Understanding endangered plant species population changes at Eureka Dunes, Death Valley National Park

By Jane Cipra and Kelly Fuhrmann

Figure 1. Eureka Dunes, Death Valley National Park.

Abstract

Eureka Valley dune grass (*Swallenia alexandrae* [Swallen]) and the Eureka Valley evening primrose (*Oenothera californica* ssp. *eurekensis* [Munz & Roos]) are both federally listed endangered species (43 FR 17910-17916, 26 April 1978) found only on three disjunct dune areas in the Eureka Valley of Death Valley National Park, California. Though these species have been monitored sporadically since the 1970s, habitat-wide surveys were impossible in the past without modern GPS equipment. Direct quantitative analysis of population trends over time is also problematic due to the shifting dune habitat. The last four years of monitoring have not revealed any positive or negative trends; however, comparison of photo points at Marble Canyon and on the Main Dune shows dramatic declines over the last 25 and 35 years, respectively. Factors such as climate change, visitor impacts, competition from invasive species, and plant-animal interactions may be contributing to the population declines and warrant further study.

Key words

endangered species, Eureka Valley, monitoring, *Oenothera*, rare endemic, *Swallenia*, vegetation mapping

EUREKA VALLEY IN DEATH VALLEY NATIONAL PARK, California, contains a dune system between 900 and 1,300 meters (2,953–4,265 ft) in elevation that is split into three dune areas: the Main Dune, the Saline Spur, and Marble Canyon (figs. 1 and 2). This dune complex is the entire range of two endemic species: the Eureka Valley dune grass (*Swallenia alexandrae* [Swallen]) and the Eureka Valley evening primrose (*Oenothera californica* ssp. *eurekensis* [Munz & Roos]), which are both federally listed as endangered species (43 FR 17910-17916, 26 April 1978).

Swallenia alexandrae is a perennial grass that forms stable hummocks approximately 1–3 m in diameter (3–10 ft), found primarily on the mobile sand that forms the steep slopes of the dunes (Pavlik 1979). The grass stems ascend up to 1 m high and are often branched. Although drifts of sand frequently bury *Swallenia* hummocks, giving the branching stems the appearance of multiple individuals emerging from the sand, *Swallenia* does not reproduce asexually through true rhizomes or stolons (Pavlik and Barbour 1985). Instead, *Swallenia* reproduction occurs solely by seed and appears to be dependent on warm-season rains in late summer and early fall (Pavlik and Barbour 1988).

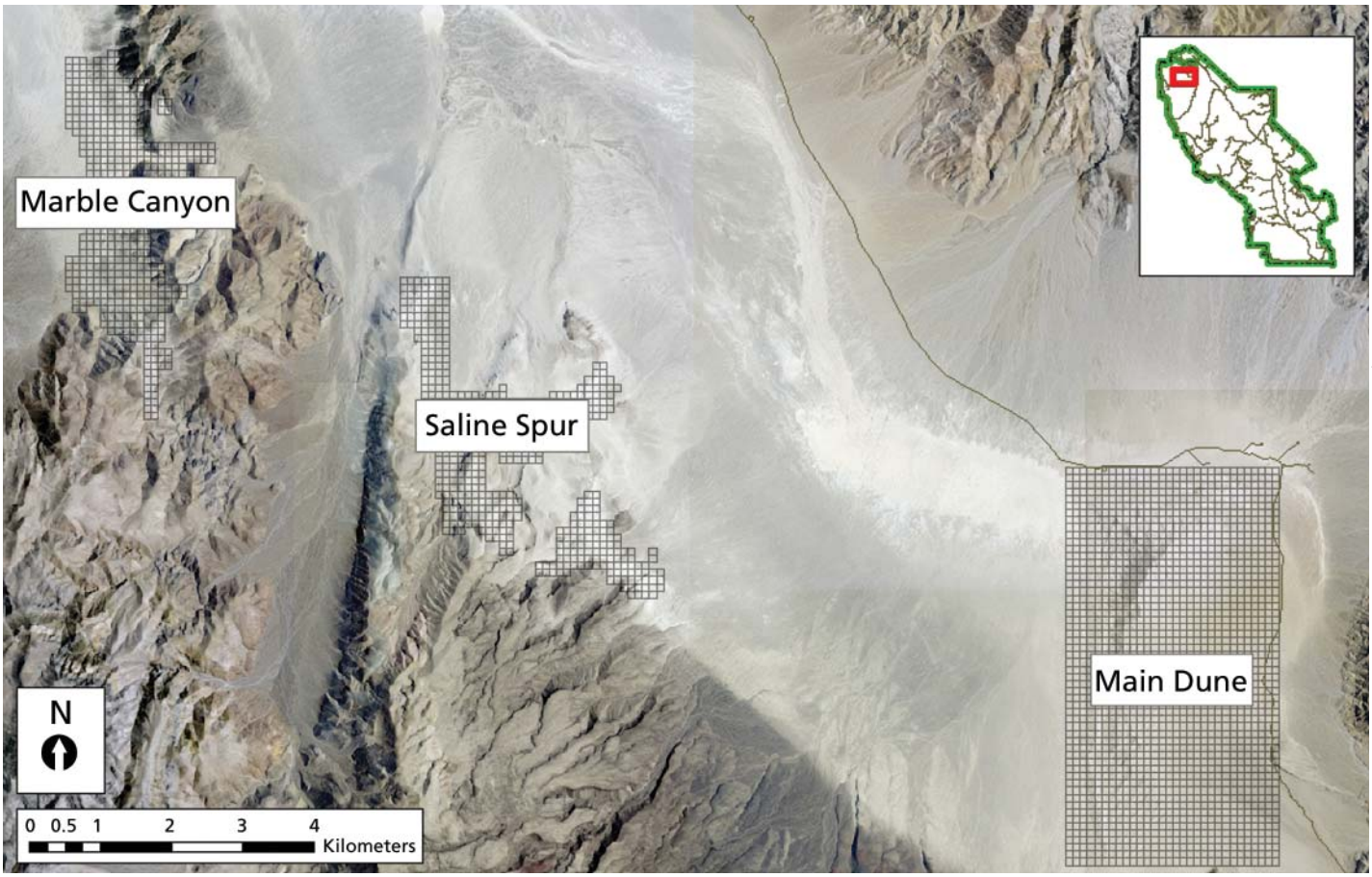

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Figure 2. Map of the Eureka Dunes Complex, including the Marble Canyon Dunes, the Saline Spur, and the Main Dune.

Oenothera californica ssp. *eurekensis* is an herbacious perennial primrose that dies back to the roots and remains dormant in the subsurface in dry years. This subspecies of *Oenothera* differs from others in that it is capable of forming new vegetative rosettes at the ends of buried branches (Pavlik 1979). *Oenothera* also reproduces by seed and is pollinated by hawkmoths (*Hyles lineata*) (Gregory 1963).

Because of the popularity of the Eureka Valley for off-road vehicle (ORV) recreation in the 1970s, *O. californica* ssp. *eurekensis* and *S. alexandrae* were both listed as endangered species in 1978, with ORV recreation cited as the threat to their populations. The Eureka Dunes were officially closed to ORV use by the Bureau of Land Management (BLM) in 1976 when *Swallenia* and *Oenothera* were proposed for listing (Noell 1994); however, enforcement of this closure was not fully implemented until 1980 (USFWS 1982). Occasional ORV trespass still occurs at the Main Dune (Death Valley National Park patrol logs).

Mapping and monitoring history

Since the listing of *Oenothera* and *Swallenia*, several attempts have been made to establish permanent plots and map the full extents of both species. A variety of mapping methods and technologies have been used over the last 40 years, which presents difficulties in measuring population trends. The biology of both *Oenothera* and *Swallenia* presents additional difficulties in estimating population densities. Both species can branch underground or become partially buried by drifting sand, obscuring the boundaries of individual plants or hummocks. In addition, *Oenothera* dies back to the roots every year, disappearing completely from the sand surface, and may not reappear for many years. Despite these obscurities, changes in population extent since 1976 have been large enough to be visible in both maps and photos.

The first known maps of the rare Eureka endemics were published in a 1976 Environmental Analysis produced by the BLM. Although these maps are extremely detailed, the methods are described simply as "field survey conducted by BLM personnel Spring 1976." A second map produced in 1979 by Mary DeDecker and later published in a 1982 report by P. G. Rowlands indicates very generalized population extents at the three dune areas, but

of particular note is a wide expanse of *Oenothera* habitat on the east side of the Main Dune.

Although the maps produced in 1976 and 1979 are very different in detail, there is one key similarity: the large population of *Oenothera* in the flat area east of the Main Dune described as a "heavy" concentration in 1976. In addition to these maps, the literature contains a verbal description of this area: "On the eastern side of the dune the primrose occupies the lower, gentle slopes and flats where it interfingers with an extensive stand of *Oryzopsis [Stipa] hymenoides*. It is in this area that the population is most concentrated, although in years of low rainfall it may seem quite scarce" (Pavlik 1979).

From 1974 to 1979, Mary Ann Henry established a series of transects and photo points to assess the potential impact of off-road vehicles (unpublished data). In 1985 Mark Bagley established an additional set of transects, permanent plots, and photo points along the north side of the Main Dune for baseline monitoring (Bagley 1986). In 2007 and 2008 the park botanist Michèle Slaton was able to relocate and resurvey all transects and photo points from the 1970s and 1980s and found reductions in *Swallenia* from 96% to 99% (Slaton 2008). She also found *Oenothera* to be reduced from 1979 to 2008, but there was considerably more fluctuation in population levels from year to year.

Slaton developed a geographic information system– (GIS) based monitoring approach by creating a virtual grid over 2,600 hectares (6,425 ac) covering all the suitable habitat at the Main Dune, Saline Spur, and Marble Canyon. In 2007 Slaton surveyed the Main Dune and in 2008 Marble Canyon and Saline Spur, and recorded presence/absence of *Swallenia* and *Oenothera* within each hectare grid.

Survey methods

In 2011 the park botanist and a team of four biological technicians accomplished a habitat-wide survey of all three dune systems in the same season for the first time. We covered all 2,658 hectares (6,568 ac) of suitable dune habitat from 15 March to 11 April. In habitat with relatively dense vegetation, two people walked straight lines through the hectare approximately 50 m apart. In habitat that was relatively sparse with sheets of bare sand, one person surveyed the hectare alone, using binoculars when necessary, to verify plant identification. We collected data on 3- by 4-foot paper maps with survey grids superimposed on National Agriculture Imagery Program (NAIP) aerial imagery. We used Trimble Juno™ GPS devices loaded with the same imagery and grids in the field for location and orientation. We recorded the presence of *Swallenia* and *Oenothera* with relative densities of low, medium, and high: "low" = 1–10 individuals, "medium" = 11–60 individuals, and "high" > 60 individuals per hectare.

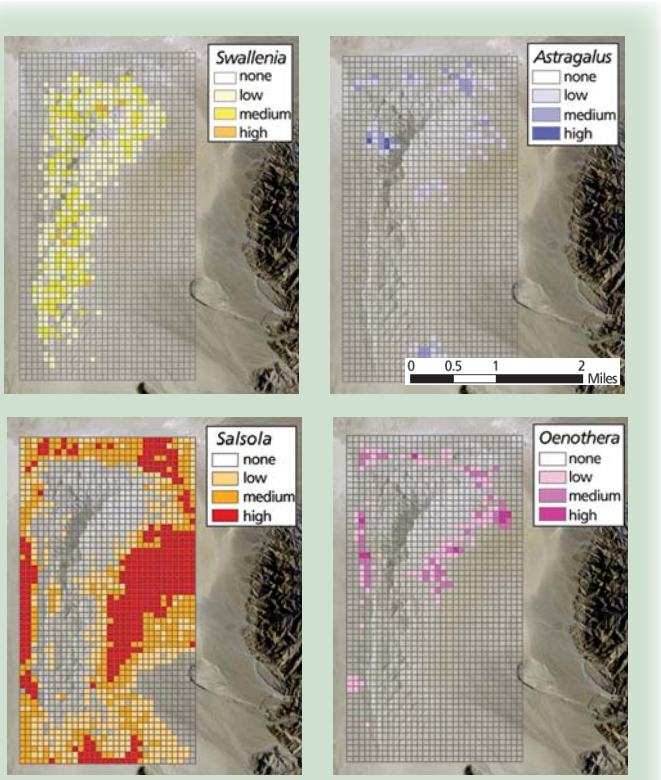
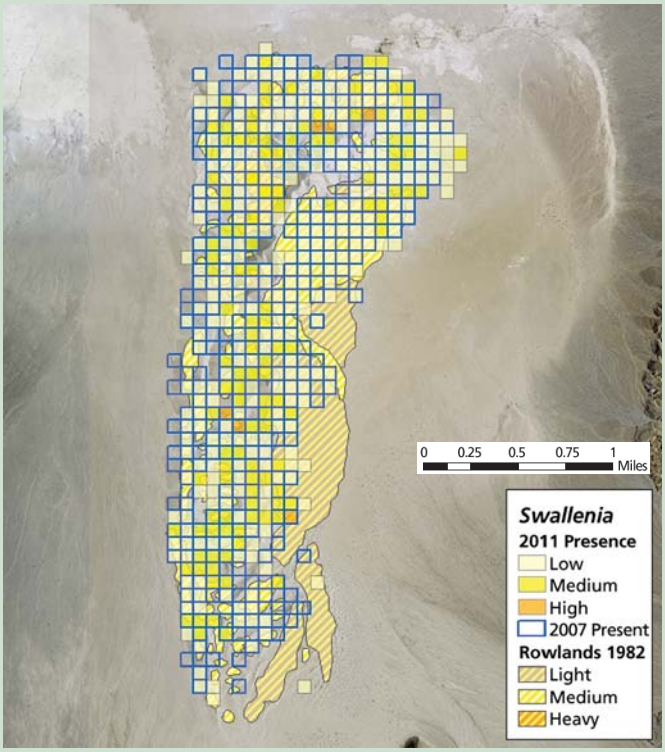


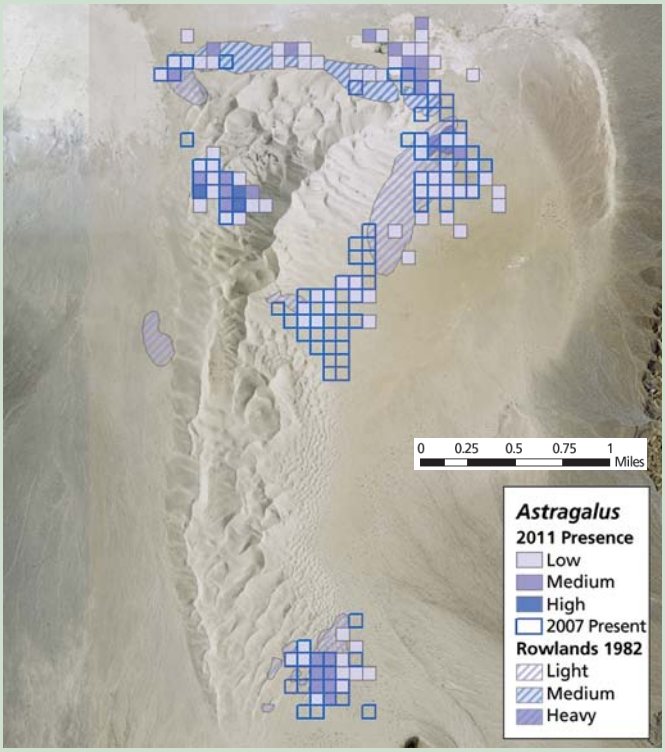
Figure 3. Abundance of rare plant and *Salsola* from surveys on the Main Dune in 2011. (Scale applies to all plates.)

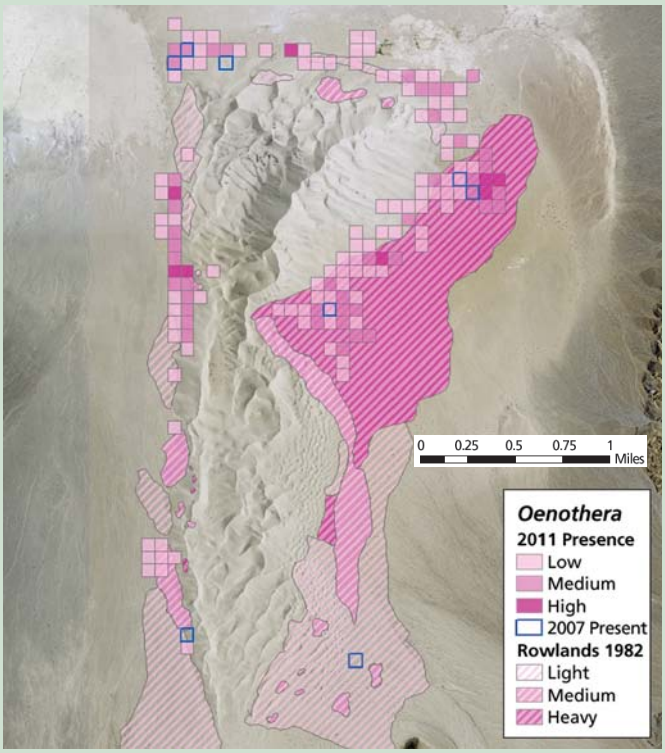
In addition to the rare plant species, we mapped Russian thistle (*Salsola gobicola* [Iljin]) in the 2011 survey. The *Salsola* biomass that was counted was almost entirely senesced and rooted plants from the previous year. Very little new *Salsola* germinated in 2011. The *Salsola* species in the Eureka Valley appears to be a hybrid of *S. paulsenii* and *S. tragus* known as *S. gobicola* (Hrusa and Gaskin 2008). It has been referred to in past literature as *Salsola paulsenii* but is referred to here by the generic epithet. Because of the large numbers of *Salsola* plants, relative densities were estimated as percent cover: "low"= 1–3%, "medium" = 4–10%, and "high" > 10% cover.

Results

The population extents and relative densities of *Swallenia*, *Oenothera*, and *Salsola* on the Main Dune in 2011 are shown in figure 3. All surveys we conducted found large amounts of *Salsola* in comparison with the rare endemic species.







Figures 4–6. Change in population extents of *Swallenia* (figure 4, above), *Astragalus* (figure 5, above right), and *Oenothera* (figure 6, below right) on the Main Dune from 1982, 2007, and 2011.

In order to quantify change over the last four years, we counted hectares that have gained or lost rare plant presence and compared across years. When comparing 2007 and 2008 surveys with that of 2011, an almost equal number of hectares lost species presence as gained it (figs. 4 and 5), with the notable exception of *Oenothera* at the Main Dune, which increased from 8 hectares (20 ac) in 2007 to 151 hectares in 2011 (fig. 6). This is an indicator of the extreme annual variability of germination and aboveground growth in *Oenothera* rather than an expansion of range over the last four years.

Although the last four years of surveys and monitoring have not shown measurable positive or negative change, there is evidence of substantial loss of *Swallenia* since the 1970s and 1980s, as can be seen from repeat photography. The photo points that illustrate the most dramatic change were taken at Marble Canyon in 1985 by Mark Bagley (fig. 7, next page). Photo points established at the Main Dune also show a substantial loss of *Swallenia* cover and density, although the trace amounts of *Swallenia* remaining have preserved the overall population extents since the 1970s (fig. 8, next page). *Oenothera* also appears to have declined based on comparisons with mapped population extents from the 1970s. However, *Oenothera* is only detectable aboveground with substantial winter rainfall and may still be present belowground in its historical habitats. Complete


BLM/MARK BAGLEY


NPS/JANE CIPRA

Figure 7. Photo point record from Marble Canyon showing substantial and widespread loss of *Swallenia* cover from July 1985 (top) to April 2011 (bottom).


BLM/MARK BAGLEY


NPS/JANE CIPRA

Figure 8. Photo point comparison from the Main Dune showing substantial loss of *Swallenia* on the dune slopes from June 1985 (top) to May 2011 (bottom).

surveys after a wet winter will be necessary to determine *Oenothera*'s real population status.

Discussion

There have been three periods of observation at the Eureka Dunes: the 1970s, the 1980s, and the last four years. The differences observed among these periods could represent a trend of dramatic decline or may simply be the result of variability in precipitation. A 30-year cycle of drought has been observed in precipitation throughout the desert region and is significantly correlated with temperature shifts in the North Pacific Ocean known as the Pacific Decadal Oscillation (Hereford et al. 2006).

The Eureka Dunes endemic plants may now be at a low ebb and will return in coming decades when this cycle of drought ends. Long-term monitoring of vegetation plots at the Nevada Test Site has revealed that desert vegetation is extremely dependent on precipitation (Webb et al. 2003), although overall cover and biomass at the Nevada Test Site have increased over the last 50 years.

Climate change can also have indirect effects by causing the loss or mistiming of *Oenothera* pollinator phenology or increased predation pressure by insects, lizards, and rodents on perennial plants in the absence of annual plant forage.

Swallenia populations have been reduced from 95% to 99% over 25 years as measured in long-term transects (Slaton 2008) and estimated from repeat photography. With additional environmental stressors, it is possible the species will not survive until the next upswing in precipitation. Additionally, climate models predict a continuing drying trend throughout the Southwest (Lenart 2007), which could mean *Swallenia* is in real danger of extinction within the next 30 years. Additional environmental stressors that could

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influence long-term population trends are visitor impact and invasive species.

Visitor impact

Visitor impact in the form of off-road vehicles was the original reason for listing these species as endangered in 1978. Although enforcement has not always been at ideal levels, ORV use at Eureka Dunes has gradually declined over the decades to isolated incidents at the Main Dune. The majority of visitors to Eureka Valley now concentrate their use in the form of foot traffic at the north end of the Main Dune. Widespread loss of *Swallenia* across the Eureka Valley, including remote areas, suggests that visitor impact is not the underlying cause of adult plant mortality. However, foot traffic could have severe impacts on the survival of delicate grass seedlings during rare germination events.

Invasive species competition

The most surprising result of the 2011 surveys was the extent of *Salsola* invasion in the Eureka Valley. *Salsola* has colonized and dominates almost all of the semistabilized sand that is favored by *Oenothera*. The only habitats where *Salsola* is not found are the actively mobile sands and the desert pavement surrounding the dunes. The maps and written accounts of *Oenothera* populations in the 1970s indicate that more than 100 hectares (247 acres) of a "heavy" *Oenothera* population on the east side of the Main Dune have been converted to a *Salsola* monoculture (fig. 3). *Salsola* could also be negatively affecting *Swallenia*. Although standing *Salsola* does not overlap heavily with *Swallenia* habitat, *Swallenia* hummocks do provide a semistabilized microhabitat that is capable of colonization by *Salsola*. Both *Swallenia* and *Salsola* are warm-season plants that share C_4 photophysiology, which may cause them to compete for water and nutrients during the same time of year (Noell 1994).

As early as 1979, Pavlik noted that "*Salsola paulsenii* is the only introduced plant commonly found on the dune." In 1988, Mary DeDecker, a prominent local botanist, wrote a letter to the Ridgecrest Bureau of Land Management office stating her concern over Russian thistle:

> I was shocked to see that the large stand of Indian rice grass had been taken over by a solid field of Russian thistle. It had been perhaps 40 acres of almost pure rice grass (*Oryzopsis [Stipa] hymenoides*) with some apricot mallow (*Sphaeralcea ambigua*) . . . There is also the likely possibility that the Russian thistle will move on and take over the large area of the endemic evening primrose nearby, a bit to the south.

Unfortunately the *Salsola* observed in 1988 has since spread throughout the Eureka Valley and is now found even in the most remote and isolated patches of sand in Marble Canyon and the Saline Spur. *Salsola* has spread far beyond the bounds where chemical or mechanical control might be effective. The only possibility for control of *Salsola* in the Eureka Valley would be the introduction of a biological control agent. An eriophid mite, *Aceria salsolae*, has been identified (Smith et al. 2009) as specific to *Salsola* species, but further testing to ensure effective control of the *S. gobicola* present in the Eureka Valley will be necessary before it can be considered for use. Direct competitive effects between *Salsola* and *Oenothera* or *Swallenia* should also be proven beyond the circumstantial evidence of shared habitat before the ecosystem is permanently altered with the introduction of biological control.

Future plans

The Eureka Dune endemics will continue to be monitored with a habitat-wide survey repeated every three to five years, and a survey of the Main Dune annually. Line distance transects to measure *Oenothera* densities were initiated in 2010 and will be monitored annually as a cooperative USGS and NPS study.

In addition to regular NPS monitoring, two USGS studies will be initiated in 2012. One study will examine how precipitation and hydrology in the Eureka Valley influence soil moisture, seed germination, plant growth, and soil mobility and whether changes observed in growth and reproduction are most related to changes in local climate, groundwater, current visitor use, or some combination of these factors.

A second USGS study will evaluate the relative importance of competition and herbivory in limiting populations of *Oenothera*. Field surveys will estimate *Oenothera* and *Salsola* density, lagomorph (i.e., rabbit) density, and patterns of mortality and reproduction. Field experiments will also evaluate competition between *Oenothera* and *Salsola* and the hypothesis that *Salsola* could confer protection against herbivory.

Additional areas for research include an analysis of Eureka Valley–specific data from radar archives to understand the role precipitation plays in the multidecadal trends of *Swallenia* recruitment. Remote sensing using improved aerial and satellite imagery could also provide precise population measurements without labor-intensive and potentially injurious ground surveys.

The U.S. Department of Agriculture is continuing research on potential biological controls for *Salsola*. If a safe and effective control is identified, consultation with the U.S. Fish and Wildlife Service (USFWS) will help determine if biological control is a suitable method to preserve the rare Eureka Dunes endemic plant species.

The USFWS had identified *Swallenia alexandrae* and *Oenothera californica* ssp. *eurekensis* as spotlight species for delisting after review of the status of recovery of the plants since listing in 1978. However, the available qualitative data demonstrate a further decline of these species. Further quantitative data collection is needed to determine population density trends of these endangered species at Eureka Dunes.

Acknowledgments

This survey would not have been possible without the dedicated work of Tim Szewczyk, Amanda Schwantes, Drew Kaiser, and Steven DelFavero, who together surveyed over 2,600 hectares (6,425 ac) and hiked over 400 miles (644 km) on sand in every kind of weather in the space of three weeks.

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