

THE STATUS OF SPHAERALCEA PSORALOIDES

(photo of plant here)

LATIN NAME: *Sphaeralcea psoraloides* Welsh

COMMON NAME: Scurfpea globemallow, or psoralea globemallow

FAMILY: Malvaceae

ORIGINAL CITATION: Welsh, S.L. 1980. Utah Flora: Malvaceae. Great Basin Naturalist 40:27-37.

STATE OF OCCURRENCE: Utah

CURRENT FEDERAL STATUS: Former Category 2

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SPECIES STATUS REVIEW

Scurfpea globemallow (*Sphaeralcea psoraloides*)

This report is a synthesis and summary of the best available information on the biology, ecology, and current status of the scurfpea globemallow (*Sphaeralcea psoraloides*). The scurfpea globemallow is a rare upland forb species, endemic to Utah and generally restricted to the outside edges of the San Rafael Swell in Emery County and northern Wayne County, Utah. This report contains the best available information about the plant's biological characteristics and the condition of each known population¹. Any gaps in the information available about the species have been noted where appropriate in the body of the report. Such gaps represent topics deserving for further research and monitoring by various agencies and individuals and are noted in part to identify areas in need of further study.

¹ The use of the term "population" in this status review is somewhat arbitrary, due to the general lack of research and surveys on this plant at the population level. The term "population" used in this status review can be equated to "element occurrence" in most cases.

I. GENERAL SPECIES INFORMATION

Nomenclature and Taxonomy

The scurfpea globemallow (*Sphaeralcea psoraloides* Welsh), originally described by foremost Utah botanist Stanley Welsh (Welsh 1980), is a perennial forb belonging to the Malvaceae family. . *S. psoraloides* is most closely related to *Sphaeralcea grossulariifolia* and *S. coccinea* (personal communication Stan Welsh, August 2003).

In general, based on the limited work done on *S. psoraloides*, there are no alternative taxonomic treatments at present for this species (Kartesz 1994, Welsh et al. 2003). Although the genus *Sphaeralcea* is known to readily hybridize, or “grade into” other members of the genus (personal communication Steven Dreher October 2003, personal communication Stan Welsh 2003, personal communication, Frank Smith August 2003 and see also “Genetic Work” section below). *S. psoraloides* is distinct, and has been retained by Stanley Welsh, the authority on Utah native plants in the most recent (2003) edition of *A Utah Flora*, declaring it a “good species” (personal communication, Stan Welsh). Thus, there is little question that *S. psoraloides* is sufficiently distinct from other members of the *Sphaeralcea* lineage based on morphology (Welsh et al. 2003, personal communication, Stan Welsh 2003).

History of knowledge of taxon: *Sphaeralcea psoraloides* was first collected near the Caineville Mesa/Caineville Spring region, northwest of Hanksville and south of the Muddy River, by Stanley Welsh in 1976. Welsh collected both the Holotype and Paratype specimens at this location, and both were placed in the Brigham Young University (BYU) Herbarium. Welsh recalls that when he first saw the plant he remarked that it resembled a *Psoralea* because of the three-lobed leaves (personal communication, Stan Welsh, August 2003). *S. psoraloides* was named as such because of the resemblance to this plant.

Following the description of *S. psoraloides* (Welsh, S.L. 1980), additional field surveys for the plant were conducted by James Harris in 1980, by Elizabeth Neese between 1980 and 1986 (Neese 1987) and by Ron Kass between 1986 and 1992 (Kass 1990a, 1990b). Recently, Debra Clark, working for both the National Park Service (NPS) and the Bureau of Land Management (BLM), has visited known populations of the plant and has also documented new locations of the species while surveying for other rare endemics (i.e. *Gilia tenuis*, Clark 2000 and 2001). In fact, nearly all of the locations of *S. psoraloides* known today were either incidental findings as researchers searched southern Utah for other rare species (i.e. those populations located by Neese and by Clark) or were only one species surveyed for among a suite of rare plants (i.e. Kass 1990a, 1990b).

Recent genetic work with *Sphaeralcea*. Until very recently, no researchers had undertaken systematic research on the genus *Sphaeralcea* since Kearney’s work in the 1930’s (Kearney 1935). Currently, Steven Dreher at the University of California Berkeley is investigating the genetic relationships among species of the genus *Sphaeralcea*, using many species of *Sphaeralcea* including *S. psoraloides*, and using both chloroplast and nuclear markers.

Dreher is now discovering what other botanists had suspected, which is that *Sphaeralcea* does not self-pollinate (personal communication Steven Dreher October 2003). Dreher is also finding that the *Sphaeralcea* genus in the western United States (including *S. psoraloides*) appears to be undergoing rapid evolution and speciation. Part of this discovery is tied to the fact that *Sphaeralcea* species appear to hybridize with sympatric or parapatric cogenitors (personal communication Steven Dreher October 2003). Additionally, Neese (1987) has reported that in some locations leaf morphology of *S. psoraloides* seem intermediate with that of *S. coccinea*. This could be construed as evidence (albeit limited) of hybridization between the two taxa.

However, although many species of *Sphaeralcea* hybridize with other members of the genus (personal communication Steven Dreher October 2003, personal communication Stan Welsh 2003, personal communication Frank Smith August 2003), Stanley Welsh retained the *S. psoraloides* species description in the most recent (2003) edition of *A Utah Flora*, declaring it a “good species.” Welsh affirms that the species is “easily distinguished...it is one of the easier species of *Sphaeralcea* to identify (personal communication Stan Welsh, October 2003). While Welsh agrees that most species of *Sphaeralcea* often hybridize where the range of one overlaps with the range of another, in the case of *S. psoraloides* he believes that the geographic restriction of this plant generally precludes hybridization (personal communication Stan Welsh, October 2003).

The work of Steven Dreher is not far enough along to suggest any need for taxonomic revision of *S. psoraloides*. In addition, the current thinking among geneticists and conservationists regarding “Evolutionary Significant Units” (ESU) of rare and imperiled species suggests using a combination of tests of ecological exchangeability and genetic exchangeability when making decisions about treating taxa as separate species, distinct population segments, or single populations (Crandall et al. 2000). Even with some genetic exchangeability (which may be the case with *S. psoraloides*), Crandall et al. still recommend ESU status if the taxon is not (and has not been) ecologically exchangeable with other related taxa (as is the case with *S. psoraloides*). The recent genetic work shows that *Sphaeralcea* in general hybridize, and that the hybrids tend to become fixed as new species, and that may be how *S. psoraloides* came to exist.

In closing, one thing that is clear is that the conservation implications involved with conserving a species that may be in “evolutionary flux” are considerable. Dreher’s research has shown that “there is something going on in Utah” with *Sphaeralcea* which is unique (personal communication Steven Dreher, October 2003). The form of *Sphaeralcea* which Stanley Welsh has named *S. psoraloides* is currently “experimenting with its genetic stock,” and this phenomenon may only be happening with this particular species of *Sphaeralcea* (personal communication Steven Dreher, October 2003). From a conservation standpoint, it may be even more important to protect a species that is in fact currently “evolving.”

Species Description

Non-technical description: *S. psoraloides* is a flowering plant with few to many stems, which cluster together and emerge from a branched, sub-woody base (Figure 1). It is a small plant,

typically six to eighteen inches tall. The leaves are small, yellowish-green, and either simple (at the base) or three-lobed to five-lobed (higher up). Both the stems and the leaves can have small hairs. The flowers are small, orange, and borne singly at each node (Neese 1987, Kass 1990a).

Here insert Figure 1 - digital photo

Technical description (Welsh et al 1993). Stems few to many from branching caudex, 1.4-3.5 dm tall or more, sparsely yellowish canescent, the foliage yellow green; leaf blades 1.3-6 cm long, 0.4-3.8 cm wide, oblanceolate to cuneate-ovate in outline, cuneate to obtuse or rounded basally, trifoliate or simple to 3-lobed below, deeply 1-5 cleft above, the lobes entire to few toothed or lobed, usually more than 5 mm wide; inflorescence racemose, the flowers solitary in the upper axils; calyx uniformly stellate, the rays of hairs radiating in a single plane, the lobes lance-acuminate; petals 8-15 mm long, orange, carpels 10, 3-4 mm high, the indehiscent part forming 2/3 to 3/4 of the carpel, reticulate on the sides, the reticulum extending on the margins of the back (Welsh et al 1993).

The range of *S. psoraloides* in Utah is sympatric with other species of *Sphaeralcea*. *S. psoraloides* can be distinguished from other globemallows in the region by a combination of leaf and inflorescence features: its lower leaves are simple or digitately three-lobed, wedge shaped to rounded at the base, and longer than broad, rather than (as in *Sphaeralcea coccinea*) 3-5 lobed, cordate, and broader than long; its flowers are borne singly at each node rather than in two or several-flowered clusters, as in *S. grossulariifolia* and *S. parvifolia* (Neese 1987).

Habitat

The scurfpea globemallow occurs on the northern Colorado Plateau, primarily along the footslopes of the San Rafael Swell, at elevations between 1370 and 1975 m. (4,500 and 6,500 ft.). The San Rafael Swell occurs in a relatively arid, temperate region characterized by arid to semi-arid climates where potential evaporation greatly exceeds precipitation. Mean annual precipitation, which arrives as both summer and winter precipitation, ranges from 12 cm to 25 cm. Mean annual temperatures also vary depending on elevation, and range from winter lows between -8°C and 0°C and summer highs between 30°C and 37°C (Loope 1977, Kass 1990a, Kass 1990b). This region is also characterized by very low average relative humidity, which contributes to great fluctuations between diurnal and nocturnal temperatures.

The San Rafael Swell lies within the Canyonlands section of the Colorado Floristic Division of the Intermountain Region (Cronquist et al. 1972). The Canyonlands section is characterized by broad desert plains dissected by deep canyons, low structural upwarps and

laccolithic mountains. The flora of the Canyonlands section has its origins with both montane and desert floras (Welsh 1978), with close floristic relationships with the Mojave, Navajoan and Great Basin deserts, as well as with the montane flora from the Wasatch and Utah High Plateau ecoregions. The geologic substrates control the development of the vegetation of the San Rafael Swell, but the development of vegetation types is closely tied to soil texture, depth, and water and ion relations as well (Neese 1987).

The geologic substrates of the San Rafael Swell affect the exposed landforms, as well as the vegetation types that cover the Swell. Differential erosion of the alternating hard and soft rock strata has resulted in a distinctive topography of staircase-like flats or mesas and steep slopes and cliffs, and in steep hogback ridges with intervening strike valleys. Resulting soils are sharply differentiated in regard to texture and chemistry. An understanding of this pattern of alternating coarse and fine rock strata and resulting topographic regime is important to understanding the distribution of *S. psoraloides* and other rare endemics found in the Swell (Neese 1987).

S. psoraloides is reported on clayey, silty and sandy semibarrens on several geologic strata in Utah, including the Carmel, Entrada, Summerville, Curtis formations, and the Tununk member of the Mancos Shale (Welsh 1980, Neese 1987, Welsh et al 1987, Kass 1990b, Clark 2001, NatureServe 2003). The plant is found at elevations ranging from 1370 and 1975 m. (NatureServe 2003). *S. psoraloides* can occur at any aspect and is most frequently associated with slopes that do not exceed 10 degrees (Kass 1990a). The globemallow prefers fine-textured, saline soils and gypsiferous substrates (Clark 2001), but is probably not limited to these substrates (Kass 1990a). *S. psoraloides* has also been found in gravelly and rocky soils (Neese 1987), which some surveyors have described as “hard pan gravel soils” (personal communication Charmain Delmatier, August 2003), or “poor, arid soils” (personal communication Elizabeth Neese, August 2003).

S. psoraloides is associated with salt desert and mixed desert shrub communities, in areas where vegetation can be sparse (Neese 1987). Other species most commonly associated with this plant include *Ephedra* spp., *Zuckia* sp. and *Atriplex* spp. It has also been found in communities with *Chrysothamnus* sp., *Artemisia* sp., *Grayia* sp., *Tetradymia* sp., *Sarcobatus baileyi*, *Gutierrezia sarothrae*, *Cryptantha jonesii*, *Sphaeralcea parvifolia*, *Sphaeralcea coccinea*, *Phacelia corrugata*, *Cryptantha tenuis*, *Erioneuron pulchellum*, *Eriogonum corymbosum*, *Eriogonum bicolor*, *Cryptantha flava*, *Lupinus pusillus*, *Astragalus lonchocarpus*, *Cleomella palmeriana*, *Thelypodopsis divaricata*, and various native perennial bunchgrasses (Welsh 1980, Neese 1987, Clark 2001). In general, *S. psoraloides* is never a dominant species in the communities where it occurs; rather it is considered an occasional to infrequent member of those communities.

There are also endangered plants and sensitive species that have been found in association with, or nearby populations of, *S. psoraloides*. These include Wright’s fishhook cactus (*Sclerocactus wrightiae*) (Neese 1987), a federally endangered species, and *Opuntia basilaris* var. *heilii*, *Cleomella palmeriana*, and *Eriogonum corymbosum*, all considered to be sensitive species in Utah (Kass, 1990a, Clark 2001).

Life History and Ecology

S. psoraloides is a self-incompatible, obligate out-crossing species, and likely pollinated by a suite of vectors (personal communication Steven Dreher October 2003, personal communication Stan Welsh October 2003). However, very little information exists on the specific pollinators for this plant. Kearney reports that most species in the genus *Sphaeralcea* have flowers with very little odor, yet they are still frequently visited by insects, especially small bees which may collect pollen instead of nectar (Kearney 1935). Stanley Welsh concurs that *S. psoraloides* is visited by a variety of bees, and doubts that the plant has only one or two specific pollinators. More likely, it is pollinated by insects that also pollinate other species in the area (personal communication Stan Welsh, October 2003). However, until detailed studies are conducted to ascertain the chief pollinators of *S. psoraloides* and the status of those species of pollinators, there is a possibility that unidentified threats to pollinators may be jeopardizing the persistence of *S. psoraloides* (Tepedino 2000).

Flowering phenology can vary slightly from year to year based on weather patterns, but generally flowering begins in mid to late May, and continues into July (Clark 2001, NatureServe 2003). Flowering occurs every year (personal communication Charmaine Delmatier, August 2003). Setting of fruit closely tracks flowering, and plants typically start setting seed in late May or early June (Neese 1987, Clark 2001). Little is known of the means of seed dispersal, nor exact germination requirements, for *S. psoraloides*. Kearney reported that the tendency for *Sphaeralcea* to have highly specialized fruits is suggestive of an adaptation for dissemination under favorable conditions (Kearney 1935). It is likely dispersed through wind and rain activities. It is not known what role seed banks play in recruitment of this species. Overall, potential dispersal distance for this species may be quite limited. This is supported by the general isolated nature of known, extant populations.

Very little is known about the role herbivory, seed predation or parasitism may have in the life history of this plant. Kearney reported that the fruits of *Sphaeralcea* tend to be structured in such a way that seeds inside are well protected from granivory (Kearney 1935). Charmaine Delmatier, who has visited and documented three separate *S. psoraloides* sites, has not seen evidence of herbivory by either small or large herbivores on the plant (personal communication Charmaine Delmatier, August 2003). Stanley Welsh has documented herbivory on *S. psoraloides* by a native species of beetle, but remarked that the year he witnessed this was an unusual year – specifically a year so dry that there was virtually “nothing else for beetles to eat” (personal communication Stan Welsh, August 2003). While herbivory by native herbivores is likely not to be a problem for the plant, grazing by domestic livestock is likely to have more of an impact than grazing by native herbivores. In terms of parasitism, Kearney reports that many species of *Sphaeralcea* are readily parasitized by weevils (*Macrorhoptus* sp.), which can destroy large number of seeds (Kearney 1935).

S. psoraloides prefers open sites with little interference from other, well-established plants (personal communication Charmaine Delmatier, August 2003). It would seem that this species does not do very well in situations that would require it to compete for space and sunlight with other plants. For example, if an exotic species of plant were to establish and

spread through occupied *S. psoraloides* habitat, *S. psoraloides* would likely suffer from competition with the exotic.

There is currently not a great deal of research that explores the role of disturbance in this plant's life history. *S. psoraloides* can occur in habitats associated with reoccurring, if not constant, wind and water erosion. The plant has been located in bottoms (Clark 2001), and near eroding wash banks, alluvial fans, and tributaries to major washes (Neese 1987). These areas experience periodic, often annual, water-driven erosion associated with spring runoff and summer thunder-showers. There are other species of *Sphaeralcea* that are known to do quite well with disturbance (personal communication Frank Smith, January 2004). However, Stanley Welsh reports that *S. psoraloides* does not tend to move into disturbed areas as readily as other species of *Sphaeralcea* are known to do, and seems to prefer undisturbed, native habitats (personal communication Stan Welsh 2003).

Being a perennial plant, the species is relatively long-lived (personal communication, Stan Welsh). Evidence of this can be found in the usually well-developed taproot typical of *Sphaeralcea* (Kearney 1935), including *S. psoraloides* (personal communication Stan Welsh, 2003). Longevity is a trait that has been connected to rarity. Longer-lived species that are relatively slow to reproduce and have lower reproductive rates may be susceptible to extinction (Nelson et al. 2002) because they cannot recover quickly following population declines (Beissinger 2000). Both theory and applied research support the general conclusion that low rates of reproduction and "slow life histories" render species more at risk of extinction (Wilson and Willis 1975; Marzluff and Dial 1991).

In summary, the limited knowledge we have on the natural history and ecology of this species paints a picture of a rare and unique endemic plant, with specific ecological requirements. Indeed, many researchers and surveyors have commented that this species requires specific habitat characteristics (personal communication Elizabeth Neese, August 2003). These factors (rarity and habitat specificity, especially in light of natural and human-caused disturbances in the San Rafael region) could increase the extinction risk faced by the scurfpea globemallow. In general, the overall lack of available information regarding *S. psoraloides*'s natural history and basic ecology is striking, and strongly underscores the pressing need for much more ecological research on the scurfpea globemallow.

II. SPECIFIC SPECIES OCCURRENCES

Range/geographic distribution

S. psoraloides is documented from only 18 locations in the world (Figure 2). All of these are in Utah, primarily within the San Rafael Swell, in Emery County and northern Wayne County. The species ranges from just north of the Price River in the north to just north of the Fremont River in the south. The largest and apparently healthiest population has been found at the Type location, or North Caineville Reef (Neese 1987). Specific descriptions of each known occurrence follow below, and the numbers of the occurrences correspond to Figure 2.

Known, Current Occurrences

Currently, there are only 18 occurrences known. In general, these populations occur along an 80 mile span of the flanks of the San Rafael Swell. Some of these “populations” are very close to each other, and may in fact represent a meta-population. Nearly all of the locations of *S. psoraloides* known today were either incidental findings as researchers searched the Swell for other rare species (i.e. those populations located by Neese and by Clark) or were only one of many species surveyed for among a suite of rare plants (i.e. Kass 1990a, 1990b). As such, most populations we know of today were not originally surveyed with the intent of determining population size, and so the exact number of individuals at many locations is currently unknown. The numbered descriptions below correspond to the occurrence locations in Figure 2.

1. Type/North Caineville population. T27S, R8E, Sections 13, 14, 23, 24, Fruita, Utah 7.5' Quad, and T27S, R9E, Sections 4, 8, 18, Factory Butte, Utah 7.5' Quad. This population occurs in Wayne County, in and around Salt Wash, about 17 miles due WNW of Hanksville, running from the east base of the Moroni slopes near the Emery County line, south and east to about 8 miles north of Caineville. The elevation of the site is estimated to be between 4700 and 5200 ft. (about 1500 m). Both the Holotype and Paratype specimens were collected by Stanley Welsh at this location (Specifically, Section 24) in the spring of 1976 (Welsh 1980).

In 1986, Elizabeth Neese and Ron Kass visited this site while conducting a habitat inventory for *Sclerocactus wrightiae* and other sensitive species, and documented 10 occurrences of *S. psoraloides* in seven sections, representing a single population. The habitat was described as sandy silt and/or loam with gypsum inclusions, with sparse gravel or rocky surface, mostly derived from the Entrada formation, but occasionally derived from the Carmel and Tununk Shale Formations (Neese 1987).

Neese and colleagues made very rough estimates of population sizes at the occurrence locations. In T27S, R9E Section 8, and also in T27S, R9E Section 18, she reported that the plants were many, or common, but the plants were not counted. In T27S, R8E Section 23, she counted 80 plants. In the other occurrence locations, she either reported “unkown” numbers of individuals, or “plants occasional.” In a follow up conversation with Neese to see if she could recall the general state of the population, especially at those occurrence sites where no counts were made, she recalled that, where the plant was found, it was generally “not locally uncommon” (personal communication Elizabeth Neese, August 2003).

No survey efforts have been carried out at the Type location since Neese’s and Kass’s visit in 1986. It is virtually impossible to make a population estimation for this location based on Neese’s limited (and now quite outdated) data, but upwards of several hundred plants is possible. It is impossible to know for certain until additional surveys are completed.

Neese did report observed threats to survival to the Type population, including Off Road Vehicle (ORV) tracks and cattle grazing (Neese 1987). Additionally, it is well known that this area currently receives considerably high ORV use (personal communication Tim Finger, Richfield BLM Field Office, October 2003), and considerable cattle use.

2. Caine Springs population. T27S, R8E, Section 2, Fruita, Utah 7.5' Quad. This population occurs about 2 miles north and west from the Type/North Caineville population, about 10 miles north of Caineville, and 1 mile north of Caine Springs. The principle geologic outcrop at the site is the Carmel formation, where it is exposed on both flat and semi-steep slopes. Soils are principally gravelly or sandy loams, sometimes with a very rocky surface. The elevation of the site is estimated to be about 5200 ft.

Neese and colleagues were the first to document this population, in 1986, while conducting a habitat inventory for *Sclerocactus wrightiae* and other sensitive species. One hundred *S. psoraloides* individuals were counted at this site (Neese 1987). The Caine Springs population overlaps School Institutional Trust Lands Administration (SITLA) holdings.

3. Caineville Reef Flats population. T29S, R8E, Sect 9, Caineville, Utah 7.5' Quad. This population was discovered in 2001 by Debra Clark, close to where the Fremont River crosses Highway 24, east of Capitol Reef National Park, at 4920 ft. elevation. Clark estimated that between 40 and 50 plants inhabit the site (Clark 2001).

Clark described the habitat at the Caineville Reef Flats site as a xeric bottomland site derived from Summerville and Curtis formations, with less than 10 degree slopes and consisting of a low desert shrub community. She reported only 100 m² of potential habitat in the vicinity. She also reported conservation concerns for this site, noting recreational vehicle traffic through the site, and both ATV tracks and dirt bike tracks. Overall, she rated the site "poor" in terms of defensibility from threats to population viability (Clark 2001). She also gave the site the lowest possible score (1 point) for the BLM's overall vulnerability rating. A vulnerability rating of 1 means that the population is at high risk; plants may be trampled and flowers picked, and the area is frequently used by visitors and within ¼ mile of a maintained primary road.

4. Gypsum Badlands population. T25S, R7E, Sect 25, Frying Pan, Utah 7.5' Quad. This population occurs southeast of Fremont Junction on I-70, along the road to Seger's Hole, in Emery County. This population was originally discovered by J. Harris in 1980 (the same year the plant was named), and a voucher specimen was collected by Harris and deposited in the BYU herbarium. This specimen was followed by another specimen taken by Duane Atwood and K. Thorne in 1987 at the same site, and also put in the BYU Herbarium. Neither Harris, nor Atwood and Thorne, estimated the size of the Gypsum Badlands population during their visits (personal communication Jim Harris September 2003, personal communication Duane Atwood October 2003).

This population was visited in 2001 by Debra Clark, as she conducted surveys for various sensitive plants in the San Rafael Swell, for both the BLM and National Park Service (Clark 2001). Clark counted 253 plants at the site, but concluded there were likely more than that present. Clark described the habitat at the Gypsum badlands site as a crest derived from the Carmel formation, with less than 10 degree slopes and consisting of a low desert shrub community. She reported about 100 acres of potential habitat in the vicinity (Clark 2001).

She also reported conservation concerns for this site, noting the road to Seger's Hole, which runs very close to the population site. Overall, she rated the site "marginal" in terms of defensibility from threats to population viability (Clark 2001). She also gave the site a score of "3" for the BLM's overall vulnerability rating. A vulnerability rating of 3 means that the population is at moderate risk; plants are growing in an area accessible to visitors, and/or plants are growing where they can't be directly stepped on by foot traffic, but flowers or seeds are easily within reach. Yet an additional potential threat to this population is the future potential for gypsum mining in and adjacent to the population site.

5. Willow Springs population. T24S, R7E, Sect 17, NW ¼, Mussentuchit flats, Utah 7.5' Quad. This population occurs west of the Muddy River, south of Interstate 70 and 3 miles southwest of North Willow Springs Reservoir in Emery County, at 5,600 ft. elevation. This population was discovered by Ron Kass in 1989 as he conducted a habitat inventory of threatened, endangered and candidate plant species in the San Rafael Swell (Kass 1990a).

The Willow Springs site occurs on the white sandstone edges of the Curtis formation, with mixed desert shrub vegetation type. The aspect is primarily western, the slope is less than 10 degrees, with open or partially open habitat and at mid-slope in terms of topographic position. Kass counted between 10 to 15 plants on the site, and noted that these individuals were flowering, and displayed normal vigor. He estimated the exact area occupied by plants to be less than 100 square yards, but noted that perhaps up to 100 acres of additional potential habitat existed in the area (Kass 1990a).

Kass described conservation concerns at the site, and because of this concern, Kass gave a "marginal" rating to this population site's 1) quality, 2) condition, 3) viability, and 4) defensibility (Kass 1990a). In addition, the Willow Spring population site is less than a mile away from a corral and stockpond, indicating that the area is likely to be fairly heavily grazed.

6. Hunts Draw population. T26S, R9E, Section 34, Hunts Draw, Utah 7.5' Quad. This population occurs just north of the hogback summit of North Caineville Reef, about 4.5 miles north of Factory Butte, near the Wayne/Emery County line, at 4,800 – 4,825 ft. elevation. This population was originally discovered by J. Harris in 1980 (the same year the plant was named), and a voucher specimen was collected by Harris and deposited in the BYU herbarium. Ron Kass and Elizabeth Neese revisited the Hunts Draw site in 1986, and they collected voucher specimens which were also submitted to BYU. The site

was revisited again by Ron Kass in May of 1989 as he conducted a habitat inventory of threatened, endangered and candidate plant species in the San Rafael Swell (Kass 1990a).

Kass described the habitat of the Hunts Draw site as occurring on the Tununk Member of the Mancos shale formation with Ferron Sandstone gravels on the surface. The vegetation type is described as salt desert shrub vegetation type. The aspect is primarily southern, the slope is less than 10 degrees, with open habitat and at either mid- or lower-slope in terms of topographic position. He counted only two plants on the site, and noted that these individuals were flowering, and displayed normal vigor. He estimated the exact area occupied by plants to be less than 100 square yards (Kass 1990a).

Kass described conservation concerns at the site, including cattle grazing and trampling. In part because of this concern, Kass gave a “marginal” rating to this population site’s 1) quality, 2) condition, 3) viability, and 4) defensibility (Kass 1990a). Today, the Hunts Draw population site is currently seeing significant ORV abuse (personal communication Ray Bloxham, chief field inventory personnel, Utah Wilderness Coalition, October 2003), making this threat to the Hunts Draw site perhaps more daunting than cattle grazing. Tom Gnojek of the Price BLM Field Office agrees that ORV use could be a problem today, acknowledging that the area is a “no mans’ land,” and that the routes are likely lacking the proper signage (personal communication Tom Gnojek, October 2003). Tim Finger, also with the Utah BLM Recreation staff, notes that the unregulated cross country travel at Hunts Draw must certainly pose a problem for rare plants, as “its hard enough as it is for plants to grow on the very fragile substrates” at Hunts Draw (personal communication Tim Finger, January 2004). All of the threats to this population and others nearby are discussed in more detail in the “Threats Section,” below.

7. Chimney South population. T25S, R8E, Sect 32, SE ¼, Frying Pan, Utah 7.5’ Quad. This population occurs 4½ mile west of the Muddy River and about 6 miles north of the Wayne/Emery County line, in Emery County, at 6300 ft. This population site was discovered by Ron Kass in 1990 as he completed a challenge cost share survey for T/E/Candidate species for the BLM in the San Rafael Swell. The population overlaps SITLA holdings.

The Chimney South site occurs on the Carmel Formation, with mixed desert shrub vegetation type. The slope is less than 10 degrees, with primarily open habitat and at mid-slope, lower-slope and bottom areas in terms of topographic position. Kass counted between 10 to 15 plants on the site, and noted that these individuals were flowering or displaying immature fruit, and displayed normal vigor. He estimated the area occupied by plants to be over 2 acres (Kass 1990a). One of the chief potential threats to this population is the future potential for gypsum mining in and adjacent to the population site.

8. Well Draw population. T26S, R11E, Section 35, Goblin Valley, Utah 7.5’ Quad. This population was discovered by J. Harris in 1980, and is located 2 miles west of Highway 24 along the Emery/Wayne County line, at 4600 ft. elevation. Harris made no

population estimate at this site (personal communication Jim Harris, September 2003), but it is not likely that the population was very large, as 1) if it was, J. Harris have likely remembered that (Harris recounts that “he didn’t run into it very often” during his plant surveys), and 2) no other collections of *S. psoraloides* have been subsequently made anywhere very close to this location. Based on this and other “typical estimates” of population size of this plant where it occurs, it is likely a conservative estimate that this population numbers not more than 100 plants.

The biggest threat to this population currently is expanding ORV use in the area. The Well Draw population site is in an area with sand dunes, which are very popular for ORV enthusiasts, and an ORV route goes right through or very nearby the population there (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). Tom Gnojek with the Price Field Office predicts that this site will soon be “discovered” by ORV users (personal communication Tom Gnojek, October 2003).

9. Jessie’s Twist population. 22S, R14E, SW ¼ of Section 24, Jessie’s Twist, Utah 7.5’ Quad. This population was discovered by Elizabeth Neese in 1980, and is located 3 miles south of I-70 and ½ mile east of the San Rafael Reef, at 4500 ft. elevation. As the species was still undescribed at the time of her collection, Neese did not make an estimate of population size at this location.²

The Jessie’s Twist population site is right in the middle of a very popular site for camping, trailer camping, hiking, ORV staging, dinosaur bone hunting, and other forms of desert recreation (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). Tom Gnojek with the BLM Price Field Office that he’s recently noticed more recreation is this area than ever before, with dispersed camping in particular being an issue “that the BLM is really not taking care of” (personal communication Tom Gnojek, January 2004).

10. Oil Well Draw population. T21 S, R11E, Sect 22, Wickiup, Utah 7.5’ Quad. This population was discovered by Stanley Welsh and S. Clark in 1977, and is located 25 miles southeast of Castledale, at 5800 ft. elevation. This site was one of the very early discoveries of *S. psoraloides*. Welsh documented the exact location and then returned a few days later to take a voucher specimen. However, upon returning he found that most of the foliage had been consumed by a beetle. He took the specimen anyway, as there were no other individuals visible at the site (personal communication Stan Welsh, August 2003). At the time, therefore, the population was exceedingly small.

11. Little Wild Horse Mesa population. T26 S, R10E, Sect 19, Little Wild Horse Mesa, Utah 7.5’ Quad. This population was discovered by J. Harris in 1980, and is located

² Since Neese’s collection at this site in 1980, Stan Welsh returned to an area immediately west of Neese’s collection site and observed what he claims to be a “continuous stretch” of *S. psoraloides* from just south of where Interstate I-70 crosses the eastern footslope of the San Rafael Swell and which likely continues along the footslope for perhaps many miles south along the Swell. Welsh surmises that this stretch is perhaps one mile wide, and could continue for many miles, even as many as 30. Unfortunately, Welsh made no population estimate during this visit, but estimates it could be over 1000 (personal communication, Stan Welsh).

about 1.5 miles east of the Muddy River and 2 miles north of the Emery/Wayne County line, in Emery County, at 4650 ft. Harris made no population estimate at this site (personal communication Jim Harris, September 2003), but it is not likely that the population was very large, since if it was, J. Harris would have likely remembered that (Harris recounts that “he didn’t run into it very often” during his plant surveys). Based on this and other “typical estimates” of population size of this plant where it occurs, it is likely a conservative estimate that this population numbers not more than 100 plants.

Chief threats suspected to impact this population includes cattle grazing and ORV abuses. The Little Wild Horse Mesa site is just over the border between the Richfield and Price Field Office boundaries, and now that the new San Rafael Travel Plan has been instated to the north of the field office boundary (Wayne/Emery County line), technically the area north of the boundary is limited to signed areas only (BLM 2003). However to the south of the boundary in the Richfield district, the area is completely open to ORV use (BLM 1983b and BLM 1988). Unfortunately, most riders ignore the new restrictions as they cross over the Field Office boundary to the north (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003), putting the *S. psoraloides* population at Little Wild Horse Mesa in potential harm’s way.

12. Keesle Country population. T26 S, R9E, Sect 4, Hunts Draw, Utah 7.5’ Quad. This population was discovered by Mark Porter and Ken Heil in 1986, and is located 3 miles northwest of Factory Butte, just below the Moroni slopes, at 4,920 ft. elevation. Porter and Heil found this population incidentally, as they were searching for other rare endemics in the region (personal communication Mark Porter August 2003, personal communication Ken Heil August 2003). No estimate of population numbers was made, but it is not likely that the population was very large, as if it was, either M. Porter or K. Heil would have likely remembered that. Based on this and other “typical estimates” of population size of this plant where it occurs, it is likely a conservative estimate that this population numbers not more than 100 plants.

In terms of threats, the Keesle Country population site is right off the main road to Hidden Splendor, one of the most popular tourist destinations in the San Rafael Swell.

13. Bentonite Hills population. T28 S, R7E, Sect 23, Fruita, Utah 7.5’ Quad. This population was discovered by E. Neese and R. Kass in 1986, and is located 5.5 miles north of the Fremont River, and just east of Capitol Reef National Park, at 5200 ft. elevation. The site was described as a salt desert shrub community. This specimen was initially identified as *Sphaeralcea grossularifolia*, and as such, no estimate of the number of individuals at this site was made. However, C. Delmatier revisited this site in the late 1990’s and only saw three plants (personal communication Charmaine Delmatier, August 2003).

The Bentonite Hills population site is likely currently heavily grazed, as there is a private section of land immediately to the south of the population which has a corral, and the area immediately north/northwest of the population is well watered, due to an abundance of creeks that drain the Waterpocket Fold.

14. Green River Cutoff North population. T19S, R13E, South ½ of Sect 12, Huntington, Utah 7.5' Quad. This population was discovered by C. Delmatier and B. Thompson in 1999, and is located 6.8 miles west of Highway 6/191 near the south side of the Woodside-Castledale Road, near the northeast flank of the San Rafael Swell, at 5,410 ft. elevation. Delmatier and B. Thompson estimated the site to contain between 36 and 50 individuals (personal communication Bob Thompson August 2003, personal communication Charmaine Delmatier, August 2003). Bob Thompson noted in 1999: “there weren’t too many there...they were very hard to find.” Bob Thompson visited the site during the field season last year and did not see any individuals at all (personal communication Bob Thompson, August 2003). In addition, this visit was shortly after a wet and cool spring (personal communication Bob Thompson, August 2003), when he expected additional germination from the seedbank.

Perhaps the chief threat facing this population is substantial ORV abuse in the area. The San Rafael Swell Travel Plan designates this area as completely open to ORV use (BLM 2003), and the BLM allows a large competitive motorcycle race right through the exact lands that house the Green River Cutoff North population. The motorcycle race is typically held every 2-3 years, usually have an average of over 100 riders, and the route does not have to be limited to existing routes and trails; the racecourse typically follows wash bottoms, cattle trails and other “ways” (personal communication Tom Gnojek, Price BLM Field Office, October 2003). Currently, the organizers of the race (the “Sage Riders”) are advocating for the entire racecourse to become a designated ORV route in the upcoming San Rafael Resource Management Plan (RMP) revision.

15. Green River Cutoff South population. T19S, R13E, northeast ¼ of Section 13, Huntington, Utah 7.5' Quad. This population was discovered by C. Delmatier in 1997, and is located 5.8 miles west of Highway 6/191 near the Woodside-Castledale Road, near the northeast flank of the San Rafael Swell, at 5,445 ft. elevation. Delmatier documented only 3 plants there (personal communication Charmaine Delmatier, August 2003).

Perhaps the chief threat facing this population is substantial ORV abuse in the area. The San Rafael Swell Travel Plan designates this area as completely open to ORV use (BLM 2003), and the BLM allows a competitive motorcycle race right through the exact lands that house the Green River Cutoff North South population. The motorcycle race is typically held every 2-3 years, usually have an average of over 100 riders, and the route does not have to be limited to existing routes and trails; the racecourse typically follows wash bottoms, cattle trails and other “ways” (personal communication Tom Gnojek, Price BLM Field Office, October 2003). Currently, the organizers of the race (the “Sage Riders”) are pushing for the entire racecourse to become a designated ORV route in the upcoming San Rafael RMP revision.

16. Tidwell Draw population. T20S, R14E, Sections, 31, 32 33, Desert, Utah 7.5' Quad. This population was discovered by R. Collins in 1989, and is located along Tidwell Draw, west of the town of Green River, at an elevation of 4520 to 4560 ft. The population site occurs on the Summerville and Morrison formations, in relatively sandy sites. Collins did not make a population estimate at the time of his visit, because he was

doing a larger survey for Threatened and Endangered Plants at the time, but reports that “it was rare,” and “only in the little draws” (personal communication Rick Collins, September 2003). Stanley Welsh and Duane Atwood revisited this population in 1999. They collected an herbarium specimen, but did not estimate the population’s size.

The Tidwell Draw population site is very accessible to cattle that are well watered by the perennial Cottonwood Wash that runs through the population site. The population also overlaps with SITLA holdings.

17. Kiahtipes population. T17S, R14E, Sect 22, Woodside, Utah 7.5’ Quad. This population was discovered by Ron Kass and F. Newman in 1992, and is located 4 miles west of the town of Woodside, at an elevation of 4,855 ft. Kass and Newman did not make a population estimate at this site, but Kass reports that all of the locations where he’s surveyed for *S. psoraloides* have had small populations, typically less than 50 plants (Personal communication Ron Kass, August 2003).

18. East Cedar Mountain Spring population. T25 S, R8E, Sect 30, Frying Pan, Utah 7.5’ Quad. This population is located near East Cedar Mountain Spring, about 7.5 miles north of the Emery/Wayne County line and 5.5 miles west of the Muddy River. The elevation is approximately 6,700 ft. The East Cedar Mountain Springs population site was discovered by S. White in 1989, but apparently no population estimate was made.

Ron Kass revisited the population in 1990 as he completed a challenge cost share survey for T/E/Candidate species for the BLM in the San Rafael Swell. Kass described the habitat of the East Cedar Mountain Spring site as occurring on the white shale barrens of the Carmel Formation, with either salt or mixed desert shrub vegetation type. He counted less than 10 plants on the site, and noted that these individuals were flowering (Kass 1990a). One of the chief potential threats to this population is the potential for future gypsum mining in or adjacent to the site.

Potential Occurrences

Potential *S. psoraloides* habitat could occur in many locations throughout the San Rafael Swell, including the center of the Swell, where so far only one population has been found. Because of the nature of *S. psoraloides*, new locations of the plant are likely to be isolated from one another as well as from known populations. The most likely areas to contain populations of *S. psoraloides* that are not yet discovered would include areas where the principle geologic strata that are known to support the plant (i.e. Carmel, Entrada, Summerville, and Curtis formations) emerge³ (Figure 3). In particular, areas adjacent to places already containing known populations of the plant are the most likely places to find new populations.

³ The GIS geology data used in this report are at a coarse scale. Occasionally the strata supporting a population is a very small outcrop and not captured by the GIS coverage. Therefore, occasionally a population will appear to “not occur in suitable *S. psoraloides* habitat.”

Occurrence Summary/Current Population Status

According to the information available about the known occurrences of *S. psoraloides*, the species now exists only in a small area of Utah. Because of incomplete survey data, it is impossible to estimate the exact number of *S. psoraloides* individuals known to exist at this time. Moreover, most of what is known about this species' current range and status is based on dated surveys (a few of which are over 20 years old). Based on the limited information available the most informed, and conservative, estimation would put the current population somewhere between 1,850 and perhaps 5,000 individuals. Of the 18 known occurrences of *S. psoraloides* for which population estimates exist, only two occurrences may be considered even of moderate size (at least 100 individual plants, which is certainly not large by any standard other than comparison with most known populations). Of the remaining known populations, 33% percent (6 occurrences) are very small - less than 25 individual plants confirmed at each location. These populations of *S. psoraloides* are quite small compared to other native forbs in similar environments; therefore they could be additionally vulnerable to disturbances. The population size is unknown for eight of the occurrences and so these sites must be resurveyed in the near future.

What we do know is that many of Utah's most prominent botanists do consider this species rare (personal communication Ron Kass August 2003, personal communication Bob Thompson August 2003, personal communication Frank Smith August 2003, personal communication Jim Harris, September 2003), and agree that it has a very limited distribution (personal communication Larry England, 2003). We also know that there have been numerous surveys for rare endemic plants throughout the San Rafael Swell in which *S. psoraloides* has not shown up. For example, Wayne Ludington of the BLM Price Field Office reports that the scurfpea has not been found in any of the NEPA-required surveys the Price Field Office has conducted for Sensitive plants that may be impacted by proposed activities or impacts within the Field Office (personal communication Wayne Ludington, August 2003). And Ron Kass "looks for it every time he's in Emery County" (personal communication Ron Kass, August 2003) and every occurrence he's documented (only five) is represented in the BYU herbarium.

Another issue that pertains to the rarity question is that this very rare species of *Sphaeralcea* can be confused with other, much more common species of globe mallow (personal communication Ron Kass, August 2003), which may mistakenly contribute to the notion that "it's not in trouble." As pointed out in this status review, this notion is unfounded.

Currently, nearly all known sites for this plant are on federal and state lands, primarily on lands managed by the Price and Richfield Field Offices of the BLM. While some would consider a plant where the majority of the species' distribution occurs on federal lands to be secure, the scurfpea globemallow does not experience this security, and in fact is probably quite threatened. As is pointed out in Section IV below, the land management status of the San Rafael Swell, where all extant populations are found, is such that much of the area is considerably threatened by ORV activities, overgrazing, and oil and gas exploration and development. The specific disturbances to which this species is known and suspected to be susceptible to are outlined below in Section IV.

III. CURRENT MANAGEMENT

Present Legal Status

The scurfpea globemallow is categorized by the Utah Natural Heritage Program as a G2 species globally and an S2 species statewide. These rankings indicate substantial rarity or other factor(s) leading to the designation of “imperiled,” and indicate rarity or other factor(s) making the species very vulnerable to extinction or extirpation (6 to 20 occurrences or few remaining individuals or acres) (Utah Natural Heritage program website 2002).

S. psoraloides was listed as a Category 2 species by the U.S. Fish and Wildlife Service until the elimination of that category several years ago (personal communication Larry England, 2003). This designation indicated that a threatened or endangered listing under the Endangered Species Act may be appropriate. Listing under Category 2, before it was done away with, afforded no formal legal protections.

All known population sites for this species are on state and federal lands - chiefly BLM lands.⁴ *S. psoraloides* is listed as Sensitive by the BLM State Office, and thus is included on the BLM Special Status Plant Species within the Price and Richfield BLM Field Offices (where the plant may be found). Under this designation, the BLM has an internal policy to treat Sensitive species as they would Candidate species, to monitor them and develop conservation plans, and ensure that actions authorized on BLM administered lands do not contribute to the need to list any Special Status Species (BLM Manual Section 6840.06C&E). However, this internal policy is not often enforced, as evidenced by general lack of BLM monitoring of sensitive species and lack of written conservation plans.

Past and Present Conservation Efforts

Since nearly all of the occurrences of *S. psoraloides* are on BLM land, the BLM has been responsible for much of the monitoring and study of the species to date. The BLM’s Richfield District conducted surveys for plant species of concern in the San Rafael Swell, including *S. psoraloides*, in the late 1980’s (Kass 1990a, 1990b). As discussed above, D. Clark has been surveying for the species in recent years in the southern half of the San Rafael Swell, at the request of and in concert with the BLM.

Currently, no federal laws specifically protect plant species that are not already on the federal Threatened or Endangered Species List, or are official candidate species. Without these designations, BLM’s regulatory mechanisms are generally inadequate to prevent extirpations on BLM managed lands. In addition, as of now no habitat management plan has been written for *S. psoraloides* by the Price or Richfield Field Offices.

In terms of incidental habitat protections for *S. psoraloides* there have been numerous conservation efforts to preserve all or portions of the San Rafael Swell. This includes seven

⁴ There are three populations that occur on School Institutional Trust Lands Administration (SITLA) holdings, but these lands tend to be in effect managed by the BLM.

Wilderness Study Areas⁵ (WSAs), a proposal by the Utah Wilderness Coalition for additional wilderness units - many of which are located in the San Rafael Swell, a short-lived effort to designate a portion of the Swell as a National Park in the mid 1980's, a recent (1999) Congressional effort to designate the area as a National Conservation Area, and a push to designate much of the Swell as a National Monument, though this was not successful. The interest shown by Congress, the state of Utah, Emery County, and local environmental groups underscores the fact that most of these interests acknowledge the biological and ecological importance of this part of Utah. This includes its role as a storehouse for what is largely considered to be one of the greatest concentrations of rare endemic plants in the state (personal communication Mike Windham 2002, personal communication Stan Welsh 2002).

As discussed above, there are several current, and imminent threats to known *S. psoraloides* populations, but so far only some of these threats have been given the attention they deserve. No direct action has been taken to protect *S. psoraloides* populations from threats or disturbances.

IV. CURRENT AND FUTURE THREATS

The chief threats facing *S. psoraloides* include livestock grazing, off-road vehicle (ORV) use, and expedited energy exploration in the region.

Livestock Grazing

Decreases in native plant species diversity, cover and density as a result of livestock grazing have been observed in a wide variety of arid ecosystems in the western U.S, including those of the Colorado Plateau of southern Utah. Moreover, these kinds of alterations to the vegetative community can in turn lead to significant repercussions for successional trajectories, the abiotic environment, and wildlife (Jones 2001).

One of the chief ways cattle grazing affects vegetative communities is by altering species composition of plant communities. This happens in two ways: 1) active selection by herbivores for or against a specific plant taxon, and 2) differential vulnerability of plant taxa to grazing. Grazing can also delay plant phenology, which in turn can have dramatic effects on communities of pollinators and seed dispersers (Fleischner 1994), thereby further disrupting the composition of a vegetative community. Studies that have documented significantly greater native plant species richness in ungrazed areas compared to those that are grazed include Brady et al. (Arizona - 1989), and Floyd-Hanna et al. (New Mexico - 2000).

While cattle grazing has been shown to decrease species richness in arid communities, it similarly affects species evenness, with considerable secondary effects. Long-term cattle grazing has been shown to decrease the abundance of perennial grasses and forbs and increase the amount of annual grasses and weeds in western deserts (in northern Arizona-

⁵ The de-facto level of protection afforded rare plants by WSA status lands is discussed in more detail in section V.

Schmutz et al. 1967; the Great Basin-Rice and Westoby 1978; central Utah-Brotherson and Brotherson 1981; California-Hanley and Page 1981; and Nevada-Medin and Clary, 1990). Any significant grazing-induced changes in cover, densities or relative abundances of certain plant species or guilds can in turn have profound implications at the community level, as these changes can translate into major conversions of community organization, for example, transforming grassland to desert (Schlesinger et al. 1990).

One particularly insidious result of cattle grazing in arid western ecosystems is the spread of exotic grasses and weeds. Grazing aids the spread and establishment of alien species in three ways: 1) dispersing seeds in fur and dung (2) opening up habitat for weedy species and 3) reducing competition from native species by eating them (Fleischner 1994). Studies that have found increased densities, cover or biomass of exotic plant species in grazed versus ungrazed sites include Green and Kaufman (Oregon -1995), Drut (Oregon - 1994) and Harper et al. (Utah - 1996).

Most of the known populations of *S. psoraloides* occur on open range, and grazing occurs in and around nearly all of these populations. *S. psoraloides* is likely to be detrimentally affected by livestock trampling. If cattle do in fact graze on *S. psoraloides*, or even if they merely travel through its habitat and trample it incidentally, then there is a possibility that the plant is differentially affected by such disturbance depending on the particular microhabitat or season. As both flowering and fruiting for this plant occur in mid May and into July, *S. psoraloides* is very likely to be even more negatively impacted by grazing disturbance during that period. Though cattle may be in general less interested in the particular microhabitats that contain *S. psoraloides*, excessive livestock densities may force cattle further from wells to feed, thus exposing *S. psoraloides* to trampling damage. Wet or dry years could compound the effects of grazing on *S. psoraloides* and the arid plant community within which it dwells.

Table 1 illustrates grazing density in the allotments known to contain populations of *S. psoraloides*. As discussed above, high densities of cattle would be considered most detrimental to populations as higher densities of cattle may result in cattle feeding on what is likely not a preferred source of forage (*S. psoraloides*) and may also force cattle to forage further from wells, thus exposing populations to potential trampling.

Table 1. BLM Grazing Allotments known to contain populations of the scurfpea globemallow, season of use, permitted AUM's, and estimated grazing density for those allotments

Allotment	Acres	Season of use	Total AUMs	Acres/AUM
North Sinbad	42630	11/01 - 5/10	737	58
Desert	62292	11//01 - 5/17	1409	44
Trail Spring	32277	11/01 - 3/31	596	54
Buckmaster	49270	12/01 - 4/30	855	58
Lone Tree	120580	11/01 - 4/15	5245	23
McKay Flat	52825	11/01 - 3/15	1274	41
Mussentuchit	58921	11/01 - 5/31	1993	30
Cathedral	14160	10/01 - 5/31	2609	5
Wild Horse	94838	9/1 - 4/15	1522	62
Hartnet	95955	10/15 - 5/31	1792	54
Hondo	103260	11/1 - 5/31	223	463

There are certain factors regarding grazing management within the San Rafael Swell that should be of concern. One is the fact that all but two of the allotments known to contain populations of *S. psoraloides* are grazed during the critical spring growing season (Table 1), widely accepted as the worst possible time of year to graze sensitive desert grasses and forbs (Cook and Child 1971, Miller and Donart 1981, Holecheck et al. 2001). Of equal concern are the over-inflated stocking rates on the Cathedral allotment, which houses the Type/North Caineville, and Caine Springs populations. With only 5 acres per AUM, the density of cattle is far higher than that typically recommended for arid rangelands in the West (Holechek et al. 2001). The BLM's most recent trend and utilization data for this allotment (1995-1997) indicates that the allotment may be overgrazed, as utilization rates of key forage species at or above 55% have been detected at two monitoring stations, and recent riparian condition assessments have found that only one spring out of 5 springs/riparian areas assessed is in Properly Functioning Condition (personal communication, Leroy Smalley, Henry Mountains Field office, January 2004).

Another matter of concern is the stocking level on the Lone Tree allotment, which contains the Willow Springs population, and the Mussentuchit allotment, which may include part of the Gypsum Badlands and East Cedar Mountain Spring populations (they are right on the border of the allotment) (Table 1). With only 23 acres per Animal Unit Month (AUM) on the Lone Tree allotment, and only 29.6 acres per AUM on the Mussentuchit allotment, the

density of cattle is close to twice what is typically recommended for arid rangelands in the West (Holechek et al. 2001). The BLM's most recent ecological condition description for these two allotments confirm that they are indeed overgrazed. The Lone Tree statistics reveal that fully 74% of the vegetation is classified as mid-seral, or fair condition - the 2nd worst condition class. And the RMP reports that 49% of the vegetation in the Mussentuchit allotment is in mid-seral condition and 14% is in early seral, or poor condition (BLM 1991).

In terms of on-the-ground, specific grazing impacts to *S. psoraloides* that are noteworthy, the Willow Spring population site is less than a mile away from a corral and stockpond. The Oil Well Draw site is extremely overgrazed, as it is less than ¾ mile from a spring-fed reservoir (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). At the Hunts Draw population site, R. Kass described conservation concerns at the site, including cattle grazing and trampling (Kass 1990a). The Bentonite Hills population site is likely currently heavily grazed, as there is a private section of land immediately to the south of the population which has a corral, and the area immediately north/northwest of the population is well watered, due to an abundance of creeks that drain the Waterpocket Fold. The Tidwell Draw population site is very accessible to cattle that are well watered by the perennial Cottonwood Wash that runs right through the population site.

Elizabeth Neese reported observed threats to survival to the Type/North Caineville population in her 1986 survey, including cattle grazing (Neese 1987). This population site is believed to be currently heavily grazed by cattle, as the population site is just south of Salt Creek, a popular perennial water source for the cattle on the Cathedral allotment (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). Of even more concern at this site is the fact that there are virtually no bunchgrasses and very little forbs in the harsh Mancos Shale badlands that typify this site, so cattle are likely to eat absolutely anything that is growing there, such as *S. psoraloides* (personal communication, Ray Bloxham Utah Wilderness Coalition, October 2003). The Hunts Draw site, discussed above, is located on the same Mancos Shale badlands, as is the Little Wild Horse Mesa population, so both of these populations are likely suffering the same fate at the Type/North Caineville population. The Little Wild Horse Mesa population may be faring even worse than the Hunts Draw site, as the former site is within easily reach of the perennial Muddy River, a critical water source for cattle in the area.

Wayne Ludington of the Price Field Office reports that term permit renewals for most grazing permits are now underway in the Field Office. Environmental Assessments are being prepared to determine the potential impacts involved with renewing most allotments at the current grazing levels or with moderate changes. However, no plant surveys are planned to determine which BLM-listed Sensitive plant species are included in these allotments and whether proposed permitted levels of livestock grazing may impact these populations (personal communication Wayne Ludington, Price BLM Field Office, August 2003).

Recreation/ORV Use

General recreation, hiking: The San Rafael Swell is a popular recreation area because of its proximity to large population centers along the Wasatch Front. The easy access, network of

roads, and scenic landscape provide virtually unlimited recreational opportunities for people traveling from nearby population centers like Denver, Las Vegas, and especially Ogden, Salt Lake City, Provo and their suburbs.

Human traffic is a considerable threat to *S. psoraloides*, especially in light of the increased popularity of the San Rafael Swell for vacationers and recreationists. Requiring hikers to remain on designated routes may be an important management provision that could benefit *S. psoraloides*. Because many of the places where *S. psoraloides* has been discovered have already been developed for human access (within one kilometer of a road) the need for careful assessment of the risks that human traffic may pose is all the greater.

In terms of specific threats of hikers, campers and recreationists to *S. psoraloides* populations, the Jessie's Twist population site is right in the middle of a very popular site for camping, trailer camping, hiking, ORV staging, dinosaur bone hunting, and other forms of desert recreation (personal communication Ray Bloxham, Utah Wilderness Coalition, August 2003). And the Keesle Country population site is right off the main road to Hidden Splendor, one of the most popular tourist destinations in the San Rafael Swell.

ORV use: Off-road vehicle (ORV) use⁶ presents another highly potential disturbance to *S. psoraloides*. This disturbance can certainly be manifested through the obvious impact of vehicles running over plants and either killing the plant outright or destroying flowers and thus the ability to set fruit and seed. Documented ORV impacts on vegetation range from complete denudation of large staging areas to selective kill-off of the most sensitive plants. Ultimately, web-like networks of ORV trails coalesce into broad areas largely denuded of vegetation. Seedlings, and seeds germinating within the ground, are some of the most sensitive organisms to ORVs and are easily killed outright or buried (Bury 1977, CEQ 1979). Indirect impacts on young plants include the upsetting of water storage, soil infiltration rates, and thermal structure of soils; these are all ORV related deficiencies that that can disrupt seed germination and seedling growth (Davidson and Fox 1974).

While the potential damage ORVs cause to plants is obvious, it is the indirect effects these vehicles can have on desert soils that may be more insidious to *S. psoraloides*. Initial physical impacts of ORVs result in stripping the surface of small plants and mechanical crusts, which stabilize the soil (Wilshire 1983, Belnap 1995). At the same time that the land is denuded, soils are compacted. Maximum compaction of typical sandy loam soils of western arid lands is attained in only 10 passes of a motorcycle on a dry, level surface (Webb 1983). Soil compaction takes place in a cylinder beneath the tracks, reaching depths of 30 cm, and soil loosening (by shear) takes place in shallow zones on both sides of the cylinder of compaction. Loss of the insulating effects of plant cover and changes in the heat capacity of compacted soils causes soil temperatures to increase by as much as 10° C in daytime and decrease by as much as 3° C in nighttime (Webb et al. 1978, Wilshire et al. 1978). Soil compaction further reduces infiltration of water, resulting in ponding in tracks and rapid evaporation, or shedding of incident precipitation by runoff. Either way, the shallow subsurface soil biota are denied their normal moisture supply. As with soil compaction, the

⁶ ORV use includes dirt bikes, All-Terrain Vehicles, jeeps, motorcycles, dune buggies, etc.

reduction of infiltration rates quickly reaches a maximum after only 10 or so passes of a motorcycle (Webb 1983). Most southwest desert soils are susceptible to the above documented effects of ORVs. The USGS conducted an 18 month study on 200 ORV sites in California, Utah and Nevada, and found that all soil types examined were vulnerable to ORV damage, except certain dry lake deposits and clay rich soils with <10% slopes (CEQ 1979). *S. psoraloides* is not known to inhabit either of these two soil types.

In terms of the impacts of ORV use to *S. psoraloides* specifically, many of the documented populations are immediately adjacent frequently traveled roads and popular ORV routes (Figure 4). At the Caineville Reef Flats population site, D. Clark reported serious conservation concerns for this site, noting recreational vehicle traffic through the site, and both ORV tracks and dirt bike tracks. Overall, she rated the site “poor” in terms of defensibility from threats to population viability (Clark 2001). She also gave the site the lowest possible score (1 point) for the BLM’s overall vulnerability rating. A vulnerability rating of 1 means that the population is at high risk, and the area is within ¼ mile of a maintained primary road.

Neese similarly reported observed threats to survival to the Type/North Caineville population in her 1986 survey, including ORV tracks (Neese 1987). Today, the extremely high levels of use at the Type/North Caineville population are spurred by the fact that this entire area is completely “Open” to all cross-country vehicle use (BLM 1983b). The area (on and near the popular Caineville Reef) is dominated by the Mancos Shale formation, a substrate that tends to be challenging for ORV riders and is thus very popular among ORV users. Additionally, the road that goes right through the area that houses the Type/North Caineville population has a great deal of ORV spur roads and trails coming off of it (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). It is estimated that the Type/North Caineville Site receives use from 500 ORV riders each year, and many of those users are traveling cross-country and certain localized areas are seeing much greater ORV activity than even a few years ago (personal communication Tim Finger, BLM Richfield Field Office, October 2003 and January 2004).

Other *S. psoraloides* population sites are currently suffering a similar fate to those in the Caineville area. The Well Draw population site is in an area with sand dunes, which are very popular for ORV enthusiasts, and an ORV route goes right through or very nearby the population there (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003). Tom Gnojek with the BLM’s Price Field Office doesn’t doubt that this site will soon be “discovered” by ORV users (personal communication Tom Gnojek, October 2003). Surveyor and botanist Debra Clark also reported conservation concerns for the Gypsum Badlands population site, noting the road to Seger’s Hole, which runs very close to the population (Clark 2001). The Hunts Draw population site is also seeing ORV abuses. The Hunts Draw site is just over the border between the Richfield and Price Field Office boundaries, and with the new conditions in BLM’s 2003 San Rafael Travel Plan, the area north of the Emery County boundary is limited to signed areas only (BLM 2003). However to the south of the boundary in the BLM’s Richfield Field Office, the area is completely open to ORV use (BLM 1983b and BLM 1988). Unfortunately, most riders either ignore or are unaware of the new restrictions as they cross over the Field Office boundary to the north

(personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003), putting the *S. psoraloides* population at Hunts Draw in considerable peril. Tom Gnojek of the Price BLM Field Office agrees that ORV use could be a problem at Hunts Draw today, acknowledging that the area is a “no man’s land,” and that the routes are likely lacking the proper signage (personal communication, Tom Gnojek, October 2003). Tim Finger, also with the Utah BLM Recreation staff, notes that the unregulated cross country travel at Hunts Draw must certainly pose a problem for rare plants at Hunts Draw (personal communication Tim Finger, January 2004). Moreover, the same problem is occurring at the Little Wild Horse Mesa population site, also just over the Field Office boundary and receiving the same sort of abuse by ORV riders (personal communication Ray Bloxham, Utah Wilderness Coalition, October 2003).

Yet another area of concern is the Green River Cutoff population sites in Emery County (both the north and south segment). The San Rafael Swell Travel Plan designates this area as completely open to ORV use (BLM 2003), and the BLM allows a competitive motorcycle race right through the exact lands that house both the Green River Cutoff North and Green River Cutoff South populations. The motorcycle race is typically held every 2-3 years, usually have an average of over 100 riders, and the route does not have to be limited to existing routes and trails; the racecourse typically follows wash bottoms, cattle trails and other “ways” (personal communication Tom Gnojek, Price BLM Field Office, October 2003). After the most recent race (November 2003) Tom Gnojek of the BLM Price Field Office admitted, “the [racecourse] area does look a little hammered, there’s no doubt” (personal communication Tom Gnojek, January 2004). Currently, the organizers of the race (the “Sage Riders”) are pushing for the entire racecourse to become a designated ORV route in the upcoming San Rafael RMP revision.

The San Rafael Swell region has shown greatly increased ORV use in recent years and those populations near roads and popular ORV routes are at considerable risk. The increase in user-days in the San Rafael Swell is indicative of a recent, massive upswelling in ORV use in the state of Utah. Recent years have seen ORV registrations and sales dramatically increase throughout Utah, with state registration for ATV’s and dirt bikes up a startling 294% in just five years; climbing from 34,000 machines registered in 1997 to over 127,000 in 2002 (<http://www.blm.gov/utah/vernal/localnews.html>, Salt Lake Tribune, May 12, 2003). BLM has been very slow to react to this explosion in use, and as a result, the lands are impacted more than they should be.

In summary, ORV use threatens nearly all occupied and potential habitat of *S. psoraloides*. Moreover, Elizabeth Neese, who has extensively surveyed for this plant, reported that “the habitat used by *Sphaeralcea psoraloides* is the kind of habitat that ORV-ers like” (personal communication, Elizabeth Neese). Rick Collins, another surveyor of *S. psoraloides* agrees that ORV use poses a huge problem to this species (personal communication Rick Collins, September 2003). Even though the San Rafael RMP designated most ORV use to “limited to existing roads and trails” (BLM 1991, and this designation was finally implemented in the 2003 San Rafael travel Plan), in reality the BLM does not have the man-power to police and enforce ORV restrictions throughout *S. psoraloides* habitat in the Price Field Office, and only routes clearly signed have any chance

of limiting use to existing trails. And of course, in the Richfield Field Office, many areas are left completely open to ORV use (BLM 1983b, BLM 1988). This means that only a fraction of routes in the San Rafael Swell really have any chance of seeing use limited to trails. In general, unregulated and abusive ORV use in the San Rafael Swell is likely to constitute one of the principle present or future threats of destruction, modification, or curtailment of habitat available within the range of *S. psoraloides*. Larry England of the USFWS Field Office in Salt Lake City believes that ORV activity may in fact represent the most insidious threat to *S. psoraloides* at this time (personal communication Larry England, 2003).

Oil and gas exploration and development

Another one of the most severe threats facing *S. psoraloides* is expedited oil and gas leasing, exploration, and development in the San Rafael Swell. In fact this threat may very well constitute the principle present or future threat of destruction, modification, or curtailment of habitat available within the range of *S. psoraloides*. All forms of oil, gas, and mineral extraction are associated with surface disturbances that may result in destruction of *S. psoraloides* and/or its habitat. Access roads, pipelines, well pads, and mines all may destroy habitat for this species.

There are multiple layers of disturbance that are widely known to accompany oil and gas development. Access roads permanently reduce and fragment habitat, and provide additional long-term opportunities for off-road vehicle intrusions into sensitive habitats. The amount of road development per well pad constructed is partly a factor of well density, but recent estimates include one mile of road per oil well (USDA-USFS Bridger-Teton National Forest 2000), 0.4 miles of road per conventional natural gas well (USDI-BLM, Pinedale Field Office 2000), and 0.3 miles of road per coalbed methane well (USDI-BLM, Buffalo Field Office 2002). Comer (1982) explains that after an oil or gas field is developed, one can expect increased recreation, particularly by ORVs. New roads, powerlines, pipelines, and railroad tracks are often constructed, further reducing and fragmenting habitat (Weller et al. 2002). Ground disturbances may introduce noxious weeds (Shuman and Whicker 1986), eliminate mycorrhizal fungi (Knapp 1996), and destroy biological soil crusts (Belnap 1995). Compressor stations and well pumps release pollutants into the air, and waste products contaminate habitat (Clarren 1999; Clifford 2001). Particularly insidious for species like *S. psoraloides*, oil, gas and mining development can remove rock outcrops that provide important habitat for specialized species such as *S. psoraloides* (Weller et al. 2002, citing BLM 1999).

Seismic exploration involving the use of vibroseis, or shot hole technology, is the precursor to oil and gas drilling, and is very destructive to sensitive plants and fragile desert soils. Vibroseis testing crushes large swaths of vegetation, destroys biological soil crusts, compacts soils, buries vegetation, decreases nitrogen fixation activity, introduces noxious weeds, and increases soil erosion by wind and water (Boyle and Connaughton 2002; BLM, Moab Field Office 2002). Even shot hole exploration may require the use of vehicles such as drilling rigs and recording trucks (Evans 1997). The effects of seismic exploration are long-lasting, and may persist for 50-300 years after activity ceases (BLM, Moab Field Office 2002; Belnap 2002). Routes used for seismic exploration often turn into established roads

(McLellan and Shackleton 1989; Crawford 2001; Zimmermann 2001; Belnap 2002; BLM, Moab Field Office 2002; Conway 2002). In fact, the BLM has acknowledged that tracks from seismic exploration conducted in the 1970's remain visible in 2002, and are often used as roads and trails by motorized vehicles (BLM, Moab Field Office 2002). Belnap (2002) observed ORV's using seismic tracks outside of Moab, despite BLM efforts to prevent this from happening.



Figure 5. Vibroseis trucks on the West Pinedale 2D Geophysical Exploration Project Area, Green River Basin, Wyoming. Photo by Scott Groene.

There have been very limited scientific studies of the impacts of vibroseis trucks on desert soils, but one study completed by Menkens and Anderson (1985) in Wyoming reported that soil compaction within the vibroseis truck tire tracks was significantly higher than in untracked areas, and remained so 14 months after the study was completed. An even later visit to the site (two years after the study was completed) revealed that vegetation within the tire tracks had yet to recover. It is noteworthy that only one vibroseis truck was used in the Wyoming study - but typically multiple trucks are used in seismic exploration (Evans 1997; BLM, Moab Field Office, 2002).

Few detailed scientific studies have been made of the effects of soil compaction on desert plant form and function. Such studies of single passes of tanks on maneuver in the Mojave Desert, however, show that such effects are certain to occur (D. Prose, unpublished data). Prose's studies show long-term effects of both soil compaction and surface disturbance caused by a single pass of a tank on typical Mojave Desert soil. These effects include larger numbers of annual plant species growing within tracks compared to adjacent undisturbed areas, but the plants in the tracks are much smaller and provide less cover for the soil than individuals of the same plant species in control areas. Further, the species composition shifts so that annual plants with lateral root spreading grow more easily within the tracks than those with vertical taproots, because a veneer of sediment accumulates in the track depressions resting on a zone of compacted soil less than a centimeter below the surface. These studies

of tanks, which are not as heavy as vibroseis trucks, indicate that profound alternations of the desert plant community can ensue as the result of seismic exploration.

The ability of *S. psoraloides* to recover from disturbances such as oil and gas exploration, development and mining have not been studied, but the likelihood of a small population (as most of the known *S. psoraloides* populations are) being able to recover from such disturbances are slim (personal communication Mark Porter, August 2003). This plant is not considered to be a “pioneer” plant, and will not readily move into profoundly disturbed sites (personal communication Stan Welsh, October 2003). One of the key traits that enables a population to withstand impacts such as drilling and site clearing is not the number of seeds produced by the population in its effort to recolonize, but rather the success of seedling establishment within the population after a large disturbance. With the amount of disturbance involved with oil and gas exploration and development, the chances are slim that populations would recover if these impacts were centered in the midst of a small population of individuals, regardless of the number of seeds they produce.

Currently, conventional oil and gas extraction leasing on Utah BLM lands is increasing at an accelerated rate (<http://ogm.utah.gov/oilgas/default.htm>). From 1999 to 2002, the BLM sold 688 federal oil and gas lease parcels involving almost 975,000 acres of public lands in Utah, primarily in eastern and southeastern Utah. These expedited lease sales are resulting in more permits to drill; between January 2000 and January 2004, the Utah BLM approved over 3,000 of the Applications for Permit to Drill that they received. The oil and gas exploration and development that will soon be underway in the San Rafael Swell could have a considerable impact on *S. psoraloides* populations and populations of other rare desert plants in this fragile region.

BLM and SITLA continue to offer lands for lease in the San Rafael Swell without stipulations to protect *S. psoraloides* and its habitat. Recently, SITLA has offered lease parcels very close to the Green River Cutoff (north) population (Figure 6).

In addition to the threat of expedited oil and gas exploration and development in Utah, and in the San Rafael Swell specifically, wells are spaced closer now than ever before. In Colorado and Wyoming, for example, wells are permitted to be spaced every 10 acres currently (CNE 2002), while 40 years ago 640 acre spacing was the maximum permitted (Clarren 1999). The proposed Nebulous/Shenendoah oil and gas development in the Uinta Basin in Utah will use spacing of less than 40 acres (personal communication Ed Forseman, BLM, 2003; personal communication Bob Lopez, BLM, 2003). In general in Utah, spacing varies between 40 and 160 acres (personal communication, Diana Mason, Utah Division of Oil, Gas and Mining, 2003). Now new wells are being drilled in existing oil and gas fields to take advantage of more relaxed spacing regulations, thus making it harder to avoid impacts to sensitive species. In the past ten years, advanced technology has allowed for year-round drilling, which has also increased the rate of oil and gas development (CNE 2002).

Also problematic is the fact that in 2002 the national BLM office in Washington, D.C. instructed all Field Offices to include a new Threatened, Endangered and Sensitive Species stipulation, which effectively defers all analysis and consultations on these species to the

Application for Permit to Drill (APD) phase for all lease sale parcels (Bisson 2002). What this means is that even lands with known populations of sensitive and listed species may be leased for oil and gas development with no habitat analysis or consultation until an APD is filed. Restricting development at the APD phase is notoriously difficult because of the monetary investment that the leasee has already made, and the fact that the BLM is reluctant to require additional rare plant surveys.

Further, the above Bisson memo does not apply to all sensitive species, as the vague wording of the memo leaves the agency wide open to disregard sensitive species in the path of oil and gas development:

“The lease areas may now or hereafter contain plants, animals or their habitats determined to be threatened, endangered, or **other special status species**. BLM **may** recommend modifications to exploration and development proposals to further its conservation and management objective to avoid BLM-approved activity that will contribute to a need to list such a species or their habitat. BLM **may** require modifications to or disapprove proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species...” (Bisson 2002, *emphasis added*)

The fact that the new regulations on avoiding take of sensitive species is so weak illustrates that rare, sensitive, candidate, and other species of concern are likely to be in even more danger of ill-managed oil and gas exploration and development since this memo was issued from the BLM Washington headquarters.

In terms of the impacts of oil and gas exploration and development to *S. psoraloides* populations specifically, the Green River Cutoff (both North and South) populations are squarely in the middle of a large area recently leased for oil and gas exploration (Figure 6).

In addition to the threats that oil and gas wells and current and future leases pose to known populations of *S. psoraloides*, these activities pose a considerable threat whenever they are sited in the known range of the species (Figure 6). Currently, there are 15 wells that overlap potential *S. psoraloides* habitat. While eight of these wells are “shut in,” these wells could be easily brought back into production. The acreage of current and future oil and gas leases that overlap predicted *S. psoraloides* habitat is substantial. In Wayne and Emery counties, about 19,720 hectares of BLM land are already leased within the plant’s habitat without any protective stipulations, and about 6,360 hectares of SITLA lands have also been leased in potential habitat (Figure7). This is of concern, as there are still many places that may contain new populations of *S. psoraloides* that have not yet been surveyed. There are undoubtedly undiscovered populations in the region, and with the acreages being leased for oil and gas development, one or more of these unknown populations might be in the path of future seismic exploration and oil and gas development.

Mineral Extraction

The chief form of mineral extraction that is ongoing in the San Rafael Swell is gypsum mining (Figure 6 – most active mines are gypsum). The removal of gypsum from the soil

requires the complete removal of topsoil. This impacts not only the area where soil is removed, but also a larger area that includes soil spoil mounds, vehicle work areas, and access routes. There is currently an active mine near the Willow Springs population, and there are many trucks that frequently travel to and from the mine, in very close vicinity to the Willow Springs population.

The RMP for the San Rafael states that over 290,000 acres on the west side of the Field Office west of the Willow Springs and Gypsum Badlands populations and squarely within the potential range of *S. psoraloides* are open for mining claims and have high potential for occurrence of gypsum (BLM 1991). In particular, there is potential for gypsum mining in and adjacent to the Gypsum badlands population site, the Chimney South population site and the East Cedar Mountain Spring population site.

Other minerals taken out of the San Rafael Swell include bentonite and zeolite. All mining involves surface disturbance. Access roads and transportation corridors must be constructed, waste rock must be disposed of, and processing facilities must be built. While mineral extraction is less widespread in *S. psoraloides* habitat than oil and gas exploration and development, this sort of mining can still cause local habitat loss and degradation. Operating mines have impacted thousands of acres in Utah and threaten even more.

Secondary impacts of mineral extraction may be the most severe. Recreation vehicle use on old mining roads is a common secondary impact. Livestock grazing use of rangelands increases in areas where mining roads now offer vehicle access to install grazing facilities and manage livestock. The management stipulations for mining rarely call for post-operation closure and restoration of mine sites or access roads.

Other Threats

A number of other potential threats to the scurfpea globemallow are still worth discussing, but at the moment likely not as potentially damaging as the threats of human traffic, grazing, ORV use, Oil and gas exploration and development, and mining outlined above. These, more minor but still potentially real, threats include:

- Road building and maintenance. Many of the populations of *S. psoraloides* (i.e. Caineville Reef Flats, Gypsum Badlands, and Keesle Country) occur very close to maintained roads. New road construction and maintenance could also impact individuals of populations, or potential habitat for the plant.
- Sand or gravel quarrying. Because *S. psoraloides* is associated with sandstone outcrops, there is the potential for use of these sites for sand or sandstone quarrying. This is particularly true for sites experiencing road maintenance or road construction where fill may be required (see Figure 6, which also depicts active sand and gravel mines).
- Pesticide Use. Although pesticides are not used to a great extent in the San Rafael Swell, use by either ranchers or the BLM could impact the pollinators of *S. psoraloides*, thereby depressing reproductive levels of the plant (Tepedino 2000). This could be true even if

spraying is somewhat distant from the population sites. This is because the home range of some of the insect pollinators can be several miles and so pesticide use over a mile away from a *S. psoraloides* population could still conceivably impact that population.

- Exotic weed infestations. Exotic weeds are slowly taking over the Intermountain West (Belnap 1998). Sites become more invasible due to increased bare soils as a result of the same activities that potentially impact *S. psoraloides*: grazing, ORV use, and mining/drilling operations. All of these activities disturb the soil, which offer greater opportunity for weed establishment, with less competition (Gelbard and Belsky, in prep, and references within). Evans and Young (1972) found that increased soil erosion (shown to be caused by both grazing and ORV use) also loosens surface soils and helps bury seeds. Exotic seeds adapted to more erosion-prone environments will benefit from this while natives likely will not. Finally, soil disturbance can further assist with weed invasions by creating warmer and drier soil microclimates through soil compaction and loss of plant, microbial crust and litter cover. The resulting warmer, drier microclimate reduces the competitive vigor of many native grasses (Piemeissal 1951, Archer and Smeins 1991), thus further increasing viability of aggressive exotics.

Once they are established weeds negatively impact western arid ecosystems in numerous ways. Weed infestations reduce biodiversity (Randall 1996), increase fire frequency (Esque 1999, Brooks et al. 1999), disrupt nutrient cycling (Vitousek 1990), alter soil microclimate (Evans and Young 1984), reduce effectiveness of wildlife habitat (Davidson et al. 1996, Knick and Rotenberry 1997), and can expedite loss of topsoil in xeric environments (Lacy et al. 1989). All of these factors can spell trouble for intrinsically rare, relatively slow reproducing species such as *S. psoraloides*.

Even in the absence of the threats listed above, *S. psoraloides* is in a delicate position due to the apparent small size of most of its populations. There is a substantial body of literature on the risks that small populations face for a wide variety of reasons (Gilpin and Soulé 1986, Lande 1987), including environmental and demographic stochasticity (Caswell 1989, Goodman 1987, Mode and Jacobson 1987, Lande 1993), Allee effects (Allee et al. 1949), and other factors. These concerns apply to this species. In many places, *S. psoraloides* faces exactly those risks because its population size may be as small as 25 individuals or less. Connectivity issues may also be a serious concern. These risks need to be considered in addition to and in concert with the particular threats outlined here.

Prolonged drought can also act in concert with one or more of the above threats to deal a crippling blow to rare endemic desert plants, especially those that already exist as small populations. Successive years of drought can have considerable consequences for perennials like *S. psoraloides* that may experience population destabilization if adult mortality increases dramatically (Caswell 1986, Silvertown et al. 1993, Hunt 2001). In particularly unpredictable and stochastic environments like deserts the sequence of good and/or poor quality seasons can be important in determining the long-term dynamics of a population and the likelihood of extirpation (EDF 1995). The impacts of prolonged drought conditions will likely exacerbate the effects of all the other threats to *S. psoraloides* described in this status review.

Different species of plants will respond to regional climate change in varying ways. Species that evolved together and adapted in response to one another's phenology may experience a loss of synchrony whereby natural events such as flowering and pollinator emergence that were once timed concurrently become offset because of differing responses to climatic cues. Species may therefore no longer be able to rely on the services once provided by other species (McCarty 2001). This may have serious implications for *S. psoraloides* pollination.

In general, regional climate change threatens to be an additional source of stress for species already threatened by local and global environmental changes, exacerbating the impacts of habitat fragmentation, for example, and increasing the risk of extinction to those species (McCarty 2001). Perhaps the best way that managers can reduce the threat of regional climate change to species and communities of concern is to effectively connect a set of core areas and reserves for species and communities, through protective management of core areas and linkages, as is consistently recommended by lead conservation biologists (Noss et al. 1999, Soule and Terborgh 1999). McCarty summarized the potential impacts of impeding regional climate change to rare species when he stated:

“Conservation scientists need to look at climate change as a current, not just a future, threat to species. Although a causal link to climate cannot yet be rigorously demonstrated, the consistent patterns indicate that the prudent course for conservation is to take these changes seriously. Certainly, cases such as the extinction of the golden toad are of immediate concern, but the changes in climate need to be taken into account as a possible factor contributing to declines in other species” (McCarty 2001)

Summary, threats to scurfpea globemallow

Stanley Welsh, noted authority on rare Utah flora observed:

“The impress of man and his activities onto the natural habitats of Utah has reduced the area available to most native or indigenous plants.....With the advent of the second half of the twentieth century, there has occurred a resurgence of economic activities, mineral exploration, and a greater use of the public lands which hitherto had been considered as useful (if considered useful at all) only for grazing and watershed [purposes]....Plant species which were once remote from the impacts of civilization - industrial, agricultural, or recreational activities - are now threatened not only by the effects of ranching, construction, and off-road travel, but even by the very agencies of the government which are established by law to oversee in the public trust the proper use and protection of the public lands. At the present time, hardly a part of Utah, even that set aside as national parks, monuments, or wilderness areas, is safe from degradation by masses of people or by those seeking to exploit the very natural resources and features these areas were established to protect. Inroads into the most remote and most arid portions of the state now guarantee further reduction of the unique flora of Utah. Naturally, those entities that will suffer the greatest from the commercialization of the state will be those which have specific and naturally restricted areas of distribution. Only the most

enlightened management and protection from unreasonable exploitation will ensure the continuation of the rich indigenous flora that these plants represent...” (Welsh 1975).

Nearly 30 years later, the threats cited by Welsh, above, are as real as ever – indeed, there are many indications that they have increased considerably. As outlined above, the chief threats facing *S. psoraloides* include livestock grazing, off-road vehicle (ORV) use, and most certainly expedited energy exploration in the region. Mineral extraction – chiefly in the form of gypsum mining – may also pose a considerable threat to certain populations. These chief threats, and their level of impacts to known, extant populations of *S. psoraloides*, are featured in Table 2. Sand and gravel quarrying, road construction and maintenance, pesticide use, and exotic weed infestations are lesser threats.

Table 2 – comprehensive threats Table – model after G. tenuis threats table

V. ADEQUACY OF EXISTING REGULATORY MECHANISMS AND MANAGEMENT

Based on the limited and small populations of *S. psoraloides*, and the significant threats they are currently facing, it is obvious that ongoing and existing regulatory mechanisms, primarily under the auspices of the Bureau of Land Management, have been ineffective in conserving this species to the extent that the overall meta-population is guaranteed to be viable well into the future.

Federal regulations: Currently, no federal laws specifically protect plant species that are not already on the federal Threatened or Endangered Species List, or are official candidate species. In absence of these designations, BLM’s regulatory mechanisms are generally inadequate to prevent extirpations on BLM managed lands. As such, we generally see industrial development spreading into areas occupied by sensitive species, harmful grazing practices remaining unchanged, and typically little or no conservation measures being taken for the sake of sensitive species.

BLM Management at State Level: *Sphaeralcea psoraloides* is currently listed on the Sensitive Species List of the state office of the BLM. Under this designation, the BLM has an internal guidance to ensure that actions authorized on BLM administered lands do not contribute to the need to list any Special Status Species (BLM Manual Section 6840.06C&E). However, this internal policy is not actively enforced, as evidenced by general lack of BLM monitoring of sensitive species and lack of written conservation plans.

Currently, the BLM State Office is in the process of conducting detailed status reviews of all plants on the newly revised BLM Sensitive Species list for Utah (personal

communication, Ron Bolander, 2002), including one for *S. psoraloides*. At this time, it is unclear what the findings of this status review will do in terms of improving management and protection of this rare and sensitive species.

Management at the BLM field office level: Currently, all areas known to contain extant populations of *S. psoraloides* are managed by the BLM.⁷ The majority of these lands are managed under the San Rafael Resource Management Plan (RMP) (BLM 1991), though some populations are covered under the Price River Field Office Management Framework Plan (MFP) (BLM 1989), and some under the Henry Mountains MFP (BLM 1983b and 1988).⁸ The RMPs state that no management action will be permitted on public lands that will jeopardize the continued existence of species considered to be sensitive by the BLM in Utah (BLM 1991). As of now no habitat management plan has been written for *S. psoraloides* by the Price or Richfield Field Offices.

Currently, two of the known, extant, *S. psoraloides* populations occur right on the boundary of Areas of Critical Environmental Concern (ACEC) (Figure 7). This includes the Little Wild Horse Mesa population on the border of the Crack Canyon ACEC, and the Keesle Country population right on the border of the Muddy Creek ACEC. In addition, these same two *S. psoraloides* populations occur on the border of Wilderness Study Areas (WSAs). This includes the Little Wild Horse Mesa population on the border of the Crack Canyon WSA, and the Keesle Country population right on the border of the Muddy Creek WSA.

It is questionable whether ACEC and WSA designations afford adequate protection to these populations. ACEC designation in itself does not automatically confer any additional protections to an area, and no specific management plans have been written for any of the ACECs known to contain populations of *S. psoraloides*. While the ACECs that contain *S. psoraloides* have No Surface Occupancy Stipulation, they can still be leased (BLM 1991, personal communication Tom Gnojek, 2002) and even the No Surface Occupancy stipulations can have various exceptions and modifications that may still permit the destruction of rare plants. In addition, when the ACECs and WSAs that contain *S. psoraloides* were designated, no reductions were made in cattle stocking rates. ORV use remains on some existing routes and trails within the ACECs and WSAs (BLM 1991, personal communication Tom Gnojek, 2002). The impacts these particular activities can have on *S. psoraloides* populations are outlined in the threats section, above.

Management by the State: There is no State Threatened and Endangered Species law that may afford protection to special status plants that are not covered under the ESA, such as *S. psoraloides*. This makes it even more likely that these Sensitive species will never be

⁷ There are three populations that occur on School Institutional Trust Lands Administration (SITLA) holdings, but these lands tend to be managed in effect by the BLM.

⁸ Currently the RMP's for both the Price and Richfield BLM Field Offices are being revised. At the time of publication of this status review, drafts of the revised RMPs were not available for review. However, personal conversations with planning staff from both Field Offices conveyed that presence of non federally listed sensitive plant species are not being given strong consideration in terms of limiting prescribed land uses in the revised RMPs (personal communication, Dave Mills, Price Field Office; personal communication, Frank Erickson, Richfield Field Office).

adequately protected in Utah. Even the State Natural Heritage Program, housed within the Utah Department of Natural Resources Division of Wildlife Resources, does not actually keep an official State Sensitive Plant and Species of Special Concern list (personal communication, Ben Franklin 2002, personal communication Ron Bolander 2002). Rather, sensitive plant lists are only kept by the U.S. Forest Service (at the Regional level) and BLM (at the statewide level) in Utah.

The Chimney South, Caine Springs, and Tidwell Draw populations overlap SITLA holdings. This does not confer any special protection to rare plants on those holdings. Even if the species were protected under the ESA, occurrences on SITLA lands would receive no protections. SITLA does not consult with the U.S. Fish and Wildlife Service. In addition, SITLA often offers its lands for state oil and gas leasing.

Summary, inadequacy of existing regulatory mechanisms and management: In summary, current management and regulatory mechanisms, primarily under the responsibility of the BLM, are likely to be ineffective in ensuring secure populations of *S. psoraloides*. Perhaps only the legal protections afforded by the ESA will result in substantive management changes that will ensure the persistence of this species on BLM lands.

VI. ASSESSMENT AND CONSERVATION RECOMMENDATIONS

The scurfpea globemallow deserves particular attention and conservation efforts because of its limited distribution and abundance, it occurs in rare ecosystems of high biological value, it is sensitive to disturbance of various kinds, and it is imminently threatened by several sources of disturbance, namely future energy exploration and development, overgrazing, and ORV use. As discussed above, it is clear that the species is very rare relative to the extent of habitat within which it occurs; only 18 populations are known to exist. Based on the limited information available the most informed, and conservative, estimation would put the current population somewhere between 1,850 and perhaps 5,000 individuals. Most of these populations are quite small, and many are threatened or potentially threatened by some form of disturbance. In general, *S. psoraloides* is likely to be highly susceptible to these disturbances because it has relatively narrow habitat requirements, and as it is a relatively long-lived species and is not a particularly “fast reproducer,” it is not likely to recover quickly from disturbance. Moreover, the plant is not known to move readily into disturbed systems or to do well in disturbed habitats.

Many *Sphaeralcea* surveyors, prominent Utah botanists, and experts in rare endemic flora of the San Rafael Swell and the Colorado Plateau agree that *S. psoraloides* is a rare species (personal communication Ron Kass August 2003, personal communication Bob Thompson August 2003, personal communication Frank Smith August 2003, personal communication Jim Harris September 2003), it has a very limited distribution (personal communication Larry England 2003), and that it faces very real threats in certain portions of its range, especially ORV use (personal communication Larry England 2003, personal communication Rick Collins September 2003,) and oil and gas extraction (personal

communication, Erin Robertson 2004). Nearly all botanists agree that additional surveys are definitely needed (i.e. Duane Atwood, personal communication October 2003, and many others). Merton A. (Ben) Franklin, botanist with the state Natural heritage Program, confessed, "I've been worried about [*Sphaeralcea psoraloides*] and have wanted to do a project on it," but admits that with a plant that has so few individuals in many distant locations and on a variety of geologic strata, the time and money needed for a comprehensive status review precludes the Heritage Program from conducting such a study now (personal communication Ben Franklin 2003).

Given what is now known about the state of the scurfpea globemallow overall, the importance of the rare habitats where it is found, the recent genetic evidence that it is rapidly evolving, and the concerns voiced by prominent Utah botanists, it is appropriate to recommend that immediate measures be taken to protect the known populations and provide for the full biological recovery of this imperiled species. With possibly no more than 18 populations of the plant in existence, and the majority of those impacted or potentially impacted by a variety of human disturbances, conservationists and land managers need to implement immediate efforts to mitigate the damage already done to the habitat of *Sphaeralcea psoraloides*, and to develop strategies to protect known populations from future threats. This would most likely be accomplished with a formal listing of the species as either threatened or endangered, under the Endangered Species Act.

Even in cases where we lack a full understanding of the complex relationship between *S. psoraloides* and some disturbances, such as cattle grazing, we should still respond preemptively to protect all existing populations, given the overall scarcity of the species. For example, there is sufficient evidence about the potential threat of trampling by cattle and off-road vehicles to warrant some protection, such as restricting vehicles to designated routes, fencing, and potentially closing areas altogether in many locations.

The threats to *S. psoraloides* and to all sensitive, xeric vegetative communities in the San Rafael Swell and southern Utah have been widely recognized. As discussed above, there has been a long list of conservation initiatives suggested for the San Rafael Swell, indicating that those who propose those initiatives appreciate the biological importance and ecological uniqueness of this region - including the myriad of rare endemic plants found here. Today this region is gravely threatened by greatly increased ORV use and expedited oil and gas exploration and development. It is clear that the impetus for listing the species, now more than ever, is strong.

There is also a clear and pressing need for more surveys of *S. psoraloides* throughout the San Rafael Swell, and possibly in additional locations, such as in the entirety of Capitol Reef National Park and surrounding public lands. Its especially important that surveyors visit the area immediately west of Jessie's Twist population site where Stan Welsh has reported a "continuous stretch" of *S. psoraloides* from just south of where Interstate I-70 crosses the eastern footslope of the San Rafael Swell and which is said to continue along the footslope for perhaps many miles south along the Swell. Other research efforts, necessary to answer unsolved questions about the ecology of the species, the role of disturbance plays in the distribution and health of populations, and demographics of specific populations, are

certainly warranted and urgently needed. Genetic work on the scurfpea and its relationship with cogenitors is underway, but not yet completed. Further research should include studies on pollinators; seed dispersal, seed germination and establishment experiments including experiments in seed longevity; and especially more detailed monitoring of known populations to further our understanding of demography, population stability and status of those populations.

VII. LITERATURE CITED

- Allee, W.C., A.E. Emerson, O. Park, T. Park, and K.P. Schmidt. 1949. Principles of animal ecology. Saunders, Philadelphia.
- Archer, S. and D.E. Smeins. 1991. Ecosystem level processes. Chapter 5 in: (R.K. Heitschmidt and J.W. Stuth, eds.) Grazing management: an ecological perspective. Timber Press, Portland OR.
- Atwood, D., Holland, J., Bolander, R., Franklin, B., House, D., Armstrong, L., Thorne, K. And L. England. 1991. Utah threatened, Endangered, and Sensitive plant field guide. Jointly published by the USFWS, BLM, NPS, Utah Nat. Heritage Progr, and The Nature Conservancy. Salt Lake City, UT.
- Beissinger, S.R. 2000. Ecological mechanisms of extinction. Proceedings of the National Academy of Science of the United States of America 97: 11688-11689.
- Belnap, J. 1995. Surface disturbances—their role in accelerating desertification: Environmental Monitoring and Assessment. 37: 39-57.
- Belnap, J. 1998. The biota and ecology of the Grand Staircase Escalante National Monument. Pp. 21-30 in: R. B. Keiter, S. B. George, and J. Walker (eds.) Visions of the Grand Staircase Escalante. Utah Museum of Natural History and Wallace Stegner Center, Salt Lake City, UT.
- Belnap, J. 2002. Letter from Jayne Belnap, Field Station Leader, U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center, Canyonlands Field Station to Maggie Wyatt and Bill Stringer, Moab BLM Field Office. 17 January 2002. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center, Canyonlands Field Station, Moab. 4 pp.
- Bisson, H.R. 2002. Oil and gas leasing stipulations. Instruction Memorandum No. 2002-174 from Henri R. Bisson, Acting Director, U.S. Dept. Of the Interior, Bureau of Land Management to all WO and FO Officials. 21 May 2002. 2 pp. plus attachments.
- BLM (Bureau of Land Management). 1983a. Final Henry Mountain Grazing Environmental Impact Statement. BLM Richfield Field Office, Richfield, UT.
- BLM (Bureau of Land Management). 1983b. Henry Mountain Management Framework Plan. BLM Richfield Field Office, Richfield, UT.

- BLM (Bureau of Land Management). 1988. Henry Mountain Coordinated Resource Management Proposals, Final Environmental Impact Statement. BLM Richfield Field Office, Richfield, UT.
- BLM (Bureau of Land Management). 1989. Decision of Record and Finding of No Significant Impact for the amendment to the Management Framework Plan for the Price River Field Office. BLM Price Field Office, Price, UT.
- BLM (Bureau of Land Management). 1991. San Rafael Field Office Resource Management Plan. Price Field Office, UT.
- BLM (Bureau of Land Management). 1999. Draft EIS for the Pinedale anticline oil and gas exploration and development project, Sublette County, WY. US Dept of Int.< BLM, Pinedale Field Office, Pinedale, WY.
- BLM (Bureau of Land Management) 2002. Yellowcat Swath 2D Geophysical Project Environmental Analysis. Bureau of Land Management, Moab Field Office, Moab, UT. 25 pp. plus appendices.
- BLM (Bureau of Land Management) 2003. The San Rafael motorized route designation plan. BLM Price Field Office, Price, UT.
- Boyle, S., and L. Connaughton. 2002. Yellow Cat Swath 2-D Geophysical Project: current and potential ecological impacts. 10 April 2002. Bio-Logic Environmental, Montrose. 38 pp.
- Brotherson, J.D. and W.T. Brotherson. 1981. Grazing impacts on the sagebrush communities of central Utah. *Great Basin Nat.*, 41: 335-340.
- Bury, R.B. 1977. Effects of off-road vehicles on vertebrates in the California desert. Washington, DC: Dept of the Interior: USFWS pub.
- Caswell, H. 1986. Life cycle models for plants. *Lectures on mathematics in the life sciences* 18:171-233.
- Caswell, H. 1989. Matrix population models. Sinauer Associates, Sunderland, Massachusetts.
- CEQ (Council on Environmental Quality). 1979. Off-road vehicles on public land. Council on Env. Quality, Washington, DC. PrEX 14.2: V53.
- Clark, D.J. 2000. 2000 survey results for Mussentuchit gilia (*Gilia tenuis*). Unpubl. Survey report. Joint effort of Capitol Reef National Park and Bureau of Land Management, Richfield Field Office.

- Clark, D.J. 2001. 2001 survey results for Mussentuchit gilia (*Gilia tenuis*). Unpubl. Survey report. Joint effort of Capitol Reef National Park and Bureau of Land Management, Richfield Field Office.
- Clarren, R. 1999. Oil wells in my backyard? High Country News. 15 March 1999. Paonia, CO.
- Clifford, H. 2001. Wyoming's powder keg. High Country News. 5 November 2001. Paonia, CO.
- CNE (Center for Native Ecosystems). 2002. Petition for a rule to list Graham's penstemon (*Penstemon grahamii*) as Threatened or Endangered under the Endangered Species Act, 16 U.S.C. 1531 et seq. (1973 as Amended) and for the designation of Critical Habitat; Petition for an Emergency Listing Rule under the Endangered Species Act, 16 U.S.C. 1533 (b)(1)(c)(iii) and 1533 (b)(7) and 50 C.F.R. 424.20. Petition brought by the Center for Native Ecosystems, Boulder, CO. October, 2002.
- Comer, R.D. Understanding secondary effects of development on wildlife resources in mitigation planning. Pps. 16-31 in: (Comer et al., eds.) Proceedings of the second symposium on issues and technology in the management of impacted western wildlife. Thorne Ecological Institute, Boulder, CO.
- Conway, K. 2002. UDWR comments on EA #UT-062-02-013 (Yellow Cat 2-d Geophysical Project). Letter from Kevin Conway, Interim Director, Utah Department of Natural Resources, Division of Wildlife Resources to Margaret Wyatt, Moab Field Office – BLM. 22 January 2002. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 2 pp.
- Cook, C.W. and R.D. Child. 1971. Recovery of desert plants in various states of vigor. *Journal of Range Management* 22:339-343.
- Crawford, B. 2001. Coalbed methane: one way road to environmental degradation. A study of road-related impacts during development. Unpublished report prepared for Wildlands Center for Preventing Roads. 19 December 2001.
- Cronquist, A.H., Holmgren, N.H. and J.L. Reveal. 1972 *Intermountain Flora*. Vol. 1. Hafner Press. New York, NY.
- Davidson, E. and M. Fox. 1974. Effects of off-road motorcycle activity on Mojave desert vegetation and soil. *Madrono* 22: 381-412.
- Darin, T.F., and T. Stills. 2002. Preserving our public lands: a citizen's guide to understanding and participating in oil and gas decisions affecting our public lands. Land and Water Fund of the Rockies, Boulder. 98 pp.
- Drut, M. S. 1994. Status of sage grouse with emphasis on populations in Oregon and Washington. Portland Audubon Soc. Portland, OR.

EDF (Environmental Defense Fund). 1995. *Defending the desert: conserving biodiversity on BLM lands in the southwest*. Spec. pub of the Env. Defense Fund. New York, NY. 1995.

Esque, T. C. 1999. *Abstract*. Managing fire and invasive plants in the Mojave Desert: defining an integrated research program to address knowledge gaps. Mojave Desert. Science Symposium. Las Vegas, NV. 25 February 1999.

Evans, B.J. 1997. *A handbook for seismic data acquisition in exploration*. Geophysical Monograph Series Number 7. W.H. Dragoset, Jr., Vol. ed. D.V. Fitterman, Series ed. Society of Exploration Geophysicists, Tulsa. 305 pp.

Evans, R.A. and J.A. Young. 1972. Microsite requirements for establishment of annual rangeland weeds. *Weed Science* 20:350-356.

Evans, R.A. and J.A. Young. 1984. Microsite requirements for downy brome infestation and control on sagebrush rangelands. *Weed Science* 32, Supplement 1: 13-17.

Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8: 629-644.

Floyd-Hanna, M.L. Fleischner, T.L. and D. Hanna. 2000. Effects of historic livestock grazing on vegetation at Chaco Culture National Historic Park. Final Report Environmental Studies Program, Prescott College. Project #CHCU-R98-0819.

Gelbard, J.L. and J.A. Belsky. In prep. Livestock grazing: a major cause of exotic plant invasions in the American West.

Gilpin, M.E., and Soulé, M.E. 1986. Minimum viable populations: processes of species extinction. In: Soulé, M.E. (ed.), *Conservation biology: The science of scarcity and diversity*. Pp. 19-34. Sinauer Associates, Sunderland, Massachusetts.

Goodman, D. 1987. The demography of chance extinction. In: Soulé, M.E. (ed.). *Viable populations for conservation*. Pp. 11-34, Cambridge University Press, Cambridge.

Green, D.M. and J.B. Kauffman. 1995. Succession and livestock grazing in a northeast Oregon riparian ecosystem. *J. Range Manage.* 48: 307-313.

Hanley, T.H. and J.L. Page. 1981. Differential effects of livestock use on habitat structure and rodent populations. *California Fish and Game*, 68: 160-173.

Harper, K.T., Van Buren, R. and S. Kitchen. 1996. Invasion of alien annuals and ecological consequences in salt desert shrublands of western Utah. In: (J.R. Barrow, E. Durant, R.E. Sosebee and E.J. Tausch, eds.) *Proceedings: shrubland ecosystem dynamics in a changing environment*. Gen Tech. Rep. -338. USFS Intermountain Research Station. Ogden, UT.

Holechek, J.L., Pieper, R.D. and C.H. Herbel. 2001. *Range Management: principles and practices*. Prentice Hall, Englewood cliffs, NJ.

- Hunt, L.P. 2001. Heterogeneous grazing causes local extinction of edible perennial shrubs: a matrix analysis. *Journal of Applied Ecology* 38:238-252.
- Jones, A.L. 2001. Review and analysis of cattle grazing effects in the arid west, with applications for BLM grazing management in southern Utah. A special publication by the Wild Utah Project. Salt Lake City, UT.
- Kartesz, J.T. 1994. A synchronized checklist of the vascular flora of the United States, Canada and Greenland (2 volumes). 2nd Edition. Timber Press, Portland, OR.
- Kass, R.J. 1990a. Final report of habitat inventory of threatened, endangered and candidate plant species in the San Rafael Swell, Utah. BLM unpubl. Report.
- Kass, R.J. 1990b. Challenge cost share report for threatened, endangered and candidate plant species. BLM unpubl. Report.
- Kearney, T.H. 1935. The North American species of *Sphaeralcea* subgenus *eusphaeralcea*. *University of California Publications in Botany* 19: 1-128.
- Knapp, P.A. 1996. Cheatgrass (*Bromus tectorum* L) dominance in the Great Basin Desert: history, persistence, and influences to human activities. *Global Environmental Change* 6(1):37-52.
- Knick, S.t. and Rotenberry. 1997. Landscape characteristics of disturbed shrubsteppe habitats in southwestern Idaho. *Landscape Ecology* 12: 287-297.
- Lacy, J.R. 1987. The influence of livestock grazing on weed establishment and spread. *Proc. Mont. Acad. Sci.* 47:131-146.
- Lande, R. 1987. Extinction thresholds in demographic models of territorial populations. *American Naturalist*. 130:624-635.
- Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. *American Naturalist*. 142:911-927.
- Loope, W.L. 1977. Relationships of vegetation to environment in Canyonlands National Park. PhD. Dissertation. Utah State University.
- Marzluff, J.M. and K.P. Dial. 1991. Life history correlates of taxonomic diversity. *Ecology* 72: 428-439.
- Medin, D.E., and W.P. Clary. 1990. Small mammal populations in a grazed and ungrazed riparian habitat in Nevada. US Intermountain Research Publication: Research Paper INT-413. USDA Forest Service, Intermountain Research Station, Ogden, UT.
- Menkens, G.E., Jr., and S.H. Anderson. 1985. Final report: The effects of vibroseis on white-tailed prairie dog populations on the Laramie Plains of Wyoming. Prepared for the

U.S. Bureau of Land Management as partial fulfillment of interagency agreement #WY910-IA2-1187. Wyoming Cooperative Fishery and Wildlife Research Unit, Laramie. 21 pp.

Miller, R.F. and G.B. Donart. 1979. Response of *Bouteloua eriopada* and *Sporobolus flexuosus* to season of defoliation. *Journal of Range Management* 32: 63-67.

Mode, C.J., and M.E. Jacobson. 1987. On estimating critical population size for an endangered species in the presence of environmental stochasticity. *Mathematical Biosciences*. 85:185-209.

NatureServe. 2003. NatureServe Online Ecological Database: <http://www.natureserve.org/>

Neese, E. 1987. Final report: Habitat inventory of *Sclerocactus wrightiae* and other associated sensitive species, Volumes I and II. Report prepared for USDOI Bureau of Land Management, Richfield District Office, Richfield, UT, by Neese Investigations, Salt Lake City, UT. Contract no. UT-910-CT5-2685.

Nelson, N.J. Keall. S.N., Brown, D. and C.H. Daugherty. 2001. Establishing a new wild population of tuatara (*Sphenodon guntheri*). *Conservation Biology* 16: 887-894.

Piemeisel, R.L. 1951. Causes affecting change and rate of change in a vegetation of annuals in Idaho. *Ecology* 32: 53-72.

Randall, J.M. 1996. Weed control for the preservation of biological diversity. *Weed Technology* 10: 370-383.

Rice, B. and M. Westoby. 1978. Vegetative responses of some Great Basin shrub communities protected against domestic stock. *J. Range Manage.* 31: 28-34.

Schlesinger, W.H., Reynolds, J.F., Cunningham, G.L., Huenneke, L.F., Jarrel, W.M., Virginia, R.A., and W.G. Whitford. 1990. Biological feedbacks in global desertification. *Science* 247: 1043-1048.

Schmutz, E.M. Michaels, C.C. and B.I. Judd. 1967. Boysag Point: a relict area on the north rim of the Grand Canyon in Arizona. *J Range Manage* 20: 363-369.

Shuman, R., and F.W. Whicker. 1986. Intrusion of reclaimed uranium mill tailings by prairie dogs and ground squirrels. *Journal of Environmental Quality* 15(1):21-24.

Silvertown, J., Franco, M., Pisanty, I. And A. Mendoza. 1993. Comparative plant demography: relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. *Ecology* 81:465-476.

Tepedino, V. 2000. The reproductive biology of rare rangeland plants and their vulnerability to insecticides. In: (G.L. Cunningham and M.W. Sampson, cords.) Grasshopper integrated pest management handbook. Tech. Bull. 1809. USDA, Animal and Plant Health Inspection Service. Washington, D.C.

Thorne, R.F. 1992. Classification and geography of flowering plants. *The Botanical Review* 58: 225-348.

USDA (U.S. Department of Agriculture), Forest Service, Bridger-Teton National Forest. 2000. Oil and gas leasing Draft Environmental Impact Statement. December 2000. U.S. Department of Agriculture, Forest Service, Bridger-Teton National Forest, Jackson. 197 pp. plus appendices.

USDI (Department of the Interior), Bureau of Land Management, Pinedale Field Office. 2000. Record of Decision for the Pinedale Anticline Oil and Gas Exploration and Development Project. U.S. Department of the Interior, Bureau of Land Management, Pinedale Field Office, Pinedale. 53 pp. plus appendices.

U.S. Department of the Interior, Bureau of Land Management, Buffalo Field Office. 2002. Draft Environmental Impact Statement and draft planning amendment for the Powder River Basin oil and gas project. WY-070-02-065. January 2002.

Vitousek, P.M. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. *Oikos* 57: 7-13.

Webb, R.H.. 1983. Compaction of desert soils by off-road vehicles. Pp. 51-79 in: Webb, R.H. and Wilshire, H.G., (eds.), *Environmental effects of off-road vehicles*. Springer-Verlag, New York.

Webb, R.H., Ragland, H.C., Godwin, W.H., and D. Jenkins. 1978. Environmental effects of soil property changes with off-road vehicle use. *Environmental Management* 2: 219-233.

Weller, C., Thomson, J., Morton, P. And G. Aplet. 2002. *Fragmenting our lands: the ecological footprint from oil and gas development*. Special publication: The Wilderness Society. Denver, CO.

Werner, P.A. 1975. Predictions of fate from rosette size in teasal (*Dipsacus fullonum*). *Oecologia* 20: 197-201.

[Welsh 1975](#)

Welsh, S.L. 1978. Problems of endemism on the Colorado Plateau. *Great Basin Naturalist Memoirs* 2: 191-195.

Welsh, S.L. 1980. Utah Flora: Malvaceae. *Great Basin Naturalist* 40:27-37.

Welsh, S.L., Atwood, N.D., Goodrich, S. And L.C. Higgins (Eds.). 1993. *A Utah flora*. 2nd edition. Brigham Young University Press. Provo, UT. 986 pp.

Welsh, S.L., Atwood, N.D., Goodrich, S. And L.C. Higgins (Eds.). 2003. *A Utah flora*. 3rd edition. Brigham Young University Press. Provo, UT. [pp.](#)

Wilshire, H.G.. 1983. The impact of vehicles on desert soil stabilizers. Pp. 31-50 in Webb, R.H. and Wilshire, H.G., (eds.), *Environmental Effects of Off-Road Vehicles*. Springer-Verlag, New York.

Wilshire, H.G., Nakata, J.K., Shipley, S., and K. Prestegaard. 1978. Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area. *Environmental Geology* 2:295-319.

Wilson, E.O. and E.O. Willis. 1975. Applied biogeography. Pp. 522-534 in (M.L. Cody and J.M. Diamond, eds) *Ecology and evolution of communities*. Belknap, Cambridge. 545 pp.

Zimmermann, E. 2001. Ecological effects of seismic testing. Unpublished report for Wildlands Center for Preventing Roads. 18 December 2001.