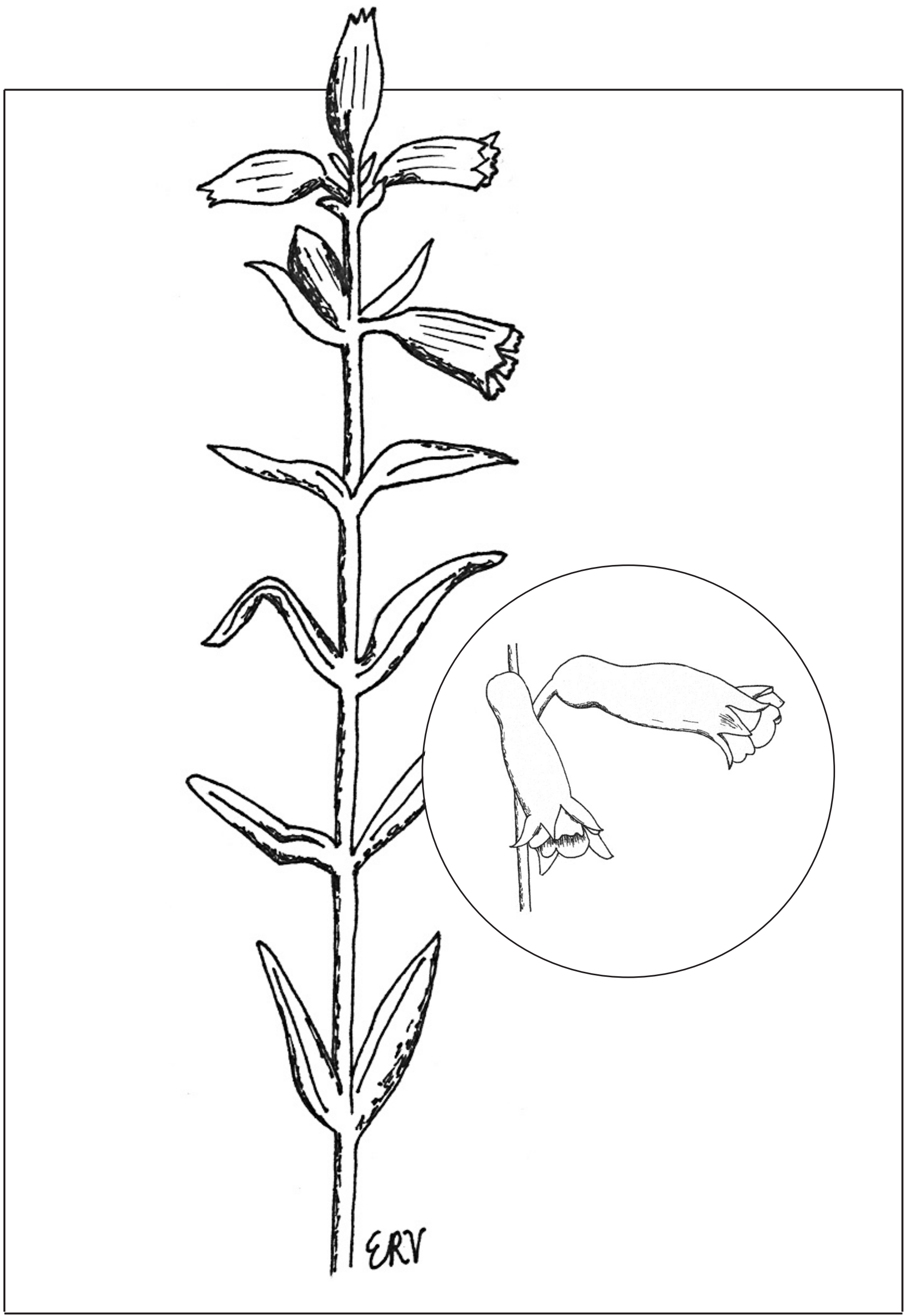
U.S. Fish & Wildlife Service

# Draft Recovery Plan for *Silene spaldingii*

## (Spalding's Catchfly)




*Silene spaldingii*/Edna Rey-Vizgirdas; *Inset*/Gina Glenne

# Draft Recovery Plan
# for
# *Silene spaldingii*
# (Spalding's Catchfly)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

# DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and other affected and interested parties. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific actions and may not represent the views nor the official positions or approval of any individuals or agencies involved in recovery plan formulation, other than our own. They represent our official position *only* after they have been signed by the Regional Director or Director as *approved*. Recovery plans are reviewed by the public and submitted to peer review before we adopt them as approved final documents. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions. Please check for updates or revisions at the website below before using.

**Notice regarding use of proprietary data**:

All plant locations given are approximate. Exact plant locations are proprietary data of the NatureServe/Heritage programs of Idaho, Montana, Oregon, Washington, and British Columbia, and cannot be redistributed by the U.S. Fish and Wildlife Service without specific authorization. Contact your local NatureServe/Heritage Program office to obtain a copy of their plant location database.

**Literature citation of this document should read as follows:**

U.S. Fish and Wildlife Service. 2005. Draft Recovery Plan for *Silene spaldingii* (Spalding's Catchfly). U.S. Fish and Wildlife Service, Portland, Oregon. 121 pp.

**Electronic copies of this document will be made available at:**
http://endangered.fws.gov/recovery/index.html

# ACKNOWLEDGEMENTS

The wide-ranging nature of this rare species has necessitated the involvement of numerous individuals. We, the U.S. Fish and Wildlife Service, gratefully acknowledge the commitment and efforts of the following individuals to the recovery of *Silene spaldingii*. Without their assistance, this plan would not have been possible.

**Julie Anderson and Mike Finch**
Swanson Lakes Wildlife Area

**Barbara Benner and Company**
Washington Bureau of Land Management

**Joanne Bigcrane**
The Confederated Salish and Kootenai Tribes of the Flathead Reservation

**Florence Caplow**
Washington Natural Heritage Program

**Carrie Cordova**
Columbia Basin Fish and Wildlife Office

**Lynn Danly**
Idaho Bureau of Land Management

**Delores Davisson**
Private Individual

**LeeAnn Eno**
Idaho Bureau of Land Management

**Frank Fink**
Idaho Natural Resources Conservation Service

**Zach Funkhouse and Company**
Idaho Transportation Department

**Karen Gray**
Idaho Conservation Data Center

**Herman Harder**
Adams County Noxious Weed Control Board

**Tom Hawkins**
Idaho Department of Lands/Craig Mountain

**Janice Hill**
Consultant

**Jerry Hustafa**
Wallowa-Whitman National Forest

**Alan and Darla Klages**
Private Landowners

**Peter Lesica**
Consultant

**Mark Lowry**
Bureau of Land Management

**Michael Mancuso**
Idaho Conservation Data Center

**Maria Mantas**
The Nature Conservancy of Montana

**Bill Mervyn**
Private Landowner

**Gary Miller**
La Grande Fish and Wildlife Office

**Kendrick Moholt**
Private Landowner

**Roger Rosentreter**
Idaho Bureau of Land Management

**Mike Rule**
Turnbull National Wildlife Refuge

**Jerry Sawyer**
Flathead State Park

**Joe Schmick**
Private landowner

**Phil Shepard**
The Nature Conservancy of Oregon

**Angela Sondenaa**
Nez Perce Tribe

**Kimberly St. Hilaire**
Bonneville Power Administration

**Roald Tangvald**
Private Landowner

**Robert Taylor**
The Nature Conservancy of Oregon

**U.S. Fish and Wildlife Service**
**Ecological Services Offices**
Boise, Idaho
Helena and Kalispell, Montana
La Grande, Oregon
Spokane and Lacey, Washington

**Lynn Verlanic**
Bison Range Complex National Wildlife Refuge

**Jonathan Wald**
Fairchild Air Force Base

**John Williams**
Oregon State University Extension Service

**Jim White and Company**
Idaho Department of Fish and Game

**Jean Wood**
Umatilla National Forest

**Eugene Yates**
Wallowa-Whitman National Forest

**Ben Zamora**
Washington State University Kramer Prairie Natural Area

# Executive Summary

**Current Species Status:** *Silene spaldingii* (Spalding's catchfly) is an herbaceous perennial plant in the pink family (Caryophyllaceae). It is a regional endemic restricted to remnants of grasslands in eastern Washington, northeastern Oregon, west-central Idaho, western Montana, and barely extending into British Columbia, Canada. *S. spaldingii* was listed as a threatened species under the Endangered Species Act on October 10, 2001 (USFWS 2001). There are currently 85 known populations of *S. spaldingii*, with more than half of these (58 populations) composed of fewer than 100 individuals each. There are an additional 20 populations with at least 100 or more individuals apiece, and the 7 largest populations are each made up of more than 500 plants. Occupied habitat includes five physiographic (physical geographic) regions: the Palouse Grasslands in west-central Idaho and southeastern Washington; the Channeled Scablands in eastern Washington; the Blue Mountain Basins in northeastern Oregon; the Canyon Grasslands of the Snake River and its tributaries in Washington and Idaho; and the Intermontane Valleys of northwestern Montana.

**Habitat Requirements and Limiting Factors:** In general *Silene spaldingii* is found in open, mesic (moist) grassland communities. However, the species is occasionally also found within sagebrush-steppe communities as well as pine forests. The bunchgrass grasslands where *S. spaldingii* primarily occurs are characterized by one or both of two dominant bunchgrass species, *Agropyron spicatum* = *Pseudoroegneria spicata* (bluebunch wheatgrass) and *Festuca idahoensis* (Idaho fescue). The plant is found at elevations ranging from 420 to 1,555 meters (1,380 to 5,100 feet), usually in deep, productive loess soils (fine, windblown soils). Plants are generally found in swales or on north or east facing slopes where soil moisture is relatively higher.

*Silene spaldingii* continues to be impacted by habitat loss due to human development, habitat degradation associated with domestic livestock and wildlife grazing, and invasions of aggressive nonnative plants. In addition, a loss of genetic fitness (the loss of genetic variability and effects of inbreeding) is a problem for many small, fragmented populations where genetic exchange is limited. Other impacts include changes in fire frequency and seasonality, off-road vehicle use, and herbicide spraying and drift.

**Recovery Priority Number:** *Silene spaldingii* has been assigned a recovery priority number of 8c on a scale from 1C (highest) to 18 (lowest), indicating its taxonomic status as a full species, a moderate degree of threats or impacts, high potential for recovery, and potential conflict with economic activities.

**Recovery Strategy:** The objective of the recovery program is to recover *Silene spaldingii* by protecting and maintaining reproducing, self-sustaining populations in each of the five distinct physiographic regions where it resides. Within each of these regions we have identified **key conservation areas** to focus conservation efforts on larger populations. A key conservation area possesses the following qualities:

- Composed of intact habitat (not fragmented), preferably 40 acres (16 hectares) in size or greater[1]
- Native plants comprise at least 80 percent of the vegetative community
- Adjacent habitat is available sufficient to support pollinating insects
- Habitat is of the quality and quantity necessary to support at least 500 reproducing individuals of *Silene spaldingii*

The protection and management of these key conservation areas, or areas that have the potential to serve as key conservation areas, forms the foundation of the recovery strategy for *S. spaldingii*.

**Recovery Goal, Objectives, and Delisting Criteria:** The goal of the recovery program is to recover *Silene spaldingii* to the point where it can be delisted, *i.e.*, to remove the species from threatened status. The primary objectives to meet this goal are to reduce or eliminate the threats to the species, and protect and maintain multiple reproducing, self-sustaining populations distributed across each of the five distinct physiographic regions where it resides sufficient to ensure the long-term persistence of the species. Delisting of the species will be considered when the following criteria have been met:

1. Twenty-six populations with at least 500 reproducing *Silene spaldingii* individuals in each and with intact habitat occur rangewide at key

[1] In some regions, such as the already severely fragmented Palouse prairie, reaching a minimum size of 40 acres (16 hectares) of contiguous habitat may not be feasible

conservation areas and are distributed throughout the 5 identified physiographic provinces as follows: 5 within the Blue Mountain Basins, 6 within the Canyon Grasslands, 8 within the Channeled Scablands, 4 within the Intermontane Valleys, and 3 within the Palouse Grasslands.

The number of key conservation areas for each physiographic province was set at a minimum of three to preserve genetic diversity. For some regions, a greater number of key conservation areas are proposed to reflect the number of populations needed to maintain connectivity and, to the extent possible, preserve historical distribution across the remaining potential habitat estimated to be available.

The validity of preserving the species based on populations composed of at least 500 reproducing individuals should be verified by the results of a population viability analysis that incorporates threats and further genetic and demographic research on *Silene spaldingii*. The analysis should be initiated within 3 years and completed within 15 years of the approval of this recovery plan. Once the population viability analysis is completed, the recovery criteria listed here will be revisited and the target of 500 reproducing individuals per key conservation area may be adjusted, as appropriate.

2. All 26 key conservation areas of *Silene spaldingii* are composed of at least 80 percent native vegetation, have adjacent habitat sufficient to support pollinating insects, and are not fragmented (*i.e*., intact; see criterion #1).

3. Populations of *Silene spaldingii* at key conservation areas demonstrate stable or increasing population trends ($\lambda \geq 0$) for at least 20 years.

4. Habitat management plans have been developed and implemented for all key conservation areas. These management plans will provide for the protection of *Silene spaldingii* habitat, and will also protect the ecosystem by addressing conservation of other rare species, reducing the identified threats (*e.g.*, off-road vehicle use, overgrazing by wildlife and domestic stock, herbicide application, etc.), protecting pollinators, enacting monitoring strategies, incorporating integrated pest management strategies, and incorporating appropriate fire management activities.

5. Invasive nonnative plants with the potential to displace *Silene spaldingii* have been continually controlled or eradicated within a 0.4 kilometer (0.25 mile) radius of all *S. spaldingii* populations within key conservation areas.

6. Prescribed burning is conducted, whenever possible, to mimic historical fire regimes within a particular physiographic region in *Silene spaldingii* habitat. Prior to burning, presence/absence surveys for the plant will be completed. Prescribed burning will not take place when it may exacerbate invasive nonnative plant populations. Where *S. spaldingii* is present, monitoring is enacted prior to and following the prescribed burn. Historical fire regimes are carefully analyzed utilizing the best available technology.

7. Seed banking occurs at all smaller *Silene spaldingii* populations (not key conservation areas or potential key conservation areas) to preserve the breadth of genetic material across the species' range.

8. A post-delisting monitoring program for the species is developed and ready for implementation. This program will be developed through coordination with the Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, Tribes, States, The Nature Conservancy, and other interested parties.

**Recovery Actions Needed:** *Silene spaldingii* cannot be protected if its habitat is not conserved and restored. The goal of this recovery plan is to manage self-sustaining *S. spaldingii* populations through good habitat (ecosystem) management at key conservation areas. This will be accomplished by developing and implementing habitat management plans at these key conservation areas that provide a strategy for managing *S. spaldingii* and its habitat; these plans must address the threats to the species. Larger populations where small population sizes and fragmentation are less of a problem should be protected (kept from harm) before small, more fragmented populations that are more vulnerable to a loss of genetic diversity. To preserve genetic diversity, populations should be conserved in each of the five physiographic regions where the plant resides; if necessary populations may need to be expanded or developed. Invasive nonnative plants need to be controlled within *Silene spaldingii* habitat with minimal impact to the species itself by utilizing integrated pest management techniques. Fire management and prescribed burning must be conducted carefully and with sound monitoring strategies and scientific information. Development of lands where *S. spaldingii* resides, especially large populations, should be prevented. Livestock grazing needs to be conducted so that *S. spaldingii* and its habitat are not deleteriously affected. To ensure these threats are adequately being addressed, monitoring and research are required to evaluate management actions. Additional needs include surveys to identify other *S. spaldingii* populations in need of protection or management, outreach to inform the public about the species so they may assist in conservation, and seed banks to protect the species from catastrophic losses. Funding is necessary to implement these actions. A regular review of this recovery plan is recommended so that new information may be incorporated and management adjusted accordingly.

**Total Estimated Cost of Recovery:** The total estimated cost for recovery of *Silene spaldingii* is $8,601,500 with an average yearly cost across the first 5 years of $349,900. Of the estimated total, roughly a quarter of the dollars are for surveys and monitoring.

**Date of Recovery**: If recovery actions are prompt and effective, delisting might be possible as early as 2040. Because *Silene spaldingii* is a long-lived perennial species, annual counts vary significantly in response to climatic events (*i.e.*, precipitation, temperature), and individuals may exhibit prolonged dormancy for up to 3 years, a minimum of 20 years of monitoring will be needed to determine long-term population trends. The earliest recovery date accounts for this long-term monitoring as well as the time it may take to supplement or establish new populations.

# TABLE OF CONTENTS

# LIST OF FIGURES

# I. Introduction and Overview

## A. INTRODUCTION

*Silene spaldingii* (Spalding's catchfly) is an herbaceous perennial plant. It is a regional endemic restricted to remnants of grasslands in eastern Washington, northeastern Oregon, west-central Idaho, western Montana, and barely extending into British Columbia, Canada. *S. spaldingii* is impacted by a variety of factors including competition with invasive nonnative plants; habitat destruction and fragmentation resulting from agricultural and urban development; habitat degradation; grazing and trampling by domestic livestock and native herbivores; herbicide treatments; annual climactic conditions (*i.e.*, drought cycles); climatic change; alterations in fire frequency, intensity, and seasonality; off-highway vehicles; and a loss of genetic material associated with small, fragmented populations.

*Silene spaldingii* was listed as a threatened species under the Endangered Species Act on October 10, 2001 (USFWS 2001). The intent of this draft recovery plan is to guide implementation of the recovery of *S. spaldingii*. The ultimate goal of our recovery program is to eliminate or eradicate threats to persistence and restore populations of threatened or endangered species to the point at which the protections of the Endangered Species Act are no longer necessary, and the species may be delisted. The broad recovery recommendations in this plan are twofold: (1) resolve the impacts to the species; and (2) ensure self-sustaining populations in the wild. Definitions for some of the terms that will be commonly used within this document are provided in Box 1.

*Silene spaldingii* has been assigned a recovery priority number of 8C on a scale of 1C (highest) to 18 (lowest), indicating a moderate degree of threats or impacts, high potential for recovery, potential conflict with economic activities, and its taxonomic status as a full species (Appendix A).

**Box 1. Definition of terms as used in this recovery plan.**

**conservation** – The controlled use and systematic protection of *Silene spaldingii* and its habitat.
**element occurrence record** – Location information stored by each State or Province's Natural Heritage Program or Conservation Data Center.
**extirpated** – Eliminated from a certain area.
**fire regime** – The frequency, intensity, and seasonality of fire within a given area.
**intact habitat** – A place or environment for *Silene spaldingii* that is not fragmented by agricultural fields, urban developments, etc., and where the native ecosystem is functioning with few invasive nonnative plants and suitable habitat for pollinators.
**key conservation area** – Significant populations and habitat of *Silene spaldingii* that have been identified by members of the technical team as the primary areas for recovery actions, protection, and conservation in this recovery plan. The defining criteria for key conservation areas are provided on page 42 of this plan.
**physiographic region** – Geographic regions delineated by their physical characteristics. These regions are segregated in this recovery plan because of their significant differences in plant communities, climate, soil properties, fire regimes, and invasive nonnative plants.
**prolonged dormancy** – When *Silene spaldingii* plants remain below the ground for up to 3 years under unfavorable conditions, such as drought. Summer dormancy is an example.
**protection (protected areas)** – Securing *Silene spaldingii* in areas that are either: (1) owned or managed by a government agency and with appropriate management standards in place for *S. spaldingii*; (2) managed by a conservation organization that identifies maintenance of the species as a primary objective for an area; or (3) on private lands with a voluntary, long-term conservation easement or covenant that commits present and future landowners to the perpetuation of the species.
**population** – An aggregation of element occurrence records of *Silene spaldingii* that are within 1 mile (1.6 kilometers) of one another.
**rangewide distribution** – *Silene spaldingii*'s distribution across all four states (Idaho, Montana, Oregon and Washington) as well as British Columbia, Canada.
**site** – Equivalent to a *Silene spaldingii* element occurrence record.

## B. SPECIES DESCRIPTION AND TAXONOMY

*Silene spaldingii* is a member of the pink or carnation family, the Caryophyllaceae. It was first collected by Henry Spalding around 1846 near the Clearwater River in Idaho (Oliphant 1934) and later described by Sereno Watson in 1875, based on the Spalding material (Watson 1875). The species has no other scientific synonyms nor has its taxonomy been questioned. Common names include Spalding's catchfly, Spalding's silene, and Spalding's campion. *S. spaldingii* overlaps in range and is somewhat similar in appearance with *S. scouleri, S. douglasii, S. cserei, S. oregana*, and *S. scaposa scaposa* var. *scaposa* (see Figure 1) (Schassberger 1988; Youtie 1990; Lichthardt 1997). A simple key for distinguishing Pacific Northwest bunchgrass *Silene* is provided in Figure 2.

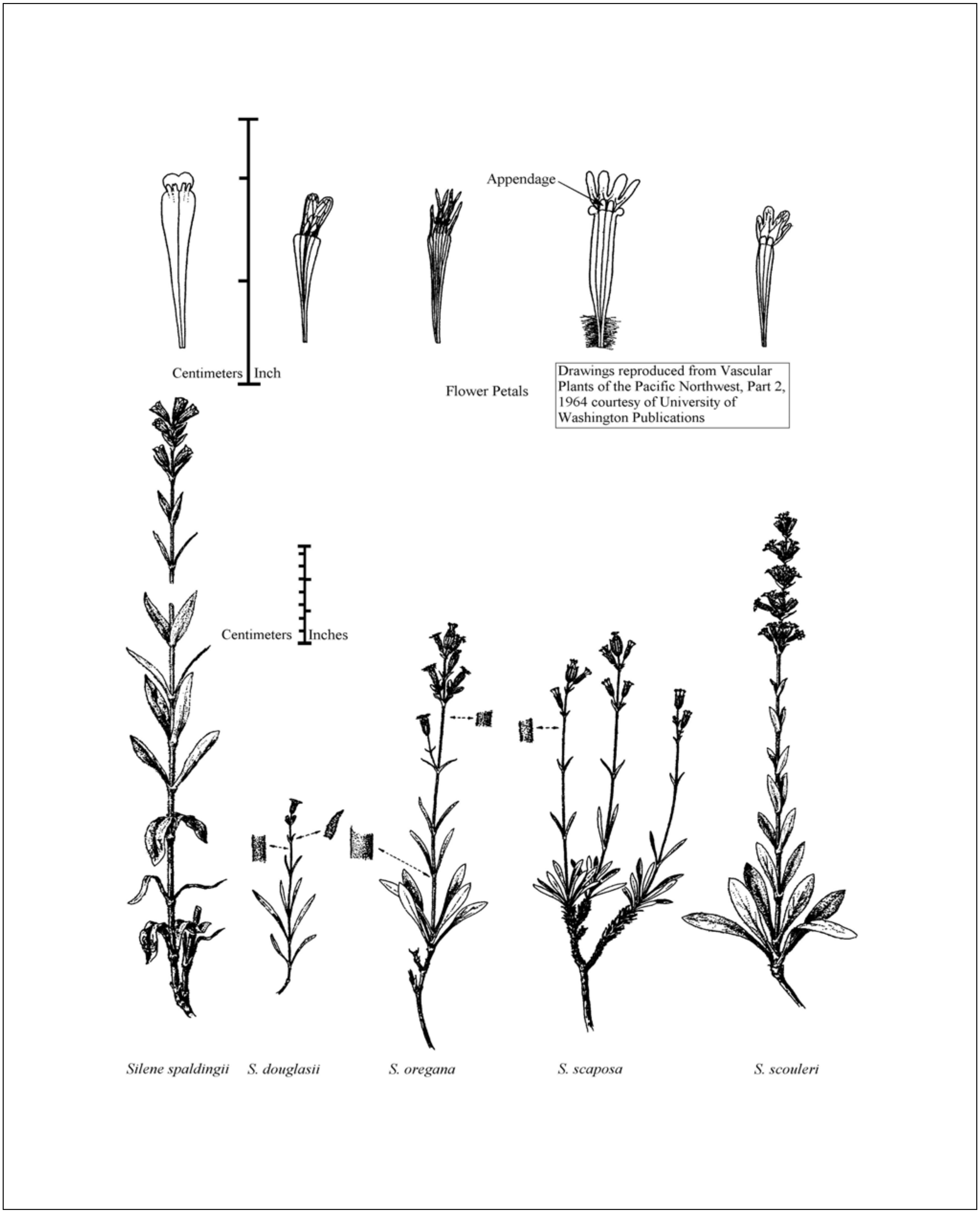
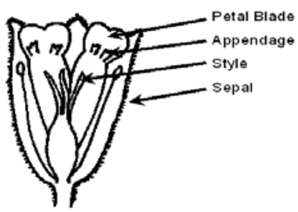



**Figure 1.** *Silene spaldingii* and a few of its closest look-alikes**.**

**1a** Styles generally 5 (the style is the narrowed portion of the pistil, connecting the stigma to the ovary)
**2a** Flowers of two separate types (male and female), petal blade >5 millimeters ………………………………………………………………… **bladder campion** (*Silene latifolia* ssp. *alba*)
**2b** Flowers of one type (contain both male and female parts), petal blade < 5mm …………………………………..………………………………… **Drummond campion** (*Silene drummondii*)
**1b** Styles generally 3
**3a** Sepals (united) smooth/hairless, often bell-shaped, depressed and indented at the point where the flower attaches to its stem, lightly 15-20-nerved, becoming membrane-like in texture; petals white, blades (upper portion of petals) 4-6 mm, bilobed, appendages lacking or reduced to tiny bumps (appendages are projections located on the inner surface of a petal at the junction of the petal blade and petal claw)
**4a** Sepals strongly inflated, up to 2 cm long when in post-flowering stage; fruit that forms is entirely surrounded by the sepal structure …………..………**maidenstears** (*Silene vulgaris* – was *S. cucubalus*)
**4b** Sepals slightly inflated, rarely as much as 1.5 cm long when in post-flowering stage; fruit that forms generally protrudes beyond the sepal structure……………………**Balkan catchfly** (*Silene cserei*)
**3b** Sepals (united) hairy, or plant not possessing the combination of characteristics listed under 3a
**5a** Annual plant (germinates, flowers, produces seed, and dies during one growing season)
**6a** Sepals (united) 25- to 30-nerved, shaped like an egg or inverted cone; depressed and indented at the point where the flower attaches to its stem; mostly over 20 mm long. Blade of petals with a small terminal notch in an otherwise rounded or blunt tip, 8-12 mm long. Appendages 2-5 mm long……………………………………………………………………….**conoid cat** (*Silene conoidea*)
**6b** Sepals (united) 10-nerved, usually tubular, and mostly not depressed and indented at the point where the flower attaches to its stem, 4-15 mm long. Blade of petals shallowly to deeply 2-lobed, 2-9 mm long; appendages 0.2-0.4 mm long
**7a** Sepals very prominently nerved with stiff, coarse hairs. Blade of petals 5-9 mm long, 2-lobed at least half of the length; appendages about 0.2 mm long ………………..**forked cat** (*Silene dichotoma*)
**7b** Sepals usually not prominently nerved with stiff, coarse hairs. Blade of petals 2-4 mm long, very shallowly-lobed at tip; appendages up to 0.4 mm long ………….**sleepy cat** (*Silene antirrhina*)
**5b** Perennial plant (generally lives for multiple years; regenerating each growing season from a persistent underground stem (caudex) just beneath the soil surface which sits atop a long, narrow taproot)
**8a** Petals, including the ovary stalk and blades, usually less than 10 (rarely 12) mm long; overall flower arrangement appears open and leafy ……………………….…. **Menzies' catchfly** (*Silene menziesii*)
**8b** Petals, including the ovary stalk and blades, usually over 12 mm long; overall flower arrangement appears more compact than as described above and mostly with considerably reduced bracts (leaf-like structures) attached below.
**9a** Blade of the petals 1-2 mm long, with no notch to a shallow terminal notch; ovary stalk smooth, without hairs or glands; appendages 4 (possibly 5-6); seeds inflated, about 2 mm long, the seed surface covered with alternating ridges and furrows…........**Spalding's catchfly** (*Silene spaldingii*)
**9b** Blade of the petals usually over 2 mm long and deeply lobed; ovary stalk mostly hairy; appendages sometimes only 2; seeds usually not over 1.5 mm long, the seed surface not covered with alternating ridges and furrows.
**10a** Appendages 4 or 6, linear; petals equally 4-lobed or the middle lobes again deeply divided; auricles usually lacking (auricles are ear-shaped lobes on the outer margins of the upper part of the petal's claw) …………………………………………..…...…**Oregon catchfly** (*Silene oregana*)
**10b** Appendages usually 2, or if 4 often not linear, or petals 2-lobed or unequally 4-lobed or with auricles
**11a** Ovary stalk 3-7mm long; petal blade 3-8 mm long, divided into 2 lobes for up to 1/3 of its length, rarely with a small lateral tooth on each margin of the petal blade
**12a** Plant with abundant glands on the overall flower arrangement itself and on the sepals; appendages mostly oblong and with more or less irregularly toothed margins, 1-3 mm long…………………………………………..…**Scouler's catchfly** (*Silene scouleri*)
**12b** Plant without glands or if present, only slightly glandular on the overall flower arrangement itself and on the sepals; appendages linear or narrowly oblong but not with irregularly toothed margins 1(rarely 3) mm long....**Douglas' catchfly** (*Silene douglasii*)
**11b** Ovary stalk 1.5-2.5 mm long; petal blade 2.5-5.5 mm long, may be almost completely unlobed or may be heart-shaped…………….**Scapose silene** (*Silene scaposa* var. *scaposa*)




Schematic *Silene* Flower

* key compiled by LeAnn Eno, Bureau of Land Management, Idaho (Hitchcock et al. 1964; Hitchcock and Cronquist 1973; Harris and Harris 1994)

**Figure 2.** Dichotomous key for Pacific Northwest Bunchgrass *Silene*.*

One closely related species, bladder campion (*S. latifolia* ssp. *alba*), is an invasive nonnative plant. It may be separated from *S. spaldingii* by bladder campion's much larger, inflated looking flowers.

*Silene spaldingii* is an herbaceous perennial, a plant that withers to the ground every fall and emerges again in spring. Plants range from 20 to 61 centimeters (8 to 24 inches) in height, occasionally up to 76 centimeters (30 inches). There is generally one light-green stem per plant, but sometimes there may be multiple stems. Each stem bears four to seven pairs of leaves that are 5 to 8 centimeters (2 to 3 inches) in length, and has swollen nodes where the leaves are attached to the stem. All green portions of the plant (leaves, stems, calyx [defined below]) are covered in dense sticky hairs that frequently trap dust and insects, hence the common name "catchfly." The plant has a persistent root crown atop a long taproot (1 meter [3 feet] or longer in length). The long taproot makes transplanting the species difficult at best, and perhaps impossible. Typically *S. spaldingii* blooms from mid-July through August, but it can bloom into September.

Three to 20 (up to 60) flowers are horizontally positioned near the top of the plant in a branched arrangement (inflorescence). Flowers are approximately 1 centimeter (0.5 inch) long; however, the majority of the flower petal is enclosed within a leaf like tube, the calyx, that resembles green material elsewhere on the plant and has 10 veins running from the flower mouth to the base of the flower. The visible portion of the five flower petals is small (2 millimeters [0.08 inch]), cream-colored, and extends only slightly beyond the calyx. Below the visible flower petals (blades) are four to six very small (0.5 millimeter [0.02 inch]) appendages, the same color as the blades (Figure 2). The flowers are perfect (have both male and female parts). Each fertilized flower matures vertically and becomes a many seeded (up to 150 seeds) cup-like fruit capsule. Fruits mature from August until September and one stem may have both flowers and mature fruit capsules at the same time. Seeds are small (2 millimeters [0.08 inch]), wrinkled, flattened, winged, and light brown when mature (the above plant description is adapted from Schassberger 1988; Gamon 1991; Lesica and Heidel 1996; Lichthardt 1997; Hill and Gray 2004a).

## C. POPULATION TRENDS AND DISTRIBUTION

Within the United States, *Silene spaldingii* is known from three counties in Idaho (Idaho, Lewis, and Nez Perce), four counties in Montana (Flathead, Lake, Lincoln, and Sanders), one county in Oregon (Wallowa), and five counties in Washington (Adams, Asotin, Lincoln, Spokane, and Whitman) (Idaho Conservation Data Center 2003; Montana Natural Heritage Program 2003; Oregon Natural Heritage Program 2003; Washington Natural Heritage Program 2003). Only one element occurrence record of *S. spaldingii* is known in British Columbia, Canada, and this site is located within 1 mile (1.6 kilometers) of plants in Montana (British Columbia Conservation Data Center 2004), therefore we consider these plants to be within one single population. Figure 3 depicts the rangewide distribution of *S. spaldingii*.

The distribution and habitat of *Silene spaldingii* are primarily restricted to mesic slopes, flats or depressions in grassland or steppe vegetation dominated by native perennial grasses such as *Festuca idahoensis* (Idaho fescue) or *Festuca scabrella* (rough fescue). Within its range, *S. spaldingii* occurs within five physiographic (physical geographic) regions: the Palouse Grasslands in west-central Idaho and southeastern Washington; the Channeled Scablands in eastern Washington; the Blue Mountain Basins in northeastern Oregon; the Canyon Grasslands of the Snake River and its tributaries in Washington and Idaho; and the Intermontane Valleys of northwestern Montana. The Palouse Grasslands, a subset of the Pacific Northwest bunchgrass habitat type (Tisdale 1986), are believed to have been at the center of *S. spaldingii*'s historical range.

Plants are tracked by State or province Heritage Programs or Conservation Data Centers by sites or element occurrence records. When *Silene spaldingii* was initially listed in 2001, it was known from 98 separate element occurrence records, or 58 populations if the element occurrence records within 1 mile (1.6 kilometers) of one another are grouped together[2]. Nine of these 58 populations were located within the Blue Mountain Basins (excluding 1 extirpated population), 5 from the Canyon Grasslands, 21 from the Channeled Scablands (excluding 2 extirpated populations and 2 with poor location records), 7 in the Intermontane Valleys (excluding 1 historical population and 1 with poor location records), and 16 within the Palouse Grasslands (excluding 1 extirpated population and 1 with poor location records). When examined by state there were 7 populations in Idaho, 6.5[3] in Montana, 9 in Oregon, 35 in Washington, and 0.5 in British Columbia, Canada (G. Glenne, *in litt*. 2004a). Some 16,500 individual plants were

[2] We defined populations of *Silene spaldingii* based on studies suggesting that genetic exchange via pollen transfer would typically not occur over a distance greater than 1 mile (1.6 kilometers) (see section D., Life History and Ecology, for details). Recent improvements in mapping technology and criteria for designating extirpated populations have allowed us to refine the delineation of *S. spaldingii* populations, suggesting that the 52 populations originally identified in the Final Rule listing the species (USFWS 2001) would have been more accurately reported as 58 populations.

[3] One population spans the border of the United States and Canada, reported here as 0.5 population.

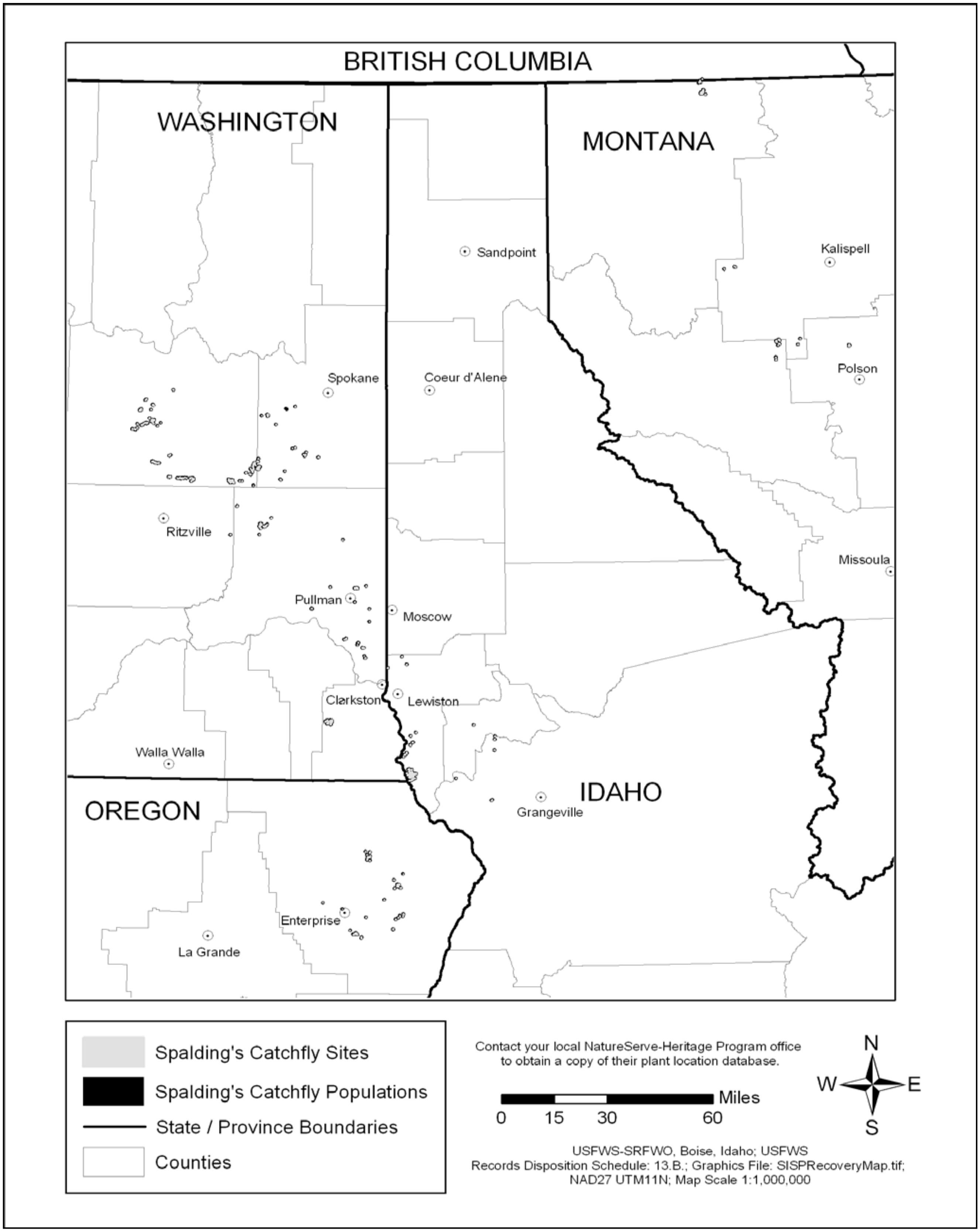



**Figure 3.** Rangewide distribution of *Silene spaldingii.*

estimated at the time of listing, although given the problems associated with counting plants due to prolonged dormancy this number should not be viewed as definitive.

Since *Silene spaldingii* was listed in 2001, increased survey efforts in suitable habitat have resulted in the identification of 27 new populations. Today we have 124 separate element occurrence records of *S. spaldingii* in 85 populations (Figure 3): 14 in the Blue Mountain Basins, 9 in the Canyon Grasslands, 35 in the Channeled Scablands, 9 in the Intermontane Valleys, and 18 in the Palouse Grasslands. When examined by state, there are 13 populations in Idaho, 8.5 in Montana, 14 in Oregon, 49 in Washington, and 0.5 in British Columbia, Canada (G. Glenne, *in litt.* 2004a). The number of individual plants in each population may range from one to several thousand. None of the newly discovered populations has resulted in any significant range extension, nor are they indicative of an increase in plant vigor. The current estimated number of plants is approximately 24,500 individuals, again a rough approximation.

It is expected that more populations of *Silene spaldingii* will be found in the future as survey efforts increase. To date, survey effort has been lower on privately owned lands than on publicly managed lands. Yet even with this lower survey effort, over half the known sites and estimated plant numbers occur on privately owned lands. Thirty-one of the known populations of *S. spaldingii* (36 percent) occur on lands that are entirely in private ownership, with an additional 19 populations (22 percent) in partial private ownership (G. Glenne, *in litt*. 2004a). The participation of private landowners, including organizations such as The Nature Conservancy, will therefore be vital in the recovery of this species.

There are only 7 populations of *Silene spaldingii* that may be considered relatively large, each with over 500 individuals (G. Glenne, *in litt*. 2004a). The largest population with over 10,000 plants is at The Nature Conservancy's Dancing Prairie Preserve in Montana, followed by Garden Creek, Idaho, with approximately 4,000 plants. The other 5 large populations range from 500 plants at Coal Creek, Washington, to some 1,613 individuals at The Nature Conservancy's Zumwalt Prairie Preserve in Oregon. Approximately 75 percent of the total known individuals of *S. spaldingii* are found within these few large populations. Of the 85 known *S. spaldingii* populations, just over two-thirds (58 populations, or 68 percent) are small populations, each made up of fewer than 100 individuals (G. Glenne, *in litt*. 2004a). Furthermore, much of the remaining habitat occupied by *S. spaldingii* is fragmented. For example, *S. spaldingii* populations in Oregon are located at least 64 kilometers (40 miles) from the nearest known populations in eastern Washington. When such small populations with few individuals are isolated and genetic exchange is not possible, they become vulnerable to the loss of genetic variation and, ultimately, the loss of the population itself (Barrett and Kohn 1991; Ellstrand and Elam 1993; see Section G-2 of this plan for further discussion).

It is not known how many *Silene spaldingii* individuals and how much habitat may have been lost to human related activities during the last 150 years since European settlement of this region. Historical documentation indicates the species has always been relatively rare (Hitchcock and Maguire 1947), but because most land conversions within the plant's historical range took place before botanical surveys had been done, we may never know how extensive or numerous *S. spaldingii* once was. Instead, we assume that the loss and alteration of large portions of suitable habitat have translated to a decline in population numbers. For example, the Palouse Prairie region (referred to in this plan as the Palouse Grasslands), centered around Pullman, Washington, and Moscow, Idaho, underwent a rapid and extensive conversion to agricultural lands around 1880 prior to significant botanical surveys of the area. It is estimated that more than 95 percent of the original Palouse Prairie and 47 percent of the Channeled Scablands habitat has been lost (Noss *et al.* 1995), with obvious ramifications for *S. spaldingii*. Today there are half as many known *S. spaldingii* populations (18 versus 35) within the Palouse Grasslands as the Channeled Scablands, but only a tenth of the plant numbers (477 versus 4,313,) indicating some measure of the loss of suitable habitat within the Palouse Grasslands and the extremely small size of the remnant populations there. Other areas such as the Canyon Grasslands have undergone a less dramatic land-use conversion, but have been and continue to be affected by livestock grazing and nonnative plant invasions.

Four population extirpations have been documented since tracking of *Silene spaldingii* began in the early 1980's (Schassberger 1988; Gamon 1991; Idaho Conservation Data Center 2003; Montana Natural Heritage Program 2003; Oregon Natural Heritage Program 2003; Washington Natural Heritage Program 2003). At least five other sites that formerly supported the species have been documented as having no plants present at the last visit (Washington Natural Heritage Program 2003). Populations are not necessarily considered extirpated, however, if sites are revisited and *S. spaldingii* is not found, because plants at these sites may be exhibiting prolonged dormancy (see discussion in Section D, Life History and Ecology, below). Subsequent visits are needed to confirm extirpations at such sites.

## D. LIFE HISTORY AND ECOLOGY

At the end of a 5-year demography study, 72 percent of *Silene spaldingii* plants remained alive (Lesica 1997), suggesting that individuals regularly reach an age of 15 to 20 years. However, it is hypothesized some individuals may live up to 30 years of age or longer. Seedlings generally sprout in spring, form rosettes the first year, and occasionally flower the second year (Lesica 1995), but generally flowering does not occur until during or after the third season (Lescia 1997). Adult plants emerge in spring, usually May, as either a stemmed plant, a rosette, or occasionally as a plant with both rosette(s) and stem(s) (Hill and Weddell 2003). Stemmed plants may remain vegetative or may become reproductive in July or August. Plants senesce or wither in fall (September or October), reappearing the next spring (Hill and Gray 2004a).

*Silene spaldingii* exhibits prolonged or summer dormancy; that is, plants can remain below the ground, without leaves, for up to 3 years when conditions are unfavorable (Lesica and Steele 1994; Lesica 1997). These unfavorable conditions are thought to be correlated with drought, although this is unclear. A preliminary analysis suggests prolonged dormancy tends to be higher in summers preceded by a wet summer and dry fall (P. Lesica, *in litt.* 2003). This prolonged dormancy can make population estimates and monitoring difficult. In one demography study, dormancy varied from a yearly low of 11 percent of individuals dormant to a high of 74 percent (Lesica 1997). Long-term monitoring is necessary to accurately assess population trends of *S. spaldingii*. Due to this ability to go dormant, population estimates of *S. spaldingii*, if based on visible plants, will always be lower than the actual population size (P. Lesica, *in litt.* 2003).

Seed dispersal studies have not yet been conducted on *Silene spaldingii*. However, the capsules of *S. spaldingii* serve as an open cup from which seeds are likely carried by the wind, jostled out by passing wildlife, or tossed when plants are knocked over. Plants are generally just taller than surrounding vegetation (Gamon 1991), and the seeds are small, flat, and somewhat winged. The plant height and seed characteristics suggest that short-distance wind dispersal may be common. In addition, the sticky nature of the plant makes it possible for portions of the plant to break off and stick to the fur of passing animals. This method of seed dispersal is probably infrequent but may provide an opportunity for more long distance dispersal. No studies have investigated how long seeds may remain dormant in the soil before they lose their viability or if they survive passage through the digestive tract of herbivores.

Two laboratory studies have looked at seed germination for *Silene spaldingii* (Lesica 1988a, 1993; A. Raven, Berry Botanic Garden, pers. comm. 2004). Both studies found an increase in germination after cold stratification (a period of chilling), suggesting germination occurs predominantly in the spring. However, results from a 4-week cold stratification period indicate some germination could occur in fall (Lesica 1988a, 1993). Lesica’s (1988a, 1993) study found 5 percent germination after 35 days without cold stratification and 60 to 70 percent germination after a 30-day cold stratification. An 8-week versus a 4-week cold stratification period greatly enhanced germination (Lesica 1988a, 1993). Preliminary results from the Berry Botanic Garden in Portland, Oregon, found the highest germination (86 percent) with an 8-week cold stratification treatment followed by growth in a germination chamber with alternating periods of time at temperatures of 10 and 20 degrees Celsius (50 and 68 Fahrenheit; thought to mimic night and day time temperature fluctuations) (A. Raven, pers. comm. 2004).

In a demography study, Lesica (1997) found that significant recruitment (germination and seedling survival) of *Silene spaldingii* occurred in only 2 of 7 years, indicating recruitment is a rare and sporadic event. After germination, Lesica (1988a) found seedlings began to grow immediately in small pots, continued growing for 2 months, remained green for another month, turned brown and went dormant for a month and a half, and then developed new leaves. It is hypothesized the initial growth would reflect early spring growth within native habitats, the dormant period would occur during the hot, dry summer, and re-growth would reflect fall growth (Lesica 1988a).

Measuring new recruits (seedlings) of *Silene spaldingii* within native habitats can be problematic. Adult plants can produce rosettes that are similar to those of seedlings. Various characteristics have been used to distinguish adult rosettes from seedling rosettes, including: seedling rosettes with a conspicuous lack of stem material between leaves (Hill and Weddell 2003; P. Lesica, *in litt.* 2003), adult rosettes with a conspicuous lack of stem material between the leaves (Hill and Weddell 2003; Hill and Gray 2004b), seedling rosettes with hairless leaves (Hill and Gray 2000; P. Lesica, *in litt.* 2003, Hill and Weddell 2003), seedling leaves with hairs only along the edges (Hill and Gray 2004b), and leaf size (Hill and Weddell 2003). None of these techniques are definitive and persons performing monitoring for the species should be aware of this constraint.

*Silene spaldingii* reproduces only by seed, with no means of vegetative reproduction (spread by vegetative growth) (Lesica 1993). The species is partially self-compatible, meaning the pollen is capable of fertilizing the female reproductive structures on the same plant. Flowers of *S. spaldingii* contain both male (stamen) and female (pistil) parts. However, the male parts mature, shed pollen, and wither prior to the female parts becoming receptive (Lesica 1988b). This reduces the chances of self-pollination within an individual flower, but still allows for pollination between different flowers on the same plant.

Using mesh bags to exclude pollinators, Lesica (1993) found significant decreases in fruit development, the number of seeds produced per fruit, germination after both a 4- and 8-week cold stratification period, seedling survival, and juvenile growth. Low pollinator visitation rates and a pollinator shifting more readily from *Silene spaldingii* to another plant species (lower pollinator constancy) were both correlated with reduced fruit set in *S. spaldingii* (Lesica and Heidel 1996). Lesica and Heidel (1996) found pollinator constancy and visitation rates were lower at sites where large displays of flowers competed for the primary pollinator, the bumblebee *Bombus fervidus*. Observational data suggested that these bumblebees preferred the nonnative invasive plant *Hypericum perforatum* (St. Johnswort) over *S. spaldingii* (Lesica and Heidel 1996). Collectively these studies suggest that *S. spaldingii* reproduces best when outcrossing occurs, pollinators are essential in maintaining the fitness of *S. spaldingii*, adjacent invasive nonnative plants may negatively impact reproduction, and pollinators must consistently visit *S. spaldingii*.

Pollinators were observed for over 20 hours at each of five *Silene spaldingii* populations across the range of the species, one in Idaho, one in Montana, one in Oregon, and two in Washington (Lesica and Heidel 1996). The populations selected occurred in relatively intact habitat with at least 100 plants in a population. Across populations, the bumblebee *Bombus fervidus* accounted for over 83 percent of all visitations. Other pollinators included solitary bees from the Halictidae family (*Lasioglossum ovaliceps*, *Halictus tripartitus*, *Dienoplus rugulosis*, *Lasioglossum* spp.), one wasp visit, and a minor contribution from a night-pollinating moth species in Oregon. Night pollination studies have not been performed.

*Bombus fervidus* is known from southern Canada and most of the United States, except the extreme south (Thorpe *et al.* 1983). The species is common within grasslands but rare in wooded foothills, and tends to build its nests either on or just below the surface of the ground, generally within the first foot (0.3 meter) of soil (Hobbs 1966). The queen emerges from hibernation in spring and establishes a seasonal colony that can contain over 200 individuals by fall (Hobbs 1966). In California, the queen flies from early April to late October, workers from early May to late October, and males from early July to early October (Thorpe *et al.* 1983). *Bombus* species are generally less faithful to a particular plant species than honey bees (*Apis* spp.) within a foraging trip and do not specialize on pollination of any one species or group of plant species; in other words, they utilize a wide range of plant species for nourishment (Stephen *et al.* 1969).

The distance that pollinators can travel is significant to plants because pollen transfer and seed dispersal are the only mechanisms for genetic exchange. In general pollinators will focus on small areas where floral resources are abundant; however, occasional longer distance pollination will occur, albeit infrequently. One study documented that bees fly 1 kilometer (0.6 mile) or less (Steffan-Dewenter and Tscharntke 1999). In another study, the bumblebee *Bombus terrestris* did not fly more than a distance of 621 meters (2,037 feet; Osborne *et al.* 1999). Another bumblebee pollinated plant species, *Scabiosa columbaria*, experienced decreased pollen flow at a patch isolation distance of 25 meters (82 feet), and little to no pollen transfer when patches were isolated by 200 meters (656 feet) (Velterop 2000). These studies suggest that genetic exchange via pollen transfer may be extremely rare for distances over 1 mile (1.6 kilometers, or 1,600 meters). This is one of the rationales we used when grouping *Silene spaldingii* sites within 1 mile (1.6 kilometers) of one another as populations.

Baldwin and Brunsfeld (1995) did a preliminary genetic analysis of *Silene spaldingii*. Leaf samples were taken from five sites, one in Idaho, one in Montana, one in Oregon, and two in Washington. Samples were collected during a year with low precipitation when many plants remained dormant and consequently sample sizes were small. All sites where material was collected were known to have at least 200 individuals in good years. This study found that genetic diversity of *S. spaldingii* was comparable to that of other rare *Silene* (*S. regia* and *S. hawaiiensis*), as well as other more common species in the genus (Dolan 1994; Westerbergh and Saura 1994). The only exception was that the Dancing Prairie site in Montana had lowered genetic diversity. This finding is consistent with the results of Lesica and Heidel's (1996) study, which reported lower pollinator visitation rates and a higher incidence of fruit abortion at the Dancing Prairie site. The Baldwin and Brunsfeld (1995) study also suggested that genetic diversity varies across the species' range, indicating that sites throughout the range of *S. spaldingii* need to be protected in order to preserve the full array of genetic variability within the species.

## E. HABITAT CHARACTERISTICS/ECOSYSTEMS

*Silene spaldingii* occurs at elevations between 420 to 1,555 meters (1,380 to 5,100 feet) (Idaho Conservation Data Center 2003; Montana Natural Heritage Program 2003; Oregon Natural Heritage Program 2003; Washington Natural Heritage Program 2003). In general summers are hot and dry, while winters are cool to cold and moist across the range of *S. spaldingii* (Western Regional Climate Center 2003a); anywhere from 45 to 65 percent of the precipitation occurs during the winter months (Daubenmire 1942; Mueggler and Stewart 1980). A drought period occurs in mid and late summer when precipitation is minimal and temperatures are high (Tisdale 1983). Consequently, most of the vegetation does not grow in summer, but can remain active during the winter months when moisture is more readily available. The majority of growth, however, occurs in spring (Daubenmire 1970). *S. spaldingii* is different; it grows during the summer drought when the majority of the surrounding vegetation is dormant.

Annual precipitation ranges from 254 millimeters (10 inches) near Odessa, Washington, to 610 millimeters (24 inches) near Moscow, Idaho (Western Regional Climate Center 2003b). Mean annual temperature ranges from a low of 6 degrees Celsius (43 degrees Fahrenheit) at Enterprise, Oregon, to 13 degrees Celsius (55 degrees Fahrenheit) at Wawawai, Washington (Hill and Gray 2004a). Average temperatures can vary significantly from winter to summer and from day to night. These are general climatic parameters; variations across the range of *S. spaldingii* can be dramatic and are heavily influenced by elevation, geography, and topography (Hill and Gray 2004a).

*Silene spaldingii* is generally found in deep loamy soils (fertile soils comprised of organic material, clay, sand, and silt) and in more mesic, moist sites such as northern slopes, swales, or other small landscape features (Hill and Gray 2004a). These mesic sites are highly productive, with total plant cover and forage dry weight sometimes three times greater than drier, more shallowly soiled bluebunch wheatgrass (*Agropyron spicatum* = *Pseudoroegneria spicata*) communities (Johnson and Simon 1987). Soils in the tri-state (Idaho, Oregon and Washington) area are loess (wind-dispersed) and ash (from volcanic eruptions) influenced (Tisdale 1986a; Johnson and Simon 1987), while soils in Montana are more glacially influenced (Schassberger 1988). *S. spaldingii* is found on a wide range of slopes, from flat areas to slopes as great as 70 percent. Most occurrences are found on grades ranging from 20 to 40 percent slope (Hill and Gray 2004a), although this may be an artifact of where intact habitat has not been converted to other uses.

*Silene spaldingii* is found primarily within the plant association known as the Pacific Northwest Bunchgrass Grasslands, extending from Washington and Oregon into parts of Montana and into adjacent British Columbia and Alberta, Canada (Tisdale 1983). This area has mistakenly, at times, been broadly described as the "Palouse Prairie" or the Palouse region (Tisdale 1983; Lichthardt and Moseley 1997; USFWS 2001). The term "Palouse Grasslands" will be used in this recovery plan to delineate a much narrower area than that covered by the Pacific Northwest Bunchgrass Grasslands (Figure 4). Pacific Northwest bunchgrasses are characterized by one or both of two main bunchgrass species, *Agropyron spicatum* (bluebunch wheatgrass) and *Fesctuca idahoensis* (Idaho fescue), with *Festuca idahoensis* sometimes co- or subdominant with *Festuca scabrella* (rough fescue) in Montana (Tisdale 1983). The summer drought across *S. spaldingii*'s range prevents tree species from establishing in most *S. spaldingii* habitats and results in a climax grassland community (Daubenmire 1968). Exceptions include the Dancing Prairie in Montana and Turnbull National Wildlife Refuge in Washington.

Primary grassland habitat types within the Pacific Northwest bunchgrass grasslands include: 1) *Festuca idahoensis – Symphoricarpos albus* (snowberry); 2) *Festuca idahoensis – Rosa* spp. (rose); 3) *Festuca idahoensis – Koeleria cristata* (prairie junegrass); 4) *Agropyron spicatum – Festuca idahoensis* or *Festuca idahoensis – Agropyron spicatum*; and 5) *Festuca scabrella* (Daubenmire 1970; Mueggler and Stewart 1980; Tisdale 1986b; Johnson and Simon 1987). Primary shrub habitats include: 1) *Artemesia tridentata* (big sagebrush) – *Festuca idahoensis*; and 2) *Artemesia tripartita* (three-tip sagebrush) – *Festuca idahoensis*. Primary forest habitat types include: 1) *Pinus ponderosa* (ponderosa pine) – *Festuca idahoensis*; and 2) *Pinus ponderosa – Symphoricarpos albus*. Seventy-three percent of known *Silene spaldingii* occurrences are within grassland habitat types, 20 percent within shrub habitat types, and 7 percent within forest habitat types (summarized by Hill and Gray 2004a). Some of the most difficult nonnative invasive plants to control in *S. spaldingii* habitat include *Centaurea solstitialis* (yellow starthistle), *Cardaria draba* (whitetop), *Centaurea maculosa* (spotted knapweed), *Euphorbia esula* (leafy spurge), *Hypericum perforatum* (St. Johnswort), and *Potentilla recta* (sulfur cinquefoil).

We have split the occupied habitat of *Silene spaldingii* into five physiographic regions that are characterized by distinctive physical features. These regions are distinctive from one another in climate, plant composition, historical fire frequencies, and soil characteristics. These differences are significant in that they may translate into

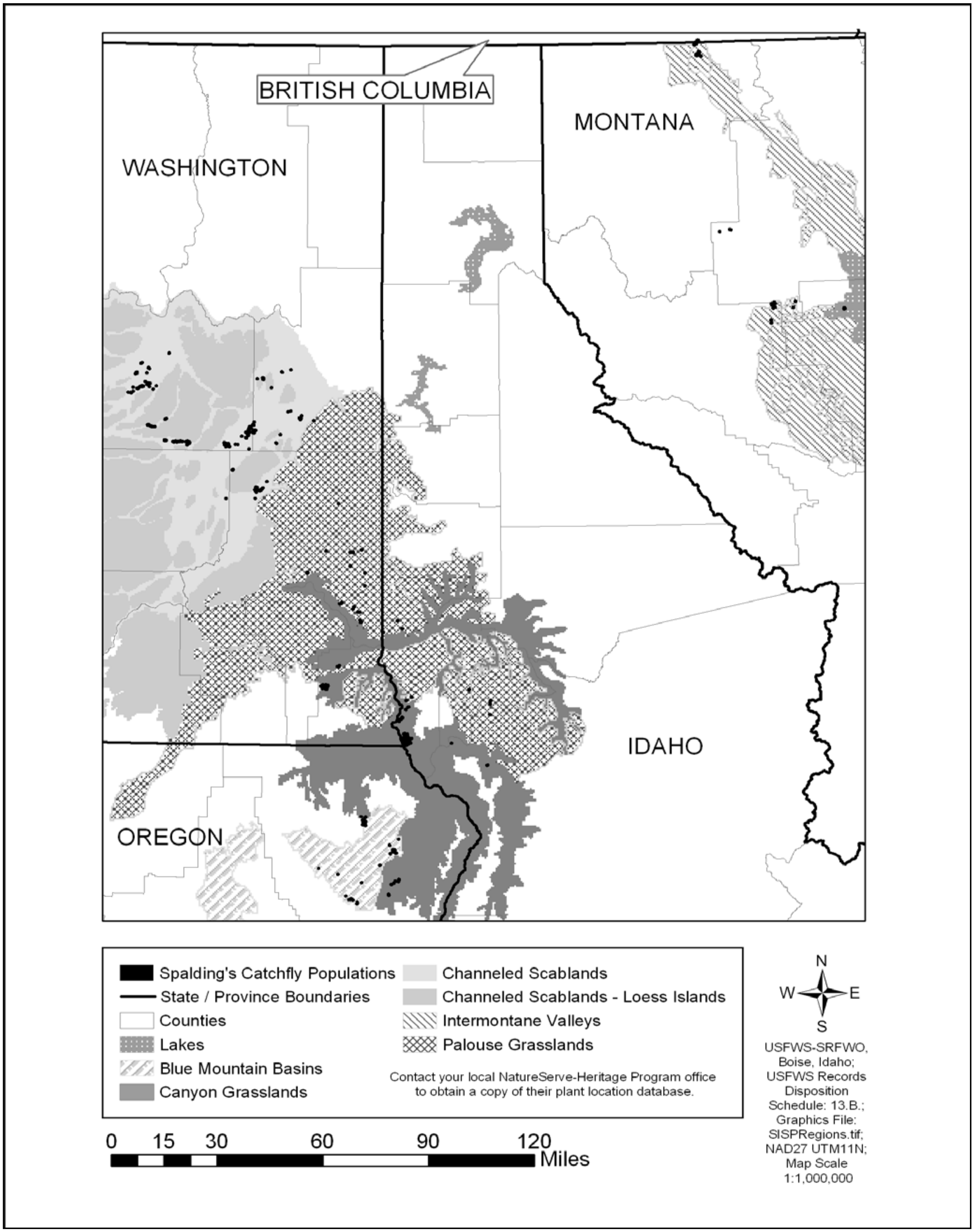



**Figure 4.** Physiographic regions where *Silene spaldingii* has been found.

differences in life histories, habitat trends, consequences of fire suppression, and types of weed control as they apply to conservation of *S. spaldingii*. The five physiographic regions utilized in this recovery plan are:

(1) the **Blue Mountain Basins** in northeastern Oregon;
(2) the **Canyon Grasslands** along the Snake, Salmon, Clearwater, Grande Ronde, and Imnaha Rivers in Idaho, Oregon, and Washington;
(3) the **Channeled Scablands** of east-central Washington;
(4) the **Intermontane Valleys** of northwestern Montana; and
(5) the **Palouse Grasslands** in southeastern Washington and adjacent west-central Idaho.

These regions are shown in Figure 4, and were delineated by taking the physiographic regions from Hill and Gray (2004a) and relating the regions to the more widely used Level IV Ecoregions for each state (U.S. Environmental Protection Agency 2004). The only *S. spaldingii* populations that did not fit well into the regions characterized in Figure 4 were those on Clear Lake Ridge in Oregon and those at Lost Trail National Wildlife Refuge in Montana. The Clear Lake Ridge populations will be included with the Blue Mountain Basins here instead of the Canyon Grasslands, as pictured in Figure 4, and the Lost Trail populations are included within Montana's Intermontane Valleys.

Of the five physiographic regions where *Silene spaldingii* is found, the habitat of the Canyon Grasslands is the most intact, largely because the canyon walls are steep and do not lend themselves to agricultural or urban developments. The Canyon Grasslands range widely in elevation, as evidenced by the presence of Hells Canyon, the deepest canyon in the United States at a depth of 2,400 meters (7,900 feet; Alt and Hyndman 1989). The lowest elevation (420 meters [1,380 feet)] population of *S. spaldingii* occurs within the Canyon Grasslands (Idaho Conservation Data Center 2003). The dramatic range in elevation within the Canyon Grasslands results in marked variations in the climate and vegetation. Soils within the Canyon Grasslands range from solid bedrock cliffs to deep loess and ash deposits (Alt and Hyndman 1989).

Within the Canyon Grasslands, *Silene spaldingii* is found at elevations from 420 to 1,220 meters (1,380 to 4,000 feet) on northerly slopes that support more mesic *Festuca idahoensis* communities. Because of their steep nature, the Canyon Grasslands are the most undersurveyed area for *S. spaldingii*, and also represent the area where large populations of *S. spaldingii* may be most easily conserved because they are more removed from human influence.

The Channeled Scablands have formed similarly to the Palouse Grasslands except that massive flooding, associated with bursting ice dams in the last ice age 12,000 to 16,000 years ago, has scoured the area (Mueller and Mueller 1997). This scouring has created a network of various habitats (loess islands surrounded by flood channels) that is far less consistent than the deep soil deposits of the Palouse Grasslands. Soils vary from basalt bedrock outcroppings to fertile loess and ash deposits to flood deposits (Daubenmire 1970). An interesting landscape feature of the Channeled Scablands is referred to as "biscuit and swale" topography, commonly used to describe small biscuit-like loess mounds that are 1 meter deep by 5 meters in diameter (3 feet deep by 15 feet in diameter) and are regularly dispersed over scablands or bare tracts of basalt outcrops (Daubenmire 1970). Like the Palouse Grasslands, the loess islands that remain in the Channeled Scablands are fertile and consequently have been largely converted to agriculture.

*Silene spaldingii* is reported to be primarily associated with relict flood channels within the Channeled Scablands (see Figure 4). More specifically, *S. spaldingii* is generally found on northern facing slopes below talus or rock outcroppings, gentle northern slopes just above valley floors, or on the northern sides of biscuits (B. Benner, *in litt*. 1993). The species is found at elevations from 472 to 747 meters (1,550 to 2,450 feet) within the Channeled Scablands. Since we lack earlier botanical surveys, we do not know how much *S. spaldingii* may have formerly occurred within the loess islands between channels. However, its affinity for deep soils elsewhere indicates that habitat conversion has most likely reduced the number of plants found on these loess islands.

The Intermontane Valleys of northwestern Montana were glaciated more heavily than any other part of Montana. The valleys have been shaped by glacial activity associated with the continental ice sheet and the formation of Glacial Lake Missoula during the last ice age (Alt and Hyndman 1986). Topography in this region is characterized as "kettle and moraine." Kettles are steep-sided hollows without surface drainage and moraines are earth and stone deposits; both are formed by glacial flows. Glacial sediments that are generally less fertile than loess or ash deposits comprise the soils (Daubenmire 1970).

*Silene spaldingii* populations within Montana are disjunct (separated by well over 160 kilometers [100 miles]) from *S. spaldingii* sites elsewhere. Plants have only been found near Eureka on the Tobacco Plains, in the Niarada and Flathead Lake area, and, most recently, on the Lost Trail National Wildlife Refuge. The species is found at elevations from 820 to 1,150 meters (2,700 to 3,800 feet) within the Intermontane Valleys. *S. spaldingii* is found in small isolated grasslands outside the larger valleys delineated in Figure 4, demonstrated by the recent discoveries at the Lost Trail National Wildlife Refuge. Within Montana, *Festuca idahoensis* is codominant or subdominant with *Festuca scabrella*, sometimes near the forest's edge.

The Palouse Grasslands, as delineated here (Figure 4), are extremely fertile and may comprise the world's best wheat land (Alt and Hyndman 1989). An underlying basalt layer is covered with deep deposits of loess and ash, forming long undulating dune-like plains of rich soils. These soil deposits can reach depths of 105 to 140 meters (350 to 450 feet), although generally less (Mueller and Mueller 1997), and have high moisture-holding capacity and water infiltration rates (Johnson and Simon 1987). Occasionally tall granitic hills ("steptoes") protrude above the undulating dunes. Beginning in 1880, the Palouse Grasslands have undergone a dramatic conversion to farm lands. So much so, it is estimated that today only 0.1 percent of the grasslands remain in a natural state (Noss 1995; Noss *et al.* 1995). The remains of the Palouse Grasslands include small remnants in rocky areas or at field corners (Daubenmire 1970; Tisdale 1986b). The Camas Prairie in Idaho between the Clearwater and Salmon Rivers is included with the Palouse Grasslands here because soil properties and land conversions are similar; however, the Camas Prairie is generally higher in elevation and cooler and moister than other portions of the Palouse Grasslands (Ertter and Moseley 1992; Lichthardt and Moseley 1997).

*Silene spaldingii* within the Palouse Grasslands is restricted to small fragmented populations ("eyebrows[5]," field corners, cemeteries, rocky areas, and steptoes) on private lands, and in larger remnant habitats such as research lands owned by Washington State University. Elevations occupied by *S. spaldingii* within the Palouse Grasslands range from 700 to 1,340 meters (2,300 to 4,400 feet). Of all the places where *S. spaldingii* resides, the Palouse Grasslands are the most threatened, and care is needed to maintain occupied sites and representative genetic material from these sites.

The Blue Mountain Basins were once contiguous Pacific Northwest Bunchgrass Grasslands. Today much of the Wallowa Valley has been converted into residential or urban areas surrounded by agricultural and grazing lands. Soils are composed of deep loess similar to the Palouse Grasslands or glacial till soils such as those at the head of Wallowa Lake.

*Silene spaldingii* ranges from 1,130 meters (3,700 feet) to its highest known elevation (1,555 meters [5,100 feet]) within the Blue Mountain Basins, specifically the Wallowa Valley (Oregon Natural Heritage Program 2003). The basin abuts habitat characterized as Canyon Grasslands, with no clear demarcation between the two regions. In the Blue Mountain Basins, *S. spaldingii* is often found along slopes of low broad ridges and ridgebrows, some with biscuit and swale topography (Hill and Gray 2004a). Within the Wallowa Valley, habitat is highly dissected by urban and agricultural lands. A large *S. spaldingii* population (over 500 individuals) occurs at the end of Wallowa Lake. This population is the largest occurring on private land, other than land owned by The Nature Conservancy, and is threatened by urban development.

[5] "Eyebrows" are patches of prairie that occur along rocky ridges that were too steep to farm. They appear as "eyebrows" on the landscape because they have more vegetation than the surrounding farmlands.

Rangewide suitable habitat for *Silene spaldingii* would include all flat and northern slopes between 420 to 1,555 meters (1,380 to 5,100 feet) in elevation within *Festuca idahoensis* and *Festuca scabrella* communities that are associated with Pacific Northwest bunchgrasses, sagebrush-steppe, and open pine forests. However, even within what is presently understood to be suitable habitat, *S. spaldingii* is quite infrequent (rare). If another habitat parameter was identified that would help to narrow the definition of suitable habitat for this species, field searches could become more focused. At present it appears that there are vast tracts of suitable habitat for *S. spaldingii* on private and public lands within the Canyon Grasslands, Channeled Scablands, Intermontane Valleys, and the Blue Mountain Basins. Identifying a mechanism to help facilitate searches on these lands may identify other large populations where conservation efforts could occur.

## F. ASSOCIATED SPECIES OF CONSERVATION CONCERN

Rare animal species that occur within *Silene spaldingii*'s range include the Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*). Rare endemic plant species include *Aster jessicae* (Jessica's aster), *Astragalus riparius* (Piper's milk-vetch), *Calochortus macrocarpus* var. *maculosus* (green-band mariposa lily), *Calochortus nitidus* (broad-fruit mariposa), *Cirsium brevifolium* (Palouse thistle), *Haplopappus liatriformis* (Palouse goldenweed), *Polemonium pectinatum* (Washington polemonium), *Rubus nigerrimus* (Northwest raspberry), and *Trifolium plumosum* var. *amplifolium* (plumed clover) (Hill and Gray 2004a). Many of these species face the same impacts as does *S. spaldingii* and some are more restricted in distribution. Conservation activities implemented through this recovery plan should, whenever possible, include the rare species listed above.

## G. REASON FOR LISTING/THREATS ASSESSMENT

Section 4(a)(1) of the Endangered Species Act identifies five factors or categories of threats that are considered when making listing, delisting, or reclassification decisions. In the narrative threat assessment that follows, we have classified the threats to *Silene spaldingii* according to these five factors, which are as follows:

A — The present or threatened destruction, modification, or curtailment of habitat or range;
B — Overutilization for commercial, recreational, scientific, or educational purposes;
C — Disease or predation;
D — The inadequacy of existing regulatory mechanisms; and
E — Other natural or man-made factors affecting the continued existence of a species.

### 1. Invasive Nonnative Plants (Factor A)

Invasive nonnative plants (weeds) are called the “silent invaders” because they subtly invade and alter diverse native communities into nonnative plant monocultures that support little wildlife. For example, in Idaho over the last 30 years, *Centaurea solstitialis* (yellow starthistle) has increased from a few small patches to 120,000 hectares (300,000 acres) (Westbrooks 1998). Since the 1960s, *Chondrilla juncea* (rush skeletonweed) has expanded in Idaho from 16 hectares (40 acres) to more than 1,600,000 hectares (4,000,000 acres) (Westbrooks 1998). *Centaurea maculosa* (spotted knapweed) is considered to be “the number one weed problem on rangeland in western Montana” (Whitson *et al.*1996) and has infested more than 1,900,000 hectares (4,700,000 acres) in the state (Westbrooks 1998). And, in southeastern Washington, *Centaurea solstitialis* has increased from 400 hectares (1,000 acres) in 1954 to more than 56,650 hectares (140,000 acres) (Westbrooks 1998).

Many experts believe that following habitat destruction, invasive nonnative plants are the next greatest threat to biodiversity (Randall 1996). Nonnative plant invasions have been identified by numerous individuals working with *S. spaldingii* as one, if not the largest, of the threats facing the species and its habitat (Hill and Gray 2004a). Invasive nonnative plants alter different attributes of ecosystems including geomorphology, fire regime, hydrology, microclimate, nutrient cycling, and productivity (for a good summary see Dukes and Mooney 2003).

Invasive nonnative plants detrimentally affect native plants, including rare plants like *Silene spaldingii*, through competitive exclusion, niche displacement, hybridization, and changes in insect predation; examples are widespread among taxa and locations or ecosystems (D’Antonio and Vitousek 1992; Olson 1999; Mooney and Cleland 2001). Examples of rare plants being affected by invasive nonnative plants follow. Invasive nonnative annual grasses (including *Bromus* spp.) significantly increased mortality and decreased survivorship, plant size, and reproductive output in an endangered annual herb (*Amsinckia grandiflora* [large-flowered fiddleneck]) (Pavlik *et al.* 1993). In another study, Huenneke and Thomson (1995) found that competition from *Dipsacus sylvestris* = *Dipsacus fullonum* ssp. *sylvestris* (teasel), an invasive nonnative plant, negatively affected growth and seedling recruitment in the threatened *Cirsium vinaceum* (Sacramento Mountains thistle). In Montana, Lesica and Shelly (1996) found that *Centaurea maculosa* reduced recruitment and population growth of the rare *Arabis fecunda* (Mt. Sapphire rockcress).

Annual invasive nonnative grasses co-occur with *Silene spaldingii* at most if not all populations and pose a threat to the species. They are most commonly represented by *Bromus japonicus* (Japanese brome), *Bromus secalinus* (cheat), *Bromus tectorum* (cheatgrass), and *Ventenata dubia* (ventenata) (Hill and Gray 2004a). *Bromus tectorum*, for example, has contributed to the widespread degradation of native rangelands throughout the western United States. Due to its ability to germinate readily under a wide variety of environmental conditions, *Bromus tectorum* is extremely difficult to eradicate once established in native plant communities (Franklin and Dyrness 1988). In rangelands that are dominated by *Bromus tectorum*, seedling establishment of native perennial species may be limited by *Bromus tectorum*'s ability to compete for moisture (Young 1994). And most significantly, invasive nonnative grasses alter natural fire regimes (D'Antonio and Vitousek 1992; see Section G-3).

Rhizomatous[6] invasive nonnative plants, because of their deep and extensive root systems, are the most difficult invasive nonnative plants to remove from *Silene spaldingii* habitat, often requiring persistent herbicides for control. Persistent herbicides, such as picloram products, remain in the soil longer where they may be transported and affect non-target plant species, such as *S. spaldingii*. Co-occurring rhizomatous species include *Acroptilon repens* (Russian knapweed), *Chondrilla juncea* (rush skeletonweed), *Cirsium arvense* (Canada thistle), *Euphorbia esula* (leafy spurge), *Hypericum perforatum* (St. Johnswort), *Linaria dalmatica* (Dalmatian toadflax), and *Poa pratensis* (Kentucky bluegrass) (Hill and Gray 2004a).

Like the invasive nonnative annual grasses, a common strategy employed by invasive nonnative plants is to produce copious quantities of seeds. These species are difficult to control because seeds are capable of quickly spreading to new *S. spaldingii* habitats. Prolific seeding invasive nonnative plants found within or near *S. spaldingii* include *Acroptilon repens*, *Centaurea solstitialis*, *Centaurea diffusa* (diffuse knapweed), *Centaurea maculosa*, *Chondrilla juncea*, *Dipsacus sylvestris* (teasel), *Hypericum perforatum*, and *Potentilla recta* (Hill and Gray 2004a). Some of these species are also rhizomatous, making them doubly difficult to control.

Some of these invasive nonnative plants can invade and displace native plant communities in a relatively short period of time. For example, at Garden Creek Ranch, the largest *Silene spaldingii* population in Idaho (Idaho Conservation Data Center 2003), *Centaurea solstitialis* spread from approximately 60 hectares (150 acres) in 1987 to 810 hectares (2,000 acres) in 1998 (J. Hill, *in litt*. 1999). Another roadside *S. spaldingii* site in Idaho (Lawyer's Creek) was apparently extirpated as a result of the disturbance caused by highway construction in 1990 and the subsequent invasion of *Centaurea solstitialis* (Lichthardt 1997).

*Centaurea solstitialis* is found in the vicinity of all *Silene spaldingii* populations in Idaho (Lichthardt 1997). This aggressive and invasive nonnative plant can form almost complete monocultures, invading and outcompeting native species. Even small areas that experience soil disturbance are almost immediately colonized by *Centaurea*

---

[6] "Rhizomatous" plants have rhizomes, horizontal underground stems with leaves and buds that serve as a means of vegetative propagation. Such plants are particularly difficult to eradicate, as the rhizomes (and thus the plant) often survive most traditional methods of plant removal.

*solstitialis* or other invasive nonnative winter annuals (Lichthardt 1997). The seeds of *Centaurea solstitialis* can remain dormant in the soil for 10 years (Callihan and Miller 1997), making effective control of this invasive nonnative plant difficult. Previously, most *Centaurea solstitialis* within the Canyon Grasslands was restricted to southern slopes where *S. spaldingii* generally does not occur (Roché 1965). However, in recent years *Centaurea solstitialis* is expanding its ecological amplitude and invading the northern slopes as well (Hill and Gray 2000).

A 2-year study investigating the effects of invasive nonnative plants, such as *Centaurea solstitialis*, on *Silene spaldingii* at Garden Creek Ranch did not find any appreciable differences in plant vigor between invaded and uninvaded sites, although all *Centaurea solstitialis* and *Bromus tectorum* infestations were at least 2 meters (6.5 feet) away from existing *S. spaldingii* individuals (Menke 2003). The researcher proposed that the similarity in vigor of *S. spaldingii* plants may have been due to the relative site productivity, or that *S. spaldingii* and the invasive nonnative plants partition resources differently in space or time. Invasive nonnative plant effects on recruitment of *S. spaldingii* were not measured in this study. Alternatively, another study found that the greater the invasive nonnative plant cover, the lower the vigor of *S. spaldingii* at the Fairchild Air Force Base in Washington (Caplow 2002a).

Competition with other plant species for a limited number of pollinators, particularly competition with invasive nonnative plants, has the potential to adversely affect both fecundity and individual fitness in *S. spaldingii* (Lesica and Heidel 1996). These deleterious effects occur: (1) when insects switch from one plant species to another resulting in a transfer and loss of pollen to a second species: and (2) because insects will demonstrate preferences for plant species (including invasive nonnative plants) where resources are more easily obtained. That is, either a plant species is more abundant or the resources (pollen and nectar) a plant provides are more nutritive (Richards 1997). For example, investigations have found visitation rates of the bumblebee *Bombus fervidus* are lower for *S. spaldingii* when it co-occurs with the invasive nonnative *Hypericum perforatum* (Lesica and Heidel 1996).

Nonnative grasses such as *Agropyron cristatum* and *A. desortum* (crested wheatgrass), *Bromus inermis* (smooth brome), and *Poa pratensis* are used in rangeland revegetation within *Silene spaldingii* habitat. These grasses are used because they are broadly-adapted, widely available as seed, establish easily, are grazing tolerant, and provide competitive invasive nonnative plant control. Rangeland revegetation focuses on providing forage for livestock, erosion control, and watershed rehabilitation. However, there is an increasing body of research that demonstrates these nonnative grasses can decrease biodiversity and compete with native plants (summarized by Harrison *et al.* 1996). For example, *Agropyron* stands in 1966 in southern Idaho had already persisted for 30 to 50 years and were spreading into adjacent habitats (Hull and Klomp 1966, 1967). Other studies have also found nonnative planted grasses invading adjacent native communities (D'Antonio and Vitousek 1992). The planting of nonnative range grasses is thought to have eliminated habitat for *S. spaldingii* in several locations across its range, particularly in the Channeled Scablands (B. Benner *in litt.* 1993, 2003; B. Weddell *in litt.* 2003; Washington Natural Heritage Program 2003). Nonnative grasses are being planted at Corral Creek, near *S. spaldingii* sites in Idaho, and spreading along road corridors (K. Gray, *in litt.* 2004). For these reasons, nonnative grasses should not be used for restoration near *S. spaldingii* sites.

### 2. Problems Associated with Small, Geographically Isolated Populations (Factors A, E)

Most populations of *Silene spaldingii* are restricted to small, remnant patches of native habitat (Gamon 1991; Lichthardt 1997; Idaho Conservation Data Center 2003; Montana Natural Heritage Program 2003; Oregon Natural Heritage Program 2003; Washington Natural Heritage Program 2003; Hill and Gray 2004a). If populations are defined by grouping together sites within 1 mile (1.6 kilometers) of one another (a long distance for pollen transfer), there are 85 known populations of *S. spaldingii*. Of these 85 populations, 48 (56 percent) have fewer than 50 plants, and another 10 populations have 100 or fewer individuals, meaning that 68 percent of the populations have 100 or fewer individual plants overall (Figure 5) (G. Glenne, *in litt* 2004a). Many of these small remnant populations exist within habitat that is generally further degraded by one or more of the threats listed here. Many *S. spaldingii* populations are isolated from other populations by large distances, and the majority occur at scattered localities separated by habitat that is not suitable for the species, such as agricultural fields. For example, extirpation appears to be certain for at least two isolated *S. spaldingii* populations in Idaho due to their small size and habitat degradation (Lichthardt 1997). One of these populations consists of four individuals, and the other population has only one *S. spaldingii* plant. Even if the habitat was completely undisturbed, these populations would not be viable into the future. Such small *S. spaldingii* populations have likely persisted due to prolonged dormancy and the relatively long life span of the plants, but the likelihood of future recruitment in these populations to replace senescent individuals is vanishingly small.

Small populations are vulnerable to relatively minor environmental disturbances such as fire, herbicide drift, and nonnative plant invasions (Gamon 1991) and are subject to the loss of genetic diversity from genetic drift and inbreeding (Ellstrand and Elam 1993). Genetic drift, more prevalent in small populations, is the loss of genetic diversity through chance mating events. Inbreeding occurs when plants "self" (fertilization occurs within the same individual) or when closely related individuals mate, thereby reducing genetic diversity. Populations with lowered genetic diversity are more prone to local extinction (Barrett and Kohn 1991). Smaller populations generally have lower genetic diversity, and lower genetic diversity may in turn lead to smaller populations by

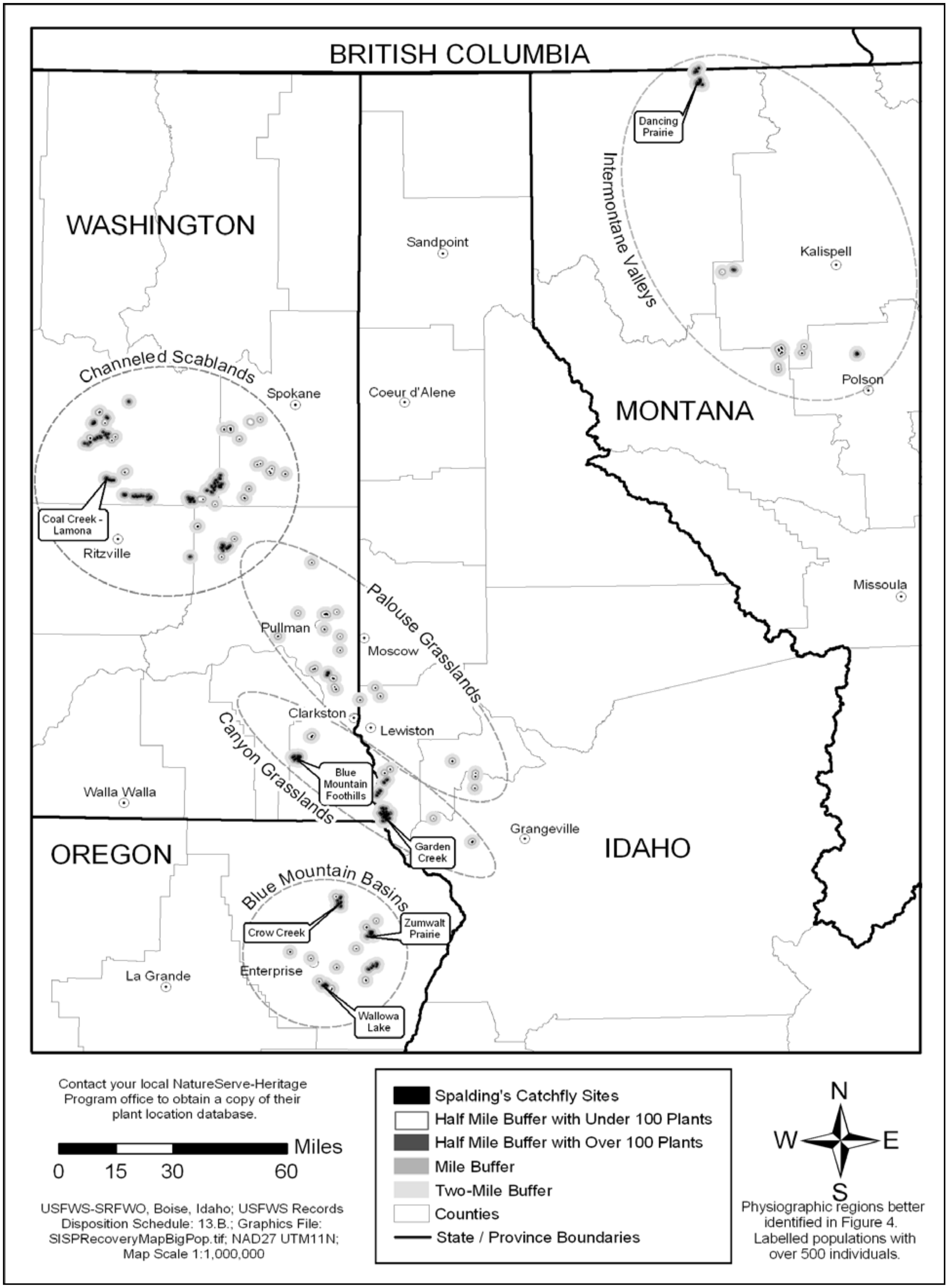



**Figure 5.** Known populations of *Silene spaldingii*.

decreasing the species' ability to adapt: a negative feedback loop. Relatively low levels of genetic exchange (one migrant per generation) are generally considered sufficient to counteract the effects of genetic drift (Newman and Tallmon 2001).

Habitat fragmentation, similar to that which has occurred in the Palouse Grasslands and other habitats where *S. spaldingii* resides, has been documented as a problem for many rare species. Often the fragments are not of sufficient size to support the natural diversity prevalent in an area and so exhibit a decline in biodiversity (Soulé 1987; Noss and Cooperrider 1994). Habitat fragments are often functionally smaller than they appear because edge effects impact the available habitat within the fragment (Lienert and Fischer 2003), and intense agricultural practices will affect adjacent fragments (Boutin and Jobin 1998). Habitat fragmentation has been shown to disrupt plant-pollinator interactions and predator-prey interactions (Steffan-Dewenter and Tscharntke1999) and alter seed germination percentages (Menges 1991a). Extensive habitat fragmentation, such as that seen in the Palouse Grasslands, can result in dramatic fluxes in available solar radiation, water, and nutrients (Saunders *et al.* 1991).

There are numerous examples of habitat fragmentation affecting native plant species. Reduced seed set, reduced plant-to-plant variability, and lower pollination intensity in smaller populations was found for a small forest herbaceous plant, *Primula elatior* (oxlip) (Jacquemyn *et al.* 2002). Lowered seed germination percentages were found in smaller prairie fragments of *Silene regia* (royal catchfly) (Menges 1991a). Within a heavily utilized agriculturally fragmented area, *Dianthus deltoides* (maiden pink) exhibited lowered diversity and abundance of both flowering plants and flower-visiting insects, as well as lowered seed set attributed to lower numbers of available pollinators (Jennersten 1988). Plants that were less capable of self-fertilization showed strongly reduced population viability with pronounced extinction thresholds at high levels of fragmentation (Lennartsson 2002). This reduced population viability was attributed to inbreeding and reduced seed production as a result of low numbers of pollinators.

For plant populations that do not reproduce vegetatively, pollen exchange and seed dispersal are the only mechanisms for gene flow. Pollen exchange, because of the opportunity for more reliable and specific long distance dispersal, is thought to be the more important of these two mechanisms (Fenster 1991; Richards 1997). Pollen dispersal in species requiring an insect for pollination, such as *Silene spaldingii*, is limited by the distance the pollinator can travel, in this case probably less than 1 mile (1.6 kilometers; see previous discussion in section D. Life History/Ecology). Reduced pollinator activity has been correlated with lowered reproductive success and possibly reduced genetic diversity for *S. spaldingii* (Lesica 1993; Lesica and Heidel 1996; Baldwin and Brunsfeld 1995). Populations of *S. spaldingii* occupying small areas surrounded by lands that do not support bumblebee colonies (*e.g*., crop lands) are not likely to persist over the long term (Lesica 1993; Lesica and Heidel 1996). In addition to agricultural conversion and pesticides, pollinators are vulnerable to plant herbicide applications, domestic livestock grazing, and fire, and these potential impacts to pollinators must therefore be considered in conservation strategies for *S. spaldingii* (Gamon 1991; Lesica 1993).

### 3. Changes in the Fire Regime and Fire Effects (Factor A)

Organisms adapt to disturbances such as historical fire regimes (fire frequency, intensity, and seasonality) with which they have evolved (Landres *et al.* 1999). Fire regimes within *Silene spaldingii* habitat in the western United States have been highly disrupted (Whisenant 1990; D'Antonio and Vitousek 1992; Mutch *et al.* 1993; Narolski 1996; Weddell 2001; Hilty *et al.* 2004). In some instances, fire suppression has allowed grasslands to be invaded by trees (Menges 1995; Conner *et al.* 2001; Lesica 1997, 1999; Lesica and Martin 2003). At the same time, in many grassland and shrub habitats fire frequencies have increased because of annual nonnative grass invasions (Whisenant 1990; D'Antonio and Vitousek 1992; Hilty *et al.* 2004). These annual nonnative invasive grasses fill gaps that would naturally occur between vegetation, dramatically increasing the ability of fire to spread. Annual nonnative invasive grasses are common within *S. spaldingii* populations rangewide (Hill and Gray 2004a). Seasonally, prescribed burns occur within *S. spaldingii* habitat during cool fall months as opposed to the hot summer months when fires would have historically burned (Hill and Gray 2004a).

The effect of fire on *Silene spaldingii* and its habitat has been investigated in two areas: the Intermontane Valleys at Dancing Prairie in Montana (Lesica 1999; Lesica and Martin 2003) and the Canyon Grasslands at Garden Creek Ranch in Idaho (Hill and Fuchs 2003; Hill and Weddell 2003; Hill *et al.* 2001; Menke 2003; Menke and Muir 2004). *S. spaldingii* and its habitat's fire response at these two sites have some similarities, but also some major differences. Both the Montana and Idaho studies found *S. spaldingii* adults were not killed by fires (Lesica 1999; Hill and Weddell 2003; Menke 2003; Hill and Gray 2004b). Fire apparently broke prolonged dormancy, so that plant numbers were higher the year subsequent to a fire in both Idaho and Montana (Lesica 1999; Hill and Fuchs 2003; Menke 2003), and more flowers were produced per plant after a fire (Lesica 1999; Hill and Weddell 2003), although fewer of these flowers developed mature fruit (Menke 2003).

Study results differed between the sites in that in Montana, *Silene spaldingii* seedling recruitment was significantly higher after fire, whereas in Idaho it was not (Hill and Weddell 2003). Habitat in Montana's Intermontane Valleys differs in that more litter accumulates in the presence of *Festuca scabrella* (over 11 centimeters [4.3 inches]) as opposed to the *Festuca idahoensis*-dominated grasslands in Idaho (1.3 centimeters [0.5 inch]) (Hill and Weddell 2003; Hill and Gray 2004a). Greater litter depth affects *S. spaldingii* seedling recruitment because it is difficult for seedlings to germinate under and grow through a dense litter layer (Lesica 1999; Hill and Gray 2004a). While fire appears necessary for maintaining grasslands and preventing tree and shrub encroachment in Montana (Lesica 1999), it may not be important in maintaining the drier grasslands within the Canyon Grasslands where a lack of moisture is thought to preclude tree and shrub invasion (Daubenmire 1970; Tisdale 1986b; Weddell 2001; Hill and Gray 2004a).

Nonnative plant invasions are affected by fires, both natural and prescribed, within *Silene spaldingii* habitat. Lesica and Martin (2003) found that the nonnative invasive plant *Potentilla recta* (sulfur cinquefoil) at Dancing Prairie in Montana demonstrated the highest recruitment within burned plots, although this recruitment did not translate to increased population growth. Also, fire seemed to reduce the efficacy of herbicide treatments on killing *P. recta*. One study at Garden Creek Ranch in Idaho found that monitoring plots established on either side of a fire line in very good-condition *Festuca idahoensis* habitat had significant increases in the frequency, basal cover, and density of both the nonnative plants *Centaurea solstitialis* (yellow starthistle) and *Bromus japonicus* (Japanese brome) in burned versus unburned plots 2 years after a burn (Hill *et al.* 2001). Another found more invasive nonnative plants at higher densities or cover in burned versus unburned sites 2 years after a burn (Hill and Weddell 2003). Conversely, another study in Idaho found decreased cover of the native *Festuca idahoensis*, an increase in the native forb *Lupinus sericeus* (silky lupine), and a constant cover in the native *Agropyron spicatum* (bluebunch wheatgrass), exotic grasses, and other forb species 2 years after a fire (Menke 2003). At one site in Washington, a prescribed burn escaped in 1997, burning *S. spaldingii* plants and habitat. Although the native bunchgrasses rebounded nicely, nonnative annual grasses are now dominant, opening the site to invasion by adjacent *Centaurea solstitialis* populations (J. Wood, *in litt.* 2004). Thus invasive nonnative plants, as a result of fire, may deleteriously affect *S. spaldingii* (see the discussion of “Invasive Nonnative Plants,” Section G-1, above).

The season or timing of fire has been shown to affect *Silene spaldingii* and its habitat. Lesica (1999) found that fall burning led to lower seedling recruitment for *S. spaldingii* than spring burning, and these effects continued to be apparent for 2 to 3 years after the burns. Most natural fires within *S. spaldingii*’s range would have historically occurred during the dry summer months, while today prescribed burning occurs during the cooler months when fires are more easily controlled. More studies are needed investigating the timing of both natural and prescribed burns and their effects on *S. spaldingii* and its habitat.

Management activities often seek to mimic historical fire regimes (Landres *et al.* 1999). Within forested stands, historical fire frequencies are relatively easy to establish by examining burn scars in tree rings. Establishing historical fire frequencies within grasslands is significantly more difficult because of the lack of trees to provide such a physical record. For example, within the Canyon Grasslands estimates of historical fire frequencies range widely, from every 6 to every 25 years (U.S Bureau of Land Management 2001; J. White, *in litt*. 2003), to infrequently (Weddell 2001). Weddell

(2001) argued that there is little specific data on the historical fire frequency of these grasslands, and that fire has damaging effects on two dominant bunchgrasses, *Festuca idahoensis* and *Hesperostipa comata = Stipa comata* (needle-and-thread grass), as well as on the microbiotic crusts commonly associated with *Silene spaldingii* that recover slowly after fire.

With or without accurate fire frequency data, *Silene spaldingii* does appear to be able to tolerate some fire (Lesica 1999; Hill and Fuchs 2003; Hill and Weddell 2003; Menke 2003). The effects of fires will vary at different *S. spaldingii* sites due to factors such as fuel moisture content, species composition, and season and intensity of burning (Lesica 1997). For example, burning while the plant is germinating or seeding will likely negatively affect reproduction. Most importantly, prescribed burning should not occur where invasive nonnative plants reside, since the establishment of these disturbance-adapted species can be promoted by fire (Christensen and Burrows 1986; Hobbs and Huenneke 1992; Lesica and Martin 2003).

### 4. Land Conversion Associated with Urban and Agricultural Development (Factor A)

Extensive land conversion has already occurred on private lands across the range of *Silene spaldingi*i, and 31 populations of *S. spaldingii* (36 percent) of those known to remain today occur entirely on privately owned lands, with an additional 19 populations (22 percent) in partial private ownership (G. Glenne, *in litt*. 2004a). These populations are currently affected by changes in land use practices, including certain livestock grazing practices, agricultural developments, and urbanization. Most surveys on private lands have been preliminary and occurred only once, often over 15 years ago, so it is difficult to know exactly how large or what impacts may be occurring at these populations. Rural population growth has increased over the last two decades in all counties where *S. spaldingii* resides (Hill and Gray 2004a).

Active housing development threatens to eliminate *Silene spaldingii* habitat near Redbird Ridge in Idaho (Lichthardt 1997). Unsurveyed residential developments immediately adjoining the Dancing Prairie Preserve owned by The Nature Conservancy in Montana, which has the largest *S. spaldingii* population rangewide, has destroyed potential habitat, increased the likelihood of nonnative plant invasions, and reduced management options such as controlled burning on the preserve (B. Martin, *in litt*. 1998). Continued development in this area is expected (B. Martin, *in litt*. 1998). *S. spaldingii* on private land near Wallowa Lake in eastern Oregon, one of the 7 sites with over 500 individuals, may be threatened by development (Oregon Natural Heritage Program 2003). Other *S. spaldingii* sites on private land in Idaho, Montana, and Washington are also threatened by development.

One *Silene spaldingii* site within Idaho is near an active gravel pit operation. Expansion of this gravel pit may be planned in the near future in association with a highway expansion project (G. Glenne *in litt.* 2004b). Although the *S. spaldingii* site will remain intact, disturbances associated with the gravel operation may increase the chance for nonnative plant invasions. In addition, dust has been shown to affect the energy and nutrient gathering processes of vegetation differentially, subsequently altering community composition (Farmer 1993).

### 5. Livestock Grazing and Trampling (Factors A, C)

Livestock grazing directly affects *Silene spaldingii* by the removal of flowers and/or seeds, thereby limiting reproduction for that season (G. Glenne, *in litt.* 2003). Most all life history stages contribute to population growth; however, for perennial herbaceous species, adult survival from one year to the next has been shown to be more important to population growth than fruit production (Silvertown *et al.* 1993; Crone 2001), and Lesica (1997) found that survival of *S. spaldingii* while dormant was most critical to population growth of this species. Livestock trampling may also affect *S. spaldingii* by destroying seedlings or breaking the root caudex[7], potentially killing the plant (B. Benner, *in litt.* 1995, 2003). *S. spaldingii* remains green when much of the surrounding vegetation is brown during late summer and so may be preferentially selected by livestock. This impact may be reduced at some sites because during late summer livestock often remain close to water sources, which are usually not near areas where *S. spaldingii* resides (B. Benner, *in litt.* 2003). Trampling by livestock may also threaten the nests of ground dwelling pollinators of *S. spaldingii*, including the bumblebee *Bombus fervidus* (Sugden 1985; Lesica 1993; Lesica and Heidel 1996).

More important than direct consumption or trampling impacts to *Silene spaldingii* is the habitat degradation associated with livestock disturbances (summarized by Fleischner 1994 and Jones 2000). Unlike the east side of the Rockies where grasslands coevolved with bison, grasslands and steppe communities west of the Rockies historically experienced little pressure from large, hooved animals (Mack and Thompson 1982) and so are impacted more severely by livestock grazing. Disturbances, most frequently linked to livestock grazing, have dramatically altered Western arid ecosystems in a progression from native perennial bunchgrass communities to invasive nonnative annual grasslands that are then susceptible to more invasive perennial plant invasions (Bock *et al.* 1993; J. DiTomaso, *in litt.* 2000; Knick *et al.* 2003). For example, the initial introduction and spread of the most prevalent invasive nonnative annual grass, *Bromus tectorum* (cheatgrass), throughout the range of *S. spaldingii* is attributed to overgrazing by livestock that occurred at the end of the 1800s and early 1900s (Mack 1981) (see the

[7] The caudex is the root crown, the persistent and often woody base of an otherwise herbaceous perennial plant.

section "Invasive Nonnative Plants" above for a better discussion on the effects of *Bromus tectorum*). Research on the nonnative *Centaurea maculosa* (spotted knapweed) and native grass *Festuca idahoensis* (Idaho fescue) found that sheep preferred *F. idahoensis*, and so accelerated the invasion of *C. maculosa* through selective grazing (Olson *et al.* 1997).

Livestock grazing has coexisted with *Silene spaldingii* for over 150 years, or an estimated seven generations of *S. spaldingii* (Mack 1981). The relatively long life span of this herbaceous perennial and its long taproot has likely helped *S. spaldingii* withstand some livestock grazing impacts. Without good historical population number estimates for comparison from the time prior to the initiation of livestock grazing, it is difficult to assess the expected declines over time. Instead, we must use shorter term, more evident losses such as loss of reproductive structures, individuals, and habitat degradation to infer an impact to *S. spaldingii* from livestock grazing. This is not to say that properly managed livestock grazing in conjunction with a good management program for invasive nonnative plants is not compatible with conservation of *S. spaldingii*.

### 6. Herbicide and Insecticide Spraying (Factor E)

Herbicide and insecticide spraying is a problem for *Silene spaldingii* both within contiguous wild lands as well as more fragmented landscapes. This problem has escalated in recent years as landowners and managers have realized that a large scale conversion to invasive nonnative plant populations is occurring, and have in turn resorted to more aggressive control measures. Herbicide spraying for invasive nonnative plants is occurring across *S. spaldingii*'s range via aerial (airplane or helicopter) spraying, boom spraying off a vehicle, and hand application on large tracts of wild lands as well as on more developed areas. On Federal lands and some State, Tribal, and private lands, surveys for *S. spaldingii* are occurring prior to spraying and if the plant is found actions are adjusted accordingly (see "Invasive Nonnative Plant Control Efforts" below). Other lands, particularly State, private, and highway right-of-ways, spray herbicides and pesticides without first surveying for *S. spaldingii* (J. White, *in litt.* 2003). In some instances these landowners are aware that *S. spaldingii* may occur within their ownership, and in other instances landowners may be unaware that the species occurs on their property.

Accidental herbicide spraying is also a possibility. One site at Cave Gulch on Craig Mountain, Idaho, was aerially sprayed in 1997; *Silene spaldingii* was later found near this site and may have been affected by this spraying (K. Gray, *in litt.* 2004). Another listed Canyon Grassland plant species, *Mirabilis macfarlanei* (Macfarlane's four-o'clock), was accidentally aerially sprayed in 1997 (C. Johnson, *in litt.* 1997). Herbicide spraying effects on *S. spaldingii* have not been researched, although it is reasonable to assume that broad spectrum herbicides such as glyphosate, picloram, and

2,4-D that kill most herbaceous perennials will also kill *S. spaldingii*. Furthermore, invasive nonnative plant control activities, if not conducted carefully, can impact other native species and so result in habitat degradation (Lass *et al.* 1999).

Smaller populations of *Silene spaldingii* that exist within small pieces of remnant habitat are often found along roads, in between fields, or in cemeteries. These small pieces of habitat are susceptible to direct herbicide application, such as those occurring along roadsides to control invasive nonnative plants. They are also susceptible to herbicide drift, which occurs when herbicides are sprayed nearby and float through the air impacting adjacent areas. Herbicide drift is especially a problem on windy days or with aerial applications where there is more opportunity for drift to occur. Herbicide drift threatens populations in Idaho (Lichthardt 1997; J. Hill, *in litt.* 1999), Oregon (J. Hustafa, U.S. Forest Service, pers. comm. 1999; J. Kagan, Oregon Natural Heritage Information Center, pers. comm. 1998), and Washington (Washington Natural Heritage Program 2003). For example, at least two *S. spaldingii* sites in Idaho are particularly vulnerable to herbicide drift because of their close proximity to cropland (Lichthardt 1997). The sticky hairs blanketing the surface of *S. spaldingii* may help to protect the plant from some herbicide drift, as observed in other hairy plant species (Miller and Westra 2004).

Grasshopper and other insect control programs generally utilize broad spectrum insecticides that will affect native bee species (Johansen *et al.* 1983). The effects of insect control programs on *S. spaldingii*'s pollinators are unknown at this time. Because the species requires pollinators to reproduce, deleterious effects to the primary pollinators of *S. spaldingii* will translate into decreased reproductive output (Tepedino 1996; Lesica and Heidel 1996).

### 7. Grazing (Herbivory) and Trampling by Wildlife Species (Factor C)

Grazing or browsing of *Silene spaldingii* inflorescences by native herbivores has been observed and is considered a threat to the species (Kagan 1989; Lesica 1993; Heidel 1995; B. Benner, *in litt.* 1999; Hill and Weddell 2003; Hill and Gray 2004a,b). While grazing or browsing of *S. spaldingii* by native herbivores has occurred historically, problems may arise when numbers of native ungulates (deer and elk) are at levels significantly higher than those to which the plant has adapted. For example, elk numbers are generally thought to have been historically low at Craig Mountain, Idaho; this is extrapolated from historical reports such as Lewis and Clark's comments on the paucity of wildlife along the Clearwater River in 1805 (Idaho Department of Fish and Game 2003). Elk were virtually absent from the Craig Mountain area until the 1960s (Idaho Department of Fish and Game 2003). In 1992 the Bonneville Power Administration purchased 60,000 acres on Craig Mountain for the State of Idaho as wildlife habitat (U.S. Bonneville Power Administration 2003). Elk herds have doubled over the last 20 years, with over 3,500 elk in the "Hells Canyon Zone" surrounding and including Craig

Mountain, and further increases are expected (Idaho Department of Fish and Game 2003). Long-term monitoring transects at Garden Creek Ranch, Craig Mountain, Idaho, found 50 percent of *S. spaldingii* reproductive stems were grazed in 2002 and 70 percent in 2003 in areas where livestock were absent, therefore native ungulates were likely responsible (Hill and Gray 2000; Hill and Weddell 2003; Hill and Gray 2004b). At the Kramer Prairie site in Washington, heavy grazing has occurred where livestock is excluded; deer are thought to be the cause (Wentworth 1996).

Rodent activity is also considered a significant factor affecting the persistence of *S. spaldingii* at several sites in eastern Washington and Idaho (B. Benner, *in litt.* 1999; Caplow 2001; Hill and Gray 2004b). For example, numerous *S. spaldingii* plants were marked with stakes and metal tags as part of a monitoring study on land managed by the Bureau of Land Management in Washington. On a site visit, the Bureau of Land Management botanist discovered that many of these plants were either broken off or missing completely and likely consumed by rodents, as evidenced by rodent burrowing activity in the area (B. Benner, *in litt.* 1999).

### 8. Off-Road Vehicle Use (Factors A, E)

Off-road vehicle impacts are known to occur at two *Silene spaldingii* populations, one in Idaho and one in Washington (Idaho Conservation Data Center 2003; Washington Natural Heritage Program 2003). At the site in Idaho, off-road vehicle use is thought to be the primary threat to *S. spaldingii* (Idaho Conservation Data Center 2003). Because the habitat where *S. spaldingii* occurs is made up of flat or rolling hills, the plant is susceptible to off-highway vehicle use at many sites rangewide. Off-highway vehicles may damage the caudex of *S. spaldingii*, likely killing the plant.

### 9. Insect Damage and Disease (Factor C)

Insect predation of foliage, flowers, and fruits of *Silene spaldingii* has been documented on numerous occasions (Heidel 1979; Kagan 1989; Youtie 1990; Gamon 1991; Lichthardt 1997; B. Benner, *in litt*. 1999; S. Riley, U.S. Forest Service, pers. comm. 1999; Hill and Gray 2000, 2004; Hill and Weddell 2003; R. Taylor, *in litt*. 2003; P. Lesica *in litt*. 2004). Predation on seed capsules has been documented to be as high as 90 percent at the Kramer Prairie, Washington, site (Heidel 1979), although lower percentages are more common. Most insect predation seems to be from larva (Hill and Gray 2000; P. Lesica, *in litt.* 2004), although a seed weevil (Kagan 1989; Youtie 1990) and some other beetles (Heidel 1979) have also been implicated. *Silene spaldingii* has coevolved with insect predation, and so some level of predation is part of the ecosystem balance. However, small population sizes and a decrease in genetic diversity, or the presence of invasive nonnative plants, may exacerbate problems with insect predation.

A fungal rust has been found on *Silene spaldingii* plants in Washington (B. Benner, *in litt*. 2004). It is unknown how this rust may be affecting the species or how often it occurs.

## 10. Impacts from Prolonged Drought and Global Warming (Factor E)

*Silene spaldingii* has adapted to drought, evident in its prolonged dormancy response. Prolonged dormancy is a great asset because it increases the likelihood of adult survival and therefore minimizes the effect of drought. Perennial plants that are adapted to arid environments, such as *S. spaldingii*, are negatively impacted by prolonged and severe droughts (Schultz and Ostler 1995). Prolonged periods of drought will increase the numbers of dormant individuals at a *S. spaldingii* site (Heidel 1995; Lesica 1997; B. Benner, *in litt.* 1999), limiting the number of individuals reproducing, which could make small populations more susceptible to extinction. Based on demographic studies of mapped individuals of *S. spaldingii*, Lesica (1997) considered plants that failed to reappear after 3 consecutive years to be dead.

Causes aside, global temperatures are increasing (U.S. Environmental Protection Agency 2000). The effects of this global warming are speculative, but it has the potential to affect rare plants such as *Silene spaldingii*. Researchers speculate that global warming will alter rainfall patterns, with some regions becoming drier and others wetter (Given 1994). Within the Pacific Northwest a recent model predicts warmer and wetter winters in 80 years (U.S. Department of Energy 2004). Because plants are stationary and can't easily move with a shifting climate, it is believed they are more susceptible to global warming than wildlife species (Wilson 1989).

## 11. Inadequacy of Existing Regulatory Mechanisms (Factor D)

*Silene spaldingii*, because of its threatened status, is protected on Federal lands where it occurs. Of the four states and one Canadian province where *S. spaldingii* resides, legal protection is provided only by the State of Oregon, where the species is listed as endangered by the Oregon Department of Agriculture (Oregon Department of Agriculture 2004). Plants listed as threatened or endangered in Oregon are protected only on State lands; however, no *S. spaldingii* plants are currently found on State lands in Oregon. Although not granted any legal protection, *S. spaldingii* is on the State of Washington's threatened species list and the red list in British Columbia. Therefore, *S. spaldingii* is not legally protected on any State or private lands. *Silene spaldingii* is not afforded protection by either the Species at Risk Act or the Canada Wildlife Act in Canada (Douglas *et al*. 2002).

Special Federal land designations such as Areas of Critical Environmental Concern, Research Natural Areas, and Botanical Special Interest Areas have not been designated within *Silene spaldingii* habitat except at Coal Creek, Washington, where an Area of Critical Environmental Concern has been established.

No protection is provided by State Natural Heritage Programs and Conservation Data Centers. However, their ranking system can help raise awareness for rare species. All four states and British Columbia rank the species as a G2 (imperiled globally because of rarity or because other factors demonstrably make it very vulnerable to extinction) S1 (critically imperiled in the applicable states or province because of rarity or some factor of its biology makes it especially vulnerable to extinction), except Washington where the State rank is S2, similar to the global (G) rank.

## H. CONSERVATION EFFORTS

### 1. Inventory Efforts

Surveys for *Silene spaldingii* are being conducted on most lands managed by the Federal government where the plant currently resides or where there is suitable habitat. Surveys for the species should be done to complete consultation under section 7 of the Endangered Species Act for projects such as invasive nonnative plant control activities, right-of-ways, power lines, Federal highway projects, military activities, prescribed burns, and land acquisitions. Although in general grazing allotments on federally managed lands have not been inventoried, grazing lease renewals are being surveyed in Washington (B. Benner, *in litt.* 2004) and in Oregon (G. Yates, *in litt.* 2004).

**(a) Idaho.** Within Idaho, extensive inventories have been conducted in the Craig Mountain Canyon Grasslands by The Nature Conservancy on their Garden Creek Ranch, by the Bureau of Land Management, during the course of a master's thesis project (Menke 2003), and by the Idaho Conservation Data Center. The Idaho Conservation Data Center has done some inventory work on the Craig Mountain Wildlife Management Area owned by the Idaho Department of Fish and Game. However, the majority of the known sites of *S. spaldingii* on Craig Mountain are located on Federal or Nature Conservancy lands. State owned lands are spread within and around these known sites and have generally not been inventoried. Surveys within the Craig Mountain area on State lands are being planned in the near future. Surveys on Tribal lands in Idaho have not yet occurred although funding has been secured to survey Nez Perce Tribal lands within *S. spaldingii*'s habitat in Idaho, Oregon, and southern Washington (A. Sondenaa, *in litt.* 2003). Palouse grasslands have generally been surveyed only in association with section 7 consultation projects, although increased attention to Palouse prairie fragments is leading to an increase in non-project specific inventory efforts.

**(b) Montana.** In Montana, the Montana Natural Heritage Program is conducting a status report, visiting all existing populations and searching some suitable habitat on the Kootenai National Forest, around The Nature Conservancy's Dancing Prairie Preserve, and in the Niarada area (C. Bjork, private consultant, pers. comm. 2003; Hill and Gray 2004a). In 2003, *Silene spaldingii* was discovered at the Lost Trail National Wildlife Refuge outside of areas delineated as suitable habitat in Figure 4. This discovery indicates that other isolated grasslands in Montana may be capable of supporting *S. spaldingii* and should be inventoried. The Plum Creek Timber Company, already working on conservation efforts for fish species, is a large landowner in the northwestern portion of Montana. Plum Creek Timber Company grasslands have not yet been searched for *S. spaldingii* (A. Wick, *in litt.* 2004). Funding is being sought to conduct further surveys for *S. spaldingii* on Tribal lands within Montana (U.S. Fish and Wildlife Service, *in litt.* 2004).

**(c) Oregon.** In Oregon, The Nature Conservancy is in the process of inventorying its recently acquired Zumwalt Prairie Preserve and their Clear Lake Ridge Preserve lands have been completely inventoried (R. Taylor, *in litt.* 2003). The Wallowa-Whitman National Forest has begun surveying active grazing allotments including areas within the Imnaha River Canyon and the lower Joseph Creek area (G. Yates, *in litt.* 2004). Funding has recently been secured for inventory work on Nez Perce lands (A. Sondenaa, *in litt.* 2003).

**(d) Washington.** In Washington, inventories are being conducted on lands owned by the Bureau of Land Management (B. Benner, *in litt.* 2003; C. Button, *in litt*. 2004), at the Fairchild Air Force Base (Caplow 2001), and at Turnbull National Wildlife Refuge (Weddell 2002). Swanson Lake Wildlife Area, owned by the State, has been partially inventoried and Wawawai Canyon near the Snake River, owned by the Washington Department of Natural Resources, has been inventoried (Caplow 2002b). Inventories for *Silene spaldingii* have been done at the Lime Hill Area of Critical Environmental Concern and in Joseph Canyon, in Asotin County, Washington (C. Button, *in litt*. 2005). Funding has recently been secured for inventories on Nez Perce Tribal lands in parts of Washington.

Many areas still remain to be inventoried where suitable habitat for *Silene spaldingii* exists. Because the Canyon Grasslands are extremely steep and quite remote, there are still significant portions of suitable habitat to be searched, particularly on the Oregon side of the Snake River directly across from Craig Mountain, along the lower Grande Ronde River in Oregon and Washington, the Imnaha River in Oregon, and the lower Clearwater and Salmon Rivers in Idaho (Hill and Gray 2004a). Over 40 percent of known *S. spaldingii* sites are on private land; in general, these private lands have had much less inventory effort. The possibility for large populations residing on private property can not be overlooked. Several recent land acquisitions in Washington (B. Benner, *in litt.* 2003), as well as The Nature Conservancy's acquisition in 2000 of the Zumwalt Prairie Preserve, have led to the discovery of large, previously unknown *S. spaldingii* populations.

## 2. Monitoring Efforts and Demographic Studies

**(a) Idaho.** In Idaho, 3 populations of *Silene spaldingii* have 19 monitoring or demography transects or plots located either on areas administered by the Bureau of Land Management or on lands managed by the Idaho Department of Fish and Game at Craig Mountain. Two of these populations, one managed by the State and the other by the Bureau of Land Management, have two permanent long-term monitoring plots each that have been monitored in 2001, 2002, and 2003 (Lichthardt and Gray 2002). The largest population in Idaho, Garden Creek Ranch, has four permanent long-term monitoring plots, all on Bureau of Land Management Lands, that were monitored in 2001, 2002, and 2003 (Lichthardt and Gray 2002), seven permanent demographic belt transects that compare a burned and unburned site within the population measured in 2002 and 2003 (Hill and Weddell 2003; Hill and Gray 2004b), three permanent belt transects that monitor nonnative plant invasions (two *Centaurea solstitialis* sites and one *Poa pratensis* site) monitored in 1999 and again in 2003 (Hill and Gray 2000; Hill *et al.* 2001; Hill and Fuchs 2002, 2003; J. Hill, *in litt.* 2003), and one permanent monitoring transect established in 1998 (U.S. Bureau of Land Management 1998). All of the monitoring plots and transects at Garden Creek Ranch are on Bureau of Land Management Lands. In addition, accurate mapping of seven *S. spaldingii* locales and invasive nonnative plants has been done at Garden Creek Ranch (Hill and Gray 2000; Hill *et al.* 2001) and a census effort was undertaken in establishing the eight permanent long-term monitoring plots for the three populations described above (Lichthardt and Gray 2002). At two of the seven permanent demographic belt transect sites, trend monitoring by census has been conducted for 5 consecutive years (Hill and Gray 2000; Hill *et al.* 2001; Hill and Fuchs 2002, 2003). In addition, 107 plots at 32 locales within the Garden Creek Ranch population on Bureau of Land Management and Nature Conservancy lands were established and monitored in 2001 and 2003 in conjunction with a master's thesis to monitor nonnative plant invasions and fire effects (Menke 2003).

**(b) Montana.** In Montana, monitoring occurred at Wild Horse Island from 1986 to 1992. A demography study has been ongoing at The Nature Conservancy's Dancing Prairie Preserve since 1987 (Lesica 1988c, 1988d, 1997, *in litt.* 2003) and at the Lost Trail National Wildlife Refuge in 2003 (P. Lesica, *in litt.* 2003).

**(c) Oregon.** In Oregon, monitoring plots were established at Clear Lake Ridge in 1990, but were not revisited until 2002 (Youtie 1990; Elseroad and Taylor 2002). The

Wallowa-Whitman Forest has funding to design a set of monitoring methodologies on their land as well as Nature Conservancy lands in Oregon (J. Hustafa, *in litt*. 2004a).

**(d) Washington.** In Washington, monitoring of individual plants has occurred at 10 sites in Lincoln County since 1995 in conjunction with habitat monitoring on lands where livestock grazing occurs (B. Benner, *in litt*. 1999, 2003). Plots have been monitored at Fairchild Air Force Base since 1995 (F. Caplow, *in litt.* 2003). Demography transects were established at Lamona and in the Blue Mountains in 2003 (P. Lesica, *in litt*. 2003).

### 3. Additional Sources of Scientific Information on *Silene spaldingii*

- Preliminary pollination biology for *Silene spaldingii* in Montana (Lesica 1988b)
- Germination requirements and seedling biology of *Silene spaldingii* (Lesica 1988a, 1993; A. Raven, pers. comm. 2004)
- Importance of pollinators for reproduction in *Silene spaldingii* in Montana (Lesica 1991, 1993)
- The effect of fire on *Silene spaldingii* in Montana (Lesica 1991, 1994, 1995, 1999)
- Preliminary genetic investigation of *Silene spaldingii* done at five locations, one in Idaho, one in Montana, one in Oregon, and two in Washington (Baldwin and Brunsfeld 1995)
- Pollination biology of *Silene spaldingii* at one site in Idaho, one in Montana, one in Oregon, and two in Washington (Lesica and Heidel 1996)
- An investigation of the utility of remote sensing techniques for mapping *Centaurea solstitialis* infestations in Idaho (Lass 1999; Hill 2002a, 2002b)
- Effects of invasive nonnative plants and fires on *Silene spaldingii* at Garden Creek Ranch, Idaho (Hill and Gray 2000; Hill et al. 2001; Hill and Fuchs 2002, 2003; Lichthardt and Gray 2002; Menke 2003; Gray and Lichthardt 2004)

### 4. Invasive Nonnative Plant Control Efforts

At the Craig Mountain Wildlife Management Area in Idaho spraying for *Centaurea solstitialis* (yellow starthistle) with 2,4-D and Tordon has occurred during the last 10 years, with approximately 20 to 220 hectares (50 to 550 acres) being treated each year. *Centaurea solstitialis* biocontrol agents have been released and monitored for the last 10 years. Approximately 4 hectares (10 acres) of *Onopordum acanthium* (Scotch thistle) have been treated for the last 15 years. Other invasive nonnative plants being treated include *Crupina vulgaris* (common crupina) and *Linaria* (toadflax). These spraying activities are expected to continue into the future. Known populations of *Silene* *spaldingii* are not sprayed; however, until 2004, surveys for *S. spaldingii* were not conducted prior to spraying (J. White, *in litt.* 2003).

Cooperative Weed Management Areas and County Weed Boards that work to control invasive nonnative plants have been established across much of *Silene spaldingii*'s range. For example, the Tri-State Weed Management Area, established by the Bureau of Land Management in 1996, encompasses 101,170 hectares (250,000 acres) on the Idaho, Oregon, and Washington borders. The intent of this Cooperative Weed Management Area is to bring together Federal, State, County, Tribal, and private organizations to control invasive nonnative plants, primarily *Centaurea solstitialis*, and educate the public about the threat invasive nonnative plants pose. The Tri-State Weed Management Area treated over 1,010 hectares (2,500 acres) of invasive nonnative plants in 2003, surveyed over 5,670 hectares (14,000 acres), and informed over 950 individuals about the dangers invasive nonnative plants pose (L. Danly, *in litt.* 2004).

The Nature Conservancy's Dancing Prairie Preserve in Montana has been the site of a research project looking at the effects of herbicides and fire on control of *Potentilla recta* (sulfur cinquefoil) (Lesica and Martin 2003). Annual and sometimes biannual spot-spraying from a backpack or ATV (all-terrain vehicle) of *Potentilla recta*, *Hypericum perforatum* (St. Johnswort), *Hieracium pretense* (meadow hawkweed), and *Centaurea maculosa* (spotted knapweed) has occurred for the last 9 years (P. Lesica, *in litt.* 2003). Biocontrol agents were released on *Hypericum perforatum* in the late 1990s. Invasive nonnative plant control efforts are expected to continue into the future (M. Mantas, *in litt.* 2003). Control of *Potentilla recta* is occurring adjacent to *Silene spaldingii* populations at The Nature Conservancy's Zumwalt Preserve in Oregon (R. Taylor, *in litt.* 2004).

Invasive nonnative plant control is an ongoing activity on most Federal lands. Because *Silene spaldingii* is a threatened species under the Endangered Species Act, Federal agencies are required to consider *S. spaldingii* in developing guidelines for all invasive nonnative plant control activities within the plant's range. The Bureau of Land Management in Spokane first surveys suitable habitat and does not treat invasive nonnative plants near *S. spaldingii* (U.S. Bureau of Land Management 2002). The Bureau of Land Management's Vale District in Oregon limits aerial herbicide treatment of invasive nonnative plants to distances greater than 152 meters (500 feet), broadcast spraying would be done no closer than 8 meters (25 feet), directed hand spraying no closer than 3 meters (10 feet), and by wicking applications only, if necessary, if within 3 meters (10 feet) of *S. spaldingii* (U.S. Fish and Wildlife Service 2002). The Bureau of Land Management's Cottonwood District in Idaho has all plants flagged within 30 meters (100 feet) of *S. spaldingii* and stipulates no boom spraying within 15 meters (50 feet) of *S. spaldingii*, hand spraying/wick/wipe applications only at a distance from 1.5 to 15 meters (5 to 50 feet), wipe or wick spraying from 1 to 1.5 meters (3 to 5 feet), and manual control only within 1 meter (3 feet). Picloram may not be used within 15 meters (50 feet) of *S. spaldingii* (U.S. Fish and Wildlife Service, *in litt.* 2003).

Invasive nonnative plant control and management specific to *Silene spaldingii* has occurred at Craig Mountain, Idaho, on Bureau of Land Management land. General mapping of invasive nonnative plants at all *S. spaldingii* locales, specific mapping of *Centaurea solstitialis* patches at seven of these locales, and manual control of *Centaurea solstitialis* and planting of native seed in disturbed areas at two of these locales has been done for 4 years at Garden Creek Ranch (Hill and Gray 1999, 2000; Hill *et al.* 2001; Hill and Fuchs 2002, 2003). The Bureau of Land Management's Cottonwood District in Idaho has released biocontrol insects for *Centaurea solstitialis* at *S. spaldingii* sites on Craig Mountain (Danly 1999).

Other control measures have included the release of biological invasive nonnative plant control agents for *Cirsium arvense* (Canada thistle), *Centaurea disffusa* (diffuse knapweed), and *Centaurea maculosa* (spotted knapweed) in 1996 at Fairchild Air Force Base in Washington (Rush and Gamon 1999; Caplow 2001). A limited amount of invasive nonnative plant control has also occurred at the Chief Joseph Gravesite monument near Joseph, Oregon and an Integrated Pest Management plan has been established for the site (T. Nitz, U.S. National Park Service, pers. comm. 2004).

Annual grasses exist near *S. spaldingii* sites at Crow Creek on the Wallowa-Whitman National Forest in Oregon where grazing practices are being altered to improve range condition. One *Centaurea solstitialis* patch, located on private land, is within 0.8 kilometer (0.5 mile) of one *S. spaldingii* site at Crow Creek and has been treated for 5 years by U.S. Forest Service personnel (J. Hustafa, pers. comm. 1999). *Centaurea maculosa* is being treated along the road to the above *S. spaldingii* site (J. Hustafa, *in litt.* 2004b).

## 5. Additional Conservation Actions

- *Silene spaldingii* seeds have been collected at one population in Idaho (Garden Creek), one population in Montana (Wild Horse Island), two populations in Oregon (Clear Lake Ridge and Crow Creek), and one population in Washington (Coal Creek) in the following quantities: 400 seeds were collected in Oregon in 1989, 2,500 seeds in Oregon in 1990, almost 3,000 seeds from Montana in 1990, almost 2,000 seeds from Oregon in 1995, 2,300 seeds from Idaho in 1999, 3,400 seeds from Washington in 2000, 2,200 seeds from Idaho in 2000, and over 31,000 seeds from Oregon in 2001. All seeds are stored at the Berry Botanic Garden in Portland, Oregon (A. Raven, *in litt.* 2004).
- A draft management plan has been developed for Garden Creek Ranch, Idaho, where *Silene spaldingii* locations have been identified and protection methodologies have been outlined (Hill 1998).
- A management plan for *Silene spaldingii* has been developed for Fairchild Air Force Base in Washington (Rush and Gamon 1999).

- A land acquisition through the Land and Water Conservation Fund and other land exchanges are ongoing for Bureau of Land Management land within *Silene spaldingii* habitat in Washington (B. Benner, *in litt.* 2003) (see Section H-1,"Inventory Efforts").
- A prescribed burning plan has been developed at The Nature Conservancy's Dancing Prairie Preserve in Montana that recommends burning similar size patches every other year. The first year of this treatment was 2003, with 40.5 hectares (100 acres) of *Silene spaldingii* habitat burned (M. Mantas, *in litt.* 2003).
- A management plan is being developed for The Nature Conservancy's Zumwalt Preserve that will include conservation strategies for *Silene spaldingii* (R. Taylor, *in litt.* 2003).

## I. BIOLOGICAL CONSTRAINTS

The long-lived nature of *Silene spaldingii*, in conjunction with sporadic and rare recruitment, delayed maturity, prolonged dormancy, and difficulties identifying seedlings, make it challenging to measure changes in numbers of individuals of this species. For plants exhibiting prolonged dormancy, population trend monitoring needs to occur for 3 or more consecutive years every 5 to 20 years to adequately assess trends at a given site (Lesica and Steele 1994; see details in Section II-A, Recovery Strategy and Rationale). Although population trend and demographic monitoring is occurring at a number of sites, long-term monitoring of this kind has occurred at only one *S. spaldingii* site, the Dancing Prairie Preserve in Montana (see section H, Conservation Efforts).

Ground disturbing activities including fires, livestock grazing, and off-road vehicle use impact *Silene spaldingii* the most during the flowering and seeding period (late July to September) and during seedling emergence in early spring.

Small, isolated populations relegated to remnant fragments of native habitat pose a problem as their viability into the future is questionable. *Silene spaldingii* requires grasslands dominated by native vegetation, with adequate numbers of pollinators available and other *S. spaldingii* populations close enough (within 1.6 kilometers [1 mile]) to provide for pollen exchange and enhance gene flow and genetic variability.

# II. Recovery Strategy and Goals

## A. RECOVERY STRATEGY AND RATIONALE

The fragmentation of *Silene spaldingii*'s habitat by human related activities has reduced the species to a mosaic of small populations (68 percent of the known remaining populations are composed of fewer than 100 individuals) occurring in isolated habitat remnants. Many of these small populations may not be viable into the future. Populations with few individuals and low effective population size are likely to suffer from low genetic diversity (Loveless and Hamrick 1984; Karron *et al*. 1988; Ellstrand 1992; Ellstrand and Elam 1993). As population size diminishes, the chance of loss of genetic diversity increases and the likelihood that gene flow from distant populations will replenish genetic variability decreases (Loveless and Hamrick 1984). The fragmented distribution of small populations further contribute to the positive feedback loop that Gilpin and Soulé (1986) have termed an "extinction vortex." Such depleted populations, and the species that they constitute, are more susceptible to both predictable and unexpected genetic, environmental, and demographic vagaries (Frankel and Soulé 1981; Shaffer 1987; Simberloff 1988; Ellstrand 1992; Ellstrand and Elam 1993).

Because small, fragmented populations with limited gene flow and susceptibility to inbreeding face a greater risk of extinction (Frankham 2003), increasing the size and connectivity of the larger remaining *S. spaldingii* populations will be an important component of the recovery strategy for the species. Preserving representative populations from across the range of *S. spaldingii*, throughout all of the physiographic regions in which it occurs, is also a key element of the recovery strategy. Reciprocal transplant studies have shown that there is often a high degree of local adaptive differentiation in plant populations (Ellstrand and Elam 1993 and references therein). Frankham (2003) points to a substantial need for the effective genetic management of fragmented populations of threatened species, but also notes that only rarely does such management take place. The preservation of genetic diversity across populations is important not only to short-term persistence (*e.g.*, Huenneke 1991; Newman and Pilson 1997; Neel and Cummings 2003), but also provides the material for future adaptation and evolutionary potential, thereby increasing the species' probability of persistence over the long-term (Lande and Barrowclough 1987; Shaffer 1987 and references therein; Simberloff 1988; Nunney and Campbell 1993; Neel and Cummings 2003).

As to how many populations are necessary, if specific genetic data on the populations selected for conservation are lacking, a recent evaluation demonstrated that anywhere from 53 to 100 percent of the remaining populations must be preserved to meet the genetic diversity conservation standard of the Center for Plant Conservation (Neel and Cummings 2003). In the absence of data, it is extremely difficult to determine the number of populations needed for long-term persistence. Especially when populations have become isolated as the result of relatively recent habitat fragmentation events, Hanski *et al*. (1996) note that even the number of extant populations may not necessarily be sufficient, as it is possible these populations have not yet reached a steady state equilibrium. Given these considerations and based on the recommendations of species experts, in this plan we propose the preservation of a minimum of 3 key conservation areas per physiographic region, and higher numbers where it is believed that suitable habitat potentially exists, to reach the total number of 26 key conservation areas across the historical range of *S. spaldingii* intended to preserve the available genetic variability within the species and provide for its long-term persistence.

Estimating the minimum population sizes needed to ensure long-term viability is also a challenge. Population viability analyses utilize computer modeling to estimate a population's viability into the future under various threats and management scenarios. A population viability analysis that incorporates threats such as fire management, genetic data, and pollinator success, as well as demographic data (transition probabilities), has not been done for *Silene spaldingii* rangewide and is needed to identify those populations that should be the focus of conservation efforts and which management scenarios will best preserve these populations (Menges 2000; Oostermeijer *et al*. 2003). Detailed information on parameters such as recruitment, growth, mortality, and age structure of the population are required to model population persistence (Menges 1990; Schemske *et al*. 1995; Lesica 1997), consequently many years of monitoring will be needed to acquire the data necessary to conduct a population viability analysis for *S. spaldingii*. Without a population viability analysis, minimum viable population numbers for plants must be estimated utilizing data from the general literature and comparisons with similar species.

Minimum viable population size is most frequently and broadly estimated at 500 reproductive individuals (summarized in Schonewald-Cox *et al.* 1983). However, caution is needed when applying a standard minimum viable population number, especially to plants, since different life strategies may make them more or less susceptible to extinction (Menges 1991b). For example, in one study, researchers determined that populations with fewer than 100 breeding individuals are highly vulnerable to extinction through mutations, although this extinction may take 100 generations (Lynch *et al.* 1995). Another study found plants that were primarily outcrossing species were more prone to extinction than other selfing species (Lennartsson 2002). Depending on factors such as population growth rates and the degree of environmental variation, some estimates of minimum viable populations range into the thousands or tens of thousands (Soulé and Simberloff 1986; Shaffer 1987; Nunney and Campbell 1993; Lande 1995). Researchers examining *Silene regia* found that population size was not the primary influencing factor, but that fire management most significantly affected survivability into the future (Menges and Dolan 1998). Clearly a population viability analysis is preferable and necessary to best estimate the minimum viable population numbers specific to *Silene spaldingii*. In the meantime, we suggest utilizing the standard minimum of 500 reproductive individuals until such a population viability analysis can be completed.

This recovery plan emphasizes conservation efforts for larger populations of *Silene spaldingii* while attempting to preserve the genetic diversity within each of the five physiographic regions where the plant resides. This is in line with the conservation strategy suggested by Nunney and Campbell (1993), which focuses on the preservation of several populations, each supporting a density of at least the minimum viable population size, across heterogenous habitats. Until additional information on the population viability of *S. spaldingii* is available, all existing habitat supporting *S. spaldingii* should be protected and managed. In particular, emphasis should be placed on populations or areas that have the potential of supporting at least 500 individuals. We have defined such populations or areas as **key conservation areas**. A key conservation area possesses the following qualities:

- Composed of intact habitat (not fragmented), preferably 40 acres (16 hectares) in size or greater[8]
- Native plants comprise at least 80 percent of the vegetative community
- Adjacent habitat is available sufficient to support pollinating insects
- Habitat is of the quality and quantity necessary to support at least 500 reproducing individuals of *Silene spaldingii*

The protection and management of these key conservation areas, or areas that have the potential to serve as key conservation areas, forms the foundation of the recovery strategy for *S. spaldingii*. Details regarding the identified key conservation areas for *S. spaldingii* are provided in the Recovery Actions Narrative (Section III-B), and the key conservation areas for each physiographic region are identified in Figures 6 through 10 of that section.

The wide range of *Silene spaldingii* creates a suite of various habitats where a complex list of threats to the species interact. This recovery plan seeks to address these threats and makes recommendations to ensure the persistence of the species. As described in detail in the Threats Assessment (Section I-G of this plan), the threats addressed include invasive nonnative plant management, small populations and habitat fragmentation, livestock use, wildlife herbivory, fire suppression and increases, habitat development, and off-road vehicle use. The aim of the recovery strategy for *S. spaldingii* is to first manage its habitat on an ecosystem basis — maintaining the habitat so that *S. spaldingii* and its natural interactions within the ecosystem (*e.g.* pollinators, fire) may be maintained. This will be accomplished by developing and implementing habitat management plans at all key conservation areas that provide guidance in managing *S.*

[8] In some regions, such as the already severely fragmented Palouse prairie, reaching a minimum size of 40 acres (16 hectares) of contiguous habitat may not be feasible.

*spaldingii*, and that also address the threats to the species. To accomplish conservation and recovery of *S. spaldingi* a series of actions need to be implemented. Invasive nonnative plants need to be controlled and managed within *S. spaldingii* habitat with minimal impact to the species itself. Larger populations where small population size and fragmentation are less of a problem should be a higher priority for protection than smaller, more fragmented populations. In addition, in order to preserve the full array of genetic variability within the species, large populations are needed in each of the five geographic regions where the plant resides. Fire management and prescribed burning need to be conducted carefully, with sound monitoring strategies and guided by the best available scientific information. Conservation actions should be implemented for those sites that occur on lands targeted for development. Off-road vehicle use within *S. spaldingii* populations should be prevented. Wildlife should be managed at levels that are compatible with *S. spaldingii* conservation, and livestock grazing should be managed so that *S. spaldingii* and its habitat are not adversely affected.

Because *Silene spaldingii* has a long life span, takes several years to reach reproductive maturity, exhibits prolonged dormancy, and has sporadic recruitment events, long-term monitoring data are necessary to adequately assess trends within populations. Lesica and Steele (1994) assessed the implications of prolonged dormany in plants for monitoring, and point out that long-term monitoring is necessary to distinguish real population trends from the variation that may be observed over the short-term due to recording error, prolonged dormancy, or other changes related to climatic fluctuations. They suggest that repeated sampling of permanent plots for 3 or more consecutive years (short-term sample) would be needed every 5 to 20 years (long-term period) to overcome the natural variability in population counts and make any statistically significant estimate of the population trend. Thus for a plant such as *S. spaldingii*, it will take at least 3 years of repeated sampling to get a single data point from which to assess trends. Monitoring 3 out of every 5 years over a 20-year time period would yield a total of four data points for each permanent monitoring plot. We considered this to be the minimum amount of data required from which to estimate long-term population trends in *S. spaldingii*, leading to our recommendation that delisting be considered only after populations have been monitored for at least 20 years.

*Silene spaldingii* should be closely monitored: 1) to determine population trends, reproductive success, and habitat conditions; and 2) to assess the effects of existing or potential threats on *S. spaldingii* and its essential habitat. Effectiveness monitoring should also be developed to address management actions and ensure that the factors affecting *S. spaldingii* are being adequately addressed. Survey efforts are needed to identify other *S. spaldingii* populations that need conservation. Outreach will inform the public about the species so they may assist in conservation, and seed banks will help to protect the species from catastrophic losses. Funding is required to implement all of these actions. Finally, a regular review of this recovery plan is needed so that new information may be incorporated and management adjusted accordingly.

## B. RECOVERY GOALS, OBJECTIVES, AND CRITERIA

The goal of the recovery program is to recover *Silene spaldingii* to the point where it can be delisted, *i.e.*, to remove the species from threatened status. The primary objectives to meet this goal are to reduce or eliminate the threats to the species, and protect and maintain multiple reproducing, self-sustaining populations distributed across each of the five distinct physiographic regions where it resides sufficient to ensure the long-term persistence of the species (Figures 4 and 5).

> **Box 2. Definitions according to section 3 of the Endangered Species Act.**
>
> **Endangered Species**
> Any species that is in danger of extinction throughout all or a significant portion of its range
>
> **Threatened Species**
> Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range

Delisting of *Silene spaldingii* will be warranted when the species no longer meets the definition of threatened or endangered under the Endangered Species Act (Act) (Box 2). We set recovery criteria to serve as objective, measurable guidelines to assist us in determining when a species has recovered to the point that the protections afforded by the Act are no longer necessary. However, the actual change in status is not solely dependent upon achieving the recovery criteria set forth in a recovery plan; it requires a formal rulemaking process based upon an analysis of the same five factors considered in the listing of a species (see page 19). The recovery criteria presented in this recovery plan thus represent our best assessment of the conditions that would most likely result in a determination that delisting of *S. spaldingii* is warranted as the outcome of a formal five factor analysis in a subsequent regulatory rulemaking. The recovery criteria and actions outlined here reflect the information currently available on this species, and identify information needs that are pertinent to the long-term conservation and management of *S. spaldingii*. The rationales for the following criteria are contained below and within the following “Recovery Action Narrative.”

### Delisting Criteria

Delisting of *Silene spaldingii* will be considered when all the following criteria are met:

1. Twenty-six populations with at least 500 reproducing *Silene spaldingii* individuals in each and with intact habitat occur rangewide at key conservation areas and are distributed throughout the 5 identified physiographic provinces as follows: 5 within

the Blue Mountain Basins, 6 within the Canyon Grasslands, 8 within the Channeled Scablands, 4 within the Intermontane Valleys, and 3 within the Palouse Grasslands.

The number of key conservation areas for each physiographic province was set at a minimum of three to preserve genetic diversity. For some regions, a greater number of key conservation areas are proposed to reflect the number of populations needed to maintain connectivity and, to the extent possible, preserve historical distribution across the remaining potential habitat estimated to be available.

The validity of preserving the species based on populations composed of at least 500 reproducing individuals should be verified by the results of a population viability analysis that incorporates threats and further genetic and demographic research on *Silene spaldingii*. The analysis should be initiated within 3 years and completed within 15 years of the approval of this recovery plan. Once the population viability analysis is completed, the recovery criteria listed here will be revisited and the target of 500 reproducing individuals per key conservation area may be adjusted, as appropriate.

2. All 26 key conservation areas of *Silene spaldingii* are composed of at least 80 percent native vegetation, have adjacent habitat sufficient to support pollinating insects, and are not fragmented (*i.e*., intact; see criterion #1).

3. Populations of *Silene spaldingii* at key conservation areas demonstrate stable or increasing population trends ($\lambda \geq 0$) for at least 20 years.

4. Habitat management plans have been developed and implemented for all key conservation areas. These management plans will provide for the protection of *Silene spaldingii* habitat, and will also protect the ecosystem by addressing conservation of other rare species, reducing the identified threats (*e.g.*, off-road vehicle use, overgrazing by wildlife and domestic stock, herbicide application, etc.), protecting pollinators, enacting monitoring strategies, incorporating integrated pest management strategies, and incorporating appropriate fire management activities.

5. Invasive nonnative plants with the potential to displace *Silene spaldingii* have been continually controlled or eradicated within a 0.4 kilometer (0.25 mile) radius of all *S. spaldingii* populations within key conservation areas.

6. Prescribed burning is conducted, whenever possible, to mimic historical fire regimes within a particular physiographic region in *Silene spaldingii* habitat. Prior to burning, presence/absence surveys for the plant will be completed. Prescribed burning will not take place when it may exacerbate invasive nonnative plant populations. Where *S. spaldingii* is present, monitoring is enacted prior to and following the prescribed burn. Historical fire regimes are carefully analyzed utilizing the best available technology.

7. Seed banking occurs at all smaller *Silene spaldingii* populations (not key conservation areas or potential key conservation areas) to preserve the breadth of genetic material across the species' range.

8. A post-delisting monitoring program for the species is developed and ready for implementation. This program will be developed through coordination with the Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, Tribes, States, The Nature Conservancy, and other interested parties.

# III. Recovery Program

The recovery program presented here is separated into two parts: (1) recovery actions specific to each of the physiographic regions; and (2) general recovery actions. Because differences are considerable between physiographic regions, this split is needed to address recovery actions specific to a physiographic region while still identifying recovery actions that are applicable rangewide.

## A. STEPDOWN OUTLINE OF RECOVERY ACTIONS

1. Conserve, identify, develop, and expand *Silene spaldingii* populations and habitat in each of the five physiographic regions where *S. spaldingii* resides.
    - 1.1. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Blue Mountain Basins (goal:  five key conservation areas).
        - 1.1.1. Conserve and work to enhance the four *Silene spaldingii* populations within the Blue Mountain Basins identified here as potential key conservation areas.
        - 1.1.2. Conduct further surveys, or work to create, at least 1 new population and key conservation area within the Blue Mountain Basins with over 500 individuals.
        - 1.1.3. Control and manage invasive nonnative plant species specific to the Blue Mountain Basins.
    - 1.2. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Canyon Grasslands (goal:  six key conservation areas).
        - 1.2.1. Conserve and work to enhance the three *Silene spaldingii* populations within the Canyon Grasslands identified here as potential key conservation areas.
        - 1.2.2. Conduct further surveys to identify at least 3 new populations and potential key conservation areas within the Canyon Grasslands with over 500 individuals.
        - 1.2.3. Control and manage invasive nonnative plant species specific to the Canyon Grasslands.
    - 1.3. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Channeled Scablands (goal:  eight key conservation areas).
        - 1.3.1. Conserve, survey, and work to enhance the 10 *Silene spaldingii* populations within the Channeled Scablands identified here as potential key conservation areas.
        - 1.3.2. Control and manage invasive nonnative plant species specific to the Channeled Scablands.

- 1.4. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Intermontane Valleys (goal: four key conservation areas).
  - 1.4.1. Conserve and work to enhance the four *Silene spaldingii* populations within the Intermontane Valleys identified here as potential key conservation areas.
  - 1.4.2. Conduct further surveys or work to supplement existing populations within the Intermontane Valleys to achieve 3 additional potential key conservation areas with over 500 individuals.
  - 1.4.3. Control and manage invasive nonnative plant species specific to the Intermontane Valleys.
- 1.5. Conserve, identify, develop, and expand *Silene spaldingii* populations and habitat within the Palouse Grasslands (goal: three key conservation areas).
  - 1.5.1. Conserve and work to enhance the two *Silene spaldingii* populations within the Palouse Grasslands identified here as a potential key conservation areas.
  - 1.5.2. Conduct a study identifying intact habitat within the Palouse Grasslands where *Silene spaldingii* may occur.
  - 1.5.3. Supplement existing populations and conduct a restoration and reintroduction program within the Palouse Grasslands to achieve the goal of 3 key conservation areas of *Silene spaldingii* with over 500 individuals.
  - 1.5.4. Control and manage invasive nonnative plant species specific to the Palouse Grasslands.

2. Conduct general recovery actions across the range of *Silene spaldingii*.
   - 2.1. Revise, and implement general management plans to include *Silene spaldingii* where the species resides.
   - 2.2. Develop *Silene spaldingii* specific habitat management plans at all key conservation areas.
   - 2.3. Habitat management plans and recovery actions should manage for impacts and threats to *Silene spaldingii* populations and habitat.
     - 2.3.1. Implement invasive nonnative plant control and management measures at all *Silene spaldingii* sites, taking care not to impact *S. spaldingii*.
     - 2.3.2. Incorporate integrated pest management programs into habitat management plans for *Silene spaldingii* at all key conservation areas.
     - 2.3.3. Conduct invasive nonnative plant control and management measures at all key conservation areas and other populations as needed.
     - 2.3.4. Ensure invasive nonnative plant control and management measures are coordinated with appropriate agencies.
     - 2.3.5. Conduct outreach activities for individuals or organizations that are involved in controlling and managing invasive nonnative plants.
     - 2.3.6. Conduct surveys for *Silene spaldingii* before invasive nonnative plant control measures are implemented.
     - 2.3.7. Develop and implement guidelines for herbicide applications around *Silene spaldingii* plants.

2.3.7.1.1. Develop set distances where various herbicide application techniques may be used near *Silene spaldingii* plants.
2.3.7.1.2. Develop set distances for specific herbicides that may be employed near known *Silene spaldingii* sites.
2.3.7.1.3. Develop guidelines for the timing of herbicide applications.

2.3.8. Conduct fire management activities within *Silene spaldingii* habitat.
2.3.8.1. Incorporate fire management plans into habitat management plans for all *Silene spaldingii* populations identified as key conservation areas on public lands.
2.3.8.2. Carefully conduct prescribed burns within *Silene spaldingii* habitat.
2.3.8.2.1. Conduct surveys for *Silene spaldingii* before prescribed burns are implemented.
2.3.8.2.2. Monitor the effects to *Silene spaldingii* and its habitat from all burns.
2.3.8.2.3. Do not conduct prescribed burns where invasive nonnative plant infestations exist.

2.3.9. Protect *Silene spaldingii* sites from development on public and private lands.
2.3.10. Effectively manage livestock grazing in *Silene spaldingii* habitat.
2.3.11. Implement effective off-road vehicle use control measures.
2.3.12. Monitor and manage wildlife populations and associated management activities to avoid impacts to *Silene spaldingii* and its habitat.

2.4. Monitor population trends and habitat conditions.
2.4.1. Monitor *Silene spaldingii* populations at key conservation areas periodically to determine population trends.
2.4.2. Conduct demographic monitoring across the range of *Silene spaldingii*.
2.4.3. Monitor and evaluate the response of *Silene spaldingii* to fire and invasive nonnative plants.
2.4.4. Obtain permission from private landowners to conduct population trend monitoring for *Silene spaldingii* on private lands.
2.4.5. Determine if sites with no plants have been extirpated.

2.5. Conduct research essential to the conservation of *Silene spaldingii.*
2.5.1. Determine population viabilities for *Silene spaldingii* populations.
2.5.2. Develop new populations or supplement existing populations of *Silene spaldingii* where appropriate.
2.5.2.1. Utilize existing key conservation areas and identify new key conservation areas with good habitat where new populations should be developed or where existing populations could be supplemented.
2.5.2.2. Determine the best techniques for creating new populations or supplementing existing populations of *Silene spaldingii*.
2.5.2.3. Determine the best techniques to restore *Silene spaldingii* habitat.

- 2.5.3. Conduct research essential to controlling and managing invasive nonnative plants within *Silene spaldingii* habitat.
- 2.5.4. Conduct research essential to managing livestock, wildlife, and insect herbivory at *Silene spaldingii* populations.
- 2.5.5. Conduct research to better determine the effects of fire on *Silene spaldingii* and identify when and where prescribed fire should occur, particularly outside of Montana.
- 2.5.6. Conduct further research regarding reproductive biology and essential pollinators for *Silene spaldingii*.
- 2.5.7. Conduct research investigating seed dispersal mechanisms for *Silene spaldingii*.
- 2.5.8. Conduct research investigating the period seeds may remain viable in the soil.
- 2.5.9. Conduct further genetic research for *Silene spaldingii*.

2.6. Conduct surveys in potential habitat areas. Manage and protect any newly discovered *Silene spaldingii* populations.

- 2.6.1. Conduct surveys on Federal lands for *Silene spaldingii*.
- 2.6.2. Conduct surveys on State and Tribal lands, especially where activities may affect *Silene spaldingii* habitat.
- 2.6.3. Obtain permission from private landowners to conduct surveys for *Silene spaldingii* on private lands.
- 2.6.4. Protect newly discovered *Silene spaldingii* populations.

2.7. Support conservation on privately owned lands.

- 2.7.1. Support conservation actions on lands owned by The Nature Conservancy.
- 2.7.2. Support conservation activities on other private lands.
- 2.7.3. Conduct outreach and education with the public regarding *Silene spaldingii*'s plight and its conservation.

2.8. Pursue land and species designations that will help facilitate conservation of *Silene spaldingii*.

2.9. Establish propagule banks, including a long-term seed storage facility for *Silene spaldingii*.

2.10. Secure funding for implementation of recovery tasks.

2.11. Validate and revise recovery objectives as needed.

3. Develop a post-delisting monitoring plan.

**Box 3. Interpretation of Figures 6 through 10, key conservation areas for *Silene spaldingii* in each of the five physiographic regions.**

- Buffers were computer generated using element occurrence record (or site) data.
- If 0.8 kilometer (0.5 mile) buffers around element occurrence records (sites) overlapped, sites were grouped together into a single population. Overlap indicated two sites were within 1.6 kilometers (1 mile) of one another.
- Physiographic regions as delineated in Figure 4 are repeated within these figures for the specific physiographic region pictured.
- One-mile and 2-mile buffers have been included to indicate satellite populations with the potential to become part of adjacent populations, depending upon further surveys.
- Population numbers and key conservation areas are identified in each figure only for the physiographic region delineated within the dashed line.
- Potential key conservation areas are indicated with labeled boxes.

## B. RECOVERY ACTION NARRATIVE

1. **Conserve, identify, develop, and expand *Silene spaldingii* populations and habitat in each of the five physiographic regions where *S. spaldingii* resides.** In general, large populations have higher genetic diversity than smaller populations and so have a higher survivability (Barrett and Kohn 1991). In addition, genes also vary across the larger landscape (Huenneke 1991). To preserve the genetic integrity of *Silene spaldingii*, larger populations are prioritized before smaller populations, and representative populations from each of the five physiographic regions are identified. Until a population viability analysis has been done for *S. spaldingii* that models which populations are viable under various management strategies, 500 reproducing individuals — assumed to represent the minimum viable population size — will be the default goal for all key conservation areas in each of the five physiographic regions (identified below and in Figures 6 through 10).

   1.1 **Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Blue Mountain Basins (goal: five key conservation areas).** The Blue Mountain Basins of Oregon, with 14 *Silene spaldingii* populations, have 4 potential key conservation areas identified here: Clear Lake Ridge, Crow Creek, Wallowa Lake, and the Zumwalt Prairie (Figure 6). The populations on The Nature Conservancy's Zumwalt Prairie Preserve were not discovered until the land was purchased in 2000, and there appear to be substantial tracts of suitable habitat on unsurveyed private, Tribal, and public lands, so it is reasonable to assume there are most likely other populations of *S. spaldingii* within the Blue Mountain Basins. Therefore, the goal of 5 populations of *S. spaldingii* with both intact habitat and over 500 reproducing individuals within the Blue Mountain

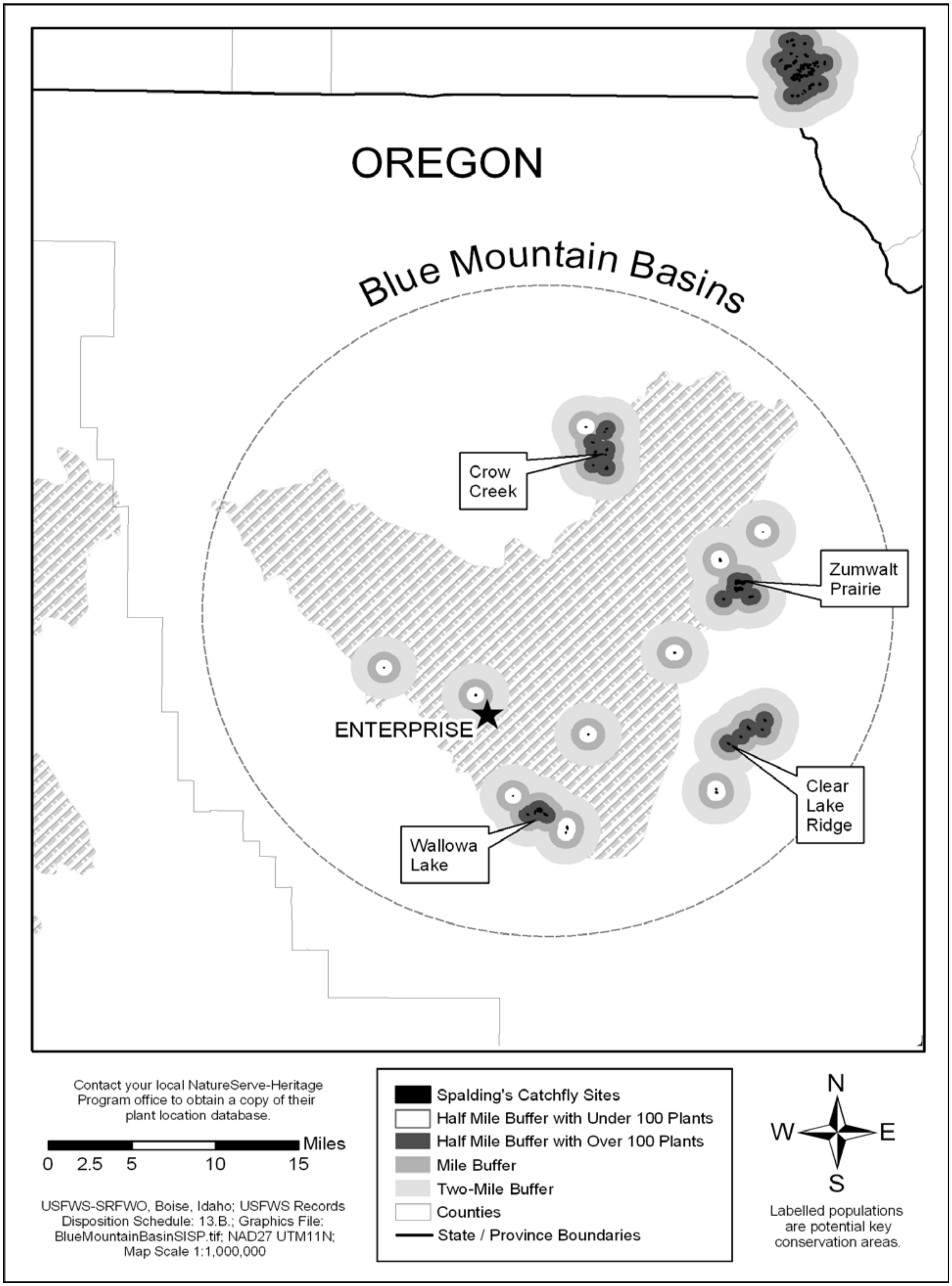



**Figure 6.** The 14 known *Silene spaldingii* populations and 4 potential key conservation areas within the Blue Mountain Basins physiographic region.

Basins is justified. Populations with fewer than 500 individuals, not identified as potential key conservation areas, should be conserved where possible, particularly on federally managed land.

1.1.1. **Conserve and work to enhance the four *Silene spaldingii* populations within the Blue Mountain Basins identified here as potential key conservation areas.** The population at Clear Lake Ridge (considered here as part of the Blue Mountain Basins and not the Canyon Grasslands) has at least 401 individuals, Crow Creek has at least 835 individuals, Wallowa Lake has at least 506 individuals, and the Zumwalt Prairie has at least 1,613 individuals. Furthermore, all four populations have other satellite populations nearby (generally within 5 kilometers [3 miles]) with intact habitat between; *Silene spaldingii* could be found in these interspaces in the future. Three of the four potential key conservation areas already have more than 500 individuals; only Clear Lake Ridge has fewer. This population should be better surveyed to potentially locate more individuals. If no more individuals can be located, supplementing the population with individuals grown from local seed sources should be considered (see Recovery Action 2.5.2). The Clear Lake Ridge population is predominantly managed by The Nature Conservancy and the Wallowa-Whitman National Forest, although some sites are on private land. Crow Creek is predominantly managed by the Wallowa-Whitman National Forest, with a small site or portions of sites on private land. The Wallowa Lake population is almost entirely privately owned with the exception of a site at the Chief Joseph Gravesite managed by the National Park Service. The Zumwalt Prairie is within the confines of The Nature Conservancy's Zumwalt Prairie Preserve. The numerous landowners involved will provide an additional challenge in conserving the species within the Blue Mountain Basins.

1.1.2. **Conduct further surveys to identify, or work to create, at least 1 new population and key conservation area within the Blue Mountain Basins with over 500 individuals.** With additional survey work, particularly on private land, it is expected that additional populations of *S. spaldingii* will be located within the Blue Mountain Basins. If new populations are not identified, supplementing existing populations (see Recovery Action 2.5.2) should be considered to achieve the recovery goal of five key conservation areas in this region.

1.1.3. **Control and manage invasive nonnative plant species specific to the Blue Mountain Basins.** Invasive nonnative plant species vary by physiographic region. Within the Blue Mountain Basins, invasive nonnative plant species of concern include: *Potentilla recta* (sulfur cinquefoil), *Centaurea maculosa* (spotted knapweed), *C. diffusa* (diffuse knapweed), and *C. solstitialis* (yellow starthistle). These invasive nonnative plant species, and others as they are discovered, should be controlled or eliminated within a 0.4 kilometer (0.25 mile) radius of *Silene spaldingii* populations at key conservation areas (see Recovery Action 2.3.1). Other invasive nonnative grass species including *Poa pratensis* (Kentucky bluegrass), *Bromus tectorum* (cheatgrass), and *Ventenata dubia* (ventenata), should be reduced to less than 20 percent cover through habitat management programs.

**1.2. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Canyon Grasslands (goal: six key conservation areas).** The Canyon Grasslands of Idaho, Oregon, and Washington, with nine *Silene spaldingii* populations, have three potential key conservation areas identified here: the Blue Mountain Foothills, Craig Mountain, and Garden Creek (Figure 7). The Canyon Grasslands are steep and therefore difficult to survey and there remain large tracts of unsurveyed intact habitat, so it is expected there may be many more populations of *S. spaldingii* within this physiographic region. Therefore, the goal of 6 populations of *S. spaldingii* with intact habitat and over 500 reproducing individuals within the Canyon Grasslands is justifiable. Populations with fewer than 500 individuals, not identified as key conservation areas, should be conserved where possible, particularly on federally managed land.

**1.2.1. Conserve and work to enhance the three *Silene spaldingii* populations within the Canyon Grasslands identified here as potential key conservation areas.** Two of these populations already number more than 500 individuals: the Blue Mountain Foothills has at least 997, and Garden Creek has at least 3,987 individuals. Two separate populations comprise the Craig Mountain key conservation area as shown in Figure 7: Captain John Creek with at least 272 individuals to the north, and Billy Creek with at least 220 individuals to the south. Much of the land between these two sites remains unsurveyed and it is expected that with further survey effort this may become one larger population. With still further surveys, it is possible that the Garden Greek and Craig Mountain key conservation areas may constitute one single large population. The Blue Mountains Foothills population is managed by the Umatilla National Forest. Craig Mountain is managed by the Bureau of Land Management Cottonwood District in the south and the Idaho Department of Fish and Game in the north. Garden Creek is managed by the Bureau of Land Management and The Nature Conservancy.

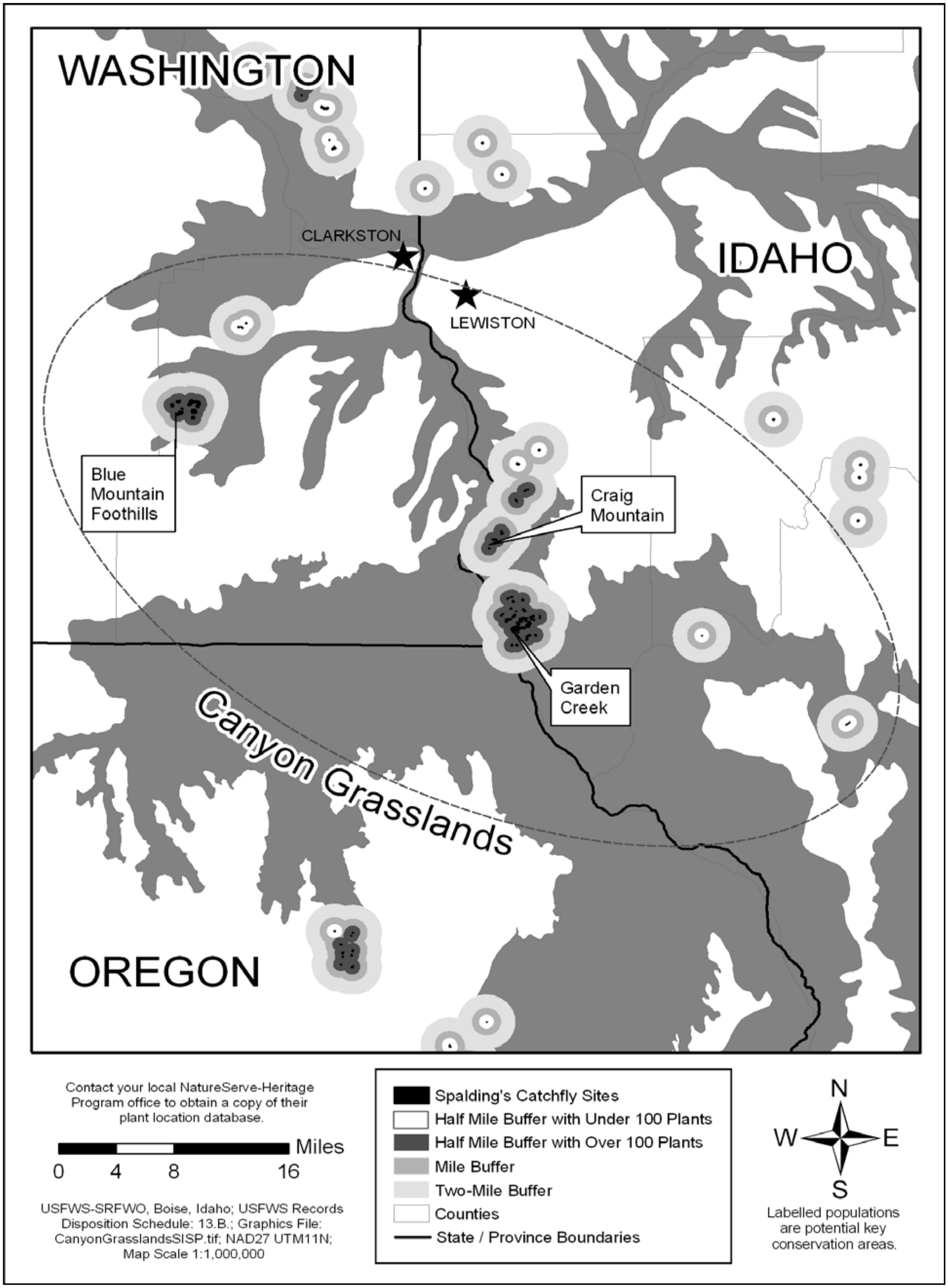



**Figure 7.** The nine known *Silene spaldingii* populations and three potential key conservation areas identified within the Canyon Grasslands physiographic region.

**1.2.2. Conduct further surveys to identify at least 3 new potential key conservation areas within the Canyon Grasslands with over 500 individuals**. All of the populations within the Canyon Grasslands have been discovered within the last 15 years, and most within the last 10 years. Prior to the discovery of these populations, the Canyon Grasslands had not been considered suitable habitat for *Silene spaldingii*. The Canyon Grasslands are extremely steep and difficult to access, which has kept the habitat relatively intact and undersurveyed. For these reasons, it is expected that there are many more populations of *S. spaldingii* within this physiographic region with intact habitat. In addition to the three potential key conservation areas already identified (Recovery Action 1.2.1), at least three additional key conservation areas must be established to meet the recovery goal for this region. If three new populations cannot be discovered with increased survey effort, the establishment of new populations should be considered (see Recovery Action 2.5.2).

**1.2.3. Control and manage invasive nonnative plant species specific to the Canyon Grasslands.** Within the Canyon Grasslands, invasive nonnative plants of concern include: *Crupina vulgaris* (common crupina), *Centaurea diffusa* (diffuse knapweed), *Euphorbia esula* (leafy spurge), *Lepidium latifolium* (perennial pepperweed), *Acroptilon repens* (Russian knapweed), *Onopordum achanthium* (Scotch thistle), *Centaurea maculosa* (spotted knapweed), *Potentilla recta* (sulfur cinquefoil), *Linaria* (toadflax), and *Cardaria draba* (whitetop). These invasive nonnative plants and others as they are discovered should be controlled or eliminated within a 0.4 kilometer (0.25 mile) radius of *Silene spaldingii* populations at key conservation areas (see Recovery Action 2.3.1). Other invasive nonnative plants including *Poa pratensis* (Kentucky bluegrass), *Bromus tectorum* (cheatgrass), *Ventenata dubia* (ventenata), *Centaurea solstitialis* (yellow starthistle), and *Hypericum perforatum* (St. Johnswort) are already relatively common within the Canyon Grasslands and so would be extremely expensive and difficult to control. Instead, these invasive nonnative plant species should be reduced to covers of less than 20 percent through management programs. Where these more widespread invasive nonnative plants are not already present within *S. spaldingii* populations, such as *Centaurea solstitialis* at the Blue Mountain Foothills, control or eradication should occur within 0.4 kilometer (0.25 mile).

**1.3. Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Channeled Scablands (goal: eight key conservation areas).** The Channeled Scablands region of Washington, with 35 *Silene spaldingii* populations, has 10 potential key conservation areas identified here: Coal Creek –

Lamona, Crab Creek, Fishtrap Lake – Miller Ranch, Rock Creek, Rock Creek – Adams County, Rocky Ford, Sprague South, Swanson Lake, Telford, and Twin Lakes (Figure 8). Intact habitat comprises many of these areas, which, if fully surveyed, have the potential to yield many more *Silene spaldingii* populations. In addition, many recent land acquisitions have led to the discovery of substantial new populations of *S. spaldingii*. Therefore, the goal of 8 populations of *S. spaldingii* with intact habitat surrounding the populations and over 500 reproducing individuals is attainable within the Channeled Scablands. Populations with fewer than 500 individuals, not identified as potential key conservation areas, should be conserved where possible, particularly on federally managed land.

**1.3.1. Conserve, survey, and work to enhance the 10 *Silene spaldingii* populations within the Channeled Scablands identified here as potential key conservation areas.** Of these 10 potential key conservation areas, only the Coal Creek – Lamona site currently has over 500 individuals. To meet the recovery goal for this region, at least 7 of the remaining potential key conservation areas must be further surveyed or enhanced to achieve the minimum of 500 individuals. At present, Crab Creek has at least 162 individuals, Fishtrap Lake – Miller Ranch has at least 387 individuals, Rock Creek has at least 173 individuals, Rock Creek – Adams County has at least 145 individuals, Rocky Ford has over 300 individuals, Sprague South has over 200 individuals, Swanson Lake has over 487 individuals at 1 population and over 220 at another, the Telford area has over 400 individuals, and Twin Lakes has 3 populations with over 100 individuals, one of these with over 271 individuals. Two of these potential key conservation areas, Swanson Lake and Twin Lakes, include more than one population of *Silene spaldingii*. Both of these sites are within relatively intact habitat which, if more thoroughly surveyed, may lead to the discovery of more *S. spaldingii* individuals in interspaces. Rock Creek and Sprague South both have satellite populations that are within 3 miles of their current geographic extent, which with further survey effort could yield one larger population. Crab Creek and Rocky Ford, with more extensive survey effort, could be part of the same population. The Coal Creek – Lamona, Crab Creek, Fishtrap Lake – Miller Ranch, Rock Creek – Adams County, Rocky Ford, and Telford key conservation areas are all managed by the Bureau of Land Management Spokane District. Rock Creek, Sprague South, and Twin Lakes are managed by both the Bureau of Land Management Spokane District as well as private landowners. Swanson Lake is managed by the Bureau of Land Management Spokane District and the Washington Department of Fish and Wildlife.

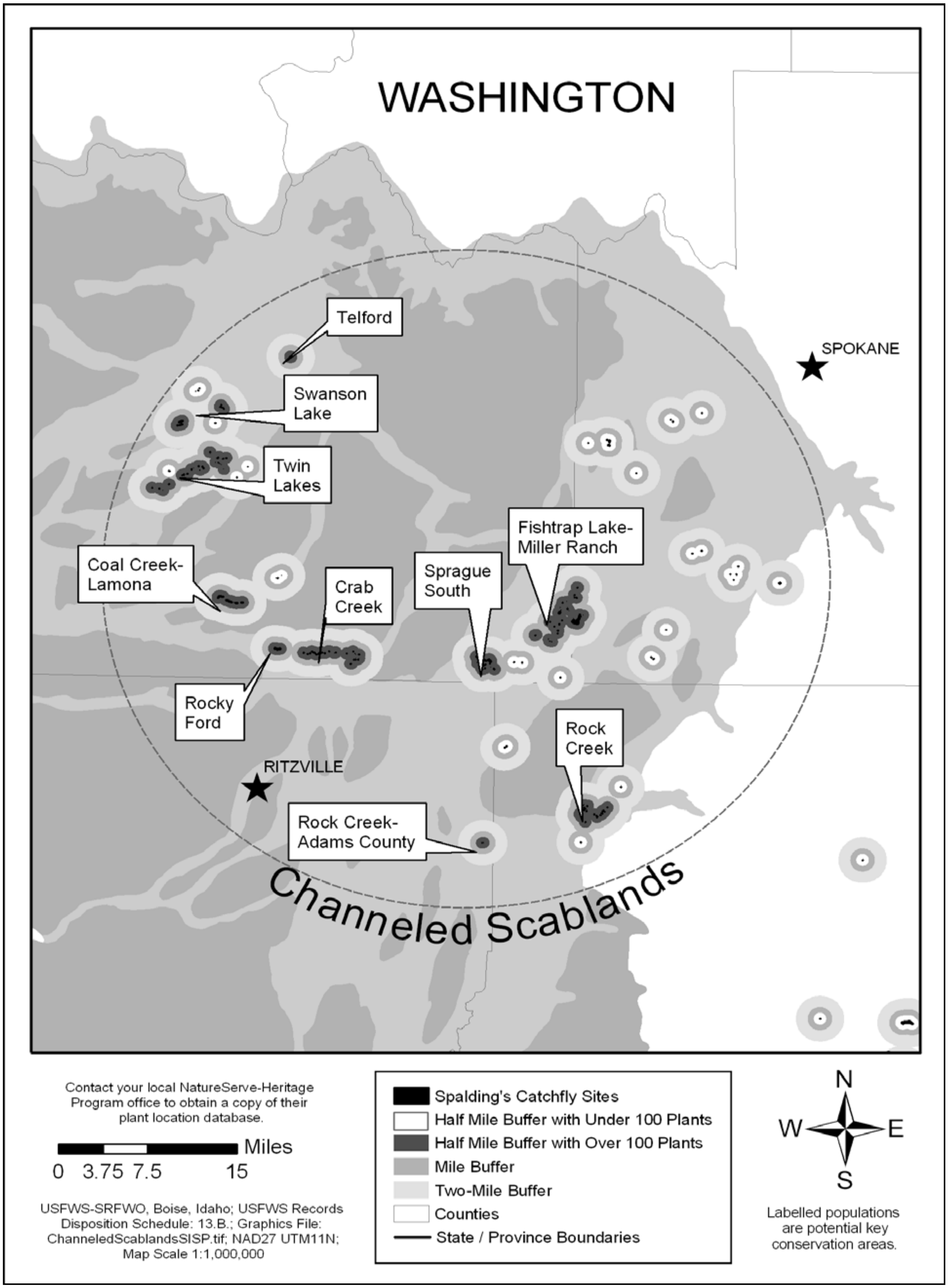



**Figure 8.** The 35 known *Silene spaldingii* populations and 10 potential key conservation areas identified within the Channeled Scablands physiographic region.

1.3.2. **Control and manage invasive nonnative plant species specific to the Channeled Scablands.** Within the Channeled Scablands, invasive nonnative plants of concern include: *Cirsium arvense* (Canada thistle), *Centaurea diffusa* (diffuse knapweed), *Chondrilla juncea* (rush skeletonweed), *Linaria* (toadflax), and *Centaurea solstitialis* (yellow starthistle). These invasive nonnative plants and others as they are discovered should be controlled or eliminated within a 0.4 kilometer (0.25 mile) radius of *S. spaldingii* populations at key conservation areas (see Recovery Action 2.3.1). Other invasive nonnative plants including *Poa pratensis* (Kentucky bluegrass), *Bromus tectorum* (cheatgrass), *Ventenata dubia* (ventenata), and *Hypericum perforatum* (St. Johnswort) are already relatively common within the Channeled Scablands and so would be extremely expensive to control. Instead, these invasive nonnative plant species should be reduced to covers of less than 20 percent through management programs.

1.4. **Conserve, identify, and expand *Silene spaldingii* populations and habitat within the Intermontane Valleys (goal: four key conservation areas).** The Intermontane Valleys of Montana, with nine *Silene spaldingii* populations, have five potential key conservation areas identified: Dancing Prairie, Lost Trail, Sullivan Hill, Tobacco Plains, and Wild Horse Island (Figure 9). Only one of these potential key conservation sites has a population with over 500 individuals, Dancing Prairie. Surveys and supplementation of already existing populations may be necessary within the Intermontane Valleys to achieve the recovery goal of 4 populations with over 500 individuals. Populations with fewer than 500 individuals, not identified within potential key conservation areas, should be conserved where possible, particularly on federally managed lands.

1.4.1. **Conserve and work to enhance the four *Silene spaldingii* populations within the Intermontane Valleys identified here as potential key conservation areas.** The Dancing Prairie key conservation area has over 10,000 individuals and is the largest known population of *Silene spaldingii*. Lost Trail is separated into 2 populations, 1 with 50 to 100 individuals, and 1 with 150 to 200 individuals; Sullivan Hill has at least 67 individuals; the Tobacco Plains have at least 223 individuals; and Wild Horse Island has at least 250 individuals. The Tobacco Plains and Dancing Prairie are within 3 miles of one another and could be part of one larger population/key conservation area if further surveys identify additional individuals of *S. spaldingii* in the interspaces. The Dancing Prairie key conservation area is composed of lands managed by The Nature Conservancy on its Dancing Prairie Preserve

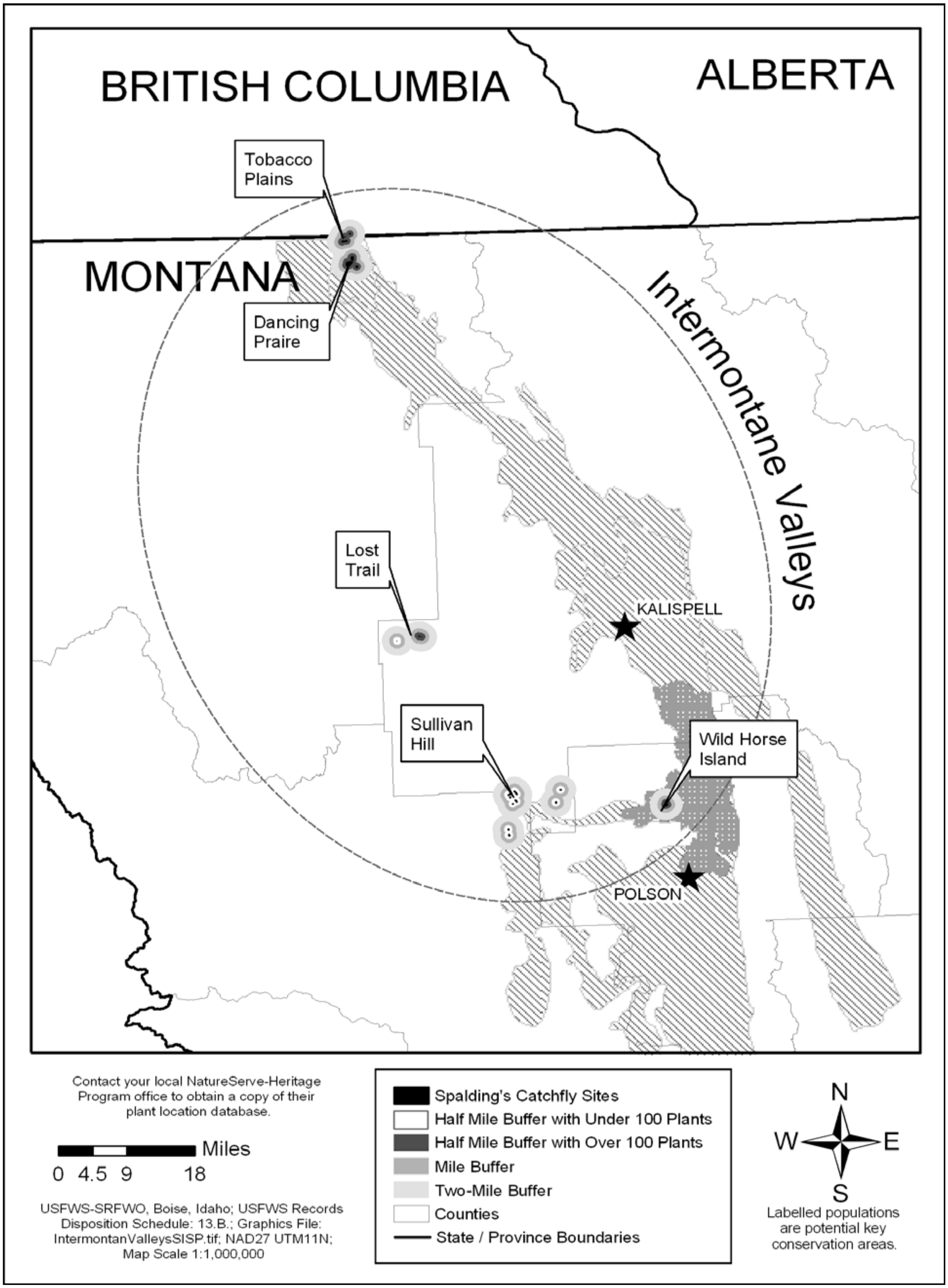



**Figure 9.** The nine *Silene spaldingii* populations and five potential key conservation areas identified within the Intermontane Valleys physiographic region.

as well as private landowners. Lost Trail includes lands managed by the U.S. Fish and Wildlife Service at the Lost Trail National Wildlife Refuge as well as adjacent State lands. Sullivan Hill is on Tribal lands managed by the Confederated Salish and Kootenai Tribes. Wild Horse Island is managed by Montana Fish, Wildlife, and Parks, and the Tobacco Plains key conservation area occurs entirely on private lands and spans the border of the United States and Canada.

**1.4.2. Conduct further surveys or work to supplement existing populations within the Intermontane Valleys to achieve 3 additional key conservation areas with over 500 individuals. The** Dancing Prairie site already meets the criteria for a key conservation area. Three additional key conservation areas with at least 500 individuals are needed to meet the recovery goal for this region. These additional key conservation areas may be established through either further survey effort or enhancement of known sites. Although not identified in Figure 9, a series of small, isolated valleys exist within Montana where suitable habitat and populations of *Silene spaldingii* may reside. If 3 new populations with over 500 individuals cannot be discovered with increased survey effort, the supplementation of existing potential key conservation area populations should be considered (see Recovery Action 2.5.2).

**1.4.3. Control and manage invasive nonnative plant species specific to the Intermontane Valleys.** Within the Intermontane Valleys, invasive nonnative plants of concern include: *Hieracium pratense* (meadow hawkweed), *Centaurea maculosa* (spotted knapweed), and *Potentilla recta* (sulfur cinquefoil). These invasive nonnative plants and others as they are discovered should be controlled or eliminated within a 0.4 kilometer (0.25 mile) radius of *Silene spaldingii* populations at key conservation areas (see Recovery Action 2.3.1). Other invasive nonnative plants including *Poa pratensis* (Kentucky bluegrass), *Bromus tectorum* (cheatgrass), *Cirsium arvense* (Canada thistle), and *Hypericum perforatum* (St. Johnswort) are already relatively common within *S. spaldingii* Intermontane Valley sites and so would be extremely expensive to control. Instead, these invasive nonnative plant species should be reduced to covers of less than 20 percent through management programs.

**1.5. Conserve, identify, develop, and expand *Silene spaldingii* populations and habitat within the Palouse Grasslands (goal: three key conservation areas).** The Palouse Grasslands of Idaho and Washington, with 18 *Silene spaldingii* populations, have 2 potential key conservation areas identified, the Kramer Palouse Natural Area and the Pitt Cemetery (Figure 10). Both of these sites are small (under 16 hectares [40 acres]) and have fewer than 500 individuals. Of the

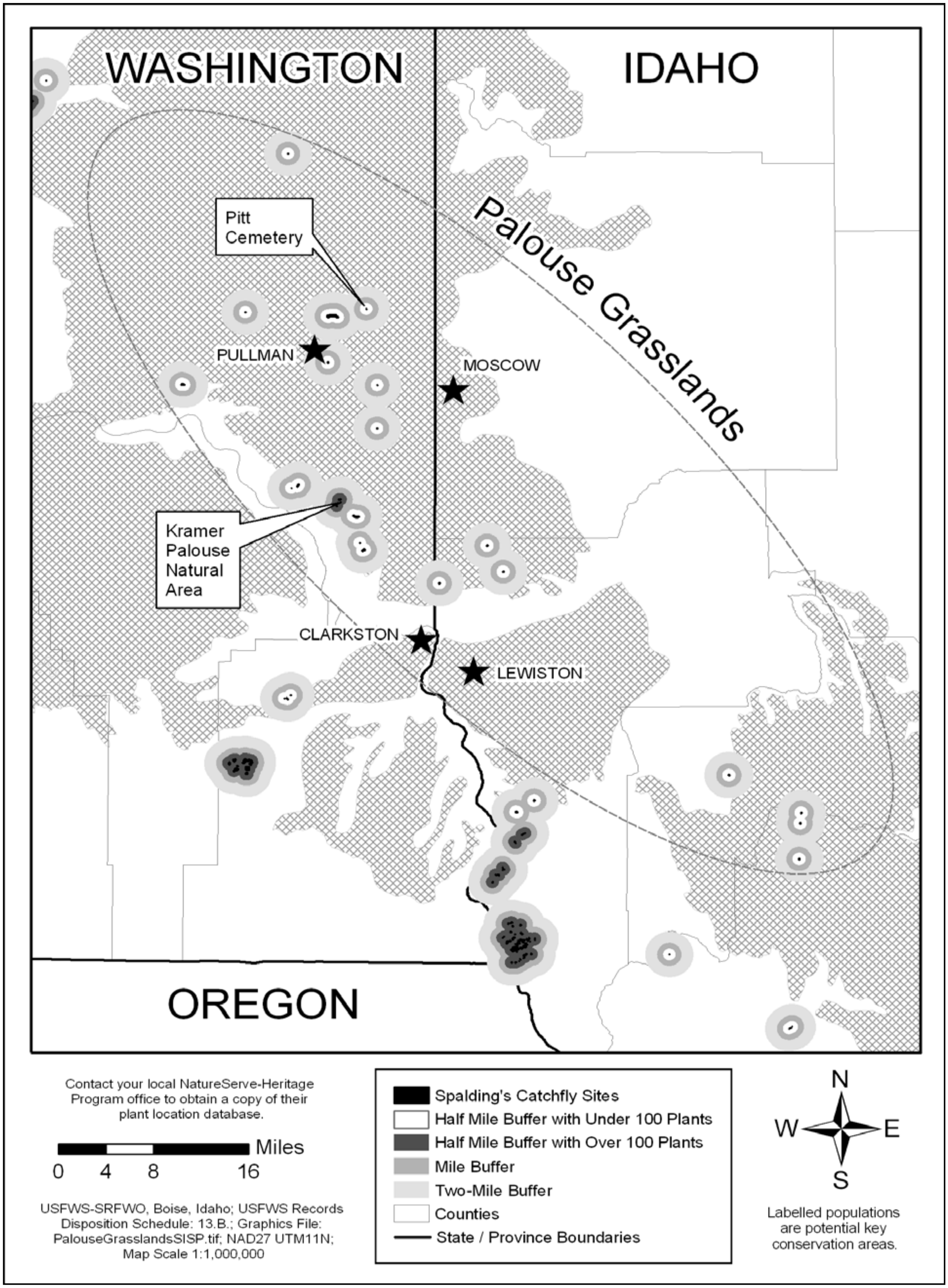



**Figure 10.** The 18 *Silene spaldingii* populations and 2 potential key conservation areas within the Palouse Grasslands physiographic region.

five physiographic regions, the Palouse Grasslands have been most heavily impacted by agricultural development with few large intact parcels of lands remaining. To better survey for potential *S. spaldingii* populations, the Palouse Grasslands need to be first surveyed for intact stands of habitat, and subsequently these should be searched for *S. spaldingii*. To preserve genetic material from this physiographic region, supplementing or developing new *S. spaldingii* populations that can be adequately conserved will be necessary to attain the goal of 3 populations with over 500 reproducing individuals. Populations with fewer than 500 individuals, not currently identified as potential key conservation areas, should be conserved where possible, particularly on federally managed lands.

**1.5.1. Conserve and work to enhance the two *Silene spaldingii* populations within the Palouse Grasslands identified here as potential key conservation areas.** The Kramer Palouse Natural Area has at least 200 *Silene spaldingii* individuals and is within 2 miles of another population with 11 individuals. The Pitt Cemetery has at least 62 *S. spaldingii* individuals. The Kramer Palouse Natural Area is managed by Washington State University and the Pitt Cemetery is privately owned. Other key conservations areas are needed where existing or new populations of *S. spaldingii* can be supplemented or established within the Palouse Grasslands (see Recovery Action 2.5.2).

**1.5.2. Conduct a study identifying intact habitat within the Palouse Grasslands where *Silene spaldingii* may occur.** With over 95 percent of the Palouse Grasslands lost to agricultural development, very few intact grasslands remain in this area. A study that identifies parcels of land that are over 4 hectares (10 acres) in size with potential *Silene spaldingii* habitat is needed. Subsequently, these parcels should be surveyed for the plant.

**1.5.3. Supplement existing populations and conduct a restoration and reintroduction program within the Palouse Grasslands to achieve the goal of 3 key conservation areas of *Silene spaldingii* with over 500 individuals.** The recovery goal for this region may be met through a combination of enhancing the two extant populations identified as potential key conservation areas (Recovery Action 1.5.1) and/or restoration and reintroduction to establish additional key conservation areas. If intact habitat exists or if adjacent habitat can be restored, existing populations of *Silene spaldingii* within the Palouse Grasslands should be supplemented (see Recovery Action 2.5.2) to create self sustaining populations of *S. spaldingii* with over 500 individuals. In the event that existing populations cannot be expanded, a new site with intact habitat that can be conserved should be identified and planted with nearby genetic material from *S. spaldingii*. If intact habitat cannot be found, restoration should occur at a site that can be conserved and subsequently planted with nearby genetic material from *S. spaldingii*.

**1.5.4. Control and manage invasive nonnative plant species specific to the Palouse Grasslands.** Within the Palouse Grasslands, invasive nonnative plants of concern include: *Chondrilla juncea* (rush skeletonweed), *Potentilla recta* (sulfur cinquefoil), *Dipsacus sylvestris* (teasel), *Linaria* (toadflax), and *Centaurea solstitialis* (yellow starthistle). These invasive nonnative plants and others as they are discovered should be controlled or eliminated within a 0.4 kilometer (0.25 mile) radius of *Silene spaldingii* populations at key conservation areas (see Recovery Action 2.3.1). Other invasive nonnative plants including *Poa pratensis* (Kentucky bluegrass), *Bromus tectorum* (cheatgrass), *Cirsium arvense* (Canada thistle), and *Hypericum perforatum* (St. Johnswort) are already relatively common within *S. spaldingii* Palouse Grassland sites and so would be extremely expensive and difficult to control. Instead, these invasive nonnative plant species should be reduced to covers of less than 20 percent through management programs

2. **Conduct general recovery actions across the range of *Silene spaldingii*.** Many recovery actions are applicable across *Silene spaldingii*'s range. These actions are condensed here instead of being repeated for each physiographic region above. These actions should protect essential (occupied and potentially suitable) habitat and implement actions that may be necessary to eliminate or control threats. Habitat should be managed to maintain or enhance viable populations of *S. spaldingii*, to protect pollinators, and to allow for the maintenance of natural ecosystem functions and processes and contribute to the long-term preservation of this species. Key conservation areas should be prioritized, however, the threats addressed through habitat management and recovery actions should be addressed at all known populations of *S. spaldingii* when feasible.

**2.1. Revise, and implement general management plans to include *Silene spaldingii* where the species resides.** Land management agencies including Federal, State, Tribal, and private entities that are responsible for the development and revision of land management plans should specifically address conservation of *Silene spaldingii* in their plans. Federal agencies include: the Bureau of Land Management (Spokane District in Washington and the Upper Columbia Salmon Clearwater District in Idaho), the Department of Defense (Fairchild Air Force Base), the National Park Service (Chief Joseph Gravesite in Oregon), the U.S. Fish and Wildlife Service (Lost Trail National Wildlife Refuge in Montana and Turnbull National Wildlife Refuge in Washington), and the U.S. Forest Service (Wallowa-Whitman National Forest in Oregon and the Umatilla National Forest in Oregon and Washington). State managed lands include: the Craig Mountain Wildlife Management Area managed by the Idaho Department of Fish and Game;

Montana State managed lands adjacent to the Lost Trail National Wildlife Refuge and on Wild Horse Island State Park; and in Washington on the Swanson Lakes Wildlife Area, at the Steptoe Butte State Historic Area, and at three sites managed by Washington State University, the Smoot Hill Reserve, the Kramer Palouse Natural Area, and the Washington State University Prairie Preserve. Tribal lands where the species resides includes lands owned by the Confederated Salish and Kootenai Tribes and the Nez Perce Tribe. *Silene spaldingii* is not currently included in any management plans for these areas. The Nature Conservancy manages three populations of *S. spaldingii* at their Garden Creek Ranch Preserve in Idaho, the Dancing Prairie Preserve in Montana, and the Zumwalt Prairie Preserve in Oregon. If management plans are developed for these sites, conservation of *S. spaldingii* should be incorporated. Actions specific to *S. spaldingii* identified within general land management plans should include recommendations made in *S. spaldingii* habitat management plans (see Recovery Action 2.2) and be consistent with the actions identified in this recovery plan.

**2.2. Develop *Silene spaldingii* habitat management plans at all key conservation areas.** All key conservation areas identified in 1.1, 1.2, 1.3, 1.4, and 1.5 above should have habitat management plans developed specifically to assist in conserving *S. spaldingii* at these sites. Management plans should include provisions to identify and control factors that may degrade habitat quality for *S. spaldingii*, such as nonnative plant invasions through integrated pest management programs, changes in the fire regime, land conversions, livestock grazing and trampling, herbicide or pesticide use, wildlife herbivory, off-road vehicle use, and insect damage and disease. When cross-agency coordination is needed for activities such as invasive nonnative plant control, prescribed burns, or herbicide use, management plans should indicate who will take the lead and how that coordination will be accomplished. Plans should incorporate principles of adaptive management.

**2.3. Habitat management plans and recovery actions should manage for impacts and threats to *Silene spaldingii* populations and habitat.**

**2.3.1. Implement invasive nonnative plant control and management measures at all *Silene spaldingii* sites, taking care not to impact *S. spaldingii*.** Invasive nonnative plants may deleteriously affect *Silene spaldingii* through direct competition and habitat degradation. Therefore, ongoing invasive nonnative plant control and management is needed at all *S. spaldingii* sites. Unfortunately invasive nonnative plant control activities, such as herbicide applications, may also negatively affect *S. spaldingii* individuals. While invasive nonnative plant control is necessary, it should be done with care to minimize effects from control activities on *S. spaldingii*. Integrated pest management strategies that enact control measures when economic and/or ecological values are affected should be incorporated into *S. spaldingii* habitat management plans.

**2.3.1.1. Incorporate integrated pest management programs into habitat management plans for *Silene spaldingii* at all key conservation areas.** Effective control and management of invasive nonnative plant species cannot be done without considering impacts to *Silene spaldingii* and, more importantly, its habitat. Without a healthy native plant community, habitat degradation is accelerated, thereby impacting the threatened species. Integrated pest management plans should seek to control nonnative plant invasions while maintaining or restoring the native plant community, not just *S. spaldingii*. Incorporating integrated pest management strategies into habitat management plans should facilitate the conservation of *S. spaldingii* as well as its habitat. Integrated pest management strategies are needed at all key conservation areas (see Recovery Actions 1.1, 1.2, 1.3, 1.4, and 1.5 above). Integrated pest management strategies should identify all control methods available such as prevention, manual control, biological control, and herbicide control. These integrated pest management strategies should include periodic weed surveys to detect new infestations or new invasive nonnative plant species, restore areas where weeds have been controlled to prevent reinvasion, and monitoring and evaluation to determine if control goals are being met.

**2.3.1.2. Conduct invasive nonnative plant control and management measures at all key conservation areas and other populations as needed.** Physiographic region specific guidelines for invasive nonnative plant control and management measures are listed above (see Recovery Actions 1.1.3, 1.2.3, 1.3.2, 1.4.3, and 1.5.4). Implementation of integrated pest management strategies should be conducted at all key conservation areas.

**2.3.1.3. Ensure invasive nonnative plant control and management measures are coordinated with appropriate agencies.** Invasive nonnative plant control and management efforts should be coordinated with the U.S. Fish and Wildlife Service, private landowners, County, Tribal, and State agencies to ensure the protection of *S. spaldingii* individuals and habitat. This will minimize the opportunity for *S. spaldingii* plants to be inadvertently harmed by invasive nonnative plant control activities.

**2.3.1.4. Conduct outreach activities for individuals or organizations that are involved in controlling and managing invasive nonnative plants.** Many organizations that conduct invasive nonnative plant control measures on a regular basis may be accidentally spraying *Silene spaldingii* because of identification problems or because they do not realize the plant is an imperiled species (U.S. Fish and Wildlife Service, *in litt.* 2004). Outreach is needed to inform invasive nonnative plant management agencies such as Weed Management Areas, County Weed Boards, and programs for herbicide applicators to prevent inadvertent spraying of *S. spaldingii*. Counties with *S. spaldingii* sites include Idaho, Lewis, and Nez Perce Counties in Idaho; Flathead, Lake, Lincoln, and Sanders Counties in Montana; Wallowa County in Oregon; and Adams, Asotin, Lincoln, Spokane, and Whitman Counties in Washington.

**2.3.1.5. Conduct surveys for *Silene spaldingii* before invasive nonnative plant control measures are implemented.** Surveys should be conducted in all suitable habitats prior to spraying for invasive nonnative plants. If possible, surveys should not be conducted during drought years, since many *Silene spaldingii* plants may remain dormant and consequently will not be visible.

**2.3.1.6. Develop and implement guidelines for herbicide applications around *Silene spaldingii* plants.** Herbicides will deleteriously affect *Silene spaldingii*; therefore, careful application is needed to minimize effects to *S. spaldingii*. Chemicals and application methods will differ by site. A preliminary set of guidelines that can be altered to match specific sites is offered below to assist land managers and owners in determining how and where to apply various herbicides. Invasive nonnative plant control, when possible, should occur when *S. spaldingii* is dormant (October thru March), to minimize effects to the plant.

**2.3.1.6.1. Develop set distances where various herbicide application techniques may be used near *Silene spaldingii* plants.** Before spraying at *Silene spaldingii* sites, all individuals should be located and flagged. All herbicide applications should occur when wind speeds are less than 5 miles (8 kilometers) an hour to minimize herbicide drift. Aerial spraying (from airplanes or helicopters) should not occur within 1,000 feet (305 meters) of known *S. spaldingii* plants; boom spraying should not occur within 50 feet (15 meters), and wiping or wicking should be the only herbicide application technique employed when within 50 feet (15 meters). Managers may want to utilize manual control techniques only when within 0.3 meter (1 foot) of individual *S. spaldingii* plants. These suggestions may be adjusted depending on the characteristics of the site where they are being employed.

**2.3.1.6.2. Develop set distances for specific herbicides that may be employed near known *Silene spaldingii* sites.** Persistent chemicals such as picloram should not be used within 50 feet (15 meters) of existing *Silene spaldingii* plants. Chemicals that do not affect members of the Caryophyllaceae family should be identified and utilized whenever possible. These suggestions may be adjusted depending on the characteristics of the site where they are being employed.

**2.3.1.6.3. Develop guidelines for the timing of herbicide applications.** Herbicide applications can occur at times when the target invasive nonnative plant is susceptible but when *Silene spaldingii* is not susceptible. For example, *S. spaldingii* actively grows from May to September while *Potentilla recta* (sulfur cinquefoil) is active from April to October. Herbicide applications to *P. recta* in April and October, when *S. spaldingii*, is dormant, will help to minimize effects.

**2.3.2. Conduct fire management activities within *Silene spaldingii* habitat.** Assessing historical fire frequencies within *Silene spaldingii* habitat (grasslands) is difficult because of the lack of trees and tree rings (used to determine fire frequencies). The wide range of *S. spaldingii* also makes analyzing the effects of fire more difficult because of the variability in habitats and historical fire regimes. For example, unlike the Intermontane Valleys, Canyon and Palouse Grasslands may have been stable ecosystems, with species composition and distribution not determined by fire (Daubenmire 1970; Tisdale 1986b). Because fire poses a threat to humans, fire suppression activities are sometimes necessary but should be done so as to minimize damage to *S. spaldingii* to the extent possible. Prescribed burning may enhance plant communities and prevent tree encroachment, but may also damage *S. spaldingii* plants or degrade its habitat by accelerating nonnative plant invasions or harm native plant communities by applying fire at times when plant communities did not historically burn. All fire management should be done carefully and with due consideration of these factors.

**2.3.2.1. Incorporate fire management plans into habitat management plans for all *Silene spaldingii* populations identified as key conservation areas on public lands.** Fire management should not be done without considering impacts to *Silene spaldingii* and, perhaps more importantly, its habitat. Furthermore, fire management plans should be considered on a physiographic region basis. For example, fire management in Montana's Intermontane Valleys with a thick litter layer and tree encroachment should differ significantly from fire management within the Canyon Grasslands with a thin litter layer and fewer problems with tree encroachment. Fire management plans should clearly describe strategies to protect *S. spaldingii* populations and habitat in the event of a wildfire, during both fire-fighting activities and post-fire rehabilitation efforts. Fire management plans should be incorporated into habitat management plans. The potential for using prescribed or wild fire to enhance *S. spaldingii* habitat, if appropriate, could also be included in fire management plans. These fire management plans should carefully assess and mimic, as closely as possible, historical fire regimes.

**2.3.2.2. Carefully conduct prescribed burns within *Silene spaldingii* habitat.** Prescribed burns should be considered as a management tool for increasing *Silene spaldingii* in areas where *Festuca scabrella* (rough fescue) is a dominant species (Lesica 1999). Additional research is needed to determine if prescribed burning will benefit *S. spaldingii* in other areas. Prescribed burning should be carefully employed across *S. spaldingii*'s range.

**2.3.2.2.1. Conduct surveys for *Silene spaldingii* before prescribed burns are implemented.** All prescribed burn areas within *Silene spaldingii* habitat should be surveyed for the plant prior to burning. If *S. spaldingii* is located, management activities should be adjusted accordingly either by not burning in the area or enacting a monitoring program to gauge the plant's response.

**2.3.2.2.2. Monitor the effects to *Silene spaldingii* and its habitat from all burns.** If a fire or a prescribed burn does occur where *Silene spaldingii* resides, trend monitoring and possibly demographic monitoring studies should be done for 3 years prior to burning, whenever possible. Post-fire monitoring should be done consecutively for 3 years, every 5 years, for a monitoring period of at least 15 years after a fire. This monitoring is needed to understand fire's effects on *S. spaldingii* recruitment and its habitat.

**2.3.2.2.3. Do not conduct prescribed burns where invasive nonnative plant infestations exist.** Fire may exacerbate nonnative plant invasions (Christensen and Burrows 1986; Hobbs and Huenneke 1992; Lesica and Martin 2003). In areas where invasive nonnative plants are present, control of invasive nonnative plants should be accomplished prior to burning. For example, within the Channeled Scablands, prior to burning, *Bromus tectorum* (cheatgrass) cover should be less than 20 percent, and all *Centaurea solstitialis* (yellow starthistle), *Potentilla recta* (sulfur cinquefoil), *Chondrilla juncea* (rush skeletonweed), and *Centaurea maculosa* (spotted knapweed) populations should be controlled or eliminated.

**2.3.3. Protect *Silene spaldingii* sites from development on public and private lands.** All *Silene spaldingii* sites and populations, especially key conservation areas, should be protected from development. Requirements of the Endangered Species Act should prevent *S. spaldingii* sites from development on Federal lands. Sites on State lands should be protected from development through habitat management plans and by needed State designations. Consideration of sales to conservation entities may also be considered. Populations of *S. spaldingii* on private land should be protected by conservation easements, consideration of deed restrictions, or possibly direct acquisition from willing landowners. Working through appropriate State, local, or County agencies, voluntary cooperation should be encouraged to protect *S. spaldingii* habitat on private lands. In particular, the conservation and protection of the large population on private lands at the north end of Wallowa Lake, Oregon, should be encouraged because of its large population size (over 500 individuals) (Oregon Natural Heritage Program 2003; Hill and Gray 2004).

**2.3.4. Effectively manage livestock grazing in *Silene spaldingii* habitat.** All Federal lands with suitable habitat for *Silene spaldingii* should be surveyed in allotments where grazing is authorized. Consultation under section 7 of the Endangered Species Act should be completed by 2010 for all Federal land allotments with suitable habitat for *S. spaldingii*. Monitoring of all known *S. spaldingii* sites within grazing allotments should be conducted on a regular basis, and if populations decline grazing practices should be amended. Effective grazing management may include the construction and maintenance of fencing, moving watering troughs, allowing for rest years, and revising allotment plans, grazing schedules, and stocking levels to maintain *S. spaldingii* habitat.

Livestock grazing should not occur within *Silene spaldingii* populations, especially at key conservation areas, when seedling germination occurs in early spring (April and May), during plant emergence and growth (May and June), or when the plant is flowering and setting seed in late July through September. Heavy grazing should not take place at any time because of the potential damage to pollinators, the chance for creating and exacerbating invasive nonnative plant problems, and the damages that *S. spaldingii* may incur.

**2.3.5. Implement effective off-road vehicle use control measures.** Off-road vehicle use should be effectively controlled in all areas containing *Silene spaldingii* habitat. This may involve the use of fencing or other barriers, and developing signs to restrict vehicle use to existing, designated roads.

**2.3.6. Monitor and manage wildlife populations and associated management activities to avoid impacts to *Silene spaldingii* and its habitat.** Analyze the potential effects of wildlife management activities on *Silene spaldingii* sites and habitat. Federal and State agencies should monitor and evaluate the effects of wildlife populations and associated activities on *S. spaldingii*.

**2.4. Monitor population trends and habitat conditions.** Measuring recovery will require monitoring of both *Silene spaldingii* individuals and habitat throughout its range in Idaho, Montana, Oregon, and Washington. Monitoring will provide information on threats to *S. spaldingii* habitat, population and habitat trends, and will also provide feedback on the effectiveness of management and conservation activities. Furthermore, monitoring will provide a measurement of when the recovery criteria have been met and delisting of *S. spaldingii* may be considered.

**2.4.1. Monitor *Silene spaldingii* populations at key conservation areas periodically to determine population trends.** Responsible agencies at potential key conservation areas should ensure that long-term monitoring is conducted, beginning within the next 3 years, to determine population trends and evaluate habitat conditions at *Silene spaldingii* populations. The effects of adjacent land uses, such as recreation, prescribed burns, grazing, and herbicide spraying on this species should be monitored annually. Monitoring programs should be designed to evaluate the effects of invasive nonnative plants, native ungulate grazing, insect predation levels, and other impacts, and be able to document declines at *S. spaldingii* sites. Use of global positioning equipment may be helpful. Because of the long-lived nature of the plant and its prolonged dormancy, to adequately assess trends monitoring should occur consecutively for 3 or more years every 5 to 20 years (Lesica and Steele 1994). In as much as possible, a standardized trend monitoring procedure should be established rangewide. This will be challenging because different areas may require different protocols. Because of the difficulties prolonged dormancy presents for monitoring, either repeated measures analysis (Lesica and Steele 1994; Lesica and Steele 1996; Lesica and Steele 1997) or mark-recapture methods (Alexander *et al.* 1997; Shefferson *et al.* 2001) should be utilized. This standardized trend monitoring procedure should identify at what time of the year monitoring should occur and standardize age classes.

2.4.2. **Conduct demographic monitoring across the range of *Silene spaldingii*.** Demographic data (good estimates of demographic transition probabilities) allow researchers to predict short-term trends, analyze factors that limit population growth and establishment (Pavlik 1994), and are necessary for conducting population viability analyses (see Recovery Action 2.5.1). Information gained from such studies can be used to guide management of *Silene spaldingii* habitat. Therefore demographic studies, dispersed across the range of the plant, are recommended.

2.4.3. **Monitor and evaluate the response of *Silene spaldingii* to fire and invasive nonnative plants.** In the event that *Silene spaldingii* sites are burned by wildfire or prescribed burning, annual monitoring should be conducted to evaluate the response of *S. spaldingii* and its habitat to fire (see Recovery Action 2.3.2.2.2). If habitat rehabilitation or enhancement measures are needed (*e.g.*, to control and manage invasive nonnative plants or erosion), these measures should be developed in conjunction with the U.S. Fish and Wildlife Service, and should be described in site-specific fire management plans. The same should be done in association with the incursion of invasive nonnative plants.

2.4.4. **Obtain permission from private landowners to conduct population trend monitoring for *Silene spaldingii* on private lands.** *Silene spaldingii* sites on private lands should be monitored to determine population trends and habitat conditions. Prior to conducting monitoring on private lands, permission will be requested and obtained from appropriate landowners.

2.4.5. **Determine if sites with no plants have been extirpated.** Many sites had no *Silene spaldingii* individuals present when last surveyed. Further surveys and methodologies are needed to determine if the plants may have been dormant at the time they were last surveyed and have since reappeared, or if the species should be considered extirpated from these sites.

**2.5. Conduct research essential to the conservation of *Silene spaldingii.*** Additional research regarding *Silene spaldingii* needs to be conducted to validate the recovery objectives for this species or to allow for their revision, as appropriate. Information on life history, population characteristics, and habitat requirements should be obtained to allow for more accurate specification of management and population goals. Partnerships with other State, Federal, or private agencies and individuals should be developed, where possible, to meet these objectives. We will work with appropriate entities to identify and support the funding to conduct essential research on *S. spaldingii*.

**2.5.1. Determine population viabilities for *Silene spaldingii* populations.** Conduct essential research, including further genetic and demographic studies, to determine the long-term population viability of *Silene spaldingii*. A population viability analysis is needed to guide management in answering how to manage sites, identifying which populations are likely to survive into the future, and which are too small and isolated to persist (Menges 1991b). Estimates of population viability for this species will require data on factors such as mortality, dispersal, and recruitment. In addition, habitat availability and threats, including manmade or anthropogenic threats, natural catastrophes, and genetic and demographic stochasticity (Menges 1991b) should also be evaluated. A population viability analysis will also assist in determining whether the current goal of 500 reproducing individuals in a potential key conservation area is valid to ensure long-term persistence, and allow for refinement of this number, if necessary.

**2.5.2. Develop new populations or supplement existing populations of *Silene spaldingii* where appropriate.** Recruitment of *Silene spaldingii* is rare and occurs slowly (P. Lesica, *in litt.* 2004), making human intervention necessary to preserve smaller populations. Preliminary studies looking at seedling growth indicate that growing *S. spaldingii* in cultivation is a possibility (Lesica 1988a, 1993; Hill and Gray 2000, 2004a; A. Brusven, *in litt.* 2004; A. Raven, *in litt.* 2004). Potential key conservation areas where populations will be supplemented or developed will need to have plans that address how these activities will occur. All new populations and supplementations will be conducted on protected areas only. When completed, the population viability analysis should assist in identifying what genetic material needs to be better conserved.

**2.5.2.1. Utilize existing key conservation areas and identify new key conservation area sites with good habitat where new populations should be developed or where existing populations could be supplemented.** The time and expense of supplementing existing populations and creating new populations should be undertaken only at areas that are protected and only at areas that have the potential to become key conservation areas. Supplementation and reintroduction should occur only if it will help facilitate the recovery of the species and meeting the goals of this recovery plan.

**2.5.2.2. Determine the best techniques for creating new populations or supplementing existing populations of *Silene spaldingii*.** More research is needed in developing the best techniques for successful establishment of *Silene spaldingii* individuals. Seeds seem to germinate easily and grow in greenhouse containers. However, techniques to successfully transplant individuals to the wild are still needed. Furthermore, growing seed as a crop (grow-out) to increase seed has not been tested. A grow-out experiment could help in providing seed for supplementing or creating new populations and minimize impacts to native populations.

**2.5.2.3. Determine the best techniques to restore *Silene spaldingii* habitat.** Before populations of *Silene spaldingii* are created or expanded, habitat restoration may be needed to mimic native habitat. This native habitat cannot be recreated without identifying and practicing the most effective restoration techniques.

**2.5.3. Conduct research essential to controlling and managing invasive nonnative plants within *Silene spaldingii* habitat.** More research is needed in determining the best invasive nonnative plant control and management methods within and adjacent to *Silene spaldingii* sites. Methods for investigation should include the most effective herbicides for various invasive nonnative plants; best times for herbicide application; the effects of prescribed burning, mowing, and biological control agents; and various other techniques that will reduce competition from invasive nonnative plants and improve habitat for *S. spaldingii*.

Additional research is needed to determine the effects of nonnative plant invasions on *Silene spaldingii*. Questions investigated should include: which species of invasive nonnative plants have the most deleterious effect on *S. spaldingii*; at which life history stage of *S. spaldingii* is competition from invasive nonnative plants most severe; and whether invasive nonnative plants are expanding into *S. spaldingii* habitat where they previously were unable to reside.

Research is needed to investigate the best restoration techniques to use in degraded *Silene spaldingii* habitats. Invasive nonnative plants may be better detected if remote sensing techniques are identified that can detect invasive nonnative plant populations in locations that are difficult to access by foot or vehicle.

**2.5.4. Conduct research essential to managing livestock, wildlife, and insect herbivory at *Silene spaldingii* populations.** Herbivory of *Silene spaldingii* occurs at all sites where *S. spaldingii* resides. The plant has adapted to some herbivory over the course of evolutionary time, while other herbivory is new or may have increased as a result of human activities. Research is needed to determine at what levels of herbivory *S. spaldingii* plants can persist, and at what levels its habitat remains intact. Livestock grazing is the most obvious form of human-related herbivory.

Information is needed on how differences in duration, intensity, and seasonality of herbivory, particularly livestock grazing, impact *Silene spaldingii*, its habitat, and nonnative plant invasions. Aside from livestock grazing, herbivory effects from wildlife species that may be at higher than historical levels need investigation. Finally, insect and small mammal herbivory needs further investigation. For example, to what extent is the presence of invasive nonnative plants increasing or decreasing natural insect herbivory levels.

**2.5.5. Conduct research to better determine the effects of fire on *Silene spaldingii* and identify when and where prescribed fire should occur, particularly outside of Montana.** Information is needed on how fires conducted during various seasons, the presence of invasive nonnative plants, and various habitat types affect *Silene spaldingii*, its recruitment rates, its habitat, and nonnative plant invasions. For example, because litter build-up varies, do fires within the Canyon Grasslands and their effects to *S. spaldingii* differ from those at the Dancing Prairie Preserve in Montana, where research has already occurred? Which invasive nonnative plants benefit from fire and which are affected deleteriously? At what densities do invasive nonnative plants proliferate with fire and at what densities do they decline? Are these densities different across various habitat types? Is tree encroachment into grasslands a problem across the range of *S. spaldingii*? What are the effects to *S. spaldingii* and its habitats from prescribed fires that typically occur outside of the historic fire season? Since some research on fire effects has already taken place on *S. spaldingii* populations in Montana, such studies are particularly needed in other areas within the species' range.

An accurate method of measuring historical fire frequency within grassland habitats is needed. In addition, research on the effects of fire on *Symphoricarpos albus* (snowberry) and *Rosa* spp. (rose) is needed to determine if fire encourages these browse species, as has been suggested by wildlife managers.

2.5.6. **Conduct further research regarding reproductive biology and essential pollinators for *Silene spaldingii*.** Research is needed to better separate self-incompatibility mechanisms from inbreeding depression and to determine if *Silene spaldingii* is capable of creating seed without the addition of pollen (apomixis). No research has investigated if outbreeding depression may be problematic for *S. spaldingii*. Information on outbreeding depression would be useful in reintroduction experiments.

Because pollinators are required for full seed set of *Silene spaldingii* (Lesica 1988b, 1993; Lesica and Heidel 1996), conservation measures should be designed to protect nearby pollinator populations. Research is needed to better design conservation measures that protect pollinators. Additional information on the requirements of pollinators, especially *Bombus fervidus*, is needed, including the locations of nests, queen overwintering sites, preferred habitats, and resource competition. Research investigating how far *Bombus fervidus* is capable of transporting pollen as well as the relative contributions of other pollinators is needed. Nighttime pollination, found to be important in another rare *Silene*, should be investigated (Kephart 2003). The effects of threats including livestock grazing and fire on *S. spaldingii*'s ground dwelling pollinators should be studied.

2.5.7. **Conduct research investigating seed dispersal mechanisms for *Silene spaldingii*.** No studies have investigated seed dispersal mechanisms for *Silene spaldingii*. Research is needed to determine how *S. spaldingii* seeds are transported, what transports seeds, and how far seeds are generally transported. This information is needed to conserve dispersal mechanisms, and to develop a better understanding of gene dispersal and what constitutes a discrete population.

2.5.8. **Conduct research investigating the period seeds may remain viable in the soil.** No studies have investigated how long *Silene spaldingii* seeds may remain viable in the ground. This information is important because if seeds are viable for only a year or two, the loss of one year's seed production to fire or grazing will dramatically reduce the amount of seed available for recruitment.

**2.5.9. Conduct further genetic research for *Silene spaldingii*.** Baldwin and Brunsfeld's (1995) genetic study was only a preliminary genetic study; they made a number of recommendations for further genetic work. First, genetic material should be collected from a wider range of samples and analyze more loci during a moist year when sample sizes can be large enough to more definitely make conclusions about the dispersal of genes across the range of *Silene spaldingii* (Baldwin and Brunsfeld 1995). And second, the higher homozygosity levels and lower pollinator visitation rates at the Dancing Prairie site need to be further investigated (Baldwin and Brunsfeld 1995).

In addition, genetic research is needed that investigates the effects of small population size, fragmentation, and genetic isolation. Genetic analyses should help to identify high priority populations for conservation efforts and should be incorporated with the population viability analysis identified in Recovery Action 2.5.1 above.

**2.6. Conduct surveys in potential habitat areas. Manage and protect any newly discovered *Silene spaldingii* populations.** Intensive field work should be conducted to locate additional populations of this species, especially within the Canyon Grasslands. The habitat of any newly discovered populations should be protected and managed as necessary.

**2.6.1. Conduct surveys on Federal lands for *Silene spaldingii*.** Intensive surveys for *Silene spaldingii* should be conducted prior to approving and implementing activities that may affect habitat (either occupied or potentially suitable) for this species in the Canyon Grasslands, Palouse Grasslands, Channeled Scablands, Blue Mountain Basins, and Intermontane Valleys. Discovering new and large populations of *S. spaldingii*, especially within intact habitat, will help meet delisting goals. Surveys are especially needed within the Canyon Grasslands where it is surmised populations may reside with minimal threats. Surveys should also be conducted in areas where ongoing activities such as livestock grazing may affect known or potentially suitable habitat for *S. spaldingii* on Federal lands, and whenever possible on State, Tribal, and private lands as well.

**2.6.2. Conduct surveys on State and Tribal lands, especially where activities may affect *Silene spaldingii* habitat.** Surveys are needed on both Tribal and State lands. Staff and funding should be identified to accomplish these activities.

**2.6.3. Obtain permission from private landowners to conduct surveys for *Silene spaldingii* on private lands.** Prior to conducting surveys on private lands, permission will be requested and obtained from appropriate landowners.

**2.6.4. Protect newly discovered *Silene spaldingii* populations.** Newly discovered populations should be granted the same protection as already discovered sites, and recovery tasks included here should apply to these newly discovered sites.

**2.7. Support conservation on privately owned lands.** Over 40 percent of the known populations of *Silene spaldingii* are on lands not managed by Federal, Tribal, or State entities (Hill and Gray 2004). Because the Endangered Species Act does not require surveys of *S. spaldingii* on private land, it is expected that many *S. spaldingii* sites remain unidentified or unreported on private lands. One of the 7 known populations with over 500 individuals is currently unprotected on private lands. Three populations with over 500 individuals are located either wholly or partially on lands managed by The Nature Conservancy, a private conservation organization. Participation with private landowners is needed for successful conservation of *S. spaldingii*. Participation from private landowners is not required by the Endangered Species Act; therefore, outreach activities are needed to encourage voluntary conservation on private lands.

**2.7.1. Support conservation actions on lands owned by The Nature Conservancy.** The Nature Conservancy has been vital in conservation of *Silene spaldingii*. The largest population of *S. spaldingii* is located on The Nature Conservancy's Dancing Prairie Preserve (Montana Natural Heritage Program 2003). The Zumwalt Prairie Preserve in Oregon and the Garden Creek Ranch in Idaho also have large populations of *S. spaldingii* (Idaho Conservation Data Center 2003, Oregon Natural Heritage Program 2003). Many research and monitoring studies have been conducted and funded on these parcels of land. The action items listed here should apply to *S. spaldingii* sites on The Nature Conservancy lands. A volunteer registry of *S. spaldingii* populations on private lands, such as the one The Nature Conservancy maintains in Washington and Montana, should be implemented and updated in all States where *S. spaldingii* resides. Registry lands should be considered for permanent easements that protect *S. spaldingii*.

**2.7.2. Support conservation activities on other private lands.** Key conservation areas on private land, such as those along Wallowa Lake in Oregon, should be identified where conservation of *Silene spaldingii* is needed. Appropriate landowners should be contacted and potential conservation activities identified and implemented whenever possible. Recommendations for protection on private lands are included in Recovery Actions 2.1, 2.2, 2.3, 2.3.3, 2.4, 2.4.4, and 2.7.1. Programs available to fund conservation activities on private lands include the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program, Private Stewardship Grants, and Landowner Incentive Program; and the Natural Resource Conservation Service's Environmental Quality Incentives Program, Wildlife Habitat Incentives Program, Conservation Reserve Program, and Grassland Reserve Program.

**2.7.3. Conduct outreach and awareness efforts with the public regarding *Silene spaldingii*'s plight and its conservation.** Without outreach and awareness activities, the public will not know about *Silene spaldingii* or its conservation needs. Written outreach material is needed in the form of newspaper articles, pamphlets, and displays at public meetings. Oral presentations are needed to invasive nonnative plant control related groups (see Recovery Action 2.3.1.3), native plant societies, Master Gardeners, Natural Resource Conservation Service personnel, County conservation committees, Soil and Water Conservation Districts, Cooperative Extension Agencies, and others to reach the public.

**2.8. Pursue land and species designations that will help facilitate conservation of *Silene spaldingii.*** Federal agencies should consider designating essential *Silene spaldingii* habitat areas on public land as special management areas (*e.g.*, as Areas of Critical Environmental Concern, Botanical Special Interest Areas, or Research Natural Areas). Protected habitat areas should include occupied habitat and potentially suitable, currently unoccupied habitat to allow for population expansion, especially near key conservation areas. Recommendations for special management designations should be incorporated into *S. spaldingii* habitat management plans. Because *S. spaldingii* is not protected on State managed lands, protection of the species occurs only through the good will of State managers (the exception is in Oregon, where the species is technically protected; however, no populations of *S. spaldingii* are known to occur on State lands in Oregon). State legislation is recommended to better protect the species on State managed lands. This legislation should also serve to protect the plant on lands owned by educational institutions that receive State funding.

**2.9. Establish propagule banks, including a long-term seed storage facility for *Silene spaldingii*.** *Silene spaldingii* seeds have been collected from only five populations, all of which are relatively large. Seeds of *S. spaldingii* should be collected according to currently accepted protocol from all populations not identified as key conservation areas, and stored at a long-term seed storage facility such as the Berry Botanic Garden in Portland, Oregon. Seeds should be collected in coordination with seed storage facilities to capture as much of the species' genetic variability as possible. The U.S. Fish and Wildlife Service will assist with securing permits for activities as appropriate.

**2.10. Secure funding for implementation of recovery actions.** Additional funding over the long term will be needed to implement the recovery actions listed here. Each land manager or owner will be responsible for securing funding to protect *Silene spaldingii*. Collaborative efforts between agencies and individuals will be necessary to accomplish larger actions such as surveying the Canyon Grasslands.

**2.11. Validate and revise recovery objectives.** This recovery plan should be updated as recovery actions are accomplished, or revised as additional information becomes available. In particular, the results of any population viability analyses conducted for *Silene spaldingii* will be considered in future recovery plan revisions.

**3. Develop a post-delisting monitoring plan.** A plan for monitoring the species for a minimum of 5 years after delisting must be in place and ready for implementation at the time of delisting. Such a plan will ensure the ongoing recovery of the species and provide a means of assessing the effectiveness of management actions.

# IV. Implementation Schedule

The Implementation Schedule that follows outlines the recommended recovery actions and estimated time and costs of the recovery program for *Silene spaldingii*, as set forth in this recovery plan. It is a guide for meeting the recovery goals outlined in this plan. The schedule indicates action priorities, action numbers, action descriptions, duration of actions, the parties responsible for actions, and estimated costs. Parties with the authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

**Definition of Action Priorities**:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

**Definition of Action Durations**:

Continual - An action that will be implemented on a routine basis once begun.

Ongoing - An action that is currently being implemented and will continue until the action is no longer necessary.

**Estimated Costs:**

Continual and ongoing costs, as well as the estimated total cost, are based on a projected 35 year timeframe to recovery and delisting of the species. Because *Silene spaldingii* is a long-lived perennial species and annual counts vary significantly in response to climatic events, a minimum of 20 years of monitoring is needed to determine long-term population trends. The earliest projected recovery date of 2040 reflects the need for this long-term monitoring as well as the time it may take to supplement or establish new populations.

**Key to Responsible Parties**:

| | |
|---|---|
| BBG | Berry Botanic Garden |
| BLM | Bureau of Land Management |
| CSKT | Confederated Salish and Kootenai Tribes |
| CBLM | Cottonwood District Bureau of Land Management, Idaho |
| CMWMA | Craig Mountain Wildlife Management Area, Idaho Department of Fish and Game |
| DPP | Dancing Prairie Preserve, The Nature Conservancy |
| DOD | Department of Defense |
| DOT | Department of Transportation |
| EDU | Higher education facilities |
| FAFB | Fairchild Air Force Base |
| FS | U.S. Forest Service |
| GCR | Garden Creek Ranch, The Nature Conservancy |
| HP | Heritage Programs and Conservation Data Centers |
| LTNWR | Lost Trail National Wildlife Refuge |
| MBLM | Montana Bureau of Land Management |
| NRCS | Natural Resource Conservation Service |
| NPT | Nez Perce Tribe |
| OCJG | Old Chief Joseph Gravesite, Nez Perce National Historic Park |
| PVT | Private landowners |
| SWCD | Soil and Water Conservation District |
| SBLM | Spokane District Bureau of Land Management, Washington |
| ST | State land management agencies |
| SLWA | Swanson Lakes Wildlife Area, Washington Department of Fish and Wildlife |
| T | Native American Tribes |
| TNC | The Nature Conservancy |
| TNWR | Turnbull National Wildlife Refuge |
| UNF | Umatilla National Forest |
| USFWS | U.S. Fish and Wildlife Service |
| VBLM | Vale District Bureau of Land Management, Oregon |
| WWNF | Wallowa-Whitman National Forest |
| WNHP | Washington Natural Heritage Program |
| WMA | Weed Management Areas |
| WHISP | Wild Horse Island State Park, Montana Fish, Wildlife, and Parks |
| ZPP | Zumwalt Prairie Preserve, The Nature Conservancy |

**Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan**

| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 1 | 1.1.1 | Conserve and work to enhance four *Silene spaldingii* populations within the Blue Mountain Basins identified here as key conservation areas. | Ongoing | EDU, NRCS, OCJG, PVT, SWCD, USFWS*, WWNF, ZPP | | | | | | | This action and associated costs will be completed through Action 2.2 below. |
| 1 | 1.2.1 | Conserve and work to enhance three *Silene spaldingii* populations within the Canyon Grasslands identified here as key conservation areas. | Ongoing | CBLM, CMWMA, EDU, GKR, NPT, UNF, USFWS*, WWNF | | | | | | | This action and associated costs will be completed through Action 2.2 below. |
| 1 | 1.3.1 | Conserve, survey, and work to enhance 10 *Silene spaldingii* populations within the Channeled Scablands identified here as key conservation areas. | Ongoing | NRCS, PVT, SBLM*, SLWA, SWCD, USFWS | | | | | | | This action and associated costs will be completed through Action 2.2 below. |
| 1 | 1.4.1 | Conserve and work to enhance four *Silene spaldingii* populations within the Intermontane Valleys identified here as key conservation areas. | Ongoing | CSKT, DPP, EDU, LTNWR, PVT, ST, USFWS*, WHISP | | | | | | | This action and associated costs will be completed through Action 2.2 below. |
| 1 | 1.5.1 | Conserve and work to enhance two *Silene spaldingii* populations within the Palouse Grasslands identified here as a key conservation areas. | Ongoing | EDU, NRCS, PVT, SWCD, USFWS*, WSU | | | | | | | This action and associated costs will be completed through Action 2.2 below. |

**Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued)**

| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 1 | 1.5.3 | Supplement existing populations and conduct a restoration and reintroduction program within the Palouse Grasslands to create 3 new populations and key conservation areas of *Silene spaldingii* with over 500 individuals. | Ongoing | CBLM, EDU, NRCS, PVT, SBLM, ST, SWCD, USFWS*, WSU | | | | | | | See subactions of Action 2.5.2 below. |
| 1 | 2.10 | Secure funding for implementation or recovery tasks. | Continual | All | | | | | | | Costs included in other actions listed. |
| 1 | 2.2 | Develop *Silene spaldingii* specific habitat management plans at all key conservation areas. | 6 | CBLM, CMWMA, CSKT, DDP, GKR, LTNWR, OCJG, PVT, SBLM, SLWA, UNF, USFWS*, WHISP, WSU, WWNF, ZPP | 465 | 77.5 | 77.5 | 77.5 | 77.5 | 77.5 | $15K at each of the 26 key conservation areas plus an additional 5 potential key conservation areas. |
| 1 | 2.3.3 | Protect *Silene spaldingii* sites from development on public and private lands. | Continual | All | 216 | 6 | 6 | 6 | 6 | 6 | $6K each year at rangewide locations. |
| 1 | 2.6.4 | Protect newly discovered *Silene spaldingii* populations. | Continual | All | | | | | | | Costs included in other actions listed. |
| 1 | 2.7.1 | Conduct conservation actions on lands owned by The Nature Conservancy. | Ongoing | TNC*, USFWS | | | | | | | Costs included in other actions listed. |

**Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued)**

| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.7.2 | Conservation activities on other private lands. | Continual | All | | | | | | | Costs included in other actions listed. |
| 2 | 1.1.2 | Conduct further surveys or work to create 1 new population and key conservation area within the Blue Mountain Basins with over 500 individuals. | Ongoing | EDU, NRCS, OCJG, PVT, SWCD, USFWS*, VBLM, WWNF, ZPP | | | | | | | This action and associated costs completed through Actions 2.3.1.5, 2.3.2.2.1, 2.5.2 (and sub-actions), 2.6 (and sub-actions), 2.7 (and sub-actions). |
| 2 | 1.1.3 | Control and manage invasive nonnative plant species specific to the Blue Mountain Basins. | Ongoing | OCJG, PVT, USFWS, VBLM, WMA, WWNF*, ZPP | 52.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | See Action 2.3.1 (and sub-actions). |
| 2 | 1.2.2 | Conduct further surveys or work to create 3 new populations and key conservation areas within the Canyon Grasslands with over 500 individuals. | Ongoing | CBLM, CMWMA, EDU, GKR, NPT, PVT, SBLM, ST, UNF, USFWS*, VBLM, WWNF | | | | | | | This action and associated costs completed through Actions 2.3.1.5, 2.3.2.2.1, 2.5.2 (and sub-actions), 2.6 (and sub-actions), 2.7 (and sub-actions). |
| 2 | 1.2.3 | Control and manage invasive nonnative plant species specific to the Canyon Grasslands. | Ongoing | CBLM, CMWMA, GKR, NPT, PVT, ST, UNF, USFWS, WMA*, WWNF | 52.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | See Action 2.3.1 (and sub-actions). |

**Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued)**

| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 2 | 1.3.2 | Control and manage invasive nonnative plant species specific to the Channeled Scablands. | Ongoing | FAFB, PVT, SBLM*, SLWA, TNWR, USFWS, WMA | 52.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | See Action 2.3.1 (and sub-actions). |
| 2 | 1.4.2 | Conduct further surveys or work to supplement existing populations within the Intermontane Valleys to establish 3 additional populations and key conservation areas with over 500 individuals. | Ongoing | CSKT, EDU, FS, LTNWR, MBLM, NRCS, PVT, ST, SWCD, USFWS* | | | | | | | This action and associated costs completed through Actions 2.3.1.5, 2.3.2.2.1, 2.5.2 (and sub-actions), 2.6 (and sub-actions), 2.7 (and sub-actions). |
| 2 | 1.4.3 | Control and manage invasive nonnative plant species specific to the Intermontane Valleys. | Ongoing | CSKT, DPP, FS, LTNWR, MBLM, PVT, ST, USFWS*, WHISP, WMA | 52.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | See Action 2.3.1 (and sub-actions). |
| 2 | 1.5.4 | Control and manage invasive nonnative plant species specific to the Palouse Grasslands. | Ongoing | CBLM, PVT, SBLM, ST, USFWS*, WMA, WSU | 17.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | See Action 2.3.1 (and sub-actions). Total cost based upon the 35 years until the first possible recovery date. |
| 2 | 2.3.1.5 | Conduct surveys for *Silene spaldingii* before invasive nonnative plant control measures are implemented. | Ongoing | All | 630 | 18 | 18 | 18 | 18 | 18 | $3K for six different surveys (1000 acres [405 hectares]) each year across all land managers. |

| Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
| | | | | | Total Cost[†] | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 2 | 2.3.2.1 | Incorporate fire management plans into habitat management plans for all *Silene spaldingii* populations identified as key conservation areas on public lands. | 6 | Same as Action 2.2 | | | | | | | Cost included in Action 2.2. |
| 2 | 2.3.2.2.1 | Conduct surveys for *Silene spaldingii* before prescribed burns are implemented. | Ongoing | All | 630 | 18 | 18 | 18 | 18 | 18 | $3K for six different surveys (1000 acres [405 hectares]) each year across all land managers. |
| 2 | 2.3.2.2.3 | Do not conduct prescribed burns where invasive nonnative plant infestations exist. | Ongoing | All | | | | | | | Cost included in Action 2.3.2.2.1. |
| 2 | 2.3.4 | Effectively manage livestock grazing in *Silene spaldingii* habitat. | Ongoing | All | 455 | 13 | 13 | 13 | 13 | 13 | $0.5K for each of 26 different land managers and owners. |
| 2 | 2.3.5 | Implement effective off-road vehicle use control measures. | Continual | All | 175 | 5 | 5 | 5 | 5 | 5 | $0.5K for each of 10 different land managers and owners. |
| 2 | 2.5.2.2 | Determine the best techniques for creating new populations or supplementing existing populations of *Silene spaldingii*. | 10 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 40 | 4 | 4 | 4 | 4 | 4 | |
| 2 | 2.5.2.3 | Determine the best techniques to restore *Silene spaldingii* habitat. | Continual | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 175 | 5 | 5 | 5 | 5 | 5 | Some of these techniqes could be borrowed from research on other species. |

**Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued)**

| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 2 | 2.9 | Establish propagule banks, including a long-term seed storage facility for *Silene spaldingii*. | Ongoing | All, BBG* | 35 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 1.5.2 | Conduct a study identifying intact habitat within the Palouse Grasslands where *Silene spaldingii* may occur. | 5 | CBLM, EDU, PVT, SBLM, ST, USFWS*, WSU | 20 | 4 | 4 | 4 | 4 | 4 | |
| 3 | 2.1 | Revise, and implement general management plans to include *Silene spaldingii* where the species resides. | As plans are revised | BLM, EDU, FAFB, FS, OCJG, ST, T, TNC, USFWS* | 100 | 10 | 10 | 10 | 10 | 10 | $5K for each general management plan at 20 different State, Federal, Tribal, and TNC managed areas. |
| 3 | 2.3.1.1 | Incorporate integrated pest management programs into habitat management plans for *Silene spaldingii* at all key conservation areas. | 6 | Same as Action 2.2 | | | | | | | Cost included in Action 2.2. |
| 3 | 2.3.1.3 | Ensure invasive nonnative plant control and management measures are coordinated with appropriate agencies. | Ongoing | All | | | | | | | Cost included in Actions 1.1.3, 1.2.3, 1.3.2, 1.4.3, and 1.5.4. |
| 3 | 2.3.1.4 | Conduct outreach activities for individuals or organizations that are involved in controlling and managing invasive nonnative plants. | Ongoing | All, USFWS* | 35 | 1 | 1 | 1 | 1 | 1 | Total cost based upon the 35 years until the first possible recovery date. |

| Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 3 | 2.3.1.6.1 | Develop set distances where various herbicide application techniques may be used near *Silene spaldingii* plants. | Once every 5 years | BLM, FS, ST, USFWS*, WMA | 7 | 1 | | | | | $1K once every 5 years (7 times total) to revisit and adaptively manage distances based upon current information. |
| 3 | 2.3.1.6.2 | Develop set distances for specific herbicides that may be employed near known *Silene spaldingii* sites. | Once every 5 years | BLM, FS, ST, USFWS*, WMA | 7 | | 1 | | | | $1K once every 5 years (7 times total) to revisit and adaptively manage distances based upon current information. |
| 3 | 2.3.1.6.3 | Develop guidelines for the timing of herbicide applications. | Ongoing; once every 5 years | BLM, EDU, FS, ST, USFWS*, WMA | 7 | | | 1 | | | $1K once every 5 years (7 times total) to revisit and adaptively manage distances based upon current information. |
| 3 | 2.3.2.2.2 | Monitor the effects to *Silene spaldingii* and its habitat from all burns. | Ongoing | All | 350 | 10 | 10 | 10 | 10 | 10 | $2K at five different burn sites each year across all land managers. |
| 3 | 2.3.6 | Monitor and manage wildlife populations and associated management activities to avoid impacts to *Silene spaldingii* and its habitat. | Continual | BLM, FS, ST*, T | 70 | 2 | 2 | 2 | 2 | 2 | $0.5K annually for each of the four states where *Silene spaldingii* resides. |
| 3 | 2.4.1 | Monitor *Silene spaldingii* populations at key conservation areas periodically to determine population trends. | Continual | Same as Action 2.2 | 1,628 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | $3K at each of the 26 key conservation areas plus an additional 5 potential key conservation areas 5 of every 10 years. |

| Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
| | | | | | Total Cost[†] | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 3 | 2.4.2 | Conduct demographic monitoring across the range of *Silene spaldingii*. | Continual | Same as Action 2.2 | 525 | 15 | 15 | 15 | 15 | 15 | $6K in each of the five physiographic regions in 5 of every 10 years. |
| 3 | 2.4.3 | Monitor and evaluate the response of *Silene spaldingii* to fire and invasive nonnative plants. | Ongoing | All | | | | | | | Included in the costs listed in Action 2.4.1. |
| 3 | 2.4.4 | Obtain permission from private landowners to conduct population trend monitoring for *Silene spaldingii* on private lands. | Continual | BLM, EDU, FS, HP, NRCS, PVT, USFWS* | | | | | | | Included in the costs listed in Action 2.4.1. |
| 3 | 2.4.5 | Determine if sites with no plants have been extirpated. | 3 | BLM, EDU, FS, HP, NRCS, PVT, USFWS* | 6 | | 2 | 2 | 2 | | 8 sites in Washington that should be visited for 3 consecutive years at $0.25K a site. |
| 3 | 2.5.1 | Determine population viabilities for *Silene spaldingii* populations. | 15 | BLM, EDU, FS, ST, TNC, USFWS* | 20 | | | | | | Some of the costs included in Action 2.4.2 (demography) and Action 2.5.9 (genetics). |
| 3 | 2.5.2.1 | Utilize existing key conservation areas and identify new key conservation areas with good habitat where new populations should be developed or where existing populations could be supplemented. | Continual | All | 525 | 15 | 15 | 15 | 15 | 15 | |

| Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
| | | | | | Total Cost† | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 3 | 2.5.3 | Conduct research essential to controlling and managing invasive nonnative plants within *Silene spaldingii* habitat. | Continual | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 175 | 5 | 5 | 5 | 5 | 5 | Some of these techniqes could be borrowed from research on other species. |
| 3 | 2.5.4 | Conduct research essential to managing livestock, wildlife, and insect herbivory at *Silene spaldingii* populations. | 20 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 200 | 10 | 10 | 10 | 10 | 10 | |
| 3 | 2.5.5 | Conduct research to better determine the effects of fire on *Silene spaldingii* and identify when and where prescribed fire should occur, particularly outside of Montana. | 20 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 200 | 10 | 10 | 10 | 10 | 10 | |
| 3 | 2.5.6 | Conduct further research regarding reproductive biology and essential pollinators for *Silene spaldingii*. | 3 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 18 | | 6 | 6 | 6 | | |
| 3 | 2.5.7 | Conduct research investigating seed dispersal mechanisms for *Silene spaldingii*. | 5 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 10 | 2 | 2 | 2 | 2 | 2 | |
| 3 | 2.5.8 | Conduct research investigating the period seeds may remain viable in the soil. | Depends on longevity | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | To be determined | 1 | 1 | 1 | 1 | 1 | Total cost will depend on the length of the study. |
| 3 | 2.5.9 | Conduct further genetic research for *Silene spaldingii*. | 5 | BLM, DOD, EDU, FS, ST, T, TNC, USFWS* | 100 | 20 | 20 | 20 | 20 | 20 | Should be concurrent with Action 2.5.1. |

| Implementation Schedule for the *Silene spaldingii* Draft Recovery Plan (continued) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Number | Action Number | Action Description | Action Duration (years) | Responsible Parties | Cost Estimates ($1,000) | | | | | | Comments |
| | | | | | Total Cost[†] | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | |
| 3 | 2.6.1 | Conduct surveys on Federal lands for *Silene spaldingii*. | Ongoing | BLM*, DOD, FS, USFWS | 630 | 18 | 18 | 18 | 18 | 18 | Costs here are for non-project related surveys, see also Actions 2.3.1.5 and 2.3.2.2.1. |
| 3 | 2.6.2 | Conduct surveys on State and Tribal lands, especially where activities may affect *Silene spaldingii* habitat. | Ongoing | HP, ST, T, USFWS | 210 | 6 | 6 | 6 | 6 | 6 | Costs here are for non-project related surveys, see also Actions 2.3.1.5 and 2.3.2.2.1. |
| 3 | 2.6.3 | Obtain permission from private landowners to conduct surveys for *Silene spaldingii* on private lands. | Ongoing | HP, NRCS, PVT*, USFWS | 210 | 6 | 6 | 6 | 6 | 6 | |
| 3 | 2.7.3 | Conduct outreach and education with the public regarding *Silene spaldingii*'s plight and its conservation. | Continual | All | 280 | 8 | 8 | 8 | 8 | 8 | $2K annually in each of the four states where *Silene spaldingii* resides. |
| 3 | 2.8 | Pursue land and species designations that will help facilitate conservation of *Silene spaldingii*. | Continual | All | 35 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 2.11 | Validate and revise recovery objectives. | Continual | All, USFWS* | 175 | | | | | | $25K every 5 years (7 times total) |
| 3 | 3.0 | Develop a post-delisting monitoring plan. | 1 year | All, USFWS* | 10 | | | | | | To be developed within 2 years of anticipated delisting. |
| **Total estimated cost for recovery** | | | | | **8,601.5** | **345.5** | **353.5** | **353.5** | **352.5** | **344.5** | |

.
. [†]All ongoing and continual total costs based upon a 35 year time frame; when the species may potentially be recovered

# V. Literature Cited

Alexander, H. M., N.A. Slade, and W.D. Kettle. 1997. Application of mark-recapture models to estimation of the population size of plants. Ecology 78:1230-1237.

Alt, D.D. and D.W. Hyndman. 1986. Roadside geology of Montana. Mountain Press Publishing Company, Missoula, Montana. 427 pp.

Alt, D.D. and D.W. Hyndman. 1989. Roadside geology of Idaho. Mountain Press Publishing Company, Missoula, Montana. 394 pp.

Baldwin, C.T. and S.J. Brunsfeld. 1995. Preliminary genetic analysis of *Silene spaldingii* (Spalding's catchfly), a candidate threatened species. Wildland Plant Ecogenetics Cooperative, University of Idaho, in cooperation with Montana Natural Heritage Program, Moscow, Idaho. 23 pp.

Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: Implication for conservation. Pages 1-30 *in* D.A. Falk and K.E. Holsinger (editors), Genetics and conservation of rare plants. Oxford University Press, Oxford, United Kingdom.

Biodiversity Legal Foundation, Montana Native Plant Society, Washington Native Plant Society, and P. Lesica. 1995. Petition to list Spalding's catchfly (*Silene spaldingii*) as threatened or endangered under the Endangered Species Act. 25 pp.

Bock, C.E., J.H. Bock, and H.M. Smith. 1993. Proposal for a system of Federal livestock exclosures on public rangelands in the Western United States. Conservation Biology 7:731-733.

Boutin, C. and B. Jobin. 1998. Intensity of agricultural practices and effect of adjacent habitats. Ecological Applications 8:544-557.

British Columbia Conservation Data Centre. 2004. Element occurrence records for *Silene Spaldingii*, includes the limited use agreements for digital data. 6 pp.

Callihan, R. C. and T. M. Miller. 1997. A pictorial guide to Idaho's noxious weeds. Pages 58-59 *in* Weed Diagnostic Laboratory, Department of Plant, Soil, and Entomological Sciences, College of Agricultures, Agricultural Communications Center, University of Idaho, Moscow, Idaho.

Caplow, F. 2001. Annual report for Spalding's Catchfly (*Silene spaldingii*) on Fairchild Air Force Base, Washington. Washington State Department of Natural Resources, Natural Heritage Program, Olympia, Washington. 11 pp.

Caplow, F. 2002a. Annual report for Spalding’s catchfly (*Silene spaldingii*) on Fairchild AFB, Washington. Washington Natural Heritage Program. 11 pp.

Caplow, F. 2002b. *Silene spaldingii* Wats. (Spalding's catchfly) field inventory and management recommendations. Washington State Department of Natural Resources, Natural Heritage Program, Olympia, Washington. 6 pp.

Christensen, P.E. and N.D. Burrows. 1986. Fire: An old tool with a new use. Pages 57-66 *in* R.H. Groves, and J.J. Burdon (editors), Ecology of biological invasions: An Australian perspective. Australian Academy of Science, Canberra, Australia.

Conner, R., A. Seidl, L. VanTassel, and N. Wilkins. 2001. United States grasslands and related resources: An economic and biological trends assessment. Available online at <http://landinfo.tamu.edu/presentations/chap1_high.pdf>. Accessed 1 August 2001.

Crone, E. E. 2001. Is survivorship a better fitness surrogate than fecundity? Evolution 55:2611-2614.

D’Antonio, C.M. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecological Systems 23:63-87.

Danly, L. 1999. Reports on bio-control insect releases. Craig Mountain, Idaho. Bureau of Land Management, Cottonwood, Idaho.

Daubenmire, R. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecological Monographs 12:53-79.

Daubenmire, R. 1968. Soil moisture in relation to vegetation distribution in the mountains of northern Idaho. Ecology 49:431-438.

Daubenmire, R. 1970. Steppe vegetation of Washington. Technical Bulletin 62. Washington State University, Washington Agricultural Experiment Station, College of Agriculture, Pullman, Washington. 131 pp.

Dolan, R.W. 1994. Patterns of isozyme variation in relation to population size, isolation, and phytogeographic history in royal catchfly (*Silene regia*; Caryophyllaceae). American Journal of Botany 81:965-972.

Douglas, G.W., D.V. Meidinger, and J.L. Penny. 2002. *Silene spaldingii*. *In* Rare native vascular plants of British Columbia, 2nd edition. British Columbia. Ministry of. Sustainable Resource. Management and Water Land and Air Protection and British .Colombia. Ministry. Forestry, Victoria, British Columbia. 359 pp.

Dukes, J.S. and H.A. Mooney. 2003. Disruption of ecosystem processes in western North America by invasive species. *In* Bradshaw, P.A. Marquet, H.A. Mooney (editors), How landscapes change: Human disturbance and ecosystem disruptions in the Americas, series: Ecological studies Vol 162. G.A.. 66 pp. <http://www.springeronline.com/sgw/cda/front page/0,10735,4-102-22-2135615-0,00.html?c>. Accessed 26 March 2004.

Ellstrand, N.C. 1992. Gene flow by pollen: implications for plant conservation genetics. Oikos 63:77-86.

Ellstrand, N.C. and D.R Elam. 1993. Population genetic consequences of small population size: Implications for plant conservation. Annual Review of Ecology and Systematics 24:217-242.

Elseroad, A. and R. Taylor. 2002. Prescribed burning for *Silene spaldingii* at Clear Lake Ridge Preserve. The Nature Conservancy of Oregon, Enterprise, Oregon. 5 pp.

Ertter, B. and R. Moseley. 1992. Floristic regions of Idaho. Journal of the Idaho Academy of Science 28:57-70.

Farmer, A.M. 1993. The effects of dust on vegetation – A review. Environmental Pollution 79:63-75.

Fenster, C.B. 1991. Gene flow in C*hamaecrista fasciculata* (Leguminosae). Evolution 45:410-422.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629-644.

Frankel, O.H., and M.E. Soulé. 1981. Conservation and evolution. Cambridge University Press, Cambridge, United Kingdom.

Frankham, R. 2003. Genetics and conservation biology. Comptes Rendus Biologies 326:S22-S29.

Franklin, J.F. and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Gamon, J. 1991. Report on the status of *Silene spaldingii* Wats. in Washington. Washington State Department of Natural Resources. Washington Natural Heritage Program, Olympia, Washington. 53 pp.

Gilpin, M.E., and M.E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 *in* M.E. Soulé (editor). Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts. 584 pp.

Given, D.R. 1994. How plants become threatened or extinct. Pages 13 – 36 *in* Principles and practice of plant conservation. Timber Press, Portland, Oregon.

Gray, K. and J.Lichthardt. 2004. Spalding’s catchfly (*Silene spaldingii*) monitoring, Craig Mountain, Idaho, second year results. Idaho Conservation Data Center, Idaho Department of Fish and Game, P.O. Box 25, Boise, Idaho. 27 pp.

Hanski, I., A. Moilanen, and M. Gyllenberg. 1996. Minimum viable metapopulation size. American Naturalist 147:527-541.

Harris, J.G., and M.W. Harris. 1994. Plant Identification Terminology: an illustrated glossary – 2nd Edition. Spring Lake Publishing, Payson, Utah. 206 pp.

Harrison, R.D., N.J. Chatterton, R.J. Page, M. Curto, K.H. Asay, K.B. Jensen, and W.H. Horton. 1996. Competition, biodiversity, invasion, and wildlife use of selected introduced grasses in the Columbia and Great basins. Utah Agricultural Experiment Station, Logan, Utah. Available online at <http://www.agx.usu.edu/agx/ResearchReports/USDAREPORT/toc.html> Accessed 11 November 2003.

Heidel, B. 1979. *Silene spaldingii.* Pages 67-69 i*n* Endangered and threatened plants in the Northern Idaho BLM District. U.S. Bureau of Land Management. Unpublished report.

Heidel, B. 1995. Preliminary status report for *Silene spaldingii* (Spalding’s catchfly), a candidate threatened species. Montana Natural Heritage Program, Helena, Montana. 11 pp.

Hill, J.L. 1998. Garden Creek Ranch cooperative resource management plan for 1998-2002. Section A - Aggressive Nonnative Plants. Draft, Unpublished report for The Nature Conservancy of Idaho and Bureau of Land Management, Cottonwood Resource Area, Cottonwood, Idaho. 16 pp.

Hill, J.L. 2002a. QuickBird Satellite Imagery for detection of yellow starthistle at the Garden Creek Ranch. Unpublished report on file at: The Nature Conservancy Field Office, Sun Valley, Idaho. 33 pp.

Hill, J. L. 2002b. Ground-truthing of 1998 tri-state hyperspectral imagery for detection of yellow starthistle at the Garden Creek Ranch. Unpublished report on file at The Nature Conservancy of Idaho Field Office, Sun Valley, Idaho. 14 pp.

Hill, J.L. and S.J. Fuchs. 2002. Special Ecological Areas Pilot Study at the Garden Creek Ranch, Craig Mountain, Idaho. Unpublished report on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, Idaho. 60 pp.

Hill, J.L. and S.J. Fuchs. 2003. Special Ecological Area Pilot Study at the Garden Creek Ranch, Craig Mountain, Idaho - 2002 Field Season. Unpublished report on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, Idaho. 16 pp.

Hill, J.L. and K.L. Gray. 1999. Summary Report: Alien and rare plant inventory and vegetation mapping, Garden Creek Ranch, Craig Mountain, Idaho. Unpublished report on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, Idaho. Cooperative Challenge Cost-share with Bureau of Land Management, Cottonwood Resource Area Headquarters, Cottonwood, Idaho. 131 pp.

Hill, J.L. and K.L. 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 on file at: The Nature Conservancy of Idaho Field Office, Sun Valley, Idaho. 18 pp.

Hill, J.L. and K.L Gray. 2004a. Conservation Strategy for Spalding's Catchfly (*Silene spaldingii* Wats.). Unpublished report prepared by the Idaho Conservation Data Center for the U.S. Fish and Wildlife Service, February 2004. 153 pp.

Hill, J.L. and K.L. Gray. 2004b. Population dynamics of Spalding's silene (*Silene spaldingii*) in canyon grasslands at the Garden Creek Ranch, Craig Mountain, Idaho, 2003 field season. Palouse Clearwater Environmental Institute. 33 pp.

Hill, J.L. and B.J. Weddell. 2003. Population dynamics of Spalding's Catchfly (*Silene spaldingii* Watts.) in the Lower Corral Creek Study Area, Garden Creek Ranch, Craig Mountain, Idaho - 2002 Field Season. Unpublished report, Challenge Cost-share for the Palouse-Clearwater Environmental Institute and the Bureau of Land Management, Cottonwood Resource Area, Cottonwood, Idaho. 29 pp.

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, Idaho. 15 pp.

Hilty, J. H., D.J. Eldridge, R. Rosentreter, M.C. Wicklow-Howard, and M. Pellant. 2004. Recovery of biological soil crusts following wildfire in Idaho. Journal of Range Management 57:89-96.

Hitchcock, C.L., and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, Washington. 730 pp.

Hitchcock, C.L. and B. Maguire. 1947. A revision of the North American species of *Silene*. University of Washington Publications in Biology, Volume 13, University of Washington Press, Seattle, Washington. 73 pp.

Hitchcock, C.L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1964. Vascular plants of the Pacific Northwest, Part 2: Salicaceae to Saxifragaceae. University of Washington Press, Seattle, Washington. 597 p.

Hobbs, G.A. 1966. Ecology of species of *Bombus Latr.* (Hymenoptera: Apidae) in Southern Alberta. IV Subgenus *Fervidobombus* Skoridov. The Canadian Entomologist 98:33-39.

Hobbs, R.J. and L.F. Huenneke. 1992. Disturbance, diversity and invasion: Implications for conservation. Conservation Biology 6:324-337.

Huenneke, L.F. 1991. Ecological implications of genetic variation in plant populations. Pages 31 to 44 *in* D.A. Falk, and K.E. Holsinger (editors), Genetics and conservation of rare plants. Oxford University Press, New York, New York. 283 pp.

Huenneke, L.F. and J.K. Thomson. 1995. Potential interference between a threatened endemic thistle and an invasive nonnative plant. Conservation Biology 9:416-425.

Hull, A.C., Jr. and G.J. Klomp. 1966. Longevity of crested wheatgrass in the sagebrush-grass type in southern Idaho. Pages 5-11 *in* Utah Agricultural Experimentation Station Journal Paper 458. Logan, Utah and Twin Falls, Idaho.

Hull, A.C., Jr. and G.J. Klomp. 1967. Thickening and spread of crested wheatgrass stands on southern Idaho ranges. Pages 222-227 *in* Utah Agricultural Experimentation Station Journal Paper 606. Logan, Utah and Twin Falls, Idaho.

Karron, J.D., Y.B. Linhart, C.A. Chaulk, and C.A. Robertson. 1988. Genetic structure of populations of geographically restricted and widespread species of *Astragalus* (Fabaceae). American Journal of Botany 75:1114-1119.

Idaho Conservation Data Center. 2003. Element occurrence records for *Silene spaldingii*. Idaho Department of Fish and Game, Boise, Idaho. 46 pp.

Idaho Department of Fish and Game. 2003. Project W-170-R-27 Progress Report, July 1, 2002 to June 30, 2003, Elk, Idaho. 109 pp.

Jacquemyn, H., R. Brys, and M. Hermy. 2002. Patch occupancy, population size and reproductive success of a forest herb (*Primula elatior*) in a fragmented landscape. Oecologia 130:617-625.

Jennersten, O. 1988. Pollination in *Dianthus deltoides* (Caryophyllaceae): Effect of habitat fragmentation on visitation and seed set. Conservation Biology 2:359-366.

Johansen, C.A., D.F. Mayer, J.D. Eves, and C.W. Kious. 1983. Pesticides and bees. Environmental Entomology 12:1513-1518.

Johnson, C.G., Jr. and S.A. Simon. 1987. Plant associations of the Wallowa-Snake Province., Wallowa Whitman National Forest R6-ECOL-TP-355A-86. U.S. Department of Agriculture, U. S. Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Baker City, Oregon. 399 pp.

Jones, A. 2000. Effects of cattle grazing on North American arid ecosystems: a quantitative review. Western North American Naturalist 60:155-164.

Kagan, J. 1989. Draft species management guide for *Silene spaldingii.* Oregon Natural Heritage Data Base, Portland, Oregon. 10 pp.

Kephart, S.R. 2003. Plant-animal interactions in coastal and montane meadows: Rarity, re-introduction and pollination of *Silene douglasii* var. *oraria*. Page 42 *In* T.N. Kaye, M. Gisler, and R. Fiegener, editors. Proceedings of a conference on native plant restoration and management on public lands in the Pacific Northwest: Rare plants, invasive species and ecosystem management. February 11-13, 2003, Oregon State University, Corvallis, Oregon. Available online at <http://www.appliedeco.org/Restoration Conference2003/ConferenceProceedings03.htm>. Accessed 1 April 2005.

Knick, Steven T., D.S. Dobkin, J.T. Rotenberry, M.A. Schroeder, W.M. Vander Haegen, and C. Van Riper III. 2003. Teetering on the edge of too late? Conservation and research issues for avifauna of sagebrush habitats. The Condor 105:611-634.

Lande, R. 1995. Mutation and conservation. Conservation Biology 9:782-791.

Lande, R., and G. F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. Pages 87-123 *in* M.E. Soulé, ed. Viable populations for conservation. Cambridge University Press, Cambridge, United Kingdom.

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural viability concepts in managing ecological systems. Ecological Application 9:1179-1188.

Lass, L.W., J.P. McCaffrey, D.C. Thill, and R.H. Callihan. 1999. Yellow starthistle biology and management in pasture and rangeland. Bulletin 805. University of Idaho, College of Agriculture, Moscow, Idaho. 19 pp.

Lennartsson, T. 2002. Extinction thresholds and disrupted plant pollinator interactions in fragmented plant populations. Ecology 83:3060-3072.

Lesica, P. 1988a. Germination requirements and seedling biology of Spalding's Catchfly (*Silene spaldingii*). Unpublished paper prepared for The Nature Conservancy, Montana/Wyoming Office, Helena, Montana. 2 pp.

Lesica, P. 1988b. A preliminary study of the pollination biology of Spalding's Catchfly in the Tobacco Valley, Lincoln County, Montana. Unpublished paper prepared for The Nature Conservancy, Montana/Wyoming Office, Helena, Montana. 5 pp.

Lesica, P. 1988c. Monitoring *Silene spaldingii* on Wild Horse Island: 1988 Progress Report. Unpublished paper prepared for The Nature Conservancy, Montana/Wyoming Office, Helena, Montana. 3 pp.

Lesica, P. 1988d. Monitoring *S. spaldingii* on Dancing Prairie Preserve: 1988 progress report. Unpublished report prepared for The Nature Conservancy, Montana Field Office, Helena, Montana. 15 pp.

Lesica, P. 1991. Inbreeding depression and the importance of pollinators to the threatened plant, *Silene spaldingii* (Caryophyllaceae). Unpublished report prepared for The Nature Conservancy, Montana Field Office, Helena, Montana. 15 pp.

Lesica, P. 1993. Loss of fitness resulting from pollinator exclusion in *Silene spaldingii* (Caryophyllaceae). Madroño 40:193-201.

Lesica, P. 1994. The effects of fire on *S. spaldingii* at Dancing Prairie Preserve – 1994 progress report. Unpublished report prepared for The Nature Conservancy, Montana Field Office, Helena, Montana. 17 pp.

Lesica, P. 1995. Effects of fire on *Silene spaldingii* at Dancing Prairie Preserve: 1995 progress report. Unpublished report to The Nature Conservancy Helena, Montana. 30 pp.

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

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

Lesica, P. and B. Heidel. 1996. Pollination biology of *Silene spaldingii*. Unpublished report prepared for the Montana Field Office, The Nature Conservancy, Helena, Montana. 16 pp.

Lesica, P. and B. Martin. 2003. Effects of prescribed fire and season of burn on recruitment of the invasive exotic plant, *Potentilla recta*, in a semiarid grassland. Restoration Ecology 11:516-523.

Lesica, P. and J.S. Shelly. 1996. Competitive effects of *Centaurea maculosa* on the population dynamics of *Arabis fecunda*. Bulletin of the Torrey Botanical Club 123:111-121.

Lesica, P. and B.M. Steele. 1994. Prolonged dormancy in vascular plants and implications for monitoring studies. Natural Areas Journal 14:209-212.

Lesica, P. and B.M. Steele. 1996. A method for monitoring long-term population trends: an example using rare arctic-alpine plants. Ecological Applications 6: 879-887.

Lesica, P. and B.M.Steele. 1997. Use of permanent plots in monitoring plant populations. Natural Areas Journal 17: 331-340.

Lichthardt, J. 1997. Revised report on the conservation status of *Silene spaldingii* in Idaho. Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho. 20 pp.

Lichthardt, J. and K. Gray. 2002. Field surveys for *Silene spaldingii* (Spalding's catchfly) in Idaho, 2001. Idaho Department of Fish and Game, Conservation Data Center, Boise, Idaho. 14 pp.

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, Idaho. 28 pp.

Lienert, J. and M. Fischer. 2003. Habitat fragmentation affects the common wetland specialist *Primula farinosa* in north-east Switzerland. Journal of Ecology 91:587-599.

Loveless, M.D., and J.L. Hamrick. 1984. Ecological determinants of genetic structure in plant populations. Annual Review of Ecology and Systematics. 15:65-95.

Lynch, M., J. Conery, and R. Burger. 1995. Mutation accumulation and the extinction of small populations. American Naturalist 146:489-518.

Mack, R.N. 1981. Invasion of *Bromus tectorum* L. into Western North America: An ecological chronicle. Department of Botany, Washington State University, Pullman, Washington. Agro-Ecosystems 7:145-165.

Mack, R. N. and J.N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119:757-773.

Menges, E.S. 1990. Population viability analysis for an endangered plant. Conservation Biology 4:52-62.

Menges, E. S. 1991a. Seed germination percentage increases with population size in a fragmented prairie species. Conservation Biology 5:158-164.

Menges, E. 1991b. The application of minimum viable population theory to plants.. Pages 45-61 *in* D.A. Falk, and K.E. Holsinger (editors), Genetics and conservation of rare plants. Oxford University Press, New York, New York. 283 pp.

Menges, E. 1995. Factors limiting fecundity and germination in small populations of *Silene regia* (Caryophyllaceae), a rare hummingbird-pollinated prairie forb. American Midland Naturalist 133:242-255.

Menges, E.S. 2000. Population viability analyses in plants: challenges and opportunities. Trends in Ecology and Evolution 15:51-56.

Menges, E.S. and R.W. Dolan. 1998. Demographic viability of populations of *Silene regia* in Midwest Prairies: Relationships with fire management, genetic variation, geographic location, population size and isolation. Journal of Ecology 86:63-78.

Menke, C. 2003. Relationships of exotic species and wildfire to the threatened plant *Silene spaldingii*. M.S. Thesis. Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon. 73 pp.

Menke, C. A. and P.S. Muir. 2004. Patterns and influences of exotic species invasion into the grassland habitat of the threatened plant *Silene spaldingii*. Natural Areas Journal 24: 119-128.

Miller, P and P. Westra. 2004. Herbicide surfactants and adjuvants. Colorado State University Cooperative Extension. No. 0.559. Available online at <http://www.ext.colostate.edu/pubs/crops/00559.html>. Accessed 2 July 2004.

Montana Natural Heritage Program. 2003. Element occurrence records for *Silene spaldingii*. Helena, Montana.

Mooney, H.A. and E.E. Cleland. 2001. The evolutionary impact of invasive species. Proceedings of the National Academy of Sciences of the United States of America. 98:5446-5451.

Mueggler, W.F. and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. Intermountain Forest and Range Experiment Station. U.S. Department of Agriculture. Forest Service General Technical Report INT-66. Ogden, Utah. 153 pp.

Mueller, M. and T. Mueller. 1997. Pages 24-29 and 74-77 *in* Fire, faults and floods. University of Idaho Press, Moscow, Idaho.

Mutch, R. W., S.F. Arno, J.K. Brown, C.E. Carlson, R.D. Ottmar, and J.L. Peterson. 1993. Forest health in the Blue Mountains: A management strategy for fire-adapted ecosystems. U.S. Dept of Agriculture Forest Service, Pacific Northwest Research Station, February 1993. 15 pp.

Narolski, S. W. 1996. Pages 1-9 and 39-45 *in* Forest inventory. Peter J. Johnson Wildlife Mitigation Unit. Prepared for: U.S. Department of Energy, Bonneville Power Administration, Project No. 92-069.

Neel, M.C., and M.P. Cummings. 2003. Effectiveness of conservation targets in capturing genetic diversity. Conservation Biology 17:219-229.

Newman, D., and D. Pilson. 1997. Increased probability of extinction due to decreased genetic effective population size: experimental populations of *Clarkia pulchella*. Evolution 51:354-362.

Newman, D. and D.A. Tallmon. 2001. Experimental evidence for beneficial fitness effects of gene flow in recently isolated populations. Conservation Biology 15:1054-1063.

Noss, R.F. 1995. What should endangered ecosystems mean to the Wildlands Project? Wild Earth 5: 20-29.

Noss, R.F. and A.Y Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Defenders of Wildlife and Island Press, Washington D.C. 416 pp.

Noss, R.F., E.T. LaRoe III, and J.M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. U.S. Department of the Interior, National Biological Service, Washington, D.C. 58 pp.

Nunney, L., and K.A. Campbell. 1993. Assessing minimum viable population size: demography meets population genetics. Trends in Ecology and Evolution 8:234-239.

Oliphant, J.O. 1934. The botanical labors of the reverend Henry H. Spalding. Washington Historical Quarterly 25:93-102.

Olson, B.E. 1999. Impacts of noxious weeds on ecologic and economic systems. Pages 6-18 i*n*: R. L. Sheley, J.K. Petroff (editors), Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis, Oregon.

Olson, B.E., R.T. Wallander, and J.R. Lacey. 1997. Effects of sheep grazing on a spotted knapweed infested Idaho fescue community. Journal of Range Management 50:386-390.

Oostermeijer, J.G.B., S.H. Luijten, and J.C.M. Den Nijs. 2003. Integrating demographic and genetic approaches in plant conservation. Biological Conservation 113:389-398.

Oregon Department of Agriculture. 2004. Oregon administrative rule. Division 73. Plants: wildflowers, and endangered, threatened, and candidate species. Oregon State Archives. Available online at <http://arcweb.sos.state.or.us/rules/OARS_600/OAR_603/603_073.html>. Accessed 14 April 2004.

Oregon Natural Heritage Program. 2003. Element occurrence records for *Silene spaldingii*. Portland, Oregon.

Osborne, J.L., S.J. Clark, R.J. Morris, I.H. Williams, J.R. Riley, A.D. Smith, D.R. Reynolds, and A.S. Edwards. 1999. A landscape-scale study of bumble bee foraging range and constancy using harmonic radar. Journal of Applied Ecology 36:519-533.

Pavlik, B.M. 1994. Demographic monitoring and the recovery of endangered plants. Pages 322-350 *in* M.L. Bowles, and C. Whelan (editors), Recovery and Restoration of Endangered Species. Cambridge University Press, Cambridge, United Kingdom.

Pavlik, B.M., D.L. Nickrent, and A.M. Howald. 1993. The recovery of an endangered plant. I. Creating a new population of *Amsinckia grandiflora*. Conservation Biology 7:510-526.

Randall, J. 1996. Weed control for the preservation of biological diversity. Weed Technology 10:370-383.

Richards, A.J. 1997. Pages192-193 *in* Population biology and gene flow, plant breeding systems. Second Edition. Chapman and Hall, United Kingdom.

Roché, B.F., Jr. 1965. Ecologic studies of yellow starthistle (*Centaurea solstitialis* L.). Ph.D. Dissertation. University of Idaho, Moscow, Idaho. 78 pp.

Rush, T. and J. Gamon. 1999. Management plan for Spalding's catchfly (*Silene spaldingii*) on Fairchild Air Force Base, Washington. Unpublished report by the Washington Natural Heritage Program, Olympia, Washington. 15 pp.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: A review. Conservation Biology 5:18-32.

Schassberger, L. A. 1988. Report on the conservation status of *Silene spaldingii*, a candidate threatened species. Montana Natural Heritage Program, Helena, Montana. 67 pp.

Schemske, D.W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75:584-606.

Schonewald-Cox, C.M., S.M, Chambers, B. MacBryde, and L. Thomas. 1983. Genetics and conservation. A reference for managing wild animal and plant populations. 469 pp.

Schultz, B.W. and W.K. Ostler. 1995. Effects of prolonged drought on vegetation associations in the northern Mojave Desert. Pages 228-235 *in* B.A. Roundy, E.D. McArthur, J.S. Haley, and D.K. Mann (editors), Proceedings: Wildland shrub and arid land restoration symposium. United States Department of Agriculture Forest Service. General Technical Report INT-GTR-315.

Shaffer, M. 1987. Minimum viable populations: coping with uncertainty. Pages 69-86 *in* M.E. Soulé (editor). Viable populations for conservation. Cambridge University Press, Cambridge, United Kingdom.

Shefferson, R.P., B.K. Sandercock, J. Proper, and S.R. Beissinger. 2001. Estimating dormancy and survival of a rare herbaceous perennial using mark-recapture models. Ecology 82: 145-156.

Silvertown, J., M. Franco, I. Pisanty, and A. Mendoza. 1993. Comparative plant demography, relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. Journal of Ecology 81:465-476.

Simberloff, D. 1988. The contribution of population and community biology to conservation science. Annual Review of Ecology and Systematics 19:473-511.

Soulé, M.E. (editor). 1987. Viable populations for conservation. Cambridge University Press, Cambridge, United Kingdom.

Soulé, M.E., and D. Simberloff. 1986. What do genetics and ecology tell us about the design of nature reserves? Biological Conservation 35:19-40.

Steffan-Dewenter, I. and T. Tscharntke. 1999. Effects of habitat isolation on pollinator communities and seed set. Oecologia 121:432-440.

Stephen, W.P., G.E. Bohart, and P.F. Torchio. 1969. The biology and external morphology of bees. Agricultural Experiment Station, Oregon State University, Corvallis, Oregon. 140 pp.

Sugden, E.A. 1985. Pollinators of *Astragalus monoensis* Barneby (Fabaceae): new host records; potential impact of sheep grazing. Great Basin Naturalist 45:299-312.

Tepedino, D.W. 1996. The reproductive biology of rare rangeland plants and their vulnerability to insecticides. *In* Environmental Monitoring and Evaluation G.L. Cunningham and M.W. Sampson (editors), Grasshoppers: Their biology, identification and management, user handbook. Section III. Available online at <http://www.sidney.ars.usda.gov/grasshopper/Handbook/III/index.htm>. Accessed 26 November 2003.

Thorp, R.W., D.S. Horning, Jr., and L.L. Dunning. 1983. Bumble bees and cuckoo bumble bees of California (Hymenoptera: Apidae). University of California Publications, Bulletin of the California Insect Survey. 7 pp.

Tisdale, E.W. 1983. Grasslands of western North America: The Pacific Northwest Bunchgrass. Pages 223-245 *in* A.C. Nicholson, A. McLean, and T.E. Baker (editors), Grassland ecology and classification symposium proceedings, Ministry of Forest, Province of British Columbia, Victoria, British Columbia, Canada.

Tisdale, E.W. 1986a. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. Bulletin No. 40. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho. 42 pp.

Tisdale, E.W. 1986b. Native vegetation of Idaho. Rangelands 8:202-207.

U.S. Bonneville Power Administration. 2003. Peter T. Johnson Unit becomes a model of restoration. June 2003 DOE/BP-3526. 4 pp.

U.S. Bureau of Land Management. 1998. Summary for 1998 special status plant monitoring survey, and management and 1999 planned work. BLM Cottonwood Resource Area. 3 pp.

U.S. Bureau of Land Management. 2001. Cottonwood Field Office, Craig Mountain Cooperative Management Area Environmental Assessment Fire Management Plan. January 31, 2001. Upper Columbia Salmon – Clearwater District. Cottonwood, Idaho.

U.S. Bureau of Land Management. 2002. Programmatic Biological Assessment with monitoring protocols (with programmatic BA) Spokane District, Border Resource Area. Spokane Washington. 14 pp.

U. S. Department of Energy. 2004. Model predicts wet winters; dry summers for northwest, state energy office project brief. U.S. Department of energy – Energy efficiency and renewable energy state energy program. Available on line at <http://eere.energy.gov/state energy program/project brief detail.cfm/pb id=96?print>. Accessed 7 July 2004.

U.S. Environmental Protection Agency. 2004. Ecoregions of Oregon, Montana, Idaho. Western Ecology Division, Corvallis, Oregon. Available online at <http://www.epa/gov/wed.pages/ecoretions/level iv.htm>. Accessed 6 July 2004. 18 pp.

U.S. Fish and Wildlife Service. 2002. Biological Opinion transmitted in a Memorandum dated 1/10/02 from State Supervisor/Deputy State Supervisor, Oregon Fish and Wildlife Office, Portland, Oregon to District Manager, Vale District Bureau of Land Management, Vale, Oregon. Subject: Formal Section 7 Consultation for the Bureau of Land Management's Vale District Integrated Noxious Weed Management Program, 2001 to 2011 (ref. no.1-7-F-01-319).

Velterop, O. 2000. Effects of fragmentation on pollen and gene flow in insect-pollinated plant populations. Master's thesis, University of Groningen, The Netherlands. 156 pp.

Washington Natural Heritage Program. 2003. Element occurrence records for *Silene spaldingii*, Olympia, Washington.

Watson, S. 1875. Revision of the genus *Ceanothus*, and descriptions of new plants, with a synopsis of the western species of *Silene*. Proceedings of the American Academy of Science 10:333-350.

Weddell, B.J. 2002. Field surveys for *Silene spaldingii* at Turnbull National Wildlife Refuge, Swanson Lakes Wildlife Area, and Wawawai Canyon DNR Parcel, August-September 2002. Report for the Department of Natural Resources, State of Washington. 7 pp.

Weddell, B.J. 2001. Fire in Steppe Vegetation of the Northern Intermountain Region. Idaho Bureau of Land Management, Technical Bulletin No. 01-14, August 2001.

Wentworth, J. 1996. Conservation recommendations for *Silene spaldingii* in Washington. Washington Natural Heritage Program, Olympia, Washington. 12 pp.

Westbrooks, R. 1998. Federal Interagency Committee for the Management of Noxious and Exotic Weeds, Department of Defense. Invasive Plant Fact Book. Available online at <http://ww.denix.osd.mil/denix/Public/ES-Programs/Conservation/Invasive/contents.htm>. Accessed 26 March 2004.

Westerbergh, A. and A. Saura. 1994. Genetic Differentiation in endemic *Silene* (Caryophyllaceae) on the Hawaiian Islands. American Journal of Botany. 81:1487-1493.

Western Regional Climate Center. 2003a. Climates of Idaho, Montana, Oregon and Washington. Available online at <http://www.wrcc.dri.edu/narratives>. Accessed 8 July 2004.

Western Regional Climate Center. 2003b. Period of record general climate summaries. Available online at <http://www.wrcc.dri.edu/cgi-bin/cliGCStP.pl?>. Accessed 6 August 2003.

Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. Pages 4-10 *in* E.D. McArthur, E.M. Romney, S.D. Smith, and P.T. Tueller (editors), Proceedings of a Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. U.S. Forest Service General Technical Report INT-276, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Whitson, T.D., Burrill, L.C., S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. 1996. Pages 88-89 *in* Weeds of the West, fifth edition. Western Society of Weed Science, Newark, California. 630 pp.

Wilson, E.O. 1989. Threats to biodiversity. Scientific American September:108-116.

Young, J.A. 1994. History and use of semiarid plant communities - changes in vegetation. Pages 5-7 *in* S.B. Monsen and S.G. Kitchen (editors), Proceedings: ecology and management of annual Rangelands; U.S. Department of Agriculture, Forest Service, Intermountain Research Station, General Technical Report INT-GTR-313.

Youtie, B. 1990. *Silene spaldingii* study on Clear Lake Ridge Preserve. Unpublished report for The Nature Conservancy of Oregon. 7 pp.

## *IN LITT.* REFERENCES

Benner, Barbara. 1993. Botanist, U.S. Bureau of Land Management, Spokane, Washington. Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Occurrence of *Silene spaldingii* in Lincoln Co. Washington. 5 pp.

Benner, Barbara, 1995. Botanist, U.S. Bureau of Land Management, Spokane, Washington. To Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* information in Washington. 1 April 1995. 1 p.

Benner, Barbara. 1999. Botanist, U.S. Bureau of Land Management, Spokane, Washington. To Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Information on *Silene spaldingii* in the Border Resource Area. 7 January 1999. 3 pp.

Benner, Barbara. 2003. Botanist, U.S. Bureau of Land Management, Spokane, Washington. T Janice Hill, private consultant, Deary, Idaho. Letter and questionnaire regarding *Silene spaldingii*. 6 May 2003. 7 pp.

Benner, Barbara. 2004. Botanist, U.S. Bureau of Land Management, Spokane, Washington. To Marilyn Hemker, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Boise, Idaho. Programmatic Biological Assessment. 5 August 2002. 78 pp.

Brusven, Annette. 2004. Horticulturalist, University of Idaho Forest Nursery, Moscow, Idaho. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Information on seedlings grown at the nursery. 25 June 2004. 4 pp.

Button, Clair. 2005. Botanist, U. S. Bureau of Land Management, Baker City, Oregon. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Survey efforts for *Silene spaldingii*. 19 January 2005. 1 pp.

Caplow, Florence. 2003. Botanist, Washington Natural Heritage Program, Olympia, Washington. To Janice Hill, private consultant, Deary, Idaho. Letter and questionnaire regarding *Silene spaldingii*. 21 May 2003. 5 pp.

Danly, L. A. 2004. Rangeland Management Specialist, U.S. Bureau of Land Management, Cottonwood, Idaho. Tri-State Weed Management Area, 2003 End–of-Year-Report. 9 pp.

DiTomaso, Joseph M. 2000. Invasive weeds in rangelands: Species, impacts, and management. Available online at Bioone.org/bione/?request=get-document&issn-0043-1745&volume+048&is. Accessed 27 May 2004. 15 pp.

Glenne, Gina. 2003. Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. To Janice Hill, private consultant, Deary, Idaho. Comments on draft conservation strategy, grazing of *S. spaldingii* plants at Zumwalt Prairie. 23 September 2003. 1 p.

Glenne, Gina. 2004a. Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Table that lists the number of extant, extirpated, historical or unknown populations determined by Edna Rey-Vizgirdas, Janice Hill and Gina Glenne as of 2000. 24 June 2004. 6 pp.

Glenne, Gina. 2004b. Botanist, U.S. Fish & Wildlife Service, Boise, Idaho. To Janice Engle, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Boise, Idaho. Gravel pits and *Silene spaldingii*. 15 April 2004. 1 p.

Gray, Karen. 2004. Botanist, Idaho Conservation Data Center, Moscow, Idaho. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Comments on the *Silene spaldingii* draft recovery strategy. 1 June 2004. 3 pp.

Hill, Janice. 1999. Private consultant, Deary, Idaho. To Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* at the Garden Creek Ranch. 6 January 1999. 4 pp.

Hill, Janice. 2003. Private Consultant, Deary, Idaho. To Janice Hill private consultant, Deary, Idaho. Questionnaire regarding *Silene spaldingii* population status including extensive documentation compiled by Janice Hill. 14 pp.

Hustafa, Jerold. 2004a. Botanist, U. S. Forest Service, Enterprise, Oregon. To Gina Glenne, Botanist, U. S. Fish and Wildlife Service, Boise, Idaho. Monitoring *Silene spaldingii*. 30 April 2004. 1 p.

Hustafa, Jerold. 2004b Botanist, U. S. Forest Service, Enterprise, Oregon. To Gina Glenne, U. S. Fish and Wildlife Service, Boise, Idaho. Weeds in Oregon found near *Silene spaldingii* populations. 30 April 2004. 1 p.

Johnson, Craig. 1997. Fisheries Biologist, U.S. Bureau of Land Management, Cottonwood, Idaho. Unauthorized Herbicide Spraying of Blackhawk Colony of MacFarlane's Four-O'clock (*Mirabilis macfarlanei).* 27 June 1997. 6 pp.

Lesica, Peter. 2003. Private consultant, Missoula, Montana. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Comments on beginning and end portions of the draft conservation strategy for *S. spaldingii*. 6 November 2003. 3 pp.

Lesica, Peter. 2004. Private consultant, Missoula, Montana. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Comments on the draft recovery strategy for *Silene spaldingii*. 1 June 2004. 7 pp.

Mantas, Maria. 2003. Botanist, The Nature Conservancy, Helena, Montana. To Janice Hill, private consultant, Deary, Idaho. Comments on the Draft conservation strategy for S*ilene spaldingii* in Montana. 17 November 2003. 6 pp.

Martin, Brian. 1998. Director of Science and Stewardship, The Nature Conservancy, Helena, Montana. To Janice Hill private consultant, Deary, Idaho . *Silene Spaldingii* conservation strategy questionnaire. 24 March 2003. 5 pp.

Raven, Andrea. 2004. Botanist, The Berry Botanic Garden, Portland, Oregon. To Gina Glenne, Botanist, U. S. Fish and Wildlife Service, Boise, Idaho. Collections of *Silene spaldingii* at the Berry Botanic Garden. 16 April 2004. 10 pp.

Rey-Vizgirdas, Edna. 1999. Botanist, U.S. Fish & Wildlife Service, Boise, Idaho. U. S. Fish and Wildlife Status Review for *Silene spaldingii*. 11 January 1999. 10 pp.

Sondenaa, Angela. 2003. Botanist, Nez Perce Tribe, Lapwai, Idaho. To Janice Hill, private consultant, Deary, Idaho. Grant proposal for *Silene spaldingii* surveys on Nez Perce Tribal lands in Idaho, Washington and Oregon. 28 May 2003. 1 p.

Taylor, Robert. 2003. Ecologist, The Nature Conservancy, Enterprise, Oregon. To Janice Hill, private consultant, Deary, Idaho. Questionnaire, Zumwalt Prairie and Clear Lake Ridge reports and maps. 4 April 2003. 7 pp.

Taylor, Robert. 2004. Ecologist, The Nature Conservancy, Enterprise, Oregon. To Gina Glenne, Botanist, U. S. Fish and Wildlife Service, Boise, Idaho. Communication stating weed control is within 100 meters of *Silene spaldingii* populations. 28 April 2004. 1 p.

U.S. Environmental Protection Agency. 2000. Global warming-climate. Available online at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html>. Accessed 6 July 2004.

U.S. Fish and Wildlife Service. 2004. Notes from public meetings held in Montana , Idaho, Washington and Oregon February and March 2004. 9 pp.

U.S. Fish and Wildlife Service. 2003. Supervisor, U.S. Fish and Wildlife Service, Boise, Idaho. To Field Manager, U.S. Bureau of Land Management, Cottonwood, Idaho. Bureau of Land Management Noxious Weed Control Program in the Snake, Salmon and Clearwater River Drainages, Idaho County, Idaho – Biological assessment and concurrence File #1005.2000 1-4-03-I-420. 3 April 2003. 15 pp.

Weddell, Bertie. 2003. Private consultant, *Draba* Consulting, Pullman, Washington. To Janice Hill, private consultant, Deary, Idaho. Questionnaire regarding *Silene spaldingii*. 27 June 2003. 7 pp.

White, Jim. 2003. Manager, Idaho Department of Fish and Game, Lewiston, Idaho. Conversation with Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. S*ilene spaldingii* on Idaho Fish and Game, Craig Mountain Wildlife Management Area properties. 16 December 2003. 1 p.

Wick, Arne. 2004. Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Kalispell, Montana. To Marilyn Hemker, Fish and Wildlife Biologist, U. S. Fish and Wildlife Service, Boise, Idaho. Occurrence of *Silene spaldingii* on Plum Creek lands is unknown. 15 April 2004. 1 p.

Wood, Jean. 2004. Botanist, U.S. Forest Service, Pendleton, Oregon. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* and weeds on the Umatilla National Forest. January 16, 2004. 1 p.

Yates, Gene. 2004. Botanist, U.S. Forest Service, Baker City, Oregon. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Comments on the draft recovery strategy. 28 May 2004. 1 p.

## PERSONAL COMMUNICATIONS

Bjork, Curtis. 2003. Private consultant, Canada. Notes from *Silene spaldingii* Conservation Strategy meeting in Lewiston, Idaho. Potential unsurveyed habitat for *S. spaldingii* exists at Bob Marshall Wilderness area, Flathead Indian Reservation, Lost Trail NWR, and the National Bison Range. 28 October 2003. 1 p.

Glenne, Gina. 2003. Botanist, U.S. Fish & Wildlife Service, Boise, Idaho. To Jim White, Manager, Idaho Department of Fish and Game. *Silene spaldingii* on Craig Mountain Wildlife Management Area properties. 16 December 2003. 1 p.

Hustafa, Jerry. 1999. Botanist, U.S. Forest Service, Enterprise, Oregon. To Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* at Crow Creek, Oregon. 14 January 1999. 1 p.

Kagan, Jimmy. 1998. Botanist, Oregon Natural Heritage Information Center, Portland, Oregon. Telephone conversation with Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Information regarding noxious weeds and herbicide spraying. 22 December 1998. 1 p.

Nitz, Timothy. 2004. Manager, U.S. National Park Service, Joseph, Oregon. Conversation with Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* at the Chief Joseph National Historical Monument. 17 February 2004. 1 p.

Raven, Andrea. 2004. Botanist, The Berry Botanic Garden, Portland, Oregon. To Gina Glenne, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. Tele-Fax with results of *Silene spaldingii* germination studies at the Berry Botanic Garden. 16 March 2004. 1 p.

Riley, Scott. 1999. Botanist, U.S. National Forest, Pendleton, Oregon. To Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service, Boise, Idaho. *Silene spaldingii* on the Umatilla National Forest, Asotin County, Washington. 3 February 1999. 1 p.

# Appendix A. Endangered and Threatened Species Recovery Priority Number Guidelines*

| Degree of Threat | Recovery Potential | Taxonomy | Conflict?† | Priority |
|---|---|---|---|---|
| High | High | Monotypic Genus | Yes | 1C |
| | | | No | 1 |
| | | Species | Yes | 2C |
| | | | No | 2 |
| | | Subspecies | Yes | 3C |
| | | | No | 3 |
| | Low | Monotypic Genus | Yes | 4C |
| | | | No | 4 |
| | | Species | Yes | 5C |
| | | | No | 5 |
| | | Subspecies | Yes | 6C |
| | | | No | 6 |
| Moderate | High | Monotypic Genus | Yes | 7C |
| | | | No | 7 |
| | | Species | Yes | 8C |
| | | | No | 8 |
| | | Subspecies | Yes | 9C |
| | | | No | 9 |
| | Low | Monotypic Genus | Yes | 10C |
| | | | No | 10 |
| | | Species | Yes | 11C |
| | | | No | 11 |
| | | Subspecies | Yes | 12C |
| | | | No | 12 |
| Low | High | Monotypic Genus | Yes | 13C |
| | | | No | 13 |
| | | Species | Yes | 14C |
| | | | No | 14 |
| | | Subspecies | Yes | 15C |
| | | | No | 15 |
| | Low | Monotypic Genus | Yes | 16C |
| | | | No | 16 |
| | | Species | Yes | 17C |
| | | | No | 17 |
| | | Subspecies | Yes | 18C |
| | | | No | 18 |

* adapted from Listing and Recovery Priority Guidelines, Federal Register 48:4309-43105
†priority is given to those species that are, or may be, in conflict with construction or other development projects or other forms of economic activity, designated by a "C" in the priority ranking system.

## Appendix B. Scientific and common names used in text

### Plants

| **Scientific name** | **Common name** |
|---|---|
| *Acroptilon repens* | Russian knapweed |
| *Agropygron desortum* | crested wheatgrass |
| *Agropygron spicatum = Pseudoroegneria spicata* | bluebunch wheatgrass |
| *Amsinckia grandiflora* | large-flowered fiddleneck |
| *Arabis fecunda* | Mt. Sapphire rockcress |
| *Artemesia tridentata* | big sagebrush |
| *Artemesia tripartita* | three-tip sagebrush |
| *Aster jessicae* | Jessica's aster |
| *Astragalus riparius* | Piper's milk-vetch |
| *Bromus inermis* | smooth brome |
| *Bromus japonicus* | Japanese brome |
| *Bromus tectorum* | cheatgrass |
| *Calochortus macroscarpus* var. *maculosus* | green-band mariposa lily |
| *Calochortus nitidus* | broad-fruit mariposa |
| *Cardaria draba* | whitetop |
| *Centaurea diffusa* | diffuse knapweed |
| *Centaurea maculosa* | spotted knapweed |
| *Centaurea solstitialis* | yellow starthistle |
| *Chondrilla juncea* | rush skeletonweed |
| *Cirsium arvense* | Canada thistle |
| *Cirsium brevifolium* | Palouse thistle |
| *Cirsium vinaceum* | Sacramento Mountains thistle |

Appendix B. Scientific and Common Names used in Text (continued)

Plants

| **Scientific name** | **Common name** |
|---|---|
| *Crupina vulgaris* | common crupina |
| *Dianthus deltoids* | maiden pink |
| *Dipsacus sylvestris = Dipsacus fullonum* spp. *sylvestris* | teasel |
| *Euphorbia esula* | leafy spurge |
| *Festuca idahoensis* | Idaho fescue |
| *Festuca scabrella* | rough fescue |
| *Happlopappus liatriformis* | Palouse goldenweed |
| *Hesperostipa comata = Stipa comata* | needle-and-thread grass |
| *Hieracium pretense* | meadow hawkweed |
| *Hypericum perforatum* | St. Johnswort |
| *Koeleria cristata* | prairie junegrass |
| *Lepidium latifolium* | perennial pepperweed |
| *Linaria dalmatica* | Dalmatian toadflax |
| *Linaria* spp. | toadflax |
| *Lupinus sericeus* | silky lupine |
| *Mirabilis macfarlanei* | Macfarlane’s four-o’clock |
| *Onopordum acanthium* | Scotch thistle |
| *Pinus ponderosa* | ponderosa pine |
| *Poa pratensis* | Kentucky bluegrass |
| *Polemonium pectinatum* | Washington polemonium |
| *Potentilla recta* | sulfur cinquefoil |
| *Primulus elatior* | oxlip |
| *Rosa* spp. | rose |
| *Rubus nigerrimus* | Northwest raspberry |

## Appendix B.  Scientific and Common Names used in Text (continued)

### Plants

| Scientific name | Common name |
|---|---|
| *Scabiosa columbaria* | dove pincushions, pincushion flower |
| *Silene cserei* | Balkan catchfly |
| *Silene douglasii* | Douglas' catchfly |
| *Silene hawaiiensis* | Hawai`i catchfly |
| *Silene latifolia* ssp. *alba* | bladder campion |
| *Silene oregana* | Oregon catchfly |
| *Silene regia* | royal catchfly |
| *Silene scaposa* var. *scaposa* | Scapose silene |
| *Silene scouleri* | Scouler's catchfly |
| *Silene spaldingii* | Spalding's catchfly, Spalding's silene, Spalding's campion |
| *Symphoricarpos albus* | snowberry |
| *Trifolium plumosum* var. *amplifolium* | plumed clover |
| *Ventenata dubia* | ventenata |

### Animals

| Scientific Name | Common Name or Type of Animal |
|---|---|
| *Bombus fervidus* | bumblebee |
| *Bombus terrestris* | bumblebee |
| *Lasioglossum* spp. | solitary bee |
| *Halictus tripartitus* | solitary bee |
| *Dienoplus rugulosis* | solitary bee |
| *Apis* spp. | honey bee |
| *Tympanuchus phasianellus columbianus* | Columbian sharp-tailed grouse |

## Appendix C. Summary of Threats and Recommended Recovery Actions for *Silene spaldingii*

This table identifies the recovery actions recommended to address the threats to *Silene spaldingii*, as well as those recovery criteria that will provide a measure of the elimination or sufficient reduction of those threats to consider delisting of this threatened species.

| Listing Factor | Threat | Recovery Criteria | Recovery Action Numbers |
|---|---|---|---|
| A | Invasive Nonnative Plants | 2, 3, 4, 5 | 1. conserve and expand populations in each physiographic region; 1.1.3. control in Blue Mountain Basins; 1.2.3. control in Canyon Grasslands; 1.3.2. control in the Channeled Scablands; 1.4.3. control in the Intermontane Valleys; 1.5.4. control in the Palouse Grasslands; 2.1 general management plans; 2.3 habitat management plans; 2.3.1 invasive nonnative plant control; 2.4 monitor; 2.5.3 control research; 2.7 private land conservation; 2.10 funding |
| A, E | Problems Associated with Small, Geographically Isolated Populations | 1, 2, 3, 4, 7 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.4 monitor; 2.5.1 population viabilities; 2.5.2 develop larger populations; 2.5.6 reproductive biology research; 2.5.7 seed dispersal research; 2.5.8 seed viability research; 2.7 private land conservation; 2.9 propagule banks, 2.10 funding |
| A | Changes in the Fire Regime and Fire Effects | 2, 3, 4, 6 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.2 fire management; 2.5.5 fire research |
| A | Land Conversion Associated with Urban and Agricultural Development | 1, 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.3 protect from development; 2.4 monitor; 2.6 surveys; 2.7 private land conservation; 2.10 funding |
| A, C | Livestock Grazing and Trampling | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.4 manage livestock grazing; 2.4 monitor; 2.5.4 research; 2.7 private land conservation; 2.10 funding |
| E | Herbicide and Insecticide Spraying | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.1.6 herbicide application guidelines; 2.4 monitor; 2.5.3 control research; 2.7 private land conservation; 2.10 funding |

## Appendix C. Summary of Threats and Recommended Recovery Actions for *Silene spaldingii* (continued)

| | | | |
|---|---|---|---|
| C | Grazing (Herbivory) and Trampling by Wildlife Species | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.6 monitor and manage wildlife; 2.4 monitor; 2.5.4 research; 2.7 private land conservation; 2.10 funding |
| A, E | Off-Road Vehicle Use | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.3.5 implement off-road vehicle control; 2.4 monitor; 2.7 private land conservation; 2.10 funding |
| C | Insect Damage and Disease | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.4 monitor; 2.5.4 research; 2.10 funding |
| E | Impacts from Prolonged Drought and Global Warming | 2, 3, 4 | 1. conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.4 monitor; 2.10 funding |
| D | Inadequacy of Existing Regulatory Mechanisms | 2, 3, 4 | 1 conserve and expand populations in each physiographic region; 2.1 general management plans; 2.3 habitat management plans; 2.4 monitor; 2.7 private land conservation; 2.8 pursue land and species designations, 2.10 funding |

Listing Factors:

A. The Present or Threatened Destruction, Modification, of Curtailment of *Silene spaldingii*'s Habitat or Range
B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
C. Disease or Predation
D. The Inadequacy of Existing Regulatory Mechanisms
E. Other Natural or Manmade Factors Affecting *Silene spaldingii*'s Continued Existence

**Region 1**
**U.S. Fish and Wildlife Service**
**Ecological Services**
**911 NE. 11th Avenue**
**Portland, Oregon 97232-4181**

**October 2005**