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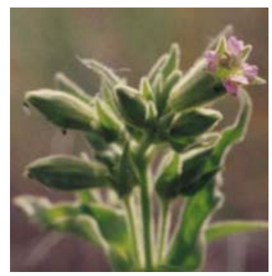
DEMOGRAPHIC MONITORING OF SPALDING'S CATCHFLY (*SILENE SPALDINGII*) IN IDAHO CANYON GRASSLANDS: 2005 FIELD SEASON



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ABSTRACT

Spalding's catchfly (*Silene spaldingii*) is a rare plant endemic to the bunchgrass, sagebrush-steppe, and open pine communities of the inland Pacific Northwest. Large portions of these habitats have been eliminated by cultivation or degraded by livestock grazing. Spalding's catchfly was listed as Threatened by the U. S. Fish and Wildlife Service in 2001. The largest occurrence of Spalding's catchfly in Idaho is in Canyon Grasslands south of Lewiston in the Snake River Canyon, along the western flank of Craig Mountain. Recently, occurrences have been documented on the eastern flank of Craig Mountain and along the Salmon River. In 2002, the Idaho Conservation Data Center (IDCDC) established eight monitoring plots on the western flank of Craig Mountain. In 2004, IDCDC established an additional plot near Eagle Creek on the east side of Craig Mountain, and another near Rice Creek on the Salmon River. The primary objective of the monitoring is to track the conservation status of Spalding's catchfly by collecting demographic data to determine the population trend. In addition, we collected information on reproductive status, herbivory, and habitat characteristics. More plants produced aboveground growth in June 2005 (356) than in June 2004 (260). However, more plants had disappeared by July 2005, with the result that more plants survived to reproduce in 2004. Fruit matured earlier, and there were more reproductive stems and reproductive structures per stem in 2004. Precipitation was higher during the growing season in 2004 than 2005, and may account for the higher reproductive output and the persistence of plants in 2004. Most rosettes arise from mature caudexes, and are not seedlings. Seedling recruitment is episodic and does not appear to be tied directly to the amount of seed output. Instead, favorable conditions for seedling recruitment are probably highly localized. Monitoring in early June and again in July illustrates that many plants, particularly rosettes, senesce or disappear by July. Because of this, demographic data collected only in July is inaccurate, and misrepresents the number of plants that produce aboveground growth. Population size, dormancy, death, and rosette recruitment cannot be inferred from data collected only in July.

Acknowledgments: Juanita Lichthardt was the prime force in establishing the original Spalding's catchfly monitoring plots in 2003. She and Beth Colket provided invaluable and much-appreciated assistance in data collection in 2005.

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INTRODUCTION

Spalding's catchfly (*Silene spaldingii*) is a rare plant endemic to the bunchgrass, sagebrush-steppe, and open pine communities of the inland Pacific Northwest (Hill and Gray 2004a). Large portions of these habitats have been eliminated by cultivation or degraded by livestock grazing. Spalding's catchfly was listed as Threatened by the U. S. Fish and Wildlife Service in 2001 (U. S. Fish and Wildlife Service 2001). The largest occurrence of Spalding's catchfly in Idaho is south of Lewiston in the Snake River Canyon, along the western flank of Craig Mountain (Idaho Conservation Data Center 2006). Recently, occurrences have been documented on the eastern flank of Craig Mountain and along the Salmon River. In 2002, the Idaho Conservation Data Center (IDCDC) established eight monitoring plots on the western flank of Craig Mountain (Lichthardt and Gray 2003). In 2004, IDCDC established an additional plot near Eagle Creek on the east side of Craig Mountain, and another near Rice Creek on the south side of the Salmon River (Hill and Gray 2005). The primary objective of these plots is to track the conservation status of Spalding's catchfly by collecting demographic information on the species and information on the condition of its habitat. Understanding population dynamics and threats for this species is critical for implementing conservation measures.

SPECIES INFORMATION

Spalding's catchfly is a herbaceous perennial plant that commonly grows up to 20-60 (78) cm tall. It typically produces one stem or rosette, but can produce multiple stems or rosettes. Each stem bears 4-7 (occasionally up to 10) pairs of leaves that are 5-8 cm long and up to 4 (6) cm wide. The foliage, stem, and flower bracts are densely covered with sticky, gland-tipped hairs that give the species its common name, "catchfly". Stems or rosettes arise from a simple or branched caudex (persistent stem just beneath the soil surface) that surmounts a long, narrow taproot. Menke and Muir (2004) reported taproots up to 85 cm long. The cream to pink to light green flowers typically have five petals, each with a long, narrow claw that is largely concealed by the calyx tube (the outer, green portion of the flower). The only visible part of the flower is the short (2 mm), expanded blade portion of the petal at the summit of the claw (adapted from Hitchcock et al. 1964; Hill and Gray 2004a). The barely-protruding blades of the corolla are diagnostic, distinguishing Spalding's catchfly from other sympatric species. Scouler's catchfly (*Silene scouleri*) also bears sticky, glandular hairs, but it has much longer petal blades, 6-7 mm, and blooms earlier in the season. In the Craig Mountain area, Scouler's catchfly is rhizomatous and usually forms patches.

Aboveground portions of Spalding's catchfly die back over the winter months. In the Canyon Grasslands on Craig Mountain, new growth emerges at the end of April, flower buds start to form in early July, and flowering continues from mid- to late July into October. Flowering plants have been observed as late as mid-October (Hill, personal observation). Plants can survive belowground from one to several years in prolonged dormancy (Lesica 1997, Hill and Gray 2005). Spalding's catchfly plants have a clumped distribution, tending to grow in irregularly-shaped clusters of varying density (Hill and Gray 2000, Lichthardt and Gray 2003). Between clusters, plants are scattered or very sparsely distributed or not present.


Photo by Janice Hill

Figure 1. Photo of Spalding's catchfly.

Spalding's catchfly reproduces solely by seed, lacking rhizomes or other means of vegetative reproduction. Self-pollination can occur (Lesica and Heidel 1996); however, offspring are more fit if cross-pollinated (Lesica 1993). The ground-nesting bumblebee, *Bombus fervidus*, is the primary pollinator (Lesica and Heidel 1996). Mature capsules can hold up to 150 seeds (Lesica and Heidel 1996) which are dispersed from the top of an upright capsule with wind movement or passing animals. Seeds germinate considerably better with a 30-day period of cold stratification, indicating germination likely occurs in early spring following cold winter temperatures (Lesica 1988). Seedlings first appear as rosettes, pairs of leaves with no stem elongation between them. However, rosettes are often produced by mature caudexes, occasionally from a caudex that sends up both rosettes and elongated stems in the same year. After the first seedling rosette, shoots may appear aboveground as rosettes, vegetative stems, or reproductive stems in subsequent years (Hill and Weddell 2003, Hill and Gray 2005). There is no linear progression from rosette to vegetative stem to reproductive stem, and any of those growth forms may follow any other in successive years, although some transitions are more likely to occur than others (Appendix 1). This aspect of Spalding's catchfly life-history makes demographic studies challenging, because the age of the plant is not correlated with the aboveground growth form, except that all seedlings begin as rosettes.

DISTRIBUTION AND HABITAT

Spalding's catchfly occurs in the Pacific Northwest Bunchgrass Grasslands, sagebrush-steppe, and open ponderosa pine stands in eastern Washington, northeastern Oregon, adjacent west-central Idaho, and a disjunct area in northwestern Montana and adjacent British Columbia (Hill and Gray 2004a). This area includes five distinct physiographic areas: 1) Palouse Grasslands of southeastern Washington and adjacent Idaho; 2) Canyon Grasslands along major river systems in the tri-state area of Washington, Idaho and Oregon; 3) channeled scablands of east-central Washington; 4) dissected basalt plateaus of northeastern Oregon; and 5) intermontane valleys of northwestern Montana and adjacent British Columbia (Hill and Gray 2004a). Portions of the Palouse Grasslands and the Canyon grasslands, subdivisions of the Pacific Northwest Bunchgrass Grasslands (Tisdale 1983), occur in Idaho. The Palouse Grasslands occur on the rolling steppe areas north and south of the Clearwater River (Lichthardt and Moseley 1997), and the Canyon Grasslands occur on steep canyon slopes of the Snake, Salmon, and Clearwater rivers (Tisdale 1986).

The majority of the fertile Palouse Grasslands has been converted to agriculture, and only small remnants of native habitat remain (Noss et al. 1995, Lichthardt and Moseley 1997). Steep terrain and inaccessibility have prevented urban, commercial, or extensive agricultural (other than grazing) development in Canyon Grasslands, and this area represents the largest remaining contiguous and intact area of Pacific Northwest Bunchgrass habitat in Idaho. These Canyon Grasslands support the majority of Spalding's catchfly plants in Idaho. The largest populations occur in the Craig Mountain area.

The climate in the study area is Mediterranean, with relatively mild, moist winters and hot, dry summers. Historically, the area was heavily grazed by sheep and cattle. Because the native bunchgrasses did not evolve to withstand grazing (Mack and Thompson 1982), native grasses diminished. Grazing facilitated invasion by non-native species (Tisdale 1986.)

In Idaho, Spalding's catchfly grows in bunchgrass communities dominated by Idaho fescue (*Festuca idahensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Prairie junegrass (*Koeleria macrantha*) and Sandberg's bluegrass (*Poa secunda*) are often present in small amounts. These "meadow steppe" communities are generally forb-rich and support scattered shrubs and shrub patches. Forbs commonly found with Spalding's catchfly in the Canyon Grasslands include prairie smoke (*Geum triflorum*), twin arnica (*Arnica sororia*), arrowleaf balsamroot (*Balsmorhiza sagittata*), meadow chickweed (*Cerastium arvense*), long-leaved fleabane (*Erigeron corymbosus*), goldenrod (*Solidago missouriensis*), western groundsel (*Senecio integerrimus*), silky lupine (*Lupinus sericeus*), spurred lupine (*Lupinus arbustus*) and western hawkweed (*Hieracium albertinum*). Snowberry (*Symphoricarpos albus*) and native roses (*Rosa nutkana* and *R. woodsii*) are often found nearby, either growing in patches or as short, scattered stems among the grasses and forbs. The rare plants Palouse goldenweed

(*Pyrrocoma liatriformis*), Palouse thistle (*Cirsium brevifolium*), and greenband mariposa lily (*Calochortus macrocarpus* var. *maculosus*) are often found with Spalding's catchfly on Craig Mountain.

MONITORING OBJECTIVES

The objectives of this study are to : 1) determine demographic parameters and dynamics of Spalding's catchfly (population size, recruitment, mortality, prolonged dormancy, reproductive and productivity effort, and population structure), 2) evaluate environmental factors affecting Spalding's catchfly populations in Canyon Grasslands (weather, rodent activity, weed invasion, herbivory, depredation, and fire), and 3) characterize the Canyon Grassland habitat and examine trends in native species and invasive, non-native species. Information from this study of Spalding's catchfly will provide an understanding about the life cycle, ecology, and population dynamics of Spalding's catchfly, help assess its long-term viability in Canyon Grasslands, and assist in the development of recovery plans and appropriate management strategies.

MONITORING METHODS

We established permanent monitoring plots to allow quantitative measurements of Spalding's catchfly populations and their associated habitat through time. In 2002, we targeted several areas based on access and land ownership. We wanted to establish monitoring in different drainages, especially the Captain John Creek/Madden Creek and Billy Creek/Camp Creek areas, where no past monitoring had been done. We also wanted to include both Idaho Department of Fish and Game (IDFG) and Bureau of Land Management (BLM) lands. We determined Spalding's catchfly locations from existing maps and selected random subpopulations from among them. As a result, we located plots in the Madden Creek and Billy Creek drainages, in the Redemsky Flat area south of Corral Creek, and on two of the ridges between Corral Creek and Middle Creek. After populations were discovered in the Salmon River Canyon, we added two plots in 2004, one near Eagle Creek, a tributary of the Salmon River, and the other near Rice Creek, on a hillside facing the Salmon River.

Three of the plots are in areas that burned recently: Eagle Creek (plot 10) burned in the Maloney Creek Fire of 2000, and two plots (5 and 8) were burned in the Corral Creek Fire of September 2001.

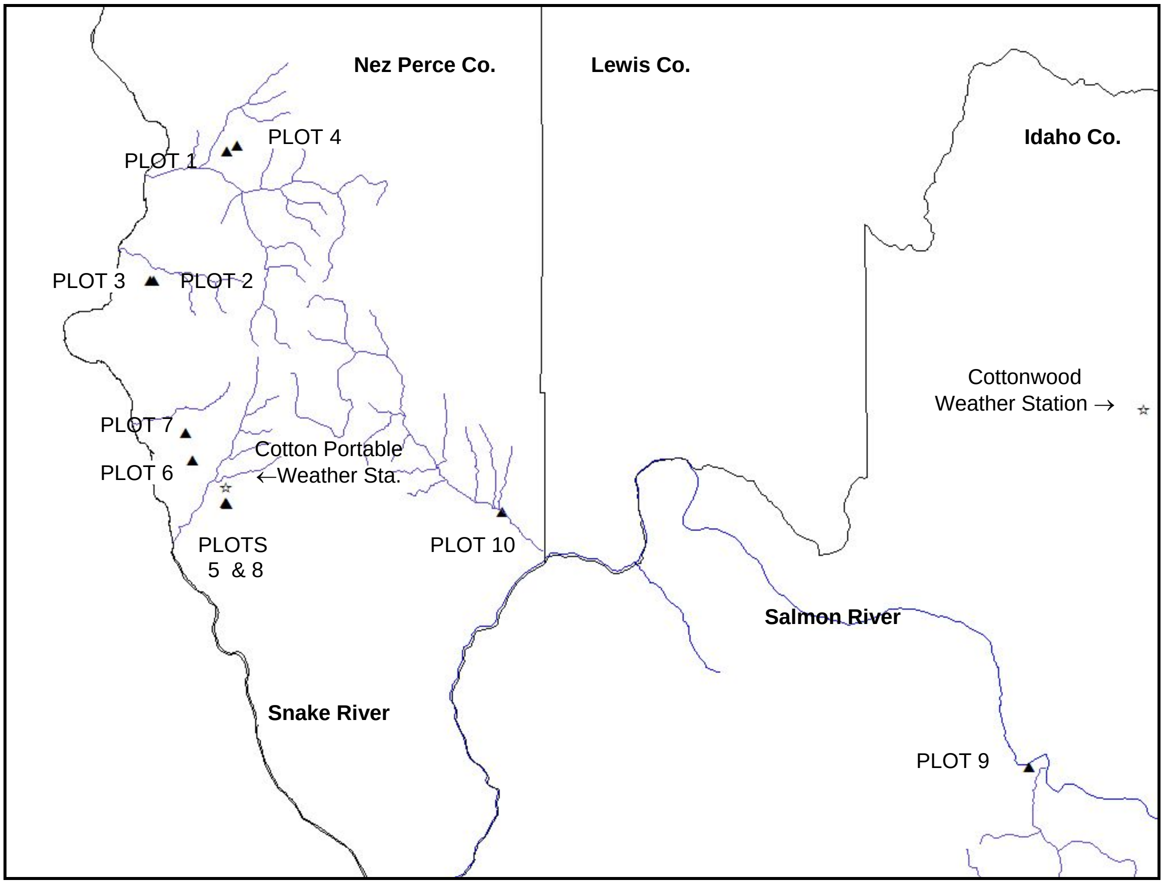


Figure 2. Locations of Spalding's catchfly monitoring plots, north central Idaho.

At each population, we thoroughly surveyed and flagged the clusters of plants present. We then numbered the clusters and selected randomly among them. Once a cluster was selected, we established a 10 x 10 m plot randomly within the cluster. To do this, we delineated the cluster as a rectangle around the aggregation of plants, with one side parallel to the slope and the other perpendicular. To ensure that every position within the cluster had an equal chance of being sampled, we randomly selected two coordinates by which to move the corner of the 10 x 10 m plot away from the corner of the rectangle defining the cluster, while still remaining within the rectangle. These coordinates marked the upslope, baseline left (looking downhill) corner of the plot (0 m, 0 m).

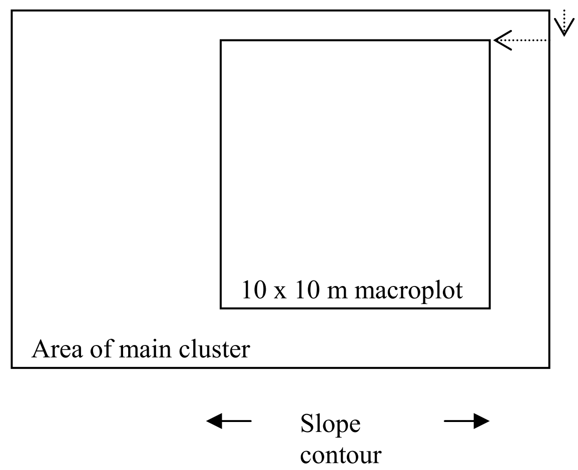


Figure 3. Example of randomizing a macroplot within a cluster of Spalding's catchfly plants.

We marked that corner with a steel fence post, and established a 10 m long baseline parallel to the slope contour. Bent rebar marks the beginnings and ends of 10 contiguous one-meter-wide transects that run downslope, perpendicular to the baseline. Transect # 0 begins at 0 m, 0 m, transect #1 begins at 0 m, 1 m…transect # 9 at 0 m, 9 m.

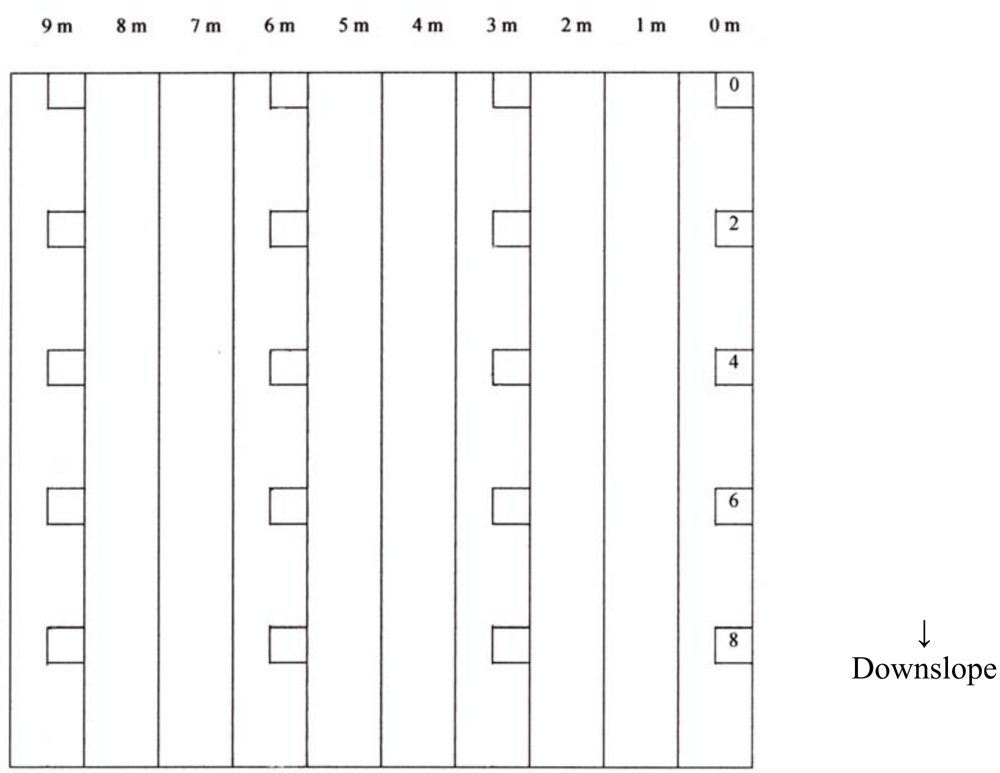
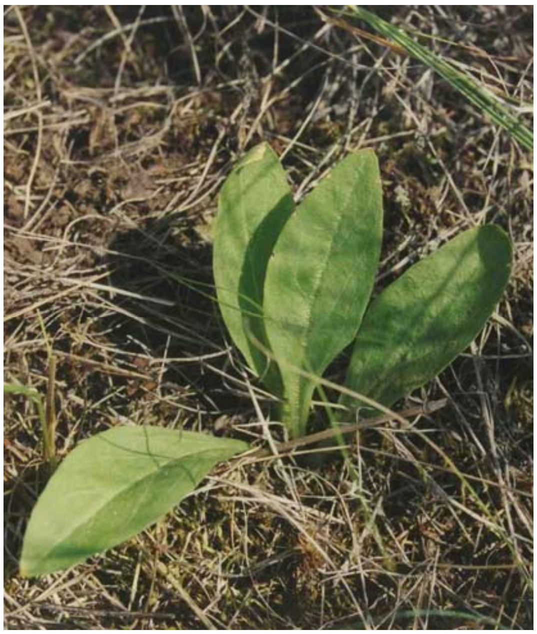


Figure 4. Layout of macroplot showing belt transects for monitoring Spalding's catchfly and microplots for measuring habitat characteristics.

In 2002, while we were developing monitoring methods, we collected data from only 3 transects in plot 1, 7 in plot 2, and 6 in plot 3. In 2003, we collected data from ten contiguous transects in all 8 plots. In 2002 and 2003, we visited plots 1-8 only in July. In 2004, we established two new plots (Rice Creek and Eagle Creek), and began collecting data from all 10 plots in both June and July. By recording the plants that are present in June, we obtain accurate data on the number of rosettes and stems that emerge each year. By July, a large portion of the plants that were present in June are absent, senescent, or broken, and many have been subjected to herbivory (Figure 5).



Photos by Janice Hill

Figure 5. Same rosette in June (at left) and July (senescent, with insect herbivory), 2004.

Spalding's catchfly

To collect demographic data, we map plant locations each year, recording the coordinates in meters along the transect line and in centimeters perpendicular to that line. Spalding's catchfly plants may spend one to several years dormant underground. Plants appear aboveground as either stemmed or rosette plants, or a combination of both (Appendix 1). Stems may become either vegetative or reproductive. Rosettes may be first-year seedlings or arise from mature caudexes, but we have never observed a rosette elongating into a stem within one growing season. Many stems and rosettes that are present in early- to mid- June are completely absent by July. Therefore, in order to obtain accurate demographic data, we record plant coordinates, growth form, number of stems, number of rosettes, number of rosette leaves, and length of longest rosette leaf in early- to mid-June. Rosettes from several other forb species resemble Spalding's catchfly rosettes. We examine the bases and petioles of the rosette leaves with a hand lens to look for the characteristic retrorse hairs along the edges of Spalding's catchfly leaves. In mid- to late July, we return to document whether each stem or rosette is present or absent, and whether it is senescent (no green tissue evident) or alive (at least some green tissue present). At this time, we record stem height, reproductive status, and the number of buds, flowers, fertilized flowers, and capsules (Appendix 2). Spalding's catchfly calyxes are closed both before and after flowering, but the orientation of the fertilized flowers changes. Flowers are oriented at more-or-less right angles to the stem (Figure 1). Fertilized flowers point upward (Figure 6).

Photo by Janice Hill

Figure 6. Spalding's catchfly immature fruit and mature capsules.

We record evidence of herbivory from ungulates (grazing), and insect herbivory of leaves and/or flowers when we observe it, whether in June or July.

To avoid stepping on plants, we work from the downslope end of each transect (at 10 m), upward toward 0 m, the baseline. Plants are more easily visible to a person looking uphill or into the hillside vegetation than to one looking downhill from above the plants. We are then able to mark plants with ribbon in order to avoid damaging them as we work. The coordinates of known plant locations are listed in descending order on the data sheets in order to facilitate relocating plants.

Habitat

We collected habitat data in three ways: 1) by collecting data for environmental characteristics and certain key plant species and lichens from 20 microplots within each macroplot, 2) by compiling a complete species list with cover values for each 10 x 10 m macroplot, and 3) by completing a Site Inspection Form (Appendix 5).

1) We placed a 50 x 50 cm microplot frame at two-meter intervals along four of the established macroplot transects perpendicular to the baseline. The microplot transects begin at 0 m, 3 m, 6 m, and 9 m along the baseline, and run perpendicular to and downhill from it. The plot frames are placed to the left of each transect line, with the upper right-hand corner of the frame at 0, 2, 4, 6, and 8 m (looking uphill).

In the pilot study (Lichthardt and Gray 2003), we recorded nested plot frequency for several indicator species in each microplot. In 2004, we attempted to combine vegetation/habitat data with two other Spalding's catchfly studies, and changed our methods in order to standardize habitat data collection among the three studies. We used the established 50 x 50 m microplots, and recorded data for native bunchgrasses, non-native grasses, rare plants, non-native forbs (weeds), the native shrubs snowberry and rose, and nonvascular species (bryophytes and lichens). In addition, we recorded information on ground characteristics, including the bare ground, litter, rodent runs and holes, gopher mounds, and large mammal disturbance (trails and prints). The data recorded in 2004 will serve as a baseline with which to compare future data. Because of a perceived increase in animal activity in 2004 from that in 2002 and 2003, we collected the percent cover of vole runs and holes, gopher activity, and large mammal activity (trails and hoofprints) in 2005 to compare with 2004 data.

2) We compiled a total plant species list for each 10 x 10 m macroplot using Western Heritage Task Force Form III – Ocular Plant Species Data (Bourgeron et al. 1991), and estimated percent canopy cover for each species present.

3) The Site Inspection Report form provides an opportunity to describe certain characteristics of the plot and the general vicinity of the plot, including slope, latitude and longitude coordinates, natural and human-caused disturbance, management, existence of weeds both in the plot and nearby, an estimation of the Spalding's catchfly population size in the area, and general notes pertinent to the plot and its surroundings. This form is designed for use with any population or subpopulation of Spalding's catchfly, whether associated with a plot or not.

Climate

We compiled temperature and precipitation records for Cottonwood Portable weather station from February 2002 (when it was established) through 2005 (Western Regional Climate Center 2006).

RESULTS

Spalding's catchfly

Location coordinates and diagrams of plants recorded from 2002 to 2005 are presented in Appendix 1, and completed 2005 plot data forms are presented in Appendix 2. Plants have been recorded at 503 coordinates since monitoring began in 2002. The total number of plants that produced aboveground growth in 2005 (356) was greater than in 2004 (260). Only plots 1 (Madden Low) and 9 (Rice Creek) had fewer plants aboveground in 2005 than 2004. However, more plants had completely disappeared by July in 2005, with the result that more plants were actually present in 2004 at reproduction time. Only 37% of plants that were present in June 2005 had the same number of live stems or rosettes in July 2005 (completely alive). By contrast, 58% of plants that were present in June 2004 were alive and intact in July of that year (Figure 7).

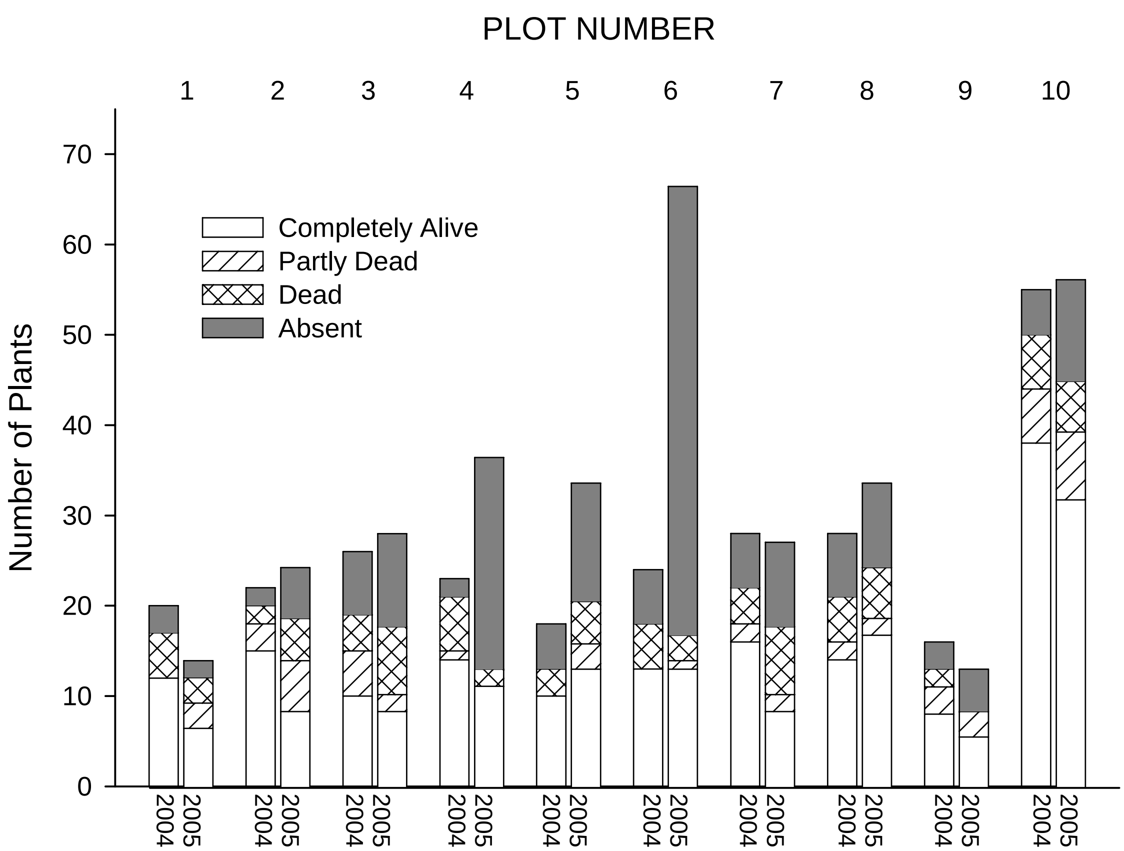


Figure 7. July status of plants present in June, 2004 and 2005.

Plants were divided into four classes. 1) Completely alive plants had at least some green tissue, and all stems or rosettes that were present in June were present in July. These plants represent the minimum amount of data that would be accurately recorded if data were collected only in July. 2) Partly dead plants had more than one stem and/or rosette in June, but at least one stem or rosette had become senescent or absent by July. Numbers of shoots of the "partly dead" plants would be inaccurate if recorded only in July. 3) Dead plants were senescent by July, and had no green tissue. Some number of senescent plants might not be seen in July, particularly if they were broken or grazed. Because they have ceased growth earlier than the plants that remain green, they are straw-colored, usually short, often withered, and difficult to see. 4) Absent plants were absent by July, and represent the minimum amount of demographic data that would not have been recorded at all if data were collected only in July.

In 2004, 81% of plants were stemmed, 16% were rosettes, and 3% were stem/rosette combinations. In 2005, 58% of plants were stemmed, 40% were rosettes, and 2% were stem/rosette combinations. Rosettes were more likely than stems to be absent or senescent by July (Table 1). In 2004, 49% of rosettes present in June were absent by July, and 18% were dead, leaving 33% alive. More extreme loss occurred in 2005, with 84% of rosettes completely absent and only 9% still alive in July. July rosette absence varied from 0% to 100% among plots.

Table 1. Number of rosettes present in June and subsequent July status, 2004 and 2005.

		Plots											
	Year	1	2	3	4	5	6	7	8	9	10	Total # ro-settes	% of Total
# rosettes present in June	2004	4	5	9	12	2	7	8	3	3	4	57	
	2005	5	10	15	31	15	49	12	10	4	9	160	
% absent by July	2004	0	80	89	17	50	57	38	67	67	50		49
	2005	0	70	87	84	80	100	58	90	100	89		84
% dead by July	2004	50	20	11	8	0	14	25	33	33	0		18
	2005	40	30	0	0	7	0	33	0	0	0		6
% alive in July	2004	50	0	0	75	50	29	38	0	0	50		33
	2005	60	0	13	16	13	0	8	10	0	11		9

Although more plants produced aboveground growth in 2005, more stems survived to July and became reproductive in 2004 (183) than in 2005 (123). In addition, reproductive structures (buds, flowers, fruit, etc.) matured earlier and there were more per stem in 2004 (Table 2). No fruits had formed in any plots by July 2005; by the same time in 2004, 570 fruits were present. The average number of structures per live reproductive stem varied from 1.0 in plot 5 to 25.4 in plot 1, with an overall average of 12.1 in 2004 and 7.5 in 2005. The total number of reproductive structures in July 2004 was more than twice that in July 2005.

Table 2. Number of reproductive structures present in July, 2004 and 2005.

Repro. Struct.	Year	Plot 1	2	3	4	5	6	7	8	9	10	Total	Ave. /stem
Buds	2004	105	87	41	45	21	12	71	36	145	479	1042	5.7
	2005	32	92	8	38	16	10	14	18	22	357	607	4.9
Flowers	2004	17	50	11	5	-	-	7	7	18	129	244	1.3
	2005	10	11	9	-	-	-	1	-	1	67	99	0.8
Fertilized flowers	2004	82	48	24	5	-	-	2	-	12	179	352	1.9
	2005	27	6	4	-	-	-	-	2	-	173	212	1.7
Fruits	2004	126	78	20	7	-	-	5	4	22	308	570	3.1
	2005	-	-	-	-	-	-	-	-	-	-	-	-
Total struct.	2004	330	263	96	62	21	12	85	47	197	1095	2208	
	2005	69	109	21	38	16	10	15	20	23	597	918	
Ave. / stem	2004	25.4	12.5	6.4	10.3	3.0	2.0	6.1	5.2	9.4	15.4		12.1
	2005	11.5	6.8	3.0	7.6	1.0	2.0	2.5	2.5	1.1	8.4		7.46

Stems that persist until July are more likely to be reproductive than vegetative. Of the stems that were present in June, 61% became reproductive by July 2004. In 2005, 43% of stems present in June became reproductive by July. Fewer stems that were present in June were vegetative in July—10% in 2004 and 19% in 2005. Live, ungrazed reproductive stems averaged taller than live, ungrazed vegetative stems in all plots both years (Table 3). The plants at Eagle Creek (plot 10) were consistently taller than those in other plots. In addition, they have leaves up to 6 cm wide, and many of the flowers are pink.

Table 3. Average heights (in cm) of ungrazed, live reproductive and vegetative stems in July, 2004 and 2005

	Year	Plots 1	2	3	4	5	6	7	8	9	10	Ave.
Average ht. live repr. stems	2004	35.5	29.5	20.4	33.0	29.0	30.8	22.7	31.7	42.3	52.9	39.5
	2005	35.3	25.5	22.9	30.6	31.6	24.6	26.8	29.6	31.0	47.6	37.3
Average ht. live veg. stems	2004	*	*	10.0	7.8	11.0	18.0	13.0	20.8	*	18.5	15.7
	2005	8.5	*	13.3	21.0	13.2	18.4	12.8	24.0	23.0	30.3	17.7

* No live vegetative stems were present in July

Single-stemmed plants are the most common form Spalding's catchfly assumes (Table 4); however 2-stemmed plants are not uncommon (12-13 %). Single rosette plants are also common (17-37% of plants).

Table 4. Percentage of plants occurring in single-stemmed, multiple-stemmed and rosette forms, 2004 and 2005.

	2004	2005
1-stemmed	60%	43%
2-stemmed	13%	12%
3-8 stemmed	5%	4%
1-rosette	17%	37%
2-rosette	1%	2%
3 rosette	1%	1%
Stemmed/rosette	3%	2%

The life form transitions of plants from 2004 to 2005 are enumerated in Table 5. Stemmed plants that were grazed or that disappeared by July could not be assigned to a reproductive state, and are not included. Some plants were present in July of 2002 or 2003, and again in 2004 and/or 2005. Although there were transitions from 2002 and 2003 to 2004 or 2005, they are not listed in the table, because the accurate number and life-form of plants present in 2002 and 2003 is unknown.

The most common transition (106 plants) is from nothing present (no aboveground growth in 2004) to rosette in 2005. At least seven of those were mature plants that were dormant in 2004 — six had been reproductive in 2003, and one was vegetative-stemmed in 2003. Forty-four of the seedlings in Plot 6 were seedling rosettes. The age-class of the remaining rosettes cannot be determined.

The 93 plants that moved from "nothing present to nothing present" were present during July of 2002 and/or 2003, and subsequently dormant or dead (no aboveground growth was present at those coordinates in 2004 and 2005). If aboveground growth is present at those coordinates in 2006, they may then be classed as dormant for 2004 and 2005. If no growth appears in 2006, either the plant is in its third year of dormancy or it is dead. It is likely that several more plants would have been in this category (dormant or dead plants) if we had data from plots 9 and 10 from 2002 and 2003, and if we had collected data from plots 1-8 in June the first two years.

Table 5. Life form transitions from 2004 to 2005

Life form transition	Number
Nothing present to rosette	106
Nothing to nothing (present 2002/2003, but not 2004/ 2005)	93
Reproductive to reproductive	68
Reproductive to vegetative-stemmed	32
Rosette to rosette	20
Vegetative-stemmed to vegetative-stemmed	17
Nothing present to vegetative-stemmed (dormant in 2004)	17
Nothing present to reproductive (dormant in 2004)	16
Reproductive to nothing present	16
Rosette to nothing present	15
Vegetative-stemmed to reproductive	11
Vegetative-stemmed to nothing present	8
Vegetative-stemmed to rosette	5
Nothing present to stemmed/rosette plant (dormant in 2004)	5
Reproductive to rosette	4
Rosette to reproductive	3
Stemmed/rosette plant to vegetative -stemmed	3
Stemmed/rosette plant to nothing present	3
Reproductive to stemmed/rosette plant	2
Stemmed/rosette to reproductive	2
Rosette to vegetative-stemmed	1
Stemmed/rosette plant to rosette	1

Of the seven plants that grew as combinations of stems and rosettes in 2005, six had been dormant in 2004 and the seventh had been reproductive for the previous two years.

A linear progression from seedling rosette to vegetative-stemmed to reproductive plant was not evident. Twenty times as many 2004 rosettes returned as rosettes than as vegetative-stemmed plants in 2005, indicating that the 2005 rosettes were not seedlings. More rosettes (3) were followed by reproductive plants than by vegetative-stemmed plants (1), and four 2004 reproductive plants appeared as rosettes in 2005.

The incidence of stems grazed by elk and/or deer was minor, consisting of 5 stems in 2004 (2%) and 24 stems in 2005 (8%). In 2004, 21% of stems and 25% of rosettes exhibited insect herbivory of leaves, and 14% of stems had flowers or capsules with insect holes. In 2005, 41% of stems and 26% of rosettes showed evidence of insect herbivory of the leaves, and 7% of stems had flowers or capsules with insect holes.

Habitat

Tables of cover, density, and frequency of plants, lichens, and ground characteristics in 50 x 50 cm microplots are presented in Appendix 3. All plots had at least some non-native species present (Table 6). Some weed species occurred in or near the macroplot, but were not documented in the microplots. Those are listed in Table 6 with no cover or density values. These data will serve as baseline for later comparisons. In 2004, Japanese brome (*Bromus japonicus*) was the most commonly occurring weed, with Kentucky bluegrass (*Poa pratensis*) close behind.

Table 6. Aggressive non-native species present in 50 x 50 cm microplots.

	Plot									
	1	2	3	4	5	6	7	8	9	10
Annual grasses	Average density of plants/50 x 50 cm microplot									
Apera interrupta	0.60	-	0.05	1.05	0.25	-	-	0.15	-	-
Bromus brizaeformis	0.50	0.20	0.60	0.05	0.10	-	0.05	0.10	-	-
Bromus japonicus	8.00	5.15	12.50	1.35	3.60	-	0.15	1.00	5.85	29.15
Bromus tectorum	-	-	-	-	0.05	-	-	-	-	-
Ventenata dubia	3.25	-	-	3.80	-	-	-	-	0.35	-
Perennial grass	Average cover of polygon encompassing shoots/50 x 50 cm microplot									
Poa pratensis	-	-	0.51	0.37	0.13	-	-	0.04	0.26	-
Forbs	Average number of stems or crowns/50 x 50 cm microplot									
Cardaria chalapensis	-	-	0.15	-	-	-	-	-	-	-
*Centaurea solstitialis**	-	-	-	-	-	-	-	-	-	-
*Dipsacus sylvestris**	-	-	-	-	-	-	-	-	-	-
*Euphorbia esula**	-	-	-	-	-	-	-	-	-	-
Galium pedemontanum	3.50	-	-	1.91	-	-	-	-	1.90	-
Hypericum perforatum	0.25	-	-	-	-	-	-	-	-	0.10
Potentilla recta (crowns)	-	-	-	-	-	-	-	-	0.50	-
*Sisymbrium altissimum**	-	-	-	-	-	-	-	-	-	-
Vicia tetrasperma	0.55	-	-	-	-	-	-	-	-	-
Vicia villosa	-	-	-	-	-	0.10	0.45	-	-	-

* Present in or near at least one macroplot, but not yet recorded in microplots.

Percent moss cover was higher than lichen cover in all plots (Table 7). Lichens were absent in the three burned plots, but present in all unburned plots. Moss cover was very low in plots 5 and 8 (burned in the Corral Creek Fire of 2001), and relatively low in plot 10 (burned in the Maloney Creek Fire of 2000).

Table 7. Average percent cover of mosses and lichens, 2004.

	Plots									
	1	2	3	4	5*	6	7	8*	9	10*
Moss cover	26.95	38.70	4.50	11.40	0.01	63.00	43.15	0.08	48.50	6.95
Lichen cover	1.70	0.40	0.01	0.75	-	4.65	0.35	-	0.75	-

* Burned

Ground disturbance from animal activities is presented in Table 8. Overall, the average cover of vole runways and holes stayed about the same: 4.8 % ground cover in 2004 and 4.5 % in 2005. However, it varied among plots and areas. It increased in Madden and Billy creeks (Plots 1 through 4), remained high in plots 5, 8, and 10 (burned), decreased in the North Bench plots (6 and 7), and stayed about the same at Rice Creek. Gopher mounds covered more area in the plots in 2005, and large mammal (cows, deer, elk) disturbance increased. Much of the large mammal disturbance increase is due to prints, trails, and “skids” from feral “trespass” cows in the Madden Creek drainage (plots 1 and 4).

Table 8. Average percent cover of animal ground disturbance, 2004 and 2005.

	Plot									
	1	2	3	4	5*	6	7	8*	9	10*
Vole disturbance 2004	1.20	0.60	1.75	2.50	9.60	7.18	8.60	7.20	1.83	7.65
Vole disturbance 2005	3.15	1.65	4.45	5.50	8.45	1.38	3.18	7.58	2.25	7.55
Gopher disturbance 2004	-	-	-	-	0.25	0.25	0.65	0.10	-	-
Gopher disturbance 2005	-	-	-	-	1.80	1.25	-	0.50	-	3.25
Large mammal dist. 2004	1.80	-	-	2.80	0.05	-	-	-	1.00	-
Large mammal dist. 2005	4.70	0.10	0.20	6.30	0.40	-	0.25	0.20	-	1.65

* Burned

Average ground litter depth varied among plots from 1.65 to 3.37 mm. The average depth of litter in unburned plots was 0.4 mm deeper than in burned plots.

A table of the species composition and estimated canopy cover of the 10 x 10 m macroplots may be found in Appendix 4 (Ocular Plant Species Data--Form III). Forms for plots 1-8 were completed in July 2002, when many native species were dead or dried. For that reason, cover could not be estimated in many cases, and some plants were not identified to species. Forms for plots 9 and 10 were completed in June and July 2004.

Climate

The Cotton Portable weather station was established on Craig Mountain in February 2002. We compiled the Cottonwood weather station data from Cottonwood, Idaho, and compared it with the Cotton Portable data (Appendix 6). Although the Cottonwood weather station is closer to Rice Creek (plot 9), the weather at the Craig Mountain Cotton Portable probably more closely approximates that at plot 9 than does the Cottonwood weather. Cottonwood is on the Camas Prairie at a higher elevation (around 3500 feet), it is within dry forest rather than grassland, and it receives approximately twice the precipitation that Cotton portable receives. Plot 9 is in fescue grasslands at 1730 feet elevation. Temperature and precipitation values from Cotton Portable weather station are presented in Figure 9. Precipitation in 2004 was high in the spring and sustained, although at a lower level, throughout the summer. In 2005, spring precipitation was not as high, there was very low precipitation in July, and none in August.

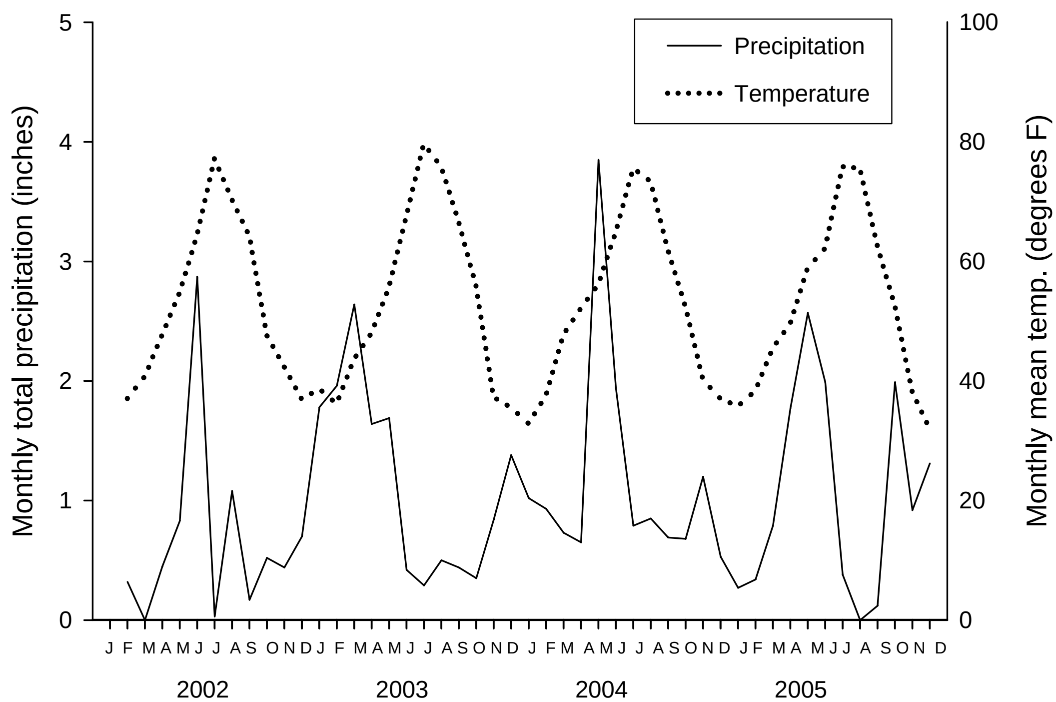


Figure 8. Temperature and precipitation, Cotton Portable weather station, 2002-2005.

DISCUSSION

Spalding's catchfly

Several aspects of Spalding's catchfly life history make it a particularly difficult plant to census and to monitor demographically. One reason is that it may remain dormant underground for one or more years. Another is the difficulty in assigning an age or development class to a plant. A mature plant may appear as a reproductive stem, a vegetative stem, or a rosette. Furthermore, size of rosette leaves or abundance of leaf hairs cannot be used dependably to differentiate seedling rosettes from rosettes of mature plants, and mature plants may send up small rosettes (Hill and Weddell 2003, Hill and Gray 2005). Partial excavation is a dependable method of determining whether rosettes are seedlings or shoots from mature plants, but it may harm the plants.

Figure 9. Seedling rosette.

The aboveground portions of many Spalding's catchfly plants that emerge in May or June are absent by July. Other plants have senesced, or are broken, grazed, or withered, and therefore often difficult to locate. To obtain accurate demographic data, it is necessary to collect information on the stems and rosettes that are present in early June. Even then, rosette leaves are often badly eaten and difficult to see. However, in the fourth year of June monitoring, it should be possible to confidently assign lifestage classes (recruit, dormant, mature, and dead) to mapped plants, if one assumes that plants do not remain dormant more than two years. Plant age will not be determinable except for seedlings that emerge during the study. A minimum age can be assigned beginning in 2002 for those plants that were present when data was collected in July of that year.

Two other characteristics of plants not easily monitored by demographic techniques are very long life spans and episodic reproduction (Elzinga et al. 1998), both of which may be characteristic of Spalding's catchfly. However, methods that capture a "snapshot-in-time" of demographic structure provide little information about population size, structure or trend. Unless plant emergence is documented in June before many of the plants disappear or are diminished, the basis for assignments of plant status will be incorrect for a large proportion of plants (Figure 6). A July "snapshot" of plant numbers in 2004 and 2005 would have indicated that more plants produced aboveground growth in 2004 than 2005, when in fact the opposite was true.

Because seedling recruitment is apparently episodic, short-term studies or studies conducted only in July will miss the appearance of many, or even most, rosettes. Rosettes are more likely to completely disappear than stems. In 2004, 49% of rosettes present in June were absent by July. In 2005, 84% of rosettes were completely absent and only 9% still alive in July. Absence varied from 0% to 100% among plots, making prediction or extrapolation unfeasible. In 2005, a recruitment event took place in plot 6, with 44 seedling rosettes appearing in the spring (Figure 10). By July, no trace of the rosettes remained, and vole runways, chopped grass stems (the work of voles), and a game trail were present in their place. It remains to be seen whether any of the recruits were able to store enough reserves to re-emerge in 2006 or 2007.

Photo by Juanita Lichthardt

Figure 10. Seedling rosettes, 15 June 2005, Plot 6.

Annual seedling recruitment does not seem to be directly tied to the size of seed output the previous year. Plot 10 at Eagle Creek had 1095 reproductive structures in July 2004; 308 had already developed into fruits, and flowering no doubt continued after July. The potential was present for the development of well over 100,000 seeds in a 100 square meter area that year. In spite of abundant seed output in 2004, there were only two potential seedling rosettes the following year. Those two rosettes had leaf lengths of 4.5 and 6.5 cm, making it unlikely that they were seedlings. The other rosettes in plot 10 in 2005 were present in stemmed or rosette form in 2004, and therefore not seedlings. By contrast, plot 6 had only 12 reproductive structures, all buds, in July 2004, but at least 44 seedling rosettes were present in 2005. In 2004, a reproductive stem grew about 30-40 cm above the patch of seedlings in plot 6. It had five branches, but only one bud on 22 July. The same plant was also present in 2003, with two reproductive stems (the number of reproductive structures was not recorded in 2003). That plant may have been the mother plant, or capsules or seeds may have originated from different plants. In any case, the plot with the fewest reproductive structures present in 2004 had the highest number of seedlings in 2005, and the plot with the highest number of reproductive structures in 2004 probably produced no seedlings in 2005. Favorable conditions for seedling germination and establishment are probably highly localized. We do not know how many years seeds remain viable.

Plant vigor is often assessed by stem height and number, number of reproductive structures, number of reproductive stems, etc. The apparent vigor of plants in 2004 compared with 2005 is probably more a reflection of that year's higher precipitation than inherent fitness of individual plants. Weather was probably the largest factor affecting the high Spalding's catchfly stem persistence and seed production in 2004, and probably influenced the initial flush of plant emergence in spring 2005. After May 2005, precipitation plunged, and many plants disappeared or became senescent. No precipitation was received in August, and an incidental visit to plot 9 (Rice Creek) in August revealed no plants (Hill, personal communication), although 14 had been present in June and 9 in July of 2005.

Habitat

Many environmental factors influence the habitat, and, both directly and indirectly, Spalding's catchfly plants. These factors include climate, weed encroachment, rodent activity, ungulate and insect herbivory, fire, and others. To further complicate matters, many of the factors are inter-related: fires generally increase weed invasion; early-drying annual weeds increase fire frequency and intensity; weather influences plants, animals, erosion, and fires; rodent activity influences native and non-native plant success and dispersion, and is influenced by weather and vegetation; St. Johnswort abundance is affected by a biological control agent; the abundance of St. Johnswort affects the pollination success of Spalding's catchfly by its bumblebee pollinator; fires probably influence the ground-nesting bumblebee's success, and so on. Many of the influences are cyclical or variable between years, including weather, vole irruptions, fires, insect herbivory, native ungulate grazing, and St. Johnswort abundance.

Vole activity was apparently not particularly noticeable in 2002. Notes from the 2002 Site Inspection Report for plot 1 say "mammal burrowing and runs (minor)" (Appendix 5). However, comments from 2003 for plot 7 state, "rodent diggings at bottom of plot (2003) with *Sisymbrium altissimum*. Rodent holes (2003)." In 2004, many plants that had been present in June were absent in July, and vole holes or runways were in their places. In some instances, we found Spalding's catchfly stems partially pulled down rodent holes. We began to record cover of runways and holes in 2004. In 2005, we again recorded cover to compare with 2004 data. Unfortunately, we do not have data from 2002 and 2003, when vole activity was presumably lower.

Photo by Janice Hill 2004

Figure 11. Spalding's catchfly stem pulled down rodent hole.

Montane voles (*Microtus montanus*) and long-tailed voles, (*Microtus longicaudis*) have both been trapped at Craig Mountain in fescue grasslands (Cassirer 1995). Randall and Johnson (1979) trapped montane and long-tailed voles at Smoot Hill in southeast Washington. They found that montane voles occupy the grass-dominant phase and long-tailed voles the shrub dominant phase of the Idaho fescue/snowberry association. Rickard (1960) also found a rather close relationship between the snowberry union and the long-tailed vole, and found the montane vole restricted to the Idaho fescue/snowberry association. He thought the spacing of the woody snowberry stems might explain why long-tailed voles apparently do not construct runways. Montane voles are probably responsible for the extensive runway construction we observed in 2004 and 2005. The vole diet is primarily graminoids and secondarily forbs (Banfield 1981). Vole runways are denuded of vegetation.

Voles and northern pocket gophers (*Thomomys talpoides*) may well cause mortality of Spalding's catchfly plants. Northern pocket gopher activity takes place primarily underground, making it difficult to monitor or assess. The roots, stems, and leaves of forbs form the bulk of their diet, and they are active all year (Banfield 1981). Even when grasses are the dominant vegetation, perennial forbs are the preferred food (Chapman and Feldhammer 1990).

Deer mice are primarily seed-eaters, but they also eat green vegetation, insects, berries, and fungi. They are active all year (mostly nocturnally), and live through the winter on stores of seed they câche near their nest during the autumn; the seeds are sorted by species (Banfield 1981, Csuti et al. 1997). Deer mice may have a role in Spalding's catchfly seed dispersal.

Elk and deer grazing was minor, consisting of 5 stems in 2004 (1.7%), and 24 stems in 2005 (8.2%). In 2002 and 2003, about 16% of stems in plots 1-8 were grazed by native ungulates (Gray and Lichthardt 2004). Plots 9 and 10 were not yet established. Deer and/or elk grazing is variable between years and locations, and can be extensive. In the Lower Corral Creek area in 1999, seven percent of plants flagged in spring had disappeared by August. Of the remaining plants, 62% were grazed by native ungulates (Hill and Gray 2000). In monitoring plots established at Garden Creek Ranch in 2003, 71% of stemmed plants were grazed by elk or deer (Hill and Gray 2004b).

Cattle grazing has been discontinued on much of Craig Mountain. However, the Madden Creek/Captain John Creek area supports a "trespass" cow population that has become feral (calves have been born in the wild for several years). Plots in Madden Creek have been directly affected, with cowpies, cow prints and skids (where the cows slid downhill on wet soil) in and near the plots. In addition to direct soil disturbance, the grazing and trampling by cows has probably contributed to the severe weed infestation in the Madden Creek/Captain John Creek drainage.

Spalding's catchfly leaves often show insect damage. In addition, at least two kinds of larvae have been found in or on flower heads, along with holes in the flower and seed heads. Seedhead depredation within plots was minor in 2004 and 2005. However, some areas have had more severe infestations, with insect holes found in 30% of reproductive structures in one study (Hill and Gray 2000).

Because Spalding's catchfly populations are most likely to occur in areas of native vegetation in good condition, most of our monitoring plots are less weedy than the areas surrounding them. This gives us the opportunity to document the progression of weed invasion. In 2002, the Billy Creek plot 2 Site Inspection Form notes indicated a whitetop (*Cardaria chalapensis*) patch 40 m below the plot. In 2004, whitetop stems occurred in two of the microplots within the macroplot. All other plots have weeds either in the plots or nearby, including plot 9, at Rice Creek, which has a leafy spurge (*Euphorbia esula*) infestation poised nearby

Two of the primary authorities on Pacific Northwest bunchgrass communities, R. Daubenmire and E. Tisdale, considered the grasslands to be stable ecosystems, with boundaries, distribution, and species composition determined by climate and soil moisture rather than by fire (Daubenmire 1968, Daubenmire 1970, Tisdale 1986). They considered most native grassland species to be fire-adapted but not fire-dependent. The characteristic mosses and lichens of the native bunchgrass communities appear to be an exception, in that fire kills them. They are not adapted to survive fire, and they recover slowly. Their presence in good-condition communities indicates that natural fire is not frequent in bunchgrass habitats.

Few lichens occur in Spalding's catchfly habitat. Squamules of the genus *Cladonia* were often present, usually growing on bare ground. The foliose lichens *Peltigera rufescens* and *P. canina* are also found. No lichens were present in the three burned plots (5, 8, and 10), but lichens were present in all unburned plots. Moss cover was lowest in two burned plots, 5 and 8. The third burned plot, plot 10, had higher average moss cover (6.95%) than the other burned plots, but the moss species differed from those in the unburned plots. Moss cover in unburned meadow steppe in the canyon grasslands is primarily composed of three species: *Brachythecium albicans*, *Homalothecium aeneum*, and *Tortula ruralis*. Although small amounts of *Homalothecium aeneum* were found at plot 10, most of the moss cover was composed of the weedy, cosmopolitan mosses *Funaria hygrometrica* and *Ceratodon purpureus* (fire moss), and *Polytrichum juniperinum*, a moss that colonizes bare soil. Although we do not have pre-burn data, this fits the pattern of the distribution of these three mosses on burned or disturbed soil (Eversman and Horton 2004, Hoffman 1966).

RECOMMENDATIONS

It is difficult, but not impossible, to conduct demographic studies of Spalding's catchfly. All aspects of Spalding's catchfly life-history are highly variable between years and sites. Many of the influences on Spalding's catchfly are also cyclical or extremely variable, including weather, vole and northern pocket gopher population size, fires, insects, and some weeds. In order to gather data useful in determining population size and trend, long-term studies are necessary. Due to the prolonged dormancy that Spalding's catchfly plants may exhibit, data must be gathered annually for at least four years. In order to collect accurate demographic data, monitoring must be done in early June when all plants produced aboveground are detectable. Information on reproductive effort, stem height and condition, and other parameters such as grazing and insect depredation may be collected at a second visit in July. Some habitat parameters that exhibit short cycles should also be collected annually, for instance vole ground disturbance. Vegetation changes such as weed invasion take place more slowly. It is probably sufficient to record vegetation data every three to five years.

We recommend collecting demographic data for the 10 Spalding's catchfly plots in June, 2006 and 2007, and making second visits in July if funding permits. Information collected on Ocular Species Form III should be supplemented at the June 2006 visit to the plots to obtain cover values for and identify plants that were senescent when data was originally collected in July, 2002. Vegetation and other data from the 50 x 50 cm microplots should be collected once more in 2007 or the last year of the study, in order to assess habitat changes.

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