DEVELOPMENT AND IMPLEMENTATION OF A MONITORING PROTOCOL FOR SPALDING'S CATCHFLY (*SILENE SPALDINGII*)

by

Juanita Lichthardt
and
Karen Gray
Conservation Data Center

April 2003

Idaho Department of Fish and Game
Natural Resources Policy Bureau
600 South Walnut, P.O. Box 25
Boise, Idaho 83707
Steve Huffaker Director

Report prepared for
Idaho Department of Parks and Recreation
through Section 6 funding from
U.S. Fish and Wildlife Service, Region 1

ABSTRACT

Silene spaldingii (Spalding's silene, Spalding's catchfly) is a plant species endemic to the bunchgrass grasslands of the inland Pacific Northwest, large portions of which have been eliminated by cultivation. *Silene spaldingii* is listed as threatened by the U.S. Fish and Wildlife Service (USFWS). The largest occurrence of Spalding's catchfly in Idaho is in the Snake River Canyon, south of Lewiston, along the western flank of Craig Mountain. The Craig Mountain metapopulation extends across more than 1,300 hectares (3,250 acres), and involves lands managed by the Bureau of Land Management (BLM), The Nature Conservancy (TNC), and Idaho Department of Fish and Game (IDFG). It has been the focus of all Spalding's catchfly monitoring in Idaho. This report documents a monitoring protocol for Spalding's catchfly, developed while establishing monitoring at six different populations that are part of the Craig Mountain metapopulation. The objective of monitoring is to assess the conservation status of the metapopulation by sampling sites in a range of locations and conditions. The protocol accommodates two different monitoring levels. At the more encompassing, but less precise level we conducted a census of the local population, documenting location and extent with GPS readings. We developed a form that was used to record this data as well as information on weeds and other attributes pertinent to habitat condition. On a more precise level, we established a permanent, 10 x 10 m plot within which we mapped all individuals of Spalding's catchfly and noted their reproductive status. At the plot-level we also recorded frequency of weeds using a nested plot frame, and community composition by canopy cover class. Ground cover (lichens, moss, litter, soil and rock) was recorded in 0.25 m^2 microplots.

TABLE OF CONTENTS

ABSTRACT i

TABLE OF CONTENTS ii

LIST OF TABLES iii

LIST OF FIGURES iii

LIST OF APPENDICES iii

INTRODUCTION 1

STUDY SITE 1

MONITORING PROTOCOL 2

- Other monitoring studies 3
- Considerations 3
- Site Inspection Report 3

IMPLEMENTATION OF MONITORING 5

- Census 5
- Plot methods 6
- Habitat condition 7
- Documentation 9
- Results 9
- Evaluation of methods 11

REFERENCES 12

TABLE

Table 1. Frequency of weed species in 0.25 m^2 microplots..10

LIST OF FIGURES

Figure 1. Example of randomizing macroplot within cluster 6

Figure 2. Layout of the macroplot with belt transects for monitoring Spalding's catchfly, and microplots for measuring rooted frequency and ground cover......8

LIST OF APPENDICES

Appendix 1. Line drawing of Spalding's catchfly (*Silene spaldingii*)

Appendix 2. Maps

Appendix 3. Site Inspection Report Form

Appendix 4. Completed Site Inspection Reports

Appendix 5. Maps of Spalding's catchfly plants within monitoring plots, and field data sheets with demographic data

Appendix 6. Community composition in eight permanent monitoring plots for Spalding's catchfly

Appendix 7. Frequency data for indicator species

INTRODUCTION

Spalding's catchfly (*Silene spaldingii*) is a geophytic herb in the family Caryophyllaceae (Appendix 1). It inhabits two disjunct ranges, one centered on the Palouse region of southeastern Washington and adjoining Idaho, and the other in northwestern Montana. Most of its former range in the Palouse grassland was converted from grassland to cultivated agriculture by about 1910 (Lichthardt and Moseley 1997). Spalding's catchfly is listed as threatened by the U.S. Fish and Wildlife Service (USFWS).

The largest occurrence of Spalding's catchfly in Idaho (006) is in the Snake River Canyon downstream from the mouth of the Salmon River, along the west flanks of Craig Mountain. The Craig Mountain metapopulation encompasses more than 1,300 hectares (3,250 acres, Appendix 2, Map 1) and 2,000 genets, and involves lands managed by the Bureau of Land Management (BLM), The Nature Conservancy (TNC), and Idaho Department of Fish and Game (IDFG). Since Spalding's catchfly was discovered there in 1993, this area has been the focus of monitoring and research in Idaho (Lesica and Heidel 1996, Hill and Gray 2000, Hill et al. 2001, Hill and Fuchs 2002, Menke and Muir 2002, Hill and Fuchs 2003, Hill and Weddell 2003).

The purpose of this project was to develop a monitoring protocol specific to Spalding's catchfly. The primary objective of this monitoring is to track the conservation status of the Craig Mountain metapopulation by sampling specific subunits in a standard way.

Our goal was a monitoring protocol for Spalding's catchfly that encompasses the entire Craig Mountain metapopulation. The design would establish monitoring sites in areas portraying a variety of habitat conditions, such as burned versus unburned, and weedy versus non-weedy habitats. The monitoring protocol should integrate population and habitat attributes and pay special attention to the serious weed invasion problem that threatens the metapopulation.

The report is in three parts: a description of the setting in which the metapopulation occurs, a description of the monitoring protocol, and details of methods used in implementing monitoring.

STUDY SITE

The Craig Mountain metapopulation of Spalding's catchfly is one of the most extensive known occurrences of the species and occupies an area of abundant habitat. It extends for 22 km (13 mi), from Redbird Creek south to Cave Gulch (Appendix 2, Map 1). Only one occurrence is known from south of this area in Idaho.

Breaklands between the Snake River and the top of Craig Mountain are extremely steep, rising more than 1500 m (4,000 ft) in less than 6.5 km (4 mi). Four main streams–Captain John Creek, Corral Creek, China Garden Creek, and Cave Gulch–dissect the area, running west and southwest into the Snake River. Within this area, Spalding's catchfly grows in mesic bunchgrass steppe, on northerly aspects from 460 to 980 m (1,500 to 3,200 ft). Habitat types are classified as *Festuca idahoensis/Koeleria cristata* and *Festuca idahoensis/Symphoricarpos albus* (Tisdale 1986). Slopes are usually steep. It also occurs on gently sloping benchlands, but these areas have largely been converted to exotics by heavy grazing or cultivation.

Livestock grazing does not effect most of the area of the metapopulation. The greatest threats to Spalding's catchfly are perceived to be aggressive weeds including Kentucky bluegrass (*Poa pratensis*) and yellow star-thistle (*Centaurea solstitialis*). Other threats that have been suggested include aerial herbicide spraying, fire, fire suppression activities, or excessive litter accumulation.

MONITORING PROTOCOL

A monitoring protocol was developed by consulting other Spalding's catchfly monitoring and research studies, and through our own experience in implementing monitoring during 2002. The primary objective of this monitoring is to track the conservation status of the Craig Mountain metapopulation by monitoring representative subunits in a standard way. We wanted the protocol to accommodate different monitoring levels (intensities) and to address parameters related to the conservation status of Spalding's catchfly, including population parameters (size, extent) and habitat parameters (weeds, litter depth, overstory shrubs, disturbance, management).

These parameters were incorporated into a Site Inspection Report form for Spalding's catchfly (Appendix 3). The Site Inspection Report represents the less intensive monitoring level within the protocol. It can be used alone or, as we did, with more precise plot methods requiring more time and materials.

A large portion of the Site Inspection Report relates to the site condition–management, disturbance, and the abundance and species of weeds present. In their site inspection report for Spalding's catchfly, Rush and Gamon (1999) included the following parameters:

- Application/effectiveness of management prescriptions (e.g., weed control or burning)
- Evidence of recent human or natural disturbance (map)
- Aggressive, non-native species
- Photopoints

To assess the conservation status of the metapopulation as a whole it is desirable to represent as many different sites and types of sites as possible, that is, sites differing in population size, type of habitat, and threat level. However, the long travel time required to reach sites, and the extent of some populations made it difficult to visit numerous populations. We decided that to justify the travel time involved, we should establish permanent plots where quantitative measurements could be make of the population and habitat indicators.

We incorporated different levels of monitoring by censusing the entire local population or, when this was not reasonable, some portion thereof. We then installed a permanent plot at the center of a randomly selected cluster of plants. The more intensive, demographic data are useful in making population projections over time and looking for population trends among sites differing in vegetation condition, disturbance level, and management. Plot methods for detailed, demographic and habitat monitoring are described later under *Implementation of Monitoring*.

Other monitoring studies

Lesica (1997, 1999) initiated demographic monitoring within a Montana population in 1991, continuing at least through 1997, and including spring burn, fall burn, and unburned treatments. Rush and Gamon (1999) developed a site inspection report as a part of a monitoring protocol for Spalding's catchfly in Washington. Annual monitoring at Fairchild Airforce Base in Washington has been conducted since 1999 (Caplow 2001). Hill and Gray (2000) visually mapped populations of Spalding's catchfly at a scale of 1:2,000 after flagging plants. These maps are very accurate and the study well-documented, thus establishing a basis for plotless monitoring. They included the distribution of yellow star-thistle within and adjacent to the population. Menke and Muir (2002) conducted population monitoring at a number of sites to investigate the relationship between exotic species, fire, and vigor of Spalding's catchfly populations. Hill and Weddell (2003) initiated population monitoring in 2002, utilizing permanent plots at two sites in the Corral Creek drainage, one of which burned in 2001.

Considerations

Spalding's catchfly tends to occur in "clusters" of plants–a clumped distribution very typical of plants without wind-dispersed seed. Most researchers working with the species use the term cluster to describe local population units, even though it is not a technical term. Between clusters, plants are very sparsely distributed.

For Spalding's catchfly, no formal hierarchy of subpopulations, populations, and metapopulations has been defined. Therefore, in this document, we will avoid using the term subpopulation and limit ourselves to "cluster" and "population." By population we refer to a group of clusters in the landscape, often with scattered plants in intervening areas, and often separated by small areas of unsuitable habitat, but not by a major east-west ridgetop.

Site Inspection Report

The Site Inspection Report (Appendix 3) is essentially a modified Rare Plant Observation Report that standardizes collection of data specific to Spalding's catchfly. Additionally, the observer is required to define the portion of the population to which the data applies by mapping at 1:24,000 and/or using a GPS unit to obtain accurate latitude/longitude coordinates. More than one monitoring level can be employed (e.g., population and permanent plot). Monitoring sites should be visited at approximately the same time each year.

Completed Site Inspection Reports should be included in a report to the agency involved, with a copy to the IDCDC. Fields used in the Site Inspection Report are explained below.

Specify the unit monitored. Spalding's catchfly populations within the Craig Mountain metapopulation defy monitoring at the population scale because of extent, variation in habitat, and variation in condition of habitat. If an entire population/subpopulation is surveyed, use a Rare Plant Observation Report to update the EOR. Otherwise, describe the unit monitored (population, cluster, plot) by mapping, taking GPS readings of the perimeter, or referring to a monumented plot.

Document location. Use GPS readings to document the unit of monitoring and attach a map of the monitoring site.

Population information. Provide an estimate of the number of plants. Indicate whether the data is a count or an estimate. Plant density drops rapidly as you move from the center of a cluster of plants. This data should be for the entire unit of monitoring or broken down by subunits. Record limits of survey using GPS readings. Where possible, identify numbers and locations of dense clusters of plants.

Phenology. Have plants begun to flower? To fruit? What proportion of plants are non-flowering?

Community comments. Note the habitat type, indicator plants, any plants not included in the plot, etc. If a complete species list is made, it should be for the unit monitored.

Ground cover. Describe the nature of the ground cover where plants are found e.g., rockiness, litter depth, moss cover etc. This may be very general unless a fixed plot is used.

Weeds. Three problematic species are indicated on the form. Indicate their abundance and proximity to the unit of monitoring (within unit, in a certain portion of unit, nearby, known from area etc.) then indicate the same for other non-native species present. *Bromus brizaeformis* is not currently considered an important indicator of habitat condition.

Disturbance. Note the type of disturbance, extent, and estimate timing/duration. What are the salient effects? Types of disturbance include fire, gophers, and terracing. Note natural as well as man-caused disturbance.

Management. What is the current site management? Are management actions planned? What have been the effects of recent management actions such as spraying and burning?

Photos. Document photopoints if used. Photos that illustrate the nature of the ground cover are useful.

Permanent plots. How many? Record locations in table provided for latitude/longitude coordinates.

IMPLEMENTATION OF MONITORING

In 2002, we targeted several areas in which to work based on access and land ownership. We wanted to look at different drainages, especially Captain John Creek and Billy Creek where no past monitoring had been done, and to involve both BLM and IDFG lands. We also chose the Corral Creek drainage because of its access and because populations there had been affected by fire. We then determined from existing maps where populations were located, eliminated those that were not reasonably accessible, and selected randomly among those remaining. Sampling was done between July 15 and July 24.

Census

Plot establishment was preceded by thorough survey by two observers. Once we arrived at a population we attempted to define it as well as possible by flagging all individuals with wire flags, or by counting individuals and using flags to mark occasional individuals in order to keep track of where we had been. At some point, plants usually became so sparsely distributed that we could not find them, or the return was greatly reduced. The point where we stopped looking was recorded as the limit of our survey, using GPS. During this process we identified one or more clusters of plants and randomly selected one. Criteria for selection required at least 10 plants in 10 square meters.

A GPS unit was used to record latitude and longitude coordinates at the center of the cluster as well as at the margins of the population as far as we had determined it. We checked a 7.5-minute topo quad in the field to make sure GPS coordinates were consistent with our position on the map.

At this point we had a fairly good census of the local population, although limited to the most easily seen plants. In some cases our survey had to be terminated due to time constraints. For example, at Billy Creek South (EO 016) we found several clusters of various sizes, and many widely scattered plants, but never determined the eastern extent the population. In some cases, further survey may have extended the size of the population, but by plotting the extent of our survey, we defined the area to which our plant counts apply.

Plot methods

Once a cluster had been selected, we established a 10 x 10 m macroplot within the central cluster of plants. Within this plot we measured:

- Frequency of indicator species (weeds, rare plants, shrubs) including Spalding's catchfly
- Density of Spalding's catchfly
- Ground cover (rock, bare soil, litter, lichen, and moss)

We also mapped individual Spalding's catchfly plants and characterized the plant community by listing the species present and estimating cover class where possible.

We delineated the central cluster as a rectangle around the densest aggregation of plants, tight enough to include little unoccupied area, and with one side parallel to the slope and the other perpendicular. To ensure that every position within the cluster had an equal chance of being sampled, we randomly selected two coordinates by which to move the corner of the macroplot away from the corner of the rectangle defining the cluster, while still remaining within the rectangle (Figure 1). Macroplots were marked in the upslope, left (as looking downslope) corner with a steel fence post, and in the other three corners with bent pieces of rebar. The central cluster was usually not much larger an area than the macroplot.

We recorded the number of plants found during our initial census of the population, the number of plants in the central cluster, and the number within the rectangle we superimposed over the cluster. In this way we obtained an overall census, density of the central cluster, and density within the plot.

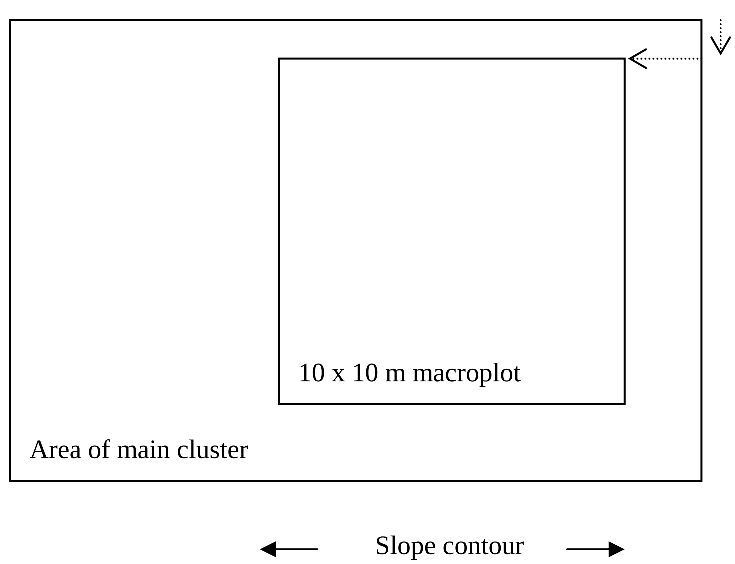

Figure 1. Example of randomizing macroplot within cluster.

We mapped Spalding's catchfly individuals within the macroplot by two coordinates, the first being the distance along the transect (away from the baseline) and the second the distance away from the transect (Figure 2). Plot methods evolved during the course of field work. At plot 1 we used three transects at 3-m intervals (0, 3, and 6 m). Transects were always one meter in width. At plot 2 we used seven, contiguous transects at 0, 1, 2, 3, 4, 5, and 6 m. At the remaining sites we mapped all Spalding's catchfly plants in the macroplot, using ten contiguous, 1 x 10 m transects (Figure 2). The latter method gives a complete census of emergent plants within the plot, and the extra time required is justified by that required getting to the plot. The status of each plant was also recorded (rosette, vegetative, reproductive, grazed). Transects were marked at both the top and the bottom with pieces of bent rebar.

In addition to frequency of indicator species, a total plant species list with corresponding cover class values was recorded for each macroplot using Western Heritage Task Force Form III – Ocular Plant Species Data (Bourgeron et al. 1991). In some cases, weed species were recorded in the macroplot that were not recorded in the nested plot frame. Because of the late date, cover of most species had decreased significantly and in some cases could not be reasonably estimated. Photos were taken of each plot and a set of slides is stored at the IDCDC.

Habitat condition

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

For the permanent plots we desired a quantitative measure of weed abundance, so we used a nested plot frequency method. A nested plot frame (microplot) was placed at 2-m intervals along each transect (0, 2, 4, 6, and 8 m tick marks). We began by using only three transects (1, 4, and 7; plots 1-3) and increased this to four in plots 4-8 (transects 1, 4, 7, and 10), so there are either 15 or 20 microplots per macroplot (Figure 2). This will be adjusted to 20 microplots each in the second year (2003). The nested plot frame consists of four nested plot sizes: 1) 10 x 10 cm; 2) 25 x 25 cm; 3) 25 x 50 cm; and 4) 50 x 50 cm. The smallest nested plot size in which a species is rooted is recorded. Rooted frequency data were collected for all non-native plant species, selected native plants, and shrubs. Frequency measurements do not work well for characterizing litter or bare ground, so cover was estimated for these attributes, as well as for mosses as a group, lichens as a group, gravel, and rock. The character of the litter layer varied dramatically among plots and we eventually partitioned litter into particulate, thin, and deep (> 1 inch). Litter cover was estimated first, before disturbing it to look for mosses and lichens. Burned, dead moss mats were considered litter. Plant basal area (mostly bunchgrasses) was included with litter.

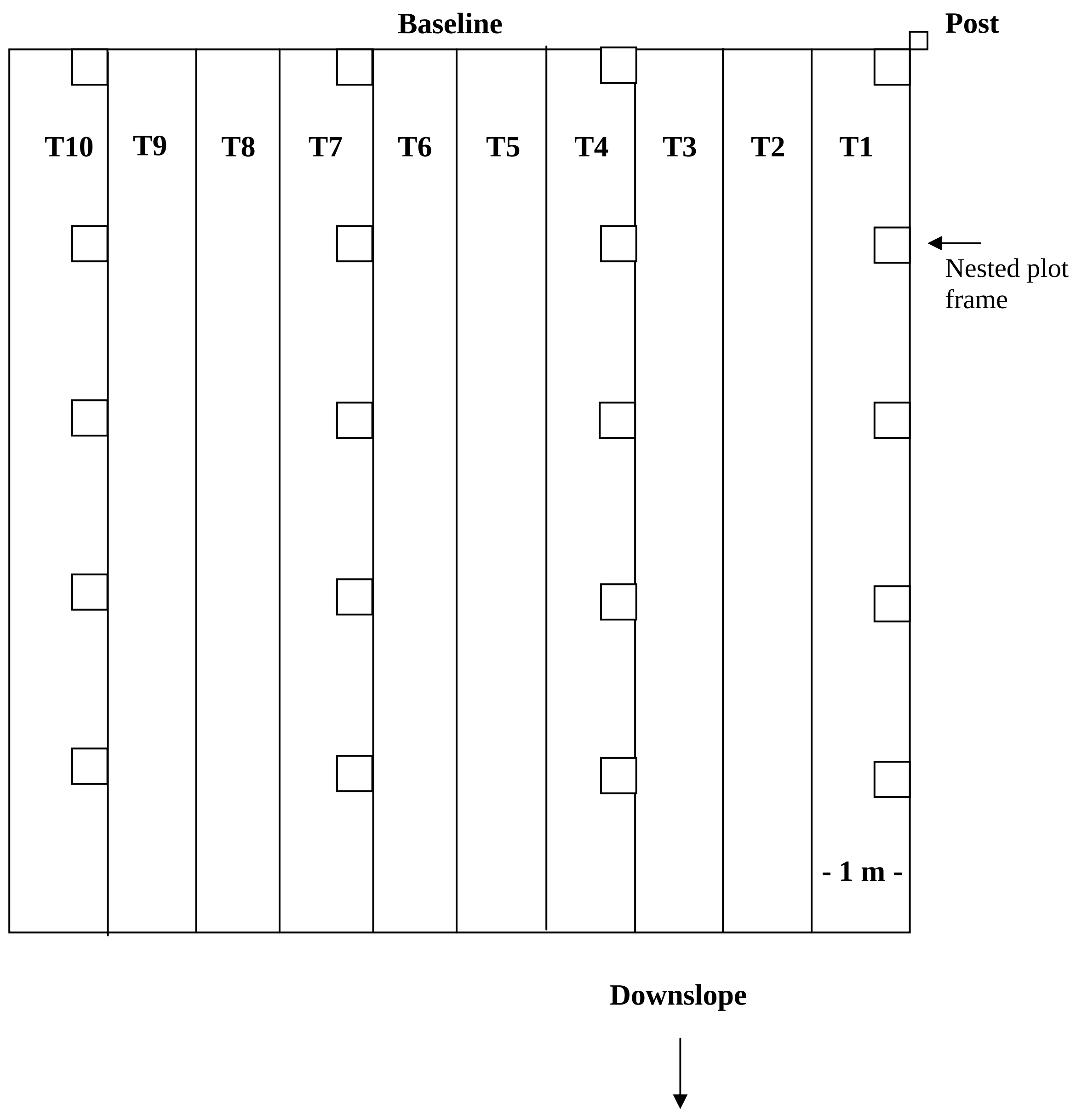

Figure 2. Layout of the macroplot showing belt transects for monitoring Spalding's catchfly, and microplots for measuring rooted frequency and ground cover.

Documentation

In addition to this report, we updated element occurrence records by indicating the location of the monitoring plots, population data (in some cases under "population" in the form and others under "subpopulation"), noting weed species, and mapping any extensions of occurrences.

Results

Completed Site Inspection Reports for monitoring sites established in 2002 can be found in Appendix 4. These include data on population size, cluster size and density, and density within the macroplot. Maps of Spalding's catchfly plants within monitoring plots, and field data sheets showing numbers of stems, reproductive status, and location coordinates for each plant are in Appendix 5. Community composition is tabled in Appendix 6. Frequency data for indicator species are summarized in Appendix 7.

The number of Spalding's catchfly plants in the 100 m^2 plot ranged from 12 (plot 3) to 26 (plot 5). The percentage of plants grazed ranged from 0 to 43% (plot 8). Four possible rosettes were observed.

Upon close examination, some non-flowering plants were found to be reproductive (anthers found within unopened bud). This prompts the question whether there is any life-stage or vigor distinction between reproductive and vegetative, elongated plants, or whether this is merely a phenological difference.

Table 1 is a synthesis of the frequency data found in Appendix 7, showing the number of times a species occurred in a 0.25 m^2 microplot (the largest nested plot size). For information on weeds not captured in the macroplot see Appendix 4. The monitoring plots succeed in showing a contrast in habitat condition. Plots 5 and 8 represent communities in poor condition based on abundance of Kentucky bluegrass. Plot 8 is at Redemsky Flats, an area of rolling terrain representing one of the weedier Spalding's catchfly sites known. Plots 3 and 7 are also on gentler slopes, but are couched in more rugged terrain. In contrast, plots 2 and 6 are essentially weed free, plot 2 having only a trace of Japanese brome. However, Japanese brome, cheatgrass, and Kentucky bluegrass occur just outside plot 6. Kentucky bluegrass and Japanese brome are the most abundant weeds overall.

Of the weeds present, Japanese brome had the highest constancy. It is widely distributed within plots and throughout the grassland, where it is particularly characteristic of the more mesic communities. It generally occurs with low cover, unlike cheatgrass which grows in dense patches when well established. Japanese brome is a Eurasian winter annual grass. Like cheatgrass and bluebunch wheatgrass, it germinates in the fall. Romo and Eddleman (1987) found that Japanese brome seedlings did not inhibit bluebunch wheatgrass seedling establishment. However, it may prevent the reestablishment of natives on disturbed sites.

Table 1. Frequency of weed species in 0.25 m^2 microplots.[1]

	Plot							
	1	2	3	4	5	6	7	8
Total possible:	15	15	15	20	20	20	20	20
Agrostis interrupta	-	-	-	-	-	-	-	P
Bromus japonicus	15	11	15	7	7	-	4	5
Bromus tectorum	3	-	-	1	1	-	-	P
Centaurea solstitialis	-	-	-	-	P	-	2	1
Cichorium intybus	-	-	-	-	-	-	-	P
Galium pedemontanum	-	-	-	5	-	-	-	-
Hypericum perforatum	5	-	-	P	-	-	-	1
Poa bulbosa	-	-	-	-	-	-	-	P
Poa pratensis	-	-	5	-	13	-	1	13
Ventenata dubia	3	-	-	7	-	-	-	-
Vicia tetrasperma	1	-	-	-	-	-	-	-
Vicia villosa	-	P	-	-	-	P	10	P?

[1] P = present in macroplot, but not in microplots. Nomenclature follows Hitchcock and Cronquist 1980.

Kentucky bluegrass is a naturalized forage and lawn grass. It is an aggressive spreading perennial that flourishes in mesic grassland and increases under grazing pressure. It forms dense swards that reduce bunchgrass abundance and overall diversity.

Common St. John's-wort, an aggressive perennial, occurs at three of the monitoring sites. It can be highly variable in abundance and seems to be set back by fire. At one of the Hill and Gray (2000) monitoring sites it occurred with a mean density of 44 plants/m^2. Common St. John's-wort is particularly troublesome because it competes for pollinators with Spalding's catchfly (Lesica and Heidel 1996).

Because of their ability to spread aggressively and compete with native vegetation, yellow star-thistle, hairy vetch, and ventenata can be expected to increase, and possibly all of the weeds listed will increase.

Hill and Gray (2000) identified twelve aggressive weeds in six stands containing Spalding's catchfly: yellow star-thistle, common St. John's-wort, cheatgrass, Kentucky bluegrass, sulfur cinquefoil (*Potentilla recta*), hairy vetch, teasel (*Dipsacus sylvestris*), Canada thistle (*Cirsium arvense*), scotch thistle (*Onopordum acanthium*), leafy spurge (*Euphorbia esula*), ventenata, and whitetop (*Cardaria draba*). The latter six were not widespread and occurred as localized patches. Ventenata only occurred at one site. In each site, the Spalding's catchfly population was surrounded, or nearly so, by yellow star-thistle which also occurred in scattered patches within the populations. All stands surveyed were in the Corral Creek drainage.

Evaluation of methods

The more intensive monitoring level implemented will result in data useful in determining life history characteristics of Spalding's catchfly, making population projections, and detecting the effects habitat degradation via weed increase. The less intensive level (Site Inspection Report) can be used whenever a population is visited or a new one found. It represents a monitoring intensity intermediate between the permanent plot and the Rare Plant Observation Form.

The extent of the Craig Mountain metapopulation merits more monitoring sites, at least at the less intensive level. However, we recommend first doing an analysis and stratification of element occurrence data at the IDCDC. Populations should be stratified by site attributes (such as slope and elevation), management, and condition if possible. This would enable us to identify site types not yet represented in our sample and determine the feasibility of establishing monitoring.

References

Bourgeron, P. S., R. L. DeVelice, L. D. Engelking, G. Jones, and E. Muldavin. 1991 WHTF site and community survey manual. Version 91C. Western Heritage Task Force, Boulder, CO. 24 p.

Caplow, F. 2001. Annual report for Spalding's catchfly (*Silene spaldingii*) on Fairchild AFB, Washington. Washington Department of Natural Resources, Natural Heritage Program. 14 p.

Hill, J.L. and K. Gray. 2000. Conservation of Spalding's catchfly (*Silene spaldingii*) in the Lower Corral Creek Study Area, Garden Creek Ranch, Craig Mountain, Idaho– 1999 Field Season. Unpublished report for The Nature Conservancy of Idaho, Sun Valley, ID. 18 p. plus appendices.

Hill, J.L. and S.J. Fuchs. 2002. Special Ecological Areas pilot study at the Garden Creek Ranch, Craig Mountain, Idaho. Unpublished report for The Nature Conservancy of Idaho, Sun Valley, ID. 60 p. plus appendices.

Hill, J.L. and S.J Fuchs. 2003. Special Ecological Area pilot study at the Garden Creek Ranch – 2002 Field Season. Unpublished report on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, ID. 16 p. plus appendices.

Hill, J.L., K.L. Gray, and S.J. Fuchs. 2001. Conservation of Spalding's catchfly (*Silene spaldingii*) in the Lower Corral Creek Study Area, Garden Creek Ranch, Craig Mountain, Idaho – 2000 Field Season. Unpublished report on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, ID. 15 p. plus appendices.

Hill, J.L. and B.J. Weddell. 2003. Population dynamics of Spalding's catchfly (*Silene spaldingii* Wats.) in the Lower Corral Creek Study Area, Garden Creek Ranch, Craig Mountain, Idaho. Unpublished report for the Bureau of Land Management, Cottonwood Resource Area. Cottonwood, ID. Draft.

Hitchcock, C.L. 1964. *Silene*. Page 594 in: Vascular plants of the Pacific Northwest. Part 2, by C.L. Hitchcock, A. Cronquist, M. Ownbey, and J.W. Thompson. University of Washington Press, Seattle. 730 p.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA.

Lesica, P. and B. Heidel. 1996. Pollination biology of *Silene spaldingii*. The Nature Conservancy, Montana Field Office, Helena, MT. 16 p.

Lesica, P. 1997. Demography of the endangered plant, *Silene spaldingii* (Caryophyllaceae) in northwest Montana. Madrono 44(4):347-358.

Lesica, P. 1999. Effects of fire on the demography of the endangered, geophytic herb *Silene spaldingii* (Caryophyllaceae). American Journal of Botany 86(7):996-1002.

Lichthardt, J. and R.K. Moseley. 1997. Status and conservation of the Palouse Grassland in Idaho. Conservation Data Center, Idaho Department of Fish and Game, Boise. 28 p. plus appendices.

Menke, C.A. and P.S. Muir. 2002. Relationships of fire and exotic species to *Silene spaldingii* in an Idaho grassland. Northwest Scientific association seventy-fifth annual meeting, March 27-30. Boise State University, Boise, ID. Abstract.

Romo, J. T., and L. E. Eddleman. 1987. Effects of Japanese brome on growth of bluebunch wheatgrass, junegrass, and squirreltail seedlings. Reclamation and Revegetation Research 6: 207-218.

Rush, T. and J. Gamon. 1999. Management plan for Spalding's catchfly (*Silene spaldingii)* on Fairchild Air Force Base, Washington. Washington Department of Natural Resources, Natural Heritage Program, Olympia, WA. 28 p.

Tisdale, E.W. 1986. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. University of Idaho, Forest, Wildlife, and Range Experiment Station. Bulletin Number 40. 42 p.