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Demographic Monitoring of Spalding's catchfly (*Silene spaldingii* Wats.) in Idaho Canyon Grasslands

2004 Field Season

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2005

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ABSTRACT

Spalding's catchfly (*Silene spaldingii* Wats.), a plant species endemic to the bunchgrass, sagebrush, and open pine communities of the inland Pacific Northwest, was listed as Threatened by the U.S. Fish and Wildlife Service (USFWS) in 2001. The largest population of Spalding's catchfly in Idaho, approximately 4,700 plants, occurs in the Canyon Grasslands along the Snake and Salmon Rivers in the Craig Mountain region. The population spans a distance of ~ 50 miles and includes lands managed by the Bureau of Land Management (BLM), The Nature Conservancy (TNC), and Idaho Department of Fish and Game (IDFG). This report presents data collected during the 2004 field season on 18 demographic monitoring plots within this population. It represents the continuation of three long-term monitoring studies including: 1) the third year of data for eight plots established by the Idaho Conservation Data Center (IDCDC) in 2002 for USFWS, 2) the third year of data for seven plots established in 2002 through a Challenge Cost-share project between the BLM and the Palouse-Clearwater Environmental Institute (PCEI), and 3) the sixth year of data for one plot established in 1999 through a Challenge Cost-share between BLM and TNC. Baseline data are also presented for two plots established at new occurrences of Spalding's catchfly in the Craig Mountain region.

Monitoring focused on demographic parameters of Spalding's catchfly (population size, demographic structure, recruitment, mortality, prolonged dormancy, reproductive effort) and environmental factors (animal disturbance, fire, weed invasion, drought) affecting Spalding's catchfly in Canyon Grasslands. Individual plants were mapped and tracked through consecutive years. Monitoring was conducted twice during the growing season in 2004, once in early June and once at flowering in late July. The early June sampling was critical for demographic monitoring because it is the time when all the plants produced aboveground for a particular growing season are detectable. Previous Canyon Grassland studies have indicated many plants present early in the season are gone or senescent and undetectable by flowering. In this study, 38% of plants present at early sampling were gone or senescent by late sampling. A higher proportion of rosette plants, 67%, were gone or senescent than stemmed plants, 30%, suggesting the ephemeral nature of the rosette plant during the growing season. Monitoring only at flowering time in Canyon Grasslands can lead to under-estimations of detectable plants, population size, and threats, inaccuracies in demographic structure and plant transitions between years, and over-estimation of prolonged dormancy.

Spalding's catchfly exhibited three aboveground growth forms in 2004: 1) stemmed plants (69%), 2) rosette plants (26%), and 3) stemmed/rosette plants (5%). All rosette plants remained as rosette plants and did not bolt into stemmed plants between early and late sampling. Stemmed plants dominated in most plots, however, rosette plants were the dominant growth form in one plot. Over the study period, several plants exhibited prolonged dormancy in which they remained undetected belowground during a growing season.

Both adults and seedlings produce rosette plants and no diagnostic, aboveground, anatomical features have been identified to distinguish between them. Annual monitoring

for at least four years is necessary to determine whether a rosette plant is a seedling. A plant appearing at a location where no plant has occurred for at least three years, the length of prolonged dormancy, can be identified as a seedling. Currently, no rosette plants have been identified as seedlings because plots have only been sampled for three years. However, many rosette plants have been documented as older plants. Based on plant transitions between years and some partial excavations, 41% of all rosette plants observed over the monitoring period were documented to be over a year old, and many of these were two or three years old. Continued annual monitoring will help to determine the status of many of the remaining rosette plants.

Rodent activity, i.e., rodent runs, holes, diggings, soil mounds, was not observed in 2002, but started during the 2003 field season, and was present at high levels in 2004. Many plots had considerably fewer numbers of plants aboveground at early sampling in 2004 than in 2002 and 2003, and rodent activity was present at the majority of missing plant sites. This activity may have caused considerable mortality of plants. Continued annual monitoring is necessary to determine whether the missing plants are in prolonged dormancy or dead.

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INTRODUCTION

Spalding's catchfly (*Silene spaldingii* Wats.) is a Threatened plant species (USFWS 2001) that occurs in Pacific Northwest Bunchgrass Grasslands, sagebrush-steppe, and open 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 plateau of northeastern Oregon, and 5) intermontane valleys of northwestern Montana and adjacent British Columbia (Figure 1 – Appendix 1). 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). Fewer than 100 Spalding's catchfly plants in seven scattered occurrences are known from the Palouse Grasslands of Idaho (IDCDC 2005; Hill and Gray 2004a). Small populations isolated from each other by large expanses of cultivated fields make these occurrences subject to pollinator limitations, inbreeding depression and high risk of extirpation from chance environmental events (Lesica 1993; Lesica and Heidel 1996).

Steep terrain and inaccessibility have prevented urban, commercial or agricultural development in Canyon Grasslands, and this area represents the largest, remaining, contiguous and intact area of Pacific Northwest Bunchgrass habitat in Idaho. The largest known occurrences of Spalding's catchfly in Idaho are located in Canyon Grasslands in the Craig Mountain area, with approximately 4,700 plants in eleven locations. The largest of these occurrences, approximately 4,000 plants, is located at the Garden Creek Ranch (Hill and Gray 2004a). The Canyon Grasslands in Idaho have been recommended for priority critical habitat for Spalding's catchfly (Lichthardt 1997). A major threat to Spalding's catchfly in Canyon Grasslands is the presence of a number of invasive, non-native plant species, which have degraded and displaced large tracts of native bunchgrass communities (Hill and Gray 2004a).

Information on population dynamics and threats for this species is critical to understanding and implementing appropriate conservation measures. Conservation of rare plant species often focuses on maintaining and/or enhancing the population; however, population size of Spalding's catchfly is difficult to determine. Long-term demographic studies in northwestern Montana have shown this species has the ability to survive underground for one to several years and reappear in subsequent years; the term "summer dormancy" was used to describe this phenomenon (Lesica 1997). The term "prolonged dormancy" will be used in this report to distinguish it from the term "summer dormancy", which is also used to describe aestivation in many Canyon Grassland plants. Preliminary demographic studies indicate prolonged dormancy is occurring for Spalding's catchfly in the Canyon Grasslands of Idaho as well (Hill and Gray 2000; Hill et al. 2001; Hill and Fuchs 2002, 2003; Hill and Weddell 2003; Hill and Gray 2004b; Gray and Lichthardt 2004; Hill and Gray 2005). Long-term monitoring is essential to determine population size and whether conservation efforts are abating threats and maintaining or enhancing this species.

Understanding the effects of fire on Spalding's catchfly and its habitat is also important for conservation of this species and its habitat. Lesica (1999) concluded that the use of fire in the rough fescue (*Festuca scabrella*) grasslands of northwestern Montana increased seedling recruitment due to decreased litter, and recommended that prescribed fire be considered a potential management tool. Rough fescue is a very productive grass that produces much larger amounts of litter annually compared to that produced by grasses that dominate Canyon Grasslands, Idaho fescue (*F. idahoensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Fire may not have the same effect on populations of Spalding's catchfly in Canyon Grasslands because far less litter is produced. Furthermore, the disturbance of fire may be problematic in areas where invasive, non-native plant species are prevalent. Studies conducted in Canyon Grasslands have shown increases in the invasive, non-native, annual bromes, cheatgrass (*Bromus tectorum*), Japanese brome (*B. japonicus*), rattlesnake brome (*B. brizaeformis*), and yellow starthistle (*Centaurea solstitialis*) following fire (Hill et al. 2003; Gray and Lichthardt 2003).

This report focuses on monitoring of Spalding's catchfly within Canyon Grasslands of the Snake and Salmon Rivers in the Craig Mountain, Idaho, region (Photos 1 & 2 – Appendix 2). This area, which includes lands managed by the BLM, IDFG, and TNC, has been the focus of surveying, monitoring and research for the species in Idaho since 1993 when it was first discovered within Canyon Grasslands (Mancuso and Moseley 1994; Lesica and Heidel 1996; Hill and Gray 1999; Hill and Gray 2000; Hill et al. 2001, Hill and Fuchs 2002; Menke 2003; Menke and Muir 2004; Baldwin and Brunsfeld 1995; Hill and Fuchs 2003; Hill and Weddell 2003; Lichthardt and Gray 2003; Gray and Lichthardt 2004; Hill and Gray 2004b, 2005).

The objectives of this study were to: 1) determine demographic parameters and dynamics of Spalding's catchfly (population size, recruitment, mortality, prolonged dormancy, reproductive and productivity effort, population structure), 2) evaluate environmental factors affecting Spalding's catchfly populations in Canyon Grasslands (fire, predation, herbivory, weed invasion, drought), and 3) characterize the Canyon Grassland habitat and examine trends in invasive, non-native species and key native species. Information from this study will provide an understanding about the life cycle, ecology, and population dynamics of Spalding's catchfly, help assess the potential long-term viability of Spalding's catchfly in Canyon Grasslands, and assist in the development of recovery plans and appropriate management strategies. It will examine the variability of Spalding's catchfly in Canyon Grasslands, describe the Canyon Grassland habitat and environmental factors affecting Spalding's catchfly in this habitat, and provide a basis for comparison with Spalding's catchfly in different habitats and regions across its range.

This project presents data collected during the 2004 field season on 18 different Spalding's catchfly monitoring plots in the Craig Mountain region and provides continuation of three long-term monitoring studies as well as baseline data for two new monitoring plots. The three long-term monitoring studies include: 1) eight plots established by the IDCDC for the USFWS (Lichthardt and Gray 2003; Gray and Lichthardt 2004); these eight plots will be referred to as the "FWS Plots", 2) seven plots established through a challenge cost-share project between the BLM and PCEI (Hill and Weddell 2003; Hill and Gray 2004b, 2005); these seven plots will be referred to as the "BLM Plots", and 3) one plot established through a challenge cost-share between BLM and TNC (Hill and Gray 2000; Hill et al. 2001; Hill and Fuchs 2002, 2003); this plot will be referred to as the 'TNC" plot. The 2004 data represents the third year of data collection for both the FWS and BLM plots and the sixth year of data collection for the TNC plot. Some results from previous years of these studies are presented for comparison and trend.

SITE DESCRIPTION

Canyon Grasslands occur on steep canyon slopes of major river systems (Snake, Salmon, Clearwater, Grande Ronde, and Imnaha rivers) in the tri-state area of Idaho, Oregon, and Washington (Tisdale 1986) (Figure 2 – Appendix 1). Known Spalding's catchfly occurrences in Idaho Canyon Grasslands occur in the Craig Mountain region located on the western border of north-central Idaho at the confluence of the Salmon River with the Snake River, 20-30 miles south of Lewiston (Figures 3 & 4 –Appendix 1). Elevation extremes, from approximately 1,000 feet at the Snake and Salmon Rivers to over 5,000 feet at the top of Craig Mountain, occur within a few miles and create the steep, rugged Snake River breaklands on the west side of the mountain and the Salmon River breaklands on the east side of the mountain. The climate is characterized by mild wet winters and hot dry summers.

The steep canyon slopes are dominated by native bunchgrass communities (Canyon Grasslands) with smaller inclusions of shrubland and forest communities. These major vegetation types occur across the landscape in a distinct pattern related to a moisture gradient determined by aspect, elevation and soils (Tisdale 1986; Mancuso 1993). Southerly and northerly aspects at the same elevation have very different soils and vegetation. From mid- to high elevations (~3,800 feet to 5,200 feet), shrubland and coniferous forest occur on northerly slopes and grasslands, primarily the Idaho fescue-bluebunch wheatgrass habitat type, occur on southerly slopes. At low to mid-elevations (~1,300 feet to 3,800 feet), northerly slopes support mesic Idaho fescue grasslands, i.e., Idaho fescue-prairie junegrass, Idaho fescue-snowberry, and Idaho fescue-rose habitat types, while southerly slopes support xeric bluebunch wheatgrass grasslands. Spalding's catchfly is restricted to the mesic Idaho fescue grasslands on northerly aspects between 1,350 feet and 4,000 feet (Hill and Gray 2004a; IDCDC 2005). In Idaho Canyon Grasslands, it is not known from the drier Idaho fescue-bluebunch wheatgrass habitat types on southerly slopes at higher elevations.

Heavy grazing by domestic cattle and sheep severely impaired the native bunchgrass ecosystem, which had not evolved with large herds of ungulates (Mack and Thompson 1982; Tisdale 1986). The deterioration of native bunchgrasses from grazing facilitated the invasion by a number of aggressive weed species, particularly those of Mediterranean origin, the annual bromes and yellow starthistle (Tisdale 1961, 1986; Daubenmire 1970). These highly competitive weed species have seriously degraded or completely displaced native bunchgrass communities in many areas of the Canyon Grasslands (Mancuso and Moseley 1994; Hill and Gray 1999).

The majority of Spalding's catchfly occurrences in Idaho Canyon Grasslands are located within the Snake River breaklands on the west side of Craig Mountain, including the largest occurrence, approximately 4,000 plants, at the Garden Creek Ranch. The Ranch is owned and managed cooperatively by TNC and BLM to maintain the high quality ecological and biodiversity values of the area. The remaining occurrences are in the Salmon River drainage, one on the east side of Craig Mountain and the other two approximately 20-30 miles upstream from the confluence with the Snake River.

Eighteen monitoring plots were established in the Craig Mountain region (Figure 4 – Appendix 1) to represent the variability of Canyon Grasslands habitat for this species, including a range of elevations, aspects, slopes, disturbance, and weed invasion.. Seventeen of the monitoring plots are located on Craig Mountain within several different drainages, including two in the Madden Creek drainage, two in the Billy Creek drainage, twelve at Garden Creek Ranch in the Corral Creek drainage and small drainages to the north (Figures 5, 6, & 7 – Appendix 1). Two new monitoring plots were established in 2004, one at Eagle Creek in the Salmon River breaklands on the east side of Craig Mountain and the other along the Salmon River near its confluence with Rice Creek (Figures 8 & 9– Appendix 1). Wildfires have occurred recently on Craig Mountain, the Maloney Creek Fire in August 2000, which covered the "point" area of the mountain and the Corral Creek Fire in September 2001 in the Redemsky Flats area of the Garden Creek Ranch. Eight of the monitoring plots occur within the area burned in the Corral Creek Fire. The Eagle Creek plot occurs within the area burned in the Maloney Creek Fire. The other plots occur in areas that have not burned in over 15 years.

SPECIES DESCRIPTION AND LIFE HISTORY

Spalding's catchfly is a herbaceous perennial plant that commonly grows up to 20-60 cm, and occasionally to 75 cm tall (Photo 1 - Appendix 2). It typically produces one stem, but can produce multiple stems, each bearing 4-7 (occasionally up to 10) pairs of leaves 5-8 cm long and up to 4 (6) cm in width. The foliage, stem, and flower bracts are densely covered with sticky, gland-tipped hairs that give the species its common name, 'catchfly'. Stems arise from a simple or branched caudex (persistent stem just beneath the soil surface) that surmounts a long, narrow taproot that can grow up to 85 cm long (Menke 2003). The cream- to pink- to light green-colored 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 blade of the flower petals is a diagnostic feature, distinguishing Spalding's catchfly from other sympatric *Silene* species. Scouler's catchfly (*S. scouleri*) has much longer petal blades, 6-7 mm, and blooms earlier in the season.

Aboveground portions of Spalding's catchfly die back over the winter months. In the Canyon Grasslands at the Garden Creek Ranch, 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). Spalding's catchfly plants can survive belowground from one to several years in prolonged dormancy (Lesica 1997; Hill and Gray 2005). Spalding's catchfly has a clumped distribution, forming irregular-shaped clusters of varying density (Hill and Gray 2000).

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).

METHODS

Spalding's catchfly and Habitat Monitoring

Monitoring plots were designed to allow quantitative measurements of Spalding's catchfly populations and associated habitat through time. Demographic monitoring that provides information on recruitment, mortality, prolonged dormancy, population size and structure, and the fate of individuals in all stages of the life cycle requires mapping and tracking individual plants for a number of consecutive years (Elzinga et al. 1998). Because prolonged dormancy in Spalding's catchfly can last up to three years (Lesica and Steele 1994), monitoring needs to continue for longer than three years to determine recruitment, mortality, and duration of prolonged dormancy.

Many Spalding's catchfly demographic monitoring studies have been conducted only at flowering (Lesica 1997, 1999; Caplow 2000, 2001; Lichthardt and Gray 2003; Gray and Lichthardt 2004). However, previous demographic monitoring of Spalding's catchfly at Garden Creek Ranch has indicated that large numbers of plants present early in the season are missing or senescent and undetectable at flowering (Hill and Gray 1999; Hill and Weddell 2003; Hill and Gray 2004b; Hill and Gray 2005). Monitoring for this project was conducted twice during the growing season, once in early to mid-June and again at flowering time in late July. Monitoring in early June when all plants were detectable allowed an accurate census of the number and stage classes of plants produced aboveground for the growing season. By monitoring twice, the loss of plants during the growing season could be quantified, and potential causes of their loss evaluated.

The basic monitoring method for Spalding’s catchfly plants was similar for all 18 monitoring plots. Individual plants were tracked from year to year within meter-wide belt transects in permanently marked plots. Bent rebar was used to mark the ends of transects and allow exact re-positioning of measuring tapes from year to year. During sampling, a measuring tape was extended the length of a transect for determination of plant locations and collection of plant data. The rooted locations of plants were recorded with two reference coordinates, the linear distance in meters along the measuring tape, and the perpendicular distance in centimeters from the tape to the plant (Plant Data Tables – Appendix 3).

Monitoring of the habitat was done to evaluate the influence of environmental factors on the long-term viability of Spalding's catchfly and to characterize the Canyon Grassland habitat and trends in key native species and invasive, non-native species. Habitat monitoring included measurement (cover, frequency, or density) of: 1) associated species (condition, quality, composition, habitat type), 2) ground factors (bare ground, ground litter), and 3) disturbance factors (ground disturbance, predation, herbivory, fire). Frequency, cover, and/or density of associated plant species and ground features were measured within 50 cm X 50 cm sampling frames within 20 sampling plots in the FWS Plots (Figure 10) and within microplots of the BLM Plots (Figure 11). Canopy cover to the nearest 1% was estimated for all plant species within the FWS Plots and within a 10m X 10m plot centered on BLM Plots (Community Composition - Appendix 4).

All plots were sampled twice during the 2004 growing season, once in early to mid-June and once in late July during flowering. At the early June sampling date, the area within each transect was thoroughly searched for Spalding's catchfly plants. Two reference coordinates were recorded for each plant. A plant appearing within 10 cm of each coordinate in following years was considered to be the same plant. Growth form, number of stems and/or rosettes per plant, number of rosette leaves, length of the longest rosette leaf, and rosette leaf surface features were also recorded. Habitat measurements were also recorded at this early sampling. At the late July sampling date, the area within each transect was thoroughly searched again for any plants that may have emerged since early sampling. Data on survival, herbivory, and senescence were recorded for each plant. In addition, stem height and reproductive data, i.e., number of buds, flowers, post-flowers, and capsules per plant, were recorded for stemmed plants.

The plot layout and monitoring methodology for FWS Plots and BLM Plots was somewhat different (Figures 10 & 11 – Appendix 1). See Appendix 6 and/or refer to Lichthardt and Gray (2003), Gray and Lichthardt (2004), Hill and Weddell (2003) and Hill and Gray (2004b, 2005) for specific plot layout and methodology. Site information for each plot was recorded in Site Inspection Forms (Appendix 5).

Plot Characteristics

Characteristics of the 18 Spalding's catchfly monitoring plots are provided in Table 1. The Plot Type column indicates whether a plot is a FWS Plot, a BLM Plot, a TNC Plot, or new plots established in 2004. The monitoring history of each plot is listed in the Late or Early Plots column. The letter “E” represents an “Early” plot that was sampled twice during the growing season, once in early June and again at flowering time. The letter “L” represents a “Late” plot that was sampled only at flowering time. For example, “L/L/E” indicates the plot was a late plot in 2002 and 2003 and an early plot in 2004. FWS Plots were late plots in 2002 and 2003 and early plots in 2004. The TNC Plot was a late plot each year from 1999-2003 and an early plot in 2004. BLM plots were early plots all three years. Both new plots were early plots in 2004. All plots were early plots in 2004. No date in the Burn Regime column indicates the plot has not burned in over 15 years. Plot layout indicates whether the plot follows the FWS or BLM plot layout and monitoring methodology (Appendix 6).

Table 1 - Spalding's catchfly Monitoring Plots, Idaho Canyon Grasslands.

Plot #	Plot Name	Plot Type	Location	Management	Elevation (feet)	Aspect (°)	Slope (%)	Plot Size (sq m)	Number of Years Monitored	Late or Early Plots	Burn Regime	Plot Layout
1	Madden Creek Low	FWS	Madden Creek	IDFG	2545	330	60	100	3	L/L/E	-	FWS
2	Billy Creek South (East)	FWS	Billy Creek	BLM	2480	45	50	100	3	L/L/E	-	FWS
3	Billy Creek South (West)	FWS	Billy Creek	BLM	2430	350	55	100	3	L/L/E	-	FWS
4	Madden Creek High	FWS	Madden Creek	IDFG	2790	320	64	100	3	L/L/E	-	FWS
5	LCC 69-M	FWS	Garden Creek Ranch	BLM/TNC	2775	350	35	100	3	L/L/E	Sept. 2001	FWS
6	LCC 225	FWS	Garden Creek Ranch	BLM/TNC	2630	329	52	100	3	L/L/E	-	FWS
7	LCC 271	FWS	Garden Creek Ranch	BLM/TNC	2670	308	46	100	3	L/L/E	-	FWS
8	LCC 69-Z	FWS	Garden Creek Ranch	BLM/TNC	2700	343	41	100	3	L/L/E	Sept. 20 01	FWS
9	Rice Creek	new	Rice Creek	BLM	1730	330	58	100	1	E	-	FWS
10	LCC 51-2B	BLM	Garden Creek Ranch	BLM/TNC	3030	325	48	5	3	E/E/E	Sept. 2001	BLM
11	LCC 51-1B	BLM	Garden Creek Ranch	BLM/TNC	3120	350	38	10	3	E/E/E	Sept. 2001	BLM
12	LCC 65-4B	BLM	Garden Creek Ranch	BLM/TNC	3130	322	42	5	3	E/E/E	Sept. 2001	BLM
13	LCC 65-3B	BLM	Garden Creek Ranch	BLM/TNC	3080	320	36	6	3	E/E/E	Sept. 2001	BLM
14	LCC 65 Weed Control	TNC	Garden Creek Ranch	BLM/TNC	3010	324	35	23	6	L/L/L/L/L/E	Sept. 2001	BLM
15	LCC 196-1U	BLM	Garden Creek Ranch	BLM/TNC	2560	320	62	8	3	E/E/E	-	BLM
16	LCC 196-3U	BLM	Garden Creek Ranch	BLM/TNC	2560	318	61	5	3	E/E/E	-	BLM
17	LCC 196-2U	BLM	Garden Creek Ranch	BLM/TNC	2560	330	63	12	3	E/E/E	-	BLM
18	Eagle Creek	new	Eagle Creek	IDFG	1800	10	65	100	1	E	August 2000	FWS

RESULTS

Spalding's catchfly Growth Forms

Three distinct growth forms of Spalding's catchfly were observed in all plots during the monitoring period: 1) stemmed plants, 2) rosette plants, and 3) stemmed/rosette plants. Stemmed plants had visible stem elongation (elongated internodes) between sets of leaves and possessed two to ten sets of leaves (Figure 12 – Appendix 1; Photo 3- Appendix 2). They often possessed more than one stem per plant, and stems were occasionally branched. Stems were either reproductive or vegetative. Multi-stemmed plants usually possessed either all reproductive stems or all vegetative stems; however, occasionally a multi-stemmed plant possessed both reproductive and vegetative stems. Stemmed plants emerged as short stemmed plants in the spring (Photo 4 – Appendix 2); internodes elongated and sets of leaves were added between early and late samplings. Rosette plants had no stem elongation between sets of leaves (internodes did not elongate) and possessed from one to four pairs of leaves. Occasionally they possessed more than one rosette per plant. Since internodes did not elongate, sets of leaves formed a cluster at or close to the soil surface (Figure 13 – Appendix 1; Photo 5 – Appendix 2). Excavations of some rosette plants revealed the petioles of the rosette leaves extended belowground and connected directly to the caudex (Hill and Weddell 2003); other rosettes appeared to have a short stem connecting the cluster of rosette leaves at the ground surface with the caudex underground. Rosette plants emerged as rosette plants in the spring and remained in a rosette growth form between early and late sampling; they did not bolt (internodes did not elongate) into stemmed plants nor did leaves increase in number or length. Stemmed/rosette plants supported both stem(s) and rosette(s) on the same plant (Figure 14 – Appendix 1; Photo 6 – Appendix 2).

The age of a plant is difficult to determine from the growth form, i.e., rosette plants can either be seedlings or mature adults, stemmed reproductive plants in one year can be vegetative stemmed plants or rosette plants the following year. Long-term monitoring is necessary to determine the age of a plant. Growth forms were used to categorize aboveground plants rather than age classes because they were consistently recognizable from year to year.

A plant in prolonged dormancy presents no aboveground vegetation for one to several growing seasons (Lesica 1997) and survives underground as caudex and taproot tissue. The presence of a dormant plant is determined by tracking individual Spalding's catchfly plants over a number of consecutive years.

Annual Plant Census

The number and growth form of plants that appeared aboveground in each plot for each year data were collected is presented in Table 2. To demonstrate changes in aboveground plants in 2002, 2003 and 2004, annual totals (and percentages) for plots monitored these three years are provided. Totals for new plots and the first three years of the TNC Plot (in parentheses) were not included in these totals. Not all transects in Plots 1, 2, and 3 were sampled in 2002 (Gray and Lichthardt 2004); totals for these plots represent only transects sampled all three years.

Table 2- Annual Aboveground Plant Census.

(2002 totals/2003 totals/2004 totals; numbers in parentheses were not included in totals)

Plot Number	Total Plants	Stemmed Plants	Rosette Plants	Stemmed/ Rosette Plants
1	6/8/8	5/8/6	1/0/2	0/0/0
2	17/18/22	17/18/18	0/0/2	0/0/2
3	10/15/24	10/15/19	0/0/3	0/0/2
4	27/46/23	23/46/13	3/0/7	1/0/3
5	26/23/18	26/23/16	0/0/1	0/0/1
6	15/23/24	15/23/17	0/0/7	0/0/0
7	30/26/28	29/26/20	0/0/8	1/0/0
8	23/19/33	23/19/25	0/0/7	0/0/1
9	(16)	(13)	(3)	(0)
10	9/7/2	8/5/1	1/2/1	0/0/0
11	30/27/26	8/8/11	22/19/14	0/0/1
12	17/14/4	10/9/4	4/3/0	3/2/0
13	18/15/15	15/12/10	3/3/4	0/0/1
14	(16/17/10)/19/14/6	(15/16/10)/16/13/2	(1/1/0)/3/1/3	(0/0/0)/0/0/1
15	10/10/2	9/9/1	1/0/1	0/1/0
16	15/20/10	14/19/8	0/1/2	1/0/0
17	27/30/9	16/20/4	8/7/5	3/3/0
18	(55)	(51)	(4)	(0)
Total	**299/315/254**	**244/273/175**	**46/36/67**	**9/6/12**
Percent	**100/100/100**	**82/87/69**	**15/11/26**	**3/2/5**

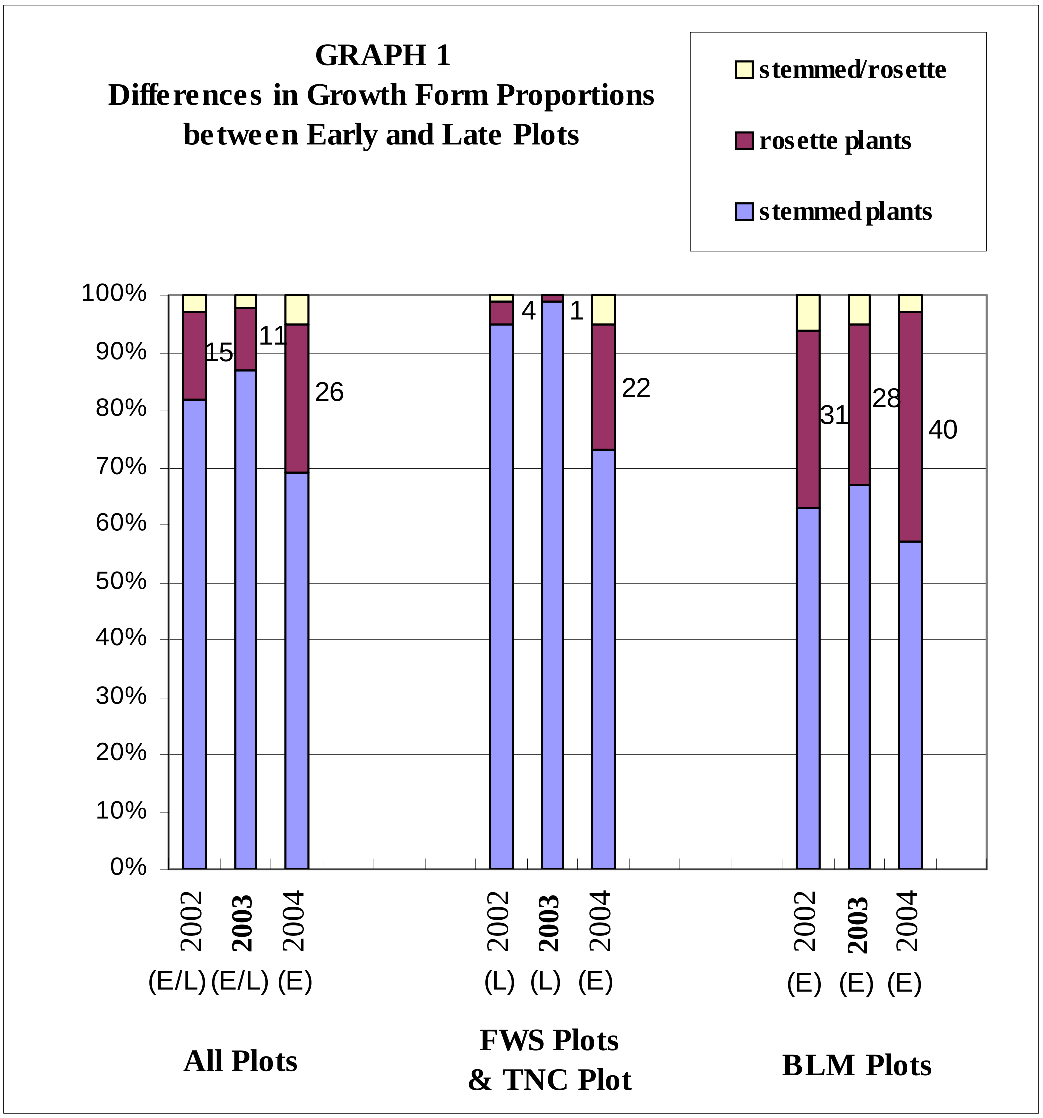
The total numbers of aboveground plants observed in plots monitored at least three years (long-term plots) were 299 in 2002, 315 in 2003, and 254 in 2004. Plant totals were similar in 2002 and 2003, but dropped considerably in 2004. Totals in Plots 4, 10, 12, 14, 15, 16, and 17 dropped 50% or more in 2004 from totals in 2003.

Stemmed plants were the dominant growth form overall, representing 82% of total aboveground plants in 2002, 87% in 2003, and 69% in 2004, and averaging 80% over the three years. Rosette plants represented 15% of total aboveground plants in 2002, 11% in 2003, and 26% in 2004, and averaged 17% over the three years. Stemmed/rosette plants represented 3% of total aboveground plants in 2002, 2% in 2003, and 5% in 2004, and averaged 3% over the three years. Proportions of growth forms varied between plots and between years, i.e., rosette plants dominated in Plot 11 all three years and in Plots 11, 14, and 17 in 2004.

Newly established plots (monitored only in 2004), had 81% and 93% stemmed plants and 19% and 4% rosette plants in Plots 9 and 18, respectively. No stemmed/rosette plants were recorded in either plot.

Differences were observed in growth form proportions between "late" and "early" long-term monitoring plots in 2002, 2003, and 2004. FWS plots and the TNC Plot were "late" plots in 2002 and 2003 but "early" plots in 2004, and BLM plots were "early" plots all three years. Graph 1 illustrates growth form proportions in 2002, 2003, and 2004 for: 1) all long-term plots, 2) FWS Plots and the TNC Plot, and 3) BLM Plots.

(E = Early Plots; L = Late Plots; numbers by bars represent percentage of rosette plants)



The first group of bars represents all plots and shows differences in growth form proportions between 2002 and 2003, which included both "late" plots (FWS Plots and TNC Plot) and "early" plots (BLM Plots), and 2004 in which all plots were "early" plots.

The proportion of rosette plants in early plots in 2004 was greater than that in late plots in either 2002 and 2003.

The second group of bars represents FWS Plots and the TNC Plot and shows differences in growth form proportions between 2002 and 2003, when these plots were "late" plots, and 2004 when these plots were "early" plots. Proportions of rosette plants were very low when these were "late" plots, but increased considerably when these plots were "early" plots. The proportion of rosette plants in 2004 (21%) was much greater than that in either 2002 and 2003 (4% and <1%, respectively).

The third group of bars represents BLM Plots, which were "early" plots all three years. These plots recorded substantial proportions of rosette plants all three years, 31% in 2002, 28% in 2003, and 40% in 2004. These proportions of rosette plants are considerably higher than the 4% in 2002 and 1% in 2003 recorded in the FWS and TNC "late" plots.

These data suggest that "late" plots sampled only once at flowering time are missing a substantial number of plants, especially rosette plants, that are present early but are not detectable at late sampling. "Early" plots which include an early sampling likely provide a more accurate representation of the actual number of plants and proportions of growth forms presented aboveground in any one growing season.

Population Size

It is difficult to know in any one year, how many plants are present at an occurrence because some plants may be undetectable belowground in prolonged dormancy. Although prolonged dormancy can last for up to three years, most episodes last one to two years (Lesica and Steele 1994). In northwestern Montana, 96% of the total population was observed after the third year of monitoring (Lesica 1997).

For plots monitored at least three consecutive years, it is likely that most of the plants in the plots will have been observed aboveground at least once. The plot population size for each long-term monitoring plot is presented in Table 3 which lists the number of plants observed in 2002, additional plants observed in 2003, and additional plants observed in 2004. The total number of plants observed in three years of monitoring, which represents 96% of the plot population, is provided. Based on this number, 100% of the total plants present in each plot, the plot population size, was calculated. The percentage of the plot population that was observed each year is provided in parentheses. These percentages are not provided for Plots 1, 2, and 3, for which only four transects were sampled in 2002 and all ten transects were sampled in 2003 and 2004, and the TNC Plot which had six consecutive years of monitoring.

Table 3 - Plot Population Size.

(* = all transects not sampled; numbers in parentheses = % of plot population)

Plot	2002 Plants	Additional Plants in 2003	Additional Plants in 2004	Number of Plants in 3 Years (96% of plot population)	Plot Population Size
1	6*	14	13	33	34
2	17*	2	4	23	24
3	10*	10	12	32	33
4	27 (39)	25 (36)	14 (20)	66	69
5	26 (57)	7 (16)	10 (22)	43	45
6	15 (44)	10 (29)	8 (24)	33	34
7	30 (67)	2 (4)	11 (24)	43	45
8	23 (54)	7 (16)	11 (26)	41	43
10	9 (90)	1 (10)	0 (0)	10	10
11	30 (75)	7 (18)	1 (3)	38	40
12	17 (94)	0 (0)	0 (0)	17	18
13	18 (95)	0 (0)	0 (0)	18	19
14	16 [1999];6 [2000]; 0 [2001]; 5 [2002]	0	1	28	29
15	10 (83)	0 (0)	1 (8)	11	12
16	15 (68)	6 (27)	0 (0)	21	22
17	27 (82)	4 (12)	1 (3)	32	33

The highest percentages of the plot population were observed in the first year of monitoring for all plots; however, higher percentages were observed in "early" plots (68-95%) than "late" plots (39-67%). Conversely, larger percentages of the plot population were observed in the third year of monitoring in "late" plots (20-26%) than "early" plots (0-8%). These data further suggest that late sampling misses plants that are present earlier but are absent or senescent and undetectable by flowering. Determination of population size in late plots will likely require more consecutive years of monitoring than early plots since not all aboveground plants are being detected in late plots.

Prolonged Dormancy

An estimate of how many plants in the plot population are surviving belowground in a growing season, the dormancy rate, can be made based on the plot population size (Table 3). Table 4 provides the plot population size, plants present aboveground each year, and plants absent aboveground (and likely in prolonged dormancy) each year, the dormancy rate. Plots that were "late" plots anytime during the three-year monitoring period were not included since annual aboveground census is likely under-estimated in these plots and would result in over-estimated dormancy rates. Barring a catastrophic event that would result in high mortality, the majority of plants absent aboveground in any one year likely represents plants in prolonged dormancy.

Table 4 - Dormancy Rate.
(Dormancy rate in percentage in parentheses)

Plot	Plot Population	Plants Present 2002	Plants Absent (Dormancy) 2002	Plants Present 2003	Plants Absent (Dormancy) 2003	Plants Present 2004	Plants Absent (Dormancy) 2004
10	10	9	1(10)	7	3(30)	2	8(80)
11	40	30	10(25)	27	13(33)	26	14(35)
12	18	17	1(6)	14	4(22)	4	14(78)
13	19	18	1(5)	15	4(21)	15	4(21)
15	12	10	2(17)	10	2(17)	2	10(83)
16	22	15	7(32)	20	2((9)	10	12(55)
17	33	27	6(18)	30	3(9)	9	24(73)
Total	**154**	**126**	**28(18)**	**123**	**31(20)**	**68**	**86(56)**

Dormancy rates in 2002 and 2003 were relatively low and similar, averaging 18% in 2002 and 20% in 2003. The number of plants that did not appear aboveground in 2004 was considerably higher, averaging 56%. Two of the plots, Plot 11 and 13, had dormancy rates similar to those in 2002 and 2003. However, the remaining five plots had much higher rates ranging from 55 to 83%. Predictably, these five plots also showed large drops in aboveground plant census in 2004 (Table 2). The large percentage of the population that did not appear aboveground in these five plots in 2004 may indicate factors other than prolonged dormancy are involved, such as increased mortality.

Rosette Plants

The criteria used to classify a plant as a rosette plant was based on internode length. A plant with no internode or a very short internode, a few mm, between sets of leaves was considered a rosette plant.

In all early plots (all 18 plots in 2004 and BLM Plots in 2002, 2003, and 2004), all rosette plants remained as rosette plants with no elongation of internodes (i.e., no bolting) or increase in leaf length between early and late sampling. No rosette plants were reproductive. By late sampling, rosette plants often had missing leaves or leaves with insect herbivory, or the entire plant was senescent or missing (Photos 10, 11 & 13; Plant Data Tables - Appendix). It is unlikely that these plants would bolt into stemmed plants after late sampling because of the dry conditions of the soil and little precipitation during this time of the growing season.

Rosette plants varied in size and shape making them difficult to detect and identify. Rosette plants with large leaves (>6 cm) were fairly easy to identify because their leaves were often similar in size and shape to those of stemmed plants. However, rosette plants with small leaves were difficult to distinguish from small rosettes of associated plant species. A feature that distinguished Spalding's catchfly rosette plants from other forb rosettes was the presence of retrorse hairs on the edges of the leaves. The hairs, which were usually non-glandular, arose from the leaf edge at approximately right angles, and the top half of the hair bent backward toward the leaf petiole. The number of hairs on the leaf edge varied from many to only a few scattered hairs. Sometimes the hairs were only present on the leaf blade near its junction with the petiole.

Both seedlings and adult plants produce rosette plants. A seedling initially produces a rosette plant during the first season of growth (Lesica 1988, 1997, 1999; Hill and Gray 2000) (Photos 7 & 8 – Appendix 2). Based on partial excavations and plant transitions between years, it has been determined that adult plants (plants older than one year) also produce rosette plants (Hill and Weddell 2003; Hill and Gray 2004b; Gray and Lichthardt 2004; Hill and Gray 2005). Careful, non-destructive removal of soil around the caudex area of nine rosette plants in BLM Plots in 2002 revealed that eight of them were connected to adult plants with mature, relatively large-diameter, and, in some cases, branching caudices that showed evidence of previous years' stem remnants and supported numerous, live stem buds (Hill and Weddell 2003) (Figure 13 – Appendix 1; Photo 9 – Appendix 2). Plant transitions between years also provided evidence that many rosette plants were greater than one year old, for example, a rosette plant present in the current year that had been present aboveground the previous year was at least one year old.

Many rosette plants have been documented to be greater than one year old. Table 5 shows the number of rosette plants recorded in each long-term plot over the monitoring period and the number of them that were determined to be adult plants (greater than one year old) based on partial excavations and plant transitions between years (Plant Data Tables – Appendix 3).

Table 5 - Adult Rosette Plants.

Plot	Total Rosette Plants in Monitoring Period	Adult Rosette Plants
1	5	0
2	2	1
3	3	0
4	10	1
5	1	0
6	7	2
7	8	2
8	7	0
10	4	2
11	55	29
12	7	4
13	10	7
14	9	3
15	2	0
16	3	2
17	20	9
Total	**153**	**62**

A large portion (41%) of the total rosette plants recorded over the monitoring period in these plots was determined to be at least one year old. Many of them were two or three years old; some had been rosette plants each of the three years of monitoring (Plant Data Tables – Appendix 3). Currently, no diagnostic, aboveground, anatomical features have been identified to distinguish seedling rosette plants from adult rosette plants (see paragraph below), and continued monitoring is necessary to determine the status of the many of the remaining rosette plants. A plant occurring at a location where no plant has occurred for three years, the length of prolonged dormancy, can be classified as a seedling. Thus far, no seedling rosette plants have been documented.

Leaf length and leaf surface features of rosette plants were recorded in 2004 to determine if these parameters could be used to distinguish between adult and seedling rosette plants (Plant Data Tables – Appendix 3). Stemmed plants typically possess leaves 5-8 cm long with gland-tipped hairs. Based on greenhouse studies (Hill and Gray 2000; Hill et al. 2001; Hill and Fuchs 2002, 2003), the rosette plants produced by seedlings initially have small leaves, less than ½ cm in length, with glabrous surfaces (Photo 7 - Appendix 2). The rosette plants documented to be adult plants (Table 5) showed a wide variability in leaf length, from 0.8 cm to 8.5 cm, and leaf surface features, from glabrous to possessing hair that was sometimes gland-tipped and sometimes not gland-tipped (Plant Data Tables - Appendix 3). The location and density of hair also varied considerably from very dense hair on both ventral and dorsal surfaces, to fewer hairs on either the dorsal or ventral surface, to only a few hairs along the mid-vein on the ventral surface. Presence of retrorse hairs on leaf edges was a consistent feature of all rosette plants. Adult rosette plants can produce small leaves with glabrous surfaces that are typical of seedling rosette plants. Furthermore, during the first season of growth, leaves of seedling rosette plants can increase in length up to several cm (Photo 8 - Appendix 2), similar to many adult rosette leaves.

No diagnostic, aboveground, anatomical features have been identified to distinguish between adult and seedling rosette plants. Long-term monitoring for at least four years appears to be the only method, short of destructive sampling that would reveal caudices and taproots, to identify seedling rosette plants.

Seasonal Loss of Plants

Many plants present at early sampling were gone or senescent and undetectable by late sampling. Table 6 shows the number of stemmed and rosette plants recorded at early sampling and the number that were absent, broken, or senescent at late sampling. Absent refers to a plant that was present at early sampling but no trace of the plant remained at late sampling. Broken refers to a plant present at early sampling but broken at the base of the plant with only a stump remaining which would be impossible to detect and identify at late sampling. Senescent refers to a plant that is still present at late sampling but has died with browned, curled, dried leaves and/or stems. Some senescent stemmed plants would likely be detectable by late sampling; however, small, senescent rosette plants would be very difficult to detect and identify (Photos 10 & 11 - Appendix 2). Some multi-stemmed plants had both intact live stems and absent, broken or senescent stems. Only those multi-stemmed plants with all stems absent, broken, or senescent (plants that could be missed if only late sampling was conducted) were included in this analysis. Stemmed/rosette plants were included in the Stemmed Plant category.

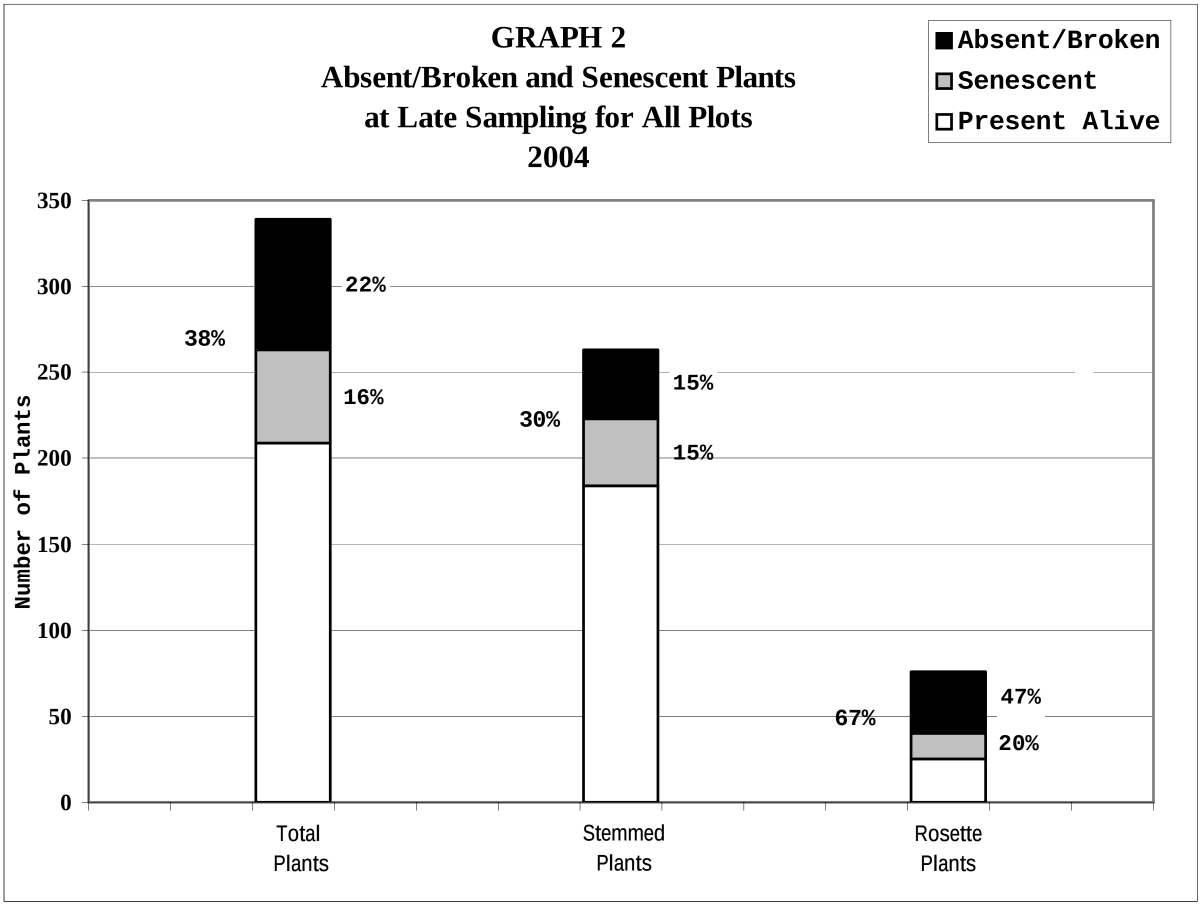
Table 6 - Absent, Broken, and Senescent Plants at Late Sampling (2004).

Plot	Total Plants (June)	Total Stemmed Plants (June)	Absent Stemmed Plants (July)	Broken Stemmed Plants (July)	Senescent Stemmed Plants (July)	Total Rosette Plants (June)	Absent Rosette Plants (July)	Senescent Rosette Plants (July)
1	20	16	3	0	3	4	0	2
2	22	20	0	0	2	2	2	0
3	26	23	5	0	3	3	3	0
4	23	16	2	0	5	7	0	1
5	18	17	3	2	2	1	1	0
6	24	17	2	1	3	7	4	1
7	28	20	3	1	1	8	3	2
8	33	26	6	2	2	7	6	1
9	16	13	1	0	1	3	2	1
10	2	1	0	0	0	1	0	0
11	26	12	1	0	5	14	7	4
12	4	4	0	0	1	0	0	0
13	15	11	1	0	3	4	1	1
14	6	3	1	0	1	3	1	1
15	2	1	0	0	0	1	0	1
16	10	8	2	0	0	2	2	0
17	9	4	0	0	2	5	2	0
18	55	51	3	1	5	4	2	0
Total	**339**	**263**	**33**	**7**	**39**	**76**	**36**	**15**
Percent	**100**	**100**	**12**	**3**	**15**	**100**	**47**	**20**

A total of 339 plants, 263 stemmed plants and 76 rosette plants, were recorded in all plots at early sampling in June. By the late July sampling, 38% of them were absent (20%), broken (2%) or senescent (16%). Of the stemmed plants, 30% were absent (12%), broken (3%) or senescent (15%) by late sampling. A much higher percentage of rosette plants, 67%, was absent (47%) or senescent (20%) at late sampling. Graph 2 shows the percentages of total plants, stemmed plants and rosette plants, present at early sampling that were absent/broken and senescent at late sampling in 2004. Broken plants were combined with absent plants because both were undetectable at late sampling; senescent plants may or may not be detectable.

If only late sampling had occurred in these plots, plants present earlier that became absent and broken would not have been detected. Plants that senesced may also be undetectable at late sampling, particularly senescent rosette plants. Rosette plants possess only a few leaves which tend to decrease in size and curl up as they senesce; pieces may break off as the season progresses. Detecting these senescent rosette plants and/or distinguishing them from other small, dried forb species is difficult (Photos 10 & 11 – Appendix 2).

Therefore, both absent and senescent rosette plants, two-thirds of the rosette plants present earlier in the season, would not have been detected if only late sampling had been done in these plots.



Absence, breakage, and senescence of Spalding's catchfly plants during the growing season may be related to such factors as herbivory, rodent damage or weather.

Herbivory

Herbivory of Spalding's catchfly plants was observed during the monitoring period and may be related to the loss or damage of plants during the growing season and possibly the mortality of plants. Herbivory consisted of three types: 1) native ungulate grazing, 2) insect herbivory, and 3) herbivory or other damage related to rodent activity.

Native Ungulate Grazing

Grazing occurred on stemmed plants and consisted of the complete removal of the upper portion of the stem (Photo 12 – Appendix 2). The point of removal was almost always below the inflorescence, so that grazing removed any reproductive structures that may have been present. The grazing occurred between early and late samplings. Elk (*Cervus* *elaphus*) and mule deer (*Odocoileus hemionus*) were the likely causes of this grazing herbivory. They inhabit the area where Spalding's catchfly occurs at Craig Mountain and have been observed grazing in and near plots. Numerous game trails exist in the area, and many of them occur within plots. Native ungulate grazing in all 18 plots was relatively low in the 2004 field season. Six of 175 stemmed plants (3%) were grazed at late sampling, and no regrowth had occurred at that time (Plant Data Tables – Appendix 3). No damage to the caudex or taproot of grazed plants was observed, and grazing probably did not cause mortality of plants. All grazed stemmed plants occurred in plots at the Garden Creek Ranch. All domestic livestock have been removed from the Ranch since 1994 (Hill and Gray 1999).

Insect Herbivory

Insect herbivory consisted of small holes in buds, flowers, capsules, or along the edges of leaves (Photo 13 – Appendix 2). Thirty-five of 339 plants (10%) had some degree of insect herbivory on reproductive structures, and 83 of 339 plants (25%) had insect herbivory on leaves (Plant Data Tables – Appendix 3).

Rodent Herbivory/Damage

Rodent activity within plots consisted of rodent runs, holes, tunnels, diggings, and soil mounds. Voles (genus *Microtus*), which were observed on several occasions, and pocket gophers (family Geomyidae) were likely responsible for the majority of this rodent activity. Typically, all vegetation within a rodent run was cut and the pathway trampled to bare ground. At some known Spalding's catchfly locations, no plant emerged in 2004, and stems were pulled down into rodent holes. Some of these stems were old stems from the previous year and some were new stems produced in 2004. Some rodent holes tunneled under known plant locations, no plant was present, and no caudex or taproot was observed in the hole under the plant location. Soil mounds were also observed and consisted of low rounded mounds up to several meters in diameter and 15-20 cm tall with no obvious outlet/inlet. [Photos 14-19 – Appendix 2].

Rodent activity increased over the three-year monitoring period. None was observed in 2002. It began during the 2003 growing season and was very high during the 2004 growing season (Hill and Weddell 2003; Hill and Gray 2004b, 2005).

In 2004, rodent activity was observed in 15 of the 18 plots; no rodent activity was observed in the two Billy Creek Plots (Plots 2 and 3) and Eagle Creek (Plot 18). Rodent activity often occurred at known plant locations, and no plant was present at early sampling in 2004. Table 7 lists the total plants observed in each long-term plot during the monitoring period, the number of missing plants at early sampling in 2004, and the number of missing plant sites with rodent activity in 2004. Data are provided for each year in those plots that were "early" plots all three years. Two totals are provided, a total for all long-term plots in 2004 and a total for each year for those plots that were "early" plots all three years.

Table 7 - Rodent Activity and Missing Plants at Early Sampling.
(* = "early" plots sampled all three years)

Plot	Total Plants During Monitoring Period	Missing Plants at Early Sampling	Rodent Activity at Missing Plant Location
1	33	13	6
2	23	1	0
3	32	6	0
4	66	44	22
5	43	25	23
6	33	9	5
7	43	15	13
8	41	8	4
10*	10	1/3/8	0/0/7
11*	38	8/11/12	0/0/6
12*	17	0/3/13	0/0/9
13*	18	0/3/3	0/3/3
14	28	22	19
15*	11	1/1/9	0/0/9
16*	21	6/1/11	0/0/9
17*	32	5/2/23	0/0/15
2004 Total (All plots)	**489**	**222**	**150**
Yearly Totals ("Early" Plots*)	**147**	**21/24/79**	**0/3/58**

A large portion of the total known plants in all long-term plots, 222 of 489 (45%), were missing at early sampling in 2004. A high percentage, 68% (150 of 222), of these missing plants had rodent activity associated with them.

For "early" plots, which included an early sampling all three years, the number of missing plants at early sampling was similar the first two years, with 21 (14%) in 2002 and 24 (16%) in 2003, but showed a large increase to 79 (54%) in 2004. No rodent activity was observed with any missing plants at early sampling in 2002 and only 3 missing plants had rodent activity in 2003. At early sampling in 2004, a high number, 58 (73%), of missing plants had rodent activity associated with them (Plant Data Tables - Appendix 3; Hill and Weddell 2003; Hill and Gray 2004).

In the absence of increased mortality, the majority of missing plants at known plant locations at early sampling would likely be plants that were in prolonged dormancy. The 21 plants in 2002 and 24 plants in 2003 in the "early" plots were probably plants remaining belowground in prolonged dormancy. However, the large increases in missing plants and the presence of rodent activity at a large majority of missing plant sites at early sampling in 2004 indicate that rodent activity is related to this large increase and may indicate mortality has occurred. Determination of mortality cannot be made until no plant has appeared at a known plant site for three years, the length of prolonged dormancy.

Weather

Weather conditions during Spalding's catchfly's growing season in Canyon Grasslands can be harsh, and may be related to the high incidence of loss and senescence of plants during the growing season and possibly mortality. The months of June, July and August, the primary growing season for Spalding's catchfly, are the hottest and driest months of the year (Western Regional Climate Center 2000).

Precipitation and temperature records for the monitoring period of 2002, 2003 and 2004 were obtained from two weather stations in close proximity of the monitoring plots, one at Lewiston, Idaho, 20-30 miles north of Craig Mountain, and a portable weather station, Cotton-Portable, at Garden Creek Ranch (Western Regional Climate Center 2005). Cotton-Portable, which was established in 2002, is located in Redemsky Flats and within a mile of the eleven monitoring plots at the Ranch. Table 8 presents total precipitation and mean monthly temperature for the period of June, July and August of 2002, 2003, and 2004 at the Lewiston and Cotton-Portable weather stations. The 55-year mean for these parameters are also presented for the Lewiston station.

Table 8 - Precipitation and Temperature During Growing Season.
(JJA = June, July, August)

Year	Lewiston (~1400 ft)		Cotton-Portable (~2600 ft)	
	Total precipitation in JJA (inches)	**Mean monthly temperature for JJA (°F)**	**Total precipitation in JJA (inches)**	**Mean monthly temperature for JJA (°F)**
2002	2.98	71.5	3.98	70.6
2003	0.93	74.2	1.21	74.3
2004	3.24	73.7	3.49	71.3
55-year mean	2.72	71.0	-	-

The generally higher precipitation and lower temperature at Cotton-Portable compared to Lewiston is a reflection of the 1,200 feet higher elevation at Cotton-Portable. Both stations show 2003 had the least precipitation and the hottest temperatures of all three monitoring years during June, July, and August. Furthermore, the mean monthly temperature at Cotton-Portable in 2003 was particularly hot for this elevation, with temperatures as hot as the Lewiston station 1,200 feet lower in elevation. The June, July, and August period of 2003 had considerably lower precipitation and considerably higher temperatures than means for these values over the last 55 years.

For the BLM Plots, the percentage of plants present at early sampling that were absent or dead by late sampling was 45% in 2002, 64% in 2003, and 49% in 2004. The highest percentage of absent or dead plants, which included all of the rosette plants, occurred in 2003, the hottest and driest of the three monitoring years (Hill and Gray 2005).

Reproduction

The percentage of plants that flowered and the number of reproductive structures (buds, flowers, capsules) produced per plant and per stem were used as indices to estimate the relative reproductive effort of Spalding's catchfly plants for all 18 plots in 2004. Seed production was not measured because many reproductive structures had not developed into mature dehiscent capsules by late July.

Flowering Plants

Reproductive plants were those that supported at least one reproductive structure (bud, flower, or capsule). Flowering was calculated in two ways: 1) the percentage of all plants that were reproductive, and 2) the percentage of intact stemmed plants that were reproductive. The first method is based on all plants produced aboveground, including rosette plants which remain vegetative through the growing season. The second method is based on intact stemmed plants, which have the potential to be reproductive, and does not include rosette plants. Absent, broken, and grazed stemmed plants were not included in the calculation because their reproductive status could not be determined. Multi-stemmed plants that possessed at least one flowering stem were counted as reproductive, even though the remaining stems may have been grazed, broken, absent or non-reproductive. Table 9 lists total plants present in June (including rosette and stemmed plants), absent, broken, or grazed plants in July, stemmed plants for which reproductive status could be determined in July, reproductive stemmed plants and percent flowering. Percent flowering includes two values, the percentage of total plants that flowered (left of slash) and the percentage of intact stemmed plants that flowered (right of slash).

Table 9 - Flowering Plants.

Plot Number	Total Plants (June)	Rosette Plants (June)	Stemmed Plants (June)	Absent Broken Grazed Stemmed Plants (July)	Reproductive Status Determinable (July)	Reproductive Stemmed Plants (July)	Percent Flowering
1	20	4	16	3	13	10	50/77
2	22	2	20	0	20	18	82/90
3	26	3	23	5	18	14	54/78
4	23	7	16	2	14	5	22/36
5	18	1	17	5	12	6	33/50
6	24	7	17	4	13	6	25/46
7	28	8	20	5	15	12	43/80
8	33	7	26	11	15	8	24/53
9	16	3	13	1	12	11	69/92
10	2	1	1	0	1	1	50/100
11	26	14	12	1	11	5	19/46
12	4	0	4	0	4	1	25/25
13	15	4	11	2	9	5	33/56
14	6	3	3	0	3	2	33/67
15	2	1	1	0	1	1	50/100
16	10	2	8	2	6	5	50/83
17	9	5	4	1	3	2	22/67
18	55	4	51	4	47	44	80/94
TOTAL	**339**	**76**	**263**	**46**	**217**	**156**	**46/72**

The flowering rate based on all plants produced aboveground in June was 46%. Of the 339 plants produced aboveground in June, 156 of the them were reproductive. All 76 rosette plants were vegetative and all 156 reproductive plants were stemmed plants.

The flowering rate based on intact stemmed plants in July was 72%. Of the 217 intact stemmed plants for which reproductive status could be determined in July, 156 of them were reproductive. The reproductive status of the 46 stemmed plants that were absent, broken or grazed could not be determined in July. It is likely that a similar proportion of these plants would have been reproductive as well if the cause of their absence, breakage or herbivory had an equal chance of occurring on vegetative stemmed plants as on reproductive stemmed plants.

Reproductive Structures Per Plant and Per Stem

The term "reproductive structures" refers to the buds, flowers, and fruit produced by Spalding's catchfly. These structures exhibited the following phenological stages: 1) Bud: developing immature floral stage; calyx closed around developing flower; buds are commonly oriented at right angles or slightly downward in relation to the stem; 2) Flower: developed floral stage; upper end of calyx open and corolla petals expanded, flowers are commonly oriented at right angles in relation to the stem, 3) Post-flower: upper end of calyx tube closed enveloping withered corolla petals; post-flowers are commonly pointing slightly upward in relation to stem, 4) Immature Fruit: ovary, capsule, and seeds developing; calyx closed, position is fully upright in relation to stem, and 5) Mature Fruit: capsule fully developed; mature seeds present; upper end of calyx and capsule widely opened for seed dispersal; fully upright in relation to stem.

The number and type of reproductive structures produced per plant and per stem for all 18 plots in the 2004 field season are presented in Table 10. Multi-stemmed plants that possessed at least one flowering stem were counted as reproductive plants, even though the remaining stems may have been grazed, broken, absent or vegetative. Stemmed/rosette plants were included in this analysis.

Averages of 15 reproductive structures per plant and 11 reproductive structures per stem were determined for all 18 plots. Considerable variation existed between plots. Some plots were represented by only one or two plants (Plots 10, 12,14,15, and 17). The highest mean number of reproductive structures was observed in Madden Creek Low (Plot 1) with a mean of 35 per plant and 27 per stem; however, these data are considerably skewed on the basis of one plant, the largest plant recorded in all plots in 2004. This plant had two stems, one of which branched 15 times; it produced 183 reproductive structures by late sampling. Even without this large plant, the other plants in this plot produced high numbers of reproductive structures per plant and per stem, 19 and 15, respectively (totals in parentheses). The next highest mean number of reproductive structures was observed in Eagle Creek (Plot 18) with a mean of 25 per plant and 15 per stem. These numbers were representative of the majority of plants in this plot, many of which were considerably larger and more productive than plants in the other plots.

Table 10 - Reproductive Structures Per Plant and Per Stem.
(Reprod. = reproductive; Fls = flowers).

Plot	Reprod. Plants	Reprod. Stems	Buds	Fls	Post Fls	Fruit	Total Reprod. Structures	Mean Reprod. Structures Per Plant	Mean Reprod. Structures Per Stem
1	10	13	105	17	102	126	350	35(19)	27(15)
2	18	21	87	50	44	78	259	14	12
3	14	15	41	11	24	20	96	7	6
4	5	6	45	5	7	8	65	13	11
5	6	7	21	0	0	0	21	4	3
6	6	6	12	0	0	0	12	2	2
7	12	14	71	7	2	5	85	7	6
8	8	9	36	7	0	4	47	6	5
9	11	22	145	18	12	22	197	18	9
10	1	2	6	0	0	0	6	6	3
11	5	5	23	1	0	0	24	5	5
12	1	1	2	0	0	0	2	2	2
13	5	8	33	0	0	0	33	7	4
14	2	2	4	0	0	0	4	2	2
15	1	1	8	0	0	0	8	8	8
16	5	7	71	9	3	0	83	17	12
17	2	2	12	1	0	0	13	7	7
18	44	73	480	129	179	308	1,096	25	15
Total	**156**	**214**	**1,202**	**255**	**373**	**571**	**2,401**	**15**	**11**

Of the 2,401 reproductive structures produced in the 18 plots, 1,202 of them, 50% of them were still in the bud stage while 571 of them, 25%, had developed to the fruit stage, indicating that sampling was conducted early in flowering phenology. Considerable variation occurred in flowering phenology between plots. In 10 plots no fruit had developed yet, while Plots 1, 2, 3, and 18 had 36%, 30%, 21% and 28% fruit, respectively. More advanced flowering phenology in these plots may be related to aspect-elevation combinations that permit earlier growth.

Productivity

Stem height and the number of stems produced by a plant were used as indices to estimate relative, aboveground biomass production of Spalding's catchfly plants.

Stem Height

Stem height is defined as the height of the stem produced by the plant; it was measured at late sampling when most plants have attained their full height. Increases in stem height after late July would likely be minimal since moisture resources in the soil are low and precipitation during this period is low. Grazed or broken stem heights were not included in this analysis since they do no represent the height of the stem produced by the plant.

Absent plants were not included in the analysis since their height could not be determined. The mean stem height of intact reproductive and vegetative stems are presented in Table 11 for all 18 plots in 2004. Stemmed/rosette plants were included in this analysis. Numbers in parentheses represent senescent stems.

Table 11 - Reproductive and Vegetative Stem Height.

Plot	Intact Reproductive Stems	Total Reproductive Stem Height (cm)	Mean Reproductive Stem Height (cm)	Intact Vegetative Stems	Total Vegetative Stem Height (cm)	Mean Vegetative Stem Height (cm)
1	13 (0)	462	35.5	3 (3)	16	5.3
2	21 (0)	619	29.5	3 (3)	29	9.7
3	15 (0)	306	20.4	9 (8)	38	4.2
4	6 (0)	198	33.0	10 (5)	55	5.5
5	7 (0)	203	29.0	6 (2)	50	8.3
6	6 (0)	185	30.8	9 (2)	140	15.6
7	14 (0)	318	22.7	5 (3)	48	9.6
8	9 (0)	285	31.7	8 (2)	151	18.9
9	22 (1)	926	42.1	2 (2)	39	19.5
10	2 (0)	59	29.5	0 (0)	0	0.0
11	5 (0)	154	30.8	9 (7)	86	9.6
12	1 (0)	25	25.0	4 (2)	30	7.5
13	8 (0)	244	30.5	5 (4)	61	12.2
14	2 (1)	70	35.0	1 (0)	13	13.0
15	1 (0)	27	27.0	0 (0)	0	0.0
16	7 (0)	228	32.6	2 (1)	27	13.5
17	2 (0)	55	27.5	2 (2)	10	5.0
18	73 (2)	3,776	51.7	6 (4)	107	17.8
TOTAL	**214 (4)**	**8,140**	**38.0**	**84 (50)**	**900**	**10.7**

Reproductive stems were 3½ times taller than vegetative stems, with the mean stem height of 38 cm for reproductive stems and 10.7 cm for vegetative stems. Most plots had mean reproductive stem heights between 20-35 cm; however, the two new plots, Rice Creek (Plot 9) and Eagle Creek (Plot 18), had the tallest mean reproductive stem heights of 42.1 and 51.7 cm, respectively. Considerably more vegetative stems, 60% (50 of 84), than reproductive stems, 2% (4 of 214), were senescent by late sampling, suggesting that vegetative status of a stem may be associated with early senescence.

Stems Per Plant

All plants were included in the analysis of number and percentage of plants that were single-stemmed and multi-stemmed since it was possible to determine the number of stems produced by a plant at early sampling before plants were grazed, absent or broken. Table 12 shows the number and percentage of single-stemmed and multi-stemmed plants in all 18 plots in 2004. Stemmed/rosette plants were included in this analysis.

Table 12 - Stems Per Plant.

Plot	Stemmed Plants	Single-stemmed plants	Percent Single-Stemmed Plants	Multi-Stemmed Plants					Percent Multi-Stemmed Plants
				2 stems	3 stems	4 stems	5 stems	6 stems	
1	16	13	81	3	0	0	0	0	19
2	20	16	80	3	1	0	0	0	20
3	23	17	74	3	3	0	0	0	26
4	16	14	88	2	0	0	0	0	12
5	17	16	94	1	0	0	0	0	6
6	17	15	88	2	0	0	0	0	12
7	20	16	80	4	0	0	0	0	20
8	26	22	85	4	0	0	0	0	15
9	13	6	46	4	0	2	0	1	54
10	1	0	0	1	0	0	0	0	100
11	12	8	67	4	0	0	0	0	33
12	4	3	75	1	0	0	0	0	25
13	11	8	73	2	0	0	1	0	27
14	3	2	67	1	0	0	0	0	33
15	1	1	100	0	0	0	0	0	0
16	8	6	75	1	1	0	0	0	25
17	4	3	75	1	0	0	0	0	25
18	51	31	61	10	4	5	0	1	39
Total	**263**	**197**	**75**	**47**	**9**	**7**	**1**	**2**	**25**

Overall, most plants, 75%, produced one stem, and 25% of plants produced more than one stem.. The most common multi-stemmed plants (71%) were double-stemmed plants. The most stems per plant was six which occurred in two plants, one each in the new plots, Rice Creek (Plot 9) and Eagle Creek (Plot 18). Considerable variation was observed between plots, ranging from 100% single-stemmed plants to 100% multi-stemmed plants; however, both of these extremes occurred in plots with only one plant each. Although most plots were dominated by single-stemmed plants; Rice Creek (Plot 9) had 54% multi-stemmed plants.

Habitat

Key indicator species of native grasses, shrubs, and forbs, invasive non-native grasses and forbs, non-vascular species, and certain ground and disturbance factors were sampled within each plot to evaluate habitat quality. Cover of all associated species in the plots was recorded to characterize the Canyon Grassland habitat for Spalding's catchfly (Community Composition - Appendix 4).

Frequency of Key Habitat Indicators

Table 13 below presents the frequency of the key habitat indicators within each of the 18 plots. See Appendix 6 for monitoring methodology in FWS and BLM Plots.

TABLE 13 – Frequency of Habitat Indicators																		
PLOT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BURN STATUS	U	U	U	U	B	U	U	B	U	B	B	B	B	B	U	U	U	B
Native grasses																		
Pseudoroegneria spicata (PSSP)	95	100	90	95	100	100	100	100	75	100	100	95	96	83	100	100	100	80
Festuca idahoensis (FEID)	100	100	95	80	95	100	95	100	100	100	100	100	100	100	100	100	100	65
Koeleria macrantha (KOMA)	70	50	85	80	80	40	35	60	40	75	80	100	63	83	50	33	17	45
Poa secunda (POSE)	15	65	15	10	-	5	15	5	-	20	20	50	5	-	25	33	50	5
Native shrubs																		
Symphoricarpos albus (SYAL)	55	-	5	15	-	-	40	-	-		40	-	-	-	-	67	33	20
Rosa nutkana & *R. woodsii* (Rosa)	-	-	-	-	10	-	-	-	-	20	15	-	75	33	-	-	-	20
Rare plants																		
Calochortus macrocarpus maculosus (CAMAM)	-	5	-	-	-	20	10	-	-	-	5	-	-	-	-	-	-	-
Cirsium brevifolium (CIBR)	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-
Pyrrocoma liatriformis (PYLI)	-	45	15	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-native grasses																		
Apera interrupta (APIN)	35	-	5	50	15	-	-	10	-	-	-	10	46	17	-	-	-	-
Bromus brizaeformis (BRBR)	35	20	40	5	10	-	5	10	-	-	-	-	-	8	-	-	-	-
Bromus japonicus (BRJA)	100	75	90	45	40	-	5	40	65	50	23	80	100	92	25	-	17	95
Bromus tectorum (BRTE)	-	-	-	-	5	-	-	-	-	-	-	-	-	17	-	-	-	-
Poa pratensis (POPR)	-	-	15	30	50	-	-	35	20	40	43	5	38	25	-	-	-	-
Ventenata dubia (VEDU)	75	-	-	50	-	-	-	-	20	-	2	-	-	8	-	-	-	-
Non-native forbs																		
Cardaria chalapensis (CACH)	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centaurea solstitialis (CESO)	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Dipsacus sylvestris (DISY)	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-
Galium pedemontanum (GAPE)	95	-	-	45	-	-	-	-	100	-	-	-	-	-	-	-	-	-
Hypericum perforatum (HYPE)	5	-	-	-	-	-	-	-	-	-	3	-	4	-	-	-	-	5
Potentilla recta (PORE)	-	-	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-	-
Sisymbrium altissimum (SIAL)	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Vicia tetrasperma (VITE)	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia villosa (VIVI)						10	30											
Non-vascular species																		
Bryophytes	100	100	80	100	10	100	100	30	100	10	10	10	5	-	100	100	100	100
Lichens	100	30	5	30	-	85	25	-	30	-	-	-	-	-	50	50	50	-
Animal disturbance																		
Rodent runs	50	30	65	65	95	85	95	100	70	85	60	85	88	83	100	67	83	90
Gopher churning	-	-	-	-	15	20	30	10	-	85	48	25	17	25	-	-	33	-
Large mammal disturbance	20	-	-	15	5	-	-	-	5	-	3	25	-	-	-	-	-	-

The native bunchgrasses, bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), and prairie junegrass (*Koeleria macrantha*), occurred in all 18 plots. Overall, bluebunch wheatgrass and Idaho fescue were present in relatively equal proportions at high frequencies, averaging 95% and 96%, respectively, across all plots. Prairie junegrass was present with generally lower frequency, averaging 60% across all plots. Sandberg's bluegrass (*Poa secunda*) was present in 14 of 18 plots, with much lower frequencies, averaging 23% in plots in which it occurred.

The native shrubs, snowberry (*Symphoricarpos albus*) and rose (*Rosa woodsii* and *R. nutkana*), occurred in the majority, 12 of 18, of plots. Most of these plots supported either one or the other of these native shrub species. Seven plots had snowberry with an average of 34% frequency, three plots had *Rosa* species, averaging 29% frequency, and two plots had both snowberry and *Rosa* species. The rare plants, green-banded sego lily (*Calochortus macrocarpus* var. *maculosus*), Palouse thistle (*Cirsium brevifolium*) , and Palouse goldenweed (*Pyrrocoma liatriformis*) were present in 4 plots, 1 plot and 3 plots, respectively, with low frequencies.

Invasive non-native grasses had higher constancy and frequency in plots than invasive forbs. Japanese brome (*Bromus japonicus*), was the most common invasive grass species, occurring in 16 or 19 plots. It had the highest frequency of invasive grasses, averaging 59% in the plots in which it occurred. Rattlesnake brome (*Bromus brizaeformis*), Kentucky bluegrass (*Poa pratensis*), and apera (*Apera interrupta*) were the next most common invasive grasses, occurring in eight to ten plots, and together averaging 19%. Ventenata (*Ventenata dubia*) occurred in five plots, averaging 35% frequency in those plots. Cheatgrass (*B. tectorum*) occurred in only two plots with low frequency. Invasive, non-native forb species occurred only in a few plots. St. Johnswort (*Hypericum perforatum*), goosegrass (*Galium pedemontanum*), and vetch (*Vicia villosa*) were the most common invasive forbs, occurring in four, three, and two plots, respectively. All other invasive forb species occurred in only one plot each. In general, fewer invasive species at lower frequencies occurred in North Bench plots (Plots 6, 7, 15, 16, 17) than in Redemsky Flats plots (Plots 5, 4, 11, 12, 13, 14) at Garden Creek Ranch. Billy Creek (Plot 2), LCC51 - 2B (Plot 10), and Eagle Creek (Plot 18) had low levels of invasive species.

Bryophyte species had high constancy, occurring in 17 of 18 plots. They had high frequency (averaging 98%) in unburned plots and low frequency (averaging 13%) in the majority of burned plots (Plots 5, 8, 10, 11, 12, 13). In one burned plot, Eagle Creek (Plot 18); however, moss had 100% frequency. Lichens were present in all unburned plots but absent in all burned plots.

Rodent activity was high in all plots. Rodent runs occurred in all 18 plots with high frequency, averaging 78%. Gopher churnings were present in 10 of 18 plots, averaging 31% frequency in the plots in which they occurred. Large mammal disturbance, which consisted primarily of hoof prints, occurred in 6 of 18 plots with low frequency.

Cover/Density of Key Habitat Indicators

Table 14 shows basal cover of native grasses, canopy cover of native shrubs, and density of rare plant species in all plots. Plots have been divided into burned and unburned categories to allow comparison; however, it is likely that many differences are due to site variability rather than the effect of fire. See acronyms for plant species in Table 13. Measurements were collected in a 50-cm x 50-cm sampling frame. See Appendix 6 for monitoring methodology in FWS and BLM Plots.

Table 14 - Cover/Density of Native Bunchgrasses, Shrubs, Rare Plants.

(BC = Basal Cover; CC = Canopy Cover; D = Density)

Plot	PSSP (BC)	FEID (BC)	KOMA (BC)	POSE (BC)	SYAL (CC)	Rosa (CC)	CAMAM (D)	CIBR (D)	PYLI (D)
Burned Plots									
5	5.30	2.58	1.81	-	-	0.15	-	-	-
8	5.30	5.10	0.66	0.05	-	-	-	0.10	-
10	5.75	4.90	1.33	0.11	-	1.10	-	-	-
11	4.33	4.68	3.41	0.09	0.38	0.60	0.05	-	-
12	3.61	4.80	3.33	0.65	-	-	-	-	-
13	7.54	2.65	2.21	0.04	-	8.50	-	-	-
14	4.84	3.80	1.67	-	-	2.08	-	-	-
18	4.98	1.80	1.53	0.05	2.55	2.81	-	-	-
Mean	**5.21**	**3.79**	**1.99**	**0.12**	**0.37**	**1.91**	**0.01**	**0.01**	**-**
Unburned Plots									
1	3.85	3.06	1.06	0.13	12.35	-	-	-	-
2	5.00	5.55	0.90	0.95	-	-	0.05	-	0.95
3	3.46	4.06	1.58	0.31	2.00	-	-	-	0.15
4	3.72	1.75	2.03	0.10	3.10	-	-	-	0.65
6	5.05	4.75	0.78	0.05	-	-	0.20	-	-
7	6.65	3.28	0.40	0.11	2.05	-	0.10	-	-
9	0.52	7.40	0.16	-	-	-	-	-	-
15	6.00	3.50	0.50	0.25	-	-	-	-	-
16	6.00	6.00	0.33	0.67	6.33	-	-	-	-
17	3.33	3.50	0.17	0.67	3.17	-	-	-	-
Mean	**4.36**	**4.29**	**0.79**	**0.32**	**2.90**	**-**	**0.04**	**-**	**0.18**

Burned plots tended to have higher basal cover of bluebunch wheatgrass and lower cover of Idaho fescue. Basal cover of bluebunch wheatgrass and Idaho fescue was similar in unburned plots. Burned plots had higher prairie junegrass than unburned plots. Burned plots had higher cover of rose and unburned plots had higher cover of snowberry. Rare plant species had low cover in burned and unburned plots.

Table 15 shows the basal cover of Kentucky bluegrass and density of other invasive, non-native grass species. Table 16 shows the density of invasive, non-native forb species.

Table 15 - Cover/Density of Non-native Grasses.
(D = Density; BC = Basal Cover)

Plot	APIN (D)	BRBR (D)	BRJA (D)	BRTE (D)	POPR (BC)	VEDU (D)
Burned Plots						
5	0.25	0.10	3.60	0.05	0.13	-
8	0.65	0.10	1.00	-	0.04	-
10	-	-	3.50	-	0.14	-
11	-	-	1.65	-	0.22	T
12	0.25	-	10.05	-	0.01	-
13	0.92	-	11.50	-	0.20	-
14	0.67	0.08	9.25	0.25	0.04	0.75
18	-	-	29.15	-	-	-
Mean	**0.34**	**0.04**	**8.71**	**0.04**	**0.10**	**0.09**
Unburned Plots						
1	0.60	0.05	8.00	-	-	3.25
2	-	0.20	5.15	-	-	-
3	0.05	0.60	12.50	-	0.51	-
4	1.05	0.05	1.35	-	0.37	3.80
6	-	-	-	-	-	-
7	-	0.05	0.15	-	-	-
9	-	-	5.85	-	0.26	0.35
15	-	-	0.25	-	-	-
16	-	-	-	-	-	-
17	-	-	0.17	-	-	-
Mean	**0.17**	**0.10**	**3.34**	**-**	**0.11**	**0.74**

Table 16 - Density of Non-native Forbs.

Plot	CACH (D)	CESO (D)	DISY (D)	GAPE (D)	HYPE (D)	PORE (D)	SIAL (D)	VITE (D)	VIVI (D)
Burned Plots									
5	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	T	-	-	-	-
12	-	-	0.05	-	-	-	-	-	-
13	-	-	-	-	0.04	-	-	-	-
14	-	0.08	-	-	-	-	0.08	-	-
18	-	-	-	-	-	-	-	-	-
Mean	**-**	**0.01**	**0.01**	**-**	**0.01**	**-**	**0.01**	**-**	**-**
Unburned Plots									
1	-	-	-	3.50	0.25	-	-	0.55	-
2	-	-	-	-	-	-	-	-	-
3	0.15	-	-	-	-	-	-	-	-
4	-	-	-	1.95	-	-	-	-	-
6	-	-	-	-	-	-	-	-	0.10
7	-	-	-	-	-	-	-	-	0.45
9	-	-	-	1.90	-	0.50	-	--	-
15	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-
Mean	**0.02**	**-**	**-**	**0.74**	**0.03**	**0.05**	**-**	**0.06**	**0.06**

Japanese brome showed considerable variation between plots in density; however, overall, it had higher densities in burned plots than in unburned plots. Ventenata and goosegrass had higher densities in unburned plots. Cover and constancy of non-native forb species was low in all the plots. Some plots had more weed species than others, i.e., Plot 14 had all six of the invasive grasses and two of the invasive forbs, whereas Plot 16 had no invasive weed species.

Table 17 shows basal cover of lichens and ground factors, canopy cover of moss, and depth of ground litter.

Table 17 - Cover/Density of Non-vascular Species and Ground Factors.
(CC = Canopy Cover; BC = Basal Cover)

Plot	Moss (CC)	Lichen (BC)	Bare Ground (BC)	Ground Litter Depth (mm)	Rodent Runs (BC)	Rodent Holes (BC)	Gopher Churning (BC)	Large Mammal Disturbance (BC)
Burned Plots								
5	0.01	-	0.70	1.76	9.60	0.15	0.25	0.05
8	0.08	-	0.65	2.13	7.05	0.15	0.10	-
10	0.01	-	0.65	1.34	6.95	-	6.80	-
11	0.01	-	3.39	1.55	2.73	0.03	2.05	0.03
12	0.01	-	2.20	1.23	4.90	0.20	3.35	0.45
13	0.01	-	1.79	2.58	3.83	0.04	0.58	-
14	0.01	-	-	3.22	6.25	0.08	1.50	-
18	6.95	-	2.60	1.74	7.65	0.05	-	-
Mean	**0.89**	**-**	**1.50**	**1.94**	**6.12**	**0.09**	**1.83**	**0.07**
Unburned Plots								
1	26.95	1.70	1.24	2.15	1.20	-	-	1.80
2	38.70	0.40	2.10	1.65	0.60	-	-	-
3	4.50	0.01	0.73	2.28	1.75	-	-	-
4	11.40	0.75	1.10	1.78	2.50	-	-	2.80
6	63.00	4.65	0.10	5.90	7.05	0.13	0.25	-
7	43.15	0.35	0.30	4.20	8.60	-	0.65	-
9	48.50	0.85	0.70	2.24	1.83	-	-	1.00
15	42.00	0.50	-	2.63	11.00	0.25	-	-
16	31.00	0.50	-	4.20	3.33	-	-	-
17	38.00	0.50	0.17	2.18	5.33	0.50	0.33	-
Mean	**34.72**	**1.02**	**0.64**	**2.92**	**4.32**	**0.09**	**0.12**	**0.56**

Much higher canopy cover of moss occurred in unburned plots than in burned plots with one notable exception, Eagle Creek (Plot 18), which had higher cover than the other burned plots. The moss, *Polytrichum juniperinum*, a colonizer of bare soil, and *Funaria hygrometrica*, a cosmopolitan moss that often colonizes burned soil, were present in Plot 18 but not in the other burned plots. Lichens occurred in all unburned plots but not in burned plots. Bare ground cover was greater in burned plots, and ground litter depth was greater in unburned plots. Slightly more cover of rodent runs and gopher churnings occurred in burned plots.

Habitat Type/Plant Association

Based on the associated plant species and their percentage cover (Community Composition - Appendix 4; Lichthardt and Gray 2003; Gray and Lichthardt 2004), the habitat type or plant association could be determined. Plots 2, 6, and 8 fit well into the Idaho fescue-prairie junegrass habitat type described by Tisdale (1986) and the Idaho fescue-prairie junegrass (low elevation) plant association described by Johnson and Simon (1987). The remainder and large majority of the plots all have a snowberry and/or rose component that precludes them from classification in the Idaho fescue-prairie junegrass type. The majority of snowberry and rose plants within these plots are short-statured and inconspicuous, seldom protruding above the bunchgrasses. Primarily, they occur as scattered, solitary stems; but occasionally as taller thickets in a mosaic within the grassland. These communities most closely fit the Idaho fescue-snowberry and Idaho fescue-rose habitat types described by Daubenmire (1970); however, the bluebunch wheatgrass present in these plots is caespitose rather than rhizomatous.

DISCUSSION

Spalding's catchfly and Canyon Grasslands Habitat

This monitoring project characterizes the demographic parameters of Spalding's catchfly, environmental impacts, and habitat within the Canyon Grasslands region. All known occurrences of Spalding's catchfly in the Canyon Grasslands of Idaho are confined to northerly aspects from west northwest to north to east northeast between 1,350 feet, the lowest elevation known for the species, to 4,000 feet elevation (Hill and Gray 2004a; IDCDC 2005). All occurrences are within mesic Idaho fescue communities, including Idaho fescue-prairie junegrass (Tisdale 1986; Johnson and Simon 1987), Idaho fescue-snowberry, and Idaho fescue-rose (Daubenmire 1970) habitat types. Spalding's catchfly is not known to occur in the drier Idaho fescue-bluebunch wheatgrass habitat types that occur on southerly aspects at higher elevations in Idaho Canyon Grasslands (Hill and Gray 1999; IDCDC 2005). The mesic Idaho fescue communities can extend to low elevations in the generally dry region of Hells Canyon as topographic climaxes by taking advantage of the higher soil moisture conditions on northerly aspects compared to southerly aspects at the same elevation. Moisture is retained longer on northerly slopes due to less direct insolation, less evaporation, and the high moisture-holding capacity of the loess- and ash-influenced soils that exist on these aspects (Daubenmire 1970; Franklin and Dyrness 1973; Tisdale 1986; Johnson and Simon 1987; Mancuso 1993).

The 18 demographic monitoring plots represent a large portion of the variability in elevation, aspect, slope, habitat types, community composition, vegetation condition, and disturbance levels in which Spalding's catchfly is known to occur within Canyon Grasslands. The demographic response of Spalding's catchfly within these plots showed considerable variability as well, including: 1) the proportion of rosette plants varied from 0% to 56% (average 26%) of the aboveground plants, 2) mean reproductive stem height varied between 20 to 52 cm (average 38 cm), 3) the proportion of multi-stemmed plants varied from 6% to 54% (average 25%) of aboveground plants, 4) the percentage of flowering plants varied from 19% to 82% (average 46%) of all plants and from 25% to 100% (average 72%) of intact stemmed plants, and 5) reproductive structures per plant varied between 2 and 35 (average 15). Plants at Rice Creek and Eagle Creek showed high levels of productivity and reproductive effort, producing taller reproductive stems, more multi-stemmed plants, and more flowering plants than the other sixteen plots. These two plots occur at the lowest elevations of all the plots, with Rice Creek at 1,730 feet and Eagle Creek at 1800 feet. Lower elevations may provide more favorable climactic conditions, such as warmer temperatures and longer growing seasons, for Spalding's catchfly.

Comparison of Spalding's catchfly between Regions

Spalding's catchfly occurs in several distinct physiographic regions (Palouse Grasslands, Canyon Grasslands, Intermontane Valleys, Channeled Scablands, Wallow Plateau) and habitats (open pine woodlands, sagebrush-steppe, Pacific Northwest bunchgrass) across its range in northeastern Oregon, eastern Washington, adjacent west-central Idaho, and a disjunct area in northwestern Montana (Hill and Gray 2004a). Demographic parameters for Spalding's catchfly likely vary between these different regions and habitats.

Some major differences were noted in demographic structure and the role and/or status of the rosette plant between this study and similar demographic studies for Spalding's catchfly across its range. Rosette plants comprised a substantial proportion of aboveground plants in this study compared to that observed in other studies in Canyon Grassland (Lichthardt and Gray 2003; Gray and Lichthardt 2004), Montana intermontane valleys (Lesica 1997, 1999), and Washington sagebrush-steppe (Caplow 2001, 2002). This may represent real differences in demographic structure between plots, habitats, or regions, or it may be related to differences in the monitoring time (this study included an early June monitoring while the other studies were monitored only in late July), and the ephemeral nature of rosette plants (see Importance of Early Sampling section that follows). Other Canyon Grassland demography studies that have included an early June monitoring also showed substantial proportions of rosette plants all three years of the monitoring period (Hill and Weddell 2003; Hill and Gray 2004; Hill and Gray 2005). The role or status of the rosette plant also appears to differ between regions. With rare exception, rosette plants in northwestern Montana were seedlings (Lesica 1997, 1999). Many of the rosette plants in this study, however, were not seedlings but plants older than one year, many of them two or three years old.

Other differences were observed in the demographic response of Spalding's catchfly between Montana (Lesica 1997, 1999), Washington (Caplow 2001, 2002), and Idaho Canyon Grassland [FWS Plots (Lichthardt and Gray 2003; Gray and Lichthardt 2004); BLM Plots (Hill and Weddell 2003; Hill and Gray 2004; Hill and Gray 2005); a thesis project (Menke 2003; Menke and Muir 2004)]. Less multi-stemmed plants (<7%) were observed in northwestern Montana than in Washington (12% and 20%) and Idaho (24% and 22% in FWS Plots; ~33% in BLM Plots; 25% in this study). Less plants flowered, averaging ~35%, in Montana than in Washington (98% and 100%) and Idaho (~73% in BLM Plots; 70% (2003) in FWS plots; ~80% in the thesis project; 72% in this study).

Less flowers per plant were produced (4 to 8) in Montana than in Washington (15 and 17) and Idaho (7 to 8 in BLM Plots; 15 in this study). Mean stem height was greater in Washington (36 cm and 38 cm) than in Idaho (26 cm in the thesis project; 28 cm (reproductive stem height) in BLM Plots), but similar to the mean reproductive stem height (38 cm) in this study.

The differences observed between the demographic parameters and reproductive and productivity effort of Spalding's catchfly may reflect the differences in habitat and climate between regions, but it also may reflect differences in monitoring methodology and time of monitoring.

Importance of Early Sampling

Objectives for this monitoring study focused on demographic parameters of Spalding's catchfly (population size, recruitment, mortality, prolonged dormancy, reproductive and productivity effort) and environmental factors that may impact Spalding's catchfly in Canyon Grasslands. Demographic monitoring examines changes in plant populations through time and considers population structure (age or stage classes) and rates of mortality, recruitment, growth, and duration of prolonged dormancy. Plants are mapped and tracked over time to determine the fate of individuals in all stages of the life cycle and the probability of moving between stage classes (transitions) (Elzinga et al. 1998). Environmental factors may affect some stage classes differently than other stage classes. Drought may affect younger plants more than older plants that have larger root reserves and longer roots to tap water sources lower in the soil profile. Larger more conspicuous plants may be grazed more often than small, inconspicuous plants (Elzinga et al. 1998).

Most demographic studies of Spalding's catchfly have been conducted only when the plant is flowering (Lesica 1997, 1999; Caplow 2000, 2001; Lichthardt and Gray 2003; Gray and Lichthardt 2004); however, there appears to be substantial problems with conducting demographic monitoring only at this time in Canyon Grasslands.

For the 18 plots in 2004 a large portion, 38%, of the total plants present in early June were absent, broken, or senescent at flowering. More rosette plants, 67%, than stemmed plants, 30%, were absent or senescent and undetectable at late sampling. The BLM plots, which included both and an early June and late July/early August sampling for three years of monitoring, showed large proportions of plants were absent or senescent and undetectable at flowering each of the monitoring years, 45% in 2002, 64% in 2003, and 49% in 2004. Over the three-year monitoring period, more rosette plants were affected, 84%, than stemmed plants, 39% (Hill and Gray 2005). FWS Plots that were "late" plots in 2002 and 2003 recorded 3% rosette plants in 2002 and 0% rosette plants in 2003 (Gray and Lichthardt 2004). The same plots that were "early" plots in 2004 recorded 20% rosette plants. These data suggest that more rosette plants were present earlier in 2002 and 2003 but were gone or senescent and undetectable by flowering.

Demographic monitoring that involves tracking individual plants through time requires monitoring at a time when plants in all stage classes are detectable. Spalding's catchfly plants in Canyon Grasslands are most detectable, especially the small, ephemeral rosette plants, early in the growing season. Monitoring at flowering, when up to one-half of the plants can be gone or undetectable, will lead to inaccurate results in many demographic parameters. 1) Aboveground annual census: The total number of plants produced aboveground for a year cannot be determined if many plants present earlier are gone or not detectable at the time of monitoring. Counts performed at flowering can under-estimate the total number of plants produced that year by as much as one-half. 2) Population size: Determination of population size for Spalding's catchfly requires monitoring for a number of years because a certain proportion of the population remains invisible belowground in prolonged dormancy in any one year. Lesica (1997) detected 96% of the population by the third year of monitoring. If annual aboveground census is under-estimated each of the three years, however, population size will also be under-estimated. 3) Demographic structure: Certain stage classes will be under-represented or over-represented if monitoring occurs when many of the plants present earlier are gone, especially if one stage class is affected more than another. Monitoring only at flowering can substantially under-represent the rosette plant stage class. In all 18 plots in 2004 and all BLM Plots in 2002, 2003, and 2004, rosette plants comprised large proportions of the total plants produced aboveground; however, the majority of them became absent or senesced and were undetectable by flowering. There were no rosette plants detectable by flowering in BLM Plots in 2003 (Hill and Gray 2004). Furthermore, dormant plants can be over-estimated. A plant cannot be classified as dormant if it produced any aboveground vegetation during the growing season; however, if plants present earlier at known locations were gone at flowering, they would be misclassified as dormant. Over-estimation of the duration of prolonged dormancy will also be made. Since stage classes are not correctly identified, the probabilities of transitions between stage classes will be incorrect as well. 5) Recruitment: If one of the rosettes present in early June had been a seedling rosette plant and became absent or senesced and was undetectable by flowering, this recruitment event would not be detected. 7) Percentage of flowering plants: The proportion of plants that flower during a season cannot be determined if it is not known how many plants were produced aboveground that season. 8) Impacts: Threats or disturbances that may be causing the loss of plants during the growing season, can be undetected or under-estimated if it is not known plants present earlier in the season were gone by flowering.

The loss of plants through the growing season appears to be much greater in Canyon Grasslands than that reported for northwestern Montana, in which 10% of plants present in May were not present by July in one year of a long-term demography study (Lesica 1997). Weather conditions and rodent activity may be possible causes of the loss and senescence of Spalding's catchfly plants over the growing season in Canyon Grasslands (see the Weather and Threats sections below).

Plant Age

Demographic studies with Spalding's catchfly in northwestern Montana have indicated a direct relationship between growth form of plants and age, i.e., rosettes are seedlings, vegetative stems are juveniles, reproductive stems are adults. These studies also indicate that these growth forms occur in an ordered progression from a young plant to an older plant, i.e., rosettes are formed the first year after juvenile vegetative stems are produced, then flowering stems (Lesica 1997, 1999). The current study and other demographic studies in Canyon Grasslands in Idaho indicate aboveground growth forms do not necessarily correlate with age of plants, and reproductive plants often revert to vegetative stemmed or rosette plants in successive years (Hill and Weddell 2003; Gray and Lichthardt 2004; Hill and Gray 2004b, 2005).

Not all rosette plants are seedlings. In northwestern Montana, Lesica (1999) states that with rare exception, all rosettes are seedlings. However, this Canyon Grasslands study has documented, either by plant transitions between years or previous excavations, that 41% of the rosette plants recorded over the three-year monitoring period were not seedlings but plants older than one year of age. Other Spalding's catchfly demographic studies in Idaho Canyon Grasslands (Hill and Gray 2005) have documented over half of all rosette plants were older than one year, several plants were rosette plants for each of the three years of the study, and the second most common plant transition from year to year was the 'rosette plant to rosette plant' transition.

The age of Spalding's catchfly rosette plants is difficult to determine. In Canyon Grasslands, rosette plants can be seedlings but they are also produced by older plants. This also occurs in the spider orchid (Hutchings 1987). Determination of age is particularly difficult for small plants which may be young plants or very old but suppressed individuals. Furthermore, age is a poor predictor of size or reproductive activity among plants (Harper 1977). Seedlings growing in dense stands or mixed with aggressive neighbors of other species may grow slowly and spend many years reaching a reproductive condition (Harper 1977; Elzinga et al. 1998). Some plants will flower only if the rosette reaches a critical size. If a rosette is too small, the plant may survive in the rosette stage until photosynthetic area and carbohydrate storage are sufficient to induce flowering (Werner 1975; Werner and Caswell 1977).

Not all vegetative stemmed plants are juvenile plants. Many vegetative stemmed plants recorded during the three years of monitoring were older plants that had been reproductive stemmed plants, vegetative stemmed plants, rosette plants, or dormant plants in previous years (Plant Data Tables - Appendix 3). Furthermore, all stemmed plants may have the potential to be reproductive the first year they are stemmed plants. In nursery studies, plants grown from seeds were rosette plants the first year and stemmed plants the second year of growth. One of these plants flowered when transplanted in the field (Hill et al. 2001); it did not require a vegetative stemmed stage prior to flowering. Reproduction in many plants depends on size or accumulation of stored reserves rather than age. Because plants grow at different rates depending on availability of resources and competition from other plants, in an optimal environment, seedlings may grow fast and reach flowering size at an early age (Barbour et al. 1987). Whether a stemmed Spalding's catchfly plant becomes reproductive or not may depend on environmental factors such as limited moisture during the growing season.

Reproductive plants can revert to vegetative plants (rosette plants or stemmed vegetative plants) in successive years. In the 18 plots during the monitoring period, many plants were reproductive stemmed plants one year and vegetative stemmed or rosette plants in following years (Hill and Gray 2004b; Hill and Gray 2005; Plant Data Tables – Appendix 3). Plants have great morphological plasticity and can take on different forms depending on various factors (Barbour et al. 1987). In certain circumstances, a plant may flower one year and revert to a vegetative state for one or more succeeding years (Rabotnov 1978).

Stage of development determines the demographic status of the individual and is a better population parameter in most plants than is age. Stage classes based on reproductive status and size reflect some ecological meaning. Reproductive plants, for example, have a different function in the population than non-reproductive plants (Elzinga et al. 1998). Two plants of the same age can have great differences in size because of environmental circumstances and can have a different impact as part of the population. For example, a large plant may produce many more seeds than a small plant (Barbour et al. 1987).

Stage classes for Spalding's catchfly in Canyon Grasslands that incorporate reproductive status, aboveground growth forms, and the belowground dormant phase could be delineated as follows: 1) non-reproductive rosette plants, 2) non-reproductive stemmed and stemmed/rosette plants, 3) reproductive stemmed and stemmed/rosette plants, and 4) dormant plants.

Fire Effects

Determination of the effects of fire on Spalding’s catchfly and its habitat in this study is difficult. Considerable variability was recorded for demographic parameters, productivity and reproductive effort in Spalding' catchfly. Environmental parameters, vegetation composition, disturbance levels and management also varied between plots. All 18 plots were established after the fires had occurred. Without pre-burn data, it is difficult to determine what, if any, of this variability is the result of fire or represents the natural range of variability of Spalding's catchfly and its habitat.

Spalding's catchfly

The effect of fire on Spalding’s catchfly in this study is further complicated by potential inaccurate data in “late” plots. Therefore, the following statements are based on only those plots that were early plots all three monitoring years, the BLM Plots. In these plots, fire appeared to decrease dormancy rate with an increase in number of detectable plants aboveground and increase the number of reproductive structures per stem. It appeared to have little effect on flowering, survival of adult plants, or recruitment (Hill and Gray 2005).

Other demographic studies at Garden Creek Ranch which included three years of pre-burn data and two years post-burn data showed a decrease in dormancy and concomitant increase in detectable plants the first year post-fire (Hill and Fuchs 2003). Pre-burn data showed a consistent detectable population size of ~200 plants and dormancy rates of

~30% each year. One year post-fire, the detectable population size increased 35% from 200 to 270 plants, and dormancy rate decreased from 30% to 10% (Hill and Fuchs 2003). In a two-year Spalding's catchfly study at Garden Creek Ranch that included one year pre-burn and one year post-burn data, Menke (2003) noted fire-stimulated dormancy-breaking may be responsible for increases in the numbers of adult Spalding's catchfly plants she observed at burned sites one-year post-fire.

Fire appeared to temporarily increase the number of reproductive structures produced by Spalding's catchfly. Menke (2003) observed the number of flowers per stem tended to be slightly greater, although not significantly, the first season after fire. Lesica (1999) observed an increase in the number of flowers produced per plant following cool-season prescribed fires in northwestern Montana; the affect was apparent for two to three years following the burn treatments.

Fire did not appear to influence percent flowering (Hill and Gray 2005; Menke 2003; Menke and Muir 2004); however, plant loss during the growing season and high levels of ungulate grazing, particularly if grazing is selective for taller, reproductive plants, can affect the accuracy of flowering rates.

Lesica (1999) reported that fire reduced the large amount of litter produced in the productive rough fescue grasslands at a Spalding's catchfly occurrence in northwestern Montana and enhanced recruitment by creating safe sites for seedlings. Although fire reduced the amount of litter in burned plots in the current study, no concomitant increase in recruitment with fire was noted in any of the 18 plots over the monitoring period. No increase in recruitment following fire was noted in other Craig Mountain Spalding's catchfly demographic studies (Hill and Weddell 2003; Menke 2003; Menke and Muir 2004; Hill and Gray 2004b; Gray and Lichthardt 2004; Hill and Gray 2005).

Lesica (1999) reported that fire had no detectable effect on survival of adults and suggested the reason may be that the burns occurred before and after the plant's active growing season. Craig Mountain demography studies have not reported any mortality of adult plants following fire that occurred when plants were flowering and seeding. Spalding's catchfly has evolved with fires occurring in the normal fire season, summer and early fall, which coincide with its active growing season. Although aboveground plants and the majority of the seed produced that season are destroyed by the fire (Hill and Weddell 2003), the perennial nature of the plant, the ability to survive underground in prolonged dormancy, and the low recruitment needed to maintain this long-lived species, are strategies for surviving fires during the active growing season in Canyon Grasslands.

Habitat

Data from the current study, which is three to four years post-fire, showed little difference in cover of Idaho fescue and bluebunch wheatgrass in burned and unburned plots. The higher cover of prairie junegrass in burned plots may be related to the fire since burning has a positive influence on prairie junegrass (Fire Effects Database 2005).

Other Craig Mountain demography studies have reported reduced basal cover of native bunchgrasses one-year post-fire, but by the third year post-fire bunchgrass basal cover in burned plots was similar to that in unburned plots (Hill and Weddell 2003; Hill and Gray 2005).

The most obvious effect of fire on Spalding's catchfly habitat is its impact on microbiotic soil crusts. High mortality of bryophytes and lichens occurred in all burned plots with very little recovery by the third year of monitoring. Microbiotic soil crusts are important components of semi-arid ecosystems increasing soil stability, retaining moisture, and slowing weed invasion (Evans and Johansen 1999). Fire causes high mortality of mosses and lichens and they are slow to recover (Antos et al. 1983; Belnap 1993; Evans and Johansen 1999; Johansen et al. 1984; Ponzetti et al. 1988; Hill and Weddell 2003; Gray and Lichthardt 2004; Hill and Gray 2005).

The higher densities of the invasive non-native, annual grass, Japanese brome, in burned plots may be a result of the fire. The disturbance of fire can favor invasive weed species (Peters and Bunting 1994; Agee 1996; Asher 1998; Sheley et al. 1999; USDI 2000). Several studies within the range of Spalding's catchfly have shown increases in invasive weeds following fire. Fireline studies at Garden Creek Ranch in an Idaho fescue site showed significant increase in Japanese brome and yellow starthistle on the burned side of the fireline one year post-fire (Hill et al. 2003). Significant increases in non-native annual brome species were observed following a recent wildfire in long-term vegetation sampling plots established in Canyon Grasslands on Craig Mountain in the 1960s through the 1980s by Dr. Ed Tisdale (Gray and Lichthardt 2003). In northwestern Montana, Lesica and Martin (2003) found recruitment of sulfur cinquefoil (*Potentilla recta*) was higher in prescribed spring and fall burn plots compared to control plots one year post-fire, and density was greater in herbicide plots that were burned than those that were not burned. In the current study, burned plots had higher cover of bare ground, less ground litter depths, and no microbiotic crust compared to unburned plots. These conditions can increase the susceptibility of the site to weed invasion.

Other Canyon Grassland fire studies have reported no weed increase following fire. Menke (2003) reported no widespread increases in aggressive weed species in Spalding's catchfly habitat the first year after fire. Fire appeared to have little effect on aggressive weed species in Spalding's catchfly plots during a three-year monitoring period (Hill and Gray 2005).

In the current study, cover of rodent runs and gopher churnings were higher in burned plots than unburned plots. The reduction of vegetation by fire may have made conditions more amenable to development of rodent runs and gopher churnings.

Weather

The much greater loss and senescence of plants, especially the smaller rosette plants, in this study compared to that reported in northwestern Montana, may be related to the hot, dry summers of the Canyon Grasslands. In plots that were "early" plots all three monitoring years, the highest loss and senescence of plants occurred in 2003 (Hill and Gray 2005) which was hotter and drier than either 2002 and 2004, and had lower than average precipitation and higher than average temperatures during Spalding's catchfly's growing season in June, July, and August. Fewer stems may become reproductive if moisture becomes very limited during the growing season. In 2004 a high proportion of vegetative stems in all plots, 60%, were senescent by late sampling. It is unknown whether these stems would have become reproductive if more precipitation had occurred during the growing season.

Prolonged dormancy appears to be associated with weather patterns (Lesica 1997) and may vary in duration between regions with different climates. Differences in climate and seasonal precipitation and temperature exist between northwestern Montana and Canyon Grasslands of Idaho. The Eureka weather station in northwestern Montana has greater annual mean precipitation and more precipitation during Spalding's catchfly's growing season and lower annual mean temperature and lower temperature during Spalding's catchfly's growing season than the Lewiston weather station in Canyon Grasslands. Eureka, Montana, has a summer-high precipitation pattern while Lewiston, Idaho has a spring-high precipitation pattern (Western Regional Climate Center 2005). The hotter and drier growing season in Canyon Grasslands may result in different rates of incidence and duration of prolonged dormancy than that in northwestern Montana.

Animal Disturbance

Native ungulate herbivory, grazing by elk and deer, and rodent activity, including rodent runs, holes, diggings and soil mounds, were major threats to Spalding's catchfly in this study and other demography studies rangewide (Caplow 2001, 2002; Hill and Weddell 2003; Gray and Lichthardt 2004; Hill and Gray 2004b, 2005).

Native Ungulate Herbivory

Levels of native ungulate grazing were variable over the monitoring period. Grazing was very low (3%) in all 18 plots in 2004. Much higher levels of grazing were reported in BLM Plots in the first two years of monitoring, with 32% in 2002 and 77% in 2003 (Hill and Gray 2005). Gray and Lichthardt (2004) recorded 16% of all stems were grazed in 2002 and 2003 in FWS Plots. Native ungulate grazing caused considerable reduction of reproductive effort in these plots for the season in which it occurred; however, it likely did not cause mortality of plants because no damage was noted to the caudex and taproot of plants.

Some plant monitoring studies have noted that native herbivores may browse flowering or fruiting plants more heavily than inconspicuous, non-flowering plants (Elzinga et al. 1998). In this study, no rosette plants appeared to be grazed, but the taller, more conspicuous stemmed plants were grazed. The question arises as to whether deer or elk selectively graze the taller reproductive stems more than the shorter vegetative stems. If selective grazing of reproductive stems had occurred, it would be expected that the percentage of flowering on the remaining intact stems would be low because remaining stems would be primarily non-flowering vegetative stems that the ungulates had not grazed. This was not the case; the percentage of flowering in remaining ungrazed plants was similar between years with a high degree of grazing, 72% in 2003, and a low level of grazing, 77% in 2004 (Hill and Gray 2004b; Hill and Gray 2005). It does not appear that native ungulates select for reproductive stemmed plants over vegetative stemmed plants.

Some of the differences observed in ungulate grazing in BLM Plots during the three years of the monitoring period may be influenced by the date at which late sampling occurred. Spalding's catchfly is one of the few late-maturing plants that is still green late in the season in Canyon Grasslands. Grazing levels likely increase as the season progresses, and sampling later in the season may report higher levels of grazing. Late sampling in BLM Plots in 2003, the year showing the highest levels of native ungulate grazing, occurred one week later than in 2002 and almost three weeks later than in 2004 (Hill and Gray 2005).

Rodent Activity

A larger impact to Spalding's catchfly than native ungulate grazing may be rodent activity, which appears not only to be partially responsible for loss of plants during the growing season, but also responsible for mortality of plants.

Rodents may be partly responsible for loss of aboveground plants during the growing season. In BLM Plots, rodent activity was absent in 2002 and only 7% of plants were absent or broken at late sampling. Rodent activity became evident during the 2003 growing season and a considerable increase in absent or broken plants, 41%, was recorded at late sampling in 2003 (Hill and Gray 2004b).

Rodent activity may also be responsible for mortality of plants. Rodent activity was associated with a large number of plants in the population that did not appear aboveground in 2004. Plots with no rodent activity had few missing plants at early sampling in 2004. Some known plant locations with missing plants had tunneling under the location and no caudex or taproot was observed underground. Herbivory or damage to underground portions of the plant may result in mortality. Spalding’s catchfly stems from both the current year and the previous year were pulled down into some rodent holes, but stems of other plant species were not observed in rodent holes. Other Craig Mountain Spalding's catchfly studies have reported similar observations (Hill and Gray 2005). This activity suggests that rodents may be targeting Spalding's catchfly plants.

Voles (genus *Microtus*) are likely responsible for the majority of the rodent activity observed, i.e., the criss-crossing rodent runs, short burrows and holes, and diggings. Voles construct runs by gnawing off the grass stems and then trampling down the paths; runways lead to short, shallow burrows. Voles do not hibernate and are active all winter. They eat primarily grasses and to a lesser degree forbs, feeding on grass roots and seed-heads in summer and underground roots, bulbs, tubers, and seeds in winter. Vole populations fluctuate dramatically, peaking every four to five years (Banfield 1981). Voles favor moist microsites with high herbaceous cover (Pearson et al. 2001) that is characteristic of mesic fescue grasslands where Spalding's catchfly occurs. It is unlikely that deer mice (*Peromyscus maniculatus*) have caused this damage because they prefer drier, more open habitats with relatively little vegetative cover (Banfield 1981; Pearson et al. 2001).

Pocket gophers (family Geomyidae) are likely responsible for the soil mounds noted in one of the burned transects in 2004. Distribution of the northern pocket gopher (*Thomomys talpoides*), occurs within the study area. Pocket gophers create a labyrinth of tunnels, consisting of shallow feeding tunnels (5-18 inches deep) and deeper permanent galleries (3-9 feet deep). The gopher pushes dirt out of the tunnels, creating low piles of earth on the surface and eventually blocking the entrance with a firm earth plug. They are active all year in their burrows, cutting roots of perennial forbs for winter storage and pulling the plant down into the burrow. During the summer months they venture aboveground at night and eat the green parts of plants. They prefer deep, moist soil in grasslands (Banfield 1981). Pocket gophers were also suspected in 7% of absent plants at the LCC 65/LCC51 Spalding's catchfly site in 1999 (Hill and Gray 2000).

The effect of rodent activity on weed invasion is unknown at this time. The soil mounds and bare ground present in rodent runs represent disturbed sites that provide ideal conditions for weed establishment (Mielke 1977). Rodents are known to disperse seeds of invasive, non-native plants (McMurray et al. 1997). Many aggressive, opportunistic weed species are present in and near Spalding's catchfly sites at Garden Creek Ranch (Hill and Gray 1999).

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