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5- Year Review Short Form

Species Reviewed: Wright fishhook cactus (*Sclerocactus wrightiae*)

Federal Register Notice Announcing Initiation of this Review: May 27, 2016. Endangered and threatened wildlife and plants; 5-year status reviews of 21 species in the Mountain Prairie Region (81 FR 33698).

Current Classification: Endangered, range-wide

Current Recovery Priority Number: 11C

This recovery priority number is indicative of a species with a moderate degree of threat, imminent conflicts with land development, and a relatively low potential for recovery.

Methodology used to complete this review:

This review was completed by the Utah Ecological Services Field Office on August 30, 2022. All pertinent literature and documents on file at the Utah Ecological Services Field Office were used for this review, including new information obtained since the last status review (USFWS 2008).

Review Summary:

Wright fishhook cactus is a member of the cactus (Cactaceae) family. It is endemic to south central Utah, where it is only known to occur in Emery, Sevier, and Wayne counties. The genus *Sclerocactus* contains 15 species (eFloras 2022), five of which are federally listed endemics of the Colorado Plateau region of Utah, Colorado, New Mexico, and Arizona (Wright fishhook cactus*, S. mesae-verdae, S. brevispinus, S. glaucus, S. wetlandicus*).

Wright fishhook cactus is a small, barrel-shaped cactus up to 7 inches (in) (18 centimeters (cm)) tall. It typically grows as a single main stem, but it can form multiple stems, especially if damaged. Wright fishhook cactus is separated from other members of the genus by having pale pink to white or yellowish funnel-shaped flowers that appear in April and May; magenta colored filaments; 1–4 central spines per areole, with the underside of spines being white to tan; and fruits that are 0.35–0.59 in (0.9–1.5 cm) long, with a lack of leaf scales (Benson 1966; Woodruff and Benson 1976; Hochstätter 2005; Welsh *et al.* 2008). The elliptical fruits turn magenta-purple when ripe and open at the base to release many black seeds (Hochstätter 2005; Welsh *et al.* 2008).

Wright fishhook cactus occurs on a variety of geologic formations, including the Morrison, Carmel, Entrada, Moenkopi, Curtis, and Summerville formations, and all members of the Mancos Shale Formation. The species occurs at elevations between 4,200 and 7,600 feet (1,280 – 2,320 meters) on flat areas, low ridges, and slopes. The species appears to favor certain soil characteristics, including texture, drainage, and chemical properties, and that these conditions are more important than the presence of certain geological formations (Neese 1987; Kass 1990). Therefore, we define suitable habitat as an occupied or unoccupied area within the known range of the species where at least three of the following four habitat conditions prevail (Neese 1987; Kass 1990):

1) presence of fine textured, presumably saline or gypsiferous strata that contribute texturally and chemically to the soil;
2) close proximity to a sand-forming geologic stratum that contributes to the substrate;
3) presence of fine- or medium-sized gravels, pebbles, or fossil oyster shells in (and particularly littering) the surface of the soil; and
4) level to gently sloping terrain.

Wright fishhook cactus grows in sparsely vegetated arid desert environments where the average annual precipitation is less than 8 in (20.3 cm; Western Regional Climate Center 2014). The species grows among salt desert shrub and piñon-juniper woodland vegetation communities where there is little competition from other plants. Frequently associated native species include piñon pine (*Pinus edulis*), Utah juniper *(Juniperus osteosperma),* valley saltbush *(Atriplex cuneata),* shadscale *(A. confertifolia),* mat saltbush *(A. corrugata),* alkali sacaton *(Sporobolus airoides),* galleta *(Pleuraphis jamesii)*, yellow cryptantha (*Cryptantha flava),* pretty buckwheat *(Eriogonum bicolor),* Indian ricegrass (*Achnatherum hymenoides),* and various pricklypears (*Opuntia* spp.). Common nonnative invasive species in the habitat of Wright fishhook cactus include cheatgrass (*Bromus tectorum*), halogeton (*Halogeton glomeratus*), and Russian thistle (*Salsola tragus*).

Wright fishhook cactus is slow to reach reproductive maturity. Individual cacti begin flowering around 4 to 5 years of life, producing flowers generally less than 50 percent of the time (per year) (Kass 2001a; Clark and Clark 2007). The highest reproductive rates are associated with large adult plants (>3.5 in (9.0 cm) in diameter), which flower between 75 and 100 percent of the time (Kass 2001a; Clark and Clark 2007; Hornbeck 2020b).

Wright fishhook cactus is pollinated almost exclusively by native ground nesting bees from the large family of halictid bees (Tepedino 2000). Pollination is limited by the foraging distance of the ground nesting bees, which is strongly correlated to body size (Greenleaf 2005). The distance that ground nesting bees travel from their nests is difficult to determine but it is believed that they do not travel far from their nests; the maximum travel distance reported for the two genera that pollinate Wright fishhook cactus is approximately a quarter mile (400 m; Tepedino 2000). Cross pollination is essential for the reproductive success of Wright fishhook cactus because the species is almost completely self-incompatible (Tepedino 2000). Genetic diversity within subpopulations is unknown. Samples have been collected for genetic evaluation and are awaiting analysis.

Range and Distribution

The overall range of the species has not changed significantly since the publication of the 1985 Recovery Plan (USFWS 1985). However, survey and inventory efforts have greatly expanded our knowledge of the distribution of the species within its range. We now know of more occupied sites that form a more continuous metapopulation than previously known. The known range of Wright fishhook cactus extends across approximately 993,705 acres (ac) (402,138 hectares (ha)) of Utah's western Emery County, southeastern Sevier County, and central Wayne County (Figure 1). and across multiple federal, state, and private landowners (Table 1).

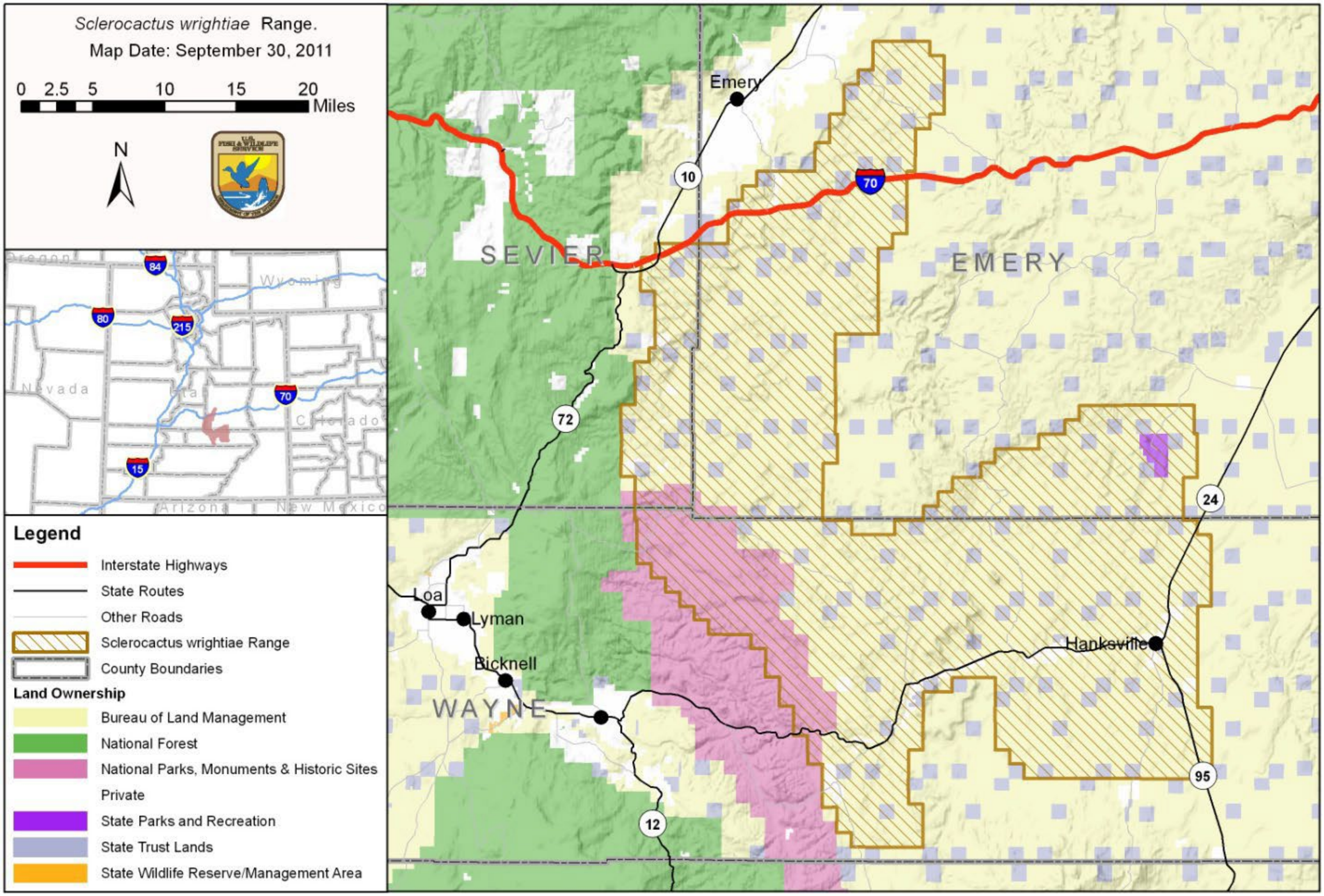

Figure 1. Wright fishhook cactus range.

Table 1. Acres of Wright fishhook cactus range by landowner type.

Landowner	Acres	Percent
Bureau of Land Management	740,383	75
Capital Reef National Park	103,075	10
U.S. Forest Service	18, 301	1.8
Utah School and Institutional Trust Lands	95,644	9.6
Utah Department of Natural Resources	9,000	<1
Private	27,135	2.7
Utah Department of Transportation	167	<1

The range of Wright fishhook cactus has not been fully surveyed so within its mapped range not all areas are expected to be suitable habitat; there is a matrix of suitable and unsuitable habitat based on the underlying substrate or natural community type. Wright fishhook cactus is found scattered throughout the range in varying densities and distances between occupied sites. To facilitate monitoring and population analysis, we currently treat the species as a metapopulation that is composed of smaller subpopulations. Subpopulations have not yet been delineated and need to be established in coordination with land and resource managers, and based on geography, genetics, vegetation type, and management.

Since being listed in 1979, population estimates for Wright fishhook cactus have varied drastically, ranging anywhere between 4,500 to 100,000 individuals. In 2008 we estimated the total range-wide population to be between 4,500 to 21,000 individuals (USFWS 2008). Based on updated inventories the current total number of individuals documented in our database for the species is 12,016 Wright fishhook cactus individuals across CRNP, BLM, and state lands. Therefore, we currently estimate the range-wide population for Wright fishhook cactus to be between 12,000 to 21,000 individuals.

This current estimate of range-wide population for Wright fishhook cactus is based on data compiled from several survey efforts occurring over several decades. This represents data collected from 1965 to 2021, with over 82 percent of those observations made within the past 20 years. This should be considered a conservative count of plant abundance since there are known areas of suitable habitat adjacent to occupied habitat that has not been surveyed, in addition to other un-surveyed areas of suitable habitat. Due to the vast range of Wright fishhook cactus, multiple landowners, inaccessible backcountry, and rough terrain, a complete survey for the species has not been conducted. Thus, our range-wide population estimate is extrapolated from existing inventory data.

POPULATION TREND

There have been several repeat survey efforts for Wright fishhook cactus. Nearly all of these survey efforts reported declines in local populations due to natural or manmade causes.

Inventory Surveys

Repeat inventories were initiated in 2014 throughout the range of the species to determine if historic sites still contain cacti and to assess their suitability for long-term population trend monitoring (BLM *et al.* 2014). The inventory documented 3,440 cacti from 45 known sites distributed across the range of the species (13 percent of all known sites at the time). Cacti were found in all, but one of the 45 sites visited. However, the inventory effort was not completed due to the lack of sufficient resources

(BLM 2014 a, b, and c; NPS 2014a). Therefore, we do not have sufficient information to determine trends of the population in these areas.

Similarly, inventories were conducted in Capitol Reef National Park (CRNP) from 2011 through 2013 of all 65 previously documented Wright fishhook cactus localities[1] in the park. The goal of this effort was to determine the species status (count), to map and collect data on individuals, and to assess threats. Cacti were found at 55 of the localities, a 15 percent reduction in the number of known localities compared with previous surveys (NPS 2014b). These one-time repeat site visits do not have sufficient information to determine trends of the population in these areas.

In 1993, three large macroplots (1.84 ac each) were established on BLM lands by a contractor and inventoried every third year from 1993 to 2009 (Kass 2001a). The BLM Richfield Office inventoried the sites again in 2013 and 2016. A consistent and sharp decline was observed from 1993 to 2009 at two of the sites, with less than six percent and 15 percent of the original population remaining by 2016 at the same two sites (Kass 2001a; Rooks 2018). The third site also declined, but 79 percent of the population remained in 2016 (Kass 2001a; Rooks 2018).

In 2019, a study was initiated to evaluate the efficacy of using small, unmanned aircraft systems (sUASs or drones) to conduct surveys for Wright fishhook cactus (Bates *et al.* 2022). Plots were established and drone flights were conducted at three heights, 10 meters (m), 15m, and 20m and then censused on foot for comparison. The study found that using automated computer detection software, specifically object-based image analysis in eCognition (Trimble Inc., Sunnyvale, CA, USA) was unsuccessful. Detection of the cactus by the system was difficult due to the specific morphological surface characteristics of the species (Bates *et al.* 2022). Therefore, the study needed to evaluate the images by hand. Even when doing the evaluation by hand Wright fishhook cactus was detected 39 percent of time at the 10m flight height when compared to the on-the-ground census surveys (Bates *et al.* 2022). Detection rates declined at the two higher flight heights. Despite a low detection rate in this initial study, the use of drones to conduct surveys across remote and previously unsurveyed areas is promising. Use of higher quality drones, cameras, or analysis software may allow for automation, improve detection rates considerably and are worth further investigation research. The equipment and techniques used in this study are valuable tools to conduct initial searches of areas that are difficult to access, so habitat suitability and occupancy can be evaluated and prioritized before sending surveyors to the site to conduct time-consuming foot-surveys.

Disturbance Effect Monitoring

There have been several livestock and disturbance monitoring programs conducted since the late 1990's, and results have been disparate between studies. In 2011, a range-wide plan for monitoring disturbance was established by an interagency team with input from the USFWS, CRNP, and the BLM. Since the establishment of this plan, CRNP and the BLM, the two primary agencies responsible for managing lands where the Wright fishhook cactus is found, have invested significant resources in documenting cactus attributes: location, diameter, number of stems, number of reproductive structures, and the presence or absence of disturbance (visible tracks within 15 cm) by livestock.

[1] Localities represent systematically surveyed areas where one or more individuals were found.

CRNP - Livestock Disturbance Monitoring 1999 to 2007

Monitoring efforts to evaluate livestock effects near a spring development project were initiated in 1987 (Clark and Clark 2007). Annual monitoring occurred in most years from 1999 through 2007, and included an area protected from grazing within a fenced exclosure and a grazed area outside of the fenced area (Clark and Clark 2007). Findings include:

- Plant density increased by more than 30% inside the exclosure as compared to outside the exclosure in the grazed area.
- Cacti density increased more rapidly within the exclosure compared to the adjacent areas with livestock grazing.
- The number of cacti within the larger size class (> 8cm in diameter) were more numerous within a livestock exclosure than outside the fenced area.
- The larger size class of cacti outside the exclosure were susceptible to uprooting by cattle, particularly if the cacti were not protected by other substantial vegetation (nurse plants).
- Within the exclosure, more large size class individuals were able to grow without the protection of substantial vegetation.
- Numbers of flowers per individual inside the livestock exclosure were higher than those outside, indicating a higher reproduction potential, likely due to a lack of livestock effects, such as trampling, especially of the larger cacti.
- During drought years (1999–2003), cacti numbers decreased by 20 - 33% in fenced and unfenced areas. Increased precipitation in 2004 and 2005 resulted in an increase in the survival and recruitment of Wright fishhook cactus plants.

CRNP - Livestock Disturbance Monitoring 2013 to 2019

In 2013 Capitol Reef National Park (CRNP) implemented a revised monitoring program for Wright's fishhook cactus to statistically quantify demographic trends, habitat conditions, and effects from cattle trampling and trailing (NPS 2013). The Park completed analyses of the 2013-2016 monitoring data in 2017 (Hornbeck 2017) and completed analyses of the full data set 2013 to 2019 in 2020 (Hornbeck 2020a). Summary findings include (Hornbeck 2020a):

- The 2013-2016 monitoring results demonstrated reduced survival, growth, fecundity, and population growth rates where cattle were present, and stable or increasing population growth where cattle were absent, and downward trends in cattle disturbed and cattle damaged populations. Results from the 2013-2016 analyses suggest that Wright fishhook cactus populations can return to stable population growth following cattle disturbance and damage once the perturbation is removed (Hornbeck 2017).
- Evaluation of this same monitoring data from 2013 to 2019 also indicated a negative association between cactus presence and demographic traits and livestock grazing.
- The species-level average 2013-2019 Wright fishhook cactus deterministic population growth rate (lambda [λ]) was 0.941 (95% CI 0.926-0.951; $n = 417$ genets), which is just below the stable range of $0.95 \geq \lambda \geq 1.05$. Interannual observed population growth rates ranged from 0.841 (2016-2017; 95% CI 0.794-0.880) to 1.013 (2013-2014; 95% CI 0.999-1.028).
- 49.7 percent of the individuals were directly affected by cattle trampling (Hornbeck 2020a).
- Future scenario models were developed based on the observed data from 2013 – 2019. Model findings include the following (Hornbeck 2020b):
    - Models with chronic livestock trampling had a rapidly declining population trend.

- Models with no livestock had a stable to increasing population trend.
- The CRNP populations cannot tolerate either chronic or episodic trampling events even when other stressors are not present. This sensitivity to trampling may be the due to cumulative effects on the population from decades of chronic trampling.

BLM – Livestock Disturbance Monitoring 2011 - 2017

- From 2011-2013, the BLM conducted repeat surveys for Wright fishhook cacti at 58 known localities across its range and documents 5,439 individuals (BLM 2013).
    - 29 percent of cacti had direct disturbance to an individual cactus from cattle trampling (BLM 2018).
- In 2011, the BLM Richfield Field Office implemented range-wide monitoring of Wright fishhook cactus on BLM managed lands where macroplots were stratified by grazing intensity (BLM 2018). A total of 30 macroplots were monitored from 2011-2017 on a 3-year rotating basis, so each plot was only measured twice during the 2011 to 2017 effort.
    - Evaluation of this data was conducted in 2013 and again in 2022.
    - Analysis of the data in 2013 found no correlation between disturbance by cattle and population density ($r^2 = 0.0873$; BLM 2013).
    - Monitoring data from 2011 to 2017 indicate a decline in population density, but the evaluation does not conclude that this decline is due to livestock grazing (Bates et. al. 2022, in press). The same study found no significant difference in cactus density between livestock disturbance levels.
- Paired livestock exclusion plots were monitored at three locations at two points in time between 2011 to 2017. Results show little difference between the grazed and non-grazed plots (BLM 2018).

BLM - Factory Butte Special Recreation Management Area

The primary goal for this monitoring effort is to determine whether unauthorized OHV related activities are affecting cacti and their habitat within and adjacent to the Factory Butte Special Recreation Management Area (SRMA, BLM 2010). A secondary goal is to determine population trends within the SRMA. The SRMA was designated in the 2008 Richfield Field Office Resource Management Plan (RMP). Three types of monitoring methods are ongoing: 1) monthly repeat photography to document disturbance; 2) biannual transect monitoring to record disturbance; 3) macroplot monitoring for disturbance and trend. In 2014, the BLM established seven macroplots within the Factory Butte Special Recreation Management Area (SRMA). Summary findings include (BLM 2022):

- From 2007 to 2016 disturbance and violations decreased significantly, as shown by repeat photography and transect monitoring.
- 2017 – 2021 showed an increase in disturbance and violations, as shown by repeat photography and transect monitoring. Photography data indicates that the disturbance level is similar to 2009, while the transect data shows a drastic decrease still from 2009 to 2021.
- The microplot disturbance data averages less than 0.5 percent, which is well below the 5 percent threshold established in the 2010 biological opinion (USFWS 2010).

- Macroplot census data shows a consistent trend across all macroplots Population in the SRMA generally declined from 2011 0 2018, increased in 2019 to 2020, and then dropped sharply again in 2021.
- Causes of mortality in the macroplots were primarily caused by small animals, cactus beetle or moth, and drought.

Threats

The previous 5-year review indicated that threats to Wright fishhook cactus are more numerous and more immediate than at the time of the listing (USFWS 2008). Current threats include anthropogenic related effects such as livestock grazing, OHV use, and illegal collection combined with natural effects such as drought, climate change, and predation.

Grazing

Within the boundaries of Capital Reef National Park, the Cathedral and Hartnet grazing allotments were each retired in 1999 and 2018 respectively. Even with these allotments retired, over 90 percent of the Wright fishhook cactus range falls within grazing allotments. Trailing through the Cathedral and Hartnet allotments continues along historic cattle trailing routes to move cattle from U.S. Forest Service lands to BLM lands within Capital Reef National Park. Conservation measures to reduce effects to Wright fishhook cactus were identified in the biological opinion issued in 2018 and monitoring is ongoing (USFWS 2018, Hornbeck 2021). Monitoring for grazing effects along the livestock trailing routes is ongoing.

As described in previous sections of this review, various grazing disturbance studies have had mixed results and come to disparate conclusions. In the most robust evaluation of grazing effects to cactus, the study found that over 49 percent of the cactus were affected by cattle trampling (Hornbeck 2020b). The study also found reduced survival, growth, fecundity, and population growth rates where cattle were present, and stable or increasing population growth where cattle were absent, and downward trends in cattle disturbed and cattle damaged populations (Hornbeck 2017; Hornbeck 2020b). Future scenario modeling evaluated the response of populations to a grazing intensity and frequency gradient (Hornbeck 2020b). The study concluded that populations exposed to chronic livestock trampling had a rapidly declining population trend at every intensity level and populations without any livestock trampling effects could have a stable to increasing population trend. The study further concludes that the study populations cannot tolerate either chronic or episodic trampling events even when other stressors are not present. This sensitivity to trampling may be the due to cumulative effects on the population from decades of chronic trampling (Hornbeck 2020b).

Livestock directly impact *Sclerocactus* and cause mortality or harm by trampling, kicking, scraping, and damaging the cactus stem, roots, or seeds. Livestock presence also changes the structure of a population by disproportionally affecting larger size classes, causing an overall shift in size structure towards smaller size classes (Hornbeck 2017, 2020a, b). Livestock indirectly affect *Sclerocactus* by manipulating vegetation communities, damaging biological soil crusts, disturbing pollinator nesting habitat, altering pollinator forage, compacting soils, reducing seedling recruitment, introducing noxious weeds, increasing wind erosion and dust, fragmenting populations, and increasing herbivory from rodents and lagomorphs (rabbits and hares; Fleischner 1994, Severson and Urness 1994, Cole et al. 1997, Sharrow 2007, Belnap et al. 2009, Hornbeck 2017). These threats affect *Sclerocactus* individuals by reducing individual fitness, survivorship, and reproductive capacity and affect

Sclerocactus populations by reducing seedling recruitment and survival, altering population age structure, reducing resiliency, and reducing gene flow (Belnap and Gilette 1998, Belnap et al. 2001, Castellano 2007, Sharrow 2007, Belnap et al. 2009, Ureta and Martorell 2009, Hornbeck 2017).

Off Highway Vehicles

Off highway vehicle (OHV) use is a threat the occurs on BLM lands and was recorded within 68 Wright fishhook localities between 1999 and 2003. On BLM lands, OHV effects to the species have declined over time since the Richfield BLM office restricted OHV use to designated routes in 2008 and implemented OHV closures at Factory Butte SRMA (BLM 2008b, BLM 2017). Since 2009, two cacti deaths were attributed to OHV use in unauthorized areas of the SRMA from a single incident (BLM 2017). Overall, compliance with the OHV designated use area in the Factory Butte SRMA has been good and effects to the species have been greatly reduced in this area.

OHV and other recreational use and road maintenance activities outside of the SRMA may cause direct mortality of Wright fishhook cactus via the crushing of plants by tires, damage to individual plants, decreased vigor from dust deposition, and effects to pollinators and their habitat (Clark 2008; Clark 2010). Injured or damaged plants may persist for several years with reduced reproductive potential before recovering or succumbing to their injuries (Figure 1). However, OHV and recreational use outside of the SRMA occurs and can lead to direct effects to cactus individuals from trampling, crushing, and uprooting.

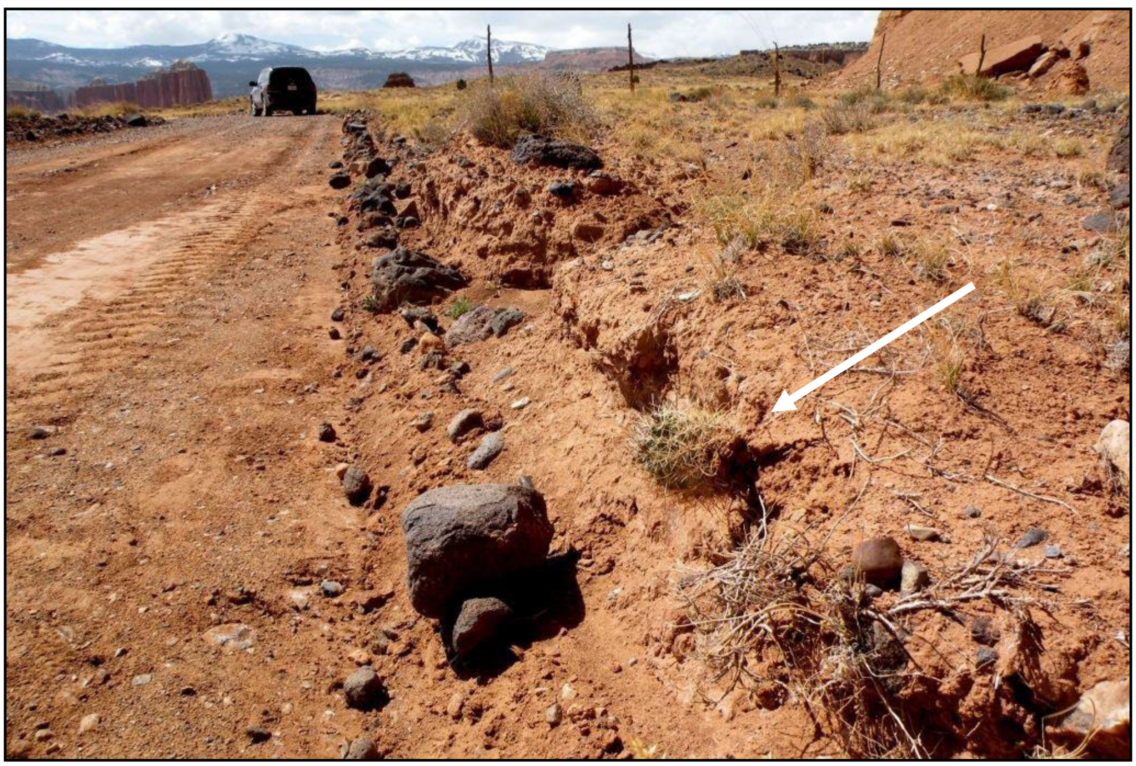

Figure 1. Wright fishhook cactus along a roadside at Capitol Reef NP, uprooted by a road grader. Photo by D. Roth / USFWS.

Energy and Mineral Exploration and Development

We identified activities associated with mineral exploration and development as primary threats to Wright fishhook cactus in the 1979 listing decision and in the original Recovery Plan of 1985 (44 FR 58866, October 11, 1979; USFWS 1985). Mining activities, including oil and gas exploration and development, can affect Wright fishhook cactus by destroying habitat, increasing erosion potential and dust deposition, fragmenting habitat through access road construction, degrading suitable habitat, and increasing invasive plant species.

Energy and mineral development and exploration are not permitted on Capitol Reef NP lands. All mining claims within Capitol Reef were either declared invalid or were nullified by 1986 (Frye 1998). By the end of the 1980s, oil and gas leases were either eliminated or suspended (Frye 1998). All national parks are now closed to new Federal mineral leasing (NPS 2006). The BLM lands within the range of Wright fishhook cactus contain saleable (sand, gravel, bentonite, building stone), locatable (gypsum, uranium, vanadium), and fluid & leasable mineral (coal, oil & gas) resources that were actively pursued by commercial and industrial development in past years (BLM 2008a, 2008b). If plants are found within known oil and gas fields, the BLM's RMPs include species specific conservation measures aimed at avoiding and reducing effects to the species from oil and gas leases. Conservation measures include avoidance and minimization measures, including buffer zones, limiting new access routes, and restoration of disturbed sites (BLM 2008a & b). The BLM RMPs do not include species specific conservation measures to protect Wright fishhook cactus from mineral development other than oil and gas development (BLM 2008a, 2008b).

In addition, approximately 64 percent of Wright fishhook cactus sites are located within areas identified as solar zones by the Western Renewable Energy Zones Initiative (Western Renewable Energy Zones Initiative 2014; USFWS 2014).

Much of the range of the species remains open to energy and mineral exploration and development. Therefore, energy and mineral exploration and development remains a potential threat across significant portions of the species' range on BLM lands. Currently, effects from energy and mineral exploration and development are low and localized but are likely to change depending on market conditions. Based on our current knowledge of the distribution of the species, energy and mineral exploration and development are significant threats to Wright fishhook cactus.

Predation

Insect and rodent predation can be a significant cause of Wright fishhook cactus mortality. Herbivores include the cactus borer beetle, Ord's kangaroo rat, white-tailed antelope ground squirrels, mice, and a recently described snout moth (genus *Rhagea*) (Kass 2001a and 2001b; Clark 2009; Borthwick and Livensperger 2017b). Predation impacts may increase under drought and grazed conditions (USFWS 2013), and were identified as the primary cause of cactus mortality and population declines at the Factory Butte SRMA (BLM 2017).

Poaching

Illegal collection of Wright fishhook cactus is a range-wide stressor that likely continues although the current scale of this effect is unknown. Wright fishhook cactus is desired in cactus collections and the Park has documented signs of scouting and poaching for the species, and illegal advertisements online.

Drought

Future climate projections for the southwest include more intense and longer-lasting heat waves, fewer cold periods, an increased probability of droughts that are worsened by higher temperatures, reduced snowpack, earlier snow melt and more frost-free days (Garfin et al. 2014, Melillo et al. 2014). Projections for precipitation changes are less certain than predictions for temperature and may increase in some areas and decrease in others (Garfin et al. 2014). However, it is expected that more precipitation will be in the form of rain versus snow, which can increase flooding of dry washes, and will occur as extreme precipitation events (Frankenson et al. 2018). As a desert species, Wright fishhook cactus has adapted to tolerate periodic drought conditions; therefore historic droughts patterns alone are not expected to cause a decline in species stability or trend. The ability to go dormant during drought periods and possessing contractile roots to retract low to the ground to reduce water loss and sun scald are two adaptive strategies that Wright fishhook uses during seasonal droughts. An analysis was attempted to distinguish between livestock effects and drought effects under current and future scenarios. However, due to the synergism between drought stress, livestock trampling, and herbivory, the degree to which drought plays a role in the population trend remains unclear (Hornbeck 2020b).

Climate Change

Climate change was not identified as a threat at the time of listing or in the recovery plan. Wright fishhook cactus appears to be highly vulnerable to future climate conditions based on one evaluation that predicted considerable range loss for the species after 2040 (Krause 2010). Wright fishhook cactus was also ranked as "extremely vulnerable" to climate change using a climate vulnerability index and an evaluation of current verses future suitable habitat locations (Still *et al.* 2015). The species predicted vulnerability to future climate conditions using predictive models and the index were based on factors that include the species' small current range, limited dispersal ability, and lack of overlap between current and future areas of suitable habitat (Krause 2010; Still *et al.* 2015).

Recommendations on species status:

After reviewing the best available scientific information on the species and its threats, we conclude that the Wright fishhook cactus remains correctly classified as an endangered species under the Act. Our review of new information compiled since our last 5-year status review (USFWS 2008) does not change our evaluation of the species' status and threats affecting the species under the five factors identified in section 4(a)(1) of the Act. Therefore, we determine that the Wright fishhook cactus is currently at risk of extinction throughout all of its range, so continues to meet the Act's definition of an endangered species. As a result, we recommend that no change in status under the Act is needed for the species at this time.

Table 1. The following table lays out the USFWS ranking system for determining Recovery Priority Numbers per our 1983 policy (48 FR 43098, September 21, 1983 as corrected in 48 FR 51985, November 15, 1983).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

Rationale:

The Wright fishhook cactus faces a high degree of threats and a low recovery potential. Threats are high because the Wright fishhook cactus could face extinction if recovery is delayed. Populations continue to decline and human activities and other factors continue to affect Wright fishhook cactus individuals and their habitat. The Wright fishhook cactus has a low recovery potential because of the range-wide extent of threats, including biological threats that are difficult to address, such as low recruitment to mortality ratios, endemism to specific soil substrates, effects from beetle predation, drought, and limited knowledge about arid land restoration. Additionally, species recoverability and survivability is in conflict with other ongoing land management activities and economic activity across the majority of its range. Therefore, we assign the Wright fishhook cactus a Recovery Priority Number of 5C.

Recommended future actions:

Based on recent discussions with conservation partners, we recommend the following future actions:

1. Work with partners to protect as much occupied and potential habitat as possible and improve habitat conditions for plants and pollinators by providing intact or restored habitat conditions;
2. Work with partners to restrict recreational use and restore degraded habitat areas to support the species and its pollinators;
3. Work with partners to collect seeds periodically from all populations to provide a genetically representative, off-site seed collection;
4. Establish a range-wide population trend monitoring program that is consistent and comparable on CRNP and BLM lands;

5. Continue existing livestock disturbance monitoring throughout the species range;
6. Continue existing OHV recreation disturbance monitoring and enforcement at Factory Butte SRMA;
7. Work with partners to improve species census data, especially within CRNP, and utilizing novel survey techniques such as drone surveys;
8. Work with researchers to develop a fine-scale species distribution model using census imagery to identify favorable seedling microsites for seed additions and support future population augmentation efforts on BLM;
9. Work with partners and researchers to conduct a germination study on BLM and CRNP to inform population models and understanding of recruitment and population dynamics;
10. Continue to investigate propagation methods for the species to reduce plant and population losses and preserve genetic diversity; and
11. Work with researchers to develop an annual detectability estimate for the species based on population monitoring data to calculate the percentage of the population above ground and detectible for section 7 consultation effects analyses and population estimates.

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Approve: ________________________ **Date:** ___________________

Yvette Converse, Field Supervisor
Utah Ecological Services Field Office

Literature Cited

Bates, H.T., V.J. Anderson, R.L. Johnson, L. Allphin, D. Rooks, and S.L. Peterson. 2022. A practical assessment of using sUASs (Drones) to detect and quantify Wright fishhook cactus (*Sclerocactus wrightiae* L.D. Benson) populations in desert grazinglands. Land, 11, 655. 13pp.

Belnap, J., Reynolds, R.L., Reheis, M.C., Phillips, S.L., Urban, F.E., and Goldstein, H.L. 2009. Sediment losses and gains across a gradient of livestock grazing and plant invasion in a cool, semi-arid grassland. Colorado Plateau, USA. Aeolian Research 1: 27-43.

Belnap, J. and D.A. Gilette, 1998. Vulnerability of desert biological soil crusts to wind erosion; the influences of crust development, soil texture and disturbance. Journal of Arid Environments 39: 133-142

Belnap, J., R. Prasse and K. Harper. 2001. Influence of biological soil crusts on soil environments and vascular plants in (eds) Belnap, J. and O. Lange Biological soil crusts; Structure function and management. Ecological Studies vol. 150 Springer-Verlag Berlin 281-300.

Benson, L. 1966. A revision of *Sclerocactus*. Cactus and Succulent Journal. 38:50–57, 101–106.

Borthwick, S. and C. Livensperger [NPS]. 2017. Wright fishhook cactus (Sclerocactus wrightiae) 2016 Annual Repeat Sampling and Demographic Monitoring Report, Capitol Reef National Park. April 4, 2018. 20p.

Bureau of Land Management, 2008a. Price Field Office Record of Decision and Approved Resource Management Plan. October 2008. 182 pp. http://www.blm.gov/ut/st/en/fo/price/planning/rod_approved_rmp0.htm

Bureau of Land Management, 2008b. Richfield Field Office Record of Decision and Approved Resource Management Plan. October 2008. 206 pp. http://www.blm.gov/ut/st/en/fo/richfield/planning/rmp/rod_approved_rmp.html

Bureau of Land Management. 2010. Monitoring plan for Wright fishhook cactus (Wright fishhook cactus) and OHV compliance in the Factory Butte Special Recreation Management Area, Wayne County, UT. 15 pp & appendices.

Bureau of Land Management. 2013. Three-year summary report 2011-2013 initial and repeat inventory for Wright fishhook cactus (*Sclerocactus wrightiae*). Bureau of Land Management, Richfield Field Office, Utah. 38 pp.

Bureau of Land Management. 2014a. 2014 Results of Initial Repeat Inventories in BLM Price Field Office. Unpublished summary report prepared by the BLM Price Field Office. August 19, 2014. 2 pp.

Bureau of Land Management. 2014b. August 2014 Meeting Summary Updates *Pediocactus winkleri,* Wright fishhook cactus. Unpublished summary report prepared by the BLM Richfield Field Office. 4 pp.

Bureau of Land Management. 2014c. 2014 Results of Initial Repeat Inventories in the BLM Richfield Field Office. Unpublished summary report prepared by the BLM Richfield Field Office. 2 pp.

Bureau of Land Management. 2017. Nine Year Summary Report 2009 – 2017 Monitoring for Wright Fishhook Cactus (Sclerocactus wrightiae) at Factory Butte Special Recreation Management Area in Richfield Field Office. 28 pp.

Bureau of Land Management, Price and Richfield field offices, Capitol Reef National Park, and USFWS Utah Field Office. 2014. Monitoring plan for Wright fishhook cactus (Wright fishhook cactus). 23 pp & appendices.

Bureau of Land Management. 2022. Summary of monitoring at Factory Butte special recreation management area, 2021. January 2022. BLM Richfield Field Office. Unpublished summary report prepared by the BLM Richfield Field Office. 19 pp.

Castellano, M.J. and T.J. Valone 2007. Livestock, soil compaction and water infiltration rate: Evaluating a potential desertification recovery mechanism. Journal of Arid Environments. 71:1 97-108

Cole, K., N. Henderson, and D. Shafer 1997. Holocene vegetation and historic impacts at Capitol Reef National Park reconstructed using packrat middens. 57(4): 315-326

Clark, T., and D. Clark. 2007. Wright fishhook cactus monitoring in Capitol Reef National Park. November 1, 2007. 23 pp.

Clark, D. 2008. Summary of Repeat Inventory Monitoring and Site Visit Accounts to Wright fishhook cactus, *Pediocactus winkleri* and *P. despainii* sites. Unpublished NPS document, Capitol Reef National Park, Torrey, Utah.

Clark, D. 2009. 2009 results of *Sclerocactus wrightiae* monitoring at Factory Butte. Unpublished report for the Bureau of Land Management, Richfield Field Office.

Clark, D. 2010. 2010 Results of Wright fishhook cactus Plot Monitoring at Factory Butte. Unpublished data summary prepared for the BLM.

eFloras. 2012. Published on the Internet http://www.efloras.org [accessed July 19, 2022] Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Fleischner, T.L. 1994. Ecological Costs of Livestock grazing in Western North America. Conservation Biology. Vol. 8, No.3: 629–644.

Frankson, R., K. Kunkel, L. Stevens and D. Easterling, 2018: Utah State Climate Summary. NOAA Technical Report NESDIS 149-UT, 4 pp.

Frye, B. 1998. An administrative history of Capitol Reef National Park, UT. Cultural Resources Selections No. 12, Intermountain Region, National Park Service. Denver, CO. Vol. 2. http://www.nps.gov/history/history/online_books/care/adhi/adhit.htm

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014: Ch. 20: Southwest.

Greenleaf, S.S. 2005. Local-Scale and Foraging-Scale Habitats Affect Bee Community Abundance, Species Richness, and Pollination Services in Northern California. PhD Thesis, Princeton University. 88 pp.

Heil, K.D., and J.M. Porter. 2004. *Sclerocactus.* In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 15+ vols. New York and Oxford. Vol. 4, pp. 197–207.

Hochstätter, F. 2005. The Genus *Sclerocactus*, (Cactaceae). Published by the author, Mannheim, Germany. 336 pp.

Hornbeck, J.H. 2017. Monitoring cattle impacts on cactus species in Capitol Reef National Park: demographic analysis results 2013-2016. Prepared for Capitol Reef National Park, Torrey, Utah. December 2017.

Hornbeck, J.H. 2020a. DRAFT Demographic Monitoring of *Pediocactus winkleri* and *Sclerocactus wrightiae* in Capitol Reef National Park: 2013-2019 Report. Prepared for Capitol Reef National Park, Torrey, Utah. Prepared by Manzanita Botanical Consulting, Salt Lake City, UT. In Draft: August 2022. 51 pp.

Hornbeck, J.H. 2020b. Utah Cactus Quantitative Recovery Criteria Development. Prepared by Manzanita Botanical Consulting, Salt Lake City, Utah for Utah Ecological Field Services Office, U.S. Fish and Wildlife Service, West Valley City, Utah. 112 pages plus appendices. September 30, 2020.

Hornbeck, J.H. 2021. DRAFT Demographic monitoring of Pediocactus winkleri and Sclerocactus wrightiae in Capitol Reef National Park: 2013 – 2019 Report. Prepared for Capitol Reef National Park, prepared by J.H. Hornbeck. In Draft. August 2020. 51 pp.

Kass, R.J. 1990. Final report - habitat inventory of threatened and endangered and candidate plant species in the San Rafael Swell, Utah. USDA, Bureau of Land Management, Salt Lake City, Utah. 87 pp.

Kass, R. 2001a. Demographic Monitoring of Wright Fishhook Cactus. Southwestern Rare and Endangered Plants: Proceedings of the Third Conference. September 25–28, 2000. Flagstaff, Arizona. USDA Proceedings RMRS-P-23, 9 pp.

Kass, R. 2001b. Western North America Naturalist. Mortality of Endangered Wright Fishhook Cactus (Wright fishhook cactus) by an Opuntia-Borer Beetle (Cerambycidae: *Moneilema semipunctatum)*. 61(4):495–497.

Krause, C.M. 2010. Conservation Ecology of Endemic Plants of the Colorado Plateau: Climate Change Impacts on Range Shifts. Dissertation. 156 pp.

Melillo, J. M., T.C. Richmond, and G.W. Yohe, Eds. 2014: Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 148 pp. ISBN 978-0-16-092388-3. Available online at http://nca2014. globalchange.gov .

National Park Service. 2013. Study Plan: Range-wide monitoring of cattle impacts on two federally listed cacti species. Capitol Reef National Park, Utah. 16pp.

National Park Service. 2014a. 2014 Results of Repeat Inventories in Capitol Reef National Park (CRNP). Unpublished preliminary summary results prepared for Capitol Reef National Park. 2 pp.

National Park Service. 2014b. Cumulative and 2013 Results of *Initial* Repeat Inventories and *Annual* Repeat Sampling for Wright Fishhook Cactus (*Sclerocactus wrightiae*)

Capitol Reef National Park, Utah. February 12, 2014. Unpublished preliminary summary results prepared for Capitol Reef National Park. 35 pp.

Neese, E. 1987. Final report - habitat inventory of Wright fishhook cactus and other associated sensitive species. Volumes 1 & 2. USDA, Bureau of Land Management, Richfield, Utah.

Rooks, D. 2018. [BLM 2018]. Central Utah Listed Cacti: Summary of Inventory, monitoring conservation actions, and suggestions from 1979 – 2017. Presentation to central Utah cactus working group, 2018. BLM Richfield Filed Office, Richfield UT. 60 pp.

Severson, K. E. and P. J. Urness. 1994. Livestock grazing: A tool to improve wildlife habitat. *In*: M. Vavra, W. A. Laycock and R. D. Pieper *eds*. Ecological implications of livestock herbivory in the West. Denver, CO: Society for Range Management: p. 232-249.

Sharrow, S.H. 2007. Soil Compaction by grazing livestock in silvopastures as evidenced by changes in soil physical properties. Agroforestry Systems 71:215-223

Still, S.M., A.L. Frances, A.C. Treher, and L. Oliver. 2015. "Using two climate change variability assessment methods to prioritize and manage rare plants: A case study." Natural Areas Journal 35: 106 – 121.

Tepedino, V.J. 2000. The reproductive biology of rare rangeland plants and their vulnerability to insecticides. Vol. III.5, pp. 1–10; Grasshopper Integrated Pest Management User Handbook, G.L. Cunningham & M. W. Sampson (Tech. Coord.) USDA APHIS Tech. Bull. No. 1809, Washington, D.C.

U.S. Fish and Wildlife Service. 1985. Wright Fishhook Cactus Recovery Plan. Prepared in cooperation with the Wright Fishhook Cactus Recovery Committee. Denver, Colorado 27pp.

U.S. Fish and Wildlife Service. 2010 Biological Opinion for Factory Butte Special Recreation Management Area. Utah Ecological Services Field Office, West Valley City, Utah. December 20, 2010. 32pp.

U.S. Fish and Wildlife Service 2013. Impacts to federally listed cacti species from livestock on the Colorado Plateau in Utah: A Review and Summary. Prepared by Tova Spector, USFWS. Utah Ecological Services Field Office, West Valley City, UT. 72pp.

U.S. Fish and Wildlife Service 2018. Biological Opinion: Conclusion of Section 7 consultation for the Issuance of Special Use Permits for Livestock Grazing and Trailing in Capitol Reef National Park. September 28, 2018. Utah Ecological Services Field Office, West Valley City, UT. 48 pp.

Ureta, C. and C. Martorell 2009. Identifying the impacts of chronic anthropogenic disturbance on two threatened cacti to provide guidelines for population-dynamics restoration. Biological Conservation. 142: 1992-2001

Welsh, S.L., N.D. Atwood, S. Goodrich, L.C. Higgins. 2008. A Utah Flora, Fourth edition, revised. 1,019 pp.

Western Regional Climate Center. 2014. http://www.wrc.dri.edu. Accessed August 11, 2014.

Western Renewable Energy Zones Initiative. 2014. Western Renewable energy Zones – Phase 1 Report. Western Governors' Association & U.S. Department of Energy. 27 pp.

Woodruff, D. and L. Benson. 1976. Changes in status in *Sclerocactus*. Cactus and Succulent Journal. 48:131-134.