Physaria didymocarpa (Hook.) Gray var. *lanata* A. Nels. (common twinpod): A Technical Conservation Assessment

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Rocky Mountain Region,
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Cover Photo Credit

Physaria didymocarpa (Hook.) Gray var. *lanata* A. Nels. (common twinpod). Photograph by Greg Karow, U.S. Forest Service.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *PHYSARIA DIDYMOCARPA* VAR. *LANATA*

Status

Physaria didymocarpa var. *lanata* (synonym *P. lanata*; common twinpod) is designated a sensitive taxon in the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). It is a regional endemic known from 20 extant occurrences rangewide, and its range lies primarily within the Rocky Mountain Region, restricted to the Bighorn Range and the adjacent northern Powder River Basin of north-central Wyoming and adjacent Montana (USFS Region 1). Population counts or estimates have been made at fewer than half of the occurrences, and the total known number is between 3,100 and 6,700 individuals. Four occurrences are on the Bighorn National Forest, and two of these have been mapped and censused. *Physaria didymocarpa* var. *lanata* is a short-lived perennial that occupies a stressful environment with low water availability, extreme temperatures, and full exposure to the forces of wind erosion. At present, there is preliminary information on the distribution of *P. didymocarpa* var. *lanata*, threats to it, and the disturbance regime as it occurs on the Bighorn National Forest to guide further status studies and management.

Primary Threats

Physaria didymocarpa var. *lanata* is potentially threatened by coal bed methane development, coal mining, road development, herbicide use, concentrated livestock trampling, and concentrated recreational use of its habitat. Indirect consequences of these land uses, including significant habitat destabilization, vegetation competition associated with stabilization, and exotic species invasion, also represent threats. All but coal bed methane development and coal mining are potential threats to occurrences on the Bighorn National Forest. Management considerations and threats have been identified across the taxon's 6,000 foot range in elevation, but these are preliminary, especially at the upper reaches of its elevation range as found on the Bighorn National Forest. Most known threats to *P. didymocarpa* var. *lanata* from human activities are localized, but they may be very important to the viability of small occurrences.

Primary Conservation Elements, Management Implications and Considerations

Physaria didymocarpa var. *lanata* is only known from four records on the Bighorn National Forest in the Rocky Mountain Region. Systematic inventory is needed, detailing distribution, occurrence attributes (numbers and extent), habitat stability or disturbance regimes, and potential threats. This information is needed to direct monitoring, research, and management. Little is known about the taxon's life history except from field observations, herbarium specimens, and inference. Demographic monitoring, in particular, is presented as a tool for documenting life history and framing research questions driven by conservation biology.

TABLE OF CONTENTS

EDITOR: Beth Burkhart, USDA Forest Service, Rocky Mountain Region

List of Tables and Figures

Tables:

Figures:

INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). *Physaria didymocarpa* var. *lanata* is the focus of an assessment because it is a sensitive species in the Rocky Mountain Region. Within the National Forest System, a sensitive species is a plant or animal species whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or in habitat capability that would reduce its distribution (USDA Forest Service 2003). A sensitive species may require special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology of *Physaria didymocarpa* var. *lanata* throughout its range with a focus on the Rocky Mountain Region. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on scientific knowledge accumulated prior to initiating the assessment (Blankenship et al. 2001). The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere, and when these have been implemented, the assessment examines the success of their implementation.

Scope

The *Physaria didymocarpa* var. *lanata* assessment examines the biology, ecology, conservation status, and management of this taxon with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature on the taxon originates from field investigations outside the region, this document places that literature in the ecological and social context of the Rocky Mountain Region. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *P. didymocarpa* var. *lanata* in the context of the current environment rather than under historical conditions. The evolutionary environment of the taxon is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. The assessment emphasizes refereed literature because this is the accepted standard in science. It also incorporates non-refereed publications or reports that comprise the primary sources of status information on this taxon. Unpublished data, such as herbarium specimen labels and natural heritage program records, were important in estimating the geographic distribution, while recognizing that they represent a diversity of objectives and methods used to collect the data.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is difficult to conduct experiments that produce clean results in the ecological sciences. Often, observations, inference, good thinking, and models must be relied on to guide our understanding of ecological relations. Confronting uncertainty then is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

In the case of *Physaria didymocarpa* var. *lanata*, there is insufficient information on its distribution or on the threats to it, as it occurs on the Bighorn National Forest, to guide management or restoration.

Publication of Assessment on the World Wide Web

To facilitate the use of species conservation assessments in the Species Conservation Project, they are being published on the USFS Region 2 World Wide

Web site. Placing the documents on the web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the web. This assessment of *Physaria didymocarpa* var. *lanata* was reviewed through a process administered by the Center for Plant Conservation, employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Physaria didymocarpa var. *lanata* has been identified as a sensitive species in the Rocky Mountain Region of the USFS (USDA Forest Service 2003, 2004). Outside of the Rocky Mountain Region, it is on the watch list of the Montana Office of the Bureau of Land Management that was established in 1996 under BLM 6840 Manual.

NatureServe (formerly the heritage division of The Nature Conservancy) recognizes the taxon as a variety of *Physaria didymocarpa* and gives it a rank of G5T2, indicating that the species is globally secure, but the variety is imperiled globally because of rarity and usually known from 6 to 20 extant occurrences. In Wyoming, the taxon is recognized at the species level (*P. lanata*) and is ranked S2 (imperiled). It is known from 16 occurrences, 15 of which are extant (Wyoming Natural Diversity Database 2004) and one that is an historical, unmappable record based on the 1901 type collection. In Wyoming, *P. didymocarpa* var. *lanata* has a low number of occurrences, low population numbers, unknown trends, and moderate vulnerability (Keinath et al. 2003). In Montana, this taxon is ranked S1 (critically imperiled) and is known from five extant occurrences (Taylor and Caners 2002, Montana Natural Heritage Program 2003). For explanations of the NatureServe ranking system, see the Definitions section of this document.

Most *Physaria didymocarpa* var. *lanata* occurrences are located on federal or state lands that are managed for multiple uses. There are no occurrences known from federal lands designated for special protection. The four Bighorn National Forest occurrences are on or near the Tongue River and Crazy Woman Creek proposed research natural areas (Welp et al. 1998a, b). However, the taxon could not be relocated when the establishment report surveys were conducted. Additional surveys are needed to determine whether it is inside or outside proposed boundaries. The Duncan Ridge occurrence is near, but not known within, the Medicine Wheel Archeological Site. Two occurrences are located on private land within conservation easements held by The Nature Conservancy on the east slope of the Bighorn Range. Two additional occurrences are found in the Amsden Creek and Bud Love Wyoming State Wildlife Habitat Management Areas. Other occurrences are on multiple use lands administered by the Bureau of Land Management, specifically by the Buffalo Field Office in Wyoming and the Miles City Field Office in Montana.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Physaria didymocarpa var. *lanata* has no protection preventing the destruction of individuals or their habitat by way of regulatory mechanisms, management plans, or conservation strategies. The extent to which this taxon has been subjected to impacts in the absence of protection is not known. There have been no known cases in which an occurrence of *P. didymocarpa* var. *lanata* was extirpated due to human activities. Recent sensitive species designation potentially affords some protection for at least its four known occurrences on the Bighorn National Forest. It is USFS policy to develop and implement management practices that ensure that sensitive species do not become threatened or endangered (USDA Forest Service 2003, 2004).

Biology and Ecology

Classification and description

Scientific Name: *Physaria didymocarpa* (Hook.) Gray var. *lanata* A. Nels., published in the Bulletin of the Torrey. Botanical Club, 1904, 31. 241. TYPE: “In the Big Horn Mountains, on steep slopes at the head of

the Middle Fork of Powder River, July 19, 1901." *L. N. Gooding 326*. The location of the holotype collection is not known, and there are no occurrences otherwise documented on the Middle Fork of the Powder River. The holotype is deposited at RM, and isotypes are at NYBC, CU, and US.

> Common Name: Common twinpod is the name given to the type variety and is used by the PLANTS database (2004) for *Physaria didymocarpa* var. *lanata* too. This taxon is also called woolly twinpod in both states where it occurs.
> Family: Brassicaceae (Cruciferae; Mustard family).
> Synonyms: *P. lanata* (A. Nelson) Rydberg, Bulletin of the Torrey Botanical Club 39: 322. 1912.

The *Physaria* genus is comprised of 22 species in the western United States (Rollins 1993), not including varieties. Members of the *Physaria* genus were first promoted from a section of the genus *Vesicaria* by Asa Gray (1848). The type species for the genus is *P. didymocarpa*, originally classified as *V. didymocarpa* by Hooker (Rollins 1939). The name is from the Greek "physos", meaning inflated, in reference to its pods (Hitchcock and Cronquist 1964). Recent molecular research, in addition to morphological, distributional, and ecological data, supports the case for uniting the *Physaria* and *Lesquerella* genera into a single genus (Al-Shehbaz-Ihsan and O'Kane 2002), but the above information refers to the *Physaria* genus in the narrow sense. There had been earlier proposals to conserve the name *Lesquerella* as the larger genus (O'Kane and Al-Shehbaz-Ihsan 1999).

Physaria didymocarpa var. *lanata* was first collected by Leslie Gooding in 1901 in the Bighorn Mountains of Wyoming. It was published three years later by Aven Nelson (1904). From 1936 to the present, it has been documented at fifteen additional sites in north-central Wyoming and at five sites in Montana, where it was first discovered in 1993.

Physaria didymocarpa var. *lanata* was elevated to species level by Per Axel Rydberg (1912). The original treatment was conserved in a partial revision of the *Physaria* genus (Payson 1918) that was later maintained by Rollins (1939). More recent interpretations offer differing views whether to treat it as a species or variety. Rollins (1993) treated it as a variety of *P. didymocarpa*, and the PLANTS database (2004) follows his treatment. It is also treated as a variety in the Wyoming checklist of vascular plants (Nelson and Hartman 1994) posted at http://www.rmh.uwyo.edu/species. It is recognized as a full species in the current state flora (Dorn 2001) with a total of 11 species of *Physaria* in Wyoming.

Physaria didymocarpa var. *lanata* is closely related to the widespread *P. didymocarpa* var. *didymocarpa* and to a state endemic taxon, *P. didymocarpa* var. *integrifolia*, which is restricted to western Wyoming outside the Rocky Mountain Region. Polyploid chromosome numbers $2n$=16 and 24 have been documented for *P. didymocarpa* var. *didymocarpa* (Mulligan 1967). The chromosome numbers documented for *P. didymocarpa* var. *lanata* are $2n$=8 and 16. Chromosome numbers for *P. didymocarpa* var. *integrifolia* are not available. It was hypothesized that polyploids in this group are autopolyploids, with morphological differentiation taking place at the diploid level, and that development of polyploidys extended the ranges of individual species (Mulligan 1967). There is one other variety of *P. didymocarpa* that is recognized, *P. didymocarpa* var. *lyrata*, which is endemic to Idaho (Rollins 1993, NatureServe 2004, USDA Natural Resource Conservation Service 2004).

The largest sets of *Physaria didymocarpa* var. *lanata* specimens are maintained at the Rocky Mountain Herbarium (RM) in Laramie, Wyoming, and much of the RM distribution data is posted electronically on the Atlas of the Vascular Plants of Wyoming (Hartman and Nelson 2003). All specimens referred to in this document are deposited at RM unless otherwise stated. The *P. didymocarpa* var. *lanata* specimens from Montana are maintained at Montana State University (MONT) in Bozeman and at the University of Montana (MONTU) in Missoula.

The members of the Mustard Family (Brassicaceae) appear to have been evolving actively in more recent geological epochs of increasing aridity (Stebbins 1974). Xeromorphic adaptations such as the extreme hairiness of *Physaria didymocarpa* var. *lanata* may confer greater survival value under increased aridity. The varietal epithet "*lanata*" refers to the wooliness of its leaf surfaces. Many of the species of *Physaria* have limited geographic distribution, and six of the 11 *Physaria* taxa in Wyoming are recognized as species of concern or potential concern (Keinath et al. 2003).

The Mustard Family has major economic importance, as it contains crop plants grown for food and oils. In particular, all species of *Lesquerella* and the closely-related genus *Physaria* possess seed-oil rich in one of three hydroxy fatty acids, which may

confer drought resistance, and have potential use in the production of plastics, lubricants, protective coatings, surfactants, cosmetics, and pharmaceuticals , with reports of recent collections by USDA Agricultural Research Service researchers (USDA Agriculture Research Service 2003).

Physaria didymocarpa var. *lanata* is a tufted, perennial herb that is densely covered with stellate trichomes that give the plant a silver, woolly appearance (**Figure 1** and **Figure 2**). The oblanceolate basal leaves are entire to coarsely dentate and shaggy-margined, with an acute tip, and 1.5 to 4 (8.5) cm long. They arise from a rootcrown and taproot. The stem leaves are shorter (1 to 2 cm) and oblanceolate. The inflorescence is prostrate or weakly ascending, on a simple flowering stem (2.5) 4 to 14 (26) cm long, with a congested cluster of yellow, 4-petaled flowers, 8 to 12 mm long. The style is 7 to 9 mm long. The mature silicles consist of two large, inflated, papery, balloon-like pods with shaggy pubescence. The replum of the mature fruit is linear to narrowly lance-shaped or oblanceolate, with two stubby

Figure 1. *Physaria didymocarpa* var. *lanata* photograph, in fruit, by Walter Fertig, used with permission.

Figure 2. *Physaria didymocarpa* var. *lanata* close-up photograph, in flower, by Greg Karow, USDA Forest Service.

funiculi in each locule (Nelson 1904, Rollins 1993, Dorn 2001). This taxon has not yet been rendered by a botanical illustrator.

Nelson (1904) highlighted pubescence characteristics as distinguishing *Physaria didymocarpa* var. *lanata* from the type variety, describing it as:

> "…white throughout with long-branched stellate hairs and a more copious simpler pubescence, giving the plant a tomentose appearance especially upon the bases of the crowded crown-leaves and to a lesser degree in the inflorescence."

Mature fruits are needed for positive identification. *Physaria didymocarpa* var. *lanata* is related to and resembles *P. didymocarpa* var. *didymocarpa*, *P. didymocarpa* var. *integrifolia*, *P. acutifolia*, and *P. brassicoides*. *Physaria lanata* var. *didymocarpa* differs in having appressed hairs on the leaves, giving them a smooth appearance, and mostly three to six ovules (funiculi per locule). *Physaria acutifolia* and *P. brassicoides* differ in having silvery stellate pubescence that also confers a smooth appearance to leaf blades. *Physaria didymocarpa* var. *integrifolia* has an elliptic replum, and the basal leaves are entire and rounded. The county distributions of *P. acutifolia* and *P. brassicoides* overlap with *P. didymocarpa* var. *lanata* in foothills and plains settings east of the Bighorn Range within Wyoming, but they are not known to be sympatric. In the horticultural literature and electronic photograph files, sometimes used for identification purposes, there is some confusion in treating *P. didymocarpa* var. *lanata* as synonymous with the widespread *P. didymocarpa*. The distinguishing characteristics of *P. didymocarpa* var. *lanata* are profiled in comparing it with other *Physaria* species in the same counties and with related varieties in Region 2 (**Table 1**).

Table 1. Distinguishing characteristics of *Physaria didymocarpa* var. *lanata* from other *Physaria* taxa (Rollins 1993, Dorn 2001).

Taxon	Shape of fruit	Number of funiculi per locule	Shape of partition between locules	Basal leaf pubescence	Basal leaf shape and outline
P. didymocarpa var. *lanata*	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Usually 2	Narrowly oblong to linear; rarely lanceolate to oblanceolate	Densely-hairy with spreading, long, simple, tangled trichomes; shaggy-looking	Leaves dentate
P. didymocarpa var. *didymocarpa*	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Mostly 3 to 6	Oblong to ovate	Trichomes appressed	Leaves obovate, repand to dentate
P. didymocarpa var. *integrifolia*	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Mostly 3 to 6	Oblong to ovate	Trichomes appressed	Leaves entire, blades rounded
P. acutifolia	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Usually 2	Narrowly oblong to linear; rarely lanceolate to oblanceolate	Smooth-looking, with stellate hairs	Leaves entire or very rarely with a few scattered teeth, blades obovate to orbicular
P. brassicoides	Silicles with little or no sinus below	Usually 2	Narrowly oblong to linear; rarely lanceolate to oblanceolate; constricted toward middle	Smooth-looking, with stellate hairs	Repand or rarely entire, blades orbicular to obovate

Distribution and abundance

Physaria didymocarpa var. *lanata* is a regional endemic of the Bighorn Mountains and Powder River Basin known from a total of 20 extant sites and one historic site. It occurs in Bighorn and Rosebud counties in south-central Montana and in Big Horn, Campbell, Johnson, Sheridan, and historically in Washakie counties in north-central Wyoming. It was first collected at the head of the Middle Fork of the Powder River in 1901. The collection label indicated that this was in Big Horn County, but the county was later split and this location falls within what is now Washakie County.

Most of the Wyoming distribution data originated from floristic information inventories of the Bighorn Mountains and the Powder River Basin by Rocky Mountain Herbarium (Hartman and Dueholm 1979, Nelson and Hartman 1984, Hartman 1992, Hartman and Nelson 1994, 1995). It was also documented in a Wyoming Natural Diversity Database (WYNDD) study of a potential conservation easement (Fertig and Britt *15082*). It is known in the vicinity of two proposed research natural areas, Crazy Woman Creek and Tongue River, (Welp et al. 1998a, b) but it was not relocated in the course of fieldwork conducted for the establishment report. Information on the taxon in Wyoming survey is summarized in Fertig (2000), posted electronically on the WYNDD homepage (http://www.uwyo.edu/wyndd), and addressed in analyzing rare species records on the Bighorn National Forest (Fertig 1999). In addition, it was most recently discovered in 2004 at Boyd Ridge by Tucker Galloway, and the Fallen City occurrence was expanded by Greg Karow and Tucker Galloway in 2004.

Physaria didymocarpa var. *lanata* was first discovered in Montana by Peter Huseby of the USDA Natural Resource Conservation Service in 1993 (Heidel 1996). Since then, it has been documented in four additional locales by Amy Taylor, contracted by the Montana Natural Heritage Program; all of these occurrences are on BLM lands in southern Bighorn and Rosebud counties (Taylor and Caners 2002). The new occurrences were documented in the course of baseline survey of areas considered for coal bed methane development. The current state species field guide entry is posted electronically by the Montana Natural Heritage Program (2004) (http://www.nris.state.mt.us).

The two-state distribution of *Physaria didymocarpa* var. *lanata* spans a distance slightly more than one degree latitude (less than 100 miles) and lies within the Powder River Basin and Bighorn Mountain ecoregions. It is concentrated on the eastern flanks of the Bighorn Mountains, with two isolated west slope occurrences and one outlying plains occurrence to the north and east, respectively (**Figure 3**). The unmappable historic record in Washakie County, Wyoming is not represented in **Figure 3**. Four occurrences are on the Bighorn National Forest, including three occurrences at montane elevations in the Medicine Wheel District on the west side of the Bighorn Mountains, and one foothills occurrence in the Tongue River District. There is one record immediately west of the Thunder Basin National Grasslands.

Counts or estimates of population size have been made at seven of the 20 occurrences (one on the Bighorn National Forest). The actual counts or size estimates range from 19 plants at Canyon Creek, Montana, to occurrences in the 1,000 to 2,000 range at Fallen City and Smith Creek in Wyoming as well as Spring Creek in Montana (**Table 2**). One of the three largest known occurrences is at Fallen City on the Tongue River District of the Bighorn National Forest; this is the only national forest occurrence that has an estimate of population size. The total number of plants rangewide, based on population estimates at seven occurrences, is 3,100 to 6,700 individuals, and most population numbers documented to date (at least 66 percent) are in Wyoming.

Occurrence boundaries are mapped and digitized for only three of the 15 extant occurrences in Wyoming. The most extensive of mapped occurrences is 16.7 acres, on the Tongue River District of the Bighorn National Forest at Fallen City. *Physaria didymocarpa* var. *lanata* is reported as locally common in places, but it is also reported at low densities and as comprised of scattered patches in scattered openings that probably represent suboccurrences. The recently reported Boyd Creek occurrence is estimated to be one-tenth of an acre. The other two occurrences on the Bighorn National Forest are known from floristic inventories that did not precisely determine location finer than section or quarter-section and did not consider population extent.

Population trend

Trend data are unavailable for *Physaria didymocarpa* var. *lanata* in Wyoming and Montana. There have not been repeated surveys at Wyoming sites, but there have been collections or surveys in proximity to known occurrences that have been interpreted as documenting greater population extent than previously known (Wyoming Natural Diversity Database 2004). One of the Wyoming occurrences may be extirpated,

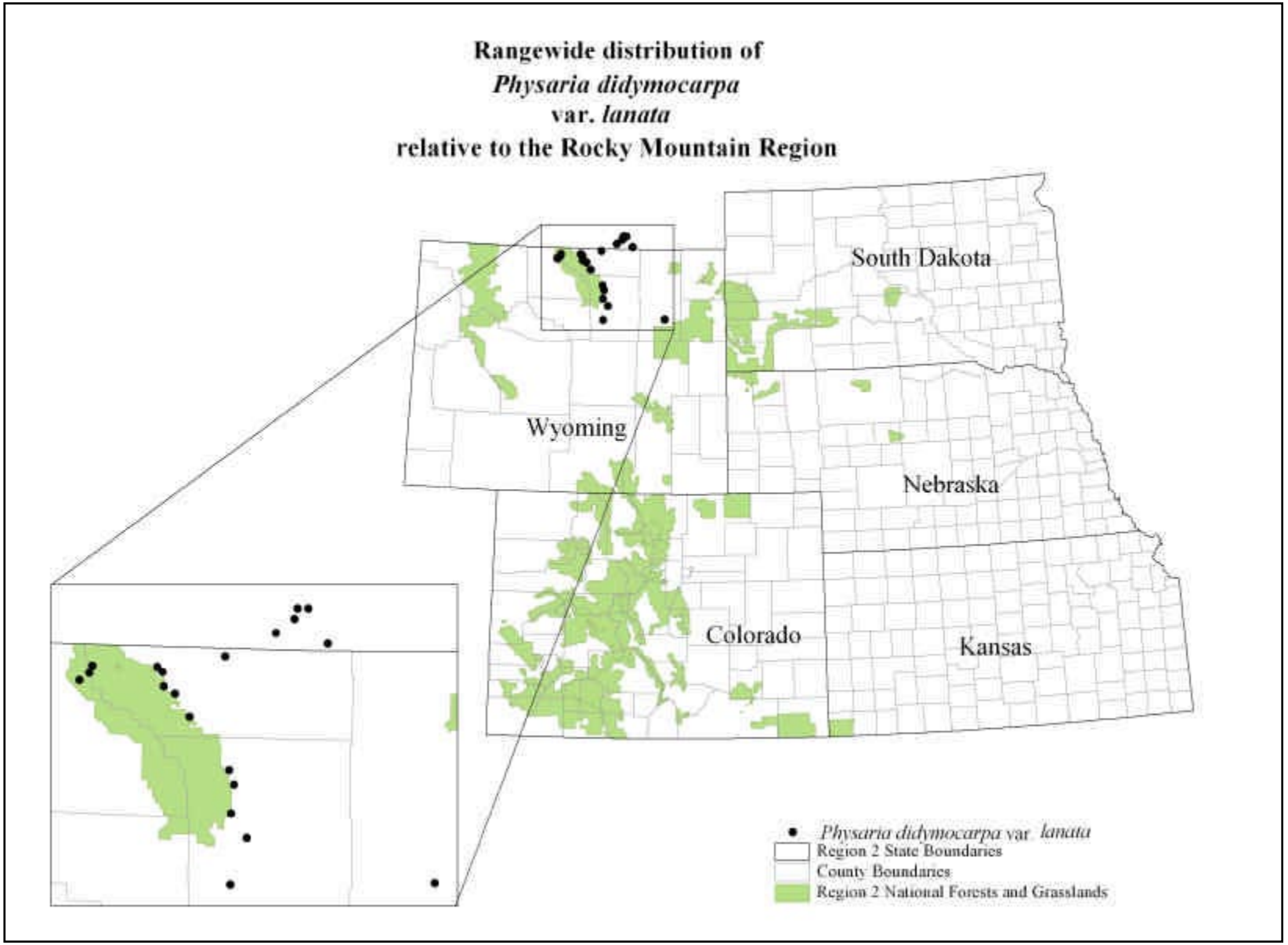

Figure 3. Rangewide distribution of *Physaria didymocarpa* var. *lanata* relative to the USDA Forest Service Rocky Mountain Region.

Table 2. Occurrences and habitats of *Physaria didymocarpa* var. *lanata* rangewide.

Site name (occurrence number)	Landowner	County, State	Estimated abundance	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Wolf Creek Canyon (001)	Private	Sheridan, WY	Not available (NA)	Not available (NA)	4,800	Brushy slopes.	Not available (NA)
Amsden Creek (002)	Amsden Creek Wildlife Habitat Management Unit (Wyoming Department of Fish and Game)	Sheridan, WY	NA	NA	4,600 to 4,800	Calcareous slopes and limestone (gypsum) outcrops above Chugwater Formation redbeds.	*Oxytropis* spp., *Eriogonum* spp.
West of Hilight (003)	Private	Campbell, WY	NA	NA	4,800	Unstable sand on south flank of butte and on talus slopes.	NA
Duncum Mountain (004)	Bighorn National Forest	Big Horn, WY	NA	NA	9,600 to 9,680	Talus-covered clay slope.	NA
Medicine Mountain (005)	Bighorn National Forest	Big Horn, WY	NA	NA	9,450 to 10,000	Moderately steep limestone talus slope and small ledges and shelves.	NA
Whitney Coal Site (006)	Private	Sheridan, WY	NA	NA	3,600 to 3,700	Ponderosa pine-juniper scrub.	NA
Smith Creek (007)	McTiernan Easements	Sheridan, WY	1,000 to 1,500	NA	5,000	Cushion plant community on open slopes with occasional ponderosa pine and limber pine. On whitish-shaley limestone slopes and ridgecrests and adjacent redbeds.	*Cercocarpus ledifolius*, *Calochortus nuttallii*, *Lupinus argenteus*, *Lesquerella alpina*, *Cryptantha celosioides*, *Yucca glauca*
Sayles Creek (008)	Bud Love Wildlife Habitat Management Unit (Wyoming Department of Fish and Game)	Johnson, WY	NA	NA	5,600	Stoney hills above rolling plains.	*Cercocarpus ledifolius*
Mayoworth Stock Trail (009)	Bureau of Land Management (BLM) Buffalo	Johnson, WY	NA	NA	5,500	Anhydrous gypsum layer and associated redbeds of Chugwater Formation.	NA
Greub Road (010)	Private	Johnson, WY	NA	NA	4,900 to 5,000	Rocky, gravelly slopes.	NA
Mosier Gulch (011)	BLM Buffalo	Johnson, WY	NA	NA	6,400	Steep slopes of sandy gravel and rock outcrops of Bighorn Dolomite. Vegetative cover about 3 percent.	*Pinus ponderosa*
Crazy Woman (012)	State of Wyoming	Johnson, WY	NA	NA	6,600 to 7,000	Limestone outcrops and rocky slopes.	NA
Little Rapid Creek (013)	Big Goose Creek Easements; State of Wyoming	Sheridan, WY	50	1	5,500	Cushion plant and bunchgrass community on sandy redbeds below a red sandstone cliff. Vegetative cover very low.	*Ratibida* spp., *Dalea* spp., *Calylophus serrulatus*, *Senecio canus*, *Cryptantha* spp.

Table 2 (concluded).

Site name (occurrence number)	Landowner	County, State	Estimated abundance	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Fallen City (Sand Turn) (014)	Bighorn National Forest	Sheridan, WY	1,000 to 2,000	16.7	6,600	Steep (60 percent) slopes of barren, loose whitish limey-clay and limestone rubble of Bighorn Dolomite and Darby Limestone. Vegetative cover less than 5 percent.	*Elymus spicatus*, *Melilotus officinalis*, *Penstemon glaber*, *Senecio canus*, *Aster glaucodes*, *Lesquerella montana*, *Cercocarpus ledifolius* var. *ledifolius*, *Erigeron compositus*, *Petrophyton caespitosum*
Middle Fork Powder River (016)	BLM Worland; State of Wyoming	Washakie, WY	NA	NA	Not available (NA)	No information available.	NA
Boyd Ridge (017)	Bighorn National Forest	Sheridan, WY	50	0.1	9,360	Limber pine; limestone talus slope.	*Zigadenus* spp., *Phlox* spp., *Achillea millefolium*, *Heuchera* spp., *Juniperus* spp., *Allium* spp., *Gentiana* spp., *Pinus flexilis*
Spring Creek (001)	Private	Big Horn, MT	1,000 to 2,000	NA	NA	Steep southwest-facing slope of red scoria and shale.	*Stipa comata*, *Agropyron spicatum*, *Oryzopsis hymenoides*, *Phlox hoodii*, *Chaenactis douglasii*, *Sphaeralcea coccinea*
Tidwell Draw (002)	BLM Billings	Big Horn, MT	100+	NA	NA	Steep, sandy, south-facing slope with sandstone outcrops and fragments.	*Juniperus scopulorum*, *Pinus ponderosa*, *Stipa comata*, *Agropyron spicatum*, *Bromus japonicus*, *Rhus trilobata*, *Artemisia tridentata*, *Ceratoides lanata*, *Astragalus gilviflorus*, *Yucca glauca*, *Opuntia polycantha*
Zook Creek (003)	BLM Billings	Rosebud, MT	50	NA	NA	Southwest-facing slope of redbed shale and sand below sandstone outcrop.	*Pinus ponderosa*, *Juniperus scopulorum*, *Yucca glauca*, *Rhus trilobata*, *Atriplex confertifolia*, *Agropyron spicatum*, *Stipa comata*, *Bouteloua curtipendula*, *Gaura coccinea*, *Psoralea* spp.
Bull Creek (004)	BLM Billings	Rosebud, MT	16	20 sq ft	NA	Sandy, rocky, southwest-facing slope of roadcut, clinker-shale mix, sparsely vegetated.	*Rhus trilobata*, *Artemisia cana*, *Agropyron spicatum*, *Artemisia frigida*, *Eriogonum* spp.
Canyon Creek (005)	BLM Billings	Rosebud, MT	19	100 sq yd	NA	Generally barren sandstone outcrops; calcium carbonate present; south-facing slope.	*Juniperus scopulorum*, *Chrysothamnus nauseosus*, *Artemisia cana*, *Rhus trilobata*, *Agropyron spicatum*

originally documented from a coal mining site under development in 1977, but it is tallied among the extant sites pending surveys.

Four occurrences of a closely-related taxon, *Physaria didymocarpa* var. *lyrata*, were monitored in Idaho, and the large occurrences appear to be stable while patterns of decline were associated with unstable slopes and high mortality / low survivorship of seedlings and juvenile plants under climate-related stress (Craig and Craig 1996, Mancuso 1996). Occurrences of *P. didymocarpa* var. *lyrata* fluctuated yearly in direct relation to the amount of spring and summer precipitation. Thus, multi-year monitoring that also considered climate was needed to determine trends. It might be expected that population numbers of *P. didymocarpa* var. *lanata* also fluctuate between years, but there is no basis for characterizing long-term trend.

Habitat

Physaria didymocarpa var. *lanata* occurs in Wyoming from 3,600 to 9,600 ft. in elevation, an elevation gradient extending from plains to montane zones. All but three of the Wyoming occurrences are at intermediate foothills elevation zones of 4,600 to 7,000 ft. Wyoming settings range from grasslands and steppes to open woodlands settings, and the taxon occupies sparsely-vegetated phases of these settings. The surrounding vegetation includes open stands of *Pinus ponderosa* (ponderosa pine) and *Juniperus scopulorum* (Rocky Mountain juniper), *Cercocarpus ledifolius* (mountain mahogany) scrub, cushion plant communities, exposed bunchgrass slopes with *Elymus spicatus* (bluebunch wheatgrass) and *Stipa comata* (needle-and-thread), and sparsely-vegetated communities. The similar open structure and rocky habitat of its settings is apparent across the elevation gradient on the Bighorn Mountains, from Smith Creek at 5,000 ft. to Boyd Ridge at 9,360 ft. (**Figure 4** and **Figure 5**). The largest occurrence on the Bighorn National Forest is on a sparsely-vegetated, 60 percent slope surrounded by woodland, as characterized in the survey information recorded by Walter Fertig at Fallen City (Wyoming Natural Diversity Database 2004). Information is lacking on associated species at the other two Wyoming occurrences on the Bighorn National Forest. A summary of associated plant species documented to date is presented in **Table 2**; based on site survey data and collection labels, this list can only be considered preliminary in characterizing associated species within and between elevation zones.

Figure 4. Habitat photograph of *Physaria didymocarpa* var. *lanata* at Smith Creek, by Walter Fertig, used with permission.

Figure 5. Habitat photograph of *Physaria didymocarpa* var. *lanata* at Boyd Ridge, by Tucker Galloway, USDA Forest Service.

There are no other reports of associated flora and fauna. Members of the Mustard Family do not form mycorrhizal relationships (Steve Miller personal communication 2002).

Physaria didymocarpa var. *lanata* occupies unproductive range sites with shallow soil and outcrops. Soils vary greatly in texture and are generally well-drained due to their slope, if not their texture. These soils are classified as entisols, lacking a well-defined profile because of persistent erosion. All of the sites have poorly-developed soils derived from sedimentary or metamorphosed sedimentary deposits, and some have steep slopes. *Physaria didymocarpa* var. *lanata* habitat appears to represent topoedaphic climax conditions or arrested succession. The substrates in Wyoming include sand eroding out of cliffs and buttes, limestone talus, and stable limestone outcrops, ledges, and shelves. The stability of the rooting substrate and vegetation in *P. didymocarpa* var. *lanata* habitats may be affected by the harsh conditions. There is almost no information on the slope and aspect of Wyoming occurrences; such information would help to further characterize the taxon's requirements. In Montana, *P. didymocarpa* var. *lanata* is only known from plains habitat at 3,800 to 4,100 ft. in elevation. Montana habitat is characterized as steep, south- to southwest-facing slopes of sandstone outcrops and red shale (Taylor and Caners 2002).

At upper elevations in Wyoming, the taxon occurs on the Amsden Formation at Fallen City in the Tongue River District of the Bighorn National Forest, and on Bighorn Dolomite in the Medicine Wheel District of the Bighorn National Forest (Love and Christiansen 1985, Greg Karow personal communication 2004, Wyoming Natural Diversity Database 2004). These formations are Mississipian marine deposits comprised mainly of limestone or dolomite. They outcrop in limited bands along the flanks of the Bighorn Mountains. The documented distribution pattern of *Physaria didymocarpa* var. *lanata* in linear bands appears to correspond with surface geology, as represented by Love and Christiansen (1985), which may be a good indication of potential habitat as the taxon occurs in the Bighorn National Forest. At lower elevations in Wyoming, *P. didymocarpa* var. *lanata* also occurs on anhydrous gypsum layers and associated redbeds of the Chugwater Formation (Fertig 2000). In Montana, the substrates occupied are coarse clay and badlands range sites (Taylor and Caners 2002).

The range in known habitat conditions, as defined by elevations, substrate, and vegetation, appears to be much broader than the taxon's known distribution, and it is possible that there is as-yet-undocumented habitat specificity or restriction due to some attribute of the taxon's biology. The environmental stresses in its habitat include low water availability, extreme temperatures, and full exposure to the forces of wind and water erosion. The habitat conditions represent a set of severe stress conditions across the taxon's range of settings.

The climate of the nearest monitoring station at Sheridan, Wyoming is characterized as a continental climate, with peak precipitation during the time when the taxon flowers in May (**Table 3**). The data from this station represent the climate at foothills and plains elevations. Montane populations would be expected to have higher precipitation and lower temperatures during the growing season, as well as shorter growing seasons. The taxon typically occupies microhabitats where evapotranspiration and temperature extremes are heightened, so the preceding values are only a rough indication of the actual climate.

Disturbance levels have not been characterized. There is no information at hand on taxon's response to fire, but it might be expected that fire frequency and fuel loads in its habitat are low. The vulnerability of its terminal buds to ground fire is not known. The deep taproot may confer resilience. The steep rubble slopes of some occurrences may be relatively unstable as evident at the Fallen City occurrence on the Bighorn National Forest (**Figure 4**). Instability in such a setting would be increased if the stabilizing vegetation were removed or if trampling were intensified.

Reproductive biology and autecology

Physaria didymocarpa var. *lanata* flowers from May through June, depending on elevation, and its fruits dehisce in late July through September. It produces four seeds per fruit, numerous fruits per inflorescence, and often many inflorescences per plant. It reproduces mainly or entirely from seed. Lateral rosettes branches have been severed by rock gardeners to propagate the closely-related *P. didymocarpa* var. *didymocarpa* vegetatively (Rock Garden Database 2001). There is no evidence that the tight cluster of stubby rootcrown branches routinely break to provide vegetative reproduction of *P. didymocarpa* var. *lanata* under natural conditions.

The flowers in the Mustard Family are relatively uniform within genera and little-differentiated, compared to the highly-differentiated fruits (Rollins 1993). Unspecialized flowers attract generalist pollinators as pollen vectors, which might enhance the reliability of pollination in its range of sparsely-vegetated habitats. Some members of the family are wholly self-incompatible, with extrorse anthers and large flowers, while others are wholly self-compatible and have small flowers with introrse anthers (Rollins 1993). *Physaria didymocarpa* var. *lanata* is characterized as an outcrossing taxon (Mulligan 1968), consistent with its relatively large flowers. Its insect pollination vectors are not known apart from anecdotal observations of bumblebees (*Bombus* spp.) on flowering plants (**Figure 6**).

Given the exposed habitat, generally steep slopes, and balloon-like fruit valves that contain the seeds, it is likely that dispersal by wind is the primary mechanism of seed dispersal. When the papery silicle splits in two, each spherical half rolls across the ground or can become airborne with strong gusts. Optimum germination requirements and seedling biology are not documented for this taxon, but the entire genus has received attention in rock gardening, and the related *Physaria didymocarpa* var. *didymocarpa* is readily propagated from ripe seed in spring or from cuttings of lateral rosettes (Rock Garden Database 2001).

Physaria didymocarpa var. *lanata* takes on a variety of growth forms, depending on environmental factors such as shade, moisture, and elevation. Plants that grow in the shade have lax, sprawling inflorescences. Some individuals have elongate inflorescences over 25 cm in length. The axis is indeterminate. The lengths of the basal leaf petioles vary so that some individuals have tight basal rosettes with almost no petiole visible, while others have loose clusters with the petiole over three times as long as the leaf blade. It is not known whether this is determined by the environment. The largest individual plant among RM specimens was a low-elevation plant collected at 4,800 ft. with a 30 cm diameter (Nelson *3252*), a relative giant compared to most specimens that are less than half this size (Heidel personal observation 2002).

Demography

Members of the *Physaria* genus are perennial (Rollins 1993). The life span of the taxon has not been

Table 3. Annual and May temperature and precipitation values at Sheridan, WY (Sheridan Airport, 3,960 ft. elevation).

	Mean Annual Value	Range in Mean Annual Values	Mean May Value	Range in Mean May Values
Temperature (°F)	44.97	41.26 to 48.18	53.07	48.85 to 60.37
Precipitation (inches)	14.76	8.23 to 23.82	2.31	0.29 to 6.8

Figure 6. *Bombus* spp. photographed on *Physaria didymocarpa* var. *lanata*, by Greg Karow, USDA Forest Service.

determined in monitoring or in greenhouse studies. Examination of herbarium specimens revealed that a few of the individual plants had one to two persisting leaf sheath clusters on the taproot below the current year's leaves (Heidel personal observation 2002). This included specimens from the highest elevations (Nelson *6203*, O'Dea *32*) as well as from foothills elevations (Fertig and Britt *14733*). If these old leaf sheath clusters represent previous year's growth, then there are a small number of plants that are at least two to three years old and most plants flower in the first year that they are established. However, lifespans of six to seven years are reported for *P. didymocarpa* var. *lyrata* (Craig and Craig 1996). It is possible that long-lived individuals of *P. didymocarpa* var. *lanata* have simply been overlooked by collectors to date. The individual plants with persisting leaf sheaths did not differ in size from other specimens.

Established plants produce one or more tight rosettes of basal leaves. Non-flowering plants are reported in recent records at three sites, one of which has recorded the relative contribution of vegetative and reproductive plants (5 percent fruiting, 95 percent vegetative in an occurrence of 50 plants) as reported in a surveys by Walter Fertig (Wyoming Natural Diversity Database 2004).

It is not known when the taxon germinates, or how long it takes for a seedling to produce a taproot and basal rosette of leaves. From preliminary herbarium observations, it appears that most reproductive plants did not have old leaf sheaths, possibly indicating that they only flower once. This inferential information indicates that *Physaria didymocarpa* var. *lanata* is a short-lived perennial.

As a short-lived perennial, rapid turnover in occurrences might be expected, requiring frequent recruitment of new individuals to maintain population numbers. There may be seed bank dynamics that are important in the life cycle of *Physaria didymocarpa* var. *lanata*. There is no information available on the viability and longevity of the seeds over time, dormancy-breaking requirements, and germination requirements. The presence of a seed bank is inferred for the related *P. didymocarpa* var. *lyrata* based on episodes of recruitment that were documented in an annual monitoring study following years of low flower production (Craig and Craig 1996). A schematic stage-based diagram of *P. didymocarpa* var. *lanata* life history stages is presented in **Figure 7**.

No Population Viability Analyses have been performed for *Physaria didymocarpa* var. *lanata*. Apparently there has never been such an analysis performed for other members of the genus *Physaria*. However, demographic monitoring of *P. didymocarpa* var. *lyrata* suggests that small plants, particularly seedlings, have high levels of mortality and may

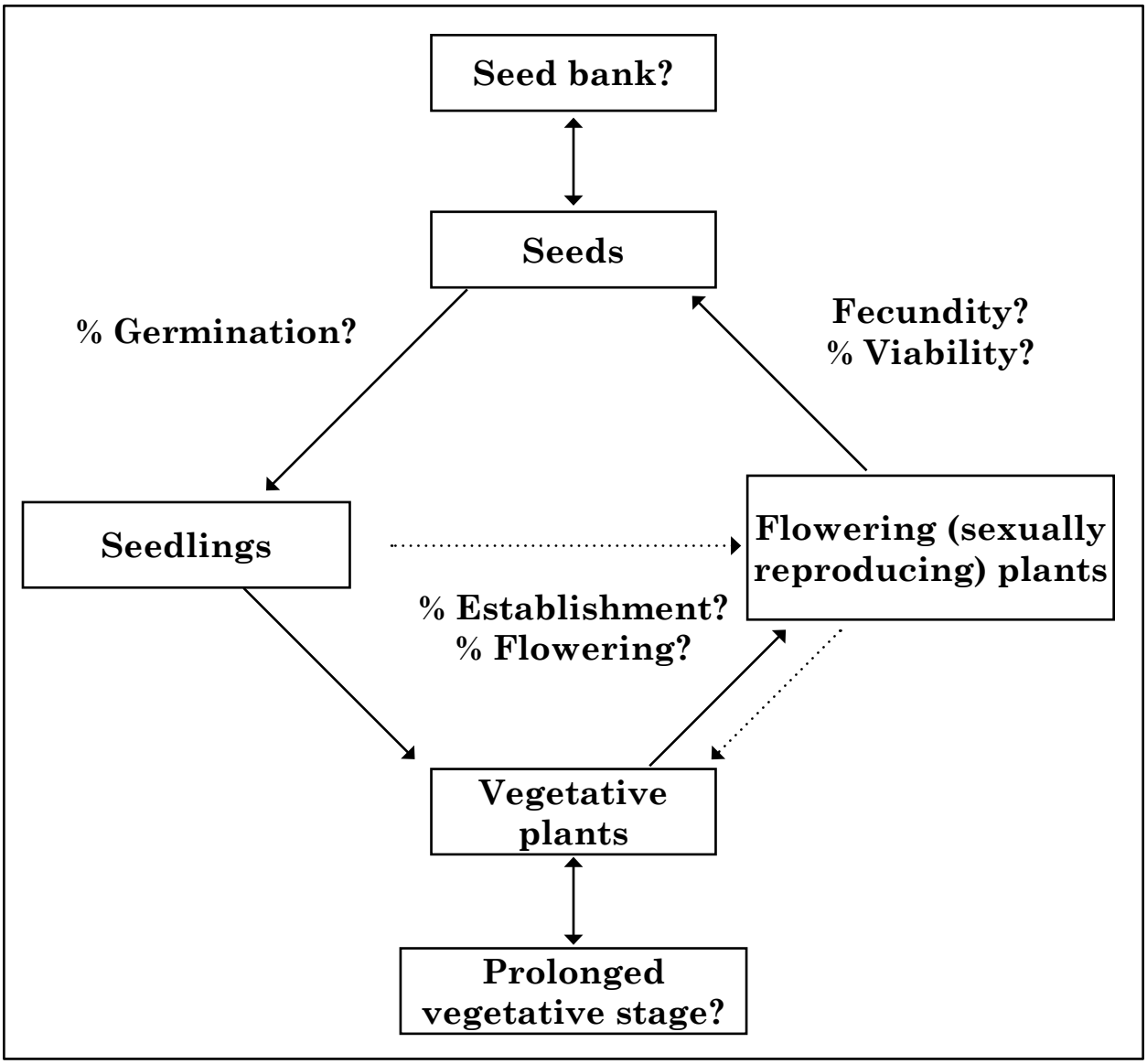

Figure 7. Life cycle diagram for *Physaria didymocarpa* var. *lanata*. Dashed lines indicate pathways that are possible but not proven.

represent the critical life history stages (Craig and Craig 1996).

Population genetics of *Physaria didymocarpa* var. *lanata* have not been examined. Only the Fallen City occurrence has been mapped in detail, indicating a system of suboccurrences separated by unsuitable habitat. If the pollinators are isolated and dispersal is limited within its elevation range, then it is possible that it could differentiate across the elevation gradient. However, no consistent qualitative or quantitative morphological differences associated with elevation were noted among specimens at RM covering its full elevational gradient. Hybrids are not known in the taxon and genus, but they are reported in the closely-related *Lesquerella* genus. Questions of genetic integrity and inbreeding or outbreeding depression are particularly important if *P. didymocarpa* var. *lanata* depends on outcrossing.

Habitat availability may be limiting for *Physaria didymocarpa* var. *lanata* occurrences in Wyoming and Montana since the taxon is confined to what are often patches of sparse vegetation. It appears that not all patches of suitable habitat are occupied, suggesting that population increase and spread may be further

limited by dispersal. Alternatively, there may be levels of disturbance factors that maintain habitat suitability. Basic information is needed about this taxon's habitat stability and disturbance regimes. While *P. didymocarpa* var. *lanata* appears to be a poor competitor, some such taxa actually benefit from neighboring plants under adverse conditions, e.g., ameliorating the effects of drought. This has been documented in the closely-related *Lesquerella* genus for *L. carinata* var. *languida* that grows in calcareous south-facing, open montane slopes. It has key stages of its life history "facilitated" by neighboring plants under drought years, switching back and forth between relationships of competition and facilitation (Greenlee and Callaway 1996). In the 3-axis model system of Grimes (2001), relative to competition, stress tolerance, and ruderal tendencies, *P. didymocarpa* var. *lanata* is first and foremost a stress-tolerant taxon..

An envirogram summarizing resources and threats for *Physaria didymocarpa* var. *lanata* is provided in **Figure 8**.

CONSERVATION

Threats

Potential threats to *Physaria didymocarpa* var. *lanata* include coal bed methane development, coal mining, herbicide use, road development, concentrated livestock trampling, off-road vehicle use, and exotic species introductions associated with the above (Fertig 2000). It was documented at the site of a proposed coal mine development site in 1977 (L.M. Meyer *937*), and this occurrence may be extirpated. Coal mining and coal bed methane development are the most direct threats, and these activities are limited to the plains and lower foothills elevation range of the taxon.

The taxon can be indirectly affected by any activities that introduce exotic species competitors. There is one exotic species that has been documented among its occurrences in both Montana and Wyoming; yellow sweetclover (*Melilotus officinalis*), a species that fixes nitrogen, may be a serious competitor or foster vegetation change. *Melilotus officinalis* is present at Fallen City, the largest known occurrence on the Bighorn National Forest. In addition, a knapweed (*Centaurea* spp.) was recently documented less than two miles down the highway from the Fallen City occurrence (Greg Karow personal communication 2004), and it is not known whether it has the potential to invade the habitat of *Physaria didymocarpa* var. *lanata*.

It is not known whether there are grasshopper spraying programs in occupied habitat, but this is more likely in plains settings. Insecticide application has been reported as a threat to other rare plant taxa (Tepedino 1998).

Physaria didymocarpa var. *lanata* may be affected by activities that either markedly stabilize or destabilize its habitat. In general, removal of entire slopes and outcrops eliminates the occurrence and the potential for recolonization by the seed bank. *Physaria didymocarpa* var. *lanata* may not disperse over long distances and is impacted by removal of entire occurrences. These threats may be particularly severe where there are likely to be multiple disturbances at a locale, as found along road corridors with or without road widening as at Fallen City and Mosier Gulch (**Figure 9** and **Figure 10**). However, one of the earlier collections (Porter *6255*) was made from a "highway cutbank" where the taxon has been relocated. The largest known occurrence on the Bighorn National Forest lies directly below a highway pull-off on a talus slope, where it would be potentially impacted by any widening activities and herbicide drift applied to the right-of-way beyond the inside of the shoulder (**Figure 9**). The Wyoming Department of Transportation may be blasting along the highway to angle the slope above the highway, i.e., above most of the occurrence, as recorded in the 2004 survey by Tucker Galloway. The occurrence itself occupies steep slopes that may be destabilized, if not directly affected, by blasting and transfer of debris. In addition, Wyoming Department of Transportation has already widened the highway through Mosier Gulch on BLM lands where the taxon occurs within the construction zone, including individuals that persist under chicken wire mesh spread across the recontoured slopes to prevent rockslides (**Figure 10**; Greg Karow personal communication 2004). The effects of this project on the occurrence are not known. In general, removal of entire slopes and outcrops eliminates the occurrence and the potential for recolonization by the seed bank. *Physaria didymocarpa* var. *lanata* is not likely to be a long-distance colonizing taxon except as new outcrops are created within or directly adjoining existing occurrences without removal of entire existing occurrences, and even this may signify net loss of habitat. The taxon may also be impacted by activities that advance succession, including bank stabilization, reseeding, and re-contouring. Most threats to the taxon from human activities are localized, but they may be very important to the viability of small occurrences. These threats may be particularly severe where there are likely to be multiple disturbances at a locale as found along road corridors such as at Fallen City (**Figure 9**).

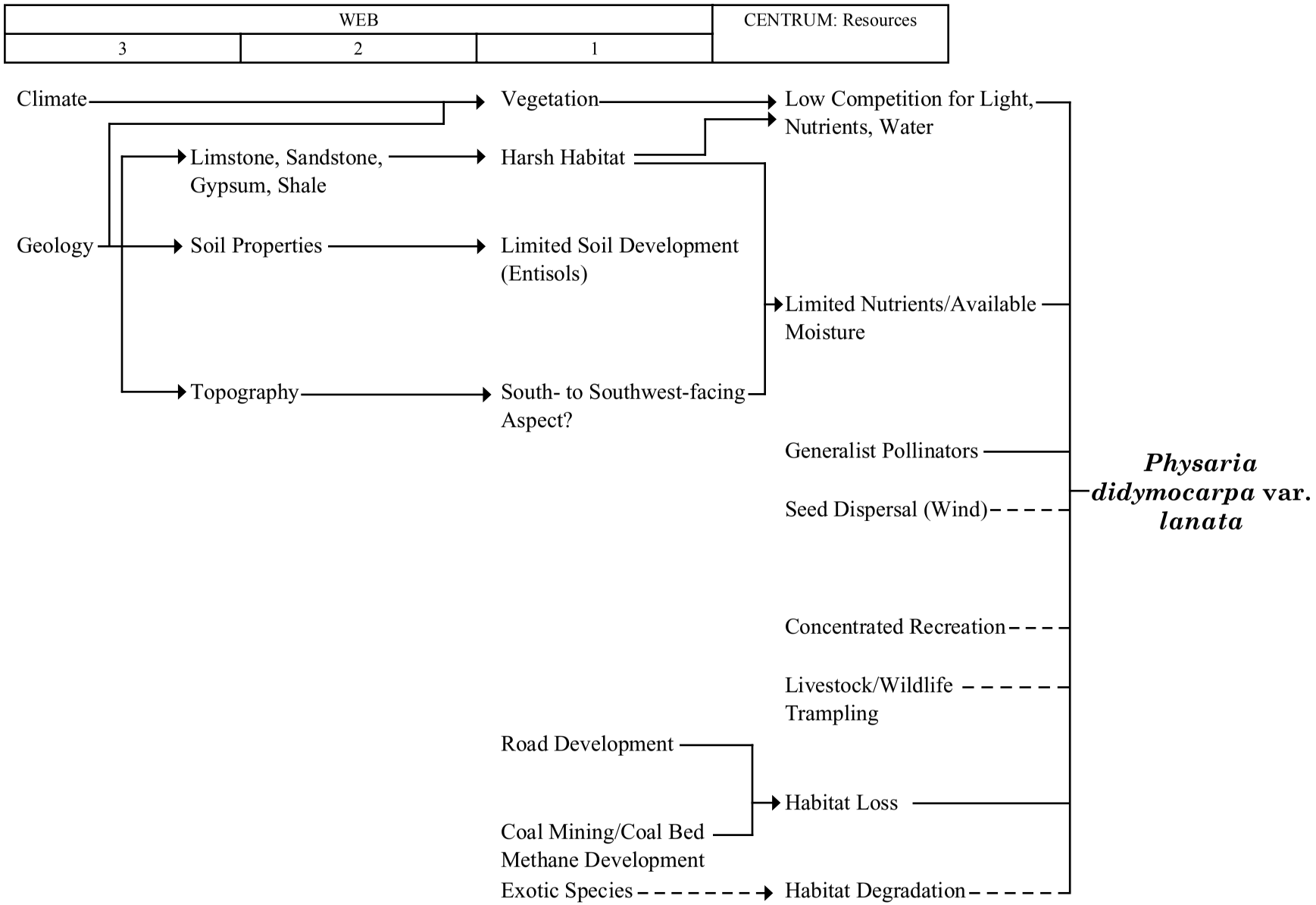

Figure 8. Envirogram of *Physaria didymocarpa* var. *lanata*.

Figure 9. Setting of *Physaria didymocarpa* var. *lanata* habitat, photographed at Fallen City, by Walter Fertig, used with permission.

Figure 10. Widening of the Highway 16 corridor, photographed at Mosier Gulch, with *Physaria didymocarpa* var. *lanata* present in recontoured and unaltered habitat (right and left, respectively), by Greg Karow, USDA Forest Service.

Ranching is the primary land use at foothills and plains sites of *Physaria didymocarpa* var. *lanata*, and all four occurrences on Bighorn National Forest are within grazing allotments. There is limited direct evidence for evaluating the taxon's response to grazing, but grazing threats were characterized as low in Wyoming (Fertig 2000). The taxon's short stature and hairiness deter grazing and browsing, and its habitat is generally secondary range, barring water developments, trailing, salt block placement, or indirect effects of grazing such as impacts to other flowering plants that support the *Physaria* pollinators. Cattle are trailed along the highway through the Fallen City occurrence in spring and trailed down in late summer. Parts of the occurrence are found in narrow bands above the highway that could be affected by the trampling of stray stock. The Bighorn National Forest occurrences are generally on steep, open slopes that are little-affected by range management practices or recreational uses. One occurrence lies close to the Medicine Wheel Archeological Site, on a steep, southwest-facing slope that is unlikely to be affected by visitation.

There are no known commercial uses for *Physaria didymocarpa* var. *lanata* apart from the general interest in the genus by rock gardeners. It is not known whether it was included in recent concerted collections of *Physaria* taxa specimens for agricultural research. There are no indications that the taxon is under collecting pressure.

An envirogram summarizing resources and threats for *Physaria didymocarpa* var. *lanata* is provided in **Figure 8**.

Conservation Status in the Rocky Mountain Region

Physaria didymocarpa var. *lanata* is a rare regional endemic with incompletely documented population distribution and numbers. It appears to be a habitat specialist within any given landscape but spanning a range of conditions across its distribution. It is possible that its specialization might be defined in terms of a range of stability and disturbance conditions, but this has not been investigated. It is designated sensitive by the USFS Rocky Mountain Region (USDA Forest Service 2003).

The short life history of the taxon makes it potentially vulnerable to short-term disturbances. It is not known whether there is a seed bank to buffer it in this intrinsic vulnerability.

The minimum population viability requirements of *Physaria didymocarpa* var. *lanata* are not known. Minimum viable populations are often on the order of 1,000 to 100,000 individuals according to Menges (1991), and annuals or short-lived perennials typically require greater numbers to maintain viable populations than long-lived perennials. There are only three occurrences of *P. didymocarpa* var. *lanata* that are known to have numbers in this range, one of which is on land managed by Bighorn National Forest (**Table 2**).

There is limited direct evidence to suggest that occurrences of *Physaria didymocarpa* var. *lanata* are at risk in the Rocky Mountain Region. This may be due to the incompleteness of status information. The most conclusive documentation of threats is available for occurrences in plains and lower foothills elevations under energy exploration and development.

There is no cryogenic storage of *Physaria didymocarpa* var. *lanata* seeds to date. This would be a safeguard even if it is not an immediate need. Such storage may be accomplished in tandem or separate from needed studies into seed longevity and germination requirements.

Management of the Species in the Rocky Mountain Region

This taxon and its habitat have not been the focus of management action by any federal agencies to date. A framework of species inventory, occurrence documentation, and habitat disturbance regime documentation are presented below as a framework for species management planning. Systematic species survey might be conducted on Bighorn National Forest using the apparent correlations of surface geology, as mapped in Love and Christiansen (1985) and closely correlating with USFS landscape units in the Amsden and Bighorn Dolomite formations (Greg Karow personal communication 2004). Substrate requirements may explain the linear pattern of this taxon's distribution on the flanks of the Bighorn Mountains. Systematic surveys might also be advanced with the use of potential distribution modeling (e.g., Fertig and Thurston 2003) to determine the best fit between multiple environmental attributes and known taxon distribution using Geographic Information System (GIS) techniques.

Population documentation is needed in concert with systematic surveys to determine population numbers and extent. Accurate estimates are possible

even for large occurrences and those on unstable slopes. In these cases, a set of population census subsamples that represent the range of taxon density might be taken and used for extrapolation. Occurrence extent should be mapped directly onto topographic maps, ideally with Global Positioning System (GPS) points taken at the outer limits of demarcation.

Habitat disturbance regimes can be described or inferred in the course of systematic inventory by documenting angles, aspects, and parent materials; using evidence of burial or undercutting of surrounding perennial vegetation, evidence of frost-heaving, and evidence of burrowing; and considering the population distribution relative to topography.

Threats can be described or inferred in the course of systematic inventory by identifying signs of damage or mortality to individual plants, and signs of degradation or loss to the taxon's habitat. This requires consultation with resource managers to address the scope of current and potential activities in any given landscape.

Monitoring may be warranted, depending on survey outcome if total numbers of the taxon are low, if there is evidence to suggest overall downward trend, or if there is evidence to suggest that the largest occurrences are vulnerable. Monitoring would be needed on an annual basis for such a short-lived taxon, and it would ideally extend past the length of the mean life cycle and beyond any extreme wet or dry climate year or pair of years. The three different levels of monitoring are described succinctly by Menges and Gordon (1996) as they address presence/absence, overall trend, and accompanying demographic trend in order to design and scale the monitoring task to the survey outcome and resulting conservation question.

Information Needs

The most pressing information needs on Bighorn National Forest are for current and complete distribution and status information, acquired by systematic surveys. There may be potential habitat in the Thunder Basin National Grassland too, though it was not found in recent floristic inventories (Ebertowski et al. 2004). Survey is needed to relocate the taxon in the historic collection locale in Washakie County, although the only federal lands in the area are administered by the BLM. As part of systematic survey, it is important to consider current population information (numbers and extent), habitat stability, evidence of the taxon's ability to colonize disturbed habitat, and existing or potential threats.

This baseline information is needed to determine the next appropriate steps. If taxon numbers are limited, then the largest occurrences and any potentially threatened occurrences might be made the subject of monitoring. Monitoring design is to be set in keeping with the research questions and management objectives that emerge from systematic survey, described in Menges and Gordon (1996) and Elzinga et al. (1998).

Since there is little information about the life history of *Physaria didymocarpa* var. *lanata*, demographic analysis warrants consideration and potentially sets the course for identifying any critical research needs. If, for example, there was low seed set, then gene flow and pollination biology warrant investigation. If there was high mortality to plants in drought years, then the habitat characteristics of settings with high and low survivorships warrant investigation. A framework for monitoring nonrhizomatous perennials is presented by Lesica (1987). For the sake of effectiveness and efficiency this stage of research should be designed to identify key conservation biology questions among the spectrum of potential research projects for maintaining healthy, sustainable populations.

Taxonomic work in the Mustard Family for the Flora of North America is in preliminary planning stages and will ultimately provide a new reference for the taxonomic treatment of this taxon as well as an updated overview of genus diversity and adaptations.

DEFINITIONS

Autopolyploid — A polyploid resulting from the multiplication of the chromosome set of a single species (see "polyploid").

Dentate — Toothed.

Endemic — Native to, and restricted to a geographic area, usually referring to taxa of limited geographic distribution.

Extrorse — Facing outwards, or away from the axis of growth; especially concerning anthers occupying the outer side of the filament, and therefore away from the stigma.

Funiculi — Seed-bearing stalk attached to the replum.

Introrse — Facing inwards, or towards the axis of growth; especially concerning anthers occupying the inner side of the filament, and therefore towards the stigma.

Locule — A seed-bearing chamber in an ovary or fruit.

Oblanceolate — Lance-shaped and broader toward the tip than the base.

Polyploid — Having more than two sets of homologous chromosomes.

Range site — Classification of forage-producing habitat based on soils characteristics at given precipitation range and elevation zone.

Repand — Wavy.

Replum — A persistent, septum-like partition between the halves of a mustard fruit that bears ovules on the margins.

Silicle — A capsule roughly one to two times as long as wide and with two valves that are deciduous from the persistent, seed-bearing partition.

Stellate — Star-shaped, as in the case of hairs with many branches from a central axis

Sympatric — Overlap in population distribution of closely-related taxa

Trichome — Any hair-like outgrowth of the epidermis.

Xeromorphic — Structural or functional plant adaptations to prevent water loss by evaporation.

NatureServe rank definitions:

G	Global rank: rank refers to the rangewide status of a taxon.
T	Trinomial rank: rank refers to the rangewide status of a subspecies or variety.
S	State rank: rank refers to the status of the taxon in a state. State ranks differ from state to state.

For each global and state rank, whether at the species or subspecies level, each taxon is ranked on a scale of 1 to 5 from most vulnerable to extirpation to least as follows:

1	Critically imperiled because of extreme rarity (often known from 5 or fewer extant occurrences or very few remaining individuals) or because some factor of a taxon's life history makes it vulnerable to extinction.
2	Imperiled because of rarity (often known from 6 to 20 occurrences) or because of factors demonstrably making a taxon vulnerable to extinction.
3	Rare or local throughout its range or found locally in a restricted range (usually known from 21 to 100 occurrences).
4	Apparently secure, although the taxon may be quite rare in parts of its range, especially at the periphery.
5	Demonstrably secure, although the taxon may be rare in parts of its range, especially at the periphery.

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