Marble Canyon Milkvetch

(*Astragalus cremnophylax* var. *hevronii*)

Monitoring Report
Redwall Monitoring Site
1997-2011

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INTRODUCTION

Astragalus cremnophylax is composed of three varieties, all of which are rare local endemics near the Grand Canyon. The three varieties were delineated based on minor morphological differences, combined with the fact that they are geographically isolated from each other (Barneby 1979, 1992). The sentry milk-vetch, *Astragalus cremnophylax* var. *cremnophylax,* occurs only in Grand Canyon National Park, and was listed endangered under the Endangered Species Act in 1990 (55 FR 50184-7). The second variety, the cliff milkvetch (*A. c*. var. *myriorrhapis*), is only known from the Buckskin Mountains on the Arizona-Utah border, where it is managed both by the U.S. Forest Service and the BLM. Marble Canyon milkvetch (*A. c.* var. *hevronii*), the variety found on the Navajo Nation, was discovered by Bill Hevron, former botanist for the Navajo Natural Heritage Program, in 1991 and described by Rupert Barneby of the New York Botanical Garden (Barneby 1992). Marble Canyon milkvetch is currently known from 8 populations along the east and west rims of Marble Canyon. Seven of these populations are located on the Navajo Nation. It is listed in group 3 (threatened) of the Navajo Endangered Species List (Navajo Nation Division of Natural Resources 2008).

Marble Canyon milkvetch is a dwarf, evergreen, perennial herb, forming a mat less than 1.5 cm high and up to16 cm in diameter (Mikesic and Roth 2008). The flowers, which are produced in April and May, are purplish-lilac and are usually held slightly above the mat. It grows on Kaibab Limestone benches, in crevices and depressions with shallow soils (Arizona Rare Plant Committee 2001). Threats to this species include trampling by visitors at scenic overlooks, damage from livestock, illegal collecting, climate variability, and natural erosional processes (Roth 2007).

In 1997, the Grand Canyon National Park received a grant from the National Fish and Wildlife Foundation to set up monitoring plots for all three varieties of *A. cremnophylax*, located on National Park Service, U.S. Forest Service, Bureau of Land Management, and Navajo Nation lands. As a part of that study, four permanent transects were established within the Redwall population of *A. c. hevronii* in June of 1997. In 2007, 2008, and 2011, the Navajo Natural Heritage Program re-visited these transects to monitor the Redwall population. Goals of the monitoring activities are to assess changes in age class distribution, reproductive output, and survivorship in the Redwall population of Marble Canyon milkvetch.

METHODS

Four permanent transects were established from June 11 through 13, 1997 at the Redwall monitoring site on the east rim of Marble Canyon. All plants along the transects were mapped and tagged with individually numbered plastic or metal tags. Each plant was placed into a size class, to serve as a surrogate for plant age. Methods for assessing size class varied among the monitoring years, due to turnover in staff (Table 1). In 1997, basal area was calculated for each plant, while in 2011, the diameter of the plant along the longest axis was measured. Because the plants are irregularly shaped, diameter could not be converted directly to basal area. Cutoff points for determining size classes in 2011 were selected to approximate those from 1997. In 2007 and 2008, plants were placed into size classes based on the botanist's professional opinion, and the exact standards used are not available.

Beginning in 2007, reproductive status was recorded for each plant; no indication of reproductive status was given in 1997, possibly because monitoring took place after the flowering season. Dead plants were also recorded and, if they still had tags from previous monitoring years, their tags were removed. Each year, the transect lines are surveyed for seedlings or previously unrecorded plants. If any are found, they are tagged and incorporated into the monitoring study.

Table 1. Criteria for classifying Marble Canyon milkvetch into size classes during the four monitoring years. Detailed methods for calculating basal area are outlined in Rowlands and Brian (1996).

Size class	1997	2007 and 2008	2011
Seedling	Meets at least one of these criteria: • Presence of cotyledons • Basal area <1cm^2 • Presence of 1-3 pinnate leaves	Expert opinion	Classified as "small"
Small	Basal area 10-30cm^2	Expert opinion	≤5cm length on longest axis
Medium	Basal area 31-90 cm^2	Expert opinion	6-10 cm length on longest axis
Large	Basal area >90cm^2	Expert opinion	>10 cm length on longest axis

RESULTS

In 2011, a total of 166 Marble Canyon milkvetch plants were found along the four transects (Table 2, Fig. 1). Nine of those plants, or five percent, were newly found. Seventeen plants were either found dead or could not be re-located from the previous monitoring year.

Total number of plants recorded has remained relatively constant throughout all monitoring years since 1997 (Table 2, Fig. 1). The reproductive proportion of the population has remained stable at an average of 70%; analysis of variance results indicate that for all three years for which reproductive data was recorded, the proportion of the population that produced flowers and fruit was statistically identical (Table 3).

Size class distribution varied quite a bit from year to year. Size class distribution was the most even in 1997, with 20% of the plants classified as seedlings, and all other classes between 25 and 28% (Table 2, Figs 2 and 3). In 2007 and 2008, the most plants were classified as "small," at 52% both years. In 2011, the majority of plants were classified as "medium," at 54%.

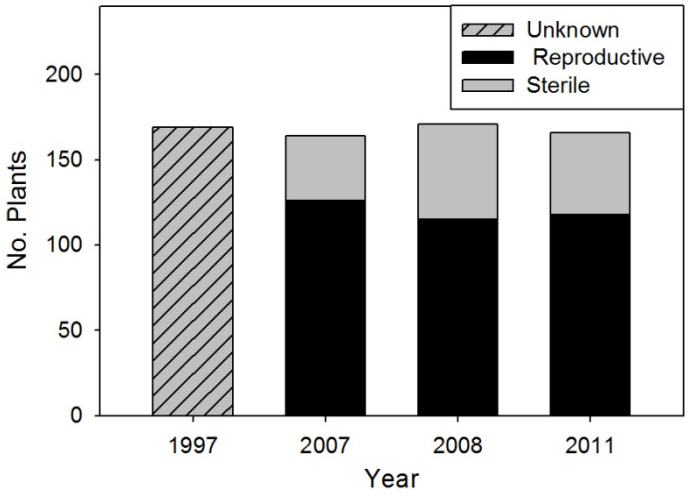

Figure 1. Number of reproductive and sterile individuals of Marble Canyon milkvetch along four transects at the Redwall monitoring site during three monitoring years. In 1997, no data on reproductive status was collected, and total number of plants is presented.

Table 2. Demographic data collected for the Redwall population of Marble Canyon milkvetch during four monitoring years.

Year	No. Plants	No. Seedlings	No. Small	No. Medium	No. Large	No. Reproductive	No. Sterile
1997	169	35	45	47	42	No Data	No Data
2007	164	12	85	50	17	126	38
2008	171	6	89	62	14	115	56
2011	166	Included as "small"	47	87	32	118	48

Table 3. Analysis of variance results testing for a difference among years in the proportion of the Marble Canyon milkvetch population that was reproductive.

Source of Variation	df	SS	MS	F	P
Year	1	0.000004	0.000004	0.0005	0.98
Residual	7	0.06	0.008		

Between 1997 and 2007, the number of seedlings declined from 21% to 7%, and then to 4% in 2008 (Fig. 2). Data for seedlings are not available in 2011, as seedlings were classified in the same category as small plants.

Marble Canyon milkvetch begins to flower while still small; over the three years that reproductive data was collected, an average of 38% of plants classified as "small" were reproductive (Fig. 3). Reproductive rates of medium and large plants are much higher, however. An average of 94% of medium plants and 100% of large plants were reproductive over the three years.

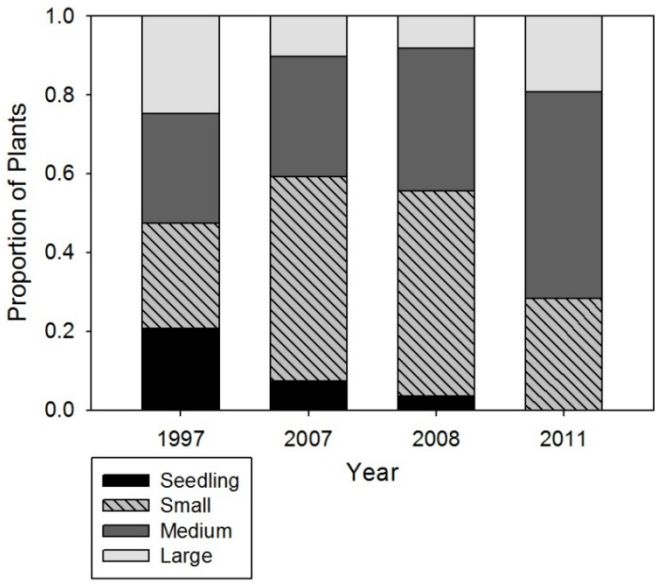

Figure 2. Size class distribution of Marble Canyon milkvetch along four transects at the Redwall monitoring site, 1997-2011. In 2011, seedlings were categorized in the "small" size class. See table X for size class parameters.

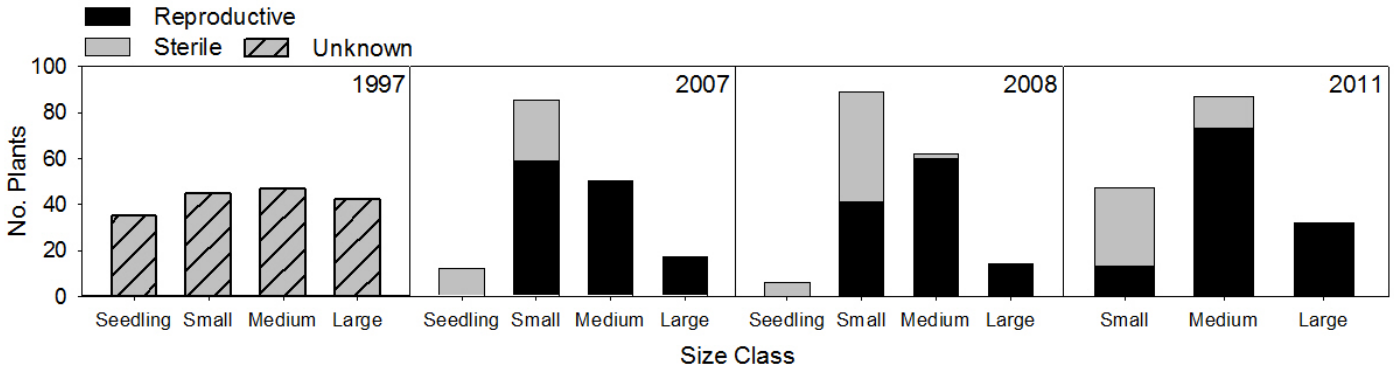

Figure 3. Size class distribution, coded by reproductive status, of the Marble Canyon milkvetch recorded along four transects at the Redwall monitoring site, during three years of monitoring. In 2011, seedlings were included in the "small" size class.

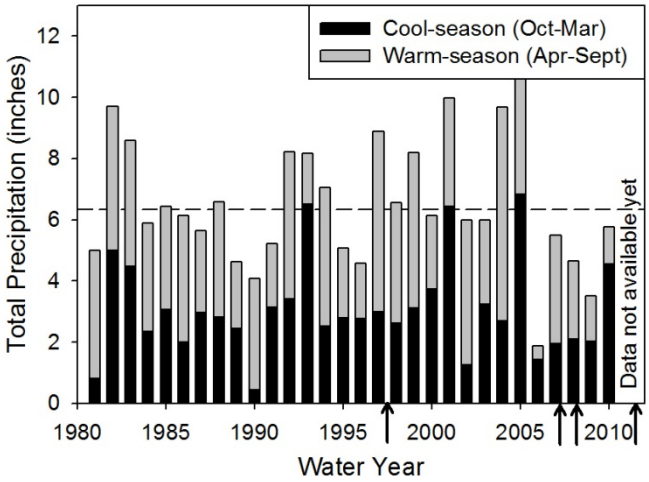

Figure 4. Total precipitation at Lees Ferry, AZ for the 30 years preceding the most recent monitoring season. The dotted line represents the 30-year annual mean. Arrows indicate the years during which the Redwall population of Marble Canyon milkvetch was monitored. Data from the Western Regional Climate Center.

DISCUSSION

While methods for determining size class have not remained completely constant over the years, the trend of a decrease in the number of large plants and an increase in the number of small plants between 1997 and 2007 strongly suggests a high turnover in the population during that decade. This is consistent with the fact that there was a drought in the early 2000's, which led to higher than normal mortality in other rare plant species (Fig. 4, USFWS 2011, Roth 2008). The increase in medium sized plants in the 2011 data set indicates that the new cohort grew a noticeable amount, though not precisely quantified, during the three years between 2008 and 2011.

The fact that the total number of plants growing along the four transects at the Redwall monitoring site has stayed relatively constant despite apparently high mortality bodes well for the future persistence of Marble Canyon milkvetch. Climate variability, especially extended drought, has been considered a major threat to the species (Roth 2007). Results of this study suggest that while drought may kill older individuals, the rate of new plant establishment is high enough to quickly replenish plant numbers and maintain a stable population. This apparently high establishment rate is likely due in part to a high rate of seed set; Allphin (2005) showed that the rate of seed set for *A. c.* var. *hevronii* is relatively high compared to closely related taxa, including *A. c.* var. *cremnophylax* and *A. humilimus*, both federally listed as endangered. Additional information on seed germination rate and environmental requirements would also be helpful in supporting this hypothesis that climate variability poses little threat to the persistence of Marble Canyon milkvetch.

That said, Marble Canyon milkvetch is still threatened by its rarity and the extreme rarity of its habitat. While not imminently threatened by habitat destruction, the few extant populations of this plant need to be protected from human development. Marble Canyon milkvetch habitat is remote and infrequently visited by people. However, its proximity to the Grand Canyon, one of the most visited natural areas in the world, makes future recreational development and other disturbance in the area always a possibility. Genetic diversity of another variety of the same species (*A. c*. var. *cremnophylax*) has already suffered a bottleneck due to decades of trampling by tourists at Grand Canyon National Park (Allphin 2005, Maschinski 1997).
It is crucial that project sponsors who want to develop close to the rim of Marble Canyon work closely with the Navajo Nation Department of Fish and Wildlife to ensure that the these few populations are not disturbed. This includes temporary disturbance such as filming movies and stunts.

Photo: D. Roth

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