Nichol's turk's head cactus
(*Echinocactus horizonthalonius* var. *nicholii*)
5-Year Review:
Summary and Evaluation

Photo courtesy of John Scheuring.

U.S. Fish and Wildlife Service
Arizona Ecological Services Office
Phoenix, Arizona
August 2021

5-YEAR REVIEW
Nichol's turk's head cactus
(*Echinocactus horizonthalonius* var. *nicholii*)

1.0 GENERAL INFORMATION

1.1 Listing History

Species: Nichol's turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*)
Date listed: October 26, 1979
FR citation(s): 44 FR 61927
Classification: Endangered
Critical habitat/4(d) rule/Experimental population designation/Similarity of appearance listing: Due to the threat of collection, critical habitat was not designated for this species as the publication of critical habitat descriptions and maps would make Nichol's turk's head cactus (herein, NTHC) more vulnerable to collection and increase enforcement problems.

1.2 Methodology used to complete the review:

In accordance with section 4(c) (2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants.

The U.S. Fish and Wildlife Service (Service) most recently evaluated the biology and status of the NTHC as part of a 5-year status review conducted in July 2009. For the current review, we examined whether new information was available and whether that new information would alter or affect analyses and conclusions made in the previous status review. Data for this current review were solicited from interested parties through a Federal Register notice announcing the review on May 5, 2021 (86 FR 23976). Additionally, we conducted a literature search and a review of information in our files.

1.3 FR Notice citation announcing the species is under active review:

86 FR 23976: Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 23 Species in the Southwest. May 5, 2021.

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 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 Updated Information and Current Species Status

2.1.1 Biology and Habitat:

The NTHC is a long-lived (35 to 95 years) succulent of the Cactaceae or Cactus Family. The taxon occurs within the Upland Division of the Sonoran Desert scrub at 732 to 1,219 meters (2,400 to 4,000 feet) elevation on 0 to 30 percent slopes (Service 1986, p. 6). The NTHC occurs in isolated mountain ranges that extend from south-central Arizona in Pima and Pinal Counties to a disjunct location in Sonora, Mexico. The plant is found almost entirely on Horquilla limestone. As of 2020, there are thought to be fewer than 1,300 total individuals (an estimated 1,024 live and 288 dead), most of which occur in the Waterman Mountains of Pima County Arizona. The status of NTHC on the Tohono O'odham Nation is uncertain. Despite surveys since the 1980s and continuing periodically through 2020, no new populations have been located outside of the four historical areas (the Waterman Mountains and Koht Kohl Hills in Pima County, Arizona; the Vekol Mountains in Pinal County, Arizona; and the Sierra del Viejo Mountains in Sonora, Mexico). A potential fifth population of 83 plants that morphologically resemble the NTHC occur in central Sonora (Van Devender and Reina-Guerrero 2012, entire). Their taxonomic status remains uncertain and until verified, the population is not considered the listed entity.

In 1995, on the upper slopes of the Waterman Mountains, monitoring of four permanent plots began within the Ironwood Forest National Monument NTHC population. Numbers of NTHC individuals within the plots have fluctuated from a high of 132 plants in 1996 to a low of 25 in 2020, with two of the plots having three individuals each remaining (Nichol's Turk's Head Cactus Working Group 2021, entire). A recent paper illustrating the results of 23 years of monitoring information indicated that 100 individuals recruited into the population and 203 individuals died (McIntosh et al. 2019, p. 11). Although drought stress, modeled by the Palmer Drought Severity Index (PDSI), was higher than average over the study period, researchers found annual mortality increased as drought stress declined, and variation in temperature and precipitation could not explain losses of plants. Additionally, the

probability of flowering increased as PDSI increased (drought stress declined) and decreased with increasing precipitation (McIntosh et al. 2019, p. 11). The researchers also documented a shift in the size distribution towards smaller individuals, with diameters and height averaging 9.6 and 6.8 cm (3.8 and 2.7 inches (in)), respectively during 1995 to 1997 versus 5.5 and 3.8 cm (2.2 and 1.5 in), respectively during 2015-2017. This change in size is likely due to a combination of larger, older plant senescence and smaller plants not growing to their full potential or shrinking due to drought. Nonnative invasive plants and small mammal herbivory were noted in the decline of plants in these plots. More significantly, the increase in native bighorn sheep (*Ovis canadensis*) and pawing of the soil were considered a larger threat to NTHC (Figure 1). This monitoring is a small sample of the total number of individuals in the Waterman Mountains. Expansion of demographic monitoring with additional climatic data collection on more plants would contribute to a more comprehensive understanding of how environmental factors are resulting in decreased plant health.

Figure 1. Former site of Nichol's turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*) in the Waterman Mountains of Southern Arizona, illustrating (white arrows) a few spine clusters left within the bighorn sheep pawed soil, indicating where NTHC plants had been. Photograph courtesy of William Peachey.

Service and BLM biologists visited six areas occupied by the NTHC in the spring and summer of 2018 to assess the status of plants for Recovery Plan amendments (Service 2019, entire). In total, we found 781 individual NTHCs, consisting of 541 live and 240 dead plants. Eighty-eight plants found were equal or less than 7.5 cm (3 in) tall and considered to be seedlings or immature plants and more vulnerable to desiccation. Forty-six of the total plants had tissue discoloration; were wholly or partially uprooted; dead, but intact; or a hollow spine basket. Survival of these plants in the near future is tentative based on their observed poor condition. On the Waterman slopes, outside of monitoring plots, biologists documented 44 live and 28 dead individuals in a 1.21 ha

(3-ac) area (Service 2019, p.3). The majority of plants were less than 15 cm (6 in) in height with green tissue. Several of the observed mortalities consisted of uprooted plants, the top of the stem broken off, or a cluster of spines next to a tag (Service 2019 pp. 4-5).

During surveys of the north edge of the Waterman Mountains within Ironwood Forest National Monument, Clark et al. (2020, p. 9) detected 438 NTHCs and documented 12.8 percent dead individuals and 24.9 percent healthy living plants. The remaining 62.3 percent of individuals had damage, desiccation, surface irregularities, necrosis, or discoloration (Clark et al. 2020, p. 9); the health of these plants may be related to drought stress and predation, but no causes were listed in the report. In addition, there is a recent report of grasshopper or other insect herbivores eating flower petals at the Ironwood Forest National Monument NTHC population, which will likely reduce insect pollination and seed set (T. Condo, BLM, pers. comm. June 8 and 10, 2020). The researcher also noted forceps at the site, which may have been used to illegally harvest cacti fruit for the cactus trade (T. Condo, BLM, pers. comm. June 8 and 10, 2020). In addition, during field work at Ironwood Forest National Monument in February of 2021, several holes were encountered where NTHC had been previously and researchers feel certain this was the result of illegal cactus poaching (McIntosh pers. comm. July 14, 2021).

2.1.2 Threats Analysis (threats, conservation measures, and regulatory mechanisms):

Threats to this species as noted in the previous 5-year review include mining on non-Federal land; habitat disturbance from illegal immigrants, drug smuggling, and associated law enforcement activities; spread of invasive plants species (e.g., buffelgrass); herbivore predation; illegal collection; and climate change (Service 2009, pp 18-20). McIntosh et al. (2019, p. 13) found nonnative invasive plants and small mammal herbivory effects rare to NTHC in their monitoring plots. More recently, Clark et al. (2020, p. 11) noted detection of cattle (e.g., trampling), an access road to mining operations (e.g., dust, collection potential, nonnative plants), and illegal human and drug trafficking activity (e.g., trampling, collection potential, nonnative plant introduction) during their 2020 surveys along the north edge of the Waterman Mountains, all of which could represent threats to the species.

While McIntosh et al. (2019, p. 13) have suspected bighorn sheep not only paw at the cacti, but consume them, other observations of cacti carcasses suggest the sheep may scrape around the plants until they are uprooted (W. Peachey, pers. comm. November 23, 2019). Volunteers with Friends of Ironwood Forest National Monument reported finding large numbers of spots cleared of NTHC and at least one damaged NTHC with most of its tissue removed with marks described as “shallow indented ellipsoidal scallops where the cortical tissues had been neatly sheared away” (W. Peachey, pers. comm. November 23, 2019, Figure 2). During times of extreme drought, herbivory of high moisture content plants such as cacti may increase (e.g., Shyrock et al. 2014, p. 1951). The very limited range and abundance of the NTHC makes it more susceptible

to natural predation that would not be a threat to larger, more widespread natural populations.

Figure 2. Photograph of the hollowed-out shell of a Nichol's turk's head cactus. The cactus was presumably loosened from the soil by pawing of and consumed by bighorn sheep. Photograph of William Peachey courtesy of Peggy Ollerhead.

Nonnative grasses such as buffelgrass (*Cenchrus ciliaris*) continue to be a fire risk within Ironwood Forest National Monument and likely a threat to the NTHC (Dimmitt and Van Devender 2003, pp. 31-35). Buffelgrass eradication at the restoration site has been successful because of the long-term volunteer and BLM funded work of Friends of Ironwood Forest National Monument and the Arizona Native Plant Society. Scheuring (2016, p. 15) noted two NTHC seedlings in the post-buffelgrass removal areas in 2016. We feel this small increase in encountered NTCH seedlings may be interpreted to mean that buffelgrass removal could improve conditions for growth of NTHC at sites in this area. We endorse buffelgrass removal to support NTCH recovery and recommend NTHC monitoring accompany any future buffelgrass eradication efforts to further understand this threat and its effects.

As reported in the 2009 5-year Status Review, there were several valid existing mining claims documented across approximately 550 acres located in occupied NTHC habitat, but no active mining or mineral development had occurred. Private landowners were interested in a land exchange with the BLM (Service 2009, p. 19). In 2014, the BLM acquired approximately 358 acres of these parcels, extending federal protection to the NTHC (BLM 2014, p 6), while also making tremendous progress in achieving a recovery action to protect the cactus by consolidating federal ownership of habitat (Service 1986, p. 24). Federal ownership of these lands prohibits new mining claims, mineral leases, and sales. The lands are also withdrawn from all forms of entry, location, and patented mining claims under public land laws, thus minimizing any potential impacts of mining on the cactus. These parcels are included in the Waterman Mountains Vegetation Habitat Management Area that is managed for the benefit of the NTHC.

Ironwood Forest National Monument is a travel corridor for undocumented immigrants, and cross-border activity is on-going. As mentioned above, Clark et al. (2020, p. 11) observed signs of illegal immigration and/or traffic near the northern edge of Ironwood Forest National Monument. Information from law enforcement indicates that traffic may continue to be very active in the area, thus precluding additional visits to NTHC habitat for safety reasons (Southern Arizona Annual Interagency Coordination Meeting 2021, entire).

Like most small cacti in Arizona, growth and reproduction are tied to climate factors. Adequate winter precipitation is required for germination and seedling growth in most cacti, with the seedling stage of small cacti the most vulnerable life stage due to susceptibility from desiccation (Aragon and Lasso 2018, p. 1-2; Nobel 1984, pp. 310, 316). For succulents, water-storing tissue developed in the first growing season following germination may determine the plant's ability to survive drought (Jordan and Nobel 1981, p. 901). In addition, many seedling cacti have very small roots, and, therefore, limited ability to access deeper water sources (Aragon and Lasso 2018, p. 2). Cacti, in general, are very slow growing. The NTHC cacti are reported to grow on average 0.35 cm per year and do not flower until around age 10 or later (McIntosh et al. 2011, p. 336).

McIntosh et al. (2019, p. 13) found in their 23-year study that NTHC plants grew less rapidly and were less likely to flower and produce seeds during severe drought. It is unknown if pollinator populations needed for seed production are in decline. Reduction in seed production ultimately results in reduced recruitment in the long term. While drought and above normal temperatures are believed to be contributing to increased mortality observed on monitoring plots (Service 2009, p. 12), results from McIntosh et al. (2019, entire) confound our understanding about climate change, as McIntosh concludes precipitation and temperature could not explain the losses of plants. This research shows that the relationship between drought and the factors directly contributing to death (e.g., desiccation) and factors indirectly contributing to death (e.g., herbivory) of cacti is complex, and more research is required. Combinations of drought, increases in temperature and aridity, sheep pawing, and other stressors cumulatively can have a greater impact than any one threat alone. Long-term conservation of rare plants like NTCH will need to consider not only the effects of climate change on species and ecosystems, but also how other factors interact with climate change to influence species viability (Souther and McGraw 2014, p. 1463).

Souther and McGraw (2014, p. 1472) performed projections of viability for a rare northeastern plant with increases in temperature over the next 70 years, with stress from illegal collection of the plant, and with the two stressors combined. They found the extinction risk was 65 percent for the combined stressors, but 6 percent and 8 percent, respectively, for these 2 stressors independently. They concluded that climate change coupled with any additional stressor could significantly diminish viability of rare plant species. Because cacti are vulnerable to disturbance due to slow growth, low frequency of germination and establishment, and little capability to recover from disturbance (Portilla-Alonso and Martorell 2011, p. 509), we anticipate small mammal herbivory or

habitat disturbance from livestock or bighorn sheep or other causes could more severely affect NTHC when coupled with the impacts of drought stress and higher than average temperatures.

The United States Geological Survey maintains their National Climate Change Viewer (NCCV) on-line (USGS 2021, entire). The NCCV includes historical (1950-2005) as well as future (2006-2100) climate and water balance projections to model climate change effects based on increasing atmospheric carbon dioxide (CO2) concentration over time. NCCV uses 20 different climate models to predict atmospheric temperature and 6 precipitation variables as they are affected by a lower CO2 emissions scenario and a higher CO2 emissions scenario. The lower emissions scenario is identified as Representative Concentration Pathways (RCP) 4.5, where atmospheric CO2 concentrations are expected to equal approximately 650 ppm after the year 2100. The higher emissions scenario is identified as RCP 8.5, where atmospheric CO2 concentrations aggressively increase to approximately 1,370 ppm after the year 2100 (IPCC 2014, p. 57).

Future climate scenarios for Pima and Pinal Counties were assessed using the NCCV Mean Model for RCP 4.5 (Figures 3 through 6). For comparison, current atmospheric CO2 concentrations are around 416 ppm (NOAA 2021, entire). Climate projections under both RCP 4.5 and RCP 8.5 for the areas supporting NTHC include increased temperatures and evapotranspiration (e.g., more stress on individual NTHC), decreased winter precipitation (needed for seedling germination), and more variability in rainfall, including more intense rainfall events and increased periods of drought between rainfall (potential for damage to NTHC from intense rainfall or from herbivory during drought).Figures 4 and 6 below show the increased variability of precipitation events into the future..

Projections of continuing drought, reduction in winter precipitation, and increases in evapotranspiration in the areas supporting NTHC make continued annual monitoring necessary to ensure the population continues to produce young plants to counteract those lost to age, drought, herbivory, or other causes. For example, casual observation suggests that aspect, a direct correlate to climate, influences reproductive success, with cooler north and west aspects experiencing drought stress and reproduction, and hotter south aspects containing very few juvenile plants due to the increased stress at these microsites.

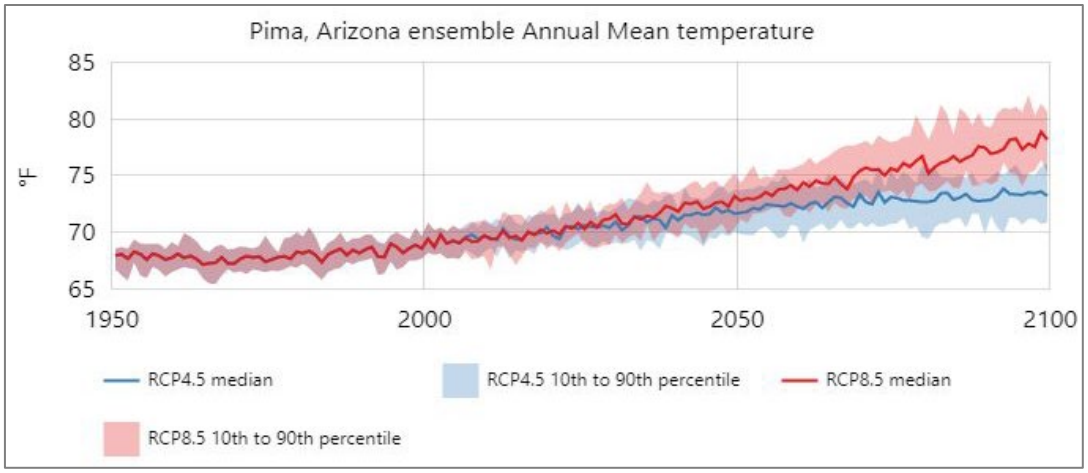

Figure 3. Using the USGS Climate Change Viewer (USGS 2021), graphs depicting historical, current, and projections of Pima County annual mean temperature. Projections indicate increased mean annual temperatures in Pima County under both the RCP 4.5 and RCP 8.5 scenarios.

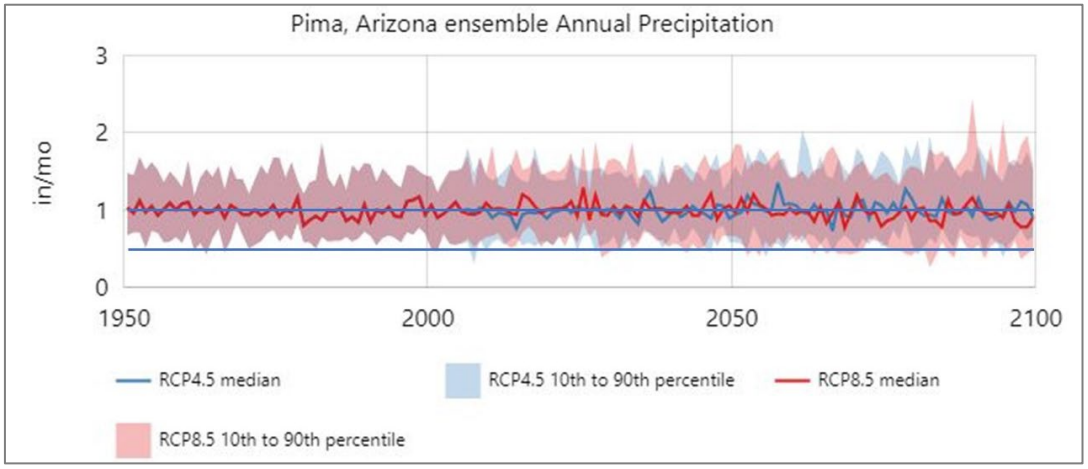

Figure 4. Using the USGS Climate Change Viewer (USGS 2021), graphs depicting historical, current, and projections of Pima County annual precipitation. Notice the increasing variability in high (e.g., flooding) and low (e.g., dryer conditions) precipitation events beginning in the early 2000s and continuing through 2100. More intense storms and longer periods of drought can both negatively impact Nichol's turk's head cactus individuals.

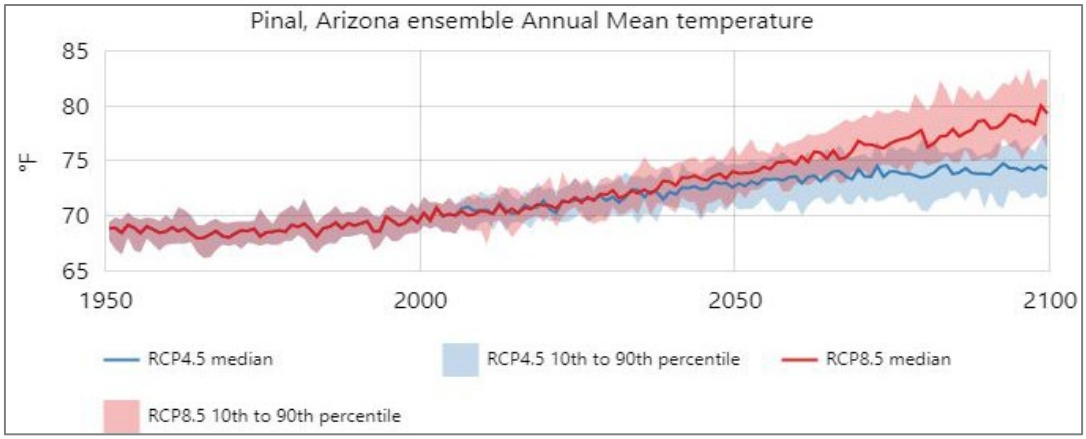

Figure 5. Using the USGS Climate Change Viewer (USGS 2021), graphs depicting historical, current, and projections of Pinal County average temperature. Projections indicate increased mean annual temperatures in Pinal County under both the RCP 4.5 and RCP 8.5 scenarios.

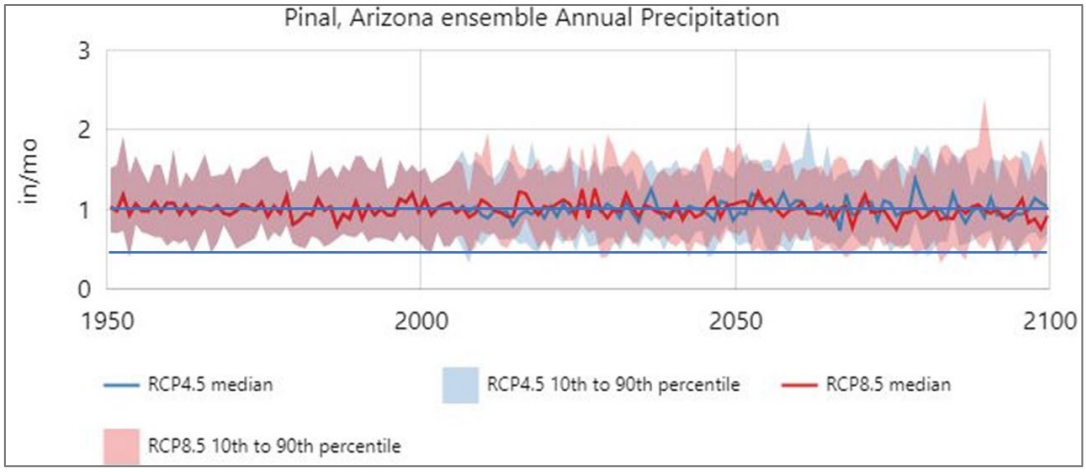

Figure 6. Using the USGS Climate Change Viewer (USGS 2021), graphs depicting historical, current, and projections of Pinal County average annual precipitation. Notice the increasing variability in high (e.g., flooding) and low (e.g., dryer conditions) precipitation events beginning in the early 2000s and continuing through 2100. More intense storms and longer periods of drought can both negatively impact Nichol's turk's head cactus individuals.

2.2 Synthesis:

The most recent available information on the NTHC consists of monitoring data for a small sample of the total number of individuals in the Waterman Mountains. This information indicates continued plant losses on the slopes of the Waterman Mountains since the 2009 5-Year Review. This area had several hundred plants in 2003 (Dimmitt and Van Devender 2003, p.23; Service 2009, p.12), but now risks being extirpated for reasons that are unclear. The status of the NTHC on the Tohono O'odham Nation is unknown. Limited information also indicates that the small population in Sierra del Viejo in Sonora, Mexico, appeared to exhibit drought stress (R. Puente, Desert Botanical Garden pers. comm. December 20, 2018).

Impacts from small mammals that damaged or killed (i.e., tissue chewed, torn, or consumed) 22 plants in 2003 (McIntosh et al. 2007, pp. 80-81; Service 2009, p. 12) were not observed in the most recent monitoring efforts. Nonnative grasses (buffelgrass) were also not observed within the plots on the slopes of the Waterman Mountains; we don't know if the bajada areas below the slopes or other sites are experiencing these impacts. Illegal collection may be occurring based on observation of collecting forceps found at one site. Signs of desiccation, discoloration, and potential predation by bighorn sheep are concerning. Expanding demographic monitoring of more plants with additional climatic data collection throughout the species range would contribute to a more comprehensive understating of how environmental factors are resulting in decreased plant health.

After reviewing the best available scientific information, we conclude that NTHC remains an endangered species. The evaluation of threats affecting the species under the factors in 4(a)(1) of the Act and analysis of the status of the species in our 2009 5-Year Status Review remains an accurate reflection of the species current status.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change is needed

3.2 New Recovery Priority Number:

No change recommended

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Our recommended future actions from the 2009 5-year Status Review remain relevant, and we provide those below with some modifications. We also recommend additional actions to improve our understanding of climatic changes on the status of the NTHC and address data needs to improve long-term species management decisions.

1. Understand trends in survival and mortality of individuals and populations. Cactus species are known to have recruitment events following sufficient precipitation; however, long-term monitoring of the NTHC demonstrates that its response to precipitation and higher temperatures are not as straightforward. With the persistent drought, it is important to continue to investigate demographic trends in order to tease out how mortality rates increase with variable climate patterns.
2. Expand the monitoring area to include a larger sample size that is representative of all populations. Locate demographic plots at sites differing in aspect and slope, and better reflect the representation and redundancy of the cactus. Explore other types of sampling methods (distant sampling transects) to compare information about demographics and changes in habitat.

3. Examine habitat suitability, including the taxon's ability to persist in all populations. Results would guide management decisions on important areas for enhancement or future recovery actions for the cactus' persistence in the future.
4. Conduct germination studies and captive propagation to support future re-establishment of plants in their native habitat, in the event we need to supplement the population or create refugia populations.
5. Evaluate the genetics of this subspecies to better understand its evolutionary history and relationship to *E. horizonthalonius*, and to assess genetic variation within and between the populations. This information would provide a better understanding of its historical range and taxonomic classification.
6. Invest and support studies examining other potential stressors (invasive grasses, herbivory, disease, and habitat disturbance) to the cactus. For example, placement of cameras and / or fencing could improve our understanding of the roll of herbivores in cactus decline.
7. The Service should continue to enhance and maintain our partnership with the Tohono O'odham Nation to cooperatively achieve long-term conservation of the NTHC on Tribal land.
8. Establish a cooperative partnership with private landowners in Sonora, Mexico that enables information exchange and advances conservation efforts to document, study, and protect the cactus.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Nichols turk's head cactus

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

FIELD OFFICE APPROVAL:

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

Approve MARK LAMB Digitally signed by MARK LAMB Date: 2021.08.20 14:48:24 -07'00' _____