

**Mesa Verde Cactus
(*Sclerocactus mesae-verdae*)
5-Year Status Review:
Summary and Evaluation**



Photo: Lauren Rangel, USFWS

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

5-YEAR REVIEW

Mesa Verde Cactus (*Sclerocactus mesae-verdae*)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office:

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505-248-6657

Lead Field Office:

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Cooperating Field Office(s):

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Cooperating Regional Office(s):

Not Applicable

1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species 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:

In conducting this five-year review, we relied on the best available information pertaining to historical and contemporary distributions, life histories, genetics, habitats, and threats of this species. Data for this current review were solicited from interested parties through a Federal Register notice announcing the review on February 2, 2022. This review considers new

information from Federal agencies, State, and Tribal entities, non-governmental organizations, academia, and the general public. Information used in the preparation of the review includes monitoring reports, surveys, section 6 funded projects, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and internet web sites. Data sources include the New Mexico Energy, Minerals, and Natural Resources Department, State Forestry Division; Navajo Nation Department of Fish and Wildlife, Navajo Natural Heritage Program; Ute Mountain Ute Tribe; and Bureau of Land Management, Farmington Field Office. The Service's New Mexico Ecological Services Field Office and Western Colorado Field Office prepared the final review and recommended classification.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

87 FR 5834; February 2, 2022

1.4.2 Listing history:

Original Listing

FR notice: 44 FR 62471

Date listed: October 30, 1979

Entity listed: Species, Mesa Verde cactus (*Sclerocactus mesae-verdae*)

Classification: Threatened, without critical habitat

Revised Listing, if applicable

FR notice: N/A

Date listed: N/A

Entity listed: N/A

Classification: N/A

1.4.3 Associated Rulemakings:

There are no associated rulemakings for this species.

1.4.4 Review History:

We initiated five-year reviews on November 6, 1991 (56 FR 56882) for all species listed before 1991, but did not complete a review for this species. We initiated a five-year review for this species on February 2, 2005 (70 FR 5460) and published the five-year review in January 2011 (USFWS 2011a, entire). Our review recommended no change in status (remain as threatened).

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

11C

Degree of threat: Moderate
Recovery Potential: Low
Taxonomy: Species

1.4.6 Recovery Plan or Outline

Name of plan or outline: Mesa Verde Cactus (*Sclerocactus mesae-verdae*) Recovery Plan

Date issued: March, 1984

Dates of previous plans/amendment or outline, if applicable: N/A

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.

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

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

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

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:

Mesa Verde cactus, or Whoosh Diikoozih (O'Kane et al. 2022, p. 5), is a perennial desert plant that grows slowly and has an estimated lifespan of at least 50 years (Coles et al. 2012, p. 313). Mesa Verde cactus can reach maturity within 2 to 3 years and can reach a reproductive size in 7 to 11 years (Coles et al. 2012, p. 313). The Navajo Natural Heritage Program found during monitoring that stems lived an average of 4.33 years, however 27 stems (out of 270 stems) survived the entire study (2008-2019; 11 years) (2021, p. 6).

We recommend referring to the previous five-year review (USFWS 2011a, pp. 6-8) for a complete discussion regarding Mesa Verde cactus biology and life history.

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:

Mesa Verde cactus is not distributed continuously throughout its range, distribution is instead sporadic and widely scattered. Mesa Verde cactus density within populations is low, rarely exceeding one plant per 10 square meters (108 square feet) (Coles et al. 2012, p. 312). Of the known Mesa Verde cactus populations, at least 80 percent of these occur on Navajo Nation lands, 15 percent on Ute Mountain Ute lands, and 5 percent on small blocks of Bureau of Land Management and New Mexico State trust lands (NMSFD 2020b, p. 2). Mesa Verde cactus are now known to occupy private land (BOR 2022, p. 18). At this time, not all potentially suitable habitat for Mesa Verde cactus has been surveyed.

Various entities have conducted Mesa Verde cactus monitoring since the last five-year review, we will discuss those efforts in the following sections.

Colorado

Ute Mountain Ute Tribal Reservation

Extensive surveying for Mesa Verde cactus was completed in 2022 to mitigate and avoid impacts for a large-scale solar project to be completed in 2023. Adkins Consulting, Inc. (2022, p. 2) identified 309 individual cacti in areas within and surrounding the original project area. Previous surveying primarily included areas only east of Highway 491. However, most of the Ute Mountain Ute Tribal lands west of Mesa Verde National Park is included within potential current range of the species. Adkins Consulting, Inc. created a Mesa Verde cactus conservation plan that categorized quality habitat for Mesa Verde cactus

within the project area and outlined project design features implemented to reduce impacts to Mesa Verde cactus (ACI 2022, entire). These habitat quality descriptions could be useful for future surveying for the species and conservation measures are applicable to other ground disturbing projects near Mesa Verde cactus habitat.

In addition to project clearance surveys prior to consultation and construction of a proposed action, the Service is continuing coordination with the Ute Mountain Ute Tribal Reservation and will use any additional information received to inform the status of the species.

New Mexico

State Trust Lands, Waterflow Monitoring Site

This population of Mesa Verde cactus is located on State Trust lands of New Mexico just north of Waterflow, New Mexico. Monitoring at this site first began in 1986, and since the last five-year review, the New Mexico Forestry Division has been biennially monitoring starting in 2014 (Figure 1) (NMSFD 2020a, p. 5).

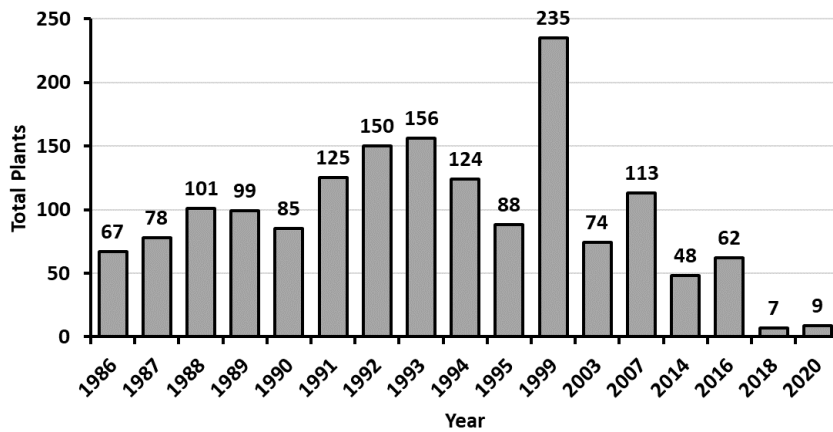


Figure 1. Total plants recorded at Waterflow monitoring site since 1986. Data obtained from D. Roth (2020a, entire).

The total number of plants detected in this plot has fluctuated throughout the study, but most significantly from a high of 235 plants in 1999 to a low of 7 plants in 2018 (NMSFD 2020a, p. 9). Two significant declines have occurred since 2007, one between 2007 and 2014, and another between 2016 and 2018. The New Mexico State Forestry Division (2018, p. 12) attributed the decline in plants between 2007 and 2014 to either a drought in 2009 and/or 2012, or rodent predation (NMSFD 2018, p. 12). Rabbits or other rodents likely contributed to the significant decline in population size between 2016 and 2018, as evident by spine clusters observed around plant tags in 2018 (NMSFD 2018, p. 9). While

this decline in plants was observed in 2018, the predation event likely occurred in 2016 (NMSFD 2018, p. 12).

Reproductive effort has varied over the years in this monitoring plot, but most significantly was highest at 94% plants flowering or fruiting in 2014, and lowest at 0% plants flowering or fruiting in 2018 (NMSFD 2020a, p. 6). The 2018 decline in reproductive effort and total plants was consistent with a drought event that spanned the entirety of 2018 (Lindsey 2019, entire).

During a Mesa Verde cactus status survey at the Hogback Area of Critical Environmental Concern (ACEC), the New Mexico State Forestry Division (2020b, p. 9) observed 38 plants within and immediately surrounding the Waterflow monitoring site. According to the New Mexico State Forestry Division (2020a, p. 11), the Waterflow population has not recovered from the 2002 population decline. Most of the plants that remained in 2002 have now died and recruitment remains low.

Bureau of Land Management, Hogback ACEC

This population is entirely within the Hogback Area of Critical Environmental Concern. There are a total of 10,367 acres within the boundary of the Hogback Area of Critical Environmental Concern, of which 960 acres are State Trust Lands (managed by the New Mexico State Land Office) (NMSFD 2020b, p. 6).

The New Mexico State Forestry Division (2020b, entire) conducted a status survey in 2020 within the Area of Critical Environmental Concern. Surveys focused on suitable habitat and 37 previously documented areas of known occupation, including the Waterflow monitoring site and five Bureau of Land Management monitoring plots (NMSFD 2020b, p. 6). Surveys of over 20 miles of suitable habitat (including occupied habitat) in 2020 yielded observations of 182 live plants and one dead plant (NMSFD 2020b, p. 7). Of the 37 previously documented sites, the New Mexico State Forestry Division (2020b, pp. 8-10) only found plants at or near 13 of the sites. Most cacti were either in vigorous (34%) or normal (59%) condition, but 7% of cacti were stressed (NMSFD 2020b, p. 7). Of the 12 locations where Mesa Verde cactus were re-located, and the previous number of plants was known, the number of plants decreased at seven locations and increased at five locations (NMSFD 2020b, pp. 8-10).

Of the Mesa Verde cactus that remain on the Area of Critical Environmental Concern, most occur either as individuals (half of the locations where Mesa Verde cactus were relocated contained only one individual when historically that location contained multiple individuals), or in small clusters (NMSFD 2020b, pp. 8-10, 15). The largest group of plants observed was in an active Bureau of Land Management monitoring plot which had 57 individuals, followed by the Waterflow monitoring site (and surrounding area) with 38

plants (discussed in Section 2.2.1.2.2.1 above), and two known sites with 21 plants (NMSFD 2020b, pp. 8-10).

Following the status survey conducted by the New Mexico State Forestry Division (2020b), the Bureau of Land Management’s New Mexico State Office established a monitoring protocol and conducted monitoring at the Area of Critical Environmental Concern in 2020 (BLM 2020, entire). In addition to this effort, the Bureau of Land Management has continued to annually monitor two plots (Plot 1 and 2). The Bureau of Land Management’s New Mexico State Office monitoring protocol calls for tagging and revisiting all tagged individuals (and a 20-meter buffer) annually (BLM 2020, pp. 2-4). Surveys will search the buffer around the individual known cactus annually, and any new individuals encountered will be tagged and become part of future monitoring efforts (BLM 2020, p. 3). The New Mexico State Office tagged and measured 36 individuals in 2020 and observed 27 seedlings (BLM 2020, p. 5). Monitoring results showed evidence of reproductive effort, with a total of 11 healthy fruits observed, 35 aborted flowers, one aborted bud, and several cacti had seeds present (BLM 2020, p. 5).

Outside of the Waterflow monitoring site discussed in the previous section (Section 2.2.1.2.2.1), there have been five monitoring plots within the Hogback Area of Critical Environmental Concern. The Bureau of Land Management has monitored three plots (Plot 1, 2, and 4) since the last five-year review, the other plots have since been abandoned (Kendall 2010-2022, entire). Within the plots Bureau of Land Management staff have at some point recorded the number of plants (presence only), reproductive phenology, recruitment, stem diameter, and mortality. Plot 1 and Plot 2 had the highest number of plants in 2022 since 2010 (Table 1). The highest number of plants in Plot 1 and Plot 2 was 61 plants (in 2002) and 189 plants (in 1992), respectively (NMSFD 2020b, p. 9).

Table 1. Number of plants at each of the Bureau of Land Management monitoring plots. The Bureau of Land Management no longer monitors Plot 4 due to access issues and low numbers. Data obtained from J. Kendall (2010-2022, entire).

Year	Plot 1 (# of plants)	Plot 2 (# of plants)	Plot 4 (# of plants)
2010	4	12 (+ 2 pups)	11
2011	6	16	8
2012	6	15	11
2013	6	14	Not monitored
2014	5	14	Not monitored
2015	7	16 (+ 4 pups)	Not monitored
2016	7	17 (+ 8 pups)	4 (+ 2 pups)
2017	9	18 (+ 9 pups)	1 (+ 2 pups)
2018	Not monitored	14 (+ 6 pups)	Not monitored
2019	10	52 (+ 13 pups)	Not monitored

2020	10	50 (+ 7 pups)	Not monitored
2021	10	60 (+ 4 pups)	Not monitored
2022	13	63 (+ 7 pups)	Not monitored

According to the New Mexico State Forestry Division (2020b, p. 16), Mesa Verde cactus at the Hogback Area of Critical Environmental Concern have not recovered from the 2002 population decline.

Navajo Nation, Shiprock and Hogback Chapter

In 2004, surveyors assessed the status of 45 known sites that have historically had Mesa Verde cactus present (from survey records prior to 2004), surveyors also surveyed seven new sites which contained suitable habitat, for a total of 52 sites (NNHP 2004, p. 20). The approximate total population estimate of Mesa Verde cactus, from before 2004, using survey records was 6,700 cacti from 37 sites (USFWS 2011a, p. 16). The number of cacti at each site, prior to 2004, ranged from just one to as high as 1,500 individuals (NNHP 2004, pp. 79-88). In 2004, surveyors counted a total of 948 live cacti, 428 dead cacti, and 20 damaged cacti across 34 surveyed sites (not including sites which had no Mesa Verde cactus present) (NNHP 2004, p. 3).

The Navajo Natural Heritage Program contracted another status update in 2022. During this update surveyors revisited each of the sites surveyed in 2004 that had at least one Mesa Verde cactus plant present, and additional surveys were conducted in an established conservation area and a proposed conservation area (NNHP 2022, pp. 8-13). Surveyors counted a total of 1,555 live cacti stems and 252 dead cacti stems across 28 surveyed sites, an 165% increase in total stems compared to 2004 (NNHP 2022, p. 16). Surveyors also collected mortality and reproductive data and compared these results to 2004 results. Surveyors recorded 252 dead stems in 2022, compared to 424 dead stems recorded in 2004 (a 59% decrease in dead stems) (NNHP 2022, p. 16). Surveyors recorded 333 reproductive stems in 2022, compared to 312 reproductive stems recorded in 2004. While there was an increase in the total number of reproductive stems, there was also a 12% reduction in proportion of reproductive stems (NNHP 2022, p. 16).

The Navajo Natural Heritage Program (2022, p. 25) suggests that there has been some recovery of cacti populations since rangewide population declines in 2002 and 2003. However, recovery to pre-2002 conditions has not occurred (Table 2).

Table 2. Results of Navajo Nation status surveys for Mesa Verde cactus (MVC).

Survey	Sites with living MVC	New sites with MVC	Sites where MVC not found	Min cacti at sites	Max cacti at sites	Total live stems
Pre-2004	45	N/A	N/A	1	1,500	N/A
2004	31	7	14	1	175	943
2022	25 (28 surveyed)	N/A	2	2 (stems)	429 (stems)	1,555

Since 2008, the Navajo Natural Heritage Program has also conducted annual monitoring at the El Malpais monitoring site within the El Malpais Conservation Area (except for 2010, and 2016) (NNHP 2021, entire). The total number of stems detected in this plot has fluctuated throughout the study, but most significantly from a high of 170 plants in 2019 to a low of 82 plants in 2013 (Figure 2) (NNHP 2021, p. 5). One significant increase in dead plants occurred in 2016 or 2017, with 43 plants observed dead in 2017 (NNHP 2021, p. 5). Causes of mortality at this monitoring site were erosion, trampling by feral horses, mechanical damage by vehicles, rodents, however in most cases the cause of death is unknown (NNHP 2021, p. 6-7).

The Navajo Natural Heritage Program recorded stem diameter during monitoring. Average stem diameter increased between 2008-2009, 2012-2013, 2014-2015, and 2018-2019 (NNHP 2021, p. 7). The period between 2017-2018 saw the largest decline in average stem diameter (NNHP 2021, p. 7).

Reproductive effort has varied over the years at this monitoring site, but most significantly was highest in 2015 with an average population reproductive effort of 4.58 structures per stem (and a total of 458 flowers and fruits produced), and lowest in 2018 with an average reproductive effort of 0.2 structures per stem (and a total of 3 immature fruits produced) (NNHP 2021, p. 10). The Navajo Natural Heritage Program (2021, p. 12) found a positive relationship between stem diameter and number of reproductive structures. The 2018 decline in reproductive effort coincided with a drought event that spanned the entirety of 2018, and the lowest winter precipitation recorded since monitoring first began in 2008 (Lindsey 2019, entire; NNHP 2021, pp. 12, 14). The Navajo Natural Heritage Program (2021, pp. 5, 15) speculates that the observed high recruitment between 2017 and 2019 is linked to the high reproductive effort observed in 2015, following multiple cycles of scarification.

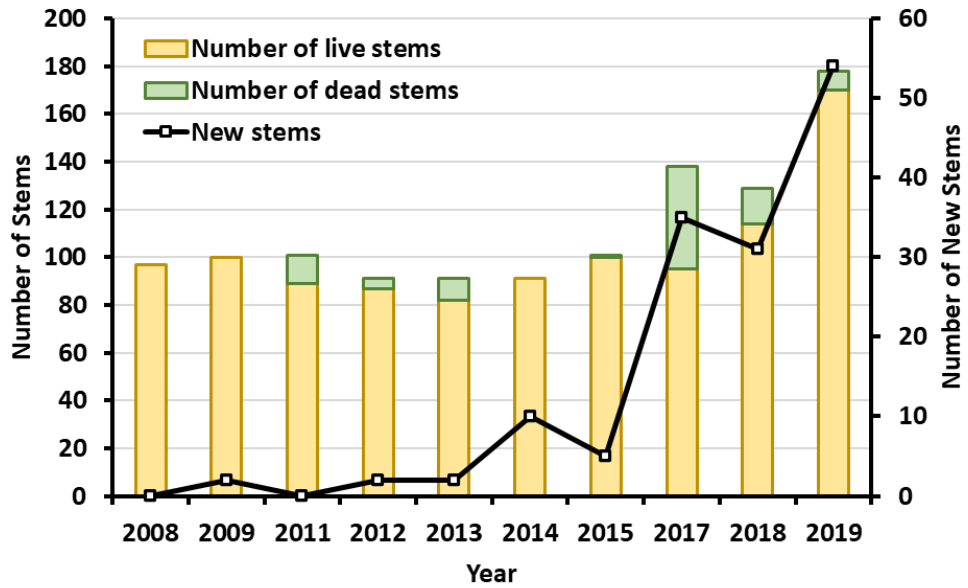


Figure 2. Total number of live, dead, and new stems at the El Malpais monitoring site since 2008. Data obtained from the Navajo Natural Heritage Program (2021, p. 5).

Navajo Nation, Sheep Springs Area

At the time of the last five-year review, this population was considered extirpated (USFWS 2011a, p. 18). We now know that Mesa Verde cactus are still extant in this area due to surveys that have occurred prior to construction activities.

Marron and Associates (2012, pp. 8-9) conducted several Mesa Verde cactus surveys in potential Mesa Verde cactus habitat prior to the New Mexico Department of Transportation improving US 491. Marron and Associates surveyed this area in 2004, 2011, and 2012 and discovered plants at two locations (Marron and Associates 2012, pp. 8-9). At the first location, Marron and Associates discovered five plants during the 2004 surveys, 14 plants in 2011, and only one seedling in 2012 (eight plants died, the others likely retreated below the ground). Marron and Associates (2012, p. 8) did discover a new cluster of five cacti at this location in 2012. Marron and Associates (2012, p. 8) attributed the 2012 decline in plants to drought conditions. At the second location, Marron and Associates discovered five plants in 2004. These cacti were not present in 2011 or 2012, but a new cluster of plants was discovered in 2011 and was also present in 2012. Marron and Associates (2012, p. 8) did discover three new locations of cacti at this location in 2012. Marron and Associates (2012, p. 8) did not provide a theory as to the disappearance of the second location's original cluster; however, they observed the slope that the original cacti were found on to show evidence of trampling by livestock.

Another survey was conducted in this area in association with the construction, operation, and maintenance of the Cudei-Tohatchi 115-kV transmission line. Surveys by Navajo Natural Heritage Program and Service biologists discovered three individuals between Sheep Springs and Naschitti, New Mexico (BIA 2018, p. 2).

The 2004 Navajo Natural Heritage Program status survey did not encounter any Mesa Verde cactus near the Sheep Spring site; therefore the 2022 status survey did not include this site (NNHP 2004, p. 20; NNHP 2022, p. 20).

Botanists are interested in Mesa Verde cactus at this location due to the geological and morphological differences of cacti found here versus in other parts of the Mesa Verde cactus range. We further discuss this below in Section 2.2.1.4.

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

At this time there are no genetic disagreements among experts or genetic studies proposed for Mesa Verde cactus.

2.2.1.4 Taxonomic classification or changes in nomenclature:

O’Kane et al. (2022, entire) described the *Sclerocactus mesae-verdae* subsp. *depressus* “Sheep Springs Cactus” or “Whoosh Diikoozih Yazhi”, a potential subspecies of the Mesa Verde cactus, based on distinct morphological and habitat differences.

Morphological differences between *Sclerocactus mesae-verdae* subsp. *depressus* and *Sclerocactus mesae-verdae* subsp. *mesae-verdae* include a shorter and narrower stem, shorter and narrower spines, different colored flowers, and a difference in tubercles (O’Kane et al. 2022, p. 2). Habitat differences include *Sclerocactus mesae-verdae* subsp. *depressus* occurring on the Menefee Formation, whereas *Sclerocactus mesae-verdae* subsp. *mesae-verdae* occurs on the Mancos Shale and Fruitland Shale Formations.

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 distributional range of Mesa Verde cactus has not changed since the last five-year review, although there are still large tracts of suitable habitat that have not been surveyed. We recommend referring to the previous five-year review (USFWS 2011a, p. 19) for additional discussion on Mesa Verde cactus spatial distribution.

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

We are currently in the process of constructing a species range map for the Mesa Verde cactus, which outlines where the species occurs or is suspected to occur. We are using known habitat metrics (such as vegetation type, geological formations, soil types, and elevation data) to construct the species range map. In this section we will discuss Mesa Verde cactus habitat metrics that we are using in the construction of the updated range map, and new information regarding habitat or ecosystem conditions.

Mesa Verde cactus is known to occupy the Fruitland and Mancos Shale formations in the northern portion of its range, and the Menefee Formation in the southern portion of its range (NNHP 2022, p. 1). We have also determined that Mesa Verde cactus is known to occur on the Pictured Cliffs Sandstone, Lewis Shale, Cliff House Sandstone, Point Lookout Sandstone, and alluvium. However, there may be inaccuracies in occurrence data, or issues with resolution in the State Geologic Map Compilation data.

Most plants during the 2022 status assessment on the Navajo Nation (which did not include cacti in the Sheep Springs area) were found on hillslope shoulders (30%), followed by backslopes (23%) and summits (21%) (NNHP 2022, p. 20). Plants were least likely to be found in valley bottoms (4%) and channels (0.4%) (NNHP 2022, p. 21). Mesa Verde cactus surveyed in this effort were found to never occupy slopes that exceed 25 degrees, and most plants occurred on slopes of less than 10 degrees (NNHP 2022, p. 21). However, cacti in the Sheep Springs area are known to occupy steeper slopes (Ventrella 2023, email).

Overlaying known Mesa Verde cactus occurrence data with the Southwest Regional Gap Analysis Mapping Project identified the following as principal land cover types for Mesa Verde cactus.

- Colorado Plateau Mixed Bedrock Canyon and Tableland
- Inter-Mountain Basins Mixed Salt Desert Scrub
- Inter-Mountain Basins Semi-Desert Grassland
- Inter-Mountain Basins Greasewood Flat
- Rocky Mountain Lower Montane Riparian Woodland and Shrubland
- Colorado Plateau Blackbrush-Mormon-Tea Shrubland
- Colorado Plateau Pinyon-Juniper Woodland
- Inter-Mountain Basins Shale Badland

We have also used occurrence data in our files to specify soil map units where Mesa Verde cactus may be found. The Navajo Natural Heritage Program (2022, p. 23) outlined soil map units where Mesa Verde cactus are known to occur on the Navajo Nation. The Navajo Natural Heritage Program (2022, pp. 19-20) observed differences in soil map unit occurrence between Mesa Verde cactus

near Sanostee, New Mexico and those north of Sanostee, New Mexico. See Table 3 for a list of soil map units where Mesa Verde cactus is known to occur.

Table 3. Mesa Verde cactus soil map units.

Soil Map Unit	Source
Avalon-Sheppard-Shiprock association, gently sloping	Service's draft range map
Badland	NNHP 2022
Badland-Genats complex, 35 to 60 percent slopes	Ventrella 2023
Badland-Hanksville complex, 35 to 60 percent slopes	Ventrella 2023
Badland-Monierco-Rock outcrop complex, moderately steep	Service's draft range map
Badland-Rock outcrop complex	Service's draft range map
Bebeever-Walrees complex, 0 to 2 percent slopes	Service's draft range map
Benally loamy sand, 1 to 3 percent slopes, overblown	Service's draft range map
Blancot-Notal association, gently sloping	NNHP 2022
Blueflat-Notal association, 2 to 10 percent slopes	NNHP 2022
Camac-Kimbeto-Badland association, 0 to 50 percent slopes	NNHP 2022
Chimrock loam, sodic, 1 to 3 percent slopes	Service's draft range map
Fajada-Huerfano-Benally family complex, 1 to 5 percent slopes	Ventrella 2023
Farview-Rock outcrop complex, 1 to 10 percent slopes	Service's draft range map
Gyptur loam, 3 to 15 percent slopes	NNHP 2022
Kimbeto-Huerfano complex, 1 to 4 percent slopes	Ventrella 2023
Littlehat-Persayo-Badland complex, 3 to 45 percent slopes	NNHP 2022
Littlehat-Persayo-Nataani complex, 1 to 15 percent slopes	NNHP 2022
Mesa fine sandy loam, 1 to 4 percent slopes	Service's draft range map
Persayo-Cairn-Patel complex, 1 to 25 percent slopes	NNHP 2022
Persayo-Fordbutte association, 1 to 10 percent slopes	NNHP 2022
Ravola very fine sandy loam, 1 to 3 percent slopes	NNHP 2022
Rock outcrop	Service's draft range map
Strych-Eagleeye-Rock outcrop complex, 15 to 70 percent slopes	NNHP 2022
Tewa fine sandy loam, 2 to 15 percent slopes	NNHP 2022
Tsebitai very fine sandy loam, 1 to 3 percent slopes	NNHP 2022
Tocito-Gullied land complex, 1 to 3 percent slopes	NNHP 2022
Torriorthents-Badland complex, 25 to 100 percent slopes	Service's draft range map
Turley clay loam, 0 to 1 percent slopes	Service's draft range map
Water-Riverwash complex	Service's draft range map
Werito loam, 1 to 3 percent slopes	Service's draft range map
Werjo, saline-Werjo loams, 0 to 1 percent slopes	Service's draft range map

The Navajo Natural Heritage Program (2022, p. 1), O'Kane et al. (2022, p. 3), and the New Mexico State Forestry Division (2020b, p. 3) identified vegetative associates of Mesa Verde cactus on the Navajo Nation, Sheep Springs population, and rangewide, in their respective status reports (Table 4).

Table 4. Other plant species associated with Mesa Verde cactus.

Species Name	Common Name	Source
<i>Artemisia spinescens</i>	Bud sagebrush	NMSFD 2020b
<i>Artemisia bigelovii</i>	Flat sagebrush	O’Kane et al. 2022
<i>Atriplex confertifolia</i>	Shadscale saltbush	NNHP 2022, O’Kane et al. 2022, NMSFD 2020b
<i>Atriplex corrugate</i>	Mat saltbush	NNHP 2022, NMSFD 2020b
<i>Atriplex cuneata</i>	Valley saltbush	NMSFD 2020b
<i>Atriplex gardneri</i>	Gardener’s saltbush	NNHP 2022, NMSFD 2020b
<i>Atriplex obovata</i>	Mound saltbush	NNHP 2022
<i>Chrysothamnus greenei</i>	Greene's rabbitbrush	O’Kane et al. 2022
<i>Cryptantha spp.</i>	Annual cryptanthas	NMSFD 2020b
<i>Eremopyrum triticeum</i>	Annual wheatgrass	NNHP 2022
<i>Eriastrum diffusum</i>	Spreading woollystar	NMSFD 2020b
<i>Eriogonum salsuginosum</i>	Salty buckwheat	NMSFD 2020b
<i>Frankenia jamesii</i>	James’ seaheath	NNHP 2022, NMSFD 2020b
<i>Hilaria jamesii</i>	James’ galleta	NNHP 2022, O’Kane et al. 2022, NMSFD 2020b
<i>Gutierrezia sarothrae</i>	Broom snakeweed	O’Kane et al. 2022
<i>Oryzopsis hymenoides</i>	Sand ricegrass	NMSFD 2020b
<i>Phacelia splendens</i>	Patch phacelia	NMSFD 2020b
<i>Phlox longifolia</i>	Longleaf phlox	Coles and Naumann 2003
<i>Sphaeralcea coccinea</i>	Scarlet globemallow	O’Kane et al. 2022, NMSFD 2020b
<i>Sporobolus airoides</i>	Alkali sacaton	NNHP 2022
<i>Sporobolus cryptandrus</i>	Sand dropseed	NMSFD 2020b
<i>Stanleya pinnata</i>	Desert prince’s plume	NMSFD 2020b
<i>Tetradymia spinescens</i>	Shortspine horsebrush	NMSFD 2020b
<i>Xanthisma gracile</i>	Slender goldenweed	O’Kane et al. 2022
<i>Zuckia brandegei</i>	Siltbush	NMSFD 2020b

2.2.1.7 Other:

Propagation

At this time there are no updates on propagation of Mesa Verde cactus. However, Roth (2020b, email), in response to the declining Waterflow population, stated that a Mesa Verde cactus ex-situ seedbank is more important than ever.

Transplanting

Mesa Verde cactus continue to be transplanted for ground disturbing projects that may result in death to the cactus. Although not highly successful, transplanting appears to be a viable strategy for salvaging cacti in areas slated for development.

In 2001, the Navajo Natural Heritage Program initiated a transplant monitoring study following the transplanting of 54 cacti from the proposed Navajo Fairgrounds to the Northern Navajo Fairground Conservation Area (NNHP 2011, p. 1). Five monitoring plots were established within a designated nondevelopment zone (NNHP 2011, p. 1). Forty-nine naturally occurring cacti served as controls within the plots (NNHP 2011, p. 1). In 2011, 19 naturally occurring, and 19 of the 54 transplanted cacti were alive (NNHP 2011, p. 2). Of the 19 surviving naturally occurring cacti, only four were of the original cacti from 2001 (NNHP 2011, p. 1). No mortality of transplanted cacti occurred between 2004 and 2011 (NNHP 2011, p. 1). In 2011, 12% and 88% of naturally occurring cacti were rated in good and excellent condition, respectively (NNHP 2011, p. 1). Transplanted cacti vigor declined slightly over time, with 45% in excellent health, 45% in good health, and 10% in fair health in 2011 (NNHP 2011, p. 1).

2.2.1.8 Conservation measures:

The standard conservation measures for plants apply to the Mesa Verde cactus. The following additional conservation measures are often included for projects with impacts to Mesa Verde cactus due to its cryptic nature and the threat of illegal collection:

- If fences around Mesa Verde cactus are proposed within a right-of-way, use fencing material similar to surrounding right-of-way fencing to look less conspicuous and be less likely to attract attention.
- Installation of temporary fences to restrict access to nearby Mesa Verde cactus populations.
- Development of a detailed construction and/or management plan for the purposes of avoiding and minimizing disturbance to Mesa Verde cactus and suitable habitat to the greatest extent possible. The plan should be

submitted to the Service and any other applicable agency (e.g., the Navajo Natural Heritage Program) for review and comments prior to any construction activities occurring.

- Retain confidentiality of specific locations of Mesa Verde Cactus, and no Universal Transverse Mercator (UTM) coordinates or similar location data should be included in any report available to the general public.
- Development of an education program for field staff and contract employees regarding identification and conservation of the Mesa Verde cactus. The program should include information about the legal and biological status of the Mesa Verde cactus, how to identify the Mesa Verde cactus, the importance of habitat preservation, the occurrence of cactus and suitable habitat in the area, avoidance areas, fines for damaging or removing cactus, and procedures for reporting cacti not previously identified.
- Where features cannot be re-routed or moved to avoid impacts to individual Mesa Verde cacti, transplant cacti to suitable habitat in cooperation with the Service, and Navajo Natural Heritage Program, Ute Mountain Ute, and Bureau of Land Management, where applicable. Monitor transplanted cacti for a minimum of 5 years.

Specific conservation measures for ground disturbing actions near Mesa Verde Cactus habitat may include the following:

- A buffer area surrounding ground disturbing activities.
- Minimization of impacts to existing native vegetation, such as minimal mowing, or surface grading, of potential pollinator habitat.
- Incorporating project design features that reduce surface impacts.
- Constrain all construction activities to established construction and maintenance areas, roads, and walkways.
- Cleaning all vehicles and equipment prior to entering the project area. Vehicles and equipment should not be moved from an area with known noxious weeds to undisturbed areas within the Project Area. Areas should not be unnecessarily watered as it could provide moisture for the germination of invasive plant species within the project area.
- Conducting monthly invasive weed inspections to determine the need to treat the spread of invasive weeds caused by construction and maintenance of the project.
- Implementing a maximum speed limit to limit the amount of fugitive dust spread. Use only water (no chemicals, reclaimed production water, or oil field brine) should be used for dust abatement measures within Mesa Verde Cactus habitat. In general, avoid use of chemicals for dust abatement throughout the project area unless prior approval is obtained.
- Minimizing potential impacts to surface waters from the proposed project by implementing best management practices to reduce

stormwater runoff, prevent accidental spills of chemicals both on and off site, and reduce sedimentation associated with construction activities.

- Reseeding the site with a native seed mix.
- Conducting post-construction monitoring to ensure that no extra or unintended disturbance occurs.

In a coordinated effort between the New Mexico State Land Office, the Bureau of Land Management, the Service, and a private landowner, a fence was installed on the Hogback Area of Critical Environmental Concern in 2022 to deter off-highway vehicle use, target practicing in unauthorized areas, and illegal dumping.

The Bureau of Indian Affairs issues grazing permits, homesite lease permits, and land use permits within the Navajo Nation. However, prior to permitting the Bureau of Indian Affairs requires applicants to complete a biological clearance survey with the Navajo Nation Department of Fish and Wildlife to ensure no federally protected species would be impacted.

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:

A variety of action agencies have consulted with the Service on various projects that have taken place in areas with occupied habitat or suitable habitat for Mesa Vere cactus. We provide a list of consultations in order to convey the number and diversity of projects with consequences to the species (Table 5). Only consultations that have been completed since the last five-year review are included in this list.

Table 5. Formal and informal consultations completed since the last five-year review.

Code	Description
2011-F-0104	In 2011, the Western Area Power Administration proposed the Lost Canyon-Shiprock 230 kV transmission access road repair and maintenance project in San Juan County, New Mexico. 123 individual plants were observed at 38 locations during surveys in 2011. This action had the potential to impact eight cacti. The Service issued a non-jeopardy biological opinion in response to the request for consultation (USFWS 2012a).
2012-F-0022	In 2011, the Bureau of Reclamation reinitiated consultation for the Animas – La Plata project in Colorado and New Mexico. This action had the potential to impact about 5.5 acres of suitable habitat, and it is likely that the action, prior to reinitiation, had already damaged or killed cacti. The Service issued a non-jeopardy biological opinion in response to the request for reinitiation (USFWS 2011b).
2012-F-0083	In 2012, the Western Area Power Administration proposed the Kayenta – Shiprock 230 kV Transmission Access Road Repair and Maintenance project in San Juan County, New Mexico and Navajo and Apache counties, Arizona. 123 individual plants were observed at 38 locations during surveys in 2011. This action had the potential to impact eight cacti. The Service issued a non-jeopardy biological opinion in response to the request for consultation (USFWS 2012b).
2012-F-0206	In 2012, the Western Area Power Administration proposed the Lost Canyon-Shiprock 230 kV transmission access road repair and maintenance project in Montezuma County, Colorado. 200 live and 76 dead plants were observed at 68 locations during surveys in 2012. This action had the potential to adversely affect the cacti. The Service issued a non-jeopardy biological opinion (USFWS 2013).
2013-I-0185	In 2012, the Colorado Department of Transportation proposed the US160 Cortez to Towaoc Resurfacing Project in Montezuma County, Colorado. No individuals were encountered during surveys in 2012, however suitable habitat was observed within the ROW. The Service issued a concurrence letter in response to the request for consultation (USFWS 2012c).
2014-F-0064	In 2014, the Office of Surface Mining Reclamation and Enforcement proposed the Four Corners Power Plant and Navajo Mine Energy Project. The Office of Surface Mining Reclamation and Enforcement made a “may affect, not likely to adversely affect” determination for Mesa Verde cactus based upon implementation of conservation measures. The Service subsequently concurred with the determination (USFWS 2015b).
2014-I-0320	In 2014, the Colorado Department of Transportation proposed an overlay and improvement project along portions of US491/US160 in Montezuma County, Colorado. Four populations were encountered during surveys in 2012. However, impacts were avoided as a result of implementation of conservation measures. The Service issued a concurrence letter in response to the request for consultation (USFWS 2014a).
2014-I-0338	In 2014, the Environmental Protection Agency proposed the issuance of a U.S. Environmental Protection Agency air quality permit allowing Four Corners Power Plant, in San Juan County, New Mexico, to increase emissions of sulfuric acid mist. The Environmental Protection Agency determined effects associated with this action to be insignificant and discountable. The Service issued a concurrence letter in response to the request for consultation (Service 2014b).

Code	Description
2015-I-0310	In 2015, the Colorado Department of Transportation proposed the slip-lining of a culvert under US160 in Montezuma County, Colorado. Surveys failed to encounter any individual Mesa Verde cactus in October of 2014, and additional surveys were planned for the April prior to construction. The Colorado Department of Transportation made a “may affect, not likely to adversely affect” determination given site conditions and absence of individuals, and the Service concurred with that determination in 2015 (USFWS 2015a).
2015-I-0701	In 2015, the Colorado Department of Transportation proposed the replacement of two failing side-by-side culverts on SH41 in Montezuma County, Colorado. Surveys in April 2015 encountered no Mesa Verde cactus, and it was found that the project area did not display Mesa Verde cactus preferred topography or allied vegetation community. The Service issued a concurrence letter in response to the request for consultation (USFWS 2015c).
2016-F-0131	In 2016, the Bureau of Indian Affairs and Bureau of Reclamation proposed the rehabilitation and improvement of two Navajo Nation irrigation units (Fruitland-Cambridge and Hogback-Cudei). The action agencies made a “may affect, not likely to adversely affect” determination for Mesa Verde cactus based upon implementation of conservation measures. The Service concurred with that determination in 2018 (USFWS 2018a).
2018-I-0172	In 2018, the Western Area Power Administration proposed the Shiprock Substation Access Road Maintenance project. The action agency made a “may affect, not likely to adversely affect” determination for Mesa Verde cactus based upon implementation of conservation measures. The Service concurred with that determination in 2018 (USFWS 2018b).
2019-F-0206	In 2018, the Western Area Power Administration initiated consultation on operation and maintenance activities in the four corners region of Colorado, New Mexico, Arizona, and Utah. Surveys encountered 540 individual plants in 2012, with 10 individuals located within the footprint of maintenance roads. The action agency made a “may affect, likely to adversely affect” determination, and the Service subsequently issued a non-jeopardy biological opinion (USFWS 2018d).
2019-I-0278	In 2018, the Bureau of Indian Affairs proposed the construction of the Navajo Tribal Utility Authority Cudei-Tohatchi 115-kV transmission line. Three Mesa Verde cactus individuals were observed within the right-of-way and the buffer during surveys in 2018. The action agency made a “may affect, not likely to adversely affect” determination for Mesa Verde cactus based upon implementation of conservation measures. The Service concurred with that determination in 2019 (USFWS 2018c).
2022-F-0122	In 2018, the New Mexico Department of Transportation and the Federal Highways Administration initiated consultation on the US Highway 64 Arizona to Shiprock, NM Reconstruction Project. Surveys encountered 57 individual plants in 2019 and 2021, with 12 individuals located within the ROW, and two individuals found to be directly impacted (and required transplantation). The action agency made a “may affect, likely to adversely affect” determination, and the Service subsequently issued a non-jeopardy biological opinion (USFWS 2022a).

Code	Description
2022-I-0227	In 2021, the Colorado Department of Transportation initiated consultation on the US160 Four Corners-Aztec Creek Reconstruction Project from the Arizona-New Mexico Stateline in San Juan County, New Mexico to Montezuma County, Colorado. The action agency made a “may affect, not likely to adversely affect” determination for Mesa Verde cactus based on negative surveys and habitat conditions present. The Service concurred with that determination in 2021 (USFWS 2021).
2022-I-0271	In 2021, the Department of Energy Office of Legacy Management initiated consultation on the Many Devils Wash decommissioning project near Shiprock, New Mexico. Surveys encountered 127 live Mesa Verde cactus in 2020, but impacts were avoided as a result of implementation of conservation measures. The Service issued a concurrence letter in response to the request for consultation (USFWS 2022b).
2001-F-0432	In 2022, the Bureau of Reclamation reinitiated consultation on the Navajo-Gallup Water Supply Project for the realignment of the northern portion of the San Juan Lateral, acquisition of select lands, and construction of additional facilities. This action had the potential to impact about 3.2 acres of suitable habitat and no more than 3 cacti. The Service issued a non-jeopardy biological opinion in response to the request for consultation (USFWS 2022c).
2023-0078012	In 2022, the Bureau of Indian Affairs initiated consultation on behalf of the Ute Mountain Ute Tribe for the MS1 Solar Project. The project will allow construction and maintenance of a 5,000-acre solar farm within Mesa Verde cactus habitat. Extensive surveying and conservation measures resulted in a Service concurrence letter for the Biological Analysis completed by Adkins Environmental on behalf of the Bureau of Indian Affairs.

Highway construction and transmission line right-of-ways

Highway construction and transmission line right-of-ways, including maintenance and repair, have negatively affected Mesa Verde cactus populations in the past and will continue to negatively affect Mesa Verde cactus populations. Large scale projects, such as those included in the list of consultations over the last 13 years (Table 5), threaten the species both directly and indirectly (by effecting suitable habitat, nurse plants, and pollinators). Conservation measures such as avoidance, transplanting, and long-term monitoring should minimize impacts within and adjacent to the construction footprint of these projects.

We recommend referring to the previous five-year review (USFWS 2011a, p. 27) for additional discussion on threats to Mesa Verde cactus associated with highways and rights-of-way.

Off-highway vehicles

Off-highway vehicle use continues to be one of the greatest human-caused threats to Mesa Verde cactus, and as off-highway vehicle use increases, the threat will only continue to increase. The New Mexico State Forestry Division (2020b, pp. 10, 14), and the Navajo Natural Heritage Program (2021, pp. 6, 16; 2022, pp. 19, 23) have observed damage to Mesa Verde cactus presumed to be caused by off-highway vehicle use during monitoring and surveying efforts. Off-highway vehicle use was the second most common disturbance observed during the 2022 Navajo Nation status survey (NNHP 2022, p. 23). The New Mexico State Forestry Division (2020b, p. 14) identified off-highway vehicle use as the primary threat to Mesa Verde cactus on Bureau of Land Management and State Trust lands. We believe that the unauthorized use of off-highway vehicles is a serious local and landscape level threat to the species and will likely increase in the foreseeable future.

At the time of the last five-year review, signs at the Bureau of Land Management's Hogback Area of Critical Environmental Concern which clearly restricted off-highway vehicle use did not deter unauthorized traffic in the area. We recommend referring to the previous five-year review (USFWS 2011a, pp. 27-29) for additional discussion on threats to Mesa Verde cactus associated with off-highway vehicle use. However, the New Mexico State Forestry Division (2020b, p. 14) emphasized the following as off-highway vehicle threats to Mesa Verde cactus:

- Direct impacts (crushing which can lead to damage or death);
- Distribution of invasive species;
- Habitat destruction;
- Soil compaction;
- Pollination success and pollinator availability;

- Disturbance to the seedbank; and,
- Reduced recruitment.

Coal mining

We recommend referring to the previous five-year review (USFWS 2011a, p. 29) for additional discussion on threats to Mesa Verde cactus associated with coal mining.

Oil and gas exploration and production

We recommend referring to the previous five-year review (USFWS 2011a, pp. 29-30) for additional discussion on threats to Mesa Verde cactus associated with oil and gas exploration and production.

Commercial and resident development

One emerging threat to the Mesa Verde cactus is utility scale solar development. We did not discuss this threat in the Mesa Verde cactus listing rule or the previous five-year review. We have consulted on one solar project with impacts to Mesa Verde cactus. Impacts associated with utility scale solar development are similar to other construction activities and can include direct loss of individuals, increased dust, effects from erosion, and habit loss.

We recommend referring to the previous five-year review (USFWS 2011a, pp. 30-31) for additional discussion on threats to Mesa Verde cactus associated with commercial and residential development.

Livestock grazing and trampling

The New Mexico State Forestry Division (2020b, p. 10), and the Navajo Natural Heritage Program (2022, pp. 19, 23; 2021, p. 6) have observed damage to Mesa Verde cactus during monitoring and surveying efforts presumably caused by livestock or wild horse trampling. Several project clearance surveys have also noted existing disturbance from livestock and wild horse trampling. Livestock and wild horse disturbance was the most common disturbance observed during the 2022 Navajo Nation status survey (NNHP 2022, p. 23).

We recommend referring to the previous five-year review (USFWS 2011a, p. 31) for additional discussion on threats to Mesa Verde cactus associated with livestock grazing and trampling.

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

Cacti are desirable plants whose wild populations in the U.S. and Mexico have been subject to illegal collection and trade (Robbins 2003, entire). Some cactus

hobbyists, known as cactophiles, are well known for their passion and interest in rare cacti. Many of these collectors have illegally obtained certain species for their private collections (Robbins 2003, entire).

Illegal Mesa Verde cactus collection does not appear to have increased since the last five-year review was published. However, the threat remains, especially to populations on Bureau of Land Management lands where plants are more accessible. During recent surveys and monitoring, the New Mexico State Forestry Division (2020b, p. 10) observed disturbance associated with illegal collection.

The threat of “gathering terrestrial plants”, specifically the collection of cactus, remains a high priority for the Colorado Natural Heritage Program in regards to Mesa Verde cactus (CNHP 2015, p. A-76).

We recommend referring to the previous five-year review (USFWS 2011a, pp. 32-33) for additional discussion on threats to Mesa Verde cactus associated with commercial, recreational, scientific, or educational overutilization.

2.2.2.3 Disease or predation:

We identified predation by the longhorn cactus beetle (*Moneilema semipunctatum*), the army cutworm (*Euxoa spp.*), and an unidentified beetle as potentially severe threats to Mesa Verde cactus in the last five-year review. Coles et al. (2012, pp. 313, 316) identified the longhorn cactus beetle larvae as the primary cause of mortality to reproductive Mesa Verde cactus stems, with few cacti in Colorado reaching the maximum diameter before being killed by the longhorn beetle. The Bureau of Land Management’s New Mexico State Office identified the longhorn cactus beetle as the leading predator of cacti in the *Sclerocactus* genus (BLM 2020, p. 2), and the Navajo Natural Heritage Program (2022, p. 1) identified herbivory by the longhorn cactus beetle, along with the army cutworm, as the primary threat to Mesa Verde cactus. While we did not identify disease as a threat to Mesa Verde cactus in the last five-year review, the native longhorn cactus beetle may cause damage to the cactus that may become susceptible to secondary infections (NMSFD 2020a, p. 10). At this time, the identity of the predatory beetle discussed in the last five-year review remains unknown. The Navajo Natural Heritage Program (2021, p. 7) did observe Carabidae larvae inside stems during monitoring at the El Malpais monitoring site in 2019. However they were likely feeding on insects that were feeding on Mesa Verde cactus rather than the cactus itself.

One other threat not discussed in the last five-year review was the threat of rodent predation. Rodent predation has been linked to several declines in Mesa Verde cactus numbers since the last five-year review. The New Mexico State Forestry Division (2020a, p. 10) attributed the mortality of most plants at the Waterflow monitoring site between 2016 and 2018 to gophers. According to the

New Mexico State Forestry Division (2020a, p. 10), this predation event which caused an 89% reduction in population size, and was the highest level of Mesa Verde cactus mortality associated with rodents on record. The Navajo Natural Heritage Program (2021, pp. 6-7, 15) observed evidence of rodent predation during surveys in 2018, a year of “unusually high rodent activity within the El Malpais plots”. Burrowing rodents can also uproot Mesa Verde cactus and/or bury Mesa Verde cactus near rodent burrows (Coles et al. 2013, p. 313; NNHP 2021, pp. 6-7).

Finally, short-horned grasshoppers (Acrididae family) were observed consuming Mesa Verde cactus flowers during the 2022 Navajo Nation status assessment (NNHP 2022, pp. 23-24, 27). Short-horned grasshopper herbivory was the third most common observed disturbance during surveys, found at 6% of sites with Mesa Verde cactus stems (NNHP 2022, p. 23).

We recommend referring to the previous five-year review (USFWS 2011a, pp. 33-34) for additional discussion on threats to Mesa Verde cactus associated with disease and predation.

2.2.2.4 Inadequacy of existing regulatory mechanisms:

Mesa Verde cactus was listed as federally threatened without critical habitat in October 1979 (44 FR 62471). The Endangered Species Act is the primary Federal law providing protection for the species. Beyond the listing of the species, these protections are afforded particularly through sections 7 and 9 of the Act. Section 7 of the Act requires Federal agencies to ensure that any action authorized, funded, or implemented by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat, although there is no critical habitat designated for this species. Section 7 also encourages Federal agencies to use their authorities to carry out programs for the conservation and recovery of listed species. Section 9 of the Act prohibits the removal, damage, or destruction of listed plants on Federal lands and on other areas in knowing violation of any State law or regulation or State criminal trespass law. The Service has addressed numerous projects within potential Mesa Verde cactus habitat through formal section 7 consultations with Bureau of Land Management, Bureau of Indian Affairs, and Bureau of Reclamation.

The National Environmental Policy Act may provide some protection for Mesa Verde cactus for projects with a Federal nexus (i.e., funding, authorization, or permitting). The National Environmental Policy Act requires that the planning process for Federal actions be analyzed to ensure that effects on the environment are considered. The National Environmental Policy Act process is intended to help public officials make better decisions based on an understanding of the environmental consequences of their actions and to take actions to protect, restore, and enhance the environment (40 CFR 1500.1). Carrying out the National Environmental Policy Act process ensures that agency

decision makers have information about the environmental effects of Federal actions and information on a range of alternatives that will accomplish the project purpose and need.

Federally listed plants occurring on private lands have very limited protection under the Act unless also protected by State laws. Mesa Verde cactus is listed as endangered by the State of New Mexico (19 NMAC 21.2), which protects it from unauthorized collection, transport, and sale. The amended New Mexico endangered species plant rule went into effect April of 2023 and now “taking” includes to “harm” and “kill” plants on Federal, private, and state lands (19 NMAC 21.2). The state of Colorado does not have a statute protecting rare plants. However, Mesa Verde cactus has a state rank of S2, meaning it is an imperiled species, and Mesa Verde cactus is outlined as a Tier 1 species in the Colorado State Wildlife Action Plan, meaning it is a high conservation priority for the State (CPW 2015, p. 337). While identification of Mesa Verde cactus as a species of conservation concern does help heighten public awareness, this designation provides no protection from direct take or habitat destruction or alteration other than those afforded by the Act on Federal lands.

The Navajo Nation Department of Fish and Wildlife defines and protects species in three Groups based on a species’ conservation status. Mesa Verde cactus is listed as a Group 2 endangered species on Navajo Nation lands, which means that the species’ “prospects of survival or recruitment within the Navajo Nation are in jeopardy or are likely within the foreseeable future to become so” (NNDFW 2020, p. 2). Title 17 § 507 of the Navajo Tribal Code makes it unlawful for any person to “take, possess, transport, export, process, sell or offer for sale or ship any species or subspecies” on the Navajo Endangered Species List.

In addition to the updates above, we recommend referring to the previous five-year review (USFWS 2011a, pp. 34-36) for additional discussion on threats to Mesa Verde cactus associated with any inadequacy of existing regulatory mechanisms.

2.2.2.5 Other natural or manmade factors affecting its continued existence:

Pesticide use

We recommend referring to the previous five-year review (USFWS 2011a, p. 36) for discussion on threats to Mesa Verde cactus associated with pesticide use.

Invasive species

We are aware of one other emerging threat to Mesa Verde cactus at this time, and that is the threat of invasive plants, halogeton (*Halogeton glomeratus*) in

particular. Halogeton is an invasive plant in the Amaranthaceae family native to Asia. Halogeton not only impedes monitoring efforts by obscuring small Mesa Verde cactus (NMSFD 2020a, p. 6), but it is also known to alter the soil chemistry of the soil it is growing in by producing mineral salts (BLM 2020, pp. 1-2; NMSFD 2020a, p. 11). The threat halogeton poses to Mesa Verde cactus at this time is largely unknown. However, it has been identified as an observed disturbance, along with the invasive Russian thistle (*Salsola kali*) (BLM 2020, pp. 1-2; NMSFD 2020b, p. 10).

Drought and climate change

Periods of drought in the southwest are common. However, the frequency and duration of droughts may be altered by climate change. Global warming and associated effects on regional climatic regimes are not well understood, but weather predictions for the southwestern United States include less overall precipitation, longer periods of drought, and increased temperatures. Based on broad consensus among 19 climate models, Seager et al. (2007, p. 1181) predicted that the southwest will become drier in the 21st century and that this change to a drier climate is already occurring. Increased aridity will become the norm for the American southwest within a timeframe of years to decades if the models are correct.

In 2021 the Intergovernmental Panel on Climate Change published a report that outlines several scenarios with a high degree of certainty to occur in the 21st century (IPCC 2021, pp. 1518-1519, 1529, 1532). These include: 1) an increase in the frequency of warm spells/heat waves over most land areas; 2) an increase in the number of hot days and nights over most land; and 3) more regions will be affected by ecological drought. Additionally, the 2021 Intergovernmental Panel on Climate Change found that there has already been an increase in hot temperature extremes globally, as well as an increase in agricultural and ecological drought across western North America (IPCC 2021, pp. 1538, 1579, 1694).

The Intergovernmental Panel on Climate Change makes equally sobering predictions for ecosystems. Conditions are likely to exceed the resilience of many ecosystems during this century by an unprecedented combination of climate change and associated disturbances (e.g., flooding, drought, wildfire, insects) (IPCC 2007a, pp. 310-312, 520, 696). With medium confidence, the IPCC predicts that approximately 20 to 30 percent of plant and animal species assessed to date are likely to be at an increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C (IPCC 2007b, p. 48).

Plants would need to adapt to a changing climate by changing their phenology (timing of life cycle events) to coincide successfully with extreme shifts in temperature, precipitation, and soil moisture, which are all part of the evapotranspiration equation (Walther et al. 2002, pp. 389, 391). Rapid climate

change could pose significant challenges for plants because they may not be able to adjust their phenology or photosynthetic mechanisms quickly enough, and there may be a temporal mismatch between plants and their pollinators.

The United States Geological Survey maintains the National Climate Change Viewer (USGS 2023, entire). The National Climate Change Viewer includes historical (1981-2010) as well as future (2025-2099) climate and water balance projections to model climate change effects based on increasing atmospheric carbon dioxide (CO₂) concentration over time. The National Climate Change Viewer uses 20 different climate models to predict atmospheric temperature and six precipitation variables as they are affected by a lower carbon dioxide (CO₂) emissions scenario and a higher CO₂ emissions scenario. The lower emissions scenario is identified as Representative Concentration Pathway 4.5, where atmospheric CO₂ concentrations are expected to equal approximately 650 ppm after the year 2100. The higher emissions scenario is identified as Representative Concentration Pathway 8.5, where atmospheric CO₂ concentrations aggressively increase to approximately 1,370 ppm after the year 2100. For comparison, current atmospheric CO₂ concentrations are around 423.68 ppm (NOAA 2023, entire).

Future climate scenarios for San Juan County, New Mexico and Montezuma County, Colorado were assessed using the National Climate Change Viewer Mean Model for Representative Concentration Pathway 4.5. Climate projections under Representative Concentration Pathway 4.5 for San Juan County, New Mexico and Montezuma County, Colorado include increased monthly temperatures, an overall increase in mean precipitation (except for April), and a decrease in mean soil storage (except for January and February) (Table 5 and 6).

Table 5. Historical (1981–2010) mean soil storage (inches) and projected changes in monthly soil storage for three future time periods under Representative Concentration Pathway 4.5 for San Juan County, New Mexico.

Month	1981–2010 mean (in)	2025–2049 change (in)	2050–2074 change (in)	2075–2099 change (in)
January	1.38	+ 0.17	+ 0.15	+ 0.11
February	2.17	-0.05	-0.21	-0.30
March	2.30	-0.42	-0.64	-0.74
April	1.58	-0.42	-0.57	-0.65
May	0.65	-0.25	-0.32	-0.37
June	0.14	-0.07	-0.09	-0.10
July	0.06	-0.03	-0.03	-0.03
August	0.05	-0.02	-0.02	-0.02
September	0.06	-0.01	-0.01	-0.01
October	0.13	-0.02	-0.04	-0.03
November	0.64	-0.18	-0.29	-0.31
December	1.04	-0.04	-0.13	-0.14

Table 6. Historical (1981–2010) mean soil storage (inches) and projected changes in monthly soil storage for three future time periods under Representative Concentration Pathway 4.5 for Montezuma County, Colorado.

Month	1981–2010 mean (in)	2025–2049 change (in)	2050–2074 change (in)	2075–2099 change (in)
January	2.51	+ 0.43	+ 0.52	+ 0.52
February	3.33	+ 0.40	+ 0.32	+ 0.40
March	4.14	-0.20	-0.37	-0.46
April	3.69	-0.52	-0.74	-0.85
May	2.42	-0.60	-0.81	-0.94
June	0.95	-0.38	-0.46	-0.51
July	0.49	-0.19	-0.21	-0.24
August	0.42	-0.12	-0.14	-0.15
September	0.51	-0.10	-0.12	-0.12
October	0.89	-0.12	-0.17	-0.14
November	1.86	-0.18	-0.36	-0.37
December	2.23	+ 0.07	-0.02	-0.02

Compared to the mean temperature in New Mexico between 1901-2000, New Mexico was 2.5 °F warmer in 2021, and 3.2 °F warmer in 2020 (NOAA 2022). Hydrologic trends are less clear, and the southwestern states show a long-term trend of increased precipitation since the 1970s (Parmesan and Galbraith 2004, p. 4; Udall and Bates 2007, pp. 6-7; Enquist and Gori 2008, pp. 4, 22).

However, Cook et al. (2015, pp. 1-2, 6) anticipates that droughts throughout the southwestern United States will increase in severity.

Exceptional Drought Conditions (D4 Drought) exceed the severity of Extreme Drought Conditions (D3 Drought) and are considered to be 25 to 50 year recurrence events. Since 2000, there have been four instances of Exceptional Drought Conditions in portions of San Juan County, New Mexico, and four instances of Exceptional Drought Conditions in portions of Montezuma County, Colorado (NDMC 2023, entire). The most recent instance of Exceptional Drought Conditions in San Juan County, New Mexico and Montezuma County, Colorado occurred between October 2020 and August 2021. Impacts from notable drought conditions anticipated by the 2005 Potential Effects of Climate Change on New Mexico report include decreases in soil moisture availability, increases in evapotranspiration, and decreases in plant productivity (NMBGMR 2022, pp. 2-4).

At the population level, Mesa Verde cactus is a spring flowering species (Heil and Porter 1994, p. 23). Growing seasons are becoming longer and warmer in many regions, including the southwest (Cayan et al. 2001, pp. 404, 407; Easterling 2002, pp. 1328, 1330-1331; Lenart et al. 2007, pp. 37, 50, 56-58; Enquist and Gory 2008, p. 4). Earlier soil moisture stress, which we anticipate (see Table 5 and Table 6), would result in decreased flowering and reproduction, and because this cactus has a limited distribution, we would predict a substantial population reduction with a long-term warming trend.

Increases in predatory insects are also predicted with climate change (Enquist and Gori 2008, pp. 11, 31). Drought and decreased soil moisture content combined with concurrent insect infestations and other threats have significantly reduced Mesa Verde cactus populations and have led to extremely slow recovery.

2.3 Synthesis

Prior to anthropogenic threats, Mesa Verde cactus populations likely adapted to more cyclic disturbance regimes with high mortality balanced by successful regeneration and reproduction. Fluctuations in the monitored natural populations appeared to be normal and relatively stable until 2002-2003, when a significant die-off of mature cacti occurred. From the early 2000s until present, natural and anthropogenic threats have continued to negatively impact this species. Recent survey results on Navajo Nation (NNHP 2022, p. 25) and Bureau of Land Management lands (Kendall 2010-2022, entire) have shown mature plant increases in some populations, indicative of the possible capacity of this species to gradually recover. However, other Mesa Verde cactus population numbers have not returned to pre-drought levels, supporting possible evidence of a low potential for recovery, especially if conditions are not favorable, as anticipated under future climate projections (see Drought and climate change section above) (NMSFD 2020a, entire).

In the last five-year review, we incorrectly considered the Mesa Verde cactus population near the Sheep Springs area extirpated. However, we now know that the species is still extant. Despite this, Mesa Verde cactus populations remain tenuous, even 20 years after the extreme die off in 2002-2003. The loss of larger adult-size classes is of concern for the species' resiliency to future impacts and the ability to recruit new individuals. A commitment to continued and expanded Mesa Verde cactus surveys, site revisits, and regular monitoring is needed to increase our understanding of the species' status and management needs. Long-term management of off-highway vehicle use in areas of sensitive habitat will be necessary to balance between species' protection and recreation. Following consultation and construction, agencies should monitor implementation of conservation measures and plant response to identify best management practices for this cactus. Long-term effects of implemented conservation measures, documented and quantified by land managers in accessible reports, should be a focus in the continued management of Mesa Verde cactus to understand how best to mitigate for Mesa Verde cactus in light of increased threats of development.

Since 2003, there is indication that some Mesa Verde cactus populations are recovering from the 2002-2003 drought, although others remain stable at reduced numbers or have continued to decline. Recent surveys for proposed projects have found new populations of Mesa Verde cactus in areas previously unknown to be occupied, suggesting that the species may be more widespread or numerous, and that thorough surveys are crucial to accurately assess the status of this cactus and its resiliency to threats.

Upon reviewing the combined significance of current threats, the Mesa Verde cactus meets the definition of a threatened species (a species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range), therefore no change in the species listing status is recommended. However, the cactus should be closely monitored to assess population trends, threats, and new population discoveries. We note that all previously identified threats are still continuing and increasing in some cases (e.g., off-highway vehicle activity, frequency of drought). If these threats notably increase in the near future, or if population trends decline and there is no evidence of recovery, or populations become extirpated, consideration of reclassification of the species to endangered may be necessary.

3.0 RESULTS

3.1 Recommended Classification:

No change is needed.

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

No change; remain at 11C.

Brief Rationale:

This indicates that Mesa Verde cactus is a full species with a moderate degree of threat and a low recovery potential. No change is recommended at this time.

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

Reclassification (from Threatened to Endangered) Priority Number: N/A

Reclassification (from Endangered to Threatened) Priority Number: N/A

Delisting (Removal from list regardless of current classification) Priority Number: N/A

Brief Rationale:

N/A

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- If possible given workloads, conduct a Species Status Assessment to inform the next five-year review and to guide the development of a revised recovery plan to reflect current number of populations, population status and demographics, and status of threats.
- We recommend stronger enforcement of off-highway vehicle laws in known and potential cacti habitat.
- Conduct additional research on taxonomy and genetics of the Mesa Verde cactus across the range of the species.
- Finalize species range map and continue to survey areas within the species' revised range to verify the presence or absence of individuals and suitable habitat.
- Develop a Mesa Verde cactus multi-agency working group to improve collaboration, discuss annual monitoring results, and to promote protection and recovery.
- Develop or adopt standardized survey and monitoring protocols range-wide for this species to be conducted annually by well trained personnel. Continue monitoring of known sites as well as adding new sites to provide a robust dataset for long-term trend analysis.
- Implement and monitor new transplant projects with experimental manipulations (watering, shading, planting depth, etc.) and controls to determine required establishment needs.
- Collect data on seed dispersal and growth past the germination stage, timing of seed set, and seedling establishment to clearly define the vulnerable life history stages of this species.
- Determine microhabitat needs of this species ("nurse" plants, pollinators, precipitation needs - amount and timing, slope and aspect requirements, disturbance patterns, etc.) to further quantify potential habitat for a transplant and mitigation site.
- Collect data on the biology, demographics, ecology, and movements of the longhorn cactus beetle and the army cutworm to determine their long-term significance as predators of this species.
- Establish additional conservation areas for the Mesa Verde cactus.

- 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.
- Conduct studies on the reproductive biology of Mesa Verde cactus, including pollination, seed development, seed dispersal, and inbreeding depression.
- Conduct additional studies on predation, impacts of invasive species to different life stages, and other emerging threats.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Mesa Verde cactus (*Sclerocactus mesae-verdae*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

No change needed

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

FIELD OFFICE APPROVAL:

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

Approve _____