Weedy Annuals In the Alpine Zone of the White Mountains, California

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Abstract

Alpine environments generally have few weedy species, and plants with annual life cycles are rare. The White Mountains of eastern California, however, have an unusually large number of alpine annuals, a number of which are weedy. Ten weedy alpine annuals in the White Mountains were identified, seven of which were introduced into California (from Europe or Eurasia). All were restricted to disturbed open areas along roadsides, waste places, and overgrazed areas. Humans and domestic animals probably played an important role in introducing annual weeds into the Alpine Zone and creating suitable habitat. Five of the ten weedy annuals occurred in a single roadside area and were ephemeral inhabitants of the alpine zone as they had small populations (less than ten plants) and were present in only one or two of the six years observations were made. The other five annuals had larger, more stable populations and have apparently successfully established populations in the Alpine Zone of the White Mountains.

Introduction

The vast majority of alpine plant species have a perennial life cycle [Billings and Mooney, 1968; Billings, 1974; Bliss, 1971]. Annuals, in contrast, are generally rare in alpine environments. This probably reflects the inability of most annuals to successfully complete their life cycle in a single, short, cold growing season [Bliss, 1971; Reynolds, 1984]. The White Mountains and Sierra Nevada of California, however, have an unusually large number of annual plants at high elevations. For example, annuals comprise 8.1 percent of 160 alpine species in the White Mountains [Spira, 1987] and 8.3 percent of 349 high subalpine and alpine species in a portion of the Sierra Nevada [Jackson, 1985] as compared to 0 to 4 percent annuals in most alpine areas.

The ability of annual plants to occupy alpine habitats in the White Mountains and the Sierra Nevada is enhanced by a summer growing season with warmer temperatures, higher levels of solar radiation, and more moderate conditions than are generally present in alpine areas [Chabot and Billings, 1972; Jackson, 1985; Spira, 1987]. An unusually large population pool of annuals at lower elevations has also contributed to the increased number of alpine annuals in the White Mountains and the Sierra Nevada [Went, 1953; Chabot and Billings, 1972; Spira, 1987].

This paper focuses on those alpine annuals in the White Mountains

which are restricted to disturbed open areas along roadsides, heavily grazed areas, and in waste places, and as such, can be considered weeds. These species are of particular interest not only because of their annual life cycle, but because weedy species are generally rare in alpine habitats [Baker, 1986] and their occurrence is poorly documented.

Study Area

The White Mountains are located in the eastern part of central California (37°13'-38°N and 117°55'-118°25'W) with the extreme northeastern portion extending into Nevada. The range has an area of about 2278 km^2. Because the Sierra Nevada occurs immediately to the west, the White Mountains are in a pronounced rain shadow and the vegetation is Great Basin in character [Lloyd and Mitchell, 1973]. Elevations vary from 1219 to 4342 m and timberline, while variable, generally occurs at an elevation of about 3505 m [Lloyd and Mitchell, 1973]. Additional information on the vegetation is available in Lloyd and Mitchell [1973], Major and Taylor [1977], and Morefield [1986].

Climatic conditions in the Alpine Zone, recorded at the Barcroft Laboratory (elevation 3801 m) from 1953-1973, indicate a mean July temperature of 7.4°C, a mean January temperature of -9.1°C, a mean annual temperature of -5.8°C, and a mean annual precipitation of 49.6 cm, of which 18.3 percent (9.1 cm) falls during June, July, and August [Pace *et al.*, 1974].

Methods

Species discussed in this paper are annuals (except for *Chenopodium rubrum*), occur in the Alpine Zone ($\geq$ 3505 m elevation), and behave as weeds. A weed, as used here, refers to plants which grow entirely, or predominantly, in situations disturbed by human activity [Baker, 1965, 1974].

Field observations in the White Mountains were made during the summer growing seasons from 1980 through 1985. Additional weedy alpine annuals may occur in the northern part of the range as observations were confined to the area south of White Mountain Peak.

Voucher specimens were deposited at the Jepson Herbarium of the University of California, Berkeley and nomenclature follows Munz [1968].

Results and Discussion

We found ten weedy annuals representing four plant families in the Alpine Zone of the White Mountains (Table 1). None of these species is included in Zwinger and Willard's [1972] list of alpine plants of the United States, Jackson's [1985] list of alpine annuals in western North American mountain ranges, or in checklists of alpine plants and regional floras examined. Thus, to our knowledge, the ten weedy annuals listed in Table 1 are not known to occur in alpine areas outside of the White Mountains.

Seven of the ten species listed in Table 1 are introduced from Europe or Eurasia. All of the introduced species are listed as weeds in California [Robbins *et al.*, 1951] and elsewhere [Muenscher, 1955]. The three native alpine annual weeds are *Monolepis nuttalliana, Chenopodium leptophyllum,* and *C. atrovirens* (all in the Chenopodiaceae). *C. leptophyllum* is

Table 1

Annual weeds in the Alpine Zone of the White Mountains, California. Geographic origin (native versus introduced) based on Munz [1968].

Species	Family	Introduced or Native Species
Capsella bursa-pastoris	Brassicaceae	Introduced
Sisymbrium irio [1]	Brassicaceae	Introduced
S. orientale [1]	Brassicaceae	Introduced
Descurainia sophia [1]	Brassicaceae	Introduced
Monolepis nuttalliana	Chenopodiaceae	Native
Chenopodium leptophyllum	Chenopodiaceae	Native
C. atrovirens	Chenopodiaceae	Native
C. rubrum [2]	Chenopodiaceae	Introduced
Senecio vulgaris [1]	Asteraceae	Introduced
Stellaria media [1]	Caryophyllaceae	Introduced

[1] Ephemeral inhabitant of alpine zone (see text for details).
[2] Has a biennial rather than annual life cycle at high elevations in the White Mountains.

also included in Robbins *et al.* [1951] as a weed. All ten species were restricted to disturbed open soils along roadsides, in waste places, and in heavily grazed or trampled areas in the Alpine Zone. In addition to creating suitable habitat for these species, human activities and domestic animals have undoubtedly played an important role in introducing ruderal species into high elevation areas of the White Mountains. For example, sheep and cattle herded from the foothills to the Alpine Zone and cars and people traveling on the White Mountain road have probably brought seeds of weedy species with them into high elevation areas.

Sheep in particular are known to be good dispersers as seeds readily adhere to their wool as they browse on low vegetation or lie down and rest in vegetated areas [Ridley, 1930]. In the early decades of this century, when the largest herds were present, an estimated 40,000 to 50,000 sheep were grazed in the White Mountains [Wehausen,1983]. Three of the species (*Chenopodium rubrum, C. leptophyllum,* and *C. atrovirens*) occurred sympatrically in a single alpine area where sheep were bedded down within an enclosure. Although domestic sheep were excluded from the range in the late 1950's, cattle remain as a potential vector of weedy species. Seeds and fruits of ruderal species such as *Chenopodium rubrum* [Williams, 1969] and *Capsella bursa-pastoris* [Ridley, 1930] may be dispersed by passing through the diges-

tive tract of cattle as well as by clinging to their coats.

Six of the ten weedy annuals listed in Table 1 were restricted to a disturbed roadside area immediately south of the entrance gate to the Barcroft Laboratory of the University of California (elevation 3536 m). These six roadside species *(Capsella bursa-pastoris, Sisymbrium irio, S. orientale, Descurainia sophia, Stellaria media,* and *Senecio vulgaris)* were probably introduced into this area by human activities since the gate was a starting point for hikers and cars parked in this area. A likely mode of introduction was through seed contamination of hay since during the fall hunting season, horses were tethered and fed hay near the entrance gate.

Of these six species, only *C. bursa-pastoris* appears to have successfully colonized the Alpine Zone. The other five species were considered to be ephemeral inhabitants of the Alpine Zone (Table 1) and were not included in a list of alpine annuals in the White Mountains [Spira, 1987] as their populations were small (generally less than ten plants), and they were present during only one or two of the six years sampled. The failure of five of these six roadside annuals to persist from one year to the next could be the result of a number of factors, one of which was poor seed production. While all five ephemeral species produced flowers, both *S. vulgaris* and *D. sophia* failed to produce seeds, and the remaining three species appeared to set few seeds.

Unlike the five ephemeral species just described, *C. bursa-pastoris* maintained a stable population of twenty-five to several hundred individuals each year, and the area occupied by this species actually increased during the six-year period of this study. *C. bursa-pastoris* has a nearly worldwide distribution and is considered to be one of the most common flowering plants [Coquillat, 1951]. Genotypic diversity in this species is well known [Bosbach and Hurka, 1981; Bosbach *et al.,* 1982; Hurka and Haase, 1982] and may increase its ability to tolerate a wide range of environmental conditions. Among the factors that contribute to its success at high elevations are an ability to photosynthesize at low temperatures [Regehr and Bazzaz, 1976] and for seeds to germinate over a wide temperature range and in flushes such that if one seedling cohort fails, another may become established [Popay and Roberts, 1970a,b]. Moreover, *C. bursa-pastoris* seeds are known to be long-lived (up to 35 years [Kivilaan and Bandurski, 1981]). Thus, if few seeds are produced (as occurred in 1982) or if seedling establishment is unfavorable in a given year, populations may be reestablished via dormant seeds produced in a previous year.

The four other annual weeds in the Alpine Zone of the White Mountains *(Chenopodium leptophyllum, C. atrovirens, C. rubrum,* and *Monolepis nuttalliana)* maintained stable populations over the six-year period of observation. *Chenopodium* spp. show a tendency to be weedy [Baker, 1972] which is illustrated by the three species found in the White Mountains. Each of these species was characterized by relatively small localized populations in disturbed areas such as where sheep had previously bedded down, near marmot burrows, and in a cleared area adjacent to the Barcroft laboratory. *C. leptophyllum* is normally found in dryish alkaline places from 1524 to 2438 m in a variety of plant communities, *C. atrovirens* is

widespread in the western United States in dry places from 2134 to 3353 m, and *C. rubrum* is known from relatively low saline places [Munz, 1968]. Large populations of *M. nuttalliana* were observed each year for six years along the White Mountain road at elevations up to 3970 m. This species usually occurs on dry or moist, often saline soils below 1524 m [Munz, 1968] and has apparently extended its elevational range in the White Mountains by colonizing disturbed roadside areas.

Although *C. rubrum* is described in the literature as an annual (see review by Williams, [1969]), it has a biennial life cycle in the Alpine Zone of the White Mountains [Spira, 1987]. For example, plants (N >100) observed from 1981 through 1983 grew vegetatively the first summer, overwintered as a taproot, and reproduced in the second summer.

It is not known what causes individuals of *C. rubrum* at high elevations to delay flowering until their second year. In short-lived monocarpic species, plants may require a cold treatment, exposure to a particular photoperiod and/or must reach some minimal size prior to flowering [Harper, 1977]. Studies by Cumming [1959] and Cook [1976] have shown that *C. rubrum* is a short-day plant requiring a critical photoperiod of 12-15 hours to induce development of floral primordia. In White Mountain populations, a sufficient number of short-day cycles may not occur prior to the onset of cool fall temperatures, requiring a second season of photo-induction prior to flowering. Older individuals of *C. rubrum* require fewer inductive cycles to flower [Cumming, 1959], increasing the probability of flowering in the second year.

In summary, the White Mountains have an unusually large number of weedy annuals in the Alpine Zone. From 1980 through 1985 we observed ten weedy annuals, none of which are known to occur in alpine areas outside of the White Mountains. Seven of the ten annual weeds in the White Mountains were introduced into California (from Europe or Eurasia) and all were restricted to disturbed open areas (*e.g.*, along roadsides, waste places, and overgrazed areas). Five of the ten annuals (all introduced) were ephemeral inhabitants of the Alpine Zone, whereas the remaining five annuals (three native and two introduced) established larger, persistent populations in the Alpine Zone.

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