# POPULATION CHARACTERISTICS AND DEMOGRAPHICS OF OBSCURE BUTTERCUP (*RANUNCULUS RECONDITUS* NELS. & MACBR.)

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## ABSTRACT

Population characteristics and demographic structure of an obscure buttercup (*Ranunculus reconditus* Nels. & Macbr.) population are being studied within the Washington State Department of Natural Resources-managed Columbia Hills Natural Area Preserve (NAP). Individual plants were tracked annually between 1996 and 1998 in three separate locations within the NAP. For each plant, the number of reproductive structures was recorded and the plant was classified into one of three life stages: seedling, vegetative, or reproductive. In addition, data on seed production were collected in 1997 and observations were made of potential pollinators. Results indicate a population structure dominated by vegetative individuals and with relatively few seedlings. Transition rates among life stages indicate a high annual survival rate (90-98%) for vegetative and reproductive stages, but only a 18-29% survival rate for seedlings. Within a given study location, estimated seed production averaged 3138 seeds/year, while seedling recruitment averaged only 23 seedlings/year. This suggests that seed survival, germination, and/or seedling establishment may be limiting for the populations at this site. Annual changes in reproductive output and seedling establishment were associated with precipitation fluctuations during the period, suggesting that recruitment may be significantly influenced by weather conditions. These baseline data will be useful for long-term tracking of population status on the site and for making informed management decisions in the future.

## INTRODUCTION

The long-term conservation of rare plants requires substantial biological information in order to accurately assess population status, prioritize management efforts, and design effective management strategies. Censuses or estimates of population size can provide accurate assessments of the size of a population, but do not provide any additional information regarding causes of changes in population size or possible management responses. Effective management response to population declines often requires more detailed information on population dynamics and reproduction, life history, and habitat characteristics than can be provided by censuses or population size estimates (Lesica 1987; Morris et al. 1999).

Demographic monitoring is generally recognized as one of the most valuable methods of gathering this type of information (e.g., Lesica 1987; Palmer 1987; Menges 1986; Schemske et al. 1994). Although very labor intensive, this type of monitoring provides detailed information on fecundity, survivorship, recruitment, and age structure that can be essential in assessing a population's status and determining causes and management solutions to any declines (Lesica 1987; Morris *et al.* 1999). While accurate assessment of population trends using transition matrices requires long-term data collection over several years, even a few years of demographic data collection can yield useful information on life history, population structure, phenology, and responses to external conditions (e.g., climate). This information can also be used in designing monitoring plans for other sites and in prioritizing monitoring and research questions.

Obscure buttercup (*Ranunculus reconditus* Nels. & Macbr.) is a local endemic of the eastern Columbia River Gorge along the Washington-Oregon border. It is known primarily from a 12 km x 0.6 km stretch of the Columbia Hills in Washington, with several smaller occurrences found nearby (within 30 km) in Washington and adjacent Oregon. Obscure buttercup is ranked as G2S1, is considered a "Species of Concern" by the U.S. Fish and Wildlife Service, and is classified as Threatened in Washington State by the Washington Natural Heritage Program (Washington Natural Heritage Program 1997). The Flora of North America Editorial Committee (1997) treats this taxon as *R. triternatus* Gray, which has a slightly wider distribution, including isolated populations in Idaho and Nevada. However, the relationship of these isolated populations to the plants found in the Columbia River Gorge has not been closely examined. Until this relationship is established, the Washington Natural Heritage Program continues to recognize *R. reconditus* as a species endemic to the eastern Columbia River Gorge (John Gamon, Washington Natural Heritage Program, pers. comm.).

Obscure buttercup is a small, herbaceous perennial 5-15cm tall with bright yellow flowers 15-30mm in diameter occurring at the end of nearly naked stalks. The leaves, which are predominately basal, are 3-4cm long x 4-5cm broad, deltoid to reniform in outline, and are triternately divided into narrow segments. Each flower produces a single seed cluster containing numerous, small achenes (Schuller and Sprague 1985). Plants emerge in late winter (February to early-March), flower in March, produce seed in April, and have typically senesced by mid-May. As the achenes mature, the peduncles bend downwards, placing the seed cluster in contact with the soil. Observations have indicated that a high percentage of seeds are dispersed beneath or immediately adjacent to the parent plants, which may at least partially account for its somewhat clumped distribution (Schuller and Sprague 1985).

Obscure buttercup occurs on the upper slopes and crests of basalt ridges overlain by loess deposits of varying depths. Plants can be found on all aspects but are most abundant on south-facing slopes. Associated plant communities are meadow-steppe and steppe habitats dominated by perennial bunchgrasses, primarily bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Löve) and Idaho fescue (*Festuca idahoensis* Elmer). A variety of perennial and annual broad-leaved herbs are also typically present. The interspaces between vascular plants generally support a crust of cryptogams (lichens and mosses), particularly where vascular plant coverage is lowest. Shrubs are generally absent or very minor, except where the species occurs on relatively shallow, coarse soils. In these habitats, low shrubs, primarily desert buckwheats (*Eriogonum* spp.), are present in moderate amounts.

As with many other rare plants, there is only limited knowledge regarding the biology and ecology of obscure buttercup. This study was designed to provide information about basic life history and demographic attributes, including population structure, transition rates among life stages, seed production, and pollination. This paper presents the preliminary results of three years of demographic data collection from a population of obscure buttercup in Washington State.

**STUDY AREA**

Data were collected from the Columbia Hills Natural Area Preserve (NAP), located 11 km north of Dallesport, Washington in southern Klickitat County (Figure 1). This site encompasses approximately 1400 ha and contains a large portion of the known populations of obscure buttercup. The site, now owned and managed by the Washington State Department of Natural Resources, was previously owned and managed as part of the Bleakney family's Dalles Mt. Ranch. The Bleakney's stewardship of the land was important in helping to maintain much of the site in good ecological condition prior to its purchase by Washington State.

The Columbia Hills NAP stretches for five miles along an east-west trending ridge system, known as the Columbia Hills, that parallels the Columbia River at the eastern end of the Columbia River Gorge. The NAP is situated along the ridgetop and upper slopes of this ridge system, with elevations ranging from 675m to 990m.

The local climate of the area is heavily influenced by topography, elevation, prevailing westerly winds, and its proximity to the "wind corridor" of the Columbia River Gorge. The climate classification is semi-arid, cold and dry, with mean annual precipitation of 44.2 cm and mean annual temperature of 9.4°C. Less than 10% of the annual precipitation falls during the dry period, July through

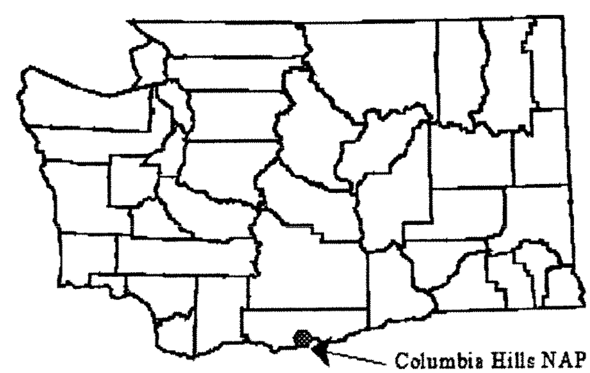


**Figure 1.** Location of Columbia Hills Natural Areas Preserve.

September. Large variations in snowpack depth and duration occur over short distances, depending on topography and aspect in relation to westerly winds. Snow is absent on south-facing slopes by mid-April, but may persist into May on northerly exposures and topographic depressions in years of heavy snow. Wind velocities are typically high in the spring and summer months.

Geologically, the Columbia Hills are composed of two basalt flows of the Columbia River Basalt Group: the Grande Ronde and the Wanapum Basalt (geology summarized from Walsh et al. 1987 and Alt & Hyndman 1984). The NAP is located above the level of the Bretz Floods, which scoured the Columbia River Gorge up to an elevation of about 1000 feet during the Pleistocene. Today the site consists mainly of moderately deep, loamy soils formed in loess that was deposited over the basalt. Some portions of exposed ridgetops and steep south- and west-facing slopes have shallow, rocky soils developed from basalt colluvium and residuum.

Vegetation on the NAP consists primarily of bunchgrass steppe communities within the Idaho fescue-houndstongue hawkweed (*Festuca idahoensis-Hieracium cynoglossoides* Arv.-Touv.) zone described by Daubenmire (1970). On loamy soils of the south-facing side of the ridge, bunchgrass steppe communities are generally dominated by bluebunch wheatgrass, with lesser amounts of Idaho fescue. Lemmon's needlegrass (*Stipa lemmonii* (Vasey) Scribn.) is abundant in places and Sandberg's bluegrass (*Poa secunda* J.S. Presl) is frequent but of low cover. A variety of forbs are present including lupines (*Lupinus spp.*), yarrow (*Achillea millefolium* L.), Columbia frasera (*Frasera albicaulis* Dougl. var. *columbiana* (St. John) Hitchc.), desert parsleys (*Lomatium spp.*), Yakima milkvetch (*Astragalus reventiformis* (Rydb.) Barneby) and Puget balsamroot (*Balsamorhiza deltoidea* Nutt.). On north aspects the loamy soils support similar communities, but Idaho fescue predominates over bluebunch wheatgrass, and Lemmon's needlegrass is less abundant. Shrubs are sparse or absent on both sides of the ridge. Annual grasses, primarily cheatgrass (*Bromus tectorum* L.), are present in these communities, with substantially higher cover on southerly exposures. A patchy but diverse cryptogam layer is present on the soil surface between vascular plants.

On shallow, rocky soils the vegetation typically consists of a low shrub layer of Douglas buckwheat (*Eriogonum douglasii* Bent.) and Hood's phlox (*Phlox hoodii* Rich.), and an herb layer dominated by Sandberg's bluegrass, Franklin's sandwort (*Arenaria franklinii* Dougl.), and a variety of forbs. Rock and bare ground are moderately abundant, and annual grasses are uncommon in most sites. A cryptogamic soil crust is present and covers approximately 25% of the soil surface.

Within the Columbia Hills NAP, obscure buttercup is found primarily on the south-facing side of the ridge. It occurs on loamy soils of moderate depth or in areas that appear transitional between loamy soils and shallow, rocky soil habitats. It also occurs in smaller amounts on north- and east-facing slopes in soils of similarly moderate or transitional depth.

## METHODS

Three sampling sites were subjectively chosen within the NAP to include the observed range of variation in habitats. Site 1 is located on the south-facing slope of the ridge in an area of extensive loamy soil habitat. Site 2 is also located on the south-facing slope of the ridge, in a habitat transitional between loamy soils and shallow, rocky soils. Both of these sites are on relatively gentle slopes of 20% or less. Site 3 is situated on a steep (60% slope), northeast-facing slope on the north side of the ridge, with soils of transitional depth. The sampling sites were required to contain relatively dense concentrations of obscure buttercup to allow for efficient data collection.

Data collection began in 1996 for Site 1 and in 1997 for Sites 2 and 3. In the first year of data collection at each site, randomly-placed, permanent quadrats were thoroughly searched for individual obscure buttercup plants. Due to considerably different plant densities at each site, it was necessary to use different quadrat sizes in order to achieve the desired sample size (250 plants per site). At Site 1, three quadrats 1m wide x 35m-50m long were used, while at Sites 2 and 3 fifteen 0.5m x 2m and thirteen 1m x 3m quadrats, respectively, were used. Each plant found within a quadrat was marked with a numbered aluminum tag inserted into the soil and classified into one of the following three life stages:

- Seedling: any plant with two or fewer leaves and each leaf with only three lobes total
- Vegetative: any plant without buds, flowers, or fruits and not classified as a seedling

- Reproductive: any plant with buds, flowers, or fruits

In addition, the number of reproductive structures (buds, flowers, and fruits) was tallied for each reproductive plant. Data were collected again in 1997 and 1998 for tagged plants, as described above. The permanent quadrats were also searched for any "new" plants, i.e., plants not previously tagged, which were then mapped in relation to existing tags and included in that year's data collection.

In 1997, seed clusters were collected from 25 plants at each site and the number of seeds per cluster recorded. In cases where there was an evident flowering stem but no seed cluster present, it was assumed that either the flower or fruit had been predated or the flower had not produced seed. Thus, these were recorded as clusters with zero seed. Since each flower produces a single seed cluster, an estimate of the total number of seeds produced in a sampling location can be calculated using the average number of seeds/cluster and the total number of reproductive structures recorded for the sampling location.

Precipitation data were obtained from the Western Regional Climate Center in order to assess the possible effects of precipitation levels on population variables. Monthly precipitation data were totaled for the October to March period prior to data collection. This period was selected as the period during which precipitation is most likely to influence obscure buttercup. Autumn and winter precipitation constitute the vast majority of annual precipitation, serving to "recharge" the soil, and since most plants grow and reach anthesis during March, precipitation after March is probably not consequential to any of the variables measured, with the possible exception of seed production.

Casual observations of insect activity were made each year and the most frequently observed insect was collected and sent to Dr. Richard Mack at Washington State University for identification.

## RESULTS

A total of 250 plants were recorded and tagged at Site 1 in 1996. In 1997, 262 and 322 plants were recorded and tagged at Site 2 and Site 3, respectively, and a total of 283 plants were recorded at Site 1. In 1998, Sites 1, 2, and 3 contained 285, 229, and 319 plants respectively. Thus, a total of 250 plants were tracked between 1996-1997 and 867 plants were tracked between 1997-1998.

Population structure was dominated at all sites and in all years by vegetative individuals, while seedlings comprised the smallest proportion at all sites in all years (Figure 2). The proportion of reproductive plants ranged from 20.1% at Site 3 in 1997 to 46.0% at Site 2 in 1998. Sites 1 and 2 had similar population structures, while Site 3 had a higher proportion of vegetative plants and a lower proportion of reproductive plants. Annual variation in population structure is illustrated in Figure 3, which shows changes in the proportions of seedlings, vegetative plants, and reproductive plants at Site 1. At this site, the proportion of plants that were seedlings was approximately twice as large in 1997 as in 1996 and 1998. In contrast, the proportion of reproductive plants was lowest in 1997 and approximately equal in 1996 and 1998.

Calculated across all sites and all years, plants classified as 'reproductive' produced an average of 1.9 reproductive structures/plant in a given year (Figure 4). Average reproductive structures per reproductive plant were highest in 1996 and lowest in 1997, although none of the differences between years was significant. The total number of reproductive structures produced at Site 1 was 225 in 1996, 92 in 1997, and 305 in 1998.

Seed clusters averaged 16.8 seeds/cluster across all sites in 1997, the only year in which seed data were collected. Average seeds/cluster was highest at Site 1, which averaged nearly twice the number of seeds/cluster at Site 3 (Table 1). Estimates of the total number of seed produced by the tagged plants at each sampling site were calculated by multiplying the mean number of seeds/cluster and the total number of reproductive structures recorded for tagged plants (see Table 1).

Transition rates among the three life stages, calculated using the combined data from all three sampling sites, are presented in Table 2. Most vegetative plants remained vegetative in both transition periods (1996-1997 and 1997-1998) and most reproductive plants remained reproductive through both transition periods. Transition rates were similar in both transition periods, except for the vegetative-to-reproductive transition and the seedling-to-vegetative transition, which were both higher in 1997-1998 than in 1996-1997. The transition from seed to seedling was

**Table 1.** Seed production, seedling recruitment, and seed-seedling transition rates. _ seed/cluster was based on seed collected in 1997.

| Site | _ seed/cluster (95% CI) | Total estimated seed | Total seedlings present | Seed-Seedling transition |
|---|---|---|---|---|
| 1 | 20.9 (3.3) | 4703 (1996)<br>3825 (1997) | 31 (1997)<br>16 (1998) | .007 (1996-1997)<br>.004 (1997-1998) |
| 2 | 17.7 (2.9) | 3009 (1997) | 11 (1998) | .004 (1997-1998) |
| 3 | 10.8 (2.7) | 1015 (1997) | 34 (1998) | .033 (1997-1998) |
| All | 16.8 (1.8) | 7849 (1997) | 61 (1998) | .008 (1997-1998) |

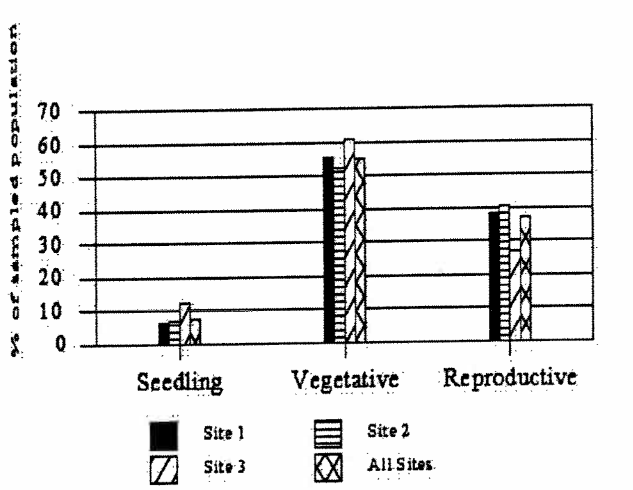


**Figure 2.** Average population structure at the 3 sampling sites.

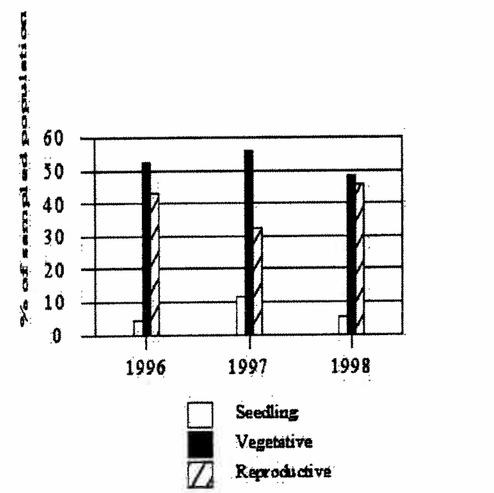


**Figure 3.** Annual variation in population structure at Site 1.

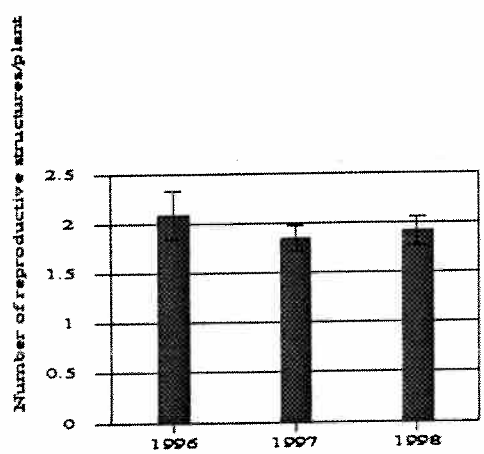


**Figure 4.** Mean number of reproductive structures per reproductive plant.

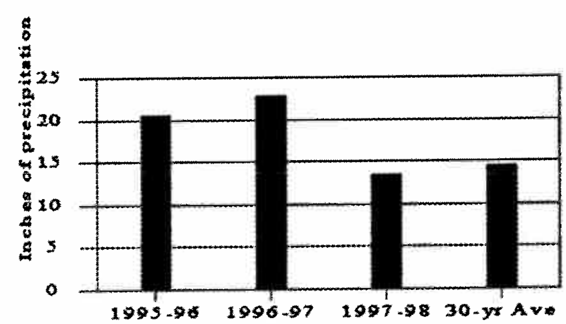


**Figure 5.** March-October precipitation during the study period.

**Table 2**. Estimated transition rates between life stages.

**Transition Period: 1996-1997**

| | | TO: Seedling | Vegetative | Reproductive | Dead/Dormant |
|---|---|---|---|---|---|
| **FROM:** | Seedling | --- | .182 | --- | .818 |
| | Vegetative | --- | .760 | .141 | .099 |
| | Reproductive | --- | .283 | .646 | .071 |

**Transition Period: 1997-1998**

| | | TO: Seedling | Vegetative | Reproductive | Dead/Dormant |
|---|---|---|---|---|---|
| **FROM:** | Seedling | --- | .293 | --- | .707 |
| | Vegetative | --- | .636 | .307 | .057 |
| | Reproductive | --- | .237 | .744 | .019 |

consistently low, ranging from 0.4% to 3.3% (Table 1). This transition was calculated using the estimated total number of seeds produced in a given year, divided by the number of seedlings recorded in the following year. Mortality was high for seedlings but relatively low for vegetative and reproductive plants.

Six of the 250 plants recorded in 1996 at Site 1 were not found in 1997, but reappeared in 1998. This suggests that plants may occasionally enter dormancy for at least one year.

October to March precipitation was 45% and 60% above the 30-year average in 1995-96 and 1996-97, respectively, and slightly below the 30-year average in 1998 (see Figure 5). Annual variation in October-March precipitation was inversely associated with annual changes in the number of reproductive structures produced, particularly the total number of structures produced at Site 1, and with annual changes in the proportion of reproductive plants at Site 1. Sites 2 and 3, where data were collected only in 1997 and 1998, showed similar patterns for these two years. The variation in October-March precipitation was positively associated with changes in the proportion of seedlings at Site 1 from 1996-1998, as well as at Sites 2 and 3 for 1997 and 1998.

The insect specimens collected from obscure buttercup flowers were identified as members of the soft-winged flower beetle genus (*Amecocerus* sp.) within the family Melyridae, order Coleoptera. Insects in this genus are apparently quite common in the region, particularly early in the spring, and are probably a generalist pollinator (Zack, pers. comm.). Given their abundance on the flowers of obscure buttercup during a number of years of casual observations, these insects are likely to be one of the major pollinators for this species. Other insects, including a species of small ant and a small fly, were observed very occasionally on obscure buttercup flowers and may also be involved in pollination.

## DISCUSSION

Populations appeared to be stable in terms of total numbers of plants present during the study period. Differences in population structure and reproductive potential between sites and in different years may be related to differences in habitat and annual precipitation fluctuations. Site 3 differs from the other two sites in being quite steep and in having a northeasterly, rather than a southerly aspect. This site had a lower proportion of reproductive plants, as well as fewer reproductive structures per reproductive plant, than the other two sites in both 1997 and 1998. In addition, seed production at this site was significantly lower than at the other two sites. These results suggest that steep slopes and/or northerly aspects may be less optimal habitat for this species than the more gentle, south-facing slopes. Cooler temperatures and/or less direct sunlight in such habitats could be directly responsible for the observed differences.

In addition, snowpack was observed to persist longer at Site 3 due to greater snow accumulations via drifting and slower snowmelt.

The consistently-observed predominance of vegetative plants at all sites, ranging from 48%-67% of all plants, suggests that population size estimates for this species based on flowering individuals alone probably significantly underestimate actual population size. This should be taken into account when conducting inventories for the species and for monitoring regimes that employ visual estimates of population size based on flowering individuals.

The association between fluctuations in October to March precipitation and reproductive variables, particularly at Site 1, suggests that wet years may negatively influence reproductive output in populations of this species. Such a relationship is somewhat unexpected, given that most herbaceous plants in this arid environment tend to respond positively to wetter years. This may be due to the very early flowering period of obscure buttercup (February to early April), as compared to the later-spring flowering period of most other herbaceous species. During this early spring period, soil moisture conditions may be less important than soil temperature, which increases more rapidly under drier conditions (Brady 1990). The positive association between October to March precipitation and seedling recruitment, on the other hand, suggests that germination and/or early seedling survival may be enhanced by higher levels of moisture availability. If this is in fact the case, it suggests a scenario where seedling establishment occurs sporadically, in wetter years and reproductive output is higher in normal-precipitation or drier years. Under such a scenario, there could be significant delays between good reproductive years when seeds are produced most prolifically, and good seedling establishment years. Thus, the length of time that seeds remain viable in the soil bank could have a significant influence on long-term recruitment levels within populations. Longer-term data collection, through a greater variety of climate variations, will be necessary to accurately assess the effects of annual climate variation on population dynamics.

The low number of seedlings produced per seed and the high level of seedling mortality suggest that seedling recruitment and survival are the most limiting stages to population maintenance and growth. A number of factors, such as high levels of seed predation or disease, low seed viability, or poor seed germination, could be responsible for the low level of seedling recruitment. Alternatively, it may be that seeds remain viable in the soil for long periods and that flushes of seedling recruitment take place under certain optimal conditions. Additional study will be necessary to explain the observed levels of seedling recruitment and to determine the degree to which this fluctuates. Similarly, seedling mortality may be affected by many variables including disease and predation, weather conditions, frost-heaving, etc. However, the consistent level of seedling mortality throughout the study period suggests that high seedling mortality may be typical.

If the suspected pollinator, *Amecocerus* sp., is responsible for the majority of pollination, genetic exchange between populations may be very limited. No individuals of this insect were observed flying during the study; rather, their mobility appears to be limited to crawling, even when attempting to escape capture. This suggests that their travel distance between plants and flowers may be very short, so that pollination occurs only between relatively closely-spaced plants. Investigation into the pollination biology and genetic variability of obscure buttercup should be conducted in order to better understand the species' biology and to determine the relative importance of different populations to conservation at the genetic level.

The information learned from this study will be useful as a baseline for assessing future population status at this site, and for potential comparisons to other populations, particularly those being grazed by livestock or that have burned recently. In addition, several priority topics for additional research have been identified: seed germination and ecology, seedling establishment, pollination ecology, and genetic variability. Demographic monitoring at this site should continue in order to gather sufficient data for use in a transition matrix model. Data from at least three transition periods should be collected in order to have acceptably accurate transition rate estimates for use in such a model. Using transition matrix modeling, useful predictions can be made including estimates of population growth rates, extinction probabilities, and elasticity analysis for further identifying sensitive life stages. This will further assist in establishing baseline conditions and in helping to direct both current and future management of the NAP.

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