Status of *Physaria didymocarpa* var. *lanata* (Woolly Twinpod), Bighorn Mountains, north-central Wyoming

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ABSTRACT

Physaria didymocarpa var. *lanata* (woolly twinpod), a regional endemic of north-central Wyoming and adjacent Montana, was surveyed for detailed information about known populations and to locate possible new populations. Maps with bedrock geology overlain on aerial photos were used to identify areas for new surveys. Specific location, population distribution, and habitat information data were gathered for many populations that were known only from specimen collections and four new populations were found. Species information, status assessment, and management recommendations are provided based on prior knowledge, current land uses, and new understanding gained from these surveys.

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INTRODUCTION

Physaria didymocarpa var. *lanata* (woolly twinpod) is a regional endemic of north-central Wyoming and adjacent Montana. Its main distribution is on, or along the periphery of, the Bighorn National Forest. The status of *P. didymocarpa* var. *lanata* was previously addressed in a state species abstract (Fertig 2000) and a species conservation assessment (Heidel and Handley 2004). Systematic survey of the taxon on the Bighorn National Forest was identified as a need in the species conservation assessment to document numbers of individuals and extent of populations, as well as to describe habitat stability, evidence of the taxon's ability to colonize disturbed habitat, and existing or potential threats. In 2010, the Wyoming Natural Diversity Database (WYNDD) and the Bighorn National Forest collaborated to attend to these information needs.

METHODS

Prior to field work, information about previous collections and surveys of *Physaria didymocarpa* var. *lanata* from the WYNDD spatial database (Biotics) and element manual files was reviewed and checked for completeness. A two-pronged approach was taken in conducting 2010 field surveys for *Physaria didymocarpa* var. *lanata*. Unsurveyed specimen collection points were surveyed to map precise *P. didymocarpa* var. *lanata* location and extent in the immediately surrounding landscape, while gathering information on the taxon and its habitat. In addition, known distribution was overlain with a compilation of limestone and dolomite bedrock formations (Love and Christiansen 1985) to compare known distribution with geology as basis for interpolation and extrapolation. The fieldwork was conducted simultaneously with surveys for two other rare calciphilic plants, *Musineon vaginatum* (sheathed musineon) and *Pyrrocoma clementis* var. *villosa* (hairy tranquil goldenweed), thinking that Forest-wide survey of all three would be more efficient than each separately.

ArcMap was utilized to create maps of known taxon distribution correlated with calcium carbonate bedrock geology based on Love and Christensen (1985). These maps, which included digital orthophotos as backgrounds, aided in selection of survey areas. The potential survey area maps were then printed out by quarter quad on 8.5 x 11 inch paper, which roughly corresponds to the 1:24,000 scale of USGS 7.5" topographic quads. The digital orthophoto printouts and USGS topographic quads were used together in the field for navigation and reference. Rocky Mountain Herbarium (RM) specimens of *P. didymocarpa* var. *lanata* and other members of the genus *Physaria* were examined to obtain useful field characters to differentiate nearby taxa (Table 1).

Surveys for *Physaria didymocarpa* var. *lanata* were conducted between 3 June and 15 August 2010, when the taxon was flowering and fruiting (Appendix A). Five botanists were involved in the surveys at different times over the course of the season. When *P. didymocarpa* var. *lanata*

was found in a survey area, plant numbers were estimated, field maps were marked, and coordinates were recorded from GPS units for georeferencing population boundaries that were later digitized as polygons into the Biotics geospatial database. Information on habitat, phenology, and plant associates were documented on WYNDD survey forms and later entered into the Biotics program.

RESULTS - SPECIES INFORMATION

Classification

Scientific name: *Physaria didymocarpa* (Hooker) A. Gray var. *lanata* A. Nelson

Synonyms: *Physaria lanata* (A. Nelson) Rydberg, *Physaria didymocarpa* (Hooker) A. Gray ssp. *lanata* (A. Nelson) O'Kane

Common name: woolly twinpod, lanate common twinpod

Family: Brassicaceae, Mustard Family

Size of the Genus: According to O'Kane (2010) the genus *Physaria* consists of 106 species, 88 species in North America north of Mexico, including 23 species in Wyoming (Heidel and O'Kane 2010). Other members of the genus occur in Mexico, Argentina, Bolivia, and northeastern Russia. These numbers represent the merging of the genus *Lesquerella* into *Physaria* by Al-Shehbaz and O'Kane (2002). Prior to the merger of the two genera, *Physaria* consisted of 22 species north of Mexico (Al-Shehbaz and O'Kane 2002).

Phylogenetic relationships: There are two other varieties of *Physaria didymocarpa*: the typical variety and *Physaria didymocarpa* (Hooker) A. Gray var. *lyrata* C.L. Hitchcock. Morphologically, *P. didymocarpa* closely resembles *P. brassicoides* and O'Kane (2010) differentiates them in the key by the presence or absence of well developed basal and apical sinuses in the fruit, respectively.

History of the Taxon: *Physaria didymocarpa* var. *lanata* was first described by Aven Nelson:

Nelson, A. 1904. *Physaria didymocarpa* (Hook.) A. Gray var. *lanata* A.Nelson. In: New plants from Wyoming XV. Bulletin Torrey Botanical Club 31: 241.

Leslie N. Goodding's type specimen (*326*) is deposited at the Rocky Mountain Herbarium (RM). The collection label states "Rocky slopes. Head of Middle Fork of Powder R., Big Horn Co., July 19, 1901." The geologic affinities of the taxon and subsequent collection settings would

indicate that this location information is probably in error. Isotypes are at COLO, GH, NY, and US.
Rydberg (1912) elevated the taxon to species status. However, Payson (1918) and Rollins (1939, 1993) conserved the original treatment. O'Kane (2007) gave the taxon the new combination as a subspecies.

Physaria didymocarpa var. *lanata* was first found on the Bighorn National Forest by Louis O. and Rua Williams (*3228*) in 1936, "Summit of Medicine Mountain" (Wyoming #005) (Table 2). In 1993, Richard Prodgers (*s.n.*) made the first Montana collection at the Spring Creek site (Montana #001) (Heidel 1996). Most of the known populations in Wyoming were discovered during general inventories in the 1970s and 1990s (described in the extant sites portion of the geographical distribution, below).

There have been only been two previous reports that discussed the status of *Physaria didymocarpa* var. *lanata*, although these were not actual status reports. In 2002, Taylor and Caners submitted a baseline survey report for *P. didymocarpa* var. *lanata* in Montana to the Bureau of Land Management. A species conservation assessment for the Rocky Mountain Region of the USDA Forest Service by Heidel and Handley was published online in 2004. Status was also addressed in a species abstract by Fertig (2000).

Legal Status

U.S. Fish & Wildlife Service status: None

Global Heritage rank: G5T2 (Imperiled).

Federal status: USDA Forest Service, Region 2 Sensitive; USDI BLM, Montana Sensitive

State Heritage rank: S2 (imperiled) in Wyoming (Heidel 2007); S1 (critically imperiled) in Montana (Montana Natural Heritage Program 2011)

The information from the 2010 surveys will be weighed in any global and state rank updates.

Description

General non-technical description: *Physaria didymocarpa* var. *lanata* is a tufted, multi-stemmed perennial herb covered with long-stalked, tangled, multi-branched woolly hairs (giving the plant a gray appearance). Basal leaves are entire to coarsely dentate, and shaggy-margined due to the long-stalked pubescence. Stem leaves are shorter, oblanceolate, and 1-2 cm long. The inflorescence consists of a congested cluster of yellow, 4-petaled flowers 8-12 mm long (Figure

1). Mature fruits consist of 2 inflated, balloon-like pods with shaggy pubescence (Figure 2). The replum of the mature fruit is narrowly lance-shaped to oblanceolate with 2 stubby funiculi per face (Dorn 2001; Rollins 1993, Fertig 2000).

Figure 1. *Physaria didymocarpa* var. *lanata* in flower. By Bonnie Heidel.

Technical description: Perennial: branched caudex; densely pubescent, trichomes often stalked, spreading through-out, tangled, several-rayed; rays furcate or simple, slightly to strongly umbonate, nearly smooth to strongly tuberculate. Stems several from base, decumbent, unbranched, leafy, ca 1 dm. Basal leaves forming a strong rosette; long-petiolate; blade obovate, 1.5-4(-8) cm, base more or less abruptly narrowing to petiole, margins dentate, rarely entire, apex usually angular, surfaces silvery. Cauline leaves: blade oblanceolate, 1-2 cm long, 4-8 mm wide, margins entire or with occasional tooth, apex acute. Racemes congested, elongated in fruit, greatly exceeding leaves. Fruiting pedicels spreading, straight or slightly curved, 8-12 mm. Sepals lanceolate to oblong, 6-8 mm, often keeled. Petals spatulate, 10-12 mm. Fruits erect, didymous, inflated, 10-20 × 10-20 mm, papery or firm, basal sinus shallow to deep, sometimes barely notched, apical sinus deep, narrow, usually closed; valves retaining seeds after dehiscence, loosely pubescent, trichomes spreading, appearing fuzzy; replum narrowly oblong to linear, rarely lanceolate to oblanceolate; ovules (4-)8 per ovary; style 7-9 mm. Seeds flattened. $2n = 8, 16$ (O'Kane 2010).

Local field characters: The loose, spreading pubescence of the basal leaves of *Physaria didymocarpa* var. *lanata* has a shaggy appearance (Figure 3). The mature fruits have two to four funiculi per locule and a relatively narrow replum.

Figure 2. *Physaria didymocarpa* var. *lanata* in fruit. By Earl Jensen

Figure 3. Loose, spreading pubescence on basal leaves of *Physaria didymocarpa* var. *lanata*. By Earl Jensen.

Similar taxa: *Physaria didymocarpa* var. *didymocarpa* has appressed hairs on the basal leaves, giving them a smooth look, and mostly 3-6 ovules/funiculi per locule (Table 1). *Physaria acutifolia* and *P. brassicoides* have smooth leaf blades (Fertig 2000). The flowers of the common associate, *P. curvipes*, have a similar yellow color and structure, but are much smaller and not easily mistaken except at a distance.

Table 1. Distinguishing characteristics of *Physaria didymocarpa* var. *lanata* from other *Physaria* taxa (Rollins 1993, Dorn 2001, O'Kane 2010).[1]

Taxon	**Shape of fruit**	**Number of funiculi per locule**[2]	**Shape of partition between locules**	**Basal leaf pubescence (use 10X hand lens)**	**Basal leaf shape and outline**
P. didymocarpa var. *lanata*	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Usually 2 (Dorn 2001); but reported as (2) 4 (O'Kane 2010)	Narrowly oblong to linear; rarely lanceolate to oblanceolate	Densely-hairy with spreading, long, simple, tangled hairs; shaggy-looking, particularly at petiole base[3]	Leaves obovate, apex angular, slightly to coarsely dentate
P. didymocarpa var. *didymocarpa*[4]	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Mostly 4 (3 to 6)	Oblong to ovate	Smooth-looking, with appressed, forked or simple hairs	Leaves obovate, apex angular, repand to dentate
P. acutifolia[5]	Silicles strongly didymous, basal and apical sinuses prominent, usually nearly equal	Usually (1) 2	Narrowly oblong to linear; rarely lanceolate to oblanceolate	Smooth-looking, with multi-ray hairs	Leaves obovate to orbicular, apex rounded or obtuse, entire or very rarely with a few scattered teeth
P. brassicoides[6]	Silicles with little or no sinus below	Usually 2	Narrowly oblong to linear; rarely lanceolate to oblanceolate; constricted toward middle	Smooth-looking, with multi-ray hairs	Leaves orbicular to obovate, apex angular, margins repand or rarely entire

[1] Modified from Heidel and Handley 2004.

[2] The number of funiculi (stalks) should correspond with the number of ovules per locule, and may be greater than the number of seeds because seed abortion or lack of fertilization are common (O'Kane 2010).

[3] 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."

[4] *P. didymocarpa* var. *didymocarpa* is not known from the Bighorn Mountains, but may be nearby in Park County.

[5] P. *acutifolia* is mainly in the basins and may reach western and eastern foothills of the Bighorn Mountains.

[6] P. *brassicoides* is mainly in the plains and may reach eastern foothills of the Bighorn Mountains.

Geographical distribution

Range: *Physaria didymocarpa* var. *lanata* is a regional endemic of north-central Wyoming and adjacent Montana. In Wyoming, it is known from the Bighorn Range and adjacent northern Powder River Basin in northeastern Big Horn, south-central Campbell, western Johnson, and western Sheridan counties. Montana populations are in the Tongue River and Hanging Woman Creek drainages in southeastern Bighorn and southern Rosebud counties (Figure 4). Within this area, it occurs only where bedrock geology and other habitat conditions are suitable.

Extant sites: *Physaria didymocarpa* var. *lanata* is known from 18 occurrences (populations) in Wyoming, including four new occurrences discovered during the 2010 surveys (Table 2; Appendix B). There are five known populations in Montana.

Figure 4. Known distribution of *Physaria didymocarpa* var. *lanata*.

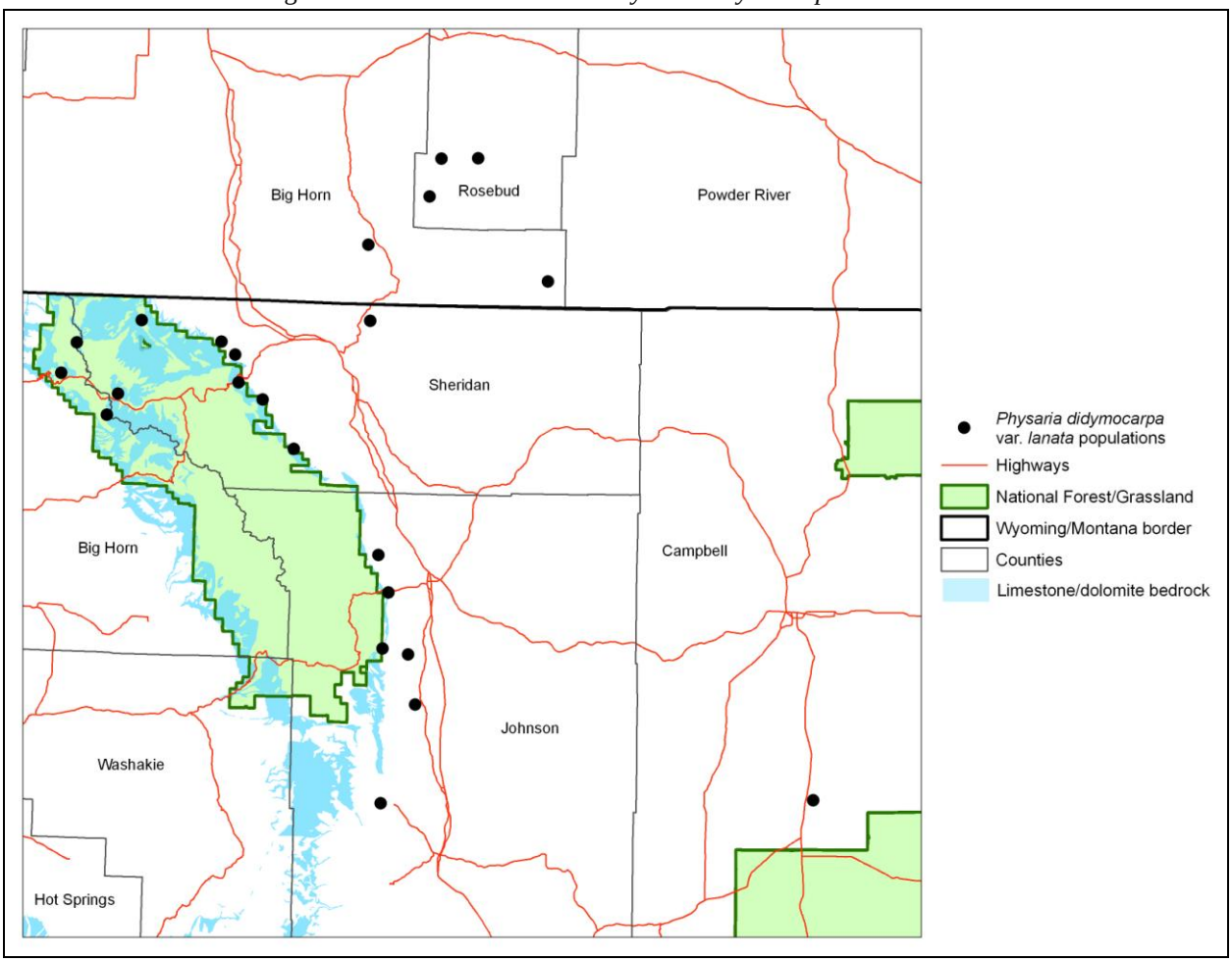

Table 2. Location information for known occurrences of *Physaria didymocarpa* var. *lanata*

EO#	Site Name	County, State	Legal Description	Elevation m (ft)	USGS 7.5' Quad	Agency
001	Wolf Creek Canyon	Sheridan, WY	T55N R86W	1460 (4800)	Wolf	Private
002	Amsden Creek WHMA	Sheridan, WY	T57N R87W Sec 34, 35	1400-1460 (4600-4800)	Dayton South	Amsden Creek Wildlife Habitat Management Area
003	West of Hilight	Campbell, WY	T45N R71W	1460-1530 (4800-5010)	Reno Junction	Private
004	Duncum and Sheep Mountains	Big Horn and Sheridan, WY	T56N R91W Sec 6; T57N R91W Sec 8, 20-23, 27, 28, 32, 33; T57N R92W Sec 12	2800-2990 (9200-9800)	Bald Mountain, Boyd Ridge, Mexican Hill	Bighorn National Forest
005	Medicine Mountain	Big Horn, WY	T56N R92W Sec 16, 21-23	2850-3010 (9360-9880)	Medicine Wheel	Bighorn National Forest
006	Whitney Coal Site	Sheridan, WY	T58N R83W	1080-1160 (3540-3790)	Acme	Private
007	Smith Creek	Sheridan, WY	T57N R87W	1520 (5000)	Dayton North, Columbus Peak	Private, The Nature Conservancy easement
008	Sayles Creek	Johnson, WY	T51N R83W Sec 4-6, 8, 9	1710-1800 (5600-5900)	Lake De Smet West, Stone Mountain	Bud Love Wildlife Habitat Management Area
009	Mayoworth	Johnson, WY	T45N R83W Sec 28-30, 33	1680-1830 (5500-6000)	Mayoworth	BLM Buffalo Field Office
010	Greub Road	Johnson, WY	T47N R82W	1490-1520 (4900-5000)	Purdy Reservoir	Private
011	Mosier Gulch	Johnson, WY	T50N R83W Sec 1-4	1650-1950 (5400-6400)	North Ridge	BLM Buffalo Field Office, Highway right-of-way
012	Crazy Woman Mountain	Johnson, WY	T49N R83W Sec 21, 22, 27, 28	2010-2310 (6600-7580)	Klondike Ranch	State of Wyoming, Bighorn National Forest
013	Little Rapid Creek	Sheridan, WY	T54N R85W Sec 18	1680 (5500)	Beckton	State of Wyoming, The Nature Conservancy easement
014	Fallen City/Sand Turn	Sheridan, WY	T56N R87W Sec 15, 22, 23, 26, 27	1950-2040 (6400-6700)	Dayton South	Bighorn National Forest
018	Hunt Mountain	Big Horn, WY	T54N R91W Sec 1; T55N R91W Sec 13, 14, 23-25, 36	2830-3100 (9300-10162)	Hidden Tepee Creek, Leavitt Reservoir	Bighorn National Forest
019	Muddy Creek	Johnson, WY	T49N R82W Sec 29	1610-1620 (5280-5320)	Klondike Ranch	State of Wyoming

020	Pole Creek	Sheridan, WY	T55N R90W Sec 7; T56N R90W Sec 32	2770-2990 (9080-9810)	Ice Creek	Bighorn National Forest
021	Dry Fork Ridge	Sheridan, WY	T57N R89W Sec 6	2170-2200 (7120-7220)	Bull Elk Park	Bighorn National Forest
001	Spring Creek	Big Horn, MT	T8S R39E Sec 14, 22	1180-1260 (3860-4130)	Half Moon Hill	BLM Miles City Field Office, Private
002	Tidwell Draw	Big Horn, MT	T9S R44E Sec 10, 15	1160-1210 (3800-3960)	Quietus	BLM Miles City Field Office, Private
003	Zook Creek	Rosebud, MT	T6S R42E Sec 2, 3	1010-1070 (3300-3500)	Birney	Zook Creek Wilderness Study Area
004	Bull Creek	Rosebud, MT	T6S R41E Sec 2	1050 (3460)	Birney SW	Private
005	South Fork Canyon Creek	Rosebud, MT	T7S R41E Sec 4, 9	1030 (3380)	Birney SW	Private

The discoveries of known extant populations in Wyoming range from 1936 to the present day. Louis O. and Rua Williams (*3228*) collected *P. didymocarpa* var. *lanata* in 1936, "Summit of Medicine Mountain" (Wyoming #005). In 1953, C.L. "Ted" Porter made a collection (*6255*) along U.S. Highway 16, ca 10 miles west of Buffalo (Mosier Gulch, #011). Gary J. Pierce (*1971*) found the population west of Hilight (Wyoming #003) in 1973. The Whitney Coal Site occurrence (#006) was first located by Lillian M. Mayer (*937*) in 1977. In 1979, Ronald L. Hartman, Keith H. Dueholm, and B.E. "Ernie" Nelson discovered several populations while doing a floristic survey of the Big Horn Mountains: Greub Road (#010) (*Dueholm 6465*), Crazy Woman Mountain (#012) (*Hartman 9664*), Amsden Creek Wildlife Habitat Management Area (Wyoming #002) (*Hartman 9838*), Smith Creek (#007) (*Hartman 9878*), Mayoworth (#009) (*Hartman 9919*), Wolf Creek Canyon (Wyoming #001) (*Nelson 3252*), and Sayles Creek (#008) (*Dueholm 8334*). B.E. "Ernie" Nelson made the first collection at Duncum Mountain (Wyoming #004) (*6203*) as the Big Horn Mountain floristic survey continued in 1980. In 1994, Walter Fertig and Janet Britt found the population at Little Rapid Creek (#013) (*15082*). Walter Fertig first located the occurrence at Fallen City/Sand Turn (#014) (*18835*) in 1998. During the 2010 surveys, Jim Zier discovered the Dry Fork Ridge population (#021) (*s.n.*); Bonnie Heidel, Bernie Bornong, and Beth Bischoff made the first collection at Hunt Mountain (#018) (*Heidel 3438*); and Bonnie Heidel found the Pole Creek (#020) (*3454*) and Muddy Creek (#019) (*3461*) occurrences.

The first Montana collection was by Richard Prodgers (*s.n.*) at the Spring Creek site (Montana #001) in 1993 (Heidel 1996). In 2001, Amy Taylor discovered four additional sites: Tidwell Draw (Montana #002), Zook Creek (Montana #003), Bull Creek (Montana #004), and South Fork Canyon Creek (Montana #005) (Taylor and Caners 2002).

Historical sites: The type collection by Leslie N. Goodding (*326*) is labeled "Rocky slopes. Head of Middle Fork of Powder R., Big Horn Co., July 19, 1901." However, there are no known

populations that match this locality, or in proximity, either in terms of location or geology. Also, Wyoming county boundaries have changed since the time of collection (B.E. Nelson, pers. comm.) and Goodding's labels from that date variously state Big Horn, Washakie, and Johnson counties for the same locality. One possibility is that this collection was made near the headwaters of the North Fork of the Powder River, outside of Mayoworth, in Johnson County. Ronald L. Hartman collected a specimen "2 mi W of Mayoworth," in 1979 and this location was found to have over 200 plants during the 2010 field season surveys (#009). Goodding's route in 1901 took him near the Mayoworth location and also went through the Barnum area, another likely site for *Physaria didymocarpa* var. *lanata* based on nearness of known populations and geology (B.E. Nelson, pers. comm.).

Unverified/Undocumented reports: None known.

Sites where present status not known: Seven Wyoming occurrences of *Physaria didymocarpa* var. *lanata* that are not on the Bighorn National Forest were not visited in 2010. Five of these sites are on private land. Amsden Creek (#002) was not visited due to distance from other survey areas and was not a priority, while Little Rapid Creek (#013) is a relatively small population that was surveyed in 1994.

Areas surveyed but species not located: USGS topographic map quadrangle quarters in which surveys were conducted and no *Physaria didymocarpa* var. *lanata* was found include: Bald Mountain NE4, Beaver Creek Hills SW4, Beckton NW4, Boyd Ridge NE4, NW4, SE4, and SW4; Brokenback Narrows SE4, Bull Elk Park NE4 and SW4, Burgess Junction SW4, Dayton South SE4 and SW4, Granite Pass SE4, Hidden Tepee Creek NW4, Hunter Mesa NE4, Ice Creek SW4, Klondike Ranch SW4, Lake Solitude SW4, Little Goose Peak NW4, Meadowlark Lake SW4, Mexican Hill NE4, North Ridge NW4, Shell Reservoir NW4, SE4, and SW4; Skull Ridge NW4, Spanish Point NW4, SE4, and SW4; Stone Mountain SE4, and Walker Mountain NE4 (Appendix A).

Physaria didymocarpa var. *lanata* was not found in the interior northern end of the Bighorn Mountains despite numerous surveys in 2010, although there are extensive outcrops of calcium carbonate-rich bedrock formations at this end (Figure 4). This apparent gap in the distribution of *P. didymocarpa* var. *lanata* may reflect particular landforms or bedrock properties. Despite the many cliffs and talus slopes of the interior northern end, there are few areas of intermediate succession, with both soil accumulation and sparse vegetation. The taxon was also not found during concerted surveys in two proposed RNAs, including one in this interior northern end of the Bighorn Mountains (Welp et al. 1998 a, b).

Physaria didymocarpa var. *lanata* is known from one location close to Thunder Basin National Grassland (west of Hilight, #003). However, it was not found in the Grassland during two floristic inventories (Hartman and Dueholm 1979, Ebertowski 2005).

Habitat

In Wyoming, *Physaria didymocarpa* var. *lanata* occurs on shallow, stony soils of exposed limestone, sandstone or shale outcrops; and is typically found on ridges, rims, buttes, and knolls (Figure 5). Montana populations are sometimes found on clinker scoria, as well as the more typical shale, sandstone and calcareous substrates (Taylor and Caner 2002). Its elevation ranges from 1,080 to 3,100 m (3,540 to 10,160 ft) in Wyoming, and is as low as 1,000 m (3,300 ft) in Montana.

Figure 5. *Physaria didymocarpa* var. *lanata* habitat on Duncum Mountain. By Bonnie Heidel.

Physaria didymocarpa var. *lanata* occupies sparsely-vegetated slopes within grasslands, shrublands, and open woodlands (Figures 6 and 7). The closely associated vegetation often has less than 10% cover, typically dominated by bunchgrasses, sometimes with a major cushion plant component. The surrounding vegetation includes usually open stands of *Pinus ponderosa* (ponderosa pine), *Pinus flexilis* (limber pine), *Picea engelmannii* (Engelmann spruce), *Juniperus scopulorum* (Rocky Mountain juniper), *Cercocarpus ledifolius* (curl-leaf mountain mahogany), bunchgrass slopes of *Pseudoroegneria spicata* (bluebunch wheatgrass), or prairie grassland associations (Jensen 2010).

Figure 6. *Physaria didymocarpa* var. *lanata* habitat at Muddy Creek. By Bonnie Heidel.

Figure 7. *Physaria didymocarpa* var. *lanata* habitat on Boyd Ridge. By Stephanie Zier.

Associated species: *Physaria didymocarpa* var. *lanata* is associated with three different suites of species at plains, montane, and subalpine elevations, so that the collective list of associated species is long (Table 3). There are not enough populations with detailed lists of associated species to tell which species are frequently associated rather than occasional or sporadic. Plains associates are not present on Bighorn National Forest. *Dryas octopetala* (eightpetal mountain-avens) and *Silene acaulis* (moss campion), associated species in part of the Hunt Mountain population, are characteristic of alpine habitats.

Table 3. Species associated with *Physaria didymocarpa* var. *lanata*.[7]

Scientific name	**Common name**	**In Bighorn NF habitat?**
Acer glabrum	Rocky Mountain maple	YES
Achillea millefolium	common yarrow	YES
Allium schoenoprasum	wild chives	YES
Antennaria umbrinella	umber pussytoes	YES
Aquilegia jonesii	Jones' columbine	YES
Arenaria hookeri	Hooker's sandwort	YES
Artemisia frigida	prairie sagewort	NO
Artemisia michauxiana	Michaux's wormwood	YES
Astragalus kentrophyta var. *tegetarius*	mat milkvetch	YES
Bromus inermis	smooth brome	NO
Bupleurum americanum	American thorow wax	YES
Calochortus nuttallii	sego lily	NO
Carex elynoides	blackroot sedge	YES
Carex geyeri	Geyer's sedge	YES
Castilleja linariifolia	Wyoming Indian paintbrush	YES
Cerastium arvense	field chickweed	YES
Cerastium beeringianum	Bering chickweed	YES
Cercocarpus ledifolius	curl-leaf mountain mahogany	YES
Clematis columbiana var. *tenuiloba*	rock clematis	YES
Clematis hirsutissima	hairy clematis	YES
Cryptantha celosioides	buttecandle	NO
Cymopterus williamsii	Williams' springparsley	YES
Dactylis glomerata	orchardgrass	YES
Dasiphora fruticosa ssp. *floribunda*	shrubby cinquefoil	YES
Douglasia montana	Rocky Mountain dwarf-primrose	YES
Draba oligosperma	fewseed draba	YES
Dryas octopetala	eightpetal mountain-avens	YES
Erigeron compositus	cutleaf daisy	YES
Erigeron ochroleucus	buff fleabane	YES
Eriogonum pauciflorum	fewflower buckwheat	NO
Eritrichium nanum	arctic alpine forget-me-not	YES
Eurybia glauca	gray aster	YES
Festuca idahoensis	Idaho fescue	YES

[7] Nomenclature follows USDA, NRCS (2011)

Gentiana spp.	gentian	YES
Gutierrezia sarothrae	broom snakeweed	NO
Hedysarum sulphurescens	white sweetvetch	YES
Ipomopsis spicata	spiked ipomopsis	YES
Juniperus scopulorum	Rocky Mountain juniper	YES
Leucocrinum montanum	common starlily	NO
Linum lewisii	Lewis flax	YES
Lithospermum incisum	narrowleaf stoneseed	NO
Lomatium cous	cous biscuitroot	YES
Lupinus argenteus	silvery lupine	YES
Lloydia serotina	common alplily	YES
Machaeranthera grindelioides	rayless tansyaster	NO
Melilotus officinalis	yellow sweetclover	YES
Minuartia nuttallii	Nuttall's sandwort	YES
Oxytropis besseyi	Bessey's locoweed	NO
Oxytropis lagopus	haresfoot locoweed	YES
Packera cana	Woolly groundsel	YES
Pedicularis cystopteridifolia	fernleaved pedicularis	YES
Pedicularis parryi	Parry's lousewort	YES
Penstemon aridus	stiffleaf penstemon	NO
Penstemon glaber	sawsepal penstemon	YES
Penstemon montanus	cordroot beardtongue	YES
Petrophytum caespitosum	mat rockspirea	YES
Phacelia hastata	silverleaf phacelia	YES
Phlox pulvinata	cushion phlox	YES
Physaria curvipes (*Lesquerella alpina*)	alpine bladderpod	YES
Picea engelmannii	Engelmann spruce	YES
Pinus flexilis	limber pine	YES
Pinus ponderosa	ponderosa pine	YES
Poa bulbosa	bulbous bluegrass	YES
Polemonium viscosum	sticky polemonium	YES
Potentilla ovina	sheep cinquefoil	YES
Pseudoroegneria spicata	bluebunch wheatgrass	YES
Psoralidium lanceolatum	lemon scurfpea	NO
Ribes spp.	currant	YES
Rhus trilobata	skunkbush sumac	NO
Schizachyrium scoparium	little bluestem	NO
Sedum lanceolatum	spearleaf stonecrop	YES
Senecio integerrimus	lambstongue ragwort	YES
Silene acaulis	moss campion	YES
Stenotus acaulis	stemless mock goldenweed	NO
Stephanomeria runcinata	desert wirelettuce	NO
Taraxacum officinale	common dandelion	YES
Telesonix heucheriformis	alumroot brookfoam	YES
Tetradymia canescens	spineless horsebrush	NO
Tetraneuris grandiflora	graylocks four-nerve daisy	YES
Thermopsis rhombifolia	prairie thermopsis	YES
Townsendia alpigena	Wyoming Townsend daisy	YES

Trisetum spicatum	spike trisetum	YES
Yucca glauca	soapweed yucca	NO
Zigadenus venenosus	meadow deathcamas	YES

One of the species most consistently found with *Physaria didymocarpa* var. *lanata* in Bighorn National Forest is *P. curvipes* (alpine bladderpod; previously treated under the *Lesquerella alpina* complex). *Physaria curvipes* flowers at the same time as *P. didymocarpa* var. *lanata* and is much more widespread in the Bighorn Mountains. Where they occur together, *P. curvipes* is often more extensive than *P. didymocarpa* var. *lanata* in the same setting.

Associated species of concern: Among rare plants, there is one Wyoming species of special concern that is sometimes found on the same slopes, *Cymopterus williamsii* (Williams' springparsley), at the south end of the Bighorn Mountains (Figure 8). There is partial overlap of *Musineon vaginatum* (sheathed musineon) and *Physaria didymocarpa* var. *lanata* in the Bighorn Mountains, in the same sections or townships, but few places, such as Dry Fork Ridge (#021), where they occupy the same habitat zones.

Figure 8. *Cymopterus williamsii*. By Bonnie Heidel.

Topography: *Physaria didymocarpa* var. *lanata* is usually restricted to topographic breaks and exposed settings where it occupies upper slope positions (Figures 5, 6, and 7). These are most often on south- to west-facing slopes, but are occasionally found to extend onto other aspects and slope positions.

Some *Physaria didymocarpa* var. *lanata* populations in the Medicine Wheel Ranger District are on slopes that are mapped as landslide surface geology. These slopes are prone to shifting or occasionally to slumping. Even in the rockiest settings, *P. didymocarpa* var. *lanata* occupies pockets of soil that accumulate in microsites between talus, rubble or gravel.

Three of the 18 populations in Wyoming are on roadcuts and appear to be persisting. Roadcuts are man-made disturbances that can simulate natural topographic breaks and exposed settings. The net effect of each roadcut on the original local population cannot be determined after the fact, but it warrants mention that one occurrence is only known from habitat destabilized by a roadcut (Fallen City/Sand Turn; #014) and the larger subpopulation has an estimated 1,000-2,000 plants (Table 4), extrapolated from an observation of ca 100 plants below U.S. Highway 14 in 1999 (*Fertig 18835*). There has been highway widening work since this time, and it is possible, but not confirmed, that the habitat has been further destabilized by blasting activity. Another one of the roadside populations is known primarily from habitat destabilized by the roadcut with no more than 10% of the population on intact upper slopes (Mosier Gulch, #011), above U.S. Highway 16. The smallest roadcut population, in extent and population size, is at the highest elevation, where the roadcut spans only part of suitable slopes, and population numbers approach 50% outside the roadcut compared to inside it (Pole Creek, #020), above U.S. Highway 14A. It appears as though these roadcuts did not produce new habitat but crossed existing habitat.

Soil relationships: The soils in *Physaria didymocarpa* var. *lanata* habitat are gravelly and well-drained. They range from entisols, where small pockets of soil accumulate amid scree, to mollisols. Geology dictates over soils and habitat suitability at any given elevation. Soils of populations on the Bighorn National Forest in particular are calcareous and associated with a suite of sedimentary geological formations that include combination of Bighorn Dolomite, Gallatin Limestone, Madison Limestone, Flathead Sandstone, Gros Ventre Formation, and Darby Formation (Love and Christiansen 1985), which exhibit an amount of erosion and decay. All *P. didymocarpa* var. *lanata* populations on Bighorn National Forest are influenced by these formations, being either directly on them or on eroded rocks and soils below them. These calcareous bedrocks once covered the top of the range but were largely eroded away (Lageson and Spearing 1988), except at the east/west perimeter, north end, and south end (outside the Forest boundaries) (Figure 4).

Although the elevation range of *Physaria didymocarpa* var. *lanata* in Wyoming is 1080-3100 m (3,540-10,162 ft) (Table 2), it does not cover the complete elevation gradient in the Bighorn Mountains. The calcareous formations it occupies cover less than 20% of the Forest, and the high-elevation outcrops are generally isolated erosion relicts (Lageson and Spearing 1988). The calcareous formations of the Bighorn Mountains are the major Paleozoic formations within Forest boundaries. Below Forest boundaries, there are a host of additional sedimentary formations that also support *P. didymocarpa* var. *lanata*. These include the Goose Egg, Fort

Union, and possibly the Niobrara and Fox Hills Formations. The presence of *P. didymocarpa* var. *lanata* at the opposite side of the Powder River Basin, in Campbell County, may raise questions about the habitat suitability across the entire Basin. However, this record appears to be at the margin of the Powder River Basin, on a landform derived from the Fort Union Formation rather than the Wasatch Formation that fills the basin center.

Regional climate: The Burgess Junction, Wyoming weather station (481220) provides the most accurate portrayal of the climate in the Bighorn Mountains. According to Western Regional Climate Center (2010) annual data, Burgess Junction has a 50% probability of 40 consecutive days with a daily minimum temperature above 0˚ C (32˚ F), with an annual precipitation of 53.39 cm (21.02 inches). Peak precipitation is usually in April, averaging 6.76 cm (2.66 inches). An estimated 53% of total annual precipitation falls as snow, with an average annual snowfall of 616.71 cm (242.8 inches). The east side of the Bighorn Mountains receives much more precipitation than the west side, which may account for the absence of *Physaria didymocarpa* var. *lanata* in the southwestern part of the Bighorn National Forest.

Local microclimate: *Physaria didymocarpa* var. *lanata* occupies wind-swept habitat with high solar radiation. These conditions are conducive to early snowmelt and early start of the growing season compared to surrounding microhabitats. Despite exposed conditions, the whitish gravelly surface has high albedo and reduces evaporation from underlying soils. Therefore, this seemingly arid microclimate retains subsurface moisture for taprooted perennials such as *P. didymocarpa* var. *lanata.*

Population biology and demography

Phenology: *Physaria didymocarpa* var. *lanata* flowers in May and June. The start of flowering may vary by over four weeks between low elevation and high elevation populations. Peak flowering is concentrated within a two-week period. The fruits dehisce in the middle to late months of the growing season, from late July through September. Within any given population, flower and fruit production are highly synchronous, except where the population or subpopulations are on different aspects.

Population size and condition: The total population of *Physaria didymocarpa* var. *lanata* is estimated to be 19,935 to over 29,955 plants in approximately 725 acres (Table 4). Nearly all of the population size data were collected during the 2010 survey. Individuals of *P. didymocarpa* var. *lanata* are fairly distinct from one another but flowering plants are more visible than vegetative individuals, so these estimates may be somewhat conservative. Also, individuals of *P. didymocarpa* var. *lanata* may be difficult to thoroughly count when scattered among, and obscured by, rocky rubble. The similar flowers of the common associate, *P. curvipes*, can cause some confusion but a quick check of the plants immediately clarifies species identification.

Since the 2010 surveys were baseline data for almost all occurrences of *Physaria didymocarpa* var. *lanata*, trend is unknown. However, most populations were in stable habitat conditions. There were no signs that the habitat is subject to vegetation encroachment. Population numbers might be expected to fluctuate due to annual shifts in weather patterns. It is not clear whether roadcuts that run through three populations increased or decreased available habitat and population numbers when the roads were originally constructed. Otherwise, the taxon does not seem to have lost or gained habitat.

Table 4. Size and extent of *Physaria didymocarpa* var. *lanata* populations

Site name	**Population size**	**Extent ha (ac)**	**Occurrence rank**
Wolf Creek Canyon	unknown	unknown	E – Verified extant (viability not assessed)
Amsden Creek WHMA	unknown	unknown	E – Verified extant (viability not assessed)
West of Hilight	unknown	unknown	E – Verified extant (viability not assessed)
Duncum and Sheep Mountains	4,000-11,250+	76 (187)	A – Excellent estimated viability
Medicine Mountain	300+	9 (22)	B? – Possibly good estimated viability
Whitney Coal Site	unknown	unknown	E – Verified extant (viability not assessed)
Smith Creek	1,000-1,500	6 (14)	B – Good estimated viability
Sayles Creek	200-400	2 (5)	AC – Excellent, good, or fair estimated viability
Mayoworth	220+	4 (11)	AB – Excellent or good estimated viability
Greub Road	unknown	unknown	E – Verified extant (viability not assessed)
Mosier Gulch	620+	3 (7)	BC – Good or fair estimated viability
Crazy Woman Mountain	180-200+	3 (8)	AB – Excellent or good estimated viability
Little Rapid Creek	50	0.4 (1)	BC – Good or fair estimated viability
Fallen City/Sand Turn	1,020-2,020	6 (15)	B – Good estimated viability
Hunt Mountain	5,800+	159 (394)	A – Excellent estimated viability
Muddy Creek	30+	<1 (<1)	C? – Possibly fair estimated viability
Pole Creek	330-380+	8 (21)	BC – Good or fair estimated viability
Dry Fork Ridge	5,000+	8 (19)	A – Excellent estimated viability
Spring Creek	1,000-2,000	4 (9)	unknown
Tidwell Draw	100+	3 (8)	unknown
Zook Creek	50	<1 (<1)	unknown
Bull Creek	16	<1 (<1)	unknown
South Fork Canyon Creek	19	<1 (<1)	unknown
TOTAL	19,935-29,955+	ca 293 (ca 725)	

Reproductive biology

Type of reproduction: *Physaria didymocarpa* var. *lanata* reproduces sexually, by seed. Although rock gardeners propagate the more common *P. didymocarpa* var. *didymocarpa* vegetatively by cutting lateral rosettes (Slabý 2010), there is no indication that caudex branches regularly break apart in nature (Heidel and Handley 2004).

In 2006, the Spring Creek (Montana #001) Coal Company transplanted individuals from an actively mined area to nearby, undisturbed areas not scheduled for mining (Johnson and Prodgers 2009). The following year, seed was harvested from some of the transplants and propagated in a nursery, and the resulting seedlings were outplanted in the fall of 2008. Both the transplants and the seedlings were very successful (Johnson and Prodgers 2009).

Pollination biology: It is unknown whether *Physaria didymocarpa* var. *lanata* is self-compatible or is an obligate outcrossing taxon, as both characters are present in Brassicaceae. *Physaria* has very similar flowers throughout the genus. Generalist pollinators, such as flies and bees, are the most likely pollinators (Rollins and Shaw 1973). During the 2010 surveys, bees of the genera *Bombus* and *Osmia* were observed traveling between flowers of *P. didymocarpa* var. *lanata*. In addition, ants were sometimes observed in the inflorescences, though on the stalks rather than visiting the flowers.

Physaria curvipes, which is much more common and is frequently found with *P. didymocarpa* var. *lanata*, has similar flowers and blooms at the same time. Subsequently, it is possible that pollinators are shared between the two taxa and the presence of *P. curvipes* may increase the number of available pollinators where the two taxa grow together.

Seed dispersal and biology: Each fruit of *Physaria didymocarpa* var. *lanata* produces four to eight seeds; there are several flowers in each raceme and numerous racemes per plant. The seeds themselves are wingless and have no other appendages for wind or animal dispersal. The fruits are not fleshy or otherwise attractive as a food source. However, the inflated pods usually detach with the seeds still inside (Rollins 1993). Therefore, gravity on slopes and wind blowing the pods along the ground is the most likely means of seed dispersal a short distance from the parent plant (Craig and Craig 1996). One area surveyed during 2010 had many plants along the edges of wildlife trails; perhaps the cross-slope trails intercept the seeds' downhill movement and provide suitable microhabitats (Jensen and Heidel pers. comm.).

Population ecology

General summary: *Physaria didymocarpa* var. *lanata* is a polycarpic perennial but little is known about its lifespan. Vegetative rosettes and reproductive plants of different sizes were

Figure 9. Small *Physaria didymocarpa* var. *lanata* plant, possibly 2 years old. By Bonnie Heidel.

Figure 10. Large *Physaria didymocarpa* var. *lanata* plant. By Bonnie Heidel.

seen during the 2010 surveys but it is difficult to determine age or lifespan (Figure 9 and 10). Clusters of leaf sheaths from previous years' growth are visible on some specimens but it is not known how long these clusters persist, or how well they indicate the age of an individual. On rare occasion, diminutive plants were seen in flower that did not seem to have any vestige of basal leaves, suggesting that the taxon can flower within two years time under favorable conditions. The vestiges of basal leaves and girth of the taproot seen on herbarium specimens suggest that long-lived individuals may survive for at least five years if not significantly more. Craig and Craig (1996) observed ages of at least six years in *P. didymocarpa* var. *lyrata*. However, average age of established plants was about three years, with mortality inversely correlated to size of the plant. *Physaria didymocarpa* var. *lyrata* was very susceptible to environmental stresses, such as high or low rainfall growing seasons, and slumping of unstable slopes.

Competition: Vegetation cover in *Physaria didymocarpa* var. *lanata* habitat is usually low and the taxon is absent from adjacent areas of high vegetation cover. This indicates that the taxon requires some abiotic condition associated with barrenness or is not a good competitor. It is not clear whether the habitat is seral as there are few signs of vegetation encroachment. *Physaria didymocarpa* var. *lanata* seems to occupy an edaphic climax community with low competition conditions.

Herbivory: There were no signs of herbivory observed on *Physaria didymocarpa* var. *lanata* during the 2010 surveys or on herbarium specimens. Members of Brassicaceae have mustard-oil glucosides that are defenses against infection of bacteria and fungi, as well as against herbivory by insects and mammals (Mabberley 2008).

Hybridization: Mulligan (1968) was unable to produce interspecific hybrids of *Physaria didymocarpa* with its nine most closely related species. Populations of the other two varieties of *P. didymocarpa* are too geographically separated from var. *lanata* for cross-pollination to occur.

Land ownership

In Wyoming, seven of the 18 occurrences of *Physaria didymocarpa* var. *lanata* are all or partly on the Bighorn National Forest (Table 2). Four occurrences are on the Medicine Wheel Ranger District, two are on the Tongue Ranger District, and one is on the Powder River Ranger District. The Amsden Creek and Bud Love Wildlife Habitat Management Areas have one population each. The Wyoming BLM Buffalo Field Office and the State of Wyoming both have two occurrences, and The Nature Conservancy has a conservation easement on the site of at least one occurrence. The other four occurrences are on private lands.

Montana populations are in the Zook Creek Wilderness Study Area, lands administered by the Montana BLM Miles City Field Office, and on private lands.

ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

Potential threats to currently known populations

Grazing: There is very little grazing in *Physaria didymocarpa* var. *lanata* habitat due to the sparse vegetation cover and often steep, rocky slopes. Indications of trampling were not observed either. Survey in the northern end of the Hunt Mountain population (#018) was conducted in August after sheep had grazed, and there no signs of grazing and trampling affects on *P. didymocarpa* var. *lanata.* Bighorn sheep were observed grazing in habitat on Medicine Mountain (#005) but again, there were no signs that the taxon was disturbed.

Physaria didymocarpa var. *lanata* habitat is usually far from water or other ungulate attractants. Attention to the placement of grazing developments can help to keep grazing and trampling affects away from known populations.

Logging: *Physaria didymocarpa* var. *lanata* usually occurs away from forested areas, out in the open. Opening of forest canopy would most likely have a positive or no affect on *P. didymocarpa* var. *lanata*. Direct mechanical damage from logging equipment would be a threat. Most *P. didymocarpa* var. *lanata* habitat would not support species that are usually seeded post-logging.

Roads: Several *Physaria didymocarpa* var. *lanata* occurrences are at least partially in roadcuts (Mayoworth, #009; Mosier Gulch, #011; Fallen City/Sand Turn, #014; and Pole Creek, #020). Road expansion or other changes to the road banks could impact these populations. Also, herbicide spraying along the road margin, or the possible drift, could be a concern at these sites.

A subpopulation of the Medicine Mountain occurrence (#005) lies beside the road access to the Medicine Wheel National Historic Landmark, connecting the parking lot to the archeological site. Motorized use of Forest Road 12 past the Medicine Wheel National Historic Landmark parking area is restricted to administrative and permitted motorized travel, and is generally very light; the road is also open to pedestrian traffic. The rocky borders of this road get light recreational use.

Weeds: Non-native species are rarely present, but are primarily in those populations or population segments occupying roadcuts. Trace amounts of weedy annuals, such as *Alyssum desertorum* var. *desertorum* (desert madwort), were sometimes present in National Forest populations occupying undisturbed habitat. Noxious weeds were not present in the vicinity,

except for *Cynoglossum officinale* (gypsyflower) in low numbers at the base of a roadcut along U.S. Highway 16 in the Mosier Gulch occurrence (#011).

Fire: There was evidence of a spot fire at the Crazy Woman Mountain occurrence (# 012) but the low vegetation cover in *Physaria didymocarpa* var. *lanata* habitat is unlikely to allow a fire to carry.

Other: Limestone quarrying is possible in some *Physaria didymocarpa* var. *lanata* habitat. There is an abandoned quarry site along the Sheep Mountain Road (#004), where *P. didymocarpa* var. *lanata* was surveyed but not found. The quarried habitat resembles some characteristics of occupied habitat nearby. The development of any new sources for road surfacing material could potentially affect the taxon.

The first occurrence discovered in Montana (Spring Creek, Montana #001) was discovered in a coal mine site, as was the Whitney Coal Site occurrence (#006) in Wyoming. The Little Rapid Creek occurrence (#013) is adjacent to a pack trail and trampling by horses or hikers may occur.

Management practices and response

There have been no studies of management practices and associated responses involving *Physaria didymocarpa* var. *lanata*. It would be insightful to document before-and-after conditions for any new management actions implemented in occupied habitat (e.g. road margin changes or grazing developments). Even more so, it would be insightful to set up a study with a control plot containing a portion of the population that is excluded from treatment.

Conservation recommendations

Recommendations regarding present or anticipated activities: The interpretation of the taxon's susceptibility to road margin alterations may warrant further evaluation with regard to current road maintenance and modification practices. Information on locations of known populations and potential habitat near roads should be provided to weed management personnel, including County Weed and Pest districts and other contractors. This information should also be shared with local Wyoming Department of Transportation personnel for construction and reconstruction projects, and for annual maintenance activities such as ditch cleaning.

Notification of U.S. Forest Service personnel of locations on National Forest: To prevent inadvertent impacts to known populations, all appropriate USFS personnel involved in planning and on-the-ground land management activities, including grazing, weed control, prescribed burn and logging, should be provided with location data for *Physaria didymocarpa* var. *lanata*. Toward this end, the updated Forest Service species evaluation (Appendix C) and state species

abstract (Appendix D) are provided as part of project products, accompanied by GIS files of all currently known occurrences.

Status recommendations

Physaria didymocarpa var. *lanata* is a rare regional endemic that is designated sensitive by the USFS Rocky Mountain Region (USDA Forest Service 2009). It appears to be a habitat specialist within the landscape. 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.

The relatively short life history of the taxon and generally local seed dispersal make 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 five occurrences of *P. didymocarpa* var. *lanata* in Wyoming that are known to have numbers in this range, four of which are on the Bighorn National Forest.

There is no direct evidence to suggest that occurrences of *Physaria didymocarpa* var. *lanata* are at risk on the Bighorn National Forest or in Wyoming.

Summary

Concerted 2010 surveys produced much new information about *Physaria didymocarpa var. lanata* distribution patterns, habitat, population estimates, threats, and area of occupancy. However, there are no expansions in range extent and only modest increases in numbers of occurrences. Thus, it is recommended that known distribution continue to be referenced for management and planning purposes.

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