Determining the Population Boundaries of a Narrowly Endemic Perennial Plant, Lane Mountain Milk-Vetch, in San Bernardino County, California.

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ABSTRACT. The Lane Mountain milk-vetch (*Astragalus jaegerianus*) is a federally endangered species. It was first discovered in 1939 by Edmund Jaeger in the central Mojave Desert of California. This plant species was not collected again until the army became interested in expanding Fort Irwin's western boundary in the 1980's. Following its rediscovery, volunteers eventually found a few scattered plants in three populations within a 10-mile radius. Army-funded surveys since 1990 defined four generally distinct populations. The most extensive survey, in conjunction with a GIS analysis of potential habitat within 50 miles of the core populations, occurred in 2001. A total of 387 transects were surveyed within twelve 7.5 minute quadrangles and nearly 4,000 plants were found on 21,000 acres. The 2001 survey established that the milk-vetch is restricted to only 4 populations and that it has specific soil and elevation requirements. Ecological studies regarding moisture-holding capacity of the substrate, seed bank availability, seed germination, resprout frequency and pollination ecology have also been conducted. A population genetic study is underway.

INTRODUCTION

The management of approximately 100,000 acres of Bureau of Land Management (BLM) land was transferred to US Army in 2003 as part of the proposed expansion of the National Desert Training Center at Fort Irwin (NTC). Two federally listed resident species occur on this property the desert tortoise and the Lane Mountain milk-vetch (*Astragalus jaegerianus* Munz). The project received a no jeopardy opinion from the US Fish and Wildlife Service (USFWS 2004). Mitigation measures are being developed at present.

HISTORY

The milk-vetch is named after its discoverer, Edmund Jaeger, the Riverside City College biology professor who was a botanical explorer during the 1930-60's and is responsible for the publication of some of the most informative popular books ever written on desert ecology. Based on Jaeger's herbarium specimen label locations, the region southwest of Fort Irwin was visited in 1941 by two of the nations top botanists and collections were made by Rupert Barneby, the *Astragalus* expert, and Phillip Munz the expert on the Southern California flora. No further collecting of this species occurred until 1985 when the expansion was first proposed and the Army sponsored botanical surveys.

Between 1939 and 1984 approximately 100 plants were found in three populations. The milk-vetch had a patchy distribution over a 10-mile long area, occurring on rocky rises within the central Mojave Desert. Repeated searches for this species by small groups

and individuals over the next 10 years turned up very few plants. Two systematic surveys by UCLA in the late 1990's (Prigge et al. 2000) found approximately 850 plants.

The Lane Mountain milk-vetch was recommended for listing as an endangered species by the USF&WS in January 1975 with the enactment of the Endangered Species Act. It, along with 1,700 other plants, made the USFWS list in June of 1976. In 1980, the Lane Mountain milk-vetch was included in the updated notice of review as a Category 1 listing. In 1983, a supplemental notice of review changed it to a Category 2; but, nine years later it was included in a listing package with six other species of milk-vetch. In 1998, following two public comment periods, it was granted endangered species status (USFWS 1998).

DESCRIPTION

The Lane Mountain milk-vetch is a vining perennial that usually grows within other shrubs. It appears to be a Pleistocene relic with very few related species. For this reason, Barneby (1964) put it in its own section. The milk-vetch's cryptic nature and scattered and limited distribution have made it very difficult to detect. In low rainfall years, it barely grows 3 inches tall before it flowers and can only be observed beneath other shrubs. In high rainfall years it overtops the host shrubs making it much easier to observe, especially when in flower or fruit. The small pink flowers with purple nectar guides are scattered on long stems, but the brown-purple pendulous leathery pods can be quite dense, making the plant most observable in either flower or fruit.

HABITAT

Early physiological studies have shown that the rocky ridges where the milk-vetch occurs stays moister than the surrounding loamy alluvial fan soils. It is assumed that rainwater is trapped in cracks in the rocks and is available to the plants later in the season. Field observations show shrubs growing on the rocky soils still contain leaves or are flowering in early summer when adjacent plants on alluvial fans are dormant. Field data and observations show that the shrubby vegetation on the rises is much smaller in stature and much more diverse in species than the surrounding deep sandy soils in the swales. The host shrubs often grow in multispecies clumps on the rocky soils. Mine digs near known populations often have a caliche layer several feet below the soil surface that may also trap water. Milk-vetch is also more common growing in nearly leafless shrub species with photosynthetic stems such as Mormon tea (*Ephedra nevadensis*) and turpentine broom (*Thamnosma montana*). It also occurs in common low growing species such as burrobush (*Ambrosia dumosa*) with only two occurrences within the much taller but co-dominant creosote bush (*Larrea tridentata*).

METHODOLOGY

In 2000-1 a massive effort was made to determine the boundaries of the populations (Charis 2002). A survey team was assembled that consisted of 35 field members. Organization, the development of field forms, and a survey scheme were complicated by the scope of the project. No one had experience working with a crew that large. Almost 750,000 dollars were spent over two seasons. The field crews were organized

with botanists experienced with the milk-vetch as team leaders, a range of botanists some with graduate degrees, interested novices, and people with no field experience or particular interest in plants. The teams were split into 4 crews of 5-7 with 3 fulltime weekday crews and a part time crew with weekday volunteers working on the weekends. Surveying began in the center of one of the known populations and more plants were found the first day than were expected during the whole field season. The same surveyors consistently found the most plants, while others consistently found the fewest. The best surveyors were a grocery store stocker and a foreign born ecologist with exceptional eyesight.

At first, surveys were contiguous and plants were continually found for several weeks. Progress was very slow because staying accurately on compass readings and waiting while field forms were filled out slowed the pace. After several weeks of surveying, the field forms were changed to take less time and surveys were moved from contiguous to being separated by a half-mile to 1 mile. The presence or absence of milk-vetch plants was a factor in determining the location of the next day's surveys.

The location, phenology, host shrub species, height, and presence of seedlings were documented in the field forms. Several field forms were developed including site forms, plant location forms, GPS log number forms, etc.

All GPS units were numbered and plant identification numbers were sequentially based on each units identification number. It was necessary to download at least every 4 days and the GPS log form identified the last number downloaded before previous results were deleted. The corners of the transects were recorded but errors in either the recording of data or in the points kept by the GPS units occurred. By cross-referencing during the data verification phase, error conflicts were rectified. GPS numbers were difficult to read in the field during the sunny late afternoons especially if the GPS surface was scratched. Individual recorders found and maintained the best contrast settings.

The second year surveys, conducted in 2002-03, consisted of a much smaller group of surveyors (Charis 2003b). Two botanists spent all spring driving roads within a 50-mile radius looking for and surveying potential habitat. The one survey crew concentrated on the perimeters of the existing populations. A few new plants were found and the population boundaries were modified slightly. Poor rainfall in some areas made surveys at some populations impossible. In some cases, plants sprouted and went dormant before the survey began. In normal years, the plants do not begin blooming until mid-April when both surveys began.

Results of other Surveys

We were asked by the BLM to document the number of Mojave fishhook cacti (*Sclerocactus polyancistrus* (Engelmann & Bigelow) Britton & Rose) observed during the surveys. Because of the large amount of

TABLE 1 Results of Phenology Data

	Beginning	Ending
Flowering	April 7	May 19
Mature Fruits Present	April 20	May 30
Pods Dehiscing	May 13	June
Plant Become Dormant	May 21	June 30

milk-vetch data, surveyors did not have the time to continue taking data on the cacti. We did document which transects contains the 4,000 plants observed during the survey.

Although field crews saw copious amounts of milk-vetch seed fall and build up at the base of the plant, observations were not made on the fate of fallen seed. It was assumed that they were scattered by wind, because evidence of seed predation was never observed. Surveyors documented seedlings under 76 shrubs for a total of 386 seedlings.

In a sample survey of 50 plants in 2001-2002, approximately 75 percent of the known plant locations from 2000-01 were relocated the next year from remaining skeletons. By 2002-03, very few of the skeletons were left. It is assumed that rabbits or rodents ate some of the dried skeletons. The skeletons were too intertwined in the shrubs to break off and blow away. Several-year old skeletons changed in color from tan to gray. Occasionally, old stems indicated the location of previous plants and careful inspection would show whether these plants were still alive. Very few apparently dead skeletons were observed during the surveys. Previous individual monitoring of plants tagged by the USF&WS at the Coolgardie Mesa population and by UCLA in the Brinkman Wash population, showed that many plants did not sprout in poor rainfall years and that plants previously not observed sprouted.

RESULTS

Eventually, approximately half the land within the delineated population boundaries was surveyed and approximately 5,000 more plants were documented. The results of the survey delineated 4 distinct subpopulations occurring at a 45-degree angle from the southwest to the northeast. Extensive efforts to find plants in adjacent areas within a 50 square-mile areas were negative. It was assumed that rolling topography, diverse shrub vegetation, granitic substrate, and elevation were primary indicators of potential habitat.

None of the portions of the known populations surveyed by UCLA in 1998-99 were resurveyed. By using similar methodology it was possible to combine data sets. Data on nearly 6,000 plants is now known. Thirty different shrub host plants were documented, many milk-vetch plants occurred in a shrub species only once or twice. One-fifth of all milk-vetch plants were found in turpentine broom. Milk-vetch was densest in areas where shrub diversity was high and several species of shrubs often occurred together. Three quarters of all milk-vetch plants occurred in one host plant but one-fifth had two host plants. The rest had multiple host shrubs, no host plants, or were in dead shrubs.

Patterns of habitat preferences within the rises were not found. Plants generally were more common in the more mesic microclimates such as the north side in some areas, but were more common on the ridge crests or at the foot of the south-facing slope of other rises. It is of interest, that 88 percent of the plants occurred between 1,025 and 1,175 meters (3,365 - 3,854 ft) elevation. The total elevation range for the milk-vetch was between 945 and 1,280 meters (3,100 - 4,200 ft) amsl.

The geology of the known habitat was complicated, with milk-vetch plants occurring mostly in light-to-extremely dark-colored granitic substrate (diorite to gabbro). Occasionally, milk-vetch

plants also occur in Pleistocene relic reddish-clay soils and a few plants occurred on Lane Mountain, a Tertiary rhyolitic dome. A comparison can be made between the geology and soil type within the population boundaries and within a 50-mile (80.5 km) radius of the populations. Note the important differences in Tables 2 and 3.

Soil surveys in the region are only a level three, in which, the boundaries of individual soil series is not determined. Electronic soil map polygons include the three major soil series occurring within the polygon and possibly an estimate of the percentage of one of the three. The milk-vetch plants were limited to two soil polygon types. The Cajon-Wasco-Rosamond and Calvista-Trigger-rock outcrop types. All these soil series are common and widespread in inland Southern California.

The milk-vetch responds to rain and has been observed sprouting any time between January and March and after summer rains. Plants will stay small and abort flowers if not enough rainfall occurs. Rainfall episodes of over an inch, every 3-4 weeks, between December and March are ideal. The second year studies had to be postponed one year due to lack of rainfall in 2001-2002. In 2002-2003, only three scattered storms occurred between December and April. Most areas received rainfall from only one of the storms, and plant growth of milk-vetch and shrubs was poor, although wildflower displays were excellent. Areas within the milk-vetch population boundaries that received precipitation from two or all three storms had good milk-vetch growth.

The surveys began in mid-April when the milk-vetch is in full bloom. The plants remain in flower for approximately one month and then quickly set fruit. The pendulous pods split only on the distal end and the small but numerous seed pour on the ground under the nurse shrub. The seed is then scattered by strong winds that can occur in mid to late summer. Seed predation by insects or birds was never observed.

Although pollinators were also not observed during the first year, one of the crew leaders conducted a pollination study two years later and easily identified several pollinators (Charis 2003c). The major pollinator is a Megachilid bee, *Anthidium dammersi*. This species is attracted to most pin-purple flowered plants.

MANAGEMENT CONSIDERATIONS

Of the four populations the eastern most and smallest is on Fort Irwin property, but is adjacent to the NASA Goldstone Deep Space Complex. It has been fenced off- limits. Army

TABLE 2. Geology bedrock types within the population boundaries and within a 50-mile radius

Bedrock	% Population Boundary	% 50-mile adjacent area
Granitic	90	32
Diorite	5	4
Gabbro	4	Trace
Disturbed/undetermined	1	45

TABLE 3. Relationships between soils within the milk-vetch populations and adjancent habitat.

Soil series map polygon	% within population boundaries	% in adjacent area
Cajon-Wasco-Rosamond	5	16
Calvista-Trigger-rock outcrop	95	11
Nickel-Arizo-Bitter	0	25
Upspring-Sparkhule-rock outcrop	0	10

maneuvers do not occur here because of potential dust interference with NASA research at Goldstone. The largest population, the Coolgardie Mesa population, is located on BLM and private land and would be best managed under the proposed West Mojave Coordinated Management Plan. There are presently three main threats to the Coolgardie population development on private land, OHV travel, and mining. The Coolgardie population is shaped like a donut and a portion of the hole is presently used by off-road vehicles, primarily during spring break. Dry sieve gold mining also takes place within population boundaries on private property. The other populations within the expansion area will be managed by the Fort Irwin Natural Resources Management Plan and within the mitigation measures to be developed under the Biologic Opinion.

The two middle populations are located within the proposed Fort Irwin expansion area. One of the populations is in the middle of a proposed battle corridor. A small portion of the other is located in an area that would receive moderate to heavy traffic. The rest of the second population is proposed to be fenced and posted off limits. The populations will be located in a no dig zone (Charis 2003a).

In January of 2004, Ray Bransfield of the USFWS issued a preliminary jeopardy opinion for the desert tortoise and the Lane Mountain milk-vetch. Minor changes were proposed for the fencing of the one population to reduce the jeopardy opinion. This was later followed by a no jeopardy opinion in April. Critical habitat was delineated in April that is slightly larger than the population delineations that followed minimum convex polygons of the outermost plants. It is now up to the army to modify the project and develop mitigation measures for the desert tortoise and milk-vetch before training on the expansion will proceed.

The army is modifying it's Integrated National Resources Management Plan to include the milk-vetch populations within the expansion area. This will reduce the need to delineate critical habitat on the army post. Also the expansion Environmental Assessment is going through the public comment time during May 2004.

DISCUSSION

The Lane Mountain milk-vetch is not as rare at once thought. The four populations occur within 21,000 acres. The total range of the species is restricted to a very small portion of the central Mojave Desert. Plants occur only on a portion of the rises within the population boundaries. There are significant differences in the habitat and vegetation between the western most and eastern most populations.

How many plants are there? The unsurveyed half within the population boundaries is lower quality habitat. It was avoided in the first place because there was a high change plants would not be found. These areas often occurred in valleys that lacked rolling hills and diverse vegetation. Only the small rises within those areas will contain small populations of plants. Conclusions that only half the population was counted because only half the area was surveyed should prove to be false. If past experience with desert cymopterus (*Cymopterus deserticola* Brandeg.) holds true, the number of plants that sprout is proportional to the amount of rainfall. In studies at Edwards AFB a seven-fold increase in plant numbers occurred

between average and above average years. In high rainfall years, many more plants should occur in the areas already surveyed than in the areas not surveyed.

Above average rainfall has not occurred in this century. The two milk-vetch survey years were slightly above normal and slightly below normal in rainfall. At 2,500 feet (762 m) elevation average rainfall is about 4.5 inches (11.4 cm). At 3,500 to 4,500 feet (1067-1372 m) elevation, the elevation range of this species, rainfall is relatively higher. In the past, high rainfall is approximately 10 inches (25.4 cm) at 2,500' (762 m). Therefore it is possible for as much as 15 inches (38.1 cm) of rain to fall in milk-vetch habitat during an exceptional season. More plants should be expected to occur during high rainfall events, although the actual number of plants should be slightly higher than documented because some were missed by surveyors.

It is extremely difficult to estimate the actual population of plants. The fact that no surveys have occurred during exceptional rainfall years means that population levels could increase dramatically when such an event should occur. The number of plants missed during the surveys should be minor because when potential habitat was located everyone began looking more carefully. When a plant was found the other surveyors would mill about looking for plants while they were waiting for other pairs to complete the field forms. This resulted in 100 percent coverage of the adjacent habitat.

This plant is so cryptic that it can be missed simply by looking from the wrong angle. Also, much of the fieldwork continued after the plants were dormant. In June, some plants would shrink and disappear while others would dry leaving skeletons that were very easy to see and document. Although many plant had disappeared by the time the survey was completed, the largest number of plants found in one day occurred in late July, while counting only dormant plants.

In order to model potential habitat for the Lane Mountain milk-vetch based on habitat features, three geospatial variables were used; elevation, soils, and geology. The range of features were rated as high, medium, and low. A multiplier of 3 was given to the dataset rated high, a 2 to the medium dataset, and a 1 for low. A 0 was given to areas and features without habitat/plants. A total of 9 points was possible, with the highest number representing the best habitat. The existing population boundaries were located within areas with 7-9 points. Several areas northwest, southeast, and south of the existing populations also had high numbers but plants were not found during scouting surveys.

Why the narrow range? One variable in the area not looked at was the variation in precipitation. Rainfall gauges and weather stations are located in Barstow, 15 miles south of the populations, Daggett 15 miles east of Barstow, and several sites located on Fort Irwin west and northwest of the plants. The variation in rainfall records between the various Fort Irwin sites and between the Barstow and Daggett sites, show that a great variation in local rainfall exists. The curious angle in which the plant populations occur may be related to storm tracks. The storms pass through the Cajon Pass, which is a separation point between the San Gabriel, and San Bernardino Mountains created by the San Andreas Fault. That,

combined with the prevailing westerly winds, may result in the most reliable rainfall occurring in the region where the milk-vetch grows.

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