusion that these two cacti are not distinct and should be considered as one species. He determined that as both plant varieties grow in size, the length of the largest spine increased, as does the average length of all of the spines per areole. Baker also found some overlap in the two varieties' morphological characteristics with no correlation to geography, and suggested it was not practical to segregate populations of *P. peeblesianus* into two varieties.

A previous study examined the phylogenetic relationships among species of *Pediocactus* and individuals of *Pediocactus peeblesianus* (Porter 2010). In contrast with Baker, Porter's preliminary results from analyzing chloroplast DNA sequences indicated support to treat *Pediocactus peeblesianus* ssp. *fickeiseniae* and *Pediocactus peeblesianus* ssp. *peeblesianus* as two distinct genetic entities. These results are consistent with the current taxonomic treatment for recognizing two subspecies of *Pediocactus peeblesianus* (Heil and Porter 2001; Heil and Porter 2003; Integrated Taxonomic Information System 2022). We continue to recognize the Peebles Navajo cactus as a distinct subspecies from the Fickeisen plains cactus until additional genetic research or information from the broader plant community directs us differently.

2.2.1.4 Taxonomic classification or changes in nomenclature:

When Peebles Navajo cactus was originally listed, we recognized the scientific name as *Pediocactus peeblesianus* var. *peeblesianus*. The cactus is differentiated from the Fickeisen plains cactus, which was originally listed as *Pediocactus peeblesianus* var. *fickeiseniae*, by the absence of a central spine and fewer radial spines. In 2021, we reviewed the taxonomic name of both varieties

largely because the scientific name of the Fickeisen plains cactus was not validly published. As a result, we revised the taxonomic name of the Peebles Navajo cactus to reflect its subspecies status *Pediocactus peeblesianus* ssp. *peeblesianus* (USFWS 2021). This is in agreement with the broader plant community that already has accepted subspecies rank for the Peebles Navajo Cactus and thus we have updated our nomenclature.

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.):

The spatial distribution of the Peebles Navajo cactus has not changed since the 2008 status review.

The Peebles Navajo cactus is endemic to a small geographic area. Its range-wide population occurs within an area measuring seven miles long by one mile wide (USFWS 1984). Plants grow on the upper slopes and flat tops of the mesas in a scattered distribution with occasional patches of higher density (e.g., permanent monitoring plots) even when apparent suitable habitat is contiguous (Heil et al. 1981; USFWS 1984; AZGFD 1986). Clumped patches of Peebles Navajo cacti may be the result of limited seed dispersal in which seedlings establish close to the maternal plant (Butterwick 1986) or due to increased survival from available shade provided by a “nurse plant” (Phillips et al. 2018).

The Service, with assistance from a BLM biologist, revised the current range of the Peebles Navajo cactus (Figure 11). We identified 645.5 square kilometers located north and south of Interstate 40 (I-40) from Winslow to State Route 77 just east of Holbrook that may be suitable habitat for Peebles Navajo cactus. These areas were selected based on the taxon's known elevation range, associated vegetation community, geologic substrates (Moenkopi and Chinle Formations), and other information indicating habitat suitability for Peebles Navajo cactus. Areas to the north, south, and east of State Route 77/Highway 180 and I-40 were not included in the revised range because they lacked appropriate characteristics. Specifically, Shinarump Conglomerate is not exposed on the surface east of Holbrook (Martz et al. 2012; Parker 2005; Reppenning et al. 1969) and soils have more clay and are unlikely to support the cactus. More information is provided in the Habitat section below.

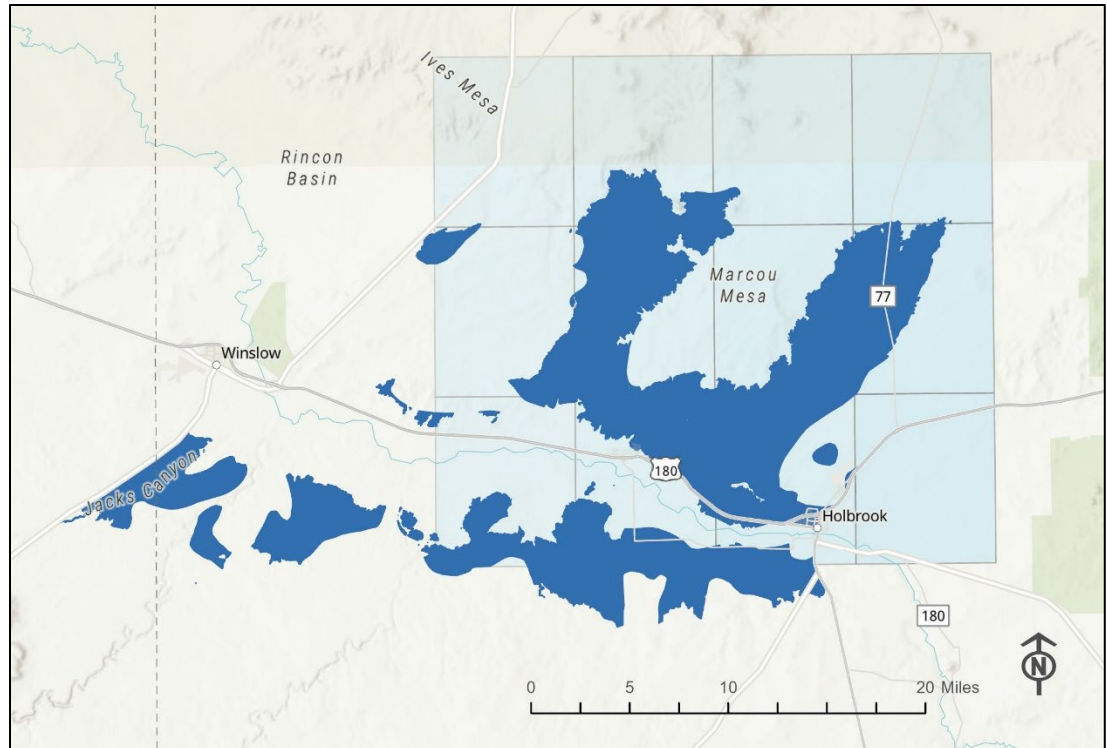


Figure 11. Revised range of Peebles Navajo cactus, shown in dark blue, that includes areas of suitable habitat north and south of Interstate 40, from just west of Winslow to State Route 77 at Holbrook. The former range, based on quarter-quadrants is shown in light blue (USFWS 2021).

Surveys of Potential Habitat

Surveys have been conducted outside of known occurrence areas but no additional populations were found. The survey efforts are described below.

The Arizona Department of Transportation (ADOT) conducted surveys for Peebles Navajo cactus in the right-of-way for two separate highway projects. Surveys occurred in 2009, 2014, and 2015 along I-40 and frontage roads between milepost (MP) 272.0 (approximately three miles west of Joseph City) and MP 295.0 (approximately six miles east of Holbrook), and along State Business Route 40 that runs between Joseph City and Holbrook. Several isolated sites in the right-of-way were identified as suitable habitat (flat hilltops, gravelly alluvium derived from the Shinarump Member of the Chinle Formation) near MP 285 and MP 287 but no plants were found (AZTEC 2009). Surveys in 2014 and 2015 found no suitable or potentially suitable habitat occurred between MP 279 and MP 279.60 north of I-40 (Logan Simpson Design, Inc. 2015).

With only one managed population and declines in known Peebles Navajo cacti, efforts to find new populations south of I-40 and potential suitable habitat for recovery purposes continues. Beginning in 1985 through 2022, the Museum of Northern Arizona, with assistance from BLM, identified parcels of land that appear suitable and search these areas when time and resources allow.

Ownership of the land is a checkerboard pattern mainly comprised of Arizona State and private lands with a few scattered parcels managed by the BLM.

In 1985, the Museum of Northern Arizona intensively searched 13 small, isolated sites where the habitat appeared excellent based on geology maps or aerial reconnaissance (Phillips et al. 1985). Field evaluations revealed some sites lacked certain attributes characteristic of Peebles Navajo cactus habitat or were heavily impacted by development (i.e., gravel pit) or recreation. In most cases, the Shinarump Member was present but only as a thin layer over clay or sandstone soil that was of different consistency and morphology than is typical of occupied Peebles Navajo cactus locations (Phillips et al. 1985). No Peebles Navajo cacti were found at any of the sites. In 2021, the researchers searched a BLM-managed parcel south of Holbrook near the community of Woodruff. No Peebles Navajo cacti were found but some potential habitat was observed (Phillips et al. 2022). Researchers recommended conducting more thorough surveys in this area.

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

We reviewed Peebles Navajo cactus occurrence data from Arizona Game and Fish Department (AZGFD) Heritage Data Management System, soil information, geology, and information describing habitat characteristics from the Recovery Plan, the 2008 status review, and monitoring reports. We compared published information on the taxon's habitat and updated current information.

Peebles Navajo cactus occurs between 1540 and 1615 meters (m) in elevation within the Plains and Great Basin Grassland vegetation community. Plants grow in open and sparsely vegetated areas normally in full sun (Figure 12). Some plants are found growing under the shade canopy of shrubs or trees. Vegetation associated with Peebles Navajo cactus habitat includes perennial grasses and scattered shrubs (Phillips et al. 2018). Dominant species include the following: Indian ricegrass (*Achnatherum hymenoides*), James' galleta (*Hilaria jamesii*), sideoats grama (*Bouteloua curtipendula*), alkali sacaton (*Sporobolus airoides*), Fendler threeawn (*Aristida purpurea*), and low woollygrass (*Dasyochloa pulchella*). A few scattered shrubs are also present consisting of Bigelow sage (*Artemisia bigelovii*), four-wing saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*), rubber rabbitbrush (*Ericameria nauseosa*), broom snakeweed (*Gutierrezia sarothrae*), and one-seed juniper (*Juniperus monosperma*).

Peebles Navajo cactus is closely associated with soils derived from the Shinarump Member of the Chinle Formation (Figure 13). The Shinarump Member is the lowest unit of the Chinle Formation, dating late Triassic. This formation overlays the Moenkopi Formation, dating middle to early Triassic

(USFWS 1984). The stratum is a loosely consolidated cobbly soil with a matrix of sandy loam (USFWS 1984; AZGFD 1986).



Figure 12. Example of Peebles Navajo Cactus habitat. Photo by USFWS, 2016.



Figure 13. Close view of cobbly soils derived from the Shinarump Member of the Chinle Formation in Peebles Navajo cactus habitat. Photo by Ian Tackett, Logan Simpson Design, Inc. 2015.

Geology in the Winslow to Holbrook region is diverse (Billingsley et al. 2013; Parker 2005; Repenning et al. 1969; Smith 1957). South of the Little Colorado River, the Moenkopi Formation is exposed, consisting of dark-red sandstone, mudstone, and gypsum beds (USFWS 1984). North of the Little Colorado River, the Moenkopi Formation thins and is overlain by light-brown sandstone and basal conglomerate deposits of the Shinarump Member of the Chinle Formation (Billingsley et al. 2013; USFWS 1984) (Figure 14). The Shinarump Member forms low cliffs, ledges, and mesas between Joseph City and Holbrook (Smith 1957). According to Repenning et al. (1969), Shinarump conglomerate is composed of well-rounded, to subangular pebbles and cobbles of quartz, quartzite, jasper, chert, and petrified wood.

In mapping the geology associated with the Peebles Navajo cactus, the majority of occurrences are on the Moenkopi Formation (Figure 15). This may be due to the broad scale used to map geologic units. Field investigations of Peebles Navajo cactus habitat report plants only occurring where the Shinarump Member is exposed. In occupied areas, the Shinarump Member overlies an eroded surface of the Moenkopi formation and the surface deposits are derived from Shinarump conglomerate. This soil specialization makes the Peebles Navajo cactus a narrow endemic.

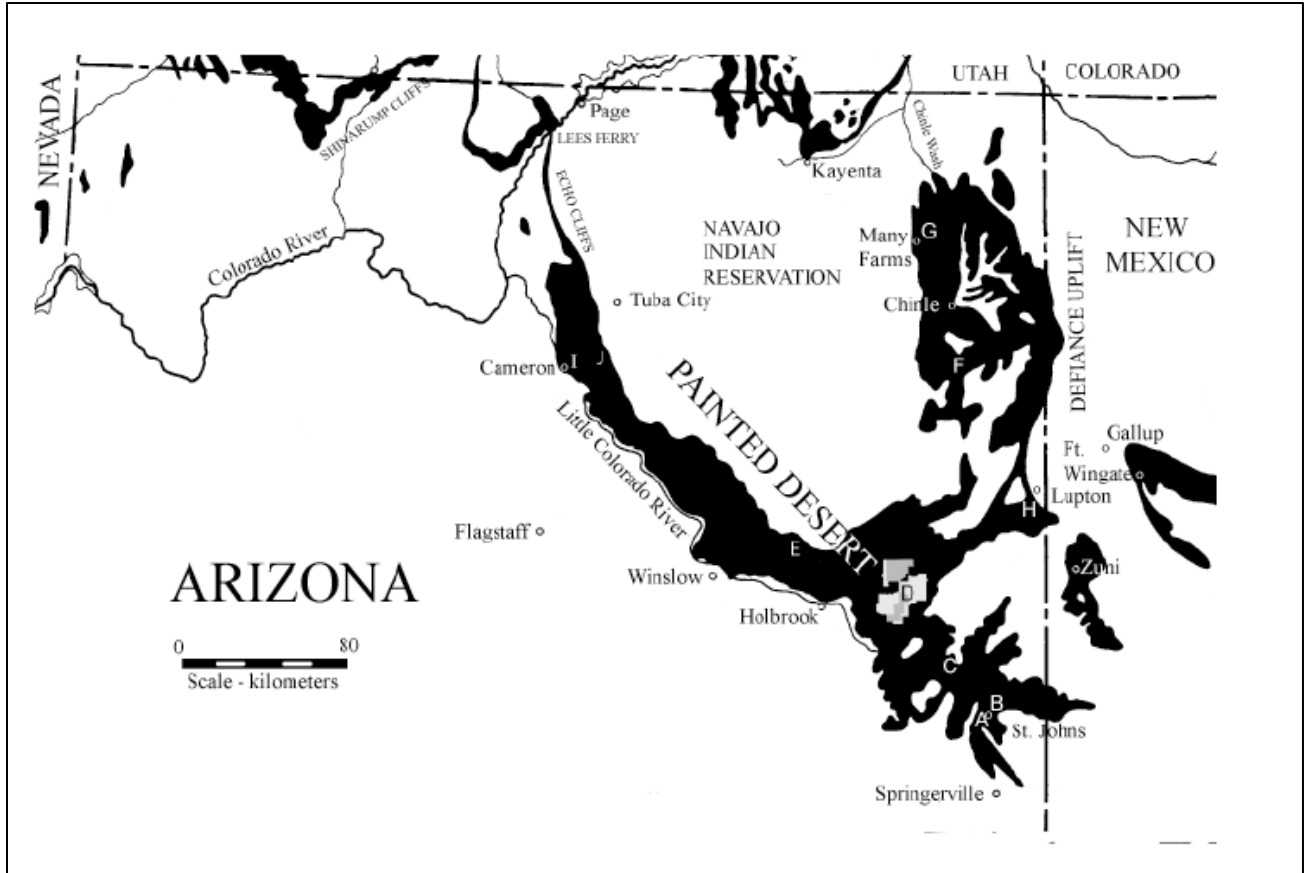


Figure 14. Map showing Chinle Formation exposures in Arizona. Letters refer to different localities described in Parker 2005. Letter E is refers to the Joseph City-Holbrook area. Reprinted from Parker 2005.

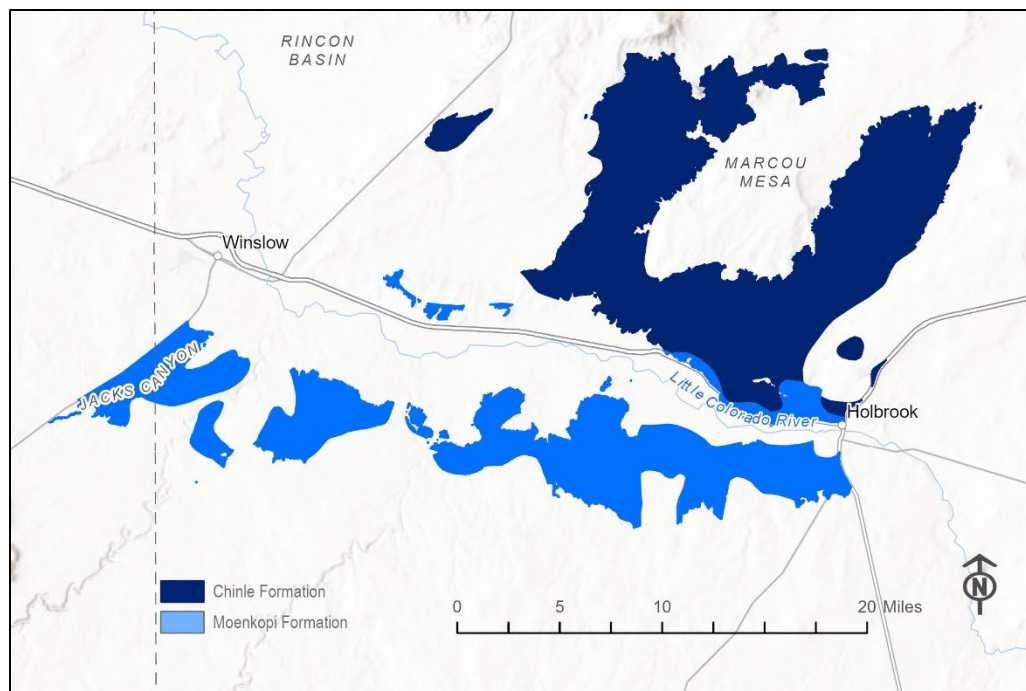


Figure 15. Geologic units within Peebles Navajo cactus range. Geologic data was accessed from the Arizona Geological Survey (Richard et al. 2002).

Associated Soil Types

We mapped soils in Peebles Navajo cactus habitat using soil information provided by the Natural Resources Conservation Service (NRCS) Soil Survey staff through Web Soil Survey (NRCS 2019, entire). Three primary soil types are associated with the Peebles Navajo cactus: Rock outcrop-Epikom complex, Badland-Torriorthents association, and Gypsiorthids-Torriorthents association.

The Rock outcrop-Epikom complex is 50 percent (%) Rock outcrop and 30% Epikom channery sandy loam (DeWall 2003). Rock outcrop is on the tops, side slopes, and vertical breaks of escarpments, buttes, and mesas, and consists of exposed areas of sandstone and mudstone. Epikom soil is shallow and well-drained, moderately alkaline and non-saline throughout. This soil formed in alluvium derived dominantly from sandstone and mudstone.

The Badland-Torriorthents association is 75% Badland and 15% Torriorthents (DeWall 2003). Badland consists of areas of multicolored siltstone, claystone, and mudstone deposits of the Chinle Formation that have been exposed by active geologic erosion. This unit is on hills and escarpments with slope of 5 to 30%. Torriorthents are shallow and very shallow, excessively-drained to well-drained soils on foot slopes below the Badland. Parent materials include eolian material, alluvium, and colluvium. The texture varies from stratified sand to clay with varying amounts of gravel over mudstone and siltstone. The surface layer is typically reddish brown channery sandy loam.

Gypsiorthids-Torriorthents association is 30% Gypsiorthids and 30% Torriorthents on hills along the Little Colorado River (DeWall 2003). These soils have varying amounts of gypsum in the profile and are underlain by stratified sand and gravel. This unit has small areas of deep, very gravelly loamy soils that contain moderate to high amounts of calcium carbonate and moderately deep and shallow, very gravelly loamy soils over bedrock. The subsoil is reddish-brown gravelly clay loam. Sandstone and mudstone is exposed on the steep side slopes of some of the hills. Gypsiorthids are deep and very deep and somewhat excessively drained. They formed in alluvium and colluvium derived from mixed sources. The texture of the soil varies from sand and gravel to very gravelly sandy clay. Torriorthents are very deep, well-drained to excessively-drained soil, forming in alluvium derived from mixed sources.

2.2.1.7 Conservation Measures:

In 2020 and 2021, The Arboretum at Flagstaff, with Cooperative Endangered Species Conservation Funds (Section 6) collected five fruits and a total of 46 seeds following the Center for Plant Conservation best management guidelines (Murray 2021). Seed collections were dried at the Arboretum at Flagstaff then sent to the National Laboratory for Genetic Resource Preservation in Fort Collins, Colorado for long-term storage. Preservation of Peebles Navajo cactus seeds provides for their use in future genetic research and reintroduction efforts (Phillips et al. 2022; Murray 2021, 2022).

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:

The listing rule identified the destruction and/or disturbance of Peebles Navajo cactus habitat by gravel pit operations on private lands, construction of I-40 around Holbrook, and rock collecting that also results in trampling of plants as threats to the cactus (USFWS 1979). Construction of I-40 is complete and with no plants found within the ADOT right-of-way this activity is no longer considered a threat. The 2008 status review described trampling or crushing from OHV-use and livestock grazing as primary threats to the Peebles Navajo cactus (USFWS 2008). All of these activities are authorized within the Tanner Wash ACEC. With the exception of gravel pit mining, livestock grazing and OHV-use are on-going activities. We do not have information that gravel pit mining or operations is currently occurring near or within Peebles Navajo cactus habitat.

Detrimental impacts to the Peebles Navajo cactus and its habitat are largely ameliorated from BLM's efforts to fence occupied areas and protect the cactus

(Cockman 2014). However, Phillips et al. (2022) reported seeing cattle tracks, cow manure, and an occasional cow within BLM's 40-acre enclosure while conducting monitoring from 2014 and 2022. In 2018, they observed a single cow inside the enclosure and notified BLM (Phillips et al. 2018). They observed soil erosion under the fences that likely allows cows to access the enclosure. Despite its presence, no cattle impacts such as trampling of a cactus, soil compaction, and cow manure was observed within the monitoring plots. The BLM routinely conducts fence inspections and has made multiple fence repairs for the 40-acre enclosure between 2016 and 2019 (BLM 2014; BLM 2017). No cows were observed in the enclosure during the 2022 monitoring period. No additional information was received.

Newly discovered Peebles Navajo cacti growing in unfenced areas may be more vulnerable to livestock trampling or at risk of being damage or killed by OHV use. It is unknown if BLM is able to fence additional Peebles Navajo cactus habitat, including the five plants discovered in 2022. There are more access roads on the east end of the Tanner Wash ACEC making cattle and OHV exclusions difficult. All OHV-use is limited to existing roads and designated trails within the ACEC (BLM 1988). In most areas, OHV traffic stays on designated roads except in the east end where BLM reported an increase in OHV-use since around 2011 and use in undesignated areas continues to be a problem (Cockman 2014). The Museum of Northern Arizona reported increased OHV-use around the 40-acre enclosure and has observed OHV tracks inside the 250-acre enclosure (Phillips et al. 2022). None of the Peebles Navajo cacti were reported to be impacted.

One past threat to the Peebles Navajo cactus may be bottom ash dust generated by the APS Cholla Power Plant. In 2004, BLM identified "fugitive dust" from the APS Cholla Power Plant bottom ash pond as a potential source of disturbance in the 10-acre enclosure that reduced and likely resulted in the extirpation of the Peebles Navajo cactus occurrence (Cockman 2014). The Cholla Power Plant, located near Joseph City, is an electric generating station that consists of four coal-fired units. It has been in operation since 1962. The coal ash (i.e., coal combustion residuals) are stored in two surface impoundments, one being a bottom ash pond that is approximately 0.16 mile from the 10-acre enclosure (APS 2018). The deposition of dust began when the bottom ash dried in the surface impoundment and was not landfilled in time, and subsequently, particles were transported through the air during windy conditions and deposited on the adjacent 10-acre enclosure (J. Servoss, USFWS, pers. comm. 2005) (Figure 16, Figure 17). APS worked to vacuum the bottom ash dust in the Peebles Navajo cactus occupied habitat and capped the bottom-ash pond with native soil to mitigate any additional effects (Cockman 2014). According to the results from a Toxicity Characteristic Leaching Procedure (e.g., tests for risk of heavy metal toxicity through leaching and absorption) and a mineral analysis of ash, bottom ash is classified as a solid but not hazardous waste and is inert (Commercial Testing and Engineering Company 1987,

McKenzie Laboratories 1997). Despite the removal of coal ash dust, the number of Peebles Navajo cacti continued to decline. The 10-acre exclosure was considered extirpated in 2006. To our knowledge no Peebles Navajo cacti have been located there since 2006. Extirpation of plants, if wholly caused by the accumulation of bottom ash deposition in combination with long-term drought, has not been investigated. The APS Cholla Power Plant is scheduled for closure in 2025.



Figure 16. A BLM biologist measures the depth of bottom ash deposited in the 10-acre exclosure. Photo taken by Jony Cockman, BLM, 2009.



Figure 17. Samples of bottom ash (gray colored material) and native soil (reddish-brown material) collected by hand in Peebles Navajo cactus habitat. Photo taken by Jony Cockman, BLM, 2020.

2.2.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: reports of illegal collection

At the time of listing, overutilization or unauthorized collection was considered a threat to the Peebles Navajo cactus (USFWS 1979). In our 2008 status review, we no longer suspected illegal collection to be a significant threat since the Peebles Navajo cactus was artificially propagated for commercial sale and we did not have available information to suggest that Peebles Navajo cacti were being illegally removed from native habitat (USFWS 2008). We are aware of the difficulty in determining that illegal collection has occurred for various reasons such as the remote location of populations and scarce law enforcement resources. Poaching cactus from their native habitat is becoming a growing problem both in Arizona (Bennett 2020; McGivney 2019; Rohrlich and Schlanger 2019) and worldwide (IUCN 2015; Service 2019). For these reasons, we remain diligent in protecting the Peebles Navajo cactus and consider illegal collection a potential threat to the taxon.

In preparation for this status review, we received reports about activities in occupied Peebles Navajo cactus habitat that could be related to illegal collection. In May 2021, a biologist with SWCA Environmental Consultants noticed tracks that appeared to be from a cart or small wagon leading towards a ridge in occupied Peebles Navajo cactus habitat while working in the 250-acre enclosure (J. Cockman, BLM, pers. comm. 2021) (Figure 18). The tracks did not appear recent but were unusual inside the enclosure, and their direction towards

occupied habitat was concerning to the BLM. These tracks may be the same OHV tracks reported by the Museum of Northern Arizona in 2018 (Phillips et al. 2022). The SWCA biologist also observed small, shallow pockets dug out in Peebles Navajo cactus habitat that looked fairly old and out of the ordinary (J. Cockman, BLM, pers. comm. 2021) (Figure 19).



Figure 18. Tracks observed in the 250-acre enclosure leading up a ridge where the Peebles Navajo cactus occurs. Photo by Corina Anderson, SWCA Environmental Consultants, 2021.



Figure 19. Small, shallow pockets resembling “digging” documented in Peebles Navajo cactus habitat. Photo by Corina Anderson, SWCA Environmental Consultants, 2021.

BLM law enforcement installed surveillance cameras in the 250-acre enclosure to capture any activity over a period of a few months. There were no signs of human foot traffic leading to occupied areas but a couple of vehicles had entered the area (J. Cockman, BLM, pers. comm. 2021). The Museum of Northern Arizona also had cameras installed in their monitoring plots for research purposes and did not capture any type of human activity. No further disturbances were documented.

During their 2019 to 2022 monitoring periods, the Museum of Northern Arizona noted a few instances of holes where a Peebles Navajo cactus previously was located (Phillips et al. 2022). They noted that when a plant disappears from the monitoring plot it is rare the dead plant remains. Its loss could be from animal herbivory, illegal collection, or death by natural causes in which case no tissue or spines are left behind.

2.2.2.3 Disease or predation:

There is no information about diseases affecting Peebles Navajo cactus.

Phillips et al. (2022) consider animal herbivory as a “possible” threat. Herbivory by rabbits and rodents has been suspected as a cause of Peebles Navajo cactus mortality; however, limited data are available. In 1989, holes and spine clusters were found where about 23 plants had been documented in the JC3 Plot. Their absence was believed to be caused by rodent or rabbit herbivory in response to exceptionally dry and warm weather (USFWS 2008, Phillips et. al. 1990). The researchers observed an “abundant” amount of rabbit feces in the

monitoring plots leading them to conclude that rabbit and rodent herbivory was responsible for the cactus declines and not illegal collection (Phillips and Phillips 2004).

The Museum of Northern Arizona installed wildlife cameras in the JC1 Plot to document any herbivory or disturbance in 2017 and 2018. The cameras did not capture any direct or suspected evidence that animals were eating Peebles Navajo cactus. Many animals were captured in the plot including a mouse, rabbits, ground squirrels, porcupine, raccoon, coyote, bobcat, mule deer, various birds, and a roadrunner using the habitat (Phillips et al. 2018).

2.2.2.4 Inadequacy of existing regulatory mechanisms:

Arizona passed House Bill (HB) 2749, titled “Endangered Species Conservation and Coordination” that went into effect on January 20201. The legislation ensures that information about a species (i. e., any species of fish, wildlife, or plants and any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature) shall be collected only through a standardized form in which the private property owners provide their written consent to have their property surveyed for endangered species, species research, or enrolled into a conservation plan. Information collected from a private property owner by any state agency or someone acting under the authority of a state agency regarding listed or candidate species under the Endangered Species Act is confidential and may not be disclosed to any person, including state or federal agencies unless the private property owner provides written consent to full or partial disclosure. Any persons that violates the private property owner confidentiality is subject to civic penalties (AZGFD 2020; State of Arizona 2020, ARS 2022).

We believe HB2749 will reinforce negative attitudes towards recovering endangered species on private lands and prevent us from re-establishing amicable relationships with the private landowners in Holbrook.

2.2.2.5 Other natural or manmade factors affecting its continued existence:

Based on statewide precipitation patterns, Arizona is experiencing a long-term drought, which is currently in its 27th year (Frankson et al. 2022). The Arizona Drought Monitoring Technical Committee forecasts northern Arizona will remain in severe drought conditions from spring to summer of 2022 (ADWR 2022). According to the Arizona Climate Summary, temperatures in the state have risen about 2.5 degrees Fahrenheit since the beginning of the 20th century. Since 1995, the number of days with a maximum temperature of 100 degrees Fahrenheit or higher has been near to above average, reaching a record high from 2015 to 2020. The number of nights with a minimum temperature of 80

degrees Fahrenheit or higher has been trending upward since 1995, also reaching a record high from 2015 to 2020 (Frankson et al. 2022).

The Museum of Northern Arizona tracks annual average precipitation and temperature during their monitoring periods and correlates weather patterns to changes in plant abundance, including seedling recruitment and reproductive effort (Phillips et al. 2018, 2022). Using precipitation data from the weather station at Winslow Municipal Airport, the monitoring years 2013 to 2016 received above-average precipitation while also being some of the hottest years on record (Phillips et al. 2022). During this time, the number of live Peebles Navajo cacti remained around 50 plants in all three plots with an increase of plants in 2017 (Phillips et al. 2022). Normally, September to July is the dry season in the Winslow area with April, May, and June the driest months on average (ADWR 2009). The extra rain may have provided some relief from increased temperatures.

Dry conditions contributed to the number of Peebles Navajo cacti retracted into the soil from 2017 to 2018, and extending into the 2019 to 2022 monitoring period. Although plants retract under dry conditions, it is unknown to what magnitude the extended drought is affecting Peebles Navajo cactus. There is the possibility that dry conditions led to fruit abortion. Aborted fruit is common in plants and can be related to resource and pollen limitation among other sources (Udovic and Aker 1981; Piña et al. 2007; Rering et al. 2020). When nutrients, pollen, and water are limited, an individual plant may halt fruit development and redirect resources elsewhere such as vegetative growth. It is reasonable to believe that the absence of fruits and aborted fruits in 2017 and 2018 from the Joseph City monitoring plots were related to drought stress.

Navajo County also experienced extreme to exceptional drought conditions in the fall of 2018 (ADWR 2018) and abnormally dry conditions in February 2019 (AZWater 2019a). Short-term drought conditions were alleviated in mid-March by heavy rainfall from Hurricane Rosa (AZWater 2019b). Examining the 2019 monitoring and precipitation data from Phillips et al. (2022), we did not observe a direct relationship between precipitation and flowering Peebles Navajo cacti. While precipitation amounts decreased in the region from 2018 to 2019 the numbers of Peebles Navajo cacti increased. Precipitation amounts decreased again from 2019 to 2020 but plant numbers remained unchanged. Phillips et al. (2022) found that 2019 was an above-average flowering year for all plots and 2022 was above-average flowering year for JC1 and JC2 plots. They identified reproductive effort as significantly related to cool season precipitation. However, they acknowledge that the relationship is “loose” with cool season precipitation explaining only 30% of the variation in flowering rate, in which, winter precipitation leading into 2019 was below-average. It is possible that higher maximum and minimum temperatures coupled with other factors such as low relative humidity and soil moisture from the drought may also be important factors effecting the Peebles Navajo cactus. It is also possible that increased

flowering could be a stress response to environmental conditions, which needs additional investigation.

2.3 Synthesis

Monitoring data over a 34-year period shows a continued decline in the number of Peebles Navajo cactus. An estimate of its abundance in 1995 and 2005 shows roughly 773 total known plants (shown in Table 2 in Section 2.2.1.2). In 2022, our conservative estimate is there are approximately 150 plants from these same areas. One site (BLM 10-acre exclosure) with 41 Peebles Navajo cacti in 1996 is now considered extirpated as no plants have been found since 2006.

The Peebles Navajo cactus is being managed as a single population. Although the rangewide population is known from two small populations, there has been no access to the population on private land since 2008 and its status is unknown. Concentrated efforts are needed to ensure that the Peebles Navajo cactus population has redundancy and resiliency into the foreseeable future. Finding another location that has features similar to the Holbrook Plot and that is either occupied or can be used for reintroductions is critical to maintaining representation of the taxon's spatial distribution and ecology.

The Peebles Navajo cactus is an endemic with a restricted distribution. Recent habitat mapping efforts have identified suitable habitats for future surveys, which may help to locate additional plants and determine future reintroduction sites. However, searches of suitable habitat south of I-40 has determined these sites to actually be unsuitable. In contrast, small numbers of Peebles Navajo cacti have been located near known occurrences. If the cactus is only found near known occurrences, this would validate its very restricted distribution and increase the need to invest in on-the-ground recovery efforts to ensure the taxon's viability.

Causes of Peebles Navajo cactus declines, low reproductive potential, and little to no recruitment are believed to be driven primarily by Arizona's long-term drought. Other potential stressors such as illegal collection, rodent and rabbit herbivory, and increased OHV use may be contributing to plant losses directly or indirectly. Although most of the known occupied areas are fenced to protect plants from disturbances, there are reported breaches of fencing and not all occurrences are fenced. Other environmental factors such as low soil moisture, levels of relative humidity, and the plant's pollination system relating to fruit abortion have not been considered and likely are related to the state's short-term and long-term drought. Investigation into all of these factors may help to determine other stressors causing downward trends in Peebles Navajo cactus.

In addition to needing additional survey efforts, recovery criterion may need to be revisited. The recommended Recovery Plan criteria to have up to 10,000 individuals to reach downlisting should be revised. There is little evidence from the 34 years of monitoring that the population has been as high as 1,000 individuals, and therefore the recommendation of 10,000 individuals as a downlisting goal now appears too high (USFWS 1984).

Based on all of the information on the Peebles Navajo cactus, we recommend the taxon remain listed as an endangered species.

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
- No change is needed

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

No change recommended.

Brief Rationale:

The Peebles Navajo cactus Recovery Priority Number of 6 is indicative of a taxon with a high degree of threats and a low recovery potential, and is appropriate for an entity listed as a subspecies. Peebles Navajo cactus continues to meet these criteria. Peebles Navajo cactus continues to decline to low numbers of individuals managed in a single population. Its range may be more restrictive than originally designated based on on-going searches for additional plants. Climate change is a threat to the taxon resulting in little to no recruitment, poor seed set, aborted fruit, and a declining population. Habitat disturbance by recreation, coal-ash dust deposition, herbivory, and potentially illegal collection may also be contributing directly or indirectly to population declines. Actions to secure the taxon's viability into the foreseeable future are needed.

3.3 Listing and Reclassification Priority Number, if reclassification is recommended (see 48 FR 43098): Not Applicable

- Reclassification (from Threatened to Endangered) Priority Number: _____
- Reclassification (from Endangered to Threatened) Priority Number: _____
- Delisting (Removal from list regardless of current classification) Priority Number: _____

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. If possible, given workloads, a Species Status Assessment could be conducted to guide the development of a revised recovery plan. We recommend revision of Peebles Navajo cactus recovery criteria. Specifically, the number of plants and populations referenced in the current recovery plan as necessary for long-term viability of the species are unrealistic, based on our knowledge of the species, and should be revised. The recovery criteria for downlisting and delisting should be adjusted accordingly.

2. Improve coordination with BLM and develop creative approaches to protect the Peebles Navajo cactus, including investing necessary resources in mitigating bottom-ash deposition, ensuring enclosure fences are maintained, and working with local partners to increase conservation efforts aimed at recovery the cactus.
3. Continue to survey areas within the species' revised range to verify the presence or absence of suitable habitat. Surveys should also focus on areas that may support future reintroductions of the Peebles Navajo cactus for recovery purposes.
4. Establish an off-site conservation program to develop captive propagation techniques that follow the Center for Plant Conservation best management practices. Conduct studies to evaluate the effectiveness of seed germination and seedling establishment. Establish a new population within Peebles Navajo cactus native habitat as a pilot project to ensure the taxon remains extant.
5. Develop incentives in the Tanner Wash ACEC to manage livestock grazing and OHV use or other recreational activities in a manner that does not result in habitat disturbance to the Peebles Navajo cactus.
6. Investigate the pollination system of Peebles Navajo cactus to identify and understand potential factors that are contributing to low recruitment, poor seed set, and fruit abortion.
7. Evaluate and test new technologies that improve the detection of rare, cryptic plants.
8. Implement concerted efforts to ensure long-term viability of this species on private lands through various conservation incentive programs available to private landowners.
9. Establish coordination meetings with the USFWS, BLM Safford District Office, and Museum of Northern Arizona to improve collaboration, discuss annual monitoring results, and proactive management of the cactus.
10. Develop public awareness and support for the conservation of the Peebles Navajo cactus.

5.0 REFERENCES

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Peebles Navajo Cactus
(*Pediocactus peeblesianus* ssp. *peeblesianus*)**

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By: Kathy Robertson, Fish and Wildlife Biologist

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service, Arizona Ecological Services Office

Approve _____