PRELIMINARY RESULTS OF AN INVESTIGATION INTO THE LIFE HISTORY AND POPULATION DYNAMICS OF *Calochortus nitidus* DOUGL. (LILIACEAE)

by

Steven L. Caicco
Natural Heritage Section
Nongame Wildlife/Endangered Species Program
Bureau of Wildlife

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Idaho Department of Fish and Game
600 South Walnut, P.O. Box 25
Boise, Idaho 83707
Jerry M. Conley, Director

Cooperative Challenge Cost Share Project
Nez Perce National Forest
Idaho Department of Fish and Game

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ABSTRACT

Calochortus nitidus, a candidate for listing as a Threatened species under the Endangered Species Act, is a regional endemic of northern Idaho and adjacent Washington. It is considered extirpated from the latter state. In Idaho, numerous isolated populations are known to occur. Most of these occur in areas which were too rocky to convert to cropland; grazing of these areas has generally reduced the populations to critically low numbers.

Most of the few vigorous populations of the species known are found on public lands of the Nez Perce National Forest. In lieu of formal listing, it was recommended that a Habitat Management Plan (HMP) be developed for populations of the species known from public lands.

In order to prepare a HMP, information on the life history and population dynamics of the species is needed. During the summer of 1988, permanent plots were established within populations of Calochortus nitidus in areas which were grazed and ungrazed by domestic livestock. About one-third of the individuals identified within the permanent plots were found to be reproductive.

Within the plot from which livestock were excluded, 89% of the nine reproductive individuals produced a total of ten fruits. In the plots open to livestock grazing, only one (0.4%) of twenty-four reproductive plants produced fruit. Of the forty-two reproductive structures (floral buds, flowers, or fruits) which were produced by the twenty-four plants in the grazed plots, all but one fruit were eliminated by grazing.

The implications of this extreme reduction in reproductive effort on the long-term viability of the species on public lands are discussed. Management options are outlined, and their probable consequences are indicated.

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INTRODUCTION

Calochortus nitidus Dougl., the broad-fruit mariposa, is a regional endemic which had a historic distribution throughout much of Idaho portion of the Palouse Prairie (Hitchcock et al. 1959); it was also known from adjacent southeastern Washington, an area where it is now thought to be extirpated (Washington Natural Heritage Program 1987).

It is also extirpated from a large area of Idaho, a fact attributable to the nearly total conversion of the deep, rich loess of its grassland habitats to agricultural uses, of which dryland farming of grains and legumes is the most common. Numerous isolated populations remain within the cropland, usually in areas that were too rocky to plow; most of these have been used for cattle pasture, and plants are present in critically low numbers (Caicco 1988).

To the east and south of the plateau grasslands of the Palouse Prairie, the range of C. nitidus extends along the rims of the canyons of the Clearwater, Salmon, and Snake Rivers. Only a few small populations remain in the Clearwater drainage (Caicco 1988). Recent inventories of public lands administered by the Nez Perce National Forest, however, have documented the presence of substantial populations of the broad-fruit mariposa on the Clearwater Ranger District (Brixen 1988) and the Slate Creek Ranger District (Caicco 1987).

For these reasons, C. nitidus has been recommended to the U.S. Fish and Wildlife Service as a Category 1 candidate species for listing under the Endangered Species Act (Caicco 1988). Because sizable populations are extant on public lands, however, it was further recommended that a Habitat Management Plan (HMP) be developed for the species in lieu of formal listing.

In order to develop a Habitat Management Plan for the broad-fruit mariposa, information is needed on both the life history and the population dynamics of the species. This report comprises a summary of the data collected during the 1988 field season, a preliminary interpretation of the results, and a discussion of several management alternatives.

NATURAL HISTORY AND MORPHOLOGY OF CALOCHORTUS NITIDUS

Despite the extent of its former range, the descriptions of its former habitat suggest that Calochortus nitidus had a broad ecological amplitude. In addition to the deep loessal soils referred to above, the broad-fruit mariposa was also found by early collectors in "moist bottoms", "rocky prairies", and "open pine forests". Today it is common only at sites with thin rocky soils derived from a basaltic substrate. The dominant plant species found on these sites include Festuca idahoensis Elmer, Koeleria cristata Pers., and Balsamorhiza hookeri Nutt.. Sites degraded by livestock grazing often have large amounts of Danthonia intermedia Vasey and various annual species of Bromus.

The broad-fruit mariposa has the uncommon facility of producing most of its food throughout the growing season from a solitary basal leaf. This leaf grows from a deep-seated overwintering bulb. The time at which this basal leaf emerges from the ground is uncertain. During late-June or early-July an inflorescence, bearing from one to four flowers, is produced at the end of an erect stem; the length of the stem and inflorescence may range from only a few inches to nearly 1 1/2 feet (2-4 dm).

Observations over the past few years suggest that the timing of flowering is unaffected by regional drought. In the hottest, driest habitats along the tops of southerly facing ridges, however, the basal leaf may have already withered by the time flowering occurs. Aspects of pollination biology are unknown.

The fruits mature during July and August, months which are typically hot and dry. Any remaining basal leaves wither during this time. Seeds are shed from erect capsules. Nothing is known about the timing of seed dispersal and seed germination, nor is anything known about growth subsequent to seed germination. Vegetative reproduction does not occur (Ownbey, 1940).

STUDY SITES

Two study sites were chosen in the Cold Spring Mountains on the Slate Creek Ranger District of the Nez Perce National Forest. The first site is at Cow Creek Saddle in Section 36 of T26N, R1W. The second site, hereafter referred to as the Elk Exclosure site, is within an elk exclosure at Joe Creek/Christie Creek Divide in Section 32 of T27N, R1E. Maps showing the specific locations of permanent plots are included in Appendix I.

METHODS

Field methods generally followed those described by Fiedler (1985,1987) in her research on the life history and population dynamics of four species of Calochortus in California. At each site, 1 meter square plots were established within populations of the broad-fruit mariposa. At the Cow Creek Saddle site, a fifty-meter line transect was established parallel to the slope contour. Plots were located every five meters along this transect beginning at the five meter mark. Two additional plots were established in areas with dense clusters of reproductive individuals. Only one plot was established at the Elk Exclosure site, although all reproductive individuals were flagged and numbered, and the perimeter of their distribution was mapped.

The plots were established on July 11th, 1988 and revisited again on July 20th and August 3rd. All individuals observed within each plot were marked with a colored plastic toothpick, and mapped on a graph paper representation of the plot. Some difficulty was encountered in identifying seedlings and non-reproductive basal leaves at the Cow Creek Saddle site because of the southerly exposure which had caused the grasslike leaf blades to wither. For this reason, data were collected only from plots which had reproductive individuals. No such difficulty was encountered inside the elk exclosure, although the dense vegetation in the ungrazed area made it necessary to search carefully for the leaves.

The following data were collected at each visit to the sites: (i) maximum above-ground length of the basal leaf; (ii) maximum width of the basal leaf; (iii) number of flowers produced; (iv) number of fruits produced; and, (v) evidence of herbivory, specifically noting the location and nature of the loss or damage to the leaves, flowers and fruits. On the second visit, the height of reproductive plants was recorded.

Eight and twenty-two seed capsules were collected from outside the plots at the Cow Creek Saddle and Elk Exclosure sites, respectively. The length and width of the capsules were measured and recorded at the time of collection, and the number of seed set per capsule was determined.

In order to examine the ability of the broad-fruit mariposa to set fruit by self-pollination, nineteen flower buds on seven plants were enclosed in opaque paper bags.

RESULTS

Summary statistics are given in Table I for the thirty seed capsules collected from the two sites. Comparative data are also shown for four species of Calochortus from the California flora (Fiedler 1985, 1987). C. nitidus appears to produce more seeds per capsule although there is a great deal more variability among the fruits when compared to those from California; the range of seed numbers is also greater. The weight of the seeds of C. nitidus is lighter than those of the Californian species, although the seed weights appear to vary more widely.

Table I. Mean seed weight (mg)± S.E. for Calochortus nitidus and mean number ± S.E. and range of seeds set per capsule. Data for five other species of Calochortus are taken from Fiedler (1987).

Species	Seed weight (mg) ± S.E.	Seeds per capsule ± S.E.	N	Range
Calochortus nitidus	1.41 ± 0.37	55.4 ± 30.2	30	20-149
C. albus	1.81 ± 0.10	39.4 ± 6.2	13	16-99
C. obispoensis	1.54 ± 0.15	39.1 ± 3.7	30	10-100
C. pulchellus	3.90 ± 0.19	35.1 ± 3.9	30	3-104
C. tiburonensis	3.38 ± 0.12	39.6 ± 3.7	37	9-66

Data were collected from a total of 10 plots, nine at Cow Creek Saddle site and one at the Elk Exclosure. The results for each site will given separately.

A total of seventy-two individual plants were identified at the Cow Creek Saddle site on July 11th. Of these, twenty-four plants (33.3 %) had produced a total of forty-two buds and one flower. When the site was revisited on July 20th, all but two of the forty-three reproductive structures had been either nipped off or the plants which bore them were gone entirely. Most of the other vegetation in the area had been grazed also, and small tussocks of bunchgrass had been uprooted and were lying about on the ground surface. Also on the ground surface were numerous cow pies. On my return visit on August 3rd, I found that one of the two surviving flowers had been nipped also. Thus the entire reproductive effort of the plants within the permanent plot, save one fruit, had been eliminated.

Inside the Elk Exclosure the results were quite different. A total of twenty-six plants were identified within the single plot located there. Of these plants, nine individuals (35%) had produced at total of fifteen flower buds by July 11th. On July 20th these fifteen buds remained on the nine plants. On August 3rd, there were ten fruits (66%) present, four of the buds (27%) had aborted, and one bud remained.

Of the nine reproductive plants, all produced a basal leaf wider than 1.1 cm, and longer than 20.1 cm. Of the seventeen non-reproductive plants (i.e., present as a basal leaf only), four (24%) produced basal leaves wider than 1.1 cm, and three (18%) produced basal leaves which exceeded 20.1 cm. The maximum basal leaf width was 2.4 cm, and the maximum leaf length was 28.0.

Also of note is the fact that of the seventeen non-reproductive plants recorded within the permanent plot at the Elk Exclosure on July 11th, seven (41%) could not be relocated during subsequent visits. These basal leaves ranged in size when first measured were from 0.2-0.9 cm in width, and between 9.0-15.9 cm in length.

In the bagged-flower experiment, the ovary enlarged in thirteen of the nineteen flowers; no seeds were set, however, in any of the enlarged ovaries, thereby strongly suggesting some mechanism which operates to prevent self-fertilization.

DISCUSSION

The seed and its properties

Insufficient data are available at this time upon which to build an interpretation of the role of the seed in the population dynamics of Calochortus nitidus. As shown in Table I, seed production in the broad-fruit mariposa appears to exceed that reported for four species of Calochortus which occur in California. The mean seed weight in C. nitidus is lighter than any of the Californian species; this may be an asset to seed dispersal by wind.

Germination tests of seeds collected during the 1988 field season will be made in order to establish the degree of seed viability. The longevity of seeds in the soil also needs to be investigated, but was beyond the scope of this initial work.

Basal leaf morphology and herbivory

Because of the hot, dry year, few data are available on basal leaf morphology at the Cow Creek Saddle site. Many basal leaves were identified and measured, however, at the Elk Exclosure.

In her studies, Fiedler (1985,1987) found that the basal leaf was not only useful in determining size-classes in the genus Calochortus, but it also "serves as the dominant photosynthetic organ and presumably determines the growth of the individual and its reproduction". For the California species of Calochortus which she studied, the maximum width attained by the basal leaf during the growing season was the sole criterion upon which size-classes were based. This measurement correlated most strongly with bulb wet-weight.

The data from the Elk Exclosure suggest that basal leaf width may be a useful predictor of reproductive performance in Calochortus nitidus also. Of the 50% of the population which attained a maximum leaf width greater than 1.1 cm, 69% produced flower buds. Maximum leaf length may be a useful predictor as well; 75% of the plants which produced a basal leaf that exceeded 20.1 cm in length went on to produce flower buds.

Fiedler (1985,1987) points out that grazing of the basal leaf can reduce the life of an individual by limiting the amount of photosynthate available for bulb renewal. As noted earlier, 41% of the non-reproductive plants that were marked within the Elk Exclosure plot during the initial visit were subsequently not relocated. Major herbivores associated with damage to the basal leaves of species of Calochortus from California include pocket gophers, rabbits, and mule deer. While both deer and elk are present within the general study area, they do not have access to the Elk Exclosure site.

Flower and fruit production and fate

The number of flowers, fruits, and their fate varied between the Cow Creek Saddle and Elk Exclosure sites. Of the forty-three flower buds produced by twenty-four plants counted on July 11th at Cow Creek Saddle, only one (2%) fruit remained on August 3rd. Although they were not directly observed, there is strong evidence that the effective reduction of reproductive success to negligible amounts was due to nipping of the flower buds and flowers by cattle, although other mammals may have contributed as well.

By contrast, the nine plants that flowered of the twenty-six plants within the Elk Exclosure plot, produced a total of 15 flower buds. Although four of these buds aborted, successful production of at least one fruit was achieved by eight plants, or 31% of the total number of individuals in the plot. This percentage of successful reproduction appears comparable to some of the values given for the larger size-classes of the four species of mariposa studied by Fiedler (1985,1987). She notes, however, that one of the species studied, C. pulchellus, may exhibit a 'chaotic' behavior pattern in which there are long periods of few individuals per population reproducing, alternating with periods of many. Casual observations of C. nitidus populations over the past few years does not suggest such behavior is occurring.

CONCLUSIONS

As Fiedler (1987) correctly emphasizes, there are inherent difficulties in gaining an understanding of an entire species from a sample of one or few populations. Nevertheless, the data reported here further our knowledge of the life history and population dynamics of Calochortus nitidus considerably. As yet, these data are partial and preliminary, and numerous gaps exist before we can begin to construct a model of the behavior of the broad-fruit mariposa.

Perhaps the most significant result of this preliminary work was documentation of the fact that herbivory can have a major impact on the population dynamics of the species. Basal leaf herbivory, presumably by small mammals, was demonstrated within the Elk Exclosure plot where 41% of the basal leaves of non-reproductive plants were removed. Photosynthesis by the basal leaf of both reproductive and non-reproductive plants is the major source of photosynthate for the annual process of bulb renewal.

Whatever significance the levels of natural depredation of basal leaves by herbivores has on the persistence and growth of plants, it must pale before the devastating effects of herbivory on

reproductive success. At Cow Creek Saddle, bud and flower removal by herbivores reduced reproduction within the permanent plots to nearly nil. The evidence indicates that the majority of the damage was attributable to cattle.

A reconnaissance of the vicinity of the plots, as well as other areas frequented by cattle, suggests that is not a localized phenomenon but one that occurs wherever cattle linger and graze within populations of the mariposa during its reproductive period. The data from Cow Creek Saddle show that nearly total elimination of reproductive success can occur in a local population as short a period as ten days; it probably can occur in a much shorter time, especially if cattle are found to prefer the succulent flower buds to other available forage.

MANAGEMENT ALTERNATIVES

Based on the available data, it appears that there are three primary management alternatives to choose from. These options, as well as their probable consequences, are discussed below.

Management Option 1. Remove livestock entirely from all occupied and potential habitat for *Calochortus nitidus*.

This option may offer the greatest enhancement of broad-fruit mariposa populations by eliminating the herbivore which appears to have the greatest impact on the reproduction of the plant. It would primarily affect the grasslands along the crest of the Cold Springs Mountains ridge from the vicinity of Cow Creek Saddle, northward through Grave Point. It would also affect areas along the spur ridges which connect to this divide from the east. Such an action would probably not be looked upon with favor by the permittee(s), and could make protection of the population at The Table Lands which lies primarily on a private inholding (Caicco 1987) more difficult. Extensive fencing would probably be necessary to implement this option.

Management Option 2. Continue the current management policy throughout the entire area.

Failure to take the sensitive status of *Calochortus nitidus* into consideration will lead to a continued decline in the size and vigor of local populations. This degree of decline would vary with the levels of domestic livestock grazing activity, but it seems likely that all areas outside of the Elk Exclosure would be affected to some degree. A few areas such as Cow Creek Plateau, The Table Lands, and Johnson Ridge should be less affected under current management, because of a light grazing regime due to their remote nature and distance from water (Caicco 1987). In

the case of Johnson Ridge, current management restricts livestock grazing in order to enhance elk habitat. The overall effect on the species, however, would probably be a continuation of the historic decline in the range and status of the species, which at some point would make formal listing as either Threatened or Endangered under the Endangered Species Act unavoidable.

Management Option 3. Actively manage livestock distribution and grazing intensities in selected areas of occupied and potential habitat for *Calochortus nitidus* in such a way as to enhance the size and vigor of local populations.

While this is certainly the more reasonable of the three alternatives, it is also the most complex, for it requires a detailed knowledge of the plant species, as well as a consideration of current livestock management practices and their effects on the grazing ecology of cattle.

In order to implement this option, several steps are necessary. First, the current studies must be continued and their timing extended to include both earlier and later site visits; this would permit the collection of the additional data required in order to develop a model of the life history and population dynamics of the species. Second, additional permanent plots must be established within areas of differing degrees of grazing intensity in order to evaluate more fully the effects of floral bud and flower depredation on the species. It should be noted that the Cow Creek Saddle vicinity offers excellent opportunities in this regard, with grazing intensities ranging from very heavy to very light.

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Submitted by: Robert K. Moseley

Robert K. Moseley
Staff Biologist
Nongame Program

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Jerry M. Conley, Director

Tom Reinecker, Chief
Bureau of Wildlife

Wayne Melquist 1/30/89

Wayne Melquist
State Nongame Manager