SPALDING'S CATCHFLY (*SILENE SPALDINGII*) MONITORING, CRAIG MOUNTAIN, IDAHO: 2ND YEAR RESULTS

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ABSTRACT

Spalding's catchfly (*Silene spaldingii*) is a rare plant endemic to the bunchgrass, sagebrush, 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 south of Lewiston in the Snake River Canyon, along the western flank of Craig Mountain. The Craig Mountain population extends across more than 1,300 hectares (3,250 acres), and involves lands managed by the Bureau of Land Management, The Nature Conservancy, and Idaho Department of Fish and Game. This population has been the focus of all Spalding's catchfly monitoring in Idaho. In 2002, the U.S. Fish and Wildlife Service contracted with the Idaho Conservation Data Center to develop and implement a monitoring protocol for Spalding's catchfly and its habitat. This report summarizes two years of data collected on individual Spalding's catchfly plants, and includes baseline information on the condition of its associated habitat.

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INTRODUCTION

Spalding's catchfly is a geophytic herb in the family Caryophyllaceae. It occurs in northeastern Oregon, eastern Washington, and adjoining north-central Idaho, with disjunct populations in northwestern Montana and adjacent British Columbia (Figure 1). It inhabits bunchgrass grasslands, shrub-steppe, and open pine forests, much of which has been converted to cropland or degraded by livestock grazing. The U.S. Fish and Wildlife Service listed it as Threatened in October, 2001 (U.S. Fish and Wildlife Service 2001).

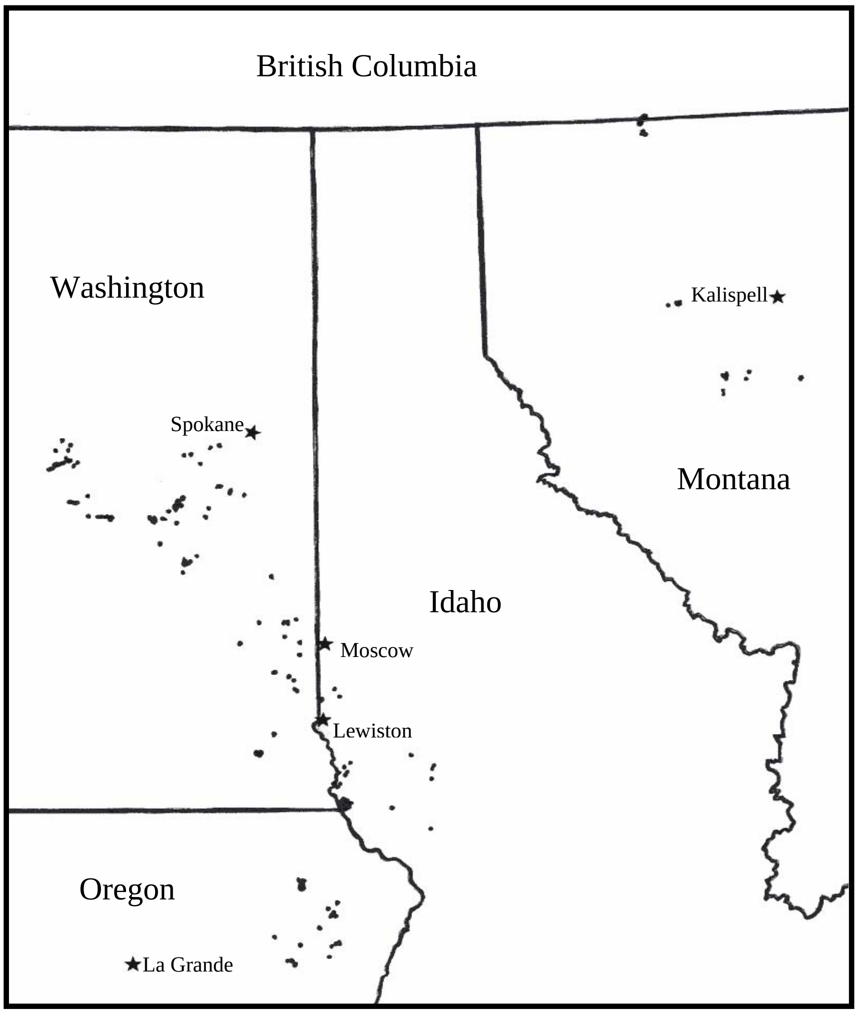

Figure 1. Rangewide distribution of Spalding's catchfly (*Silene spaldingii*).

The largest occurrence of Spalding's catchfly in Idaho is in the Snake River Canyon downstream from the mouth of the Salmon River, along the west flanks of Craig Mountain (Appendix 1, Map 1). The Craig Mountain population encompasses more than 1,300 hectares (3,250 acres), and more than 4500 genets (Lichthardt and Gray 2003, Hill and Gray 2004a). It inhabits lands managed by the Bureau of Land Management (BLM), The Nature Conservancy (TNC), and Idaho Department of Fish and Game (IDFG). Since Spalding's catchfly was discovered on Craig Mountain in 1993, the area has been the focus of monitoring and research in Idaho (Lesica and Heidel 1996, Hill and Gray 2000, Hill et al. 2001, Hill and Fuchs 2002, Menke and Muir 2002, Menke 2003, Hill and Fuchs 2003, Hill and Weddell 2003, Lichthardt and Gray 2003).

The purpose of this project is to track the conservation status of the Craig Mountain population by sampling specific subunits in a standard way. In 2002, we developed and implemented a monitoring protocol to document Spalding's catchfly population information and the condition of its associated habitat. In this report, we present two years of data.

STUDY SITE

The Craig Mountain occurrence of Spalding's catchfly is one of the most extensive known populations, occupying an area of abundant habitat extending from Redbird Creek south for 22 km (13 mi) to Cave Gulch. Breaklands between the Snake River and the top of Craig Mountain are generally extremely steep, rising more than 1,500 m (4,000 feet) in less than 6.5 km (4 mi). Four main streams—Captain John Creek, Corral Creek, China Garden Creek, and Cave Gulch—dissect the area, running west and southwest to the Snake River. Within this area, Spalding's catchfly grows in mesic, forb-rich, bunchgrass steppe, on northerly aspects from 427 to 1036 m (1,400 to 3,400 ft) elevation (Hill and Gray 2004a) Slopes where it occurs are usually steep, but it also grows on gently sloping benchlands, most of which are heavily infested with exotic plants as a result of past heavy livestock grazing or conversion to pasture.

SPECIES INFORMATION

General nontechnical description

Spalding's catchfly is a herbaceous, perennial member of the pink family (Caryophyllaceae) that can grow to 60 cm tall (occasionally to 80 cm). One to several erect stems arise from a simple or branched caudex (persistent stem just beneath the soil surface) that surmounts a long, narrow tap root. The leaves are arranged opposite each other in pairs, and are oblanceolate below to lanceolate or oblong-lanceolate above. Widths range up to nearly 5 cm. The stem, leaves and calyx bear gland-tipped hairs that render them extremely sticky. The inflorescence is sparsely branched. The outer, green portion of the flower (the calyx, formed by five united sepals) forms a tube with 10 distinct nerves or veins. The flowers have five cream-colored or greenish-colored (occasionally pink) petals. The long, narrow, lower section of each petal ("claw") is concealed by the calyx tube. The blade, or flared portion of the petal above the claw, is shallowly two-lobed and only about 2 mm long. At the junction of the claw and blade are four short (0.5 mm), lance-shaped appendages. The flower blades barely protrude beyond the calyx, a feature that is diagnostic when plants are in flower. The capsules are one-celled; each may hold as many as 150 seeds (Hitchcock 1964, Lesica and Heidel 1996, Hill and Gray 2004a).

Life history

On Craig Mountain, plants begin to emerge in late April. Flowering begins in July and can continue into mid-October (Hill and Gray 2004a). The wide range of the flowering period is due to asynchronous flowering. Capsules and seeds begin maturing in late July, and disperse from August through October. Plants senesce from the bottom of the stem upward, and die back at the end of the growing season.

Spalding's catchfly reproduces solely by seed. It lacks rhizomes or other means of vegetative reproduction It is partially self-compatible (Lesica & Heidel 1996), but its offspring are more fit if cross-pollinated (Lesica 1993). In a particular flower, anthers mature and dehisce pollen before the styles expand and become receptive. This discourages pollination within the same flower. However, because two or more flowers may be open on the plant at the same time, the possibility for pollination by another flower on the same plant is present, allowing for self-pollination. Most flowers are cross pollinated, primarily by a ground-nesting bumblebee, *Bombus fervidus* (Lesica and Heidel 1996).

Each capsule may hold up to 150 seeds (Lesica and Heidel 1996). Dispersion is from the top of the upright capsule, with seeds apparently bumped out. Many seeds stick to the glandular foliage, and it is possible passing ungulates inadvertently pick the sticky seeds up on their hair. Ungulates apparently eat the upper portions of some plants, and it is possible they spread seeds in their droppings.

Seeds require stratification (a period of cold temperature) to germinate, and thus germinate mainly in the spring (Lesica and Heidel 1996). Germinating seeds first form rosettes. Hill and Weddell (2003) observed that older, established plants may also produce rosettes, alone or in combination with elongated stems. Lesica (1999) observed seeds that germinate in the fall may appear as vegetative stems the next spring. Mature plants may pass from the vegetative or rosette growth form to the reproductive state, or they may stay in the same form in subsequent years. They may also change from the reproductive state one year to the vegetative or rosette form in the next.

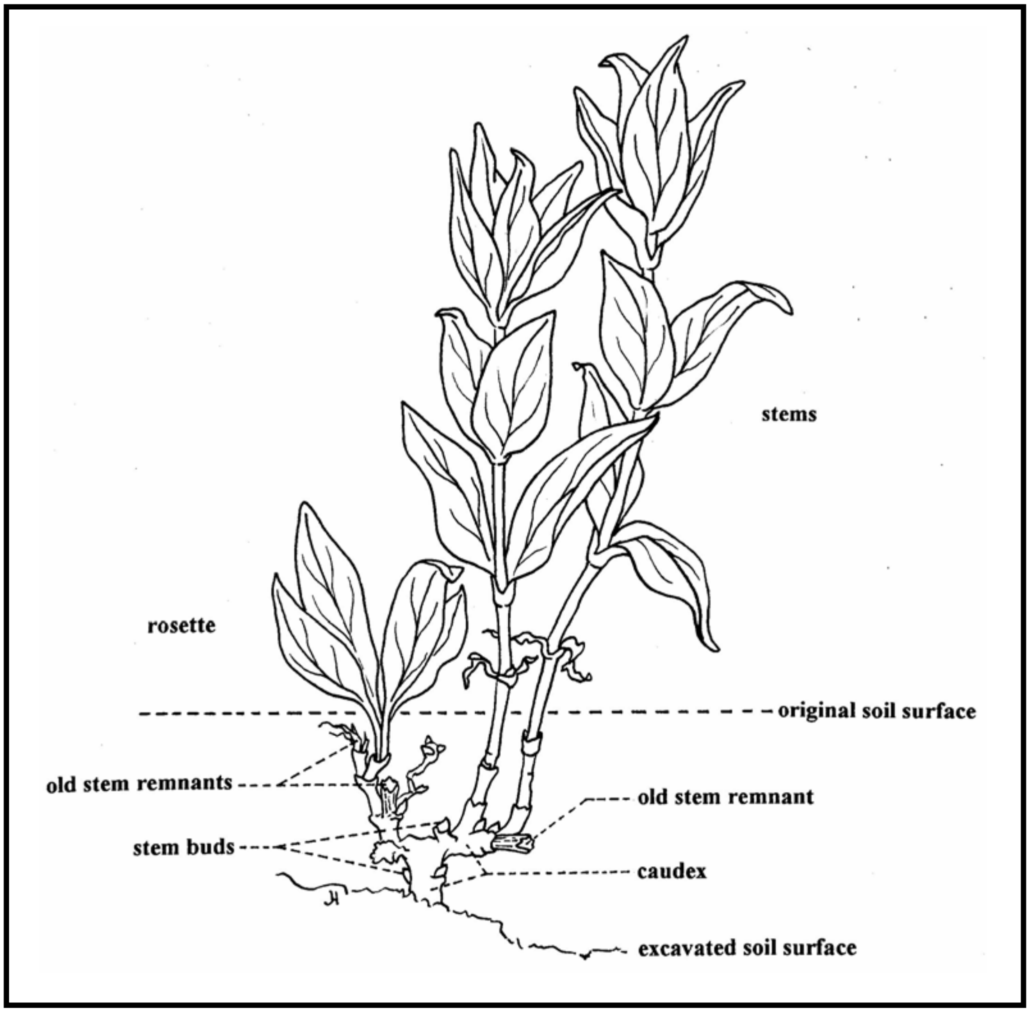

Illustration by Janice Hill

Figure 2. Diagram of mature Spalding's catchfly plant illustrating underground structures. The taproot crown is below the line of excavation, and not shown.

Spalding's catchfly plants exhibit dormancy, a condition in which plants may remain underground for 1-3 consecutive years. Dormancy complicates both surveys and monitoring, as not all plants appear aboveground in any year. Several factors may influence dormancy, vigor, and reproduction, including weather, grazing by ungulates, capsule depredation, and fire.

THREATS

At present, weeds (aggressive, non-native species) are perceived to be the primary threat to Spalding's catchfly habitat (Lichthardt and Gray 2003, Hill and Gray 2004a). Weeds are most abundant in areas where cattle or sheep once congregated, such as near barns and corrals, and on flatter areas that may have once been used as pasture. Some invasive, non-native perennial grasses were planted as pasture grasses or introduced in hay. Livestock grazing has been suspended on much of Craig Mountain, but some allotments remain. There are continuing problems with trespass cows in some areas.

Non-native annual grasses such as cheatgrass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*) threaten the integrity of the bunchgrass communities. Yellow starthistle (*Centaurea solstitialis*) and several other herbaceous weeds pose threats to Spalding's catchfly and its habitat. Yellow starthistle is common on Craig Mountain, especially at low-to-mid elevations and on south-facing slopes.

Spalding's catchfly plants may experience depredation, either by insects, small mammals, or ungulates. Northern pocket gophers (*Thomomys talpoides*) apparently consume plants underground, and small mammal runways (probably of voles and mice) are often completely denuded of vegetation where Spalding's catchfly plants were once documented.

Other threats that have been suggested include small population size, population fragmentation, aerial herbicide application, fire and fire suppression activities, disturbance of pollinator nests, and excessive litter accumulation.

MONITORING PROTOCOL

The primary objective of this monitoring is to track the status of the Craig Mountain population by monitoring representative sub-units in a standardized manner. We wanted the protocol to accommodate different monitoring levels (intensities) and to address parameters related to the conservation status of Spalding's catchfly, including population parameters (size, extent, evidence of depredation or grazing, and reproductive status) and habitat parameters (weeds, litter depth, overstory shrubs, disturbance, and management).

These parameters were incorporated into a Site Inspection Report form for Spalding's catchfly (Appendix 3). The Site Inspection Report represents the less intensive monitoring level within the protocol, and is essentially a modified Rare Plant Observation Report that standardizes collection of data specific to Spalding's catchfly. Additionally, the observer is required to define the portion of the population to which the data apply by mapping at 1:24,000 and/or using a GPS unit to obtain accurate latitude/longitude coordinates. More than one monitoring level can be employed (e.g., population and permanent plot). The Site Inspection Report can be used alone or, as we did, with more precise plot methods requiring additional time and materials. A large portion of the Site Inspection Report relates to the site condition, such as management, disturbance, and abundance of the species of weeds present. Fields used in the Site Inspection Report are explained in Appendix 3.

To more completely assess the conservation status of the population, it is desirable to represent as many sites and types of sites as possible, i.e., sites differing in population size, type of habitat, and threat level. However, the time required to reach sites and the rough terrain made it difficult to sample efficiently. We established permanent plots to make quantitative measurements of population and habitat characteristics. We mapped and collected information on individual Spalding's catchfly plants within the plots and gathered nested-plot frequency and cover data on selected indicator species. The more intensive, demographic data are useful in making population projections over time and looking for population trends among sites differing in vegetation condition, disturbance level, and type of management In addition, we recorded a complete plant species list with corresponding cover values for each plot using Western Heritage Task Force Form III — Ocular Plant Species Data (Bourgeron et al. 1991). In some cases, weed and rare plant species were recorded in plots that were not recorded in the nested microplots.

METHODS

In 2002, we targeted several work areas based on access and land ownership. We wanted to establish monitoring in different drainages, especially Captain John/Madden creeks and Billy Creek, where no past monitoring had been done, and to involve both BLM and IDFG lands. We also chose the Corral Creek drainage because some populations there had been affected by fire. We determined Spalding's catchfly locations from existing maps, eliminated locations impractical to access, and selected randomly among those remaining.

We sampled from 15-24 July in 2002, and 21-23 July in 2003. Plot establishment was preceded by a thorough survey conducted by two observers. We defined the boundaries at each population by flagging all individuals with wire flags. We recorded the point where we stopped looking as the limit of our survey, using GPS. During this process we identified clusters of plants, numbered them, and randomly drew numbers to select clusters to monitor. We used a GPS unit to record latitude and longitude at the center of the cluster as well as the margins of the population. We checked a 7.5 minute topographic quad in the field to make sure GPS coordinates were consistent with our position.

At this point we had a good census of the local population, although limited to the most easily seen plants. In some cases our survey had to be terminated due to time constraints. For example, at the Billy Creek South site we found several clusters of various sizes, and many widely scattered plants, but never determined the eastern extent of the population. In this and other cases, further survey effort may have extended the size of the mapped population. By plotting the extent of our survey, we defined the area to which our counts applied.

Once a cluster had been selected, we established a 10 x 10 m plot randomly within the cluster. We delineated the cluster as a rectangle around the aggregation of plants, including little unoccupied area, with one side parallel to the slope and the other perpendicular. To insure 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 (Appendix 8). We marked the upslope, baseline left corner of the plot (looking downhill toward the baseline) with a steel fence post and the remaining three corners with bent rebar. We established 10 transects (1 every meter, parallel to the slope) and marked the top and bottom of each with bent rebar.

Spalding's catchfly

In 2002, we recorded the number of plants found during our initial census of the population and the number of plants within the rectangle. We also mapped individual Spalding's catchfly plants in the permanent plot. In this way we obtained an overall census, density of the cluster, and density within the permanent plot. In 2003, we resampled only the permanent plot.

We mapped Spalding's catchfly individuals within the plot by the distance in meters along the transect (away from the baseline) and the distance in centimeters away from the transect (Appendix 2). We mapped all Spalding's catchfly plants in the plot, using ten, contiguous 1 x 10 m transects. For this study, we assumed that a plant appearing near the same coordinates (within 10 cm) in consecutive years is the same plant, and recognize that in a few instances, more than one plant may be growing in close proximity. We recorded the status of each stem (rosette, vegetative, reproductive, and grazed) and number of stems per individual. If a grazed stem bore reproductive structures, we recorded it as reproductive grazed. Because plot methods evolved, some of the early plots (1 and 3) in 2002 had fewer transects. In 2003, we expanded our mapping and data collection to include all 10 contiguous transects in those plots.

Habitat

To evaluate habitat condition, we completed a Site Inspection Report (Appendix 4) for each plot. The form was developed during fieldwork and is based on perceived threats to Spalding's catchfly (weeds, litter buildup, grazing) and possible management activities in its habitat.

We used the nested plot frequency method to record presence of certain habitat quality indicator species. We placed a nested plot frame (microplot) at 2-meter intervals (at 0, 2, 4, 6, and 8 m) along transects spaced 3 m apart. In 2002, we began by using only 3 transects (at 0, 3, and 6 m) in plots 1-3, and increased this to four in plots 4-8 (at 0, 3, 6, and 9 m), so there were either 15 or 20 microplots per plot. In 2003, we collected data on the fourth transects in plots 1-3; data collection is now complete for 20 microplots in each plot.

The nested plot frame consists of four plot sizes: 1) 10 x 10 cm, 2) 25 x 25 cm, 3) 25 x 50 cm, and 4) 50 x 50 cm. The smallest nested plot size in which a species is rooted is recorded. We collected rooted frequency data for all non-native plant species, native shrubs snowberry (*Symphoricarpos albus*) and rose (*Rosa nutkana* and *R. woodsii*), mosses as a group, lichens as a group, and all rare plants (including Spalding's catchfly). This baseline information represents the initial frequency of several indicator species.

Because collecting data on the microplots may disturb both the soil and vegetation, we determined to gather nested plot data at three-year intervals.

Frequency measurements do not work well for characterizing litter or bare ground, so we estimated percent cover for these attributes, as well as for mosses as a group, lichens as a group, gravel, and rock. We used the 50 x 50 cm size of the indicator microplots for the cover estimates. We partitioned litter into particulate, thin, and deep (> 1 inch). We estimated the litter cover first, before disturbing it to look for mosses and lichens. We considered burned, dead moss mats and plant basal area (mostly bunchgrasses) to be litter. We also recorded a complete plant species list with corresponding cover class values for each plot using Western Heritage Task Force Form III – Ocular Plant Species Data (Appendix 5).

RESULTS

<u>Spalding's catchfly</u>

Data collected on individual Spalding's catchfly plants in permanent plots in 2002 and 2003 are summarized in Table 1. We collected data in all 10 contiguous transects in plots 1 and 3 in 2003, but because we collected data in fewer transects in 2002, we present only the data from those transects for comparison to 2003 data.

Of the total plants recorded in the permanent plots, more plants and stems were present above ground in 2003 than in 2002. However, three plots (5, 7, and 8) had fewer plants and stems in 2003. Two of those plots (5 and 8) were burned in the Corral Creek Fire of 30 September 2001. Overall, there were more reproductive stems and fewer vegetative stems in 2003 than 2002. The majority of stems were reproductive in all plots except the two burned plots, 5 and 8. We recorded only 4 solitary (i.e., not with an associated stem) rosettes in 2002, and none in 2003.

About 16% of all stems were grazed in both 2002 and 2003. The heaviest grazing occurred in Plot 3 in 2003 (43% of stems), Plot 6 in 2002 (25%), and the two burned plots, Plot 5 (28% in 2002; 35% in 2003), and Plot 8 (43% in 2002; 30% in 2003). In 2002, 24% of plants were multi-stemmed, and 22% were multi-stemmed in 2003.

Table 1. Number and status of Spalding's catchfly plants, 2002 and 2003.

	Plot 1[1]	Plot 2[2]	Plot 3[2]	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	
	Mad-den Cr Low	Billy Cr. S East	Billy Cr. S West	Mad-den Cr High	LCC 69M	LCC 225	LCC 271	LCC 69Z	Total
Total plants 2002	6	17	10	27	26	15	30	23	154
Total plants 2003	8	18	16	46	23	23	26	19	179
Total stems 2002	8	22	12	30	36	16	47	28	195
Total stems 2003	11	31	21	50	29	27	41	23	233
Repr. stems 2002	7	17	9	16	7	2	32	5	95
Repr. stems 2003	11	24	12	44	9	14	38	8	160
Veg. stems 2002[3]	0	5	2	11	19	10	11	11	69
Veg. stems 2003[3]	0	2	0	6	10	11	2	8	39
Grazed stems 2002[4]	0	1	1	0	10	4	4	12	32
Grazed stems 2003[4]	0	5	9	1	10	3	2	7	37
Solitary rosettes 2002	1	0	0	3	0	0	0	0	4
Solitary rosettes 2003	0	0	0	0	0	0	0	0	0
Rosette + stem 2002	0	0	0	1	0	0	1	0	2
Rosette + stem 2003	0	0	0	0	0	0	0	0	0
Multi-stemmed 2002	2	4	1	3	8	1	13	5	37
Multi-stemmed 2003	2	10	4	4	4	3	9	3	39
Capsule depred. 2002	0	0	0	0	0	0	0	0	0
Capsule depred. 2003	0	1	0	0	0	0	0	0	1

[1]Only data from transects at 0, 3, 6, and 7 m are presented
[2]Only data from transects at 0 – 6 m are presented
[3]Does not include solitary rosettes
[4]Includes grazed stems with reproductive structures present

Data from the 94 plants that were present at the same coordinates (within 10 cm) in both 2002 and 2003 are presented in Table 2. In 2003, 66 (70%) of these plants were reproductive. Of these 66 plants, 62% had also been reproductive in 2002, and 34% had been vegetative in 2002.

Two plants that were rosettes in 2002 were reproductive in 2003. Nine percent of the plants were vegetative in both years (at time of sampling), and 4% of those flowering in 2002 were vegetative in 2003.

Table 2. Status of Spalding's catchfly plants present in both 2002 and 2003.

	Plot 1[1]	Plot 2	Plot 3[2]	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	
	Mad-den Cr Low	Billy Cr. S East	Billy Cr. S West	Mad-den Cr High	LCC 69M	LCC 225	LCC 271	LCC 69Z	Total
	Number of plants								
Plants repr. in both 2002 and 2003	1	7	2	8	3	2	14	3	40
Plants repr. in 2002 and veg. in 2003					2		1	1	4
Plants repr. 2002, grazed repr. 2003		1					1		2
Plants grazed repr. 2002, grazed 2003		1							1
Plants repr. 2002, grazed 2003			2		1				3
Plants repr. 2002, broken 2003		1							1
Plants veg. in 2002 and repr. in 2003		2	1	4	4	3	2		16
Plants veg. in 2002 and veg. in 2003				1	1	4		2	8
Plants veg. 2002, graz. repr. 2003						1			1
Plants veg. 2002, grazed 2003		1			2			1	4
Plants graz. in 2002 and repr. in 2003						1	3	1	4
Plants graz. in 2002 and veg. in 2003					1				1
Plants graz. in 2002 and grazed in 2003					2			2	4
Plants grazed repr. 2002, grazed 2003		1							1
Solitary rosette in 2002, repr. in 2003				2					2
Ros. + repr. stem 2002, repr. 2003				1					1
Ros. + veg. stem 2002, graz. 2003							1		1

[1] Only data from transects at 0, 3, 6, and 7 m are presented
[2] Only data from transects at 0-6 m are presented

Data from Spalding's catchfly plants that appeared aboveground in only one of the two years are presented in Table 3. In 2003, 86 plants were recorded at coordinates at which no plant was present in 2002. They represent 48% of all plants present in 2003, and were most likely dormant in 2002.

Table 3. Status of Spalding's catchfly plants present in only one of the two monitoring years.

	Plot 1[1]	Plot 2	Plot 3[2]	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	
	Mad-den Cr Low	Billy Cr. S East	Billy Cr. S West	Mad-den Cr High	LCC 69M	LCC 225	LCC 271	LCC 69Z	Total
2002 only									
# of plants present (aboveground)	5	4	5	11	11	4	8	13	61
Reproductive plants	4	3	4	5	1		6	1	24
Vegetative plants		1		5	8	3	1	6	24
Grazed plants			1		2	1	1	6	11
Rosette plants	1			1					2
Reproductive stems	6	5	5	5	1		11	1	34
Vegetative stems		1		5	8	3	1	7	25
Grazed stems			1		2	1	1	6	11
2003 only									
# of plants present (aboveground)	7	5	11	30	8	12	4	9	86
Reproductive plants	7	5	7	26	2	4	4	2	57
Vegetative plants				4	5	6		4	19
Grazed plants			4	1	1	1		3	10
Rosette plants									0
Reproductive stems	11	9	9	27	2	5	8	2	73
Vegetative stems				5	5	7		3	20
Grazed repro. stems		1		1					2
Grazed/broken stems		2	5		2	1		3	13

[1] Only data from transects at 0, 3, 6, and 7 m are presented.
[2] Only data from transects at 0-6 m are presented.

The number of vegetative plants appearing in only one of the two years was similar (24 in 2002 in comparison to 19 in 2003), but there were nearly twice as many reproductive plants (57) in 2003 as in 2002 (24). Plot 4, in Madden Creek, contributed 21 of the 33-plant increase in reproductive plants in 2003. More (11) of the plants that were grazed in 2002 were absent or dormant in 2003 than reproductive (4), vegetative (1), or grazed (4).

Habitat

Frequencies of rare plants, weeds, mosses, lichens and shrubs in 0.25 sq. meter microplots (20 per plot) are recorded in Table 4.

Table 4. Rooted frequency of indicator species in 0.25 sq. m microplots.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	
	Mad-den Cr Low	Billy Cr. S East	Billy Cr. S West	Mad-den Cr High	LCC 69M	LCC 225	LCC 271	LCC 69Z	Total of 160 poss.
Non-native grasses									
Agrostis interrupta				P	P			P	0
Bromus brizaeformis	P	P	P		P	OP	P	P	0
Bromus japonicus	20	15	19	7	7	OP	4	5	77
Bromus tectorum	3	P		1	1	OP			5
Poa bulbosa								P	0
Poa pratensis			8		13	OP	1	13	35
Ventenata dubia	4			7					11
Non-native forbs									
Centaurea solstitialis					P		2	1	3
Cichorium intybus								1	1
Galium pedemontanum	4			5					9
Hypericum perforatum	6			P	P			1	7
Sisymbrium altissimum			OP					P	0
Vicia tetrasperma	4								4
Vicia villosa						P	10	P	10
Rare species									
Calochortus m. v. *mac.**		OP			P			P	0
Cirsium brevifolium		P	1		2	P		1	4
Haplopappus liatriformis	P	6	2	8					16
Silene spaldingii	3	2	1	2	2	P	1	1	12
Shrubs									
Rosa nutkana					2				2
Rosa woodsii				P					0
Symphoricarpos albus	12	OP	1	4			5		22
Non-vascular species									
Moss	20	20	20	20	2	20	20	6	128
Lichen	13	6	3	6		17	5		50

P = in plot, but not recorded in microplots.
OP = not in plot, but nearby, out of plot.
**Calochortus macrocarpus* var. *maculosus*

Japanese brome and Kentucky bluegrass (*Poa pratensis*) were the two most frequently occurring non-native invasive grasses, followed by ventenata (*Ventenata dubia*) and cheatgrass. Of the weedy forbs, vetch (*Vicia villosa*) occurred in 10 microplots, all in Plot 7. Vetch was also present in plots 6 and 8, but did not occur in the nested microplots. St. John's-wort (*Hypericum perforatum*) occurred in both Madden Creek plots (1 and 4) and both burned plots (5 and 8). Piedmont bedstraw (*Galium pedemontanum*) occurred in plots 1 and 4 (Madden Creek). Yellow starthistle occurred in small numbers in 3 plots. (In Plot 5, it was recorded in the plot species list, but not in the microplots.)

The rare plants Palouse goldenweed (*Haplopappus liatriformis*) and Palouse thistle (*Cirsium brevifolium*) often occurred with Spalding's catchfly. Greenband mariposa lily (*Calochortus macrocarpus* var. *maculosus*), also rare, did not occur in any of the microplots, but was present in or near plots 2, 5, and 8.

Mosses were present in 100% of unburned microplots, but in only 20% of burned microplots. Lichens were present in 42% of unburned microplots, but were entirely absent in burned microplots.

DISCUSSION

Spalding's catchfly

Spalding's catchfly population and demographic data are influenced by several factors, including ungulate and other herbivory, dormancy, and weather.

Herbivory

Instances of ungulate grazing, insect damage, rodent consumption, and apparent rodent "trampling" of Spalding's catchfly appear highly variable in different years and areas. This is probably due to chance and also due to unknown factors such as food availability, population fluctuation, or other factors influencing insect and animal presence and abundance.

The effects of ungulate grazing make information regarding the status of stems less clear, in that there is no way of knowing whether most grazed stems would have been reproductive or vegetative Occasionally, a stem that has been grazed sends out axillary branches that subsequently flower. We recorded 2 such stems in 2002 and 5 in 2003. Only 16% of total stems were grazed in 2002 and 2003. Chance may be a major factor determining which plants are grazed. Also, the later in the season data are collected, the more likely ungulate grazing will have occurred. In a 1999 study in Corral Creek, 62% of 453 Spalding's catchfly stems of plants flagged in late June and early July had been grazed by late August and early September (Hill and Gray 2000). However, in transects within the same stand (subsequently burned in the 2001 Corral Creek Fire), only 3% of stems were grazed by August, 2002 (Hill and Weddell 2003). At a nearby, unburned site, in 2002, Hill and Weddell (2003) found 49% of stems grazed in 2002.

Daubenmire (1970) believed that ungulate grazing pressure played no significant role in the evolution of ecotypes of Washington steppe plants. Historically, big game levels were probably relatively low in the canyon grasslands (Daubenmire 1942, 1970, Tisdale 1986, Mack and Thompson 1982). It is possible that ungulate grazing pressure is more intense at present, because big game levels may be higher than in the past. Cheatgrass is widespread on Craig Mountain and provides green forage early in the spring that was not historically available.

Insects bore holes into Spalding's catchfly flowers and lay eggs that subsequently become larvae that consume its seeds. Also, some leaf herbivory occurs. We observed only one instance of insect herbivory of a reproductive structure (capsule or flower). However, many of our plants were in the pre-bud or early bud stage. It may be that insect damage increases over the growing season, or that insect populations are cyclical, or both. Hill and Gray (2000) recorded insect holes in 30% of Spalding's catchfly reproductive structures observed in late August and early September.

Northern pocket gophers, mice, and voles are important members of bunchgrass communities. Pearson et al. (2001) believe small mammals play significant roles in ecosystem functions. They also influence and are influenced by non-native plants. Small mammals create disturbance sites that exotics can invade, they consume native and non-native plants and seeds, câche seeds, and can also consume biological control agents. Exotic plants in turn influence mammal species composition and biomass, which can alter small mammal ecology in complex ways (Pearson et al. 2001). The impacts of small mammals and non-native plants on Spalding's catchfly are probably interrelated and complex.

Caplow (2004) found that herbivory and rodent activity at Fairchild Air Force Base (Fairchild AFB) monitoring plots varied considerably. In 2002, activity was greatly reduced compared to 2001 and 2003. In 2003, Hill and Gray (Hill and Gray 2004b) recorded plants in June that were absent when revisited in August. Small mammal runways or pocket gopher churnings were present where the plants had been. Litter in many plots was nearly nonexistent in many 2003 plots due to mammal runways or pathways.

Dormancy

Because Spalding's catchfly plants may remain dormant underground for 1-3 consecutive years, an element of uncertainty is present when counting mapped plants. Stems that are mapped within 10 cm of each other are likely to arise from the same caudex. However, it is possible for stems mapped less than 2-3 cm apart to originate from different caudexes (Hill and Gray 2004b). Spalding's catchfly seeds have no wings or protrusions that might aid in dispersal. Most seeds probably fall near the mother plant, and plants that are mapped near the same coordinates in different years could be two close-growing plants. This presents a problem when concluding that a particular plant was present in sequential years. Excavation around the plants is the only way to determine how many plants are present at certain coordinates. However, unless carefully done, excavation may injure the plant. Because this is a long-term monitoring program, and each plant is mapped every year, repeated measurements will probably reveal whether more than one plant is present near the same point.

In 2003, 86 plants appeared at coordinates at which no plants were present in 2002. They represent 48% of all plants present in 2003, and were most likely dormant in 2002. The number of plants that emerged from dormancy varied considerably, from 15% in Plot 7 to 87.5% in Plot 1. In monitoring plots established by Caplow (2004) on Fairchild AFB, 57.5% of plants she observed in 2002 were apparently dormant the previous year, and 55% of plants recorded in 2003 had been dormant in 2002 (i.e., they were either present only in 2003 or in both 2001 and 2003). Wide variation in proportion of plants emerging from dormancy was also evident among Caplow's plots, ranging from 0 – 100%. In his study of Spalding's catchfly in Montana, Lesica (1997) found that plants in his plots spent nearly 50% of their summers dormant. In an annual census of flagged plants, Hill and Fuchs (2003) found 33% of 270 plants appeared in 2002 that were absent, and probably dormant, in 2001.

It is possible that the appearance of a plant where none was the year before represents a recruit or seedling. However, because no rosettes were present in 2003, it is unlikely that we encountered any recruits in our plots in 2003. Although a given rosette may not be a recruit, all recruits begin as rosettes. Rosettes that appear for the first time in 2005 will most likely be recruits, but rosettes that appear before then may be attached to established caudexes of plants that have been dormant. Excavation around the caudexes of rosettes that appear in 2004 is the only method of determining demographic status.

Unless plants can remain dormant for three consecutive years, we will be able to estimate the number of plants that were actually dormant in 2002 after we collect data in 2004. We will also be able to estimate the total number of plants in each plot, as the 2004 data should include plants that were dormant in both 2002 and 2003.

Reproductive vs. vegetative status

We recorded plants with buds, flowers, or capsules as reproductive. Some plants bore ambiguous structures. We found anthers enclosed in terminal, rather thick leaf clusters, with no evidence of a developing corolla. In 2004, we will try to mark some of these plants and revisit them to see if flowers develop. Also, it is possible some plants that appear as non-reproductive elongated stems would develop flowers later in the season, perhaps induced by summer precipitation.

About 69% of the 233 stems present in 2003 were reproductive (bearing buds, flowers or capsules at time of sampling). Plants that were reproductive in 2003 were likely to have been either reproductive or dormant in the previous year (Figure 3). The largest proportion of 2003 plants (32%) were reproductive plants that had been dormant in 2002, followed by plants that were reproductive in both years (24%). Plants that were dormant in 2002 and vegetative in 2003 represent the next largest group, 11%. A few plants changed from reproductive to vegetative (2%), and two plants moved from the rosette form in 2002 to reproductive plants in 2003.

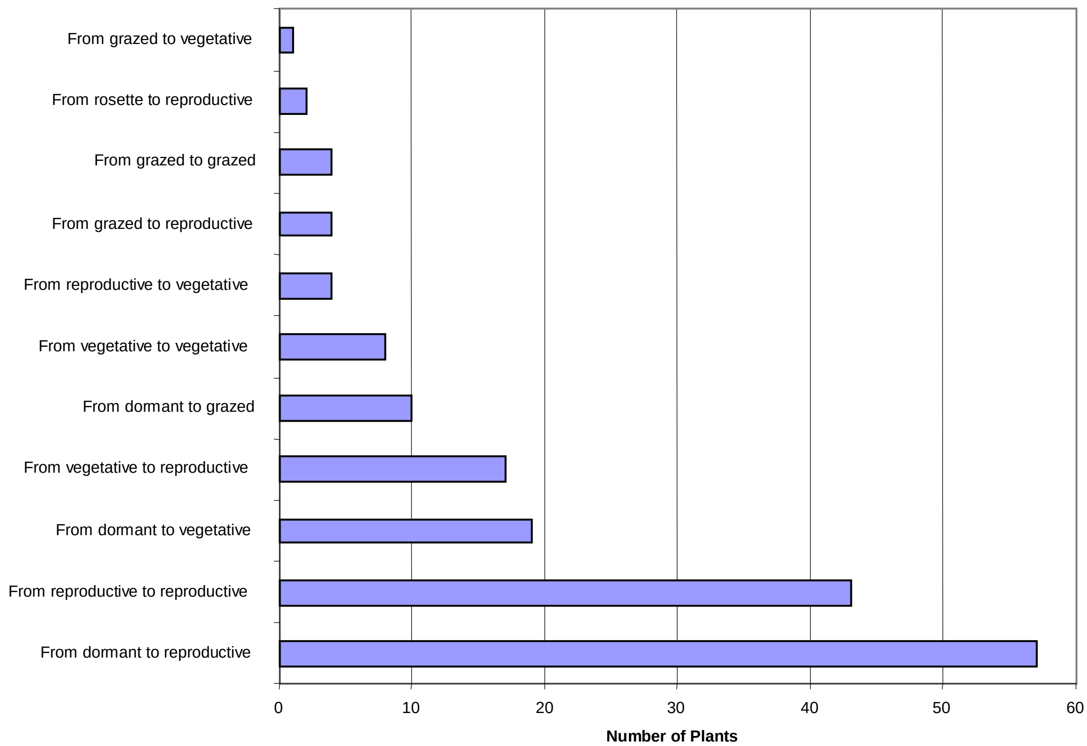

Figure 3. Growth form transitions, 2002 to 2003

Fire

The percentage of plants that were rosettes, vegetative, grazed, and reproductive are presented in Figure 4. Two plots, 5 and 8, are located within the boundaries of the Corral Creek Fire of September, 2001. Both plots showed small decreases in both stem and plant number. Unburned Plot 7, west of Corral Creek, also showed a decrease in stems in 2003. However, stems in Plot 7 were overwhelmingly reproductive in both 2002 and 2003, whereas the majority of stems in the burned plots were vegetative in both years. Another unburned plot, Plot 6, had a high proportion of vegetative stems in 2002. However, in 2003, Plot 6 showed a substantial increase in both number of stems and reproductive plants. The number of plants and stems in burned plots could be decreasing, and burned plants may tend to be vegetative. However, because both dormancy and reproductive status are extremely variable among plots and years, plants in those plots may be exhibiting natural variation unrelated to fire. Information from long-term data collection on mapped, individual Spalding's catchfly plants will give insight into variation in dormancy and incidence of reproduction.

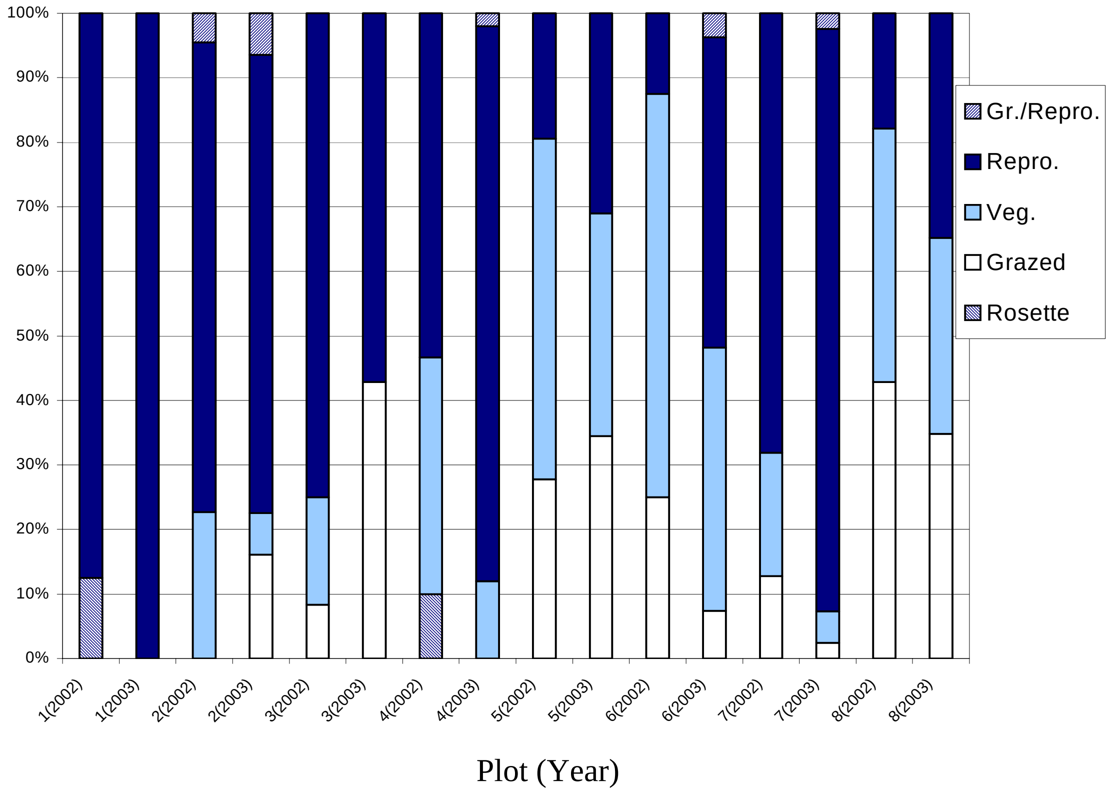

Figure 4. Percent of Spalding's catchfly stems that were rosettes, vegetative, grazed, or reproductive, 2002 and 2003.

Hill and Weddell (2003) found little difference in percent of flowering plants in unburned (70%) vs. burned (71%) stands in the year following the Corral Creek Fire.

Fire may affect the primary pollinator of Spalding's catchfly, *Bombus fervidus*, which prefers to nest underground. In southern Alberta, queens establish nests in May or June. An average of 8 cocoons are laid in the first brood, and 26-29 days are required to produce workers. Colonies that produced queens averaged from 200 to nearly 300 cocoons per season (Hobbs 1966). Stephen (1957) cites collection dates from April 13 to September 11 (queens between April 13 and August 13, workers from June 18 to September 15, and males from June 23 to September 5). We do not know the effect of burning on underground bumblebee reproduction sites.

<u>Habitat</u>

Good condition Spalding's catchfly habitat is dominated by bunchgrasses interspersed with a diverse assemblage of forbs. Often snowberry and/or native rose patches are present, and mosses are common, particularly in and around the bunchgrass clumps. Bluebunch wheatgrass (*Pseudoroegneria spicata)* and Idaho fescue (*Festuca idahoensis*) are the primary bunchgrasses in these relatively moist communities, but prairie junegrass (*Koeleria micrantha*) and Sandberg's bluegrass (*Poa secunda*) are also generally present. The presence of Idaho fescue indicates the moisture conditions that Spalding's catchfly requires. Stands supporting only bluebunch wheatgrass and Sandberg's bluegrass are apparently too dry. Habitat condition among the plots varied considerably, from nearly without weeds (Plot 6) to very weedy (Plots 1, 5 and 8).

Weeds

Craig Mountain has severe infestations of non-native aggressive weeds, including yellow starthistle, St. John's-wort, Canada thistle (*Cirsium arvense*), scotch thistle (*Onopordum acanthium*), sulfur cinquefoil (*Potentilla recta*), teasel (*Dipsacus sylvestris*), whitetop (*Cardaria chalapensis*), and leafy spurge (*Euphorbia esula*). In addition, annual grasses such as Japanese brome and cheatgrass, and the perennial, Kentucky bluegrass, are common. Monitoring plots represent a range of conditions. No weeds were recorded in Plot 6 microplots, but other plots supported one to several weed species

In our plots, Japanese brome was the most ubiquitous non-native species, appearing in 7 of the 8 plots, and 77 microplots. Cheatgrass occurred in only 5 microplots. On south-facing slopes, cheatgrass is the dominant invasive species, in many places forming nearly continuous ground cover between bluebunch wheatgrass clumps. On north-facing slopes, Japanese brome seems to be more widely distributed than cheatgrass. It is often abundant, but grows in a more scattered fashion, interspersed between the native plants. When cheatgrass does occur on north slopes, it more often forms dense, localized patches, making it less likely to be recorded in frequency plots. Japanese brome is a Eurasian winter annual grass. Along with cheatgrass, it provides flammable, continuous fuel early in the season. Another annual grass, ventenata, occurred in both Madden Creek plots, particularly in the terracing caused by game trails.

Kentucky bluegrass was present in 4 plots (3, 5, 7, and 8). It was found in 13 microplots within plots 5 and 8, the two burned plots. Plot 3, (unburned, in Billy Creek), was also infested, with 8 microplots supporting Kentucky bluegrass. Weddell and Lichthardt revisited transects established by Daubenmire in the 1950s at Kramer Prairie, Washington (Weddell and Lichthardt 1998). Daubenmire recorded no Kentucky bluegrass in 1958. Weddell and Lichthardt found it occurred in 98% and 100% of the two Daubenmire plots they repeated in 1998. Daubenmire (1970) called the domination of Kentucky bluegrass in meadow steppe brought on by grazing a "zootic climax," and concluded that it was seemingly irreversible.

Yellow starthistle was present in small amounts in 3 plots. Although it initially colonized south-facing slopes on Craig Mountain, it has recently moved into the more north-facing Spalding's catchfly habitat. Piedmont bedstraw is present in both Madden Creek plots (1 and 4). It forms a tangled mat, and may be a serious problem in the future.

St. John's-wort was present but infrequent in 4 plots. St. John's-wort populations vary in response to population fluctuations of an imported bio-control insect. Besides competing for resources, St. John's-wort flowers during the same time period as Spalding's catchfly and competes for the pollinator, *Bombus fervidus*. Lesica and Heidel (1996) documented pollination bouts at Garden Creek Ranch in which one third of visits to Spalding's catchfly flowers were followed by visitation to flowers of other species, most commonly St. John's-wort.

In 2005, we plan to re-collect frequency data on weeds and other indicator species in order to document changes.

Rare plants

Three rare plants occur in Spalding's catchfly monitoring plots: Palouse thistle, Palouse goldenweed, and greenband mariposa lily. We consider these rare plants to be indicators of good-condition habitat.

Shrubs

Some researchers suspect shrub encroachment is a threat to Spalding's catchfly (Heidel 1995). Others believe that shrub thickets and grasslands form stable mosaics (Daubenmire 1970, Franklin and Dyrness 1973). Long-term data collection in permanent monitoring plots may help resolve this issue.

Mosses and lichens

Microbiotic soil crusts (composed of varying proportions of mosses, lichens, cyanobacteria, liverworts, and algae) are important components of semi-arid ecosystems. They increase soil stability, affect the moisture regime, and apparently play a role in slowing weed invasion (Evans and Johansen 1999).

Canyon grasslands in good condition generally support ground cover of three mosses: *Tortula ruralis*, *Brachythecium albicans*, and *Homalothecium* (*aeneum*?). On south-facing slopes, *Tortula ruralis* predominates, but on north-facing slopes, all three are common between plants and within bunchgrass clumps. Mosses were present in all 120 unburned microplots, but were present in only 8 of the 40 burned microplots. In the burned microplots, mosses were present only in traces (usually 0.1%) This is not unexpected. Ponzetti et al. (1998) found *Tortula ruralis* and *Brachythecium albicans* substantially reduced in burned plots at the Lawrence Grasslands in Oregon. Hill and Weddell (2003) recorded an average of 76% moss cover in unburned Spalding's catchfly monitoring plots, compared to 5-10% moss cover in burned plots.

Lichens are usually present in smaller amounts than mosses in north-facing grasslands. In monitoring plots, *Cladonia* squamules often cover patches of bare soil. Podetia are rarely found, but those we observed were those of *Cladonia fimbriata*, leading us to believe that the unreproductive squamules may also be of *C. fimbriata*. The foliose lichens *Peltigera rufescens* and *Peltigera canina* grow in mesic grasslands on Craig Mountain. We recorded lichens (above species combined) in 50% of the unburned microplots. Lichens were completely absent in burned plots; they appear to be even more susceptible to fire than mosses. Ponzetti et al. (1998) also recorded decreases in both *Cladonia* spp. and *Peltigera* spp. after prescribed burns in bunchgrass habitat.

Mosses and lichens were almost completely eliminated from a bunchgrass community one year after a human-caused fire in western Montana (Antos et al. 1983). *Brachythecium albicans* and *Cladonia pyxidata* cover on burned sites was only 5% of that found on unburned sites. After three years, moss recolonization was by weedy, cosmopolitan species, rather than by *Brachythecium albicans*. Microbiotic crusts are usually severely damaged by and slow to recover from fires (Antos et al. 1983, Belnap 1993, Evans and Johansen 1999, Johansen et al. 1984). The loss of the microbiotic crust is the most conspicuous result of the Corral Creek Fire.

Weather

In February, 2002, the BLM established a weather station (Cotton-portable) in the Corral Creek drainage. Data from this station will allow us to examine trends in plant numbers in relation to temperature and precipitation. Figure 5 presents the average monthly temperatures at Cotton-portable and Lewiston, Idaho, in 2002. Monthly averages from long-term records at Lewiston (1971-2000) are included for comparison. Temperatures at Lewiston and Corral Creek follow each other fairly closely. From mid-June until mid-July, 2002, temperatures at Corral Creek and Lewiston were higher than the long-term Lewiston average, but for most of the rest of the year, they were slightly below average.

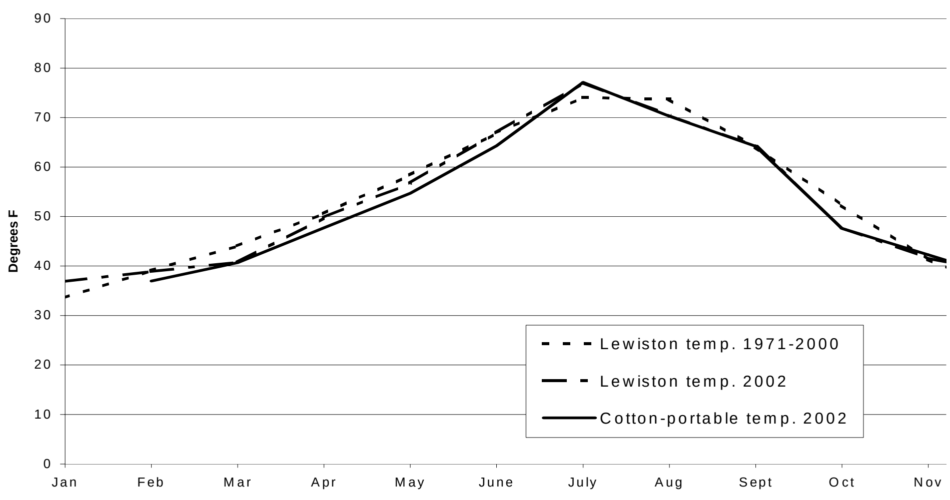

Figure 5. 2002 and long-term average monthly temperature.

In 2003, temperatures at both weather stations were higher than the long-term average from June through October, with a peak in July of 79.6º F at Corral Creek, and 78.6º F in Lewiston. The long-term Lewiston average for July is 74.1º F (Figure 5).

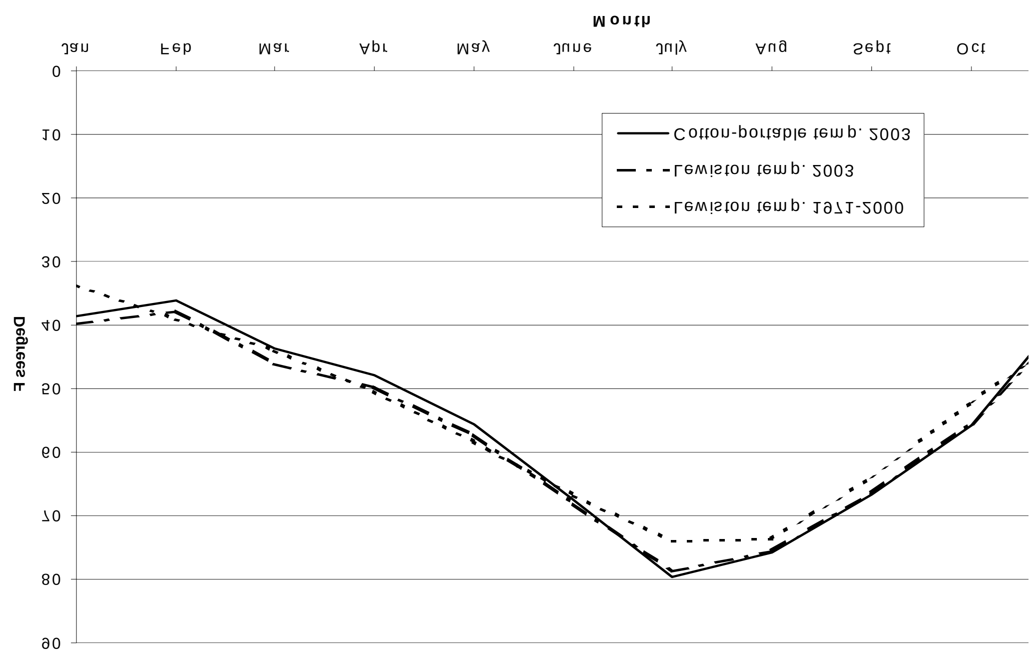

Figure 6. 2003 and long-term average monthly temperature.

Precipitation amounts at Lewiston and Corral Creek follow each other less closely than temperatures, probably reflecting localized rain events. In 2002, Lewiston yearly precipitation was 10.12 inches, 2.31 inches less than the Lewiston long-term average. The Cotton-portable station was not established until February, so a yearly total is unavailable for 2002.

Although the yearly averages were lower, both Corral Creek and Lewiston experienced precipitation spikes in June and August, 2002 (Figure 7). Precipitation was very low in July (0.03 in at Corral Creek, and 0.15 in Lewiston); the long-term average precipitation for Lewiston in July is 0.67 in. From September through December, precipitation was also well below Lewiston averages.

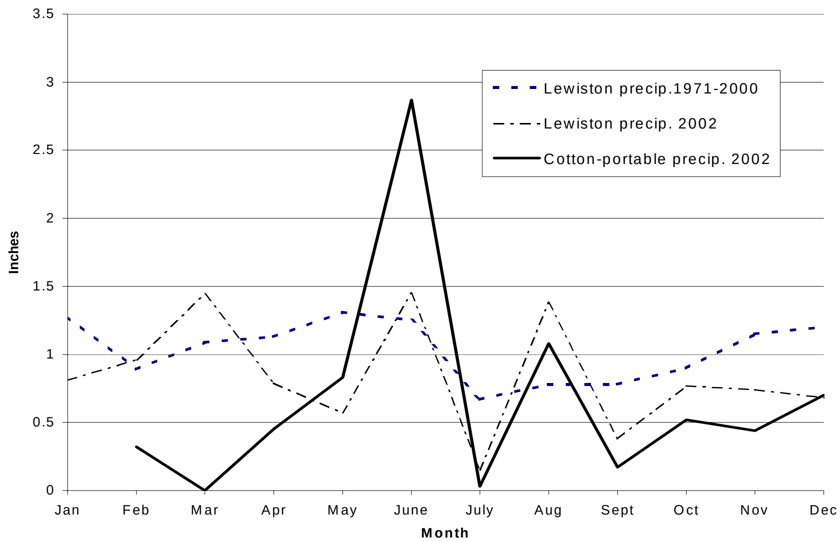

Figure 7. 2002 and long-term average monthly precipitation.

In 2003, both Lewiston and Corral Creek received higher than average rainfall for the year (Figure 8). Corral Creek received high precipitation from December through May, but from June through November, precipitation was well below average. The wet winter may have induced observed increases in reproductive plants and stems.

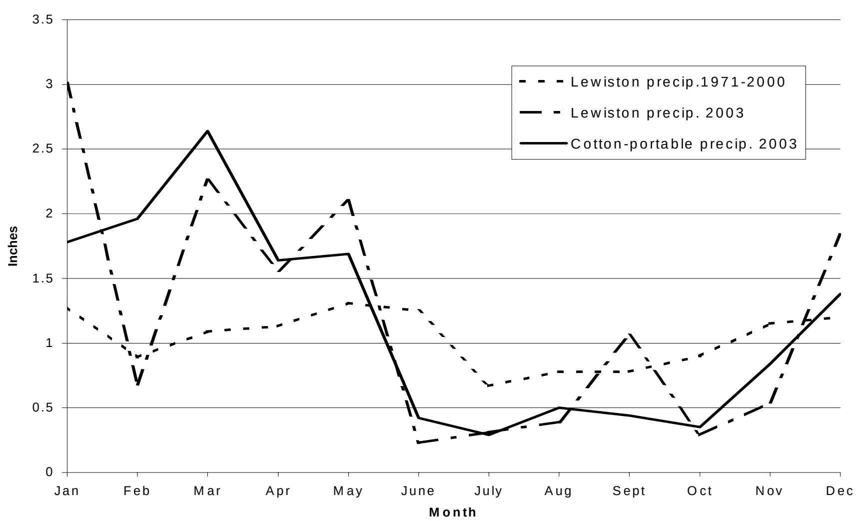

Figure 8. 2003 and long-term average monthly precipitation.

Fire

Monitoring may help elucidate the effects of fire on Spaldings catchfly and its habitat. Fire affects, and is affected by, alien species such as yellow starthistle and annual bromes. The annuals cause an increase in the amount of dry fuel in grassland communities. Cheatgrass and Japanese brome senesce early in the season and provide dry, continuous fuel. Fires ignite and spread more easily in cheatgrass-invaded communities. Fires in turn enhance cheatgrass invasion. Ultimately, cheatgrass decreases fire return intervals, and the decreased fire intervals favor cheatgrass establishment (D'Antonio and Vitousek 1992, Billings 1994, Tausch et al. 1995).

There is little specific data bearing on natural fire intervals in Pacific Northwest bunchgrass steppe. Most estimates are based on extrapolation from midwestern prairie, shrub steppe, or dry coniferous forests (Weddell 2001). Because steppe is by definition treeless, the usual methods of inferring fire intervals, charcoal layers or tree ring scars, cannot be used. Historical accounts of canyon grassland vegetation are few, often vague, and rarely mention fire (Gray 2001).

The two primary authorities on northwest bunchgrass communities, Daubenmire and Tisdale, considered the grasslands to be stable, with species composition, boundaries, and distribution determined by climate and soil rather than by fire (Daubenmire 1970, Tisdale 1986). They considered most native species to be fire-adapted, but not fire-dependent. With the exception of nonvascular species such as mosses and lichens, it appears that most plants of Pacific Northwest bunchgrass communities survive natural fire. However, weeds are often favored by conditions following fire, and native communities ultimately become degraded because of invasion by non-native species (D'Antonio and Vitousek 1992, Hobbs and Huenneke 1992, Tausch et al. 1995).

CONCLUSIONS

We have established baseline information on Spalding's catchfly and selected habitat indicator species at 8 different sites. Dormancy, herbivory, and reproductive effort varied considerably among plots and years. Several factors likely influence Spalding's catchfly persistence, including weather, herbivory, fire, and non-native plant invasion.

By collecting data and mapping individual Spalding's catchfly plants annually through 2005, we should have the data necessary to begin to determine recruitment and mortality. These demographic data will help us understand population trends. Tracking movement of plants into recruit, juvenile, and reproductive size classes remains problematic until then, however, because plants may move from reproductive to vegetative stem or rosette forms in subsequent years. Also, some plants that are vegetative when sampled may become reproductive later in the season. Because age class cannot be inferred from plant form or reproductive status, it will not be possible to perform demographic analysis until 2005. From that year forward, we will be able to identify recruits with some confidence.

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