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# NECTAR SOURCE DIVERSITY AS AN INDICATOR OF HABITAT SUITABILITY FOR THE ENDANGERED UNCOMPAHGRE FRITILLARY, *BOLORIA ACROCNEMA* (NYMPHALIDAE)

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**ABSTRACT.** Pairwise comparisons between occupied and apparently suitable, yet unoccupied, *Boloria acrocnema* sites in the San Juan Mountains of southern Colorado indicated that occupied sites have a greater diversity of nectar source genera than unoccupied sites. This suggests a means of improving the efficiency of search efforts for additional populations of this endangered butterfly.

**Additional key words:** habitat, Colorado, conservation, biological indicators.

The Uncompahgre fritillary, *Boloria acrocnema* (Gall and Sperling) (Nymphalidae), was discovered on a high ridge near Uncompahgre Peak in the San Juan Mountains, Hinsdale County, Colorado in 1978 (Gall & Sperling 1980). A second colony subsequently was found in 1982 near Red Cloud Peak, approximately 16 km south of the type locality (Gall 1984a). Despite considerable effort throughout the 1980's, U.S. Fish and Wildlife Service, Forest Service, and Bureau of Land Management personnel and others were unable to document the existence of any additional colonies. Gall (1984b) estimated the total brood size of the Uncompahgre Peak colony at 650–750 individuals in 1980. The Red Cloud colony consisted of 1,000–1,500 individuals in 1982 (Gall 1984b). Anecdotal accounts indicated that both known colonies were declining.

Given the extreme endemicity of this butterfly and its apparent rarity, the species was considered for endangered status under the U.S. Endangered Species Act in 1982 (Federal Register, Vol. 49, No. 100, P. 2167). Work was begun in 1987 to characterize the habitat of the Uncompahgre fritillary, determine the status of the known populations, and discover any existing colonies near the known ones (Britten & Brussard 1992, Britten et al. 1994). Because the populations were declining, and because the odd-year brood of this biennial butterfly was apparently extirpated at its type locality in 1987 (Britten et al. 1994), the Uncompahgre fritillary was listed as endangered in 1991 (Federal Register, Vol. 56, No. 121, P. 28712).

The 1993 draft recovery plan for the Uncompahgre fritillary stipulates that delisting of the butterfly will occur when stable colonies exist for 10 consecutive years at 10 or more locations. Because only small numbers ($n<15$) of butterflies were located at three additional sites (Brussard & Britten 1989), delisting will occur only with the discovery of a substantial number of new colonies. However, the search for colonies is hampered by a number of difficulties. First, the known colonies exist at high elevations, approximately 4,000 m, in areas which generally are inaccessible by road. Thus, foot travel or high altitude helicopters are the only realistic means of access to potential habitat areas. Second, this butterfly's flight season is short, lasting from early- to mid-July to early August. In addition, weather conditions are unpredictable at high elevations. This diminishes further the duration of suitable flight conditions in which searches can be conducted. As poor flight conditions frequently occur during investigations, it is often impossible to eliminate a site as potential habitat. The final difficulty in locating new colonies is that apparently suitable habitat is ubiquitous in the San Juan Mountains and nearby ranges.

Larval *B. acrocnema* feed on snow willow, *Salix nivalis* (Booth) (Salicaceae) (Scott 1986), which occurs in fairly discrete patches from below tree-line to near the limit of vegetative growth in the San Juan Mountains. The two known colonies and other areas where the butterfly has been located, have approximately 15% snow willow cover, occur on northeast facing slopes with up to 45% grades, and contain snow fields and numerous flowers during the flight season (Brussard & Britten 1989). These characteristics describe a very large portion of the alpine zone of the southern Rocky Mountains. All sites examined have similar habitat components, yet only a small fraction of them support *B. acrocnema* populations. Thus, an efficient method of habitat assessment is much needed.

A number of studies have correlated adult butterfly resources, such as nectar supply, with population densities and individual movements (Gilbert & Singer 1975, Thomas & Singer 1987, Williams 1988). We examined data on nectar source inflorescences to test for a similar correlation between occupancy at potential *B. acrocnema* sites and nectar source abundance. Any such quantifiable differences between occupied and unoccupied sites could then be used to establish search priorities among sites for this rare butterfly.

## MATERIALS AND METHODS

Data were gathered during the 1988 flight season from the five occupied sites and from five unoccupied sites which were paired to the former on the basis of elevation, slope, aspect, geographical location, and percent cover of snow willow. Unoccupied sites were no more than 200 m from the occupied sites with which they were paired. The unoccupied sites originally had been identified as good potential sites, due mostly to the presence of a patch of snow willow, and were surveyed for butterflies, along with a total of approximately 50 such sites, in the initial efforts to locate new colonies. The unoccupied sites were selected for comparison with the occupied sites because of their proximity to the latter. Nearness of paired sites is desirable for these comparisons, because it insures that unoccupied sites are as ecologically similar to the occupied sites as possible.

Data on frequency of nectar source inflorescences by genus were determined using a line intercept method along habitat transects (Smith 1980). This was accomplished by laying a 50 m tape measure across the potential habitat patch and tallying all flowering plants which came into contact with the tape measure (Britten 1991). Flowering plants are referred to as "nectar sources" if *B. acrocnema* was observed visiting the species during the flight season (Britten 1991). Transect length varied from 75 m to 150 m according to the length of the site, but the majority of sites were sampled with 100-m transects. Size of a site was not correlated with occupancy. Sites were characterized by frequency of inflorescences by genus (occurrence per meter) and the number of genera represented.

The hypothesis that occupied sites are floristically more diverse than unoccupied sites was tested against a null hypothesis that unoccupied sites are equally or more floristically diverse than occupied sites. Thus, one-tailed statistical tests were appropriate for the rejection of the null hypothesis.

The diversity of nectar source genera was compared among paired sites using N, the number of genera per site, and 1/D, the reciprocal of the Berger-Parker index of dominance (Magurran 1988). The Berger-Parker index indicates how dominant the most common taxon is within a site. Its reciprocal, therefore, gives an estimation of evenness. Taken together, taxon richness (N) and evenness (1/D) estimate site diversity. These data may not be normally distributed, and, thus, they require nonparametric analysis. The Wilcoxon signed ranks test was used to

TABLE 1. Inflorescences present (+) or absent (−) on paired occupied (O) and unoccupied (U) *Boloria acrocnema* sites in the San Juan Mountains.

| | Sites | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Uncompahgre | | Red Cloud | | A | | B | | C | |
| Genus | O | U | O | U | O | U | O | U | O | U |
| *Aster* (Asteraceae) | + | + | − | + | + | − | + | + | + | + |
| *Bistorta* (Polygonaceae) | − | + | − | − | − | − | − | − | + | + |
| *Caltha* (Ranunculaceae) | − | − | − | − | − | + | − | − | − | − |
| *Castilleja* (Scrophulariaceae) | + | + | + | + | + | − | + | + | + | + |
| *Draba* (Cruciferae) | − | − | + | − | − | − | − | − | − | − |
| *Dryas* (Rosaceae) | − | − | − | − | − | − | + | − | − | − |
| *Hymenoxys* (Asteraceae) | + | − | − | − | − | − | − | − | − | − |
| *Lomatium* (Umbelliferae) | − | − | + | − | − | − | − | − | − | − |
| *Mertensia* (Boraginaceae) | + | − | − | − | − | − | − | − | − | − |
| *Penstemon* (Scrophulariaceae) | − | − | − | − | − | + | − | − | − | − |
| *Phlox* (Polemoniaceae) | + | − | − | − | − | − | + | + | − | − |
| *Polygonum* (Polygonaceae) | + | − | + | + | − | − | + | − | − | − |
| *Potentilla* (Rosaceae) | + | + | + | + | + | + | + | + | + | − |
| *Silene* (Caryophyllaceae) | − | − | + | + | + | + | + | − | − | − |
| *Trifolium* (Fabaceae) | + | − | + | − | − | − | + | − | + | − |
| *Zigadenus* (Liliaceae) | − | − | + | − | − | − | − | − | − | − |

compare N and 1/D between occupied and unoccupied sites. Paired sites were further compared using the frequencies of all flowers encountered per meter of transect and the frequency of *Potentilla* (Rosaceae) species encountered per meter of transect. *Potentilla* was chosen for this analysis because it was by far the most abundant flower on the study sites. These final between-site comparisons were made with a t-test, as nonparametric tests were not required (Sokal & Rohlf 1981).

## RESULTS

The results of the analyses demonstrate that occupied *B. acrocnema* colony sites are more floristically diverse than nearby unoccupied sites. Flowers present at each site are indicated in Table 1. The number of

TABLE 2. Comparison of nectar source diversity for paired occupied and unoccupied *Boloria acrocnema* colony sites. N is the number of nectar source genera represented on each site and 1/D is the reciprocal of the Berger-Parker index of dominance (Magurran 1988).

| | N | | 1/D | |
|---|---|---|---|---|
| Paired sites | Occupied | Unoccupied | Occupied | Unoccupied |
| Uncompahgre* | 8 | 4 | 3.00 | 2.09 |
| Red Cloud | 8 | 5 | 1.70 | 1.77 |
| A | 4 | 4 | 1.65 | 1.50 |
| B | 8 | 4 | 3.10 | 1.20 |
| C | 5 | 3 | 3.20 | 1.30 |
| | P = 0.03 | | P = 0.04 | |
| | 1-tailed Wilcoxon signed ranks tests | | | |

* Type locality.

genera in flower per site, N, was higher at occupied than unoccupied sites (P=0.03; Table 2). The reciprocal of the Berger-Parker index, 1/D, was higher at occupied sites (P=0.04; Table 2). The number of flowers encountered per meter was higher at occupied sites (P=0.04; Table 3). This may be, in part, because of the dominance of *Potentilla* species at most sites. The frequency of *Potentilla* species was higher at occupied sites (P=0.03; Table 3). Finally, *Trifolium* species (Fabaceae) occurred at four out of the five occupied sites, but at none of the unoccupied sites (Table 4).

## DISCUSSION

The results of the present study are similar to those of Williams (1988) for the montane checkerspot *Euphydryas gillettii* (Barnes) (Nymphalidae) in the Rocky Mountains. Williams (1988) quantified 10 habitat variables including topographic characteristics, larval host abundances, and nectar source abundances at 15 *E. gillettii* sites in Wyoming,

TABLE 3. Comparison of flower density among paired occupied and unoccupied *Boloria acrocnema* sites.

| | Flowers/meters | | *Potentilla*/meter | |
|---|---|---|---|---|
| Paired sites | Occupied | Unoccupied | Occupied | Unoccupied |
| Uncompahgre* | 0.16 | 0.15 | 0.05 | 0.07 |
| Red Cloud | 0.57 | 0.19 | 0.33 | 0.10 |
| A | 1.19 | 0.12 | 0.72 | 0.08 |
| B | 1.67 | 0.20 | 0.46 | 0.16 |
| C | 0.73 | 0.47 | 0.23 | 0.00 |
| | P = 0.04 | | P = 0.03 | |
| | 1-tailed *t*-tests | | | |

* Type locality.

TABLE 4. Presence (+) or absence (−) of *Trifolium* species in flower at paired occupied and unoccupied *Boloria acrocnema* sites.

| Paired sites | Occupied | Unoccupied |
|---|---|---|
| Uncompahgre | + | − |
| Red Cloud | + | − |
| A | − | − |
| B | + | − |
| C | + | − |

Montana, Idaho, and Alberta. Nectar source abundance was the only variable that significantly correlated with *E. gillettii* colony size (Williams 1988). Likewise, the higher floristic diversity of occupied *B. acrocnema* sites relative to nearby unoccupied sites is probably the result of ecological correlations rather than direct causal mechanisms, such as relative nectar source availability. In other words, habitat characteristics which make a site more suitable to flowering plants also may do the same for *B. acrocnema*. Therefore, it is possible that some as yet unknown set of habitat variables determine habitat suitability for *B. acrocnema* and that the frequency of inflorescences is an ecological indicator of these favorable habitat sites.

The search efforts of federal personnel up to this point have relied on three criteria for the identification of potential *B. acrocnema* colony sites: 1) the presence of snow willow, 2) northeastern aspects, and 3) approximate elevations greater than 3500 m. The results of the present study suggest that it would be prudent to include some assessment of flower frequency in the evaluation of potential habitat. This perhaps could be accomplished with a technique as simple as estimating the density of flowering *Potentilla* plants and noting the presence of *Trifolium* on all investigated sites.

High quality *Boloria acrocnema* habitat seems to be characterized by quantifiable parameters with respect to nectar source inflorescences. These habitat measures should not replace population studies, but they may be used to expand search efforts temporally. Thus, whereas current search efforts are possible only during the three week flight season, habitat assessment including nectar source evaluation could occur throughout the summer. Such inventories could be used to locate new colonies and prioritize sites for further monitoring during the flight season.

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