

Species Status Assessment Report
for
Gierisch mallow
(Sphaeralcea gierischii)



U.S. Fish and Wildlife Service

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The document is available on-line at the [Gierisch Mallow Species Profile](#).

EXECUTIVE SUMMARY

Gierisch mallow (*Sphaeralcea gierischii*) is a perennial flowering plant endemic to Northwestern Arizona and Southwestern Utah. The U.S. Fish and Wildlife Service (FWS, we) listed the Gierisch mallow as an endangered species with critical habitat on August 13, 2013 (78 FR 49149, 78 FR 49165). We designated two critical habitat units that encompass 5,189 hectares (12,822 acres).

Botanists originally thought Gierisch mallow plants belonged to a closely related species. Atwood and Welsh (2002, pp. 161–163) described it as a distinct species in 2002 based on unique morphological features. Species in the genus *Sphaeralcea* can have overlapping morphological distinctions, often as a result of hybridization (Atwood and Welsh 2002, p. 159). We do not know if Gierisch mallow hybridizes with other *Sphaeralcea* species.

Gierisch mallow is associated with gypsum rock outcrops of the Harrisburg Member of the Kaibab Formation (Atwood and Welsh 2002, p. 161), though plants can also occur between these outcroppings (Rink, G., Far Out Botany, pers. comm., June 1, 2023b). Gypsum deposits commonly have biological soil crusts composed of algae, bacteria, cyanobacteria, fungi, and cryptogams (plants that reproduce from spores rather than flowers and seeds) such as lichens, mosses, and liverworts, on the surface or within a few millimeters of the surface of the soil (Belnap *et al.* 2003a, p. 3). These crusts perform important ecological functions in desert scrub and grassland communities (Belnap *et al.* 2003b, p. 283; George *et al.* 2003, p. 120; Reynolds *et al.* 2001, p. 7126; Warren 2001, pp. 350–351, 356). Like many species of *Sphaeralcea*, Gierisch mallow readily grows in disturbed areas (Figure 4) and occurs in greater abundances in areas in early seral states (BLM 2022a, p. 3; Cort and Pavlik 2016, entire).

Because it is a recently described species, we do not know its historical range. The Bureau of Land Management (BLM) has mapped currently occupied areas. To delineate Gierisch mallow populations for our analysis in this SSA report, we used NatureServe’s guidelines and grouped mapped plant concentrations on gypsum outcrops separated by one kilometer (0.6 mile) from other concentrations (NatureServe 2004, p. 6). We further delineated the distribution into subpopulations based on concentrations of plants surveyed as a unit in the past and gypsum outcrops with records of Gierisch mallow. Our methodology results in 24 subpopulations within the three populations; two subpopulations in the North population, 20 in the Central population, and two in the South population (Figure 5 and Table 1).

The BLM regularly monitors Gierisch mallow at eight subpopulations. The lack of monitoring at the remaining subpopulations, coarse estimates of overall plant abundance, gaps in monitoring duration, and interannual variation in plant numbers make it difficult to detect trends in Gierisch mallow abundance.

Because Gierisch mallow is restricted to a specific geological formation in a small geographical range, it is highly susceptible to activities that could destroy or modify the plant and its habitat, such as from mineral extraction, livestock grazing, and recreational use. Other factors such as seed collection, climate change, nonnative invasive species, and wildfires, may also affect the species. Reclamation efforts have shown some encouraging results for reestablishing Gierisch

mallow and native plant communities on sites disturbed by mineral extraction (BLM and Red Butte Garden 2018, entire; Pavlik *et al.* 2018, entire).

We used the conservation principles of resiliency, redundancy, and representation (together, the 3Rs) (Shaffer and Stein 2000, pp. 307, 309–210; Wolf *et al.* 2015, entire) to evaluate Gierisch mallow's viability, or its ability to persist over the long term and avoid extinction. We evaluated Gierisch mallow's overall resiliency by evaluating the resiliency of its subpopulations and populations, both of which range from low to high. We conclude that Gierisch mallow has moderate redundancy and low representation due mostly to its endemism. More information about its current status and the potential for threats to affect populations and subpopulations will inform the future viability of the species and direct conservation actions needed for recovery.

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CHAPTER 1 - INTRODUCTION

1.1 Background

Gierisch mallow (*Sphaeralcea gierischii*) is a perennial flowering plant endemic to northwest Arizona and southwest Utah. Concentrations of plants grow on soils on gypsum outcrops. The U.S. Fish and Wildlife Service (FWS, we) listed Gierisch mallow as endangered under the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 *et seq.*) on August 13, 2013 (78 FR 49149). We identified habitat modification resulting from mining as the primary threat to the species, with additional habitat modification stressors from recreational activities, spread of nonnative plants and resulting alteration in wildfires, and soil compaction and soil crust removal from cattle grazing. At the time of listing, we designated 5,189 hectares (ha) (12,822 acres [ac]) as critical habitat, one unit in Mohave County, Arizona, and one unit in Washington County, Utah (78 FR 49165). These two critical habitat units encompass all the known concentrations of Gierisch mallow plants.

1.2 Species Status Assessment Framework

FWS developed the Species Status Assessment (SSA) framework as a tool to provide an in-depth review of a species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability (USFWS 2016a, entire). The SSA report is intended to support all functions of the ESA: candidate assessments, listing, section 7 consultations, and recovery. As such, the SSA report functions as a living document that can be easily updated as new information becomes available, and upon which other documents, such as listing rules, recovery plans, and 5-year status reviews, are based.

Based upon the best available information, this SSA Report for Gierisch Mallow provides a thorough review of the biology and natural history, demographic risks, stressors, limiting factors, and conservation measures in the context of determining the viability of Gierisch mallow. The information contained in this SSA Report will support the development of a streamlined recovery plan that complies with FWS's Draft Recovery Planning Internal Handbook (NOAA and USFWS 2019, entire). Although draft, it is the most up-to-date guidance document.

Using the SSA framework, we consider what a species needs to maintain viability by characterizing the status of a species in terms of the conservation principles of resiliency, redundancy, and representation (together, the 3Rs) (Shaffer and Stein 2000, pp. 307, 309–210; Wolf *et al.* 2015, entire). We use the 3Rs to better inform our view of what contributes to a species' probability of persistence, how best to conserve them, and achieve recovery. For this document, we define viability as the ability of a species to persist over the long term and avoid extinction.

Resiliency describes the ability of a population to withstand stochastic events (arising from random factors). We can measure resiliency using metrics of population health such as population size and growth rates. Highly resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations).

Representation describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among population and gauges the probability that a species can adapt to environmental changes. The more representation, or diversity, a species has, the more it can adapt to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

This SSA Report includes:

- A discussion of the resource needs (life history and habitat) of Gierisch mallow plants (Chapter 2);
- A review of abundance estimates and monitoring data for the Gierisch mallow (Chapter 3);
- A discussion of the factors that likely influence Gierisch mallow viability (Chapter 4); and
- A discussion of the above for a description of current viability of Gierisch mallow in terms of resiliency, redundancy, and representation (Chapter 5).

CHAPTER 2 - INDIVIDUAL NEEDS

In this chapter, we describe the biological and ecological needs of Gierisch mallow plants. As a newly described species, Gierisch mallow has been the subject of little research. Therefore, much of the information in this chapter is derived from monitoring reports and information about closely related species and species that inhabit similar habitats.

2.1 Description and Taxonomy

Gierisch mallow is a perennial plant in the mallow family of the genus *Sphaeralcea*, commonly referred to as globemallows (Figure 1). The following description is from Atwood and Welsh (2002, pp. 161–163). Gierisch mallow produces few to many stems from a woody caudex (short, thickened, stem that is usually subterranean or at ground level). The stems are 43 to 103 centimeters (cm; 17 to 41 inches [in]) tall and are often dark red-purple. The foliage is bright green and glabrous (smooth) or nearly glabrous. The leaf blades are 1.2 to 4 cm (0.47 to 1.57 in) long, 1 to 5 cm (0.4 to 1.9 in) wide, and usually longer than wide. The leaves are usually flat and egg-shaped; the leaf base is cordate (heart-shaped) to truncate (with a flat base), with three to five lobes. The inflorescence (flowering stalk) is compound, with more than one flower per node. The calyx (outer whorl of the flower that encloses the petals) is 5 to 10 millimeters (mm) (0.2 to 0.4 in) long, green, and uniformly glabrous, and the orange petals are 15 to 25 cm (0.6 to 0.98 in) long.

The genus *Sphaeralcea* consists of taxa whose morphological distinctions overlap in many characters, often as a result of hybridization (Atwood and Welsh 2002, p. 159). We do not have documentation of Gierisch mallow hybridizing with other *Sphaeralcea* species, but it is not unlikely based on the prevalence of hybridization within the genus. Dreher (2014, p. 11) found approximately one-third of interspecific crosses between 30 *Sphaeralcea* taxa successful.

Botanists originally thought Gierisch mallow to be Rusby's globemallow (*S. rusbyi*), which overlaps in range with Gierisch mallow. Closer examination of the key features revealed differences, and Atwood and Welsh (2002, pp. 161–163) described it as a distinct species based on unique morphological features. Gierisch mallow is considered a distinct species and there are no taxonomic disputes (Missouri Botanical Garden 2008, n.p.; ITIS 2022, n.p.). Gierisch mallow is distinguished from Rusby's globemallow by the glabrous (smooth) foliage, or few stellate (star-shaped) hairs restricted to the leaf margins and larger flowers. Rusby's globemallow can vary in degree of pubescence on the stems and leaves but typically has stellate-hairy sepals (leaf-like structures surrounding the petals), while Gierisch mallow has glabrous sepals with hairs on the inner surface that give the sepal margins a hairy appearance (Atwood and Welsh 2002, p. 161; G. Rink, Far Out Botany, pers. comm., June 1, 2023b) (Figure 2).

Genetic studies have not been completed on Gierisch mallow; therefore, no genetic information is available.



Figure 1. Gierisch mallow (credit: USFWS).

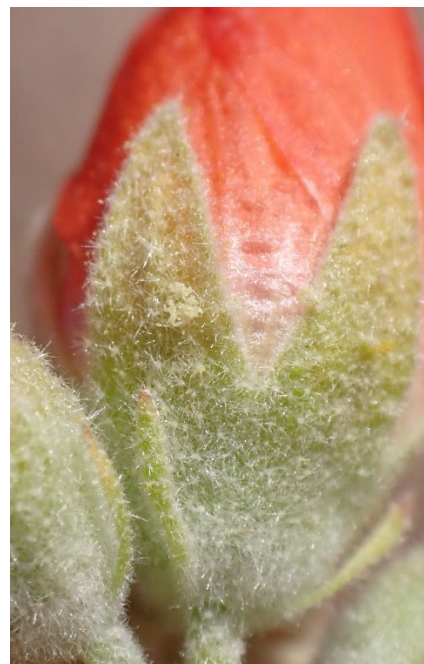


Figure 2. Calyx of Gierisch mallow (left) and Rusby's globemallow (right) (credit: USFWS).

2.2 Habitat

Gierisch mallow grows in a small area of the eastern Mojave Desert in northern Mohave County, in northwestern Arizona, and adjacent southern Washington County, in southwestern Utah. The climate is dry and warm. The 30-year normal minimum temperature in Gierisch mallow's range from 1991-2020 in January, the coldest month, was 31.8 degrees Fahrenheit (F; -0.1 degrees Celsius [C]), and the 30-year normal maximum temperature in July, the hottest month, was 101.2 degrees F (38.4 degrees C)(PRISM Climate Group 2022, n.p.). The 30-year normal annual precipitation was 23 cm (9.07 in).

Gierisch mallow occurs at elevations from approximately 755 to 1,150 meters (m) (2,477 to 3,772 feet [ft]) and on various slope aspects (USFWS 2020, unpublished data). Gierisch mallow plants are concentrated on gypsum rock outcrops of the Harrisburg Member of the Kaibab Formation (Atwood and Welsh 2002, p. 161). The Kaibab Formation comprises a continuous layer of exposed limestone rock in the Grand Canyon region (Clark 2021, p. 1) and forms the resistant cap rock at both the north and south rims of the Grand Canyon. The Harrisburg Member is the most recent (topmost) exposed geologic layer of the Kaibab Formation; its soils contain high levels of gypsum (gypsiferous soils) (Clark 2021, p. 10). Gierisch mallow may also grow sparsely in between gypsum outcrops in other geologic formations, such as the Moenkopi (Rink, G., Far Out Botany, pers. comm., June 1, 2023b). Based on this, Gierisch mallow is likely a gypsovag (can colonize both gypsum and other soils) rather than a gypsophile (soil-specific).



Figure 3. Undisturbed Gierisch mallow habitat (credit: USFWS).

Gypsum soils are inhospitable to many plants, as they are high in calcium and sulfur and almost devoid of nitrogen and other essential nutrients. The vegetation community within and around Gierisch mallow habitat is warm desert shrub (Mojave desertscrub) (NatureServe 2022, n.p.).

Dominant native plants include creosote bush (*Larrea tridentata*), blackbrush (*Coleogyne ramosissima*), saltbush (*Atriplex* sp.), yucca (*Yucca* sp.), ragweed (*Ambrosia* sp.), and Mormon tea (*Ephedra* spp.) (NatureServe 2022, n.p.; Figure 2.2). McBride (2022a, Appendix A) lists additional native plants associated with Gierisch mallow.

Gypsum deposits commonly have biological soil crusts composed of algae, bacteria, cyanobacteria, fungi and cryptogams (plants that reproduce from spores rather than flowers and seeds) such as lichens, mosses, and liverworts, on the surface or within a few millimeters of the surface of the soil (Belnap *et al.* 2003a, p. 3). Biological soil crusts are important biotic components of dryland ecosystems such as the Mohave Desert, because they perform critical functions that influence the abundance, diversity, and performance of other living communities in their habitats (Belnap *et al.* 2003b, entire). Nitrogen fixation by organisms in the crusts can be the dominant source of nitrogen in desert shrub and grassland communities that support few nitrogen-fixing plants (Belnap *et al.* 2003b, p. 283). Additionally, they capture wind-borne dust deposits that add nutrients to soil, including nutrients important to plants such as sodium, phosphorous, potassium, and manganese (Reynolds *et al.* 2001, p. 7126). Physically, biological soil crusts improve water infiltration into the soil, reduce erosion, and conserve soil moisture (Warren 2001 pp. 350–351, 356; George *et al.* 2003, p. 120). Biological soil crusts are highly vulnerable to destruction from natural erosion or manmade surface disturbance activities and climate change (Belnap *et al.* 2001, p. 50; Escolar *et al.* 2012 pp. 3094–3095).

While biological soil crusts can benefit vascular plants through the ways discussed in the previous paragraph, we do not know the importance of them to Gierisch mallow specifically. Biological soil crusts, in various levels of cover, occur where Gierisch mallow grows (McBride, W., pers. comm., October 11, 2022b). In a soil treatment experiment, Munro's globemallow (*S. munroana*) grown in substrate with biological soil crust had greater shoot and root biomass than plants in the control groups and were the only plants to produce flowers (Pendleton *et al.* 2003, p. 274). Additionally, Munro's globemallow plants grown in substrate with biological soil crust had higher nitrogen concentrations in their tissues than plants grown in the control groups (Pendleton *et al.* 2003, p. 276). Gierisch mallow may similarly benefit from growing in association with biological soil crusts.

Gierisch mallow readily grows in disturbed areas (Figure 4), occurs in greater abundances in areas in early seral states (BLM 2022a, p. 3), and has naturally reestablished on restored gypsum mine sites (Cort and Pavlik 2016, entire). Other *Sphaeralcea* species thrive in disturbed habitats (James *et al.* 1998, p. 299; Ott *et al.* 2013, p. 182; Gucker and Shaw 2018a, p. 6; 2018b, p. 7).



Figure 4. Gierisch mallow growing on a manmade pile of dirt in a decommissioned OHV trail (credit: USFWS).

2.3 Life History

Gierisch mallow plants die back to the ground during the early winter (December) and then re-sprout from their woody bases during late winter and spring (January to March), depending on daytime temperatures and rainfall. Flowering occurs from April through June (Cort and Pavlik 2016, p. 10). Gierisch mallow can also flower again in the late summer to early fall with sufficient monsoon moisture (Cort and Pavlik 2016, p. 10; McBride 2022a, p. 17).

In field experiments, germination occurred in the fall, not in the spring (Cort and Pavlik 2016, p. 8; Pavlik *et al.* 2018, p. 20). In general, Gierisch mallow seeds need a period of cold stratification during the winter before germinating the following fall, although a small proportion of seeds germinate without this dormant period (Cort and Pavlik 2016, p. 9). Gierisch mallow seeds likely persist for several years in the seedbank and germinate when conditions are favorable (Cort and Pavlik 2016, p. 10).

Gierisch mallow plants produce flowers within about 1.5 years (Cort and Pavlik 2016, p. 10). We do not know how long Gierisch mallow plants typically live. In a greenhouse study, six of 21 plants survived for at least four years (Cort and Pavlik 2016, p. 9).

2.4 Pollination

A variety of small- to medium-sized solitary bees pollinate Gierisch mallow in the spring including the following species that McBride (2022a, p. 14) identified as the most effective pollinators (evidenced by the proportion of Gierisch mallow pollen collected from the bodies): *Ancylandrena larreae*, *Andrena imitatrix*, *Ashmeadiella femorata*, *Ashmeadiella prosopidis*, *Calliopsis subalpina*, *Colletes* sp., *Diadasia* cf. *lutzi*, *Diadasia* cf. *palmarum*, *Lasioglossum* (subfamily Dialictus) spp., *Dufourea* cf. *vernalis*, *Macrotera* sp., and *Melissodes tristis*. McBride (2022a, p. 14) additionally recorded a variety of beetles visiting the flowers, however only four species were effective pollinators: *Acmaeodera tuta*, *Acmaeodera labyrinthica*, *Eupompha schwarzi*, and an unidentified species from family Melyridae, subfamily Dasytinae, cf. *Listrini*.

We do not know if Gierisch mallow is capable of self-pollination (McBride 2022a, p. 18), but outcrossing is important to many globemallow species (Pendery and Rumbaugh 1993, p. 128), and some globemallow species are self-sterile (Dreher 2014, p. 9). Thus, Gierisch mallow reproduction is likely largely dependent on pollinators (McBride 2022a, p. 18). Pollinators are additionally important in gene flow within and between Gierisch mallow concentrations. Pollinators also potentially facilitate hybridization; other species of *Sphaeralcea* (e.g., gooseberry leaf globemallow [*S. grossulariifolia*], and small-leaf globemallow [*S. parvifolia*]) occur around and in between Gierisch mallow concentrations and share some pollinator species (McBride 2022a, p. 17). We do not have information about whether hybridization occurs between Gierisch mallow and other *Sphaeralcea* species.

CHAPTER 3 – POPULATION DEMOGRAPHICS

In this chapter, we describe what is known of Gierisch mallow population demographics, including distribution and abundance and population trends.

3.1 Distribution

We have no information regarding the historical range of Gierisch mallow, because it is a newly described species with limited previous studies. Because of its association with a specific habitat type, gypsum rock outcrops associated with the Harrisburg Member of the Kaibab Formation, we assume that Gierisch mallow has historically been an endemic plant with a narrow, limited range. At the time of listing, we grouped Gierisch mallow records into 18 locations scattered across northern Mohave County, Arizona, and adjacent Washington County, Utah (78 FR 49149). The surrounding area contains several rare plants and, thus, has received extensive survey efforts (Atwood, D., Brigham Young University, pers. comm., February 29, 2008).

Two herbarium specimens at the New York Botanical Garden Steere Herbarium collected in 2000 and 2001, prior to recognition of the species, resemble Gierisch mallow and, if confirmed, would expand the species' range approximately 64 kilometers (km; 40 miles [mi]) to the south. We do not include these records in our population delineation in this SSA, because we have not confirmed their identity as Gierisch mallow (R. Lindley, pers. comm. August 5, 2022; G. Rink, Far Out Botany, pers. comm., January 12, 2023a; G. Rink, Far Out Botany, pers. comm., June 1, 2023b).

To delineate Gierisch mallow populations, we used NatureServe's guidelines and grouped mapped plant concentrations on gypsum outcrops separated by one km (0.6 mi) from other concentrations (NatureServe 2004, n.p.). This is greater than the expected flight distance of Gierisch mallow bee pollinators, 700 m (0.4 mi) (McBride 2022a, p. 19); thus, genetic exchange between these concentrations is likely uncommon. If Gierisch mallow plants are distributed between gypsum outcrops those plants could facilitate pollen exchange between populations; however, we have little information about the occurrence or abundance of these plants.

Our methodology resulted in three populations of Gierisch mallow: North, Central, and South (Figure 5 and Table 1). We further delineated populations into subpopulations based on concentrations of plants surveyed as a unit in the past and gypsum outcrops with records of Gierisch mallow but no population estimates (unsurveyed subpopulations). This results in 24 subpopulations within the three populations; two subpopulations in the North population, 20 in the Central population, and two in the South population (Figure 5 and Table 1). The North Population occurs in both Arizona and Utah, approximately 1.5 to 4 km (1 – 2.5 mi) north of Interstate 15. The Central and South populations occur wholly in Arizona, south of the Black Knolls with the southernmost portion on the edge of Black Rock Gulch near Mokaac Mountain.

Our delineation of populations and subpopulations represents the best available information about Gierisch mallow distribution. The few records of Gierisch mallow plants occurring off of gypsum outcrops is problematic for our delineation. We do not know how commonly Gierisch mallow occurs outside of our subpopulations or whether these plants mostly occur rarely as small groups and in small clusters on suitable microhabitats or in a more continuous distribution

throughout the range. Additionally, the variation of physical features within and between Gierisch mallow and Rusby's globemallow raises could cause confusion in identification of Gierisch mallow. More surveys outside of mapped subpopulations and careful attention to physical characteristics would improve our understanding of Gierisch mallow distribution. In the absence of this information, we focus on the populations and subpopulations we delineate in this SSA report.

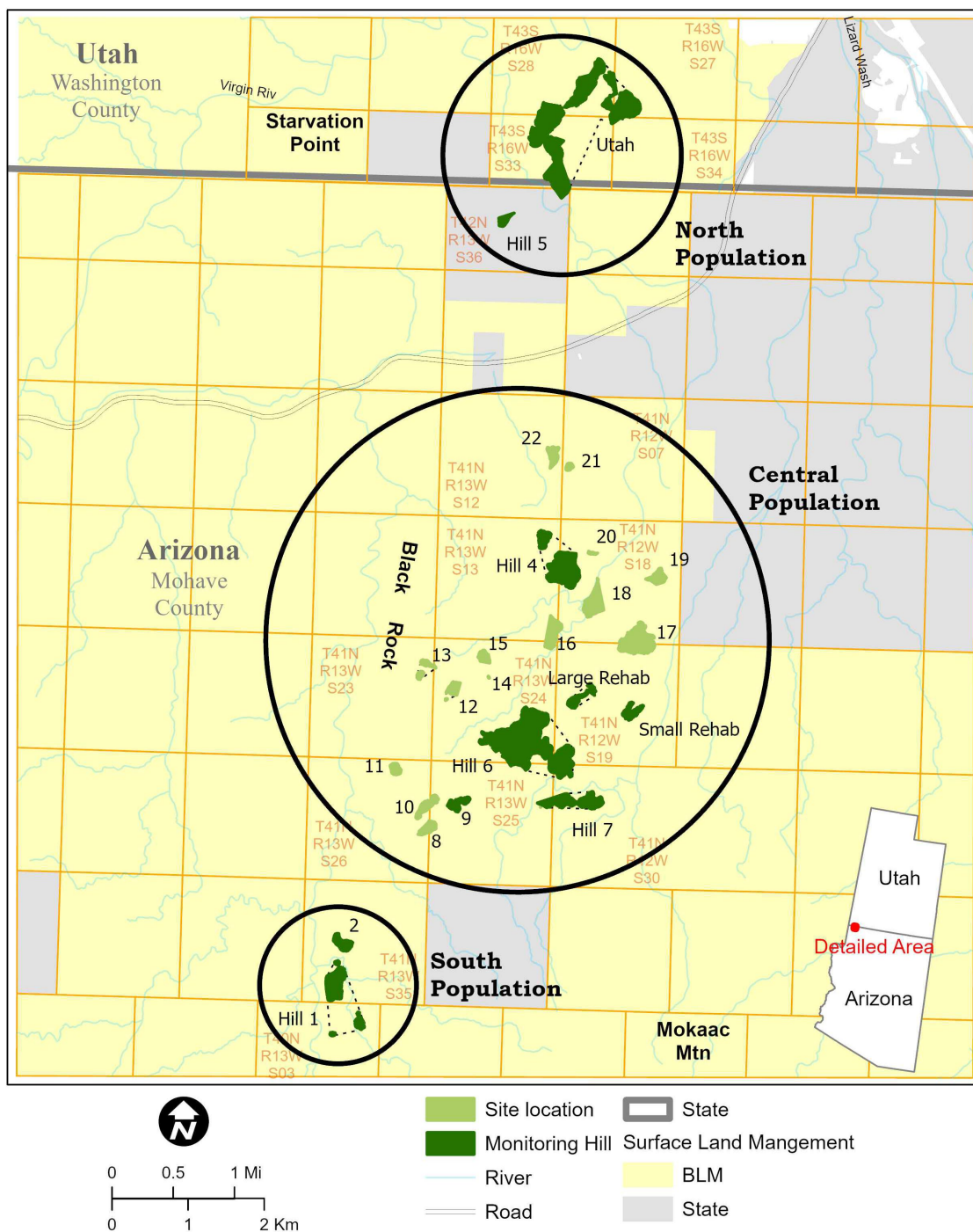


Figure 5. Gierisch mallow range in Arizona and Utah. Light and dark green polygons are Gierisch mallow concentrations on individual gypsum outcrops. Subpopulations are numbered or named. Dark green polygons are the locations that have some survey or monitoring data. Black circles indicate Gierisch mallow populations.

Table 1. Description of known Gierisch mallow subpopulations and estimated abundances (BLM 2022a, p. 1–2). BLM = Bureau of Land Management, ASDL = Arizona State Land Department.

Subpopulation	Habitat Area in ha (ac)	Estimated Abundance (No of Plants)	Year Last Monitored	Land Manager	Notes
North Population					
Utah	49.98 (123.51)	5,000-8,000	2012	BLM	Unoccupied suitable habitat and pollinator habitat located on Utah State Trust Lands.
Hill 5	1.44 (3.56)	presumed extirpated	2003	ASLD	Located within Georgia Pacific Mine.
Central Population					
Hill 4	16.64 (41.13)	10,000+	2022	BLM	Located within Western Minerals' Black Rock Mine. The BLM approved a mine expansion.
Hill 6	47.47 (117.31)	3,000-4,000	2012	BLM	
Hill 7	9.30 (22.97)	2,000	2018	BLM	
22	2.35 (5.81)	No Data	No Data	BLM	
21	0.64 (1.59)	No Data	No Data	BLM	
20	0.20 (0.50)	No Data	No Data	BLM	
19	2.62 (6.48)	No Data	No Data	BLM	
18	6.37 (15.75)	No Data	No Data	BLM	
17	11.78 (29.10)	No Data	No Data	BLM	
16	5.04 (12.46)	No Data	No Data	BLM	
15	1.66 (4.11)	No Data	No Data	BLM	
14	0.02 (0.06)	No Data	No Data	BLM	
13	1.50 (3.70)	No Data	No Data	BLM	
12	1.99 (4.92)	No Data	No Data	BLM	
11	1.52 (3.75)	No Data	No Data	BLM	
10	2.85 (7.05)	No Data	No Data	BLM	
9	2.62 (6.48)	No Data	No Data	BLM	
8	2.26 (5.58)	No Data	No Data	BLM	
Large Rehab	2.76 (6.81)	300	2020	BLM	Located within Western Minerals' Black Rock Mine.
Small Rehab	2.52 (6.23)	600	2020	BLM	Located within Western Minerals' Black Rock Mine.
South Population					
Hill 1	9.73 (24.05)	100	2019	BLM	
Hill 2	2.90 (7.16)	300	2019	BLM	

3.2 Abundance and Population Trends

We have estimated abundance data from 2012 or more recently from eight subpopulations: the Utah subpopulation in the North population; Hills 4, 6, 7, Small Rehab and Large Rehab subpopulations in the Central Population; and Hills 1 and 2 subpopulations in the South population (BLM 2022a, p. 1–2) (Table 1). These subpopulations comprise approximately 76 percent (141 ha [349 ac]) of the total area known or historically occupied by Gierisch mallow (186 ha [460 ac]). Based on the abundance estimates of these subpopulations (using the middle number when reported as a range and using 10,000 when reported as “more than 10,000”), we estimate that 23,300 Gierisch mallow plants occur in those eight subpopulations. Of those, 95 percent (22,000) occur in four subpopulations (the Utah subpopulation in the North Population and Hills 4, 6, and 7 in the Central population), with at least 43 percent (10,000) in the Hill 4 subpopulation. Four of the monitored subpopulations (Hills 1 and 2 in the South population and both reclaimed mine sites in the Central population) each have 600 or fewer estimated plants (BLM 2022a, p. 1–2). The BLM has identified the location and estimated the extent of the remaining 15 extant subpopulations (all in the Central population) but has not estimated the number of plants occurring there. As a result, we do not yet have a confident estimate of the total number of Gierisch mallow plants rangewide. Based on the percentage of area occupied by the surveyed populations and the average density across those areas, we estimate 30,600 Gierisch mallow plants occur rangewide; however, this is speculative, because we do not know the densities of the plants at the unsurveyed subpopulations.

The BLM conducts transect monitoring at some of the subpopulations: Utah (North population), Hills 4 and 6, Small Rehab, and Large Rehab (Central population), and Hills 1 and 2 (South population). Monitoring has been inconsistent across the years due to insufficient funds, limited personnel time, and challenges with accessing sites. Additionally, surveys have utilized different methods including presence/absence surveys, transect counts, and total population estimates. For these reasons, we cannot confidently make conclusions about trends within subpopulations or populations. We provide the data and discuss the abundance and trends by population in the subsections below.

3.2.2 North Population

The North population is composed of the Utah and Hill 5 subpopulations. We have abundance estimates for the Utah population but not for Hill 5, because it is in an active mine.

The Utah subpopulation occurs in Utah on land managed by the BLM. Unoccupied, potentially suitable habitat occurs nearby on lands managed by the Utah State Institutional Trust Lands Administration (SITLA). The BLM designated the State Line Area of Critical Environmental Concern (ACEC) in Utah in 2016 that includes most of the Utah subpopulation (excluding the small portion in Arizona) (USFWS 2016b, p. 51). This ACEC was established, in part, to protect the natural ecosystems, habitat, and locations that Gierisch mallow occupies (see section “Habitat Protection”).

The most recent total abundance estimate we have from the Utah subpopulation is 5,000 to 8,000 plants in 2012 (Table 1). The BLM established a count transect and a trend belt transect in the Utah subpopulation in 2009 and 2012, respectively; however, they have not repeated counts at

the count transect after 2012 or at the trend belt transect after 2014. Because we lack recent and repeated survey data, we cannot evaluate the population trend in the Utah subpopulation. For our analysis, we estimate the Utah population has 6,500 plants (the median of the estimated range from 2012; Table 1); however, we need more current data to confirm the status.

Hill 5 occurs in Arizona on land managed by the Arizona State Land Department (ASLD). The most recent total abundance estimate we have from the Hill 5 subpopulation is 3,000 plants in 2003 (Table 1). Mining operations began at Hill 5 after 2003, and aerial imagery shows ground disturbance over the entire area previously estimated occupied by Gierisch mallow (Esri *et al.* 2020 n.p.). Therefore, we assume that mining has extirpated Hill 5. Gierisch mallow could potentially reestablish the site after restoration as has happened with the Large Rehab and Small Rehab sites in the Central Population, if topsoil is replaced such that seeds in the seedbank can germinate. We have records of at least a few dozen plants occurring 700 to 1,000 m (0.4–0.6 mi) east of Hill 5, outside of the areas delineated and previously monitored for Hill 5. Some of these plants occur on the Moenkopi Formation. In this SSA, we are not considering these plants to be part of Hill 5, because we think they are examples of plants that may commonly occur at low densities between concentrations of plants on gypsum outcrops.

3.2.2 Central Population

We have monitoring data for five of the 20 subpopulations in the Central population, three undisturbed sites (Hill 4, Hill 6, and Hill 7) and two rehabilitated sites that occur in past mining operations (Large Rehab and Small Rehab; Table 2). We have no abundance data for the remaining 15 subpopulations in the Central Population.

Hill 4 has an estimated 10,000 or more plants, based on the most recent survey in 2020 (Table 1). This subpopulation has the greatest estimated number of plants of all the subpopulations rangewide with estimated abundance data. The plants are not restricted to one hill but are scattered among several smaller hills that all contain gypsum outcrops. We have trend belt transect data from the subpopulation for most of the years from 2003 to 2019 (Table 2). In each year from 2009 to 2018 there were greater than 100 plants in the trend belt transect (108–178 plants); from 2019 to 2022, there were no more than 62 plants. Hill 4 occurs in an existing gypsum mining lease area. Western Mining and Minerals, Inc. (Western Minerals) submitted a Plan of Operations to mine a portion of the area in 1989 (BLM and Red Butte Garden & Arboretum 2018, p. 2). Mining has been occurring at one of the larger gypsum outcrops in the area and has removed a large amount of topsoil. We do not have survey data for Gierisch mallow in the area within the active mining footprint prior to the disturbance. Based on the distribution of the subpopulation between multiple hills, Gierisch mallow likely also occupied the disturbed area. In 2009, prior to Gierisch mallow listing under the ESA, the BLM approved the Black Rock Gypsum Mine Plan of Operations that expands the Black Rock Gypsum Mine into the Twisted Hills area (BLM 2009a, entire; 2009b, p. 4). That new area currently includes the largest portion of the Hill 4 subpopulation, containing approximately 90 percent of the estimated over 10,000 plants in the subpopulation (BLM 2022a, p.1–2). Because the demand for gypsum declined along with the decrease in the housing market in the early 2000s, mining activity has not yet reached the expansion area (Cox, R., BLM, pers. comm., December 2, 2011; Cox, R., BLM, pers. comm., October 12, 2022). Based on the perceived decrease in the number of plants in monitoring transects and the likely removal of plants and habitat in the active mining area, the

number of plants in this subpopulation has likely decreased. Future mining may disturb additional occupied habitat.

Hill 6 has an estimated 3,000 to 4,000 plants, based on the most recent survey in 2019 (Table 1). We have trend belt transect data from 2012 to 2019. During that timeframe, the number of individuals ranged from a low of 12 in 2012 to a high of 56 in 2022 (Table 2). The numbers fluctuated greatly during the years with no clear trend.

Hill 7 has an estimated 2,000 plants, based on the most recent survey in 2018 (Table 1). The BLM counted plants in a count transect at Hill 7 four times from 2012 to 2018. The number of plants ranged from 129 (in 2012) to 225 (in 2014). There is not enough repeat data to indicate a trend.

We have over 10 years of data from transect counts at the two rehabilitated sites, Small Rehab and Large Rehab, within the Western Mining and Minerals, Inc. gypsum mining operation (BLM 2022a, p. 1–2). Mining occurred at these sites during the late 1980s and early 1990s, and reclamation efforts began in 1997 or 1998 (Cort and Pavlik 2016, p. 4). The plants in these subpopulations naturally reestablished themselves from the seedbank in areas where reclamation efforts redistributed the topsoil (BLM and Red Butte Garden & Arboretum 2018, p. 8). The transect data from the Small Rehab and Large Rehab sites show a general increase in Gierisch mallow plants from initial surveys through 2016 and 2017. The number of individuals has decreased some after 2016 and 2017, though they remain much higher than the first few years of the survey period (Table 2). In addition to the naturally recolonized areas, Red Butte Garden sowed Gierisch mallow seeds in experimental restoration plots (Pavlik *et al.* 2018, p. 5).

3.2.3 South Population

The BLM has monitored the two Gierisch mallow subpopulations that comprise the South population since 2001, shortly after the plant was described as a species. Hill 1 had an estimated 100 plants in 2019 (Table 1). Data from a count transect surveyed in most years from 2001 to 2022 indicates wide fluctuations in the numbers of plants (13 to 155) with no clear trend (Table 3). Hill 2 had an estimated 300 plants in 2019 (Table 1). The number of plants in a count transect was under 100 in each of the six years monitored from 2003 to 2014 and has increased to over 100 in every year from 2015 to 2022 (Table 3). There are no mining operations currently occurring in this population, and we are not aware of plans for future mining.

3.2.4 Summary

We estimate 23,300 Gierisch mallow plants from surveyed subpopulations that comprise approximately 76 percent of the estimated areas occupied by Gierisch mallow. We have no estimates for 16 subpopulations, 15 in the Central Population and Hill 5 in the North Population, which we assume is extirpated. The 15 subpopulations in the Central Population comprise approximately 25 percent (43.44 ha [107.34 ac]) of the total rangewide area occupied by Gierisch mallow concentrations (Table 1), thus, potentially contain a similar proportion of the total number of Gierisch mallow plants rangewide.

The lack of monitoring at many of the subpopulations, coarse estimates of overall plant abundance, and gaps in monitoring duration make it difficult to detect trends for all

subpopulations and populations. The available monitoring data demonstrate a great interannual variation in plant numbers, likely due in part to responses to variable precipitation between years. Such variation emphasizes the importance of regular and continued monitoring and statistical analysis to assess trends at Gierisch mallow subpopulations and understand the species' response to annual weather conditions and other potential threats.

Table 2. The number of Gierisch mallow adult plants in monitoring transects in the Central Population.

Transect	2003	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hill 4, trend belt transects (2)	180	No data	176	65	108	170	136	116	135	113	178	181	145	119	62	55	56	51
Hill 6, trend belt transect	No data	No data	No data	No data	No data	No data	No data	12	29	21	27	27	29	21	19	19	15	56
Hill 7, count transect	No data	No data	No data	No data	No data	No data	No data	129	No data	225	No data	No data	203	193	No data	No data	No data	No data
Small Rehab, count transect	No data	68	No data	85	50	52	67	116	175	268	364	702	833	660	231	314	445	450
Large Rehab, count transect	38	No data	54	60	30	61	No data	75	No data	207	192	519	451	340	219	210	459	275
Large Rehab, trend belt transect	No data	No data	No data	1	2	2	1	6	9	14	67	64	57	50	16	14	36	56

Table 3. The number of Gierisch mallow adult plants in monitoring transects in the South Population.

	2001	2003	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hill 1, count transect	100	30	58	No data	155	85	No data	No data	65	No data	77	35	34	59	26	13	83
Hill 2, count transect	100	31	15	37	23	No data	26	No data	95	147	214	335	328	285	237	246	146

CHAPTER 4 – FACTORS THAT INFLUENCE VIABILITY

In this chapter, we describe the threats and stressors that are influencing Gierisch mallow viability. The conceptual model below (Figure 4.1) depicts the relationships between known anthropogenic and environmental stressors, habitat and demographic factors, population resiliency, and ultimately, species viability. We discuss threats potential identified to the Gierisch mallow in the subsections below.

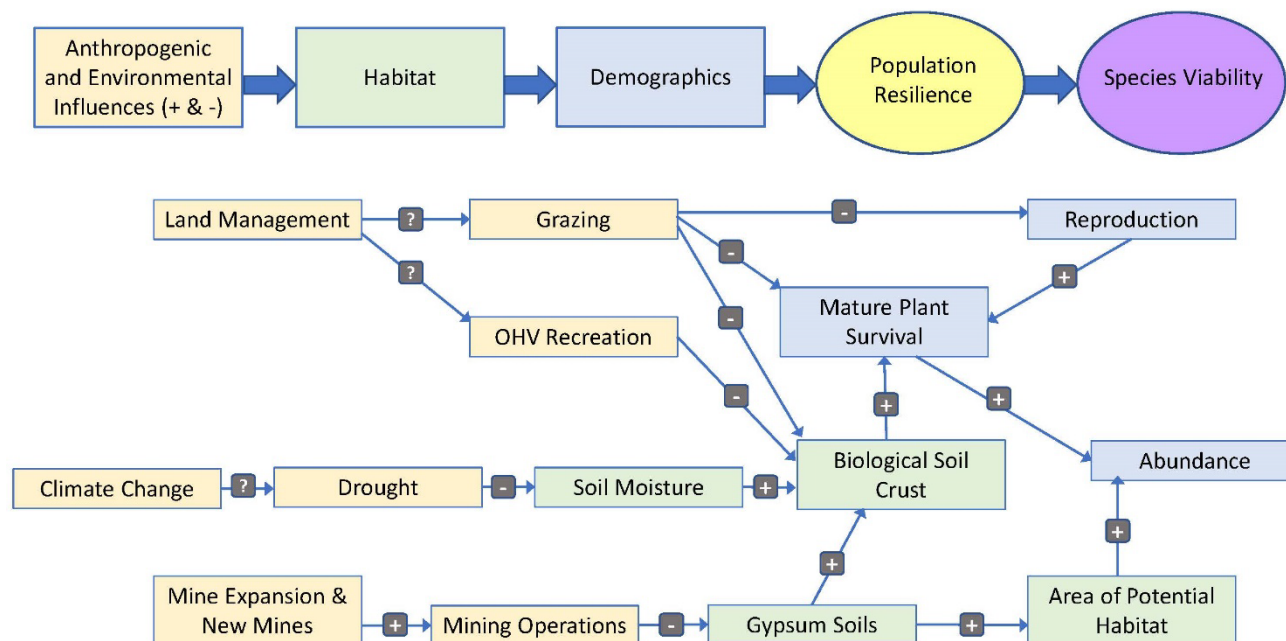


Figure 6. Factors influencing Gierisch mallow viability.

4.1 Destruction and Modification of Habitat

Because Gierisch mallow is restricted to a specific geological formation in a small geographical range, it is highly susceptible to habitat destruction and modification. Destruction and modification of habitat can occur from mineral extraction, invasion of nonnative grass species, livestock grazing, recreational activities, and wildfires. Gierisch mallow habitat includes a native vegetation and pollinator community, and changes to these communities may also have effects on Gierisch mallow (see section “4.4.4 Changes to pollinator community”).

4.1.1 Mineral Extraction

Gypsum mining is an ongoing source of habitat modification in gypsiferous soils, where Gierisch mallow grows. Gypsum is used in construction, such as in the manufacturing of drywall, and as a soil amendment in agriculture. Gypsum deposits are found in various strata within the Harrisburg Member. Many of the most valuable gypsum deposits are not at ground level and require removal of surface material for access. After the gypsum is removed, the stockpiled surface material is then used to reclaim the area.

The topsoil removal required to mine an area kills Gierisch mallow plants and associated plant species and removes seeds with the soil. When the topsoil is replaced after completion of the mining operation, native plants, including Gierisch mallow, can naturally recolonize from seed, as demonstrated by the Small Rehab and Large Rehab sites (BLM 2018, p. 8). However, the original structure of the gypsum soil is altered, biological soil crust is destroyed, and seeds may be buried and unable to germinate after topsoil is replaced. Recovery times for biological soil crusts are highly variable and depend largely on the timing of disturbance and amount of moisture. The disturbed habitat may be less suitable for the native plant community. Ground disturbance in general can facilitate the invasion of nonnative species (see “4.1.3 Nonnative, Invasive Species”); however, the addition of gypsum red-fines (sifted waste rock from mining operations) as a soil amendment during reclamation may reduce *Bromus* spp. invasion (BLM 2018, p. 5). The Small Rehab and Large Rehab subpopulations currently have lower *Bromus* spp. cover than the surrounding habitat (Figure 7).

As discussed in section “3.3 Abundance and Population Trends,” mining has affected and likely will affect portions of the North and Central populations. We assume that Hill 5 (North population) has been extirpated by the Georgia-Pacific Mine. The Large Rehab and Small Rehab subpopulations (Central population) were historically mined. Ninety percent of the Gierisch mallow plants at Hill 4 (Central population) occur in an area approved as an expansion of the Black Rock Gypsum Mine that will likely be mined in the future. In addition to these existing mines, ASLD has issued several exploration permits in the area on ASLD lands surrounding Hill 5 (Dixon, J., pers. comm., December 13, 2011). Some drilling had occurred before 2012; we do not know the current status of the mining activity on ASLD land. While these permits may not cover areas containing known Gierisch mallow, it underscores the potential for mining to occur in Gierisch mallow habitat.

Limited conservation measures to protect Gierisch mallow and its habitat have been incorporated into project plans associated with mining on Federal lands. Instead, the BLM can require conservation measures to reclaim lands after mining has occurred to benefit the species (R. Cox, BLM, pers. comm., February 9, 2012). For example, as part of the approved expansion of the Black Rock Gypsum Mine, the BLM required seed collection of Gierisch mallow to aid in reestablishing the species in future reclaimed areas (see section “4.5.2 Habitat Restoration”).

Restoration efforts have shown some success in restoring reclaimed mine sites with native vegetation, including Gierisch mallow (BLM and Red Butte Garden & Arboretum 2018, p. 5; Pavlik *et al.* 2018, p. 32) (see “4.5 Conservation Measures section below”). Gierisch mallow naturally recolonized related topsoil at the Small Rehab and Large Rehab subpopulations. The estimated number of plants at each of these sites has been over 200 plants every year from 2014 to 2022 (BLM 2022a, p. 1–2). We cannot compare the current abundances of Gierisch mallow at these sites to pre-mining abundances because we do not have pre-mining data. Though Gierisch mallow plants have established at restored sites, these sites may not be able to or may take many years to support the composition and percent cover of native vegetation and biological soil crusts found in undisturbed sites (BLM and Red Butte Garden & Arboretum 2018, p. 5).



Figure 7. Small Rehab site. *Bromus* spp. is scarce on the rehab site (foreground) compared to the surrounding habitat (background) (credit: USFWS).

4.1.2 Livestock Grazing

Livestock have continuously grazed much of the Mojave Desert since the mid-1800s (Lovich and Bainbridge 1999, p. 310), and heavy grazing occurred within the range of the Gierisch mallow in the late 1800s (J. Lambeth, BLM, pers. comm. April 17, 2023). In contrast to past grazing activities, the BLM's current grazing permitting system regulates stocking levels and grazing timing and duration. The legacy effects of grazing on the ecosystem persists across much of the western landscape, and recovery time of the ecosystem is slow (Lovich and Bainbridge 1999, p. 312).

In the final listing rule, we concluded that livestock do not typically spend much time in Gierisch mallow habitat due to the steeper hillsides that this plant inhabits. However, reports indicate that livestock access Gierisch mallow habitat, trample and consume Gierisch mallow plants, including their flowering stalks, more than we originally thought (Atwood, D.L., Brigham Young University, pers. comm., February 29, 2008; Reisor, R., University of Utah, pers. comm., October 15, 2012; McBride 2022a, p. 20) (Figure 9). Livestock increase their consumption on Gierisch mallow plants during drought years when other forage is reduced or unavailable.

Gierisch mallow plants are heavily browsed near water sources (stock tanks and drinkers) where livestock tend to concentrate (Falk, M., USFWS, pers. comm., February 12–12, 2008).

Plant tissue damage from grazing reduces plant fitness. McBride (2022a, p. 19) observed stunted plant growth due to drought and loss of reproductive material to livestock grazing that resulted in very few flowering individuals. When surveying Gierisch mallow populations during drought years, Atwood (Atwood, D.L., Brigham Young University, pers. comm., February 29, 2008) was unable to locate any fruit, because all of the flowering stalks had been consumed by livestock. The decrease in fitness and reproduction over time may reduce the population size of Gierisch mallow.

The effects of grazing on the vegetation community vary with plant species and phenology; grazing season, frequency, and intensity; and local conditions (Lovich and Bainbridge 1999, p. 312). Grazing can change the composition of the vegetation community, including facilitating the establishment and spread of nonnative, invasive species such as cheatgrass (*Bromus tectorum*) and red brome (*B. rubens*) (Brooks 1995, p. 67; Reisner *et al.* 2013, p. 1048). Brooks (2000, p. 105) observed lower abundance and diversity of native plants and animals in grazed areas compared to ungrazed areas in the Mojave Desert. Nonnative invasive species can compete with Gierisch mallow for resources, increase the risk of wildfire (see section “4.1.3 Invasive, nonnative species”), and affect pollinator populations (see section “4.4.4 Changes to pollinator community” below).

In addition to damaging vegetation, grazing can also affect the physical structure of habitat that supports Gierisch mallow. Loss of biological soil crusts due to livestock grazing is a great concern in the Mojave Desert (Floyd *et al.* 2003, p. 1704). Soil crust disturbance could decrease the nutrients available to Gierisch mallow and associated plants (see section “2.2.3 Biological Community”). Damaged soil crusts and soil compaction from livestock trampling can reduce water infiltration (Fleischner 1994, p. 634; Floyd *et al.* 2003, p. 1704) and increase erosion by both wind and water (Neff *et al.* 2005, p. 87). Increased erosion and decreased water infiltration can affect some plants by altering soil structure. Additionally, seedlings of some plants may have difficulty taking root in unstable soils. We do not know how these effects on soil structure may affect Gierisch mallow specifically.

Grazing occurs in all three Gierisch mallow populations and most subpopulations (Figure 6). Gierisch mallow occurs on two BLM-managed grazing allotments in Utah (Lambing-Starvation and Curly Hollow) and three in Arizona (Lambing-Starvation, Black Rock, and Purgatory), as follows:

The Curly Hollow Allotment includes 46.29 ha (114.39 ac) of occupied Gierisch mallow habitat (Table 4), which is most of the Utah subpopulation in the North population. This Allotment contains BLM and SITLA lands. Gierisch mallow only occurs in the River Pasture, which livestock usually graze from November 1 through February 28 each year, outside of the Gierisch mallow flowering season. However, the BLM may authorize grazing later in the season in response to conditions in other pastures (*e.g.*, wildfire in other pastures) (Douglas, R.L., BLM, pers. comm. February 16, 2012).

The Lambing-Starvation Allotment encompasses 5,446 ha (13,457 ac) in Arizona and includes 8.13 ha (20.08 ac) of Gierisch mallow occupied areas (Table 4), a small part of the Utah subpopulation, all of Hill 5, and all of two Arizona subpopulations in the Central population. These subpopulations occur in two of the three pastures in this allotment, North Freeway and South Freeway. The BLM authorizes grazing in these two pastures in an alternating seasonal pattern which includes part of the Gierisch mallow flowering season. Grazing is restricted from the third pasture (which does not contain Gierisch mallow) during the growing season, because it contains critical habitat for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*), the endangered Virgin chub (*Gila seminuda*) and the endangered woundfin (*Plagopterus argentissimus*). Because of this, livestock are more concentrated in the North Freeway and South Freeway pastures, which contain Gierisch mallow, during the spring growing season. ASLD excludes grazing from the Georgia-Pacific Mine lease area, which contains Hill 5.

The Black Rock Allotment encompasses 15,250 ha (37,685 ac) and includes 130.15 ha (321.62 ac) of Gierisch mallow occupied habitat (Table 4), most of Hill 1; all of Hill 4, Hill 6, Hill 7, Large Rehab, Small Rehab, and the 14 subpopulations in the Central population. These sites occur in three of the nine pastures in this allotment: Lizard, Lizard 1, and Lizard 2. The BLM authorizes grazing in these pastures from January 1 to April 30, which includes Gierisch mallow flowering season, every other year.

The Purgatory Allotment encompasses 1,985 ha (4,905 ac) and includes 1.62 ha (4 ac) of Gierisch mallow occupied habitat (Table 4), a small portion of Hill 1 and one other subpopulation in the South population. Livestock graze the single pasture from December 1 through May 31, including Gierisch mallow flowering season, every year.

While we know that livestock graze on Gierisch mallow and that grazing can result in reduced fitness and reproduction in individual plants, we do not know the effect that is having on subpopulations and populations. In addition, we do not know if Gierisch mallow, like many mallow species that thrive in disturbed areas, may benefit from some level of disturbance, such as ground disturbance from livestock. The effects of grazing on Gierisch mallow will vary with the intensity, frequency, and timing of the grazing. We do not know the extent of Gierisch mallow prior to grazing or how historical levels of grazing may have affected its distribution. Gierisch mallow persisted during heavy grazing periods to occupy its current distribution in which the threat of grazing has diminished from historical levels. We do not have a good understanding of the potential threat livestock grazing poses to Gierisch mallow and how that may vary with grazing practices and range conditions.

Table 4. Allotments and pastures containing Gierisch mallow managed for livestock grazing.

Allotment	Pastures	Gierisch Mallow Habitat Area Included in ha (ac)	Authorized Grazing Period	Rest Years
Curly Hollow	River	46.30 (114.39)	1/1 – 2/28	0
Lambing-Starvation	North Freeway, South Freeway	8.13 (20.08)	03/01 – 5/15 or 11/16 – 02/28	0
Black Rock	Lizard 1, Lizard 2, Lizard	130.15 (321.62)	01/01 – 04/30	1 in every 2
Purgatory	Purgatory	1.62 (4.00)	12/01 – 5/31	0

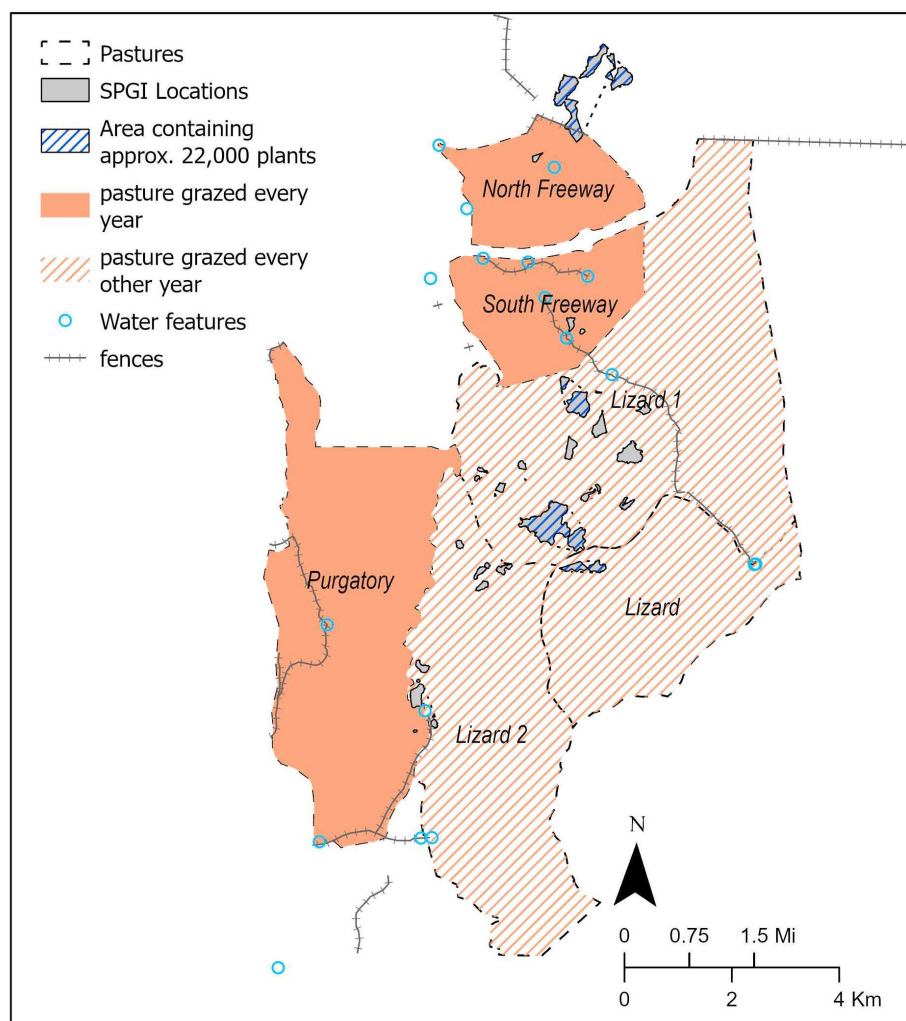


Figure 8. Livestock pastures containing Gierisch mallow.

4.1.3 Fire

We do not know Gierisch mallow's response to fire. Gierisch mallow occurs in habitat sparsely vegetated with native plants that are not likely to readily carry fire, and fire was likely infrequent historically in surrounding creosote shrub habitat (Brooks *et al.* 2003 pp. 2–3). However, the invasion of cheatgrass and red brome increases the potential for fire in Gierisch mallow habitat (Brooks and Pyke 2001, p. 5, Grace *et al.* 2001, p. 43, Brooks *et al.* 2003, p. 3).

Many western globemallow species thrive in disturbed areas. Scarlet globemallow (*S. coccinea*) and gooseberryleaf globemallow occur in burned areas within the first three years of fires (Ott *et al.* 2013, p. 182). Another globemallow species, desert globemallow (*S. ambigua*), is common to disturbed areas in the Mojave desert (Wallace and Romney 1980, p. 32; Abella 2009, p. 1264; 2010, p. 704). Because other globemallows thrive in disturbed habitats, Gierisch mallow is likely to reestablish in burned areas; however, its response could vary with frequency and intensity of fires. The proliferation of invasive annual grasses is fueling an annual burn-reburn wildfire cycle in the Red Cliffs Reserve, north of Gierisch mallow's range in the St. George area (McLuckie *et al.* 2017, p. 10), and climate change is contributing to increased frequency of wildfires in the western United States (Abatzoglou and Williams 2016, entire). Gierisch mallow habitat could experience a similar pattern. We do not have information to determine the potential threat that increased fire poses to Gierisch mallow.

4.1.4 Recreational Use

Recreational use, especially off-highway vehicle (OHV) use, can cause substantial damage to soils and vegetation in desert ecosystems. OHV use may kill or damage plants to the point that they are no longer viable or able to produce seed, and seedlings may not be able to reach maturity and reproduce. Vollmer *et al.* (1977, p. 124) demonstrated that off-road areas exposed to repeated driving contained fewer annuals than unexposed areas, and shrubs in exposed areas received heavy damage. In addition to damaging vegetation, OHV use results in habitat effects, including soil compaction, loss of soil crusts, erosion, and spread of nonnative, invasive species (Webb *et al.* 1978, entire). See the discussion of these effects in section "4.1.2 Livestock Grazing".

The proximity of Gierisch mallow's range to St. George, Utah, makes it vulnerable to recreational use. Washington County, where St. George is located, is one of the fastest growing counties in Utah, with a growth rate of 30.8 percent between 2010 and 2020 (U.S. Census Bureau 2021, n.p.). The relatively flat terrain and ease of access makes it especially appealing to OHV use. At a 2007 site visit, FWS noticed several of the smaller hills within the Utah subpopulation crisscrossed with tracks from OHV use in unauthorized areas (Falk, M., USFWS, pers. comm., March 10, 2008). However, we have no current reports of unauthorized OHV use in Gierisch mallow habitat. The BLM prohibits OHV use off designated trails in the range of Gierisch mallow (BLM 2018, entire). In addition to OHV use, people have used areas near the Utah population in the past for target shooting and trash dumping, resulting in additional human trampling of habitat (Falk, M., USFWS, pers. comm., March 10, 2008). Heavy pedestrian activity from these uses and other recreational uses could have effects similar to those from OHVs.

4.2 Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

A European company offered Gierisch mallow seeds for sale on its website prior to 2012 through 2023 (Frates, T., Utah Native Plant Society, pers. comm., October 16, 2012). The website advertised the seeds as being collected in the wild in Mohave County, Arizona. We do not know how many Gierisch mallow seeds the company sells each year or how seed collection is affecting Gierisch mallow. Seed collection of Gierisch mallow on Federal and ASLD lands is prohibited without a permit (see “4.4 Existing Regulatory Mechanisms”, below).

4.3 Disease or Predation

We have no information that disease affects Gierisch mallow. Wildlife utilize other globemallow species (Pendery and Rumbaugh 1993, p. 128) and will also likely utilize Gierisch mallow. We have no information that native wildlife grazing is having population- or subpopulation-level effects on Gierisch mallow. We discuss the threat of livestock herbivory in “4.1.2. Livestock grazing”.

4.4 Existing Regulatory Mechanisms

Regulatory mechanisms may reduce or eliminate the effects from one or more identified threats to a species. In this section, we review existing State and Federal regulatory mechanisms that apply to Gierisch mallow.

4.4.1 State Regulations

Utah has no regulations to protect Gierisch mallow individuals or habitat, including the suitable habitat that is located on SITLA managed lands. SITLA lands contain potentially suitable habitat but no known Gierisch mallow subpopulations.

Prior to listing under the ESA, Arizona did not offer protection for Gierisch mallow. After listing, the Arizona Department of Agriculture (ADA) categorized the Gierisch mallow as a “Highly Safeguarded” species under the Arizona Native Plant Act (ANPA). Plants in the “Highly Safeguarded” category under the ANPA include, “plants resident to this State and listed as endangered, threatened, or category 1 in the Federal Endangered Species Act of 1973” (State of Arizona 2016, 3-901). The ANPA regulates collecting “Highly Safeguarded” species (State of Arizona 2016, 3-904-3-916). State agencies must use a specified disposal method to salvage removed plants. Furthermore, seed collection on ASLD lands is prohibited. While the ANPA provides for some protection of individual Gierisch mallow plants, there are no regulations protecting Gierisch mallow habitat.

The ASLD has strict reclamation provisions and bonding requirements when they approve a Mining Plan of Operation; however, any decision that the ASLD makes on leasing land is based strictly on the benefit of the State Trust. The ASLD would not deny a mine, or any other project, based on the presence of an endangered or threatened species; however, they can have stipulations written into the ASLD lease or the mining company’s reclamation plan that would require the mining company to make allowances for federally listed species (Dixon, J., ASLD, pers. comm., February 15, 2012). With listed plants, these stipulations can include seed collection or transplanting plants from the footprint of the mine. The only known Gierisch

mallow on ASLD land was in the Hill 5 subpopulation, which is presumed extirpated. Mining activity extirpated Gierisch mallow at Hill 5 prior to its listing under the ESA; therefore, none of the above requirements would have applied.

4.4.2 Federal Regulations

We have previously identified habitat loss associated with gypsum mining as a threat to the species. Mining on BLM-managed lands occurs pursuant to the Mining Law of 1872 (30 U.S.C. 21 *et seq.*), enacted to promote exploration and development of domestic mineral resources and settlement of the western United States. It permits U.S. citizens and businesses to freely prospect hardrock (locatable) minerals and, if a valuable deposit is found, to file a claim giving them the right to use the land for mining activities and sell the minerals extracted without having to pay the Federal Government any holding fees or royalties (GAO 1989, p. 2). Gypsum is mined as a locatable mineral, and gypsum mining is, therefore, subject to the Mining Law of 1872. The BLM implements the Mining Law through Federal regulations at 43 CFR 3800.

The operators of mining claims on BLM lands must reclaim disturbed areas (Cox, R., BLM, pers. comm., February 9, 2012). The BLM's regulations also require the mitigation of mining operations so operations do not cause unnecessary or undue degradation of public lands (BLM 2022b, p. 26). Unnecessary or undue degradation is "harm to the environment that is either unnecessary to a given project or violates specified environmental protection statutes" (South Fork Band *et al.* v. United States Department of Interior, *et al.*, 588 F.3d at 723-24). It is unclear what specific activities would constitute unnecessary or undue degradation in relation to Gierisch mallow and its habitat.

The BLM issued the permit for the Black Rock Gypsum Mine prior to the listing of Gierisch mallow as an endangered species; therefore, no consultation with FWS was required under section 7 of the ESA. Future Federal actions on BLM land are subject to section 7 consultation, which can incorporate conservation measures for Gierisch mallow and its habitat, including critical habitat. These actions include mining and livestock grazing; however, section 7 of the ESA provides limited opportunities for conservation of Gierisch mallow within mining claims due to limitations imposed by the Mining Law of 1872, as described above. The BLM can require conservation measures to protect Gierisch mallow with the Standards and Guidelines applicable to the livestock grazing permits they issue.

Section 9 of the ESA does not provide the same prohibitions for take of plants as it does for wildlife. The protection of listed plants under the ESA is limited to the removal and reduction to possession of federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of State law or regulation or any violation of State criminal trespass law.

Gierisch mallow is listed as a BLM sensitive species in both Arizona and Utah. Sensitive species designation on BLM lands is afforded through the Special Status Species Management Policy Manual #6840 (BLM 2008, entire), which states the BLM shall manage BLM sensitive species and their habitats on BLM-administered lands to minimize or eliminate threats affecting the status of the species, or to improve the condition of the species' habitat (BLM 2008, glossary 2).

4.5 Other Natural or Manmade Factors

4.5.1 Small Population Size and Restricted Range

Gierisch mallow has a known range that extends approximately 13 km (8 mi) from north to south. Within this range, each of the 24 subpopulations is small, ranging from 0.003 ha (0.01 ac) to 49.98 ha (123.51 ac) (Table 1). Gierisch mallow can be dominant in small areas of suitable habitat, containing thousands of individuals. However, the small areas of occupation and the narrow overall range of the species make it susceptible to stochastic events that may lead to local extirpations.

Small population size and restricted range are intrinsic characteristics to Gierisch mallow and may not rise to the level of a threat on their own. However, they can interact with other threats to increase the extirpation risk of Gierisch mallow subpopulations. A disturbance, such as a mining operation or heavy recreational use, could extirpate an entire subpopulation. Plant species with limited ranges and restricted habitat requirements are also more vulnerable to the effects of global climate change, if they are adapted to a narrow range of conditions that may be exacerbated under future climate conditions (Krause 2010, p. 137; IUCN 2022, p. 49) (see section “4.4.2 Climate Change”). We do not know the climate conditions Gierisch mallow can tolerate.

Extirpations of subpopulations may reduce the connectivity within a Gierisch mallow population if the extirpation results in greater distances between subpopulations. Greater distances could restrict pollinator flight between subpopulations and, thus, reduce gene flow.

4.5.2 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.” (IPCC 2014, p. 30). Greenhouse gas emissions from human activities is causing global warming, and continued emissions at or above current rates will cause further warming with broad implications for living organisms across the planet and their habitats (IPCC 2014, p. 8). Climate models indicate that the transition to a more arid climate is already underway and predict that in this century the arid regions of the southwestern U.S. will become drier and warmer, and have fewer frost days, decreased snow pack, increased frequency of extreme weather events (heat waves, droughts, and floods), declines in soil moisture, and greater water demand by plants, animals and humans (Archer and Predick 2008, p. 23; Garfin *et al.* 2013 pp. 5–6). Global annual surface temperatures have risen an average of 0.09°C (0.17°F) each decade from 1901 to 2020 (USEPA 2021a, n.p.). Temperature increases in the contiguous U.S. since the late 1970s have surpassed the global rates for that period, increasing from 0.17 to 0.30°C (0.31 to 0.54°F) each decade. In addition to increasing average temperatures, heatwaves in the U.S. have become more frequent, more intense, longer in duration, and more likely to occur over a longer season (USEPA 2021b, n.p.).

Bai *et al.* (2014, p. 304) documented a warming trend in both air and soil temperatures in the Mojave Desert from 1982 through 2000, further noting that periods of low annual precipitation appear to be correlated to the increasing air and soil temperatures. In combination, low

precipitation and high temperatures produce a high vapor pressure deficit that in turn increases moisture loss in soils and evapotranspiration rates of plants, creating drought conditions. As a result of climate change, Alder (2014, n.p.) projects the monthly mean vapor pressure deficit (*i.e.*, drought) in Mohave County, Arizona, to increase in 2050 to 2074 compared to that from 1981 to 2010 (Figure 7), resulting from increased temperatures (Figure 8) despite a similar amount of projected precipitation (Figure 9).



Figure 9. Actual monthly mean vapor pressure deficit for Mohave County, Arizona from 1981 through 2010 (gray line) and modeled monthly mean vapor pressure deficit for 2025 through 2049 (mean of 20 climate models) based on two different representative concentration pathway (RCP) emission scenarios, based on projected emissions of greenhouse gases (higher numbers correspond to higher level of emissions): RCP4.5 (blue line) and RCP8.5 (red line) (Alder 2014).



Figure 10. Actual mean monthly temperatures for Mohave County, Arizona from 1981 through 2010 (gray line) and modeled mean monthly temperatures for 2025 through 2049 (mean of 20 climate models) based on two different representative concentration pathway (RCP) emission

scenarios, based on projected emissions of greenhouse gases (higher numbers correspond to higher level of emissions): RCP4.5 (blue line) and RCP8.5 (red line) (Alder 2014).

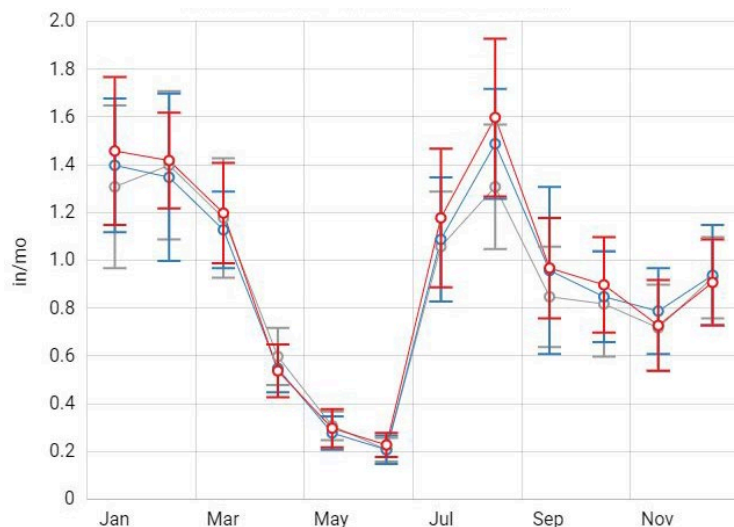


Figure 11. Actual mean monthly precipitation for Mohave County, Arizona from 1981 through 2010 (gray line) and modeled mean monthly temperatures for 2025 through 2049 (mean of 20 climate models) based on two different representative concentration pathway (RCP) emission scenarios, based on projected emissions of greenhouse gases (higher numbers correspond to higher level of emissions): RCP4.5 (blue line) and RCP8.5 (red line) (Alder 2014).

Rainfall in the Mojave Desert is historically low, fluctuates highly, and is generally only enough to support small amount of vegetation (Wallace and Romney 1980, p. 31); therefore, we expect plant populations to naturally fluctuate with seasonal rainfall variation. For example, in some years of low rainfall few annuals may be recorded, whereas in moist years, biomass and cover may increase by several orders of magnitude (Abella 2010, p. 1265). Perennial plants may rely on years with higher precipitation for flowering, germination, and recruitment (Anderton 2002, n.p.; Van Buren and Harper 2003, p. 239; Roth 2008, p. 3). Drought conditions during 2001 through 2004 led to a noticeable decline in survival, vigor, and reproductive output of other rare and endangered plants in the Southwest (Anderton 2002, n.p.; Van Buren and Harper 2003, p. 239; Roth 2008 pp. 2–3). In contrast, these plants may respond positively to the unusually high precipitation during the 2022/2023 winter (NOAA 2023, n.p.) Although we have no quantitative information on how Gierisch mallow responds to variations in precipitation and temperatures, other globemallow species generally increase in numbers during wet years and decrease during dry years (Pendery and Rumbaugh 1993, pp. 127–128). Gierisch mallow likely also utilizes this strategy. McBride (2022a, pp. 6–7) observed stunted growth and decreased reproduction in 2021 after a period of low precipitation and high temperatures from April through September. Desert-adapted plants like Gierisch mallow are accustomed to periods of drought and some annual fluctuations; however, increased extreme events that adversely affect Gierisch mallow growth and reproduction could adversely affect the Gierisch mallow’s long-term persistence and make it less resilient to other threats.

Climate change could also affect Gierisch mallow habitat. Changes in temperature and precipitation patterns may affect the diversity and composition of biological soil crust communities and their potential to recover after disturbances (Escolar *et al.* 2012, entire). The elevated levels of carbon dioxide driving climate change may facilitate nonnative, invasive species growth and reproduction, specifically cheatgrass and red brome, in Gierisch mallow habitat (Smith *et al.* 2000, p. 80; Ziska *et al.* 2005, pp. 1328–1329). An increase in nonnative, invasive plants, may affect Gierisch mallow by competing with it for resources, increasing the frequency and intensity of wildfires (see sections “4.4.3 Nonnative, Invasive Species” and “4.1.3 Fire”), and changing the vegetation and pollinator community (see section “4.4.4 Changes to pollinator community”).

4.5.3 Nonnative, Invasive Species

In a literature review of threats to plants of conservation concern in the United States, Wilcove *et al.* (1998, p. 608) identified nonnative, invasive species as the second most common threat, after habitat loss. Nonnative, invasive plant species have invaded and become naturalized into new habitats. They are ubiquitous in many landscapes, and they can exclude native plants (Gioria and Osborne 2014, pp. 3–4). For example, cheatgrass and red brome outcompete native species for soil nutrients and water, reducing the fitness of native plants (Melgoza *et al.* 1990, pp. 10–11; Aguirre and Johnson 1991, pp. 351–352; Matthew 2000, pp. 98–103). Changes in the vegetation community alter the composition and abundance of floral resources available to pollinators and can affect the native pollinator community (see section “4.4.4 Changes to pollinator community”).

Cheatgrass and red brome are particularly problematic nonnative, invasive annual grasses in the intermountain west. Both occur within Gierisch mallow habitat (Figure 10); red brome is more prevalent (Roaque, J., BLM, pers. comm., February, 15, 2012; McBride 2022a, p. 17). Red brome does not grow as well in gypsum soils compared to other soil types in the area (Abella *et al.* 2012, p. 51); however, wet years can facilitate its establishment (Roaque, J., BLM, pers. comm., February, 15, 2012). Nonnative, invasive species often invade areas in response to surface disturbances from activities such as livestock grazing and recreational use (Hobbs and Huenneke 1992, entire). Cheatgrass and red brome are likely to increase due to climate change (see section “4.4.2 Climate Change”) because invasive annuals increase biomass and seed production at elevated levels of carbon dioxide (Mayeaux *et al.* 1994, p. 96; Smith *et al.* 2000, pp. 80–81; Ziska *et al.* 2005, pp. 1328–1329).

In addition to competing with native vegetation for resources, invasions of annual, nonnative plant species, such as cheatgrass and red brome, are well documented to contribute to increased fire frequencies (Brooks and Pyke 2001, p. 5; Grace *et al.* 2001, p. 43; Brooks *et al.* 2003, p. 3). The disturbance caused by increased fire frequencies creates favorable conditions for increased invasion by cheatgrass and red brome (D’Antonio and Vitousek 1992, p. 73). The result is a positive feedback loop where an increase in invasive species results in more fires, more fires create more disturbances, and more disturbances lead to increased densities of invasive species. The risk of fire is expected to increase from 46 to 100 percent when the cover of cheatgrass increases from 12 to 45 percent or more (Link *et al.* 2006, p. 117). The invasion of red brome, another nonnative grass, into the Mojave Desert of the Intermountain West poses similar threats

to fire regimes, native plants, and other federally protected species (Brooks *et al.* 2004, entire). See section “4.1.3 Fire” for discussion on the potential threat of fire to Gierisch mallow.



Figure 12. A Gierisch mallow plant with browsed flowering stalks in a dense stand of red brome (credit: Wendy McBride).

Cheatgrass and red brome are prevalent in high densities throughout the Mojave Desert in northwest Arizona and southwest Utah, including throughout all four grazing allotments containing Gierisch mallow (Roaque, J., BLM, pers. comm., February 15, 2012; Douglas, R.L., BLM, pers. comm. February 16, 2012). McBride (2022a, p. 16) found cheatgrass, red brome, redstem stork's bill (*Erodium cicutarium*), Arabian schismus (*Schismus arabicus*), and African mustard (*Strigosella africana*) in and around Gierisch mallow habitat, with red brome being the most common. Nonnative, invasive species abundance is patchy and varies widely within and between subpopulations McBride (2022a, p. 16).

4.5.4 Changes to pollinator community

Changes in floral composition, floral phenology, and availability of nesting substates (*e.g.*, bare ground for *Diadasia* spp.) (Eickwort *et al.* 1997, p. 3) could potentially affect the pollinator community and, as a result, Gierisch mallow reproduction and genetic diversity.

The potential threats to Gierisch mallow and its habitat discussed in the sections above also may negatively affect pollinators. The effects of nonnative, invasive plant species and livestock grazing on the vegetation community can alter the quantity and quality of nectar available to pollinators (Levine *et al.* 2003, p. 777), which can alter pollinator visitation rates to native species, potentially increasing or decreasing the number of visits (Traveset and Richardson 2006, pp. 211–212; Bartomeus *et al.* 2008, p. 765). We do not have information about changes in the community or abundance of pollinators important to Gierisch mallow reproduction.

4.6 Summary of Factors that Influence Viability

At the time of listing, we identified destruction and modification of habitat as a major threat to Gierisch mallow, and we continue to identify it as the major threat to the species. Gypsum mining has likely extirpated at least one Gierisch mallow subpopulation, and a recent mine expansion and explorations indicate that mining in the range of Gierisch mallow will likely continue. Recreational use continues to be a potential substantial threat to the North Population, and, because of the growing population in the St. George, Utah, area, this threat will increase and may expand to other populations. At the time of listing, we did not consider livestock grazing a major contributor to destruction and modification of habitat because we assumed that livestock did not commonly access Gierisch mallow habitat due to its steep terrain. However, recent observations indicate that livestock occurrence in Gierisch mallow habitat is common in some areas. Because of this and the active grazing allotments across the species' range, we now consider grazing a potential threat to Giersch mallow.

Destruction and modification of habitat is exacerbated by other factors. Gierisch mallow's restricted range makes a substantial portion of the range vulnerable to similar threats. Additionally, the small subpopulations are particularly vulnerable to extirpation. Climate change will alter Gierisch mallow habitat and potentially exacerbate the effects of the other threats by stressing plants and making them less resilient to other threats, increasing grazing pressure in Gierisch mallow habitat, and creating favorable conditions for nonnative, invasive species and altered fire regimes.

4.7 Conservation Measures

4.7.1 Habitat Protection

The BLM has completed a transportation network for the Arizona Strip District, which covers the Gierisch mallow's range in Arizona (BLM 2018, entire). The transportation network designates routes for specified types of public access. The BLM prohibits vehicular travel off designated routes.

The BLM designated the State Line ACEC in Utah in 2016 that includes the Utah subpopulation of Gierisch mallow (USFWS 2016b, p. 85). ACECs are areas located on public lands where BLM requires special management to: 1) protect and prevent irreparable damage to important historic, cultural, or scenic values, fish, and wildlife resources, or other natural systems or processes; or 2) protect life and safety from natural hazards. Land management within these this ACEC provides some protective measure to Gierisch mallow and its critical habitat, such as prohibiting OHV use off designated roads and trails; prohibiting dispersed camping; and applying a No Surface Occupancy stipulation to fluid mineral leasing (USFWS 2016b, p. 86). The designation still allows livestock grazing and mining under the General Mining Law of 1872 in the ACEC (USFWS 2016b, p. 86).

4.7.2 Habitat Restoration

In the late 1990s, Western Mining and Materials, Inc., restored small gypsum outcrops that were surfaced mined in the late 1980s to early 1990s (BLM and Red Butte Garden 2018, entire). The company recontoured the mined pits, supplemented the topsoil with gypsum red-fines, a by-

product of the gypsum extraction, and sowed native seeds. Gierisch mallow established naturally in the restored areas, and the BLM monitors the populations (Small Rehab and Large Rehab). These sites have supported Gierisch mallow populations of over 200 plants every year from 2014 to 2022 (BLM 2022a, p. 1–2).

Red Butte Garden & Arboretum at the University of Utah (Red Butte Garden) has studied the potential to rehabilitate highly disturbed gypsum soils and seed native vegetation, including Gierisch mallow, in the Mojave Desert. Gierisch mallow seeds sown in study plots in disturbed areas germinated at low rates, approximately 0.4 percent after one year in one study (Pavlik *et al.* 2018, p. 20) and 2.1 percent after three years in another study (Cort and Pavlik 2016, p. 8). Pavlik *et al.* (2018, p. 20) observed that approximately 44 percent of seedlings found in restoration sites in 2017 had survived and developed inflorescences in 2018. Cort and Pavlik (2016, p. 8) observed that 9.2 percent of the seedlings that germinated from seeds sown in fall 2012 survived to fall 2015. These germination and survival rates necessitate sowing many seeds to introduce a self-sustaining Gierisch mallow population. Cort and Pavik (2016, p. 9) estimate a need to sow at least 63,000 seeds for a population of 50 plants. However, these sites contained few or no Gierisch mallow plants prior to restoration.

Red Butte Garden (Pavlik *et al.* 2018, p. 21) reestablished Gierisch mallow at one site by salvaging and transplanting mature plants. Of 46 salvaged plants transplanted at the reclaimed site in 2016, 39 percent (18 plants) were surviving in April 2018 and 30 percent (14 plants) had inflorescences.

In their study plots, Red Butte Garden investigated the use of different site preparation techniques, including amending the soil with gypsum red-fines derived from local mining waste rock (Pavlik *et al.* 2018, entire). The results between treatment plots in that study did not show a consistent significant difference between the two sites after two years for Gierisch mallow plants or other native or nonnative plants (Pavlik *et al.* 2018, p. 31). However, adding gypsum red-fines may have long-term effects on the vegetation community that establishes reclaimed sites. Habitat restoration implemented in the mid to late 1990s on two reclaimed mine sites found increased native shrub establishment and reduced nonnative, invasive plant establishment in areas with added gypsum red-fines (BLM and Red Butte Garden 2018, p. 3). Though those sites primarily contain native plant species, as of 2018 the density of shrubs in the reclaimed area is less than the surrounding, undisturbed areas and soil crusts have not developed (BLM and Red Butte Garden 2018, p. 5).

Reclamation efforts have shown some encouraging results for reestablishing Gierisch mallow and native plant communities on disturbed sites. The research and planting efforts by the Red Butte Garden will help to inform future habitat restoration efforts. Establishing Gierisch mallow in areas where they do not naturally recolonize from the seedbank may require considerable effort and resources. Continued monitoring is necessary to evaluate success, and we do not know if it is possible or how long it might take for previously disturbed sites to achieve their pre-disturbance potential. In a review of multiple studies evaluating plant succession after a disturbance in the Mojave and Sonoran deserts, Abella (2010, p. 1258) found that it could take 5 to 335 years for perennial plant cover at disturbed sites to reach the level of cover at undisturbed sites and 7 to 152 years to reach the level of species richness at undisturbed sites.

CHAPTER 5 - CURRENT CONDITION

In this chapter, we present information on the demographic and habitat factors we used to evaluate the current condition of Gierisch mallow, and how it influences the species' viability in terms of the 3Rs.

5.1 Species Resiliency

Resiliency is the ability of a species to withstand environmental stochasticity (year-to-year variations in environmental conditions such as temperature and rainfall), periodic disturbances within the normal range of environmental variation (*e.g.*, fire, floods, storms), and demographic stochasticity (*e.g.*, normal variation in demographic rates such as mortality and fecundity) (Redford *et al.* 2011, p. 42). In general, to be considered resilient, Gierisch mallow needs populations and subpopulations with abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction through the natural range of favorable and unfavorable conditions. In addition, there are anthropogenic factors, such as land use and land management, that may also affect resiliency. We can best gauge resiliency by evaluating population- and subpopulation-level characteristics such as demography (abundance and the components of population growth rate – survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity. We base our discussion on Gierisch mallow resiliency on the limited information we have on Gierisch mallow populations and subpopulations.

5.1.1 Plant abundance

In general, larger populations should be able to better withstand stochastic events, as the probability of extirpating an entire population is reduced. However, we do not have enough robust monitoring data on the species to establish a scientifically based minimum viable population size for Gierisch mallow. For rare plants in general, a minimum population size of 100 is suggested to prevent inbreeding depression, and more than 1,000 individuals may be required to maintain evolutionary potential (Jamieson and Allendorf 2012, p. 580; Maschinski and Albrecht 2017, p. 392). Pavlik (1996, p. 137) estimates minimum viable population size between 50 and 2,500 depending on a plant's life history characteristics. Using that methodology and what we know about the life history characteristics of Gierisch mallow, we estimate its minimum viable population size at 1,275 (J. Crawford, USFWS, pers. comm., November 28, 2022).

The North and Central populations contain more than 1,275 plants (up to 8,000 and over 10,000 plants, respectively), and the South population contains fewer (an estimated 400 plants) (Table 1). The abundance of plants in the North and Central populations make them more resilient to stochastic disturbance events and contributes to representation across the landscape by maintaining genetic and ecological diversity. Because of its low number of plants, the South population is less resilient to stochastic events and contributes less to the representation and redundancy of the species.

5.1.2 Subpopulations

Gierisch mallow populations are composed of subpopulations occurring on gypsum outcrops separated by habitat that does not support concentrations of the plants. Based on pollinator flight distances, we assume that genetic exchange occurs regularly between subpopulations within a population to contribute to the overall genetic diversity of the population. Additionally, because of their geographical separation, subpopulations may be exposed to different levels of threats or demographic stochasticity.

We assume that Gierisch mallow populations are more resilient if they are composed of more than one resilient subpopulation. Of the eight subpopulations for which we have estimated abundance, four contain more than 1,275 plants. These subpopulations are especially important to Gierisch mallow resiliency. The North population contains one (Utah); the Central population contains three (Hill 4, Hill 6, and Hill 7); and the South population does not contain any.

5.1.3 Habitat Area

The potential number of Gierisch mallow plants in a population is likely related, in part, to the amount of suitable habitat available. The area of gypsum outcrops in mapped subpopulations ranges from 1.44 to 50.00 ha (3.56 to 123.51 ac; Table 1). The area may give some indication of how many Gierisch mallow plants a subpopulation could potentially support; however, the habitat quality for Gierisch mallow is likely not equally suitable between and within these mapped areas. Densities of Gierisch mallow plants range from about 10 to 601 plants per ha (4 to 243 plants per ac). Habitat quality could vary with natural conditions, human-caused disturbances, and seral stage. We do not have enough information about Gierisch mallow needs and threats to know if the habitat of subpopulations with lower densities have the potential to support more plants.

5.1.4 Subpopulation Connectivity

The North population does not contain any subpopulations. The distances between subpopulations in the Central population range from 122 to 534 m (400 – 1,752 ft.) with a median of 211 m (682 ft.). The two subpopulations in the South population are 143 m (469 ft.) apart. Genetic exchange is more likely to occur between subpopulations that are closer to each other because pollinators have a shorter distance to fly between them. Additionally, the potential for pollinators to encounter other species of *Sphaeralcea* between subpopulations could facilitate hybridization if it occurs between Gierisch mallow and other species.

5.1.4 Summary

Species with few populations across a narrow range, like Gierisch mallow, have lower overall resiliency than a widespread species with many populations. We evaluate Gierisch mallow's overall resiliency by evaluating the resiliency of its populations and subpopulations. Subpopulations with more plants have higher resiliency. Extant Gierisch mallow subpopulations range from low resiliency (Hill 1 with 100 plants) to high resiliency (Hill 4 with over 10,000 plants). We do not have abundance data to evaluate the resiliency of 15 subpopulations. Populations with a greater number of resilient subpopulations have higher resiliency. Gierisch mallow populations range from low resiliency (the North population with one extant

subpopulation with more than 1,275 plants and the South population with two subpopulations with fewer than 1,275 plants) to high (the Central population with 20 extant subpopulations, at least three of which have more than 1,275 plants).

5.2 Species Redundancy

Redundancy is the ability of a species to withstand catastrophic events that have the potential to result in population extirpation, regardless of population health and adaptive capacity (Mangal and Tier 1993, p. 1083). Redundancy is best gauged by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. Such analysis involves assessing the cumulative risk of catastrophes occurring over time. We can best gauge redundancy by analyzing the number and distribution of populations and subpopulations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time.

Gierisch mallow has a limited distribution, with the three populations restricted to a small range in Arizona and Utah and concentrations found in a very specific habitat type (*i.e.*, gypsum outcrops) within that range. There are three known populations consisting of 23 extant subpopulations, all of which contribute to redundancy. This distribution in multiple subpopulations gives the species some protection against very localized catastrophic events or disturbances, such as mining and recreational use. However, Gierisch mallow's narrow range makes it susceptible to larger catastrophic events or widespread disturbances, such as drought, especially when 95 percent of the total number of estimated plants occur in four subpopulations (the Utah subpopulation in the North Population and Hills 4, 6, and 7 in the Central population).

We do not have data suggesting that Gierisch mallow's current redundancy has changed substantially from its historical redundancy. The presumed extirpation of one subpopulation (Hill 5) has decreased species redundancy. This subpopulation contained an estimated 10 percent (2,500) of the total estimated Gierisch mallow plants from the nine subpopulations for which we have monitoring data (25,800, including the extirpated population).

We consider Gierisch mallow to have moderate redundancy, because of its distribution in three populations and 23 extant subpopulations. The 23 subpopulations protect it against localized catastrophic events and disturbances; however, its inherent limited distribution makes it vulnerable to more widespread catastrophic events and changes in conditions.

5.3 Species Representation

Representation describes the ability of a species to adapt to both near-term and long-term changes in its physical (*e.g.*, climate conditions, habitat conditions, habitat structure) and biological (*e.g.*, pathogens, competitors, predators) environments. Such adaptive capacity is essential for overall viability, as species need to continually adapt to their continuously changing environments (Nicotra *et al.* 2015, p. 1269). We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas.

Currently, we do not have phenotypic or genetic information for Gierisch mallow to demonstrate or suggest genetic variation between populations. For rare, endemic plants such as Gierisch

mallow, ecological diversity is presumably low because they are found in a narrow range of conditions. Gierisch mallow's restriction to a very narrow geographical range and specific habitat type demonstrates its low ecological diversity and likely indicates low ability to adapt to changing conditions (Nicotra *et al.*, p. 1272).

5.4 Summary

In this SSA we have considered the best available information about Gierisch mallow's life history and habitat needs and data about the species' distribution, abundance, and population trends. We discussed potential threats to the species and conservation of the species. Mining has the potential to remove entire subpopulations of plants; however, these subpopulations may reestablish disturbed areas if properly reclaimed. While other threats, such as livestock grazing, OHV use, and nonnative invasive species, likely negatively affect individual Gierisch mallow plants, we do not know their effects on Gierisch mallow populations or subpopulations.

We used the information in this SSA to evaluate Gierisch mallow's current condition based on the 3Rs. We conclude that Gierisch mallow's resiliency is largely influenced by the four largest subpopulations and that it has moderate redundancy and low representation due mostly to its endemism. More information about the current status of Gierisch mallow and the potential for threats to affect populations and subpopulations will inform the future viability of the species and direct actions needed for its conservation.

LITERATURE CITED

- Abatzoglou, J. T., and A. P. Williams. 2016. Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences* 113:11770–11775.
- Abella, S. R. 2009. Post-fire plant recovery in the Mojave and Sonoran Deserts of western North America. *Journal of Arid Environments* 73:699–707.
- Abella, S. R. 2010. Disturbance and Plant Succession in the Mojave and Sonoran Deserts of the American Southwest. *International Journal of Environmental Research and Public Health* 7:1248–1284.
- Abella, S. R., T. M. Embrey, S. M. Schmid, and K. A. Pregaman. 2012. Biophysical Correlates with the Distribution of the Invasive Annual Red Brome (*Bromus rubens*) on a Mojave Desert Landscape. *Invasive Plant Science and Management* 5:47–56.
- Aguirre, L., and D. A. Johnson. 1991. Influence of temperature and cheatgrass competition on seedling development of two bunchgrasses. *Journal of Range Management* 44:347.
- Alder, J. R. 2014. [National Climate Change Viewer](#). U.S. Geological Survey.
- Anderton, L. 2002. Summary of Spence's *Schoenocrambe barnebyi* monitoring plot, 1998-2001. Capital Reef National Park.
- Archer, S. R., and K. I. Predick. 2008. Climate change and ecosystems of the Southwestern United States. *Rangelands* 30:23–28.
- Atwood, D. L. 2008. Notes from a phone conversation with Dr. Duane Atwood, Assistant Curator of the S.L. Welsh Herbarium, Brigham Young University, Provo, UT. February 29, 2008.
- Atwood, N. D., and S. L. Welsh. 2002. Overview of *Sphaeralcea* (Malvaceae) in Southern Utah and Northern Arizona, U.S.A., and description of a new species. *Novon* 12:159.
- Bai, Y., T. A. Scott, and Q. Min. 2014. Climate change implications of soil temperature in the Mojave Desert, USA. *Frontiers of Earth Science* 8:302–308.
- Bartomeus, I., M. Vilà, and L. Santamaría. 2008. Contrasting effects of invasive plants in plant–pollinator networks. *Oecologia* 155:761–770.
- Belnap, J., B. Budel, and O. L. Lange. 2003a. Biological soil crusts: characteristics and distribution. Pages 3–30 in J. Belnap, editor. *Biological soil crusts: structure, function, and management; with 30 tables*. 1. ed., rev. 2nd printing 2003. Springer, New York, NY.
- Belnap, J., R. Prasse, and K. T. Harper. 2003b. Influence of biological soil crusts on soil environments and vascular plants. Pages 281–300 in J. Belnap, editor. *Biological soil crusts: structure, function, and management; with 30 tables*. 1. ed., rev. 2nd printing 2003. Springer, New York, NY.

- Belnap, J., R. Rosentreter, S. Leonard, J. H. Kaltenecker, J. Williams, and D. Eldridge. 2001. Biological soil crusts: ecology and management. Technical Reference, Bureau of Land Management, Denver, CO. 118 pp.
- [BLM] Bureau of Land Management. 2008. BLM Manual, MS-6840. ESA and BLM Guidance and Policy Manual 6840. 48 pp.
- _____. 2009a. Environmental assessment, proposed right-of-way grant and plan of operations, Black Rock Gypsum Mine. St. George, UT. 124 pp.
- _____. 2009b. Finding of no significant impact: proposed right-of-way grant and plan of operations, Black Rock Gypsum Mine. St. George, UT. 18 pp.
- _____. 2018. Finding of No Significant Impact and Decision Record: Transportation Network for St. George Basin and Colorado City Travel Sub-regions. St. George, Utah. 51 pp.
- _____. 2022a. Gierisch mallow monitoring data. St. George, UT. 12 pp.
- _____. 2022b. The Federal Land Policy and Management Act of 1976, as amended. Office of Public Affairs, Washington, D.C. 110 pp.
- [BLM] Bureau of Land Management and Red Butte Garden & Arboretum. 2018. 2018 BLM Reclamation and Sustainable Mineral Development Awards Program, The Hardrock Mineral Small Operator Award. 18 pp.
- Brooks, M. L. 1995. Benefits of protective fencing to plant and rodent communities of the Western Mojave Desert, California. *Environmental Management* 19: 65–74.
- Brooks, M. L. 2000. Competition between alien annual grasses and native annual plants in the Mojave Desert. *American Midland Naturalist* 144(1):92–108.
- Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. *Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species Miscellaneous Publication No. 11:1–14.*
- Brooks, M. L., T. C. Esque, and T. Duck. 2003. Fuels and fire regimes in creosotebush, blackbrush, and interior chaparral shrublands. Page 18. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, MT. 18 pp.
- Brooks, M., C. M. D'Antonio, D. M. Richardson, J. B. Grace, J. E. Keeley, J. M. DiTomaso, R. J. Hobbs, M. Pellant, and D. Pyke. 2004. Effects of Invasive Alien Plants on Fire Regimes. *Bioscience* 54(7):677–688.
- Clark, R. A. 2021. Stratigraphy, Lithology, and Depositional Environments of the Lower Permian Kaibab Formation, Northwestern Arizona. Contributed Report CR-21-E, Arizona Geological Survey. 92 pp.
- Cort, C., and B. Pavlik. 2016. Final Report: Gierisch's Globemallow Propagation and Reintroduction Project. Red Butte Garden & Arboretum, University of Utah, Salt Lake City, UT. 24 pp.

- Cox, R. 2011. Notes from a phone call about the Black Rock Gypsum Mine, December 2, 2011.
- _____. 2012. Email to B. Wooldridge, FWS, regarding gypsum mining and the mining law, February 9, 2012.
- _____. 2022. Email to B. Wooldridge, FWS, regarding gypsum mining at Black Rock Mine, October 12, 2022.
- Crawford, J. 2022. Email to J. Miller, FWS, with estimate of Gierisch mallow minimum viable population size, November 28, 2022.
- D'Antonio, C. M. and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. *Annual Review of Ecology and Systematics* 23:63–87.
- Dixon, J. 2011. Email to B. Wooldridge, FWS, regarding gypsum mining on Arizona State Land Trust lands, December 13, 2011.
- Dixon, J. 2012. Email to B. Wooldridge, FWS, regarding gypsum mining on Arizona State Land Trust lands, February 15, 2012.
- Douglas, R. L. 2012. Email to B. Wooldridge, FWS, regarding the Curly Hollow Allotment, February 16, 2012.
- Dreher, S. E. 2014. Interspecific hybridization in *Sphaeralcea* (Malvaceae). The Claremont Graduate University. 88 pp.
- Eickwort, G. C., K. R. Eickwort, and Linsley. 1997. Observations on Nest Aggregations of the Bees *Diadasia olivacea* and *D. diminuta* (Hymenoptera: Anthophoridae). *Journal of the Kansas Entomological Society* 50:1–17.
- Escolar, C., I. Martínez, M. A. Bowker, and F. T. Maestre. 2012. Warming reduces the growth and diversity of biological soil crusts in a semi-arid environment: implications for ecosystem structure and functioning. *Philosophical Transactions of the Royal Society B: Biological Sciences* 367:3087–3099.
- Esri, Maxar, Earthstar Geographics, and the GIS User Community. 2020. [World Imagery](#). Accessed 10/05/2022.
- Falk, M. 2008. Notes from a meeting with Lee Hughes, BLM ecologist, and site visit, February 12-13, 2008. March 10, 2008.
- Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8:629–644.
- Floyd, M. L., T. L. Fleischner, D. Hanna, and P. Whitfield. 2003. Effects of historic livestock grazing on vegetation at Chaco Culture National Historic Park, NM. *Conservation Biology* 17(6):170–1711.
- Frates, T. 2012. Comments to proposal to list Gierisch mallow under the ESA, October 16, 2012.

- [GAO] U.S. General Accounting Office. 1989. Federal land management: the mining law of 1872 needs revision. Report to the Chairman, Subcommittee on Mining and Natural Resources, Committee on Interior and Insular Affairs, House of Representatives. 48 pp.
- Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, editors. 2013. Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment. Island Press/Center for Resource Economics, Washington, DC.
- George, D. B., B. A. Roundy, L. L. St. Clair, J. R. Johansen, G. B. Schaalje, and B. L. Webb. 2003. The effects of microbiotic soil crusts on soil water loss. *Arid Land Research and Management* 17:113–125.
- Gioria, M., and B. A. Osborne. 2014. Resource competition in plant invasions: emerging patterns and research needs. *Frontiers in Plant Science* 5.
- Grace, J. B., M. D. Smith, S. L. Grace, S. L. Collins, and T. J. Stohlgren. 2001. Interactions between fire and invasive plants in temperate grasslands of North America. *Proceedings of the Invasive Species Workshop: the role of fire in the control and spread of invasive species. Fire Conference 2000*:40–65.
- Gucker, C. L., N. L. Shaw. 2018a. Munro's globemallow (*Sphaeralcea munroana*). In: Gucker, C. L. and N. L. Shaw, editors. *Western forbs: Biology, ecology, and use in restoration. Great Basin Fire Science Exchange*, Reno, NV. 19 pp.
- Gucker, C. L., N. L. Shaw. 2018b. Small-leaf globemallow (*Sphaeralcea parvifolia*). In: Gucker, C. L. and N. L. Shaw, editors. *Western forbs: Biology, ecology, and use in restoration. Great Basin Fire Science Exchange*, Reno, NV. 19 pp.
- Hobbs, R. J., and L. F. Huenneke. 1992. Disturbance, Diversity, and Invasion: Implications for Conservation. Pages 164–180 in *Ecosystem Management*. Springer, New York, NY.
- [IPCC] Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014: Synthesis Report Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. 151 pp.
- [ITIS] Integrated Taxonomic Information System. 2022. *Sphaeralcea gierischii*. N. D. Atwood & S. L. Welsh.
- [IUCN] International Union for Conservation of Nature, Standards and Petitions Committee. 2022. *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 15.1.
- James, R. D., B. D. M. Finch, C. Edminster, and R. Hamre, 1998. Use of native species in revegetation of disturbed sites (Arizona). Pages 297–303 in *The Future of Arid Grasslands: Identifying Issues, Seeking Solutions. Proceedings RMRS-P-3*. Fort Collins, CO.
- Jamieson, I. G., and F. W. Allendorf. 2012. How does the 50/500 rule apply to MVPs? *Trends in Ecology & Evolution* 27:578–584.

- Krause, C. 2010. Conservation ecology of endemic plants of the Colorado Plateau: climate change impacts on range shifts. PhD Thesis, Northern Arizona University, Flagstaff, AZ. 156 pp.
- Lambeth, J. 2023. Comments on draft species status assessment attached to an email to J. Miller, FWS. April 17, 2023.
- Levine, J. M., M. Vilà, C. M. D. Antonio, J. S. Dukes, K. Grigulis, and S. Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. *Proceedings of the Royal Society of London. Series B: Biological Sciences* 270:775–781.
- Lindley, R. 2022. Email to Glenn Rink, Far Out Botany, about identification of *Sphaeralcea* herbarium specimens south of establish Gierisch mallow range. August 5, 2022.
- Link, S. O., C. W. Keeler, R. W. Hill, and E. Hagen. 2006. *Bromus tectorum* cover mapping and fire risk. *International Journal of Wildland Fire* 15:113–119.
- Lovich, J., and D. Bainbridge. 1999. Anthropogenic degradation of the Southern California Desert ecosystem and prospects for natural recovery and restoration. *Environmental Management* 24:309–326.
- McLuckie, A. M., R.J. Bowers, M.M. Linke, and R.A. Fridell. 2017. Regional Desert Tortoise Monitoring in the Red Cliffs Desert Reserve, 2017. Publication Number 18-02. Utah Division of Wildlife Resources. Salt Lake City, UT.
- Mangal, M., and C. Tier. 1993. A simple direct method for finding persistence times of populations and application to conservation problems. *Proceedings of the National Academy of Sciences of the USA* 90:1083–1086.
- Maschinski, J., and M. A. Albrecht. 2017. Center for Plant Conservation’s Best Practice Guidelines for the reintroduction of rare plants. *Plant Diversity* 39:390–395.
- Matthew, B. L. 2000. Competition between alien annual grasses and native annual plants in the Mojave Desert. *American Midland Naturalist* 144:92–108.
- Mayeaux, H. S., H. B. Johnson, and H. W. Polley. 1994. Potential interactions between global change and intermountain annual grasslands. Pages 95–100 in S. B. Monson and S. G. Kitchen, editors. *Proceedings - Ecology and Management of Annual Rangelands*, May 18-21, 1992, Boise, ID. USDA Forest Service, Intermountain Research Station, Ogden, UT.
- McBride, W. 2022a. Pollination ecology of *Sphaeralcea gierischii*. Arizona Department of Agriculture, Endangered Species Act Section 6 Grant Program, Grant No. Segment 25-2019–2021-4. 47 pp.
- McBride, W. 2022b. Email to J. Miller, FWS, regarding Gierisch mallow and soil crusts, October 11, 2022.

- Melgoza, G., R. S. Nowak, and R. J. Tausch. 1990. Soil Water Exploitation after Fire: Competition between *Bromus tectorum* (Cheatgrass) and two native species. *Oecologia* 83:7–13.
- Missouri Botanical Garden. 2008. [Flora of North America](#). Accessed: 04/19/2023.
- NatureServe. 2004. A habitat-based strategy for delimiting plant element occurrences: guidance from the 2004 working group. 15 pp.
- NatureServe. 2022. [NatureServe Biodiversity Location Data](#) accessed through NatureServe Explorer. Accessed 10/14/2022.
- Neff, J. C., R. L. Reynolds, J. Belnap, and P. Lamothe. 2005. Multi-decadal impacts of grazing on soil physical and biogeochemical properties in southeast Utah. *Ecological Applications* 15(1):87–95.
- Nicotra, A.B., E.A. Beever, A.L. Robertson, G.E. Hofmann, and J. O’Leary. 2015. Assessing the components of adaptive capacity to improve conservation and management efforts under global change. *Conservation Biology* 29:1268–1278.
- [NOAA] National Oceanic and Atmospheric Administration. 2023. Quarterly Climate Impacts and Outlook for the Western Region – March 2023. 2 pp.
- [NOAA and USFWS] National Marine Fisheries Service and Fish and Wildlife Service. 2019. Draft Recovery Planning Internal Handbook. Internal Document.
- Ott, J. E., E. D. McArthur, and S. Sanderson. 2013. Plant community dynamics of burned and unburned sagebrush and pinyon-juniper vegetation in West-Central Utah. Pages 177–191 in E. D. McArthur, E. Durant, and D. J. Fairbanks, editors. *Shrubland ecosystem genetics and biodiversity: proceedings; 2000 June 13–15; Provo, UT*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.
- Pavlik, B. M. 1996. A framework for defining and measuring success during reintroductions of endangered plants. Pages 127–156 in D. Falk, C. Millar, and P. Olwell, editors. *Restoring Diversity. Strategies for Reintroduction of Endangered Plants*. Island Press, Washington, D.C.
- Pavlik, B., A. Uslander, and A. Chapman. 2018. Final report: Using Gypsum Red-Fines Waste Rock to Repair Damage to the Habitat of Gierisch Globemallow II. Monitoring and Restoring Experimental Cells. Page 48. Red Butte Garden & Arboretum, University of Utah, Salt Lake City, UT.
- Pendery, B. M., and M. D. Rumbaugh. 1993. Globemallows. *Rangelands* 15:127–130.
- Pendleton, R. L., B. K. Pendleton, G. L. Howard, and S. D. Warren. 2003. Growth and Nutrient Content of Herbaceous Seedlings Associated with Biological Soil Crusts. *Arid Land Research and Management* 17:271–281.
- PRISM Climate Group. 2022. [PRISM Time Series Data](#). Accessed: 07/21/2022.

- Redford, K. H., G. Amato, J. Baillie, P. Beldomenico, E. L. Bennett, N. Clum, R. Cook, G. Fonseca, S. Hedges, F. Launay, S. Lieberman, G. M. Mace, A. Murayama, A. Putnam, J. G. Robinson, H. Rosenbaum, E. W. Sanderson, S. N. Stuart, P. Thomas, J. Thorbjarnarson. 2011. What does it mean to successfully conserve a (vertebrate) species? *BioScience* 61(1):39–48.
- Reisner, M. D., J. B. Grace, D. A. Pyke, and P. S. Doescher. 2013. Conditions favouring *Bromus tectorum* dominance of endangered sagebrush steppe ecosystems. *Journal of Applied Ecology* 50:1039–1049.
- Reisor, R. 2012. Comments to the determination status for the Gierisch mallow and designation of critical habitat; proposed rule. October 15, 2012.
- Reynolds, R., J. Belnap, M. Reheis, P. Lamothe, and F. Luiszer. 2001. Aeolian dust in Colorado Plateau soils: Nutrient inputs and recent change in source. *Proceedings of the National Academy of Sciences* 98:7123–7127.
- Rink, G. 2023a. Draft report for Gierisch mallow surveys proposed for 2023, sent via email to J. Miller, FWS. January 12, 2023.
- Rink, G. 2023b. Email to J. Miller, FWS, about Gierisch mallow identification. June 1, 2023.
- Roaque, J. 2012. Email regarding grazing systems in allotments with Gierisch mallow. February 15, 2012.
- Roth, D. 2008. Monitoring report: *Pediocactus bradyi*. Navajo Natural Heritage Program, Window Rock, AZ.
- Shaffer, M. L., and B. A. Stein. 2000. Safeguarding our precious heritage [Chapter 11]. Pages 299–321 in B. A. Stein, L. S. Kutner, and J. S. Adams, editors. *Precious heritage: The Status of Biodiversity in the United States*. Oxford University Press, New York, NY.
- Smith, S. D., T. E. Huxman, S. F. Zitzer, T. N. Charlet, D. C. Housman, J. S. Coleman, L. K. Fenstermaker, J. R. Seemann, and R. S. Nowak. 2000. Elevated CO₂ increases productivity and invasive species success in an arid ecosystem. *Nature* 408:79–82.
- State of Arizona. 2016. Arizona Native Plants. The Arizona Administrative Code.
- James, R. D. 1998. Use of native species in revegetation of disturbed sites (Arizona). Pages 297–303 in Tallman, B. D. M. Finch, C. Edminster, and R. Hamre, editors. *The future of arid grasslands: identifying issues, seeking solutions*. 1996 Oct. 9–13; Tucson, AZ. Proceedings RMRS-P-3. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO. 392 pp.
- Traveset, A., and D. Richardson. 2006. Biological invasions as disruptors of plant reproductive mutualisms. *Trends in Ecology & Evolution* 21:208–216.
- U.S. Census Bureau. 2021. [Quick Facts: St. George City, UT](#). Accessed 10/04/2022.

- [USEPA] U.S. Environmental Protection Agency. 2021a. Climate Change Indicators in the United States. U.S. and Global Temperatures.
- _____. 2021b. Climate Change Indicators in the United States. Heat Waves. U.S. Environmental Protection Agency.
- [USFWS] U.S. Fish and Wildlife Service. 2016a. USFWS Species Status Assessment Framework: An Integrated Analytical Framework for Conservation. Ecological Services Headquarters, U.S. Fish and Wildlife, Bailey's Crossroads, VA.
- _____. 2016b. Biological opinion for the proposed resource management plan (RMP)/final environmental impact statement (EIS) for the Red Cliffs National Conservation Area (NCA), the proposed RMP/final EIS for the Beaver Dam Wash NCA, and the proposed St. George Field Office RMP amendment. Page 156. Biological Opinion, West Valley City, UT. 156 pp.
- _____. 2020. SPGI Topography Analysis. 4 pp.
- Van Buren, R., and K. T. Harper. 2003. Demographic and environmental relations of two rare *Astragalus* species endemic to Washington County, Utah: *Astragalus holmgreniorum* and *A. ampullarioides*. Western North American Naturalist 63:236–243.
- Vollmer, A. T., B. G. Maza, P. A. Medica, F. B. Turner, and S. A. Bamberg. 1977. The impact of off-road vehicles on a desert ecosystem. Environmental Management 1:115–129.
- Wallace, A., and Romney. 1980. Role of pioneer species in revegetation of disturbed desert areas. Great Basin Naturalist Memoirs 4:31–33.
- Warren, S. D. 2001. Synopsis: Influence of Biological Soil Crusts on Arid Land Hydrology and Soil Stability. Pages 349–360 in J. Belnap and O. L. Lange, editors. Biological Soil Crusts: Structure, Function, and Management. Springer, New York, NY.
- Webb, R. H., H. C. Ragland, W. H. Godwin, and O. Jenkins. 1978. Environmental effects of soil property changes with off-road vehicle use. Environmental Management 2:219–233.
- Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying Threats to Imperiled Species in the United States. BioScience 48:607–615.
- Wolf, S., B. Hartl, C. Carroll, M. C. Neel, and D. N. Greenwald. 2015. Beyond PVA: Why Recovery under the Endangered Species Act Is More than Population Viability. BioScience 65:200–207.
- Ziska, L. H., J. B. Reeves, and B. Blank. 2005. The impact of recent increases in atmospheric CO₂ on biomass production and vegetative retention of Cheatgrass (*Bromus tectorum*): implications for fire disturbance. Global Change Biology 11:1325–1332.