Physaria saximontana Rollins var. *saximontana* (Fremont County twinpod): A Technical Conservation Assessment

Prepared for the USDA Forest Service,
Rocky Mountain Region,
Species Conservation Project

June 22, 2004

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Peer Review Administered by
Center for Plant Conservation

Glisson, B. (2004, June 22). *Physaria saximontana* Rollins var. *saximontana* (Fremont County twinpod): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/physariasaximontanavarsaximontana.pdf [date of access].

Acknowledgements

This research was facilitated by the timely assistance and willingness to share information of many experts. Information provided by the Wyoming Natural Diversity Database (WYNDD) formed the cornerstone of this document, and I would especially like to thank Bonnie Heidel and Tessa Dutcher for their efforts in providing Element Occurrence Records and internal natural heritage program reports. I would also like to acknowledge the use of photos and drawings extracted from earlier WYNDD reports, in particular the photos of Charmaine Refsdal and Walt Fertig, and the drawings of Walt Fertig and Robin Jones. I would like to thank Ron Hartman and other personnel at the Rocky Mountain Herbarium for providing herbarium records and excerpts of relevant student research conducted at the University of Wyoming. Jeff Carroll of Wyoming BLM provided valuable information regarding distribution and threats on BLM lands. Bob Budd provided valuable input regarding populations on The Nature Conservancy's Red Canyon Ranch Preserve. Walt Fertig (formerly of WYNDD, now with BLM Grand Staircase-Escalante National Monument) was very helpful in providing recent distribution modeling information and discussing the species' ecology. I would like to acknowledge other Species Conservation Project assessment authors who made copies of their draft assessments available for review during preparation of this document. In particular, Dr. Juanita Ladyman's and David Anderson's drafts were extremely helpful. I would like to thank the independent reviewers for their comments and direction. Finally, I would like to thank Beth Burkhart, USFS Region 2, for her timely, impartial reviews and even-handed management of this project.

Author's Biography

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Cover Photo Credit

Physaria saximontana Rollins var. *saximontana* (Fremont County twinpod) photo taken by Walt Fertig. Used with permission.

Summary of Key Components for Conservation of *Physaria saximontana* var. *saximontana*

Status

Physaria saximontana var. *saximontana* (Fremont County twinpod) is a rare plant taxon endemic to west-central Wyoming, including portions of the Shoshone National Forest. It presently has no federal status under the Endangered Species Act or in Region 2 of the USDA Forest Service, but it is listed as a sensitive species by the Bureau of Land Management in Wyoming. NatureServe ranks *P. saximontana* var. *saximontana* G3T2, "imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range)". It is considered imperiled (S2) by the Wyoming Natural Diversity Database.

Rangewide threats are mainly potential climate change and environmental stochasticity. Human-related threats are generally low due to the taxon's occurrence in relatively remote, rugged terrain that is not regularly accessed, coupled with a relatively low-to-moderate potential for natural resource extraction within its known habitat. *Physaria saximontana* var. *saximontana* may be vulnerable to impacts from a variety of anthropogenic threats, primarily off-road vehicle use, non-motorized recreational activities such as hiking, livestock grazing, disturbance from road construction, and residential, oil, gas, or mineral development. While these threats are currently low, they may become more serious if management policies change or levels of use increase. Invasive weeds do not appear to pose a threat at present. Management-related threats to USDA Forest Service occurrences in Region 2, which are restricted to the Shoshone National Forest, are generally low but include oil, gas, and mining activities and associated road construction, livestock trampling, and non-motorized recreational activities such as hiking. This taxon is thought to have a naturally limited range and is not known to have suffered significant population or habitat loss as a result of human activities. The taxon's rareness is likely due in part to discontinuous habitat availability across a narrow geographic range, which is also responsible for its inherent ecological and geographic vulnerability. Due to the species isolation, human activities that affect the quality and quantity of the habitat of individual populations of *P. saximontana* var. *saximontana* could also adversely impact the long-term survival of this species.

There is much about this taxon's distribution, basic biology, and environmental requirements that is unknown at present. To achieve more effective management and identify appropriate intervention measures, a conservation approach would aim to identify and preserve habitat, avoid impacts to known populations (i.e., minimize surface disturbance, maintain important habitat microenvironmental conditions), and identify ongoing research needed to provide a better understanding of population trends, life histories, reproductive ecology, autecology, etc., with the goal of more effective management and identification of appropriate intervention measures, if any exist. Primary conservation elements, management implications and considerations are related to the inherent risks to small populations and narrow distribution associated with a naturally rare endemic taxon. USDA Forest Service management considerations include assessing the need for designation as a sensitive species, preserving and resurveying known populations, surveying additional potential habitat areas, monitoring existing populations to collect trend-line data, conducting pre-project surveys, and initiating basic demography studies.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS), Rocky Mountain Region (Region 2). *Physaria saximontana* var. *saximontana* is the focus of an assessment because it is a rare taxon that is known to occur on forests in Region 2. Within the National Forest System, a sensitive species is a plant or animal 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 a species distribution (FSM 2670.5 (19)). A sensitive species may require special management so knowledge of its biology and ecology is critical. Although *P. saximontana* var. *saximontana* presently has no formal status within the National Forest System (i.e., it is not a sensitive species or a Management Indicator Species), it may be considered for such designation in the future as these lists are updated (Kratz personal communication 2003).

This assessment addresses the biology of *Physaria saximontana* var. *saximontana* throughout its range in Region 2, which is restricted to west-central Wyoming. This introduction defines the goal of this 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 a thorough discussion of the biology, ecology, conservation status, and management of certain species, based on available scientific knowledge. 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 relevant management recommendations proposed elsewhere for two closely related species in the mustard family that are federally listed as Threatened, *Physaria obcordata* and *Lesquerella congesta* (now *P. congesta*) (U.S. Fish and Wildlife Service 1990, 1993a, 1999).

Scope

The *Physaria saximontana* var. *saximontana* assessment examines the biology, ecology, conservations status, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *P. saximontana* var. *saximontana* in the context of the current environment rather than under historical conditions.

In producing the assessment, all available information was reviewed including refereed literature, non-refereed publications, research reports, personal communications, and data accumulated by state natural heritage programs and resource management agencies. The assessment emphasizes refereed literature to the extent possible because this is the accepted standard in science. However, refereed literature pertaining specifically to this taxon is limited to two publications, which provide taxonomic descriptions and generalized discussions of its distribution range. As a result, the use of non-refereed literature, mainly herbarium records and natural heritage program data and reports, was essential in developing this assessment, particularly in estimating the species' geographic distribution and assessing its habitat characteristics. Such a heavy reliance on natural heritage program data and reports and on personal communications could be considered a potential limitation of this assessment. However, the Wyoming Natural Diversity Database botanists responsible for the data collection and management over the years are very experienced and highly regarded in the field. Furthermore, most of the element occurrences are documented with voucher specimens.

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 for 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. These scientific tools are to be used in concert with the most complete species status data to produce a robust analysis. The data and analyses presented in this assessment on *Physaria saximontana* var. *saximontana* in the Rocky Mountain Region address all information and records produced as documentation of its distribution and biology. The strength of evidence for particular interpretations or ideas is noted, and alternative explanations are described when appropriate.

The biggest challenge encountered in developing this assessment was the complete lack of refereed literature pertaining to the specific biology and ecology of *Physaria saximontana* var. *saximontana*. The discussion of these topics in this document is mostly derived from natural heritage program data and reports as well as inferential information adapted from the generic level (i.e., *Physaria*). Additionally, much of the discussion relating to threats and management issues was derived from personal communication with knowledgeable individuals from the land management agencies, The Nature Conservancy, and the Wyoming Natural Diversity Database (WYNDD).

Publication of Assessment on the World Wide Web

To facilitate their use in the Species Conservation Project, species assessments are being published on the 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 their release on the Web. This report 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 saximontana var. *saximontana* has no special status (i.e., sensitive species or Management Indicator Species) in USFS Region 2 (Kratz personal communication 2003). It is listed as a sensitive species in Wyoming by the Bureau of Land Management (BLM) (Bureau of Land Management 2001a, Carroll personal communication 2003). NatureServe (2003) considers *P. saximontana* var. *saximontana* to be "imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range)" (G3T2). It is considered imperiled (S2) by the Wyoming Natural Diversity Database (WYNDD) (Wyoming Natural Diversity Database 2003a). These rankings are assigned in part because the plant is only known from 21 element occurrences, all of which are restricted to the eastern and northern slopes and adjacent basins of the Wind River and Absaroka mountains of Wyoming (Wyoming Natural Diversity Database 2003a).

Physaria saximontana var. *saximontana* is not listed as Threatened or Endangered on the Federal Endangered Species List, but it was formerly listed as a Category 2 (C2) Candidate for listing under the Endangered Species Act (U.S. Fish and Wildlife Service 1993b). The C2 list included taxa that might have warranted listing as Threatened or Endangered, but for which appropriate or substantial biological information was not on file to support immediate rulemaking. The C2 program was eliminated in 1996 (U.S. Fish and Wildlife Service 1996).

Two of the 21 known occurrences of *Physaria saximontana* var. *saximontana* are located in areas managed for multiple use on the Shoshone National Forest, in the Wind River Range in Fremont County, Wyoming (Fertig 1998, Wyoming Natural Diversity Database 2003b). Nine occurrences of this taxon are located on lands managed for multiple use by the BLM Lander and Worland Field Offices; two additional BLM occurrences are on special management areas in the Beaver Rim and Red Canyon Areas of Critical Environmental Concern (ACEC). One occurrence is on the Red Canyon Ranch Preserve, which is managed

by The Nature Conservancy. Three occurrences are on the Wind River Indian Reservation. One occurrence is on land managed by the State of Wyoming, and three occurrences are on private lands (Fertig 1992, 1995, 1997, 1998; Mills and Fertig 2000; University of Wyoming 1998; Welp 1997; Welp et al. 1996, 2000; Wyoming Natural Diversity Database 2003a, 2003b).

To date, several species of *Physaria* (including former *Lesquerella*) have been federally listed. These include *P. obcordata* and *L. congesta* (now *P. congesta*), narrow geologic endemics of the Piceance Basin in Colorado (U.S. Fish and Wildlife Service 1990, 1993a, 1999). Information pertaining to the biology of these species is minimal and was of limited use in preparing this species assessment, although suggested management approaches from the recovery plans for these species were applicable to this assessment.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Physaria saximontana var. *saximontana* is not listed as Threatened or Endangered in accordance with the Endangered Species Act. Therefore, there are no federal laws concerned directly with its conservation. It also has no formal status designated by Region 2 of the USFS, the only known area of its occurrence on National Forest System lands. As a BLM-listed sensitive species for Wyoming, *P. saximontana* var. *saximontana* is provided some limited benefits by the BLM in terms of inventories, monitoring, and information exchange, and the taxon is considered in land use planning, National Environmental Policy Act analysis, and application of "best practices" (Bureau of Land Management 2001b). The BLM does not have a specific management plan or conservation strategy for *P. saximontana* var. *saximontana*. Several populations of *P. saximontana* var. *saximontana* are afforded a higher level of protection by virtue of their location within areas emphasizing management for biological or botanical resources. Two occurrences are within the Beaver Rim and Red Canyon ACEC's (Bureau of Land Management 1987); however, the ACEC's were not specifically established to manage for *P. saximontana* var. *saximontana*. Another population is partially within the Red Canyon Ranch Preserve, which is managed by The Nature Conservancy.

Physaria saximontana var. *saximontana* has no specific legal protection that prevents destruction of individuals or habitat. As of this writing, no conservation strategy has been written for this species at a national level by the USFS or any other federal agency. There have been no known instances in which an occurrence of *P. saximontana* var. *saximontana* was extirpated as a result of human activities or failure to enforce any existing regulations. However, this does not necessarily indicate that current regulations or their enforcement are adequate for on-going protection of this taxon.

Biology and Ecology

Observational information provided the basis for most of the biology, habitat, and life history discussions contained herein. Experimental data was restricted to phylogenetic analysis in support of taxonomy, and even that was directed mainly at the generic level and very limited for this particular taxon.

Classification and description

Physaria saximontana var. *saximontana* is a member of the large, cosmopolitan mustard family (Brassicaceae), which includes approximately 350 to 381 genera and 3,000 species mostly distributed in the northern temperate zones (Walters and Keil 1996). Many of these are herbs or shrubs of significant agricultural and economical importance, such as cabbage, cauliflower, broccoli, kohlrabi, kale, brussel sprouts, radish, and horseradish (Walters and Keil 1996). The seeds of *Brassica nigra*, *B. juncea*, and other species are used to prepare mustard. Rapeseed and other mustard oils have industrial uses, while Canola oil (an edible form of rapeseed oil) is used for human consumption (Walters and Keil 1996). Various mustards are planted as ornamentals, some annual and biennial forms are aggressive and weedy, and the foliage and seeds of some species are poisonous to livestock (Walters and Keil 1996).

The Brassicaceae is characterized by a 4-merous perianth with the petals arranged in the form of a cross (giving rise to the alternate family name of Cruciferae, or cross-bearer). Other typical features include alternate leaves with branched or stellate hairs, tetradynamous stamens, a 2-carpellate superior ovary with parietal placentation, a membranous septum or replum that divides the ovary into two locules, and peculiar capsular fruits termed siliques (long and slender) or silicles (fruit is only twice as long as wide or less) (Walters and Keil 1996).

The Brassicaceae family is in the class Magnoliopsida and subclass Dilleniidae (Walters and Keil 1996; ITIS 2003; NRCS 2003). Systematic studies of Brassicaceae have historically focused

on morphological variation of the silique/silicle, a fruit that is unique to the genus. The classical view of Brassicaceae has been changing as molecular systematics reveals new insights to evolutionary relationships. Recent phylogenetic analyses of ribosomal DNA and chloroplast genomes, combined with analyses of gene sequences and morphological data, place the Brassicaceae in a monophyletic order, Brassicales (O'Kane 2002). All of the Brassicales produce sulfur-containing compounds known as glucosinolates (O'Kane 2002). The Brassicales is placed within a larger monophyletic group often referred to as the Eurosids II that includes such families as the Malvaceae, Onagraceae, Anacardiaceae, and Sapindaceae (O'Kane 2002).

The genus *Lesquerella* has recently been united with the earlier published *Physaria*, following an unsuccessful attempt to preserve the more speciose *Lesquerella* (Al-Shehbaz and O'Kane 2002). As previously circumscribed, the genus *Physaria* was polyphyletic, while *Lesquerella* was paraphyletic. The much-expanded *Physaria* resolves a long-standing taxonomic division along a continuum of intergrading characteristics between the two genera that has historically been recognized as somewhat arbitrary (Rollins and Shaw 1973). This new, larger, monophyletic *Physaria* is characterized by 1) stem leaves that are attenuate or cuneate to a petiole-like base, 2) a perennial life form, although some have reverted to biannual and rarely annual life durations from perennial ancestors, 3) chromosome numbers based on n = 4, 5, 6, or 7 (with a few polyploids derived from these numbers), 4) stellate to stellate-peltate (often webbed between the rays) trichomes, nearly always tuberculate, and 5) no documented interspecific hybridization (Al-Shehbaz and O'Kane 2002).

Physaria is one of five genera with four to ten colpate pollen grains in contrast to all other genera in the Brassicaceae which are tricolpate (Al-Shehbaz and O'Kane 2002). Much of the previous literature pertaining to the life history and autecology of the larger, more heavily investigated former genus *Lesquerella* has been applied to *Physaria* for preparation of this document. The newly circumscribed genus *Physaria* is almost exclusively known from North America, with several species occurring in South America, and one species extending into Greenland and Arctic Russia (Al-Shehbaz and O'Kane 2002). Of the 22 species previously recognized in *Physaria*, 19 were known to occur in Utah, Wyoming, or Colorado (Al-Shehbaz and O'Kane 2002).

The first specimen of *Physaria saximontana* var. *saximontana* was collected in 1946 by M. C. Wiegand. However, it was not officially recognized as a new taxon until 1984, when it was described by Rollins (Rollins 1984) [*P. saximontana* var. *saximontana* Rollins, Contributions from the Gray Herbarium 214: 13. 1984. TYPE. U.S.A.: Wyoming, Fremont Co., Lander, *Rollins & Rollins 81374*, 20 June 1981.] Weigand's specimen was originally identified as *P. australis* by R. T. Clausen of Cornell University, but it was annotated by Robert Dorn in 1986 (Hartman personal communication 2003a). Although Wiegand's original collection location was not precisely noted, it is thought to be from the same location as Rollins' type collections (i.e., Element Occurrence Record (EOR) 004, Red Canyon Rim) (Wyoming Natural Diversity Database 2003a).

The holotype for this taxon is in the Gray Herbarium at Harvard University, while the Rocky Mountain Herbarium in Laramie, Wyoming houses an isotype and a paratype (C. L. Porter 5727) (Hartman personal communication 2003, Wyoming Natural Diversity Database 2003a).

Dorn (2001) recognizes 10 species of *Physaria* in Wyoming, two of which are recognized at the varietal level. Since only one variety of *P. saximontana* occurs in Wyoming and it is the type variety, Dorn does not mention the varietal level distinction.

Physaria saximontana var. *saximontana* is a tap-rooted, perennial herb with a basal rosette of mostly entire, spoon-shaped or rounded, hairy, grey-green, long-petioled leaves (Rollins 1984, Fertig 1992, Mills and Fertig 2000). Herbage is silvery pubescent throughout, with a dense cover of stellate trichomes (Rollins 1984, Fertig 1992). Flowering stems are usually prostrate to decumbent with small, linear leaves (Fertig 1992, Mills and Fertig 2000). The leaf surfaces are densely covered by appressed, stellate hairs or trichomes (Fertig 1992, Mills and Fertig 2000). Flowers are yellow with four petals, 8 to 10 mm long. Mature fruits are grey-hairy, inflated, and deeply notched at the top, but not at the base. The inflated fruits appear to be composed of two fused pods, which are actually halves of a single fruit and contain the seeds (Rollins 1984, Fertig 1992). The replum dividing each half of the fruit is oval with two stubby stalks (funiculi) on each face (Rollins 1939, Rollins 1984, Fertig 1992, Fertig et al. 1994, Fertig 1995, Mills and Fertig 2000). The replum and funiculi are best observed on plants that have already lost their fruit (Fertig 1992). The seeds are

oval to broadly oblong, wingless, slightly compressed, smooth, approximately 3 mm long, and approximately 2 mm wide (Rollins 1984, Fertig 1992). **Figure 1** and **Figure 2** are an illustration and close-up photograph, respectively, of *P. saximontana* var. *saximontana*.

Species within *Physaria* are taxonomically distinguished on the basis of multiple features. Primitive characteristics in the genus include large siliques, large number of ovules dispersed almost entirely around the replum, and simple trichomes (Rollins and Shaw 1973). *Physaria saximontana* var. *saximontana* generally exhibits advanced evolutionary characteristics such as small siliques, differentiated trichomes, and fewer ovules that are situated in the upper-replum area.

As Fertig (1992) notes, the species of *Physaria* are notoriously difficult to distinguish in the field and in the herbarium since morphological differences between species are often weak and intergradations typically occur. Similar species that may co-occur with *P. saximontana* var. *saximontana* include *P. didymocarpa* and *P. acutifolia*. *Physaria didymocarpa* has longer leaves and three or more funiculi on each face of the partition, and it tends to occur in canyon bottoms rather than on ridgetops and slopes. *Physaria acutifolia* has a linear replum and fruits that are equally lobed above and below (Fertig 1992, Fertig et al. 1994, Mills and Fertig 2000) in contrast to *P. saximontana* var. *saximontana* which has a broad partition attached near the base of the fruit and unequally lobed fruit with the upper division much deeper than the lower one. Fertig (1992) also notes that mature fruit are essential for correct identification of this species **Figure 3** illustrates distinguishing characteristics of the fruits of *P. saximontana* var. *saximontana* and these similar taxa known from the area (i.e., *P. didymocarpa* and *P. acutifolia*).

Distribution and abundance

Physaria saximontana is known from the Wind River Basin and the southern Big Horn Basin in Wyoming and from north-central and south-central Montana. Wyoming populations belong to var. *saximontana*, while all known Montana populations are classified as var. *dentata* (Rollins 1984, 1993; Fertig 1992). *Physaria saximontana* var. *saximontana* is a local endemic with its global distribution limited to west-central Wyoming in USFS Region 2. It is known from 21 extant occurrences in Wyoming, 15 of which have been relocated or discovered since 1990 (**Table 1**, **Figure 4** and **Figure 5**; Roderick et al. 1999, Rocky Mountain Herbarium 2003, Wyoming Natural Diversity Database 2003a, 2003b, 2003c). There are no major

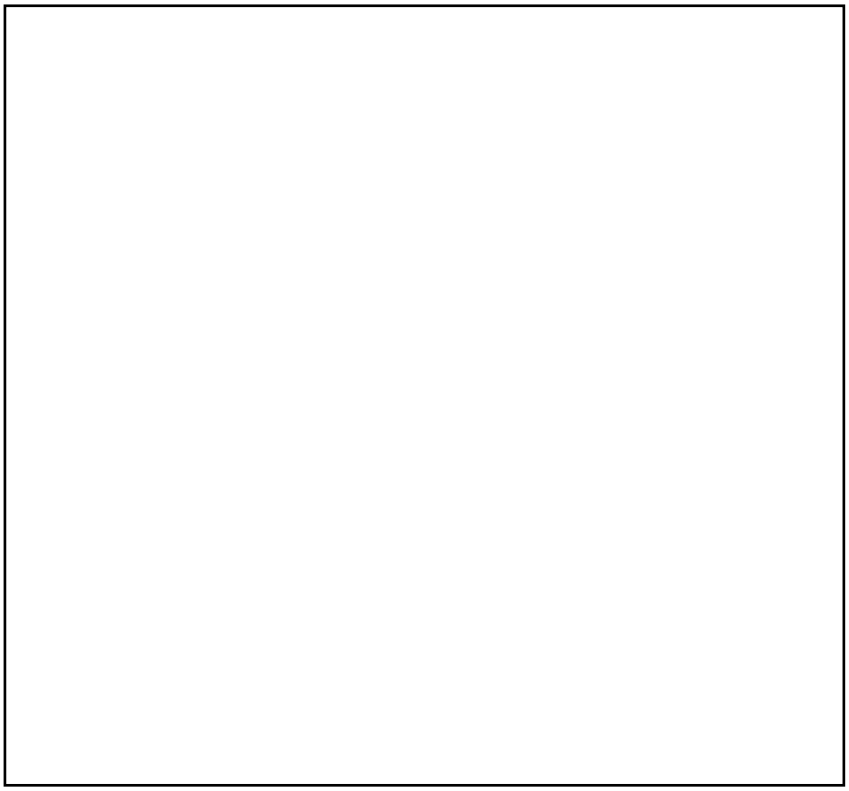


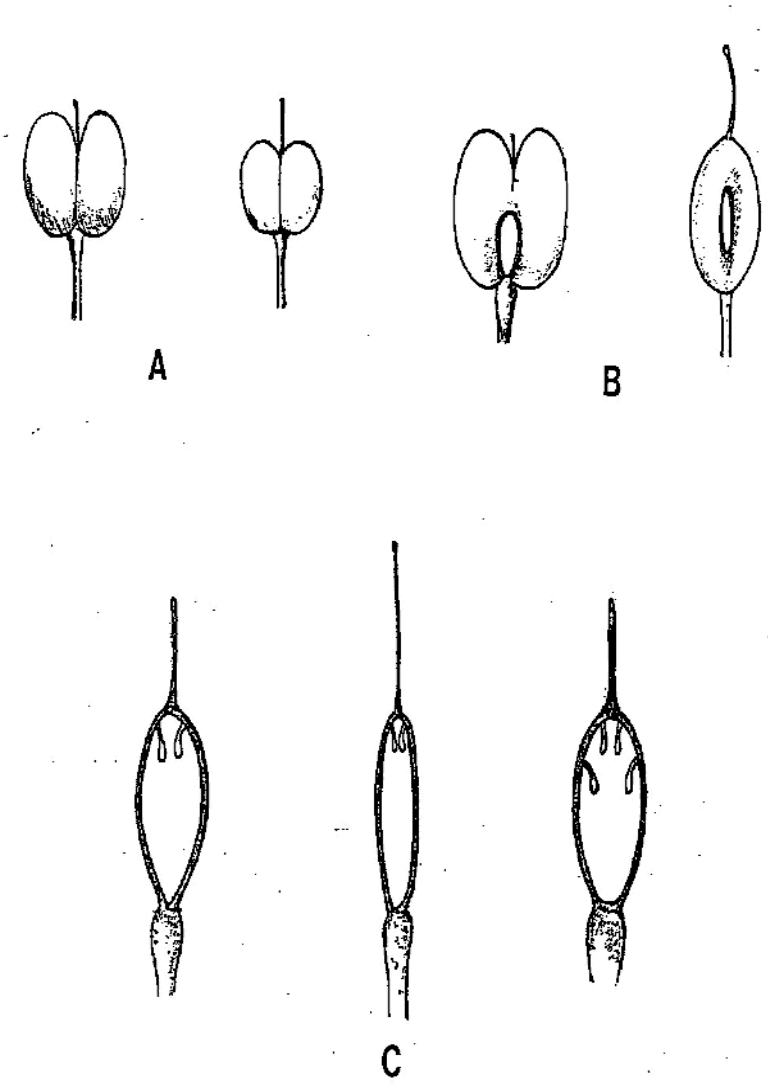
Figure 1. Illustration of *Physaria saximontana* var. *saximontana* by Robin Jones, from Fertig et al. 1994.

Figure 2. Closeup of *Physaria saximontana* var. *saximontana* by Charmaine Refsdal, from Fertig et al. 1994.

geographic barriers to the distribution of the species within its relatively narrow range, although geographic barriers such as the Wind River Mountains likely define the boundaries of its range.

The bulk of the known occurrences and the largest reported populations of *Physaria saximontana* var. *saximontana* are known from lands not administered by USFS in the southern Bighorn Basin and the Wind River Basin, and in the foothills of the Wind River and Absaroka ranges in Fremont, Hot Springs, and Carbon counties. Two occurrences of this taxon are known from the Shoshone National Forest, in the Wind River Range in Fremont County, Wyoming (Fertig 1998, Wyoming Natural Diversity Database 2003b). These populations are located along the western edge of the taxon's range. Twelve occurrences are reported from BLM lands, although three (EOR's 002, 012, and 020) may represent a single extended population (Wyoming Natural Diversity Database 2003b). Two of the BLM populations are situated entirely or partially in the Beaver Rim and Red Canyon ACEC's, and several may extend onto adjacent State of Wyoming or private lands (Wyoming Natural Diversity Database 2003b). Three populations are reported on the Wind River Indian Reservation, three populations are entirely on private lands, and one population is on land managed by the State of Wyoming (Wyoming Natural Diversity Database 2003b). *Physaria saximontana* var. *saximontana* was recently reported in northwest Carbon County by Roderick et al. (1999), but no EOR has been filed for this population (Rocky Mountain Herbarium 2003, Wyoming Natural Diversity Database 2003b).

The total number of individual *Physaria saximontana* var. *saximontana* plants, based on the 10 EOR's that include numerical estimates of population size, is greater than 14,400 (Wyoming Natural Diversity



A. Fruit of P. saximontana var. saximontana (left) and P. acutifolia (right).

B. (Left) fruit of Physaria saximontana with tissue removed to expose the elliptical orifice, located at the base of the fruit. (Right) similar view of P. acutifolia showing linear orifice located at middle of fruit.

C. Replum with persistent funiculi, (left) P. saximontana, (middle) P. acutifolia, (right) P. didymocarpa.

Figure 3. Characters of *Physaria* species (Fertig 1992).

Table 1. Selected distribution and abundance information from Element Occurrence Records for *Physaria saximontana* var. *saximontana*. The table does not include the reported but unconfirmed occurrence from Carbon County, WY. Bolded = USFS Region 2 occurrence.

Element Occurrence Record No.	Ownership	Location/(County)	Estimated Population Size	Estimated Population Extent in Acres	Date Last Observed	Threats
001	Bureau of Land Management (BLM), Beaver Rim Area of Critical Environmental Concern (ACEC)	Beaver Rim/(Fremont)	locally common, but widely scattered along rim	approximately 9,000	6/13/94	low
002; may be confluent with EOR's 012 and 020	BLM	Sheep Mountain/ (Fremont)	locally common (ca. 100 plants in one colony)	three small colonies	8/1/95	unknown
003	Private	West of Little Popo Agie River/(Fremont)	unknown	unknown	5/28/81	unknown
004	BLM, Red Canyon ACEC and private	Red Canyon Rim/ (Fremont)	large occurrence; > 10,000 plants, probably a conservative number; seedlings observed to be numerous at some sheltered sites; additional habitat may be present in vicinity	180	6/6/95	low - population on BLM's Red Canyon ACEC and The Nature Conservancy's Red Canyon Preserve
005	Wind River Indian Reservation	Crow Mountain/ (Fremont)	unknown	unknown	7/9/81	unknown
006	**Shoshone National Forest, Wind River Ranger District – may extend onto adjacent lands managed by State of Wyoming**	**Torrey Rim - Trail Lake/(Fremont)**	**500 to 700 – good age structure and reproduction; plants often in clusters of 5 to 15 individuals, with individual clusters widely spaced**	**2 to 3**	**6/14/96**	**low, but near trailhead; active grazing allotment**
007	Wind River Indian Reservation	Whiskey River Basin – Winchester Butte/ (Fremont)	unknown	unknown	7/22/83	unknown
008	Wind River Indian Reservation	Crowheart Butte/ (Fremont)	unknown	unknown	6/22/81	unknown
010	BLM – Grass Creek Resource Area	South Fork Owl Creek/ (Hot Springs)	unknown	unknown	8/24/91	unknown
011	Private	Little Popo Agie River valley – Dry Lake/ (Fremont)	unknown	unknown	6/16/89	unknown

Table 1 (concluded).

Element Occurrence Record No.	Ownership	Location/(County)	Estimated Population Size	Estimated Population Extent in Acres	Date Last Observed	Threats
012; may be confluent with EOR's 002 and 020	BLM	Western Wind River Basin – Cedar Ridge/ (Fremont)	unknown	unknown	7/1/91	unknown
013	Private	Western Wind River Basin – Twin Creek/ (Fremont)	unknown	unknown	6/12/91	unknown
014	BLM – Grass Creek Resource Area	Anchor Reservoir – 35 mile west-northwest of Thermopolis, Absaroka foothills/(Hot Springs)	approximately 650 – total of three subpopulations, ranging from <10 to >300 plants	unknown	7/4/92	secure site from grazing due to steep terrain
015	BLM - Grass Creek Resource Area, and State of Wyoming	Grass Creek – Adam Weiss Peak, Absaroka foothills/(Hot Springs)	ca. 300 total, in clusters of six to eight plants– replaced by *P. acutifolia* at base of slope	two to three	7/9/92	relatively secure from grazing due to rugged habitat, adjacent road not a threat
016	BLM – Grass Creek Resource Area	Twin Buttes, Absaroka foothills/(Hot Springs)	< 150 – replaced by *P. acutifolia* at base of slope	unknown	7/10/92	relatively secure
017	State of Wyoming – next to BLM	Grass Creek – Sanford Creek/(Hot Springs)	ca. 75	small	7/11/92	potential threat from development and nearby timber sale
018	BLM – Grass Creek Resource Area	Southern Bighorn Basin – Wagonhound Creek/ (Hot Springs)	unknown	unknown	6/16/83	unknown
019	**Shoshone National Forest, Washakie Ranger District**	**Fossil Hill - southern Wind River Range/ (Fremont)**	**ca. 10 - small population, but maybe more extensive (on south slope), but Physaria were too young to positively determine species**	**unknown**	**6/29/95**	**active cattle allotment**
020; may be confluent with EOR's 002 and 012	BLM and private	Wind River Basin – Beaver Rim/(Fremont)	> 2000, moderately large	40 to 50	6/30/95	unknown
021	BLM	Wind River Basin – Sweetwater Plateau/ (Fremont)	250 to 400 – medium sized, total of two subpopulations	3 to 5	7/12/97	livestock grazing and uranium strip-mine in vicinity
022	BLM – Grass Creek Resource Area	Bighorn Basin – Blueberry Rim/(Hot Springs)	unknown	unknown	7/1/98	7/1/98

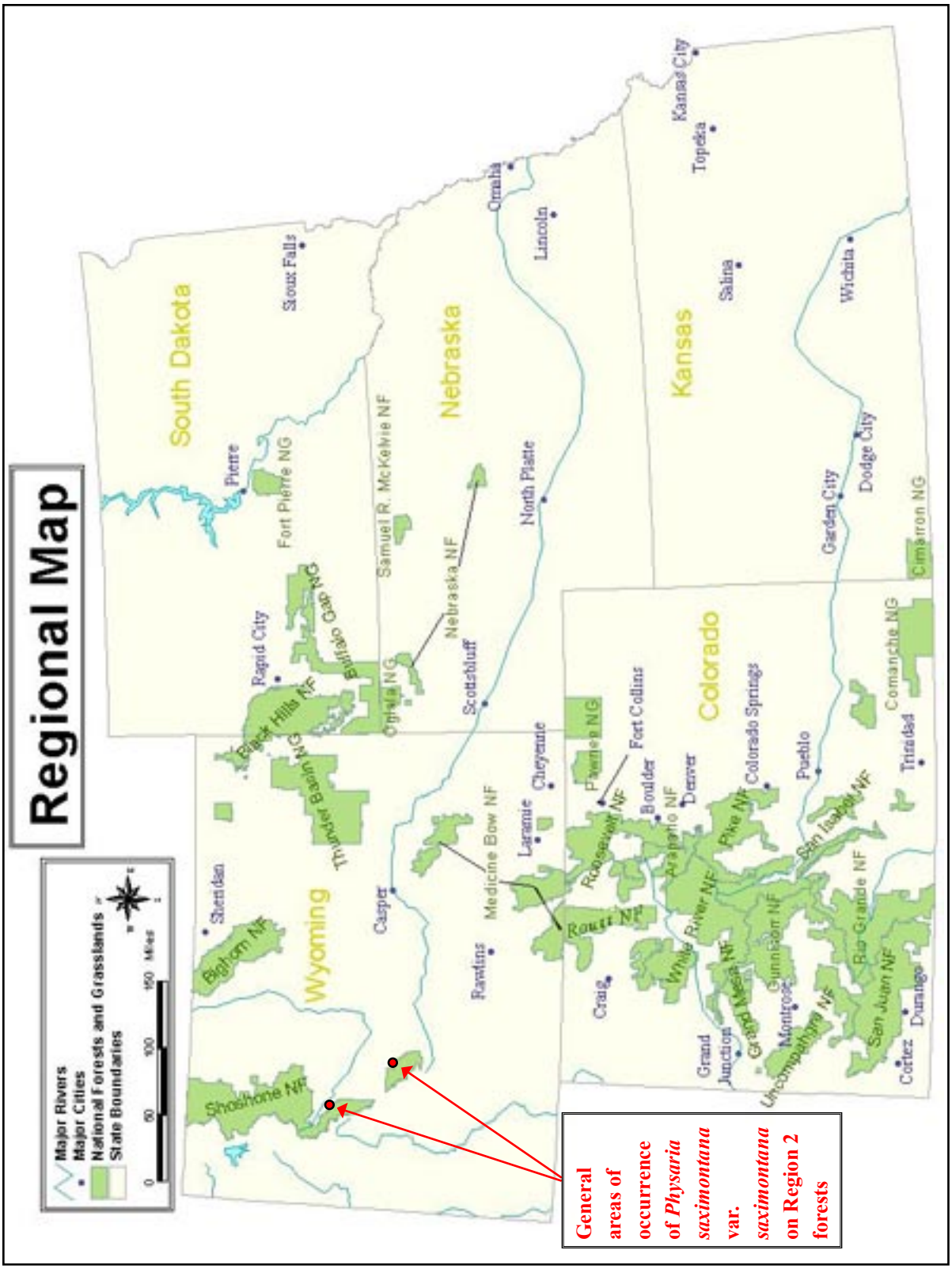


Figure 4. Map of USDA Forest Service Region 2 and occurrence areas of *Physaria saximontana* var. *saximontana*.

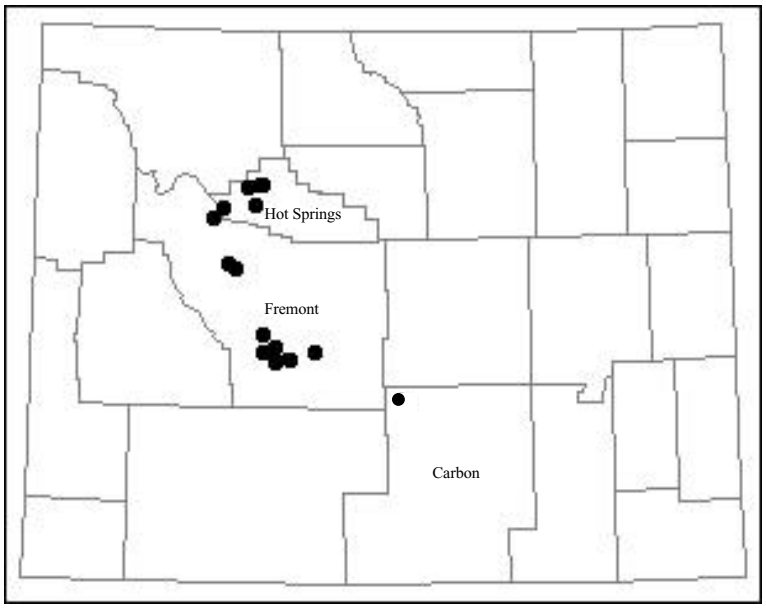


Figure 5. Distribution of *Physaria saximontana* var. *saximontana* in the state of Wyoming, annotated to include population in Carbon County, from University of Wyoming – Rocky Mountain Herbarium 1998. One point on the map may represent multiple occurrences.

Database 2003b). Individual populations may be small and sparse to locally abundant, depending on the suitability of habitat. Population size estimates are reported for some EOR's and range from as few as 10 individuals to over 10,000 plants (**Table 1**; Wyoming Natural Diversity Database 2003b). Several EOR's note clusters of large numbers of seedlings. The population at EOR 001 is within the BLM's designated Beaver Rim ACEC and consists of locally abundant but widely scattered colonies spread over 9,000 acres (Wyoming Natural Diversity Database 2003b). The population at EOR 004 is partially within the BLM's Red Canyon ACEC and also extends onto the Red Canyon Ranch Preserve, which is managed by The Nature Conservancy (Budd personal communication 2003; Wyoming Natural Diversity Database 2003b). The Red Canyon population is the largest reported population, estimated to contain over 10,000 individual plants across 180 acres (Wyoming Natural Diversity Database 2003b).

The two populations on the Shoshone National Forest, EOR's 006 and 019, were first observed in 1995. EOR 006 is located on the Wind River Ranger District, approximately 7 miles south of Dubois, on the foothill slopes at the south end of Torrey Rim. It reportedly contains between 500 and 700 individual plants. This population may also extend onto adjacent lands managed by the Wyoming Game and Fish Department (Wyoming Natural Diversity Database 2003b). EOR 019 is located on the Washakie Ranger District on Fossil Hill, and it is reportedly a small population consisting of approximately 10 individuals (Wyoming Natural Diversity Database 2003b). Another rare plant, *Lesquerella fremontii*, reportedly co-occurs at the Fossil Hill location. Additional *Physaria* populations in the vicinity of EOR 019 could not be definitively identified at the time of the survey because they were not fully developed (Wyoming Natural Diversity Database 2003b). An additional occurrence reported for the Shoshone National Forest by Rosenthal (1998) is based on a misidentified specimen (Wyoming Natural Diversity Database 2003a). See **Figure 4** and **Figure 5** for Region 2 Forest Service boundaries and locations of EOR's in Wyoming.

As of 1992, six populations of *Physaria saximontana* var. *saximontana* were known from the BLM's Grass Creek Resource Area in Hot Springs County. Mid-elevation slopes and ridges on the western edge of the Grass Creek Resource Area may still have undocumented populations of *P. saximontana* var. *saximontana*; low-elevation basins and limestone outcrops in the Grass Creek Resource Area mostly supported other species of *Physaria* (Jones and Fertig 1992). Additional habitat may also exist in the foothills of the Big Horn Basin in southern Park County (Jones and Fertig 1992).

There is no information regarding historical distribution and abundance, other than what can be

gleaned from the EOR's and other WYNDD reports. None of the available information suggests that *Physaria saximontana* var. *saximontana*'s range, habitat availability, or populations have decreased, although there is no empirical data available for specific reference or comparison. It is unclear if, or how, past human activities have altered the distribution and abundance of *P. saximontana* var. *saximontana*. It is also unclear how past natural events have altered the distribution and abundance of the species. *Physaria saximontana* var. *saximontana* occurs in a relatively concentrated area as a narrow endemic. Geographic variation (i.e., ranging from dissected, highly erosive, sparsely vegetated low elevation slopes and ridges with rocky or thin soils, including talus slopes, to higher elevation forest or shrub dominated slopes) within the area is high. On a regional basis, extant populations are highly clustered and discontinuous habitat contributes to isolation between populations. According to WYNDD (2003b), several populations reported under different EOR's may be confluent and may actually comprise one larger population. In addition, other populations may exist between known EOR's.

It is possible that this species evolved in place, as with many endemic species, and its distribution continues to be limited by environmental or biotic conditions that are presently unknown. Isolation between populations is generally not extreme across the taxon's range, although the two populations on the Shoshone National Forest may be some of the most isolated from the core populations. It is unknown if gene flow occurs between any of the populations.

Population trend

There is no hard data regarding population stability over time at any scale, and it is unknown if there has been any overall increase of decrease of the species' available habitat. Similarly, there is no information available as to whether any of the individual populations have declined or are at any immediate risk of declining. Thirteen occurrences have not been visited and assessed in the last 10 years. No population trend data are available. The overall population trend has been reported as stable by some researchers (Fertig 1992, Mills and Fertig 2000), but this assessment is based on observations recorded in EOR's and summary reports authored by WYNDD for various land management agencies. While monitoring data is lacking, several EOR's suggest that ongoing reproductive recruitment was evident at the time of the most recent site visit, as indicated by the presence of mature and immature individuals, including clusters of numerous seedlings. Based on anecdotal observations, the Red Canyon Ranch Preserve population appears to be stable or increasing (Budd personal communication 2003).

Habitat

Physaria species typically occupy arid substrates that support sparse vegetation. In some cases *Physaria* species may be the only species, or one of a very few species, on a site (Al-Shehbaz and O'Kane 2002). Since no habitat descriptions for *Physaria saximontana* var. *saximontana* have been published to date, this assessment relied on other sources such as herbarium records, natural heritage program data, and reports prepared for the USFS and BLM. *Physaria saximontana* var. *saximontana* exhibits an apparent, although not exclusive, preference for ridges and slopes (Mills and Fertig 2000, Wyoming Natural Diversity Database 2003b). It is found on sparsely vegetated slopes on sandy, gravelly soils, rocky rims and outcrops, shale-siltstone, conglomerate bedrock, or talus of limestone, red sandstone (Chugwater formation), or clay between 5,200 and 8,850 feet (Fertig 1992, Mills and Fertig 2000, Wyoming Natural Diversity Database 2003b). Selected habitat information as reported from EOR's is presented in **Table 2** (Wyoming Natural Diversity Database 2003b), and **Figure 6** depicts representative habitat for *P. saximontana* var. *saximontana*.

Physaria saximontana var. *saximontana* reportedly occurs on all aspects, but most often on dry, south facing slopes (Budd personal communication 2003). It can be found in narrow, eroded draws with low vegetative cover, and occasionally in dry stream bottoms. Soil and microhabitat have been variously described in EOR's as loose, fine textured soils, in dry stream bottom; silt-clay soil; sandy-gravelly talus slope on south face of ridge surrounded by limber pine/juniper grove; fine, grey shale slopes below ledges of sandstone; open, steep slope in reddish siltstone-clay ridges below outcrops of grey clay-shale; open, gently sloping north-facing slope near top of ridge on coarse sandy soil with sandstone outcrops and boulders; limestone scree or gravelly soil; dry benches and south-facing slopes above creek; open, 25 to 50 degree slopes in dry, fine silt-clay soil, but absent from adjacent clay barrens dominated by *Artemisia pedatifida*; and soil covered by irregular reddish-grey sandy-shale flakes. The Shoshone National Forest populations occur on weakly developed calcareous soils characterized by high cover of bare ground and rock (Houston personal communication 2003).

Table 2. Selected habitat information from Element Occurrence Record . **Bolded** = Region 2 Forest Service occurrence. Wyoming Natural Diversity Database (WYNDD) Occurrence Rank definitions: The A-D scores assigned for WYNDD EO ranks are approximate cumulative summaries (i.e., excellent, good, fair, poor; respectively) of quality, condition, and sustainability of the population and its habitat. EO ranks are assigned only for those occurrences where the species has been surveyed. EO ranks are assigned by botanists with species' and landscape familiarity, although no defined EO rank standards have been developed and reviewed specifically for *Physaria saximontana* var. *saximontana*. An "E" rank indicates an occurrence is extant.

Element Occurrence Record No.	Elevation (ft)	WYNDD Occurrence Rank	Landform - Soil	Aspect	Vegetative Cover	Habitat Condition
001	6,800 to 7,100	A	siltstone and conglomerate bedrock and colluvium on limestone slopes	north, south	sparsely vegetated slopes, cushion plant communities	unknown
002	6,950	B	sandstone, limestone, and redbeds, Chugwater Formation	west	sparsely vegetated slopes	unknown
003	5,700	Unknown	unknown	unknown	unknown	unknown
004	5,700 to 6,600	A	loose, fine textured on slopes of Chugwater redbed sandstone below rimrock, also occasionally on redbeds on top of rim and on shale-siltstone slopes in narrow eroded draws	west, south	low	unknown
005	8,300	Unknown	clay knob	unknown	unknown	unknown
006	**7,700 to 7,850**	**B**	**foothill slopes – fine, gray shale slopes below ledges of shalestone. Soil covered by irregular reddish-grey sandy-shale flakes. Absent from limey sandstone talus or adjacent redbed outcrops**	**east, southeast**	**mostly 20 to 30 percent, some 5 percent**	**good condition**
007	unknown	Unknown	unknown	unknown	unknown	unknown
008	unknown	Unknown	unknown	unknown	unknown	unknown
010	8,420 to 8,850	Unknown	dry benches	south	unknown	unknown
011	5,600	Unknown	red soil, slope of limestone-capped ridge	east	sparse	unknown
012	5,800	Unknown	rocky rim	unknown	unknown	unknown
013	6,800	Unknown	rocky outcrop on small ridge	unknown	unknown	unknown
014	6,400 to 7,400	A	shale-sandstone talus slopes just below ridgelines, above shallow draw	northeast, east, south, southwest	unknown	unknown
015	6,600 to 6,800	AB	ridge above creek, boulder and talus slope on mid-slope of small ridge	south, southeast	semi-open	unknown
016	6,600 to 7,100	B	sandy and gravelly soil on flat sandstone outcrops and upper slopes	unknown	open canopy - barren	unknown

Table 2 (concluded).

Element Occurrence Record No.	Elevation (ft)	WYNDD Occurrence Rank	Landform - Soil	Aspect	Vegetative Cover	Habitat Condition
017	7,200	B	Absaroka foothills, sandy-gravelly talus slope on south face of ridge	south	open talus area surrounded by limber pine/juniper grove	unknown
018	5,200	Unknown	dry stream bottom	unknown	unknown	unknown
019	**7,880**	**BC**	**limestone slope, scree or gravelly soil**	**southeast**	**opening in big sagebrush**	**unknown**
020	5,800 to 6,100	A	slopes and summits of Chugwater redbed shales and sandstones	east, southeast	10 to 20 percent, cushion plant community	mostly in good condition, lots of other suitable habitat in vicinity
021	6,900 to 7,100	B	southwest aspect - open, steep slope in reddish siltstone-clay ridges below outcrops of gray clay-shale; n aspect – 25-50 degree slopes in fine dry silt-clay soil	southwest, north	sparse	good habitat and much additional potential habitat in vicinity
022	5,600	E	open, gentle slope near top of ridge on coarse, sandy soil with sandstone outcrops and boulders	north	sparse, cushion plant community	unknown

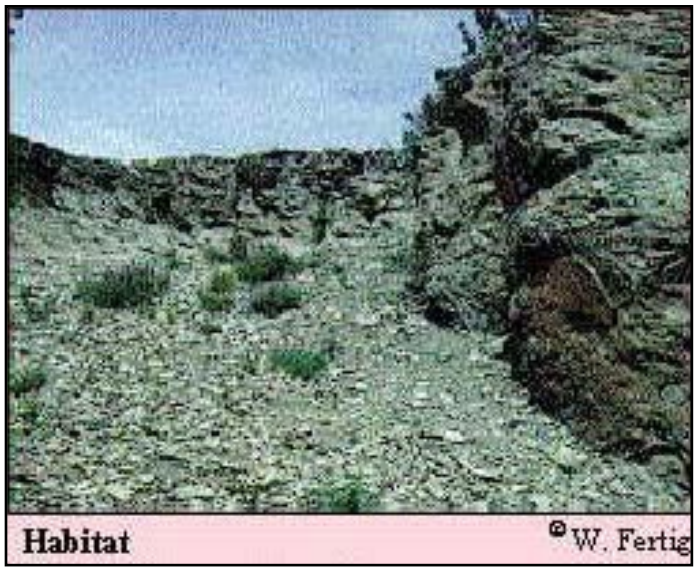


Figure 6. Habitat of *Physaria saximontana* var. *saximontana* by Walt Fertig, from Fertig et al. 1994.

Total vegetative cover reportedly averages 20 to 30 percent, but it may be as low as 5 percent. *Physaria saximontana* var. *saximontana* reportedly occurs in cushion plant communities associated with scattered *Juniperus scopulorum*, *Pinus flexilis*, *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, and *Artemisia nova* vegetation types (Wyoming Natural Diversity Database 2003b).

Summaries of climate data for reporting stations in the vicinity of known populations indicate a climate characterized by cold winters and warm to hot summers. Precipitation is concentrated in the spring to early summer months, and snow cover is minimal (i.e., 1 to 2 inch snow depth) throughout the winter months. According to data for Thermopolis 25 WNW (station 488888, elevation 5,570 feet), which is in the vicinity of several EOR's on BLM lands, total annual precipitation is 12.44 inches, with average temperatures ranging from 7.2 °F in January to 82.0 °F in July; precipitation is concentrated in May (2.32 inches) and June (2.06 inches); first frost generally occurs in early September but may be as early as mid-August; last frost is typically in early to mid-June; and extreme temperatures from 1951 to 2001 ranged from approximately - 40 °F to + 98 °F (Western Regional Climate Center 2003). According to data for Dubois (station 482715, elevation 6,930 feet), which is in the vicinity of a population on the Shoshone National Forest, total annual precipitation is 9.12 inches, with average temperatures ranging from 10.7 °F in January to 78.6 °F in July; precipitation is concentrated in the spring months in April (1.09 inches), May (1.38 inches), and June (1.40 inches); first frost generally occurs in mid- to late August; last frost is typically in late June, to mid-July in some years; and extreme temperatures from 1951 to 2001 ranged from approximately - 50 °F to + 100 °F (Western Regional Climate Center 2003).

As discussed earlier, the geographic range of this species is limited, and this is likely due to the high degree of geographic and geologic variation within Region 2 (i.e., its preferred habitat is not continuous across the region) (Mills and Fertig 2000, Wyoming Natural Diversity Database 2003b). The important differences among habitats that will allow us to predict habitat quality for this species are not well documented at this time. According to WYNND (2003a), the habitat trend (relative to quantity and quality) is not known. Recent habitat modeling has identified potential habitat for *Physaria saximontana* var. *saximontana* including areas along the eastern flank of the Wind River Mountains on the Shoshone National Forest (Fertig and Thurston 2003).

Reproductive biology and autecology

No specific literature pertaining to the reproductive biology or autecology of *Physaria saximontana* var. *saximontana* exists. Also, no relevant reproductive biology data were available for other federally listed *Physaria* species, including *P. obcordata* or *Lesquerella congesta* (U.S. Fish and Wildlife Service 1990, 1993a, 1999).

Physaria saximontana var. *saximontana* is a vernally adapted perennial species whose active growth and flowering period coincides with the peak of the

annual wet cycle. Flowering typically occurs from May through late June (Fertig et al. 1994, Mills and Fertig 2000, Wyoming Natural Diversity Database 2003a). Mature fruits are generally present from mid-June to early August (Fertig 1992, Mills and Fertig 2000). When the fruit dries, the sides of the fruits (valves) separate from the replum and fall to the ground. The seeds fall out and the membranous replum remains attached to the receptacle (Walters and Keil 1996).

Most *Physaria* species are characterized by self-incompatible breeding systems (i.e., they are obligate out-crossers) typical of many Brassicaceae, although some exhibit self-compatible breeding (Rollins and Shaw 1973). Most populations of *Physaria* species (and the former *Lesquerella* species) occur in open situations, and plants tend to be aggregated together in localized places, suggesting that cross-pollination is the norm for the genus (Rollins and Shaw 1973). Rollins' (1984) description of *P. saximontana* var. *saximontana* was one of the earlier recognitions of an endemic *Physaria* taxon as a niche or geologic specialist. Previously, most of the described *Physaria* taxa were widely distributed habitat generalists. *Physaria saximontana* var. *saximontana* does not appear to be an exclusive geologic or edaphic specialist, although it is often reported from certain redbed sandstone and limestone shales, associated with the Chugwater Formation (Fertig personal communication 2003, Wyoming Natural Diversity Database 2003b). Rollins and Shaw (1973) also noted that polyploidy is generally infraspecific.

Base chromosome number was one of the characteristics previously used to separate *Physaria* species (n = 4) from *Lesquerella* species (n = 5 or 6) (Rollins 1939), although subsequently at least some *Physaria* species (e.g., *P. acutifolia*) were reported to have a base chromosome number of 5 (Rollins 1993). Base chromosome numbers for the expanded *Physaria* genus are 4, 5, or 6, although some polyploidy and aneuploidy are known to occur (i.e., n = 8, 10, 12, or 18) (Rollins 1939, Al-Shehbaz and O'Kane 2002). The chromosome number for *P. saximontana* var. *saximontana* has not been reported.

The dense, highly developed trichomes associated with *Physaria* species represent an important adaptive feature to arid environments (Rollins and Shaw 1973). The net effect of dense cover of trichomes serves to decrease water loss, through increased reflection of light, increased boundary layer effects (i.e., decrease airflow at the plant surface), and a decreased evaporation gradient.

In the Competitive/Stress-Tolerant/Ruderal model (Grime 2001), *Physaria saximontana* var. *saximontana* exhibits a suite of characteristics that most closely approximate those of stress-tolerant species: long lifespan (e.g., 10 years or more), adaptations to windy and xeric conditions, low reproduction rates, caespitose growth form, and taproot. Many *Physaria* species exhibit characteristics of disturbance-adapted species as well, as evidenced by their ability to rapidly colonize suitable habitat as it becomes available (Rollins 1939). *Physaria saximontana* var. *saximontana* is also apparently adapted for recruitment in areas subject to at least some natural disturbance (i.e., natural sloughing and creep associated with talus and scree slopes) and low competition from other plants. This is based on its apparent preference for barren or sparsely vegetated slopes and ridges and reports of numerous seedlings in the vicinity of parent plants at some occurrences (Wyoming Natural Diversity Database 2003b). However, as a presumably long-lived taxon, it is less likely that established plants are adapted for survival in response to disturbance. Accordingly, *P. saximontana* var. *saximontana* may be expected to withstand light to moderate disturbance, but there is no hard evidence to support this premise (Fertig personal communication 2003). The species' apparent ability to readily colonize unoccupied or sparsely occupied habitats, coupled with a long-lived life strategy suggests that *P. saximontana* var. *saximontana* may share characteristics of both r-selected (ruderal, annuals, etc.,) and k-selected (long-lived) species (MacArthur and Wilson 2001).

There has been no specific pollination research conducted on *Physaria saximontana* var. *saximontana*, although bees, flies, and other insects reportedly may visit the flowers of *Lesquerella* (Rollins and Shaw 1973). *Physaria* and four other genera are unique from other Brassicaceae on the basis of pollen grain structure (Al-Shebhaz and O'Kane 2002). The pollen of *Physaria* species are generally pentacolpate or hexacolpate (colpi are longitudinal furrows on pollen grains), as opposed to that of most other Brassicaceae which are tricolpate (Rollins and Shaw 1973, Al-Shebhaz and O'Kane 2002).

The highly inflated thin-walled valves of the genus *Physaria*, including *P. saximontana* var. *saximontana*, typically enclose one or more seeds. As a result, the valves of many *Physaria* species, including *P. saximontana* var. *saximontana*, are the units of dispersal as opposed to the seeds themselves. This is apparently an adaptation for wind dispersal (Rollins 1983). Seeds from plants growing on exposed sites are probably

readily dispersed with the fruits by wind, at least over short distances. The clumpy distribution noted for several EOR's is consistent with a mechanism of wind dispersal of intact valves to transports seeds, which then are dispersed in the immediate vicinity as the valve decays (Wyoming Natural Diversity Database 2003b). It is less clear how effective wind transport may be across habitat discontinuities. Although wind transport of the lightweight, bladdery fruits is a likely dispersion mechanism (Rollins 1983), WYNDD (2003a) concluded dispersal vectors are unknown.

There is no information pertaining to seed production, viability, parasites or predation.

The range of morphologic variability and phenotypic plasticity of *Physaria saximontana* var. *saximontana* in response to varying environmental conditions such as light and moisture have not been clearly defined.

Mycorrhizal relationships are not documented for *Physaria saximontana* var. *saximontana*, but for the genus as a whole they are at best weak and facultative (Medve 1983).

There are no known hybrids of *Physaria saximontana* var. *saximontana*. In fact, the lack of hybridization is one of the defining characteristics of the newly expanded *Physaria* genus (Al-Shebhaz and O'Kane 2002).

Demography

Demographic parameters, such as recruitment, survival, age to reproductive maturity, proportion of population reproducing, etc., have not been investigated for *Physaria saximontana* var. *saximontana*. Additional information specific to this taxon, including life history stages, population structure, longevity, mortality, pollination biology and seed biology, is also unavailable (Wyoming Natural Diversity Database 2003a). Therefore, there are no definitive data regarding the vital rates that contribute to species fitness. Stage-based models based on population matrices and transition probabilities and corresponding life cycle diagrams could be constructed, if such data were available. A life cycle diagram is a series of nodes that represent the different life stages connected by various arrows that represent vital rates (i.e., survival, fecundity). **Figure 7** depicts a life cycle diagram for *P. saximontana* var. *saximontana*. As illustrated by the dashed lines depicting areas of uncertainty, many important components of the relevant life history for this taxon are unknown.

Seedlings are likely to be the most vulnerable life stage, with a high likelihood of succumbing to drought stress. As with many species, successful recruitment events may be episodic, depending on favorable precipitation and soil moisture conditions during the initial establishment period of the first growing season. Patch dynamics at the microhabitat scale may also influence recruitment success and seedling survival.

No population viability analysis (PVA) has been reported for *Physaria saximontana* var. *saximontana* or other *Physaria* species, including the federally listed species, *P. obcordata* and *Lesquerella congesta* (U.S. Fish and Wildlife Service 1990, 1993a).

In general, *Physaria* species are aggressive colonizers of disturbed habitats and tend to be some of the most frequently encountered, non-weedy mustards along road cuts in the low to mid-elevations of mountains of the Rocky Mountains and Intermountain West. There is some indication that *P. saximontana* var. *saximontana* may share this preference for disturbed habitat, as noted in the Reproductive Biology and Autecology section. However, there are no specific reports of its response to disturbance, and any assessment of its disturbance tolerance is speculative at this time (Wyoming Natural Diversity Database 2003b).

In addition, many species of *Physaria* are relatively long-lived (i.e., greater than 10 years). Rollins (1938) speculated that a mechanism to move propagules away from a long-lived mother plant might provide a competitive advantage for existing plants, somewhat counteracting the disadvantages of greater longevity in a rapid buildup of plants in favorable sites. He also noted the long-term effect of an effective transport mechanism, coupled with aggressive colonization, would be to keep gene pools dispersed and allow for quick utilization as new habitat becomes available (Rollins 1983).

There has been no molecular analysis of genetic variation within and between populations of *Physaria saximontana* var. *saximontana*. The genetic characteristics of *P. saximontana* var. *saximontana* have not been examined, and it is unclear if the metapopulation exhibits a high degree of genetic diversity or if it is relatively homogeneous. The largest reported population occurs at the Red Canyon area and exceeds 10,000 individuals. This may serve as an important source of genetic diversity for the species and may play a role in metapopulation stability, although there is no data characterizing inter- or intra-population genetic diversity. Some narrow endemics have a

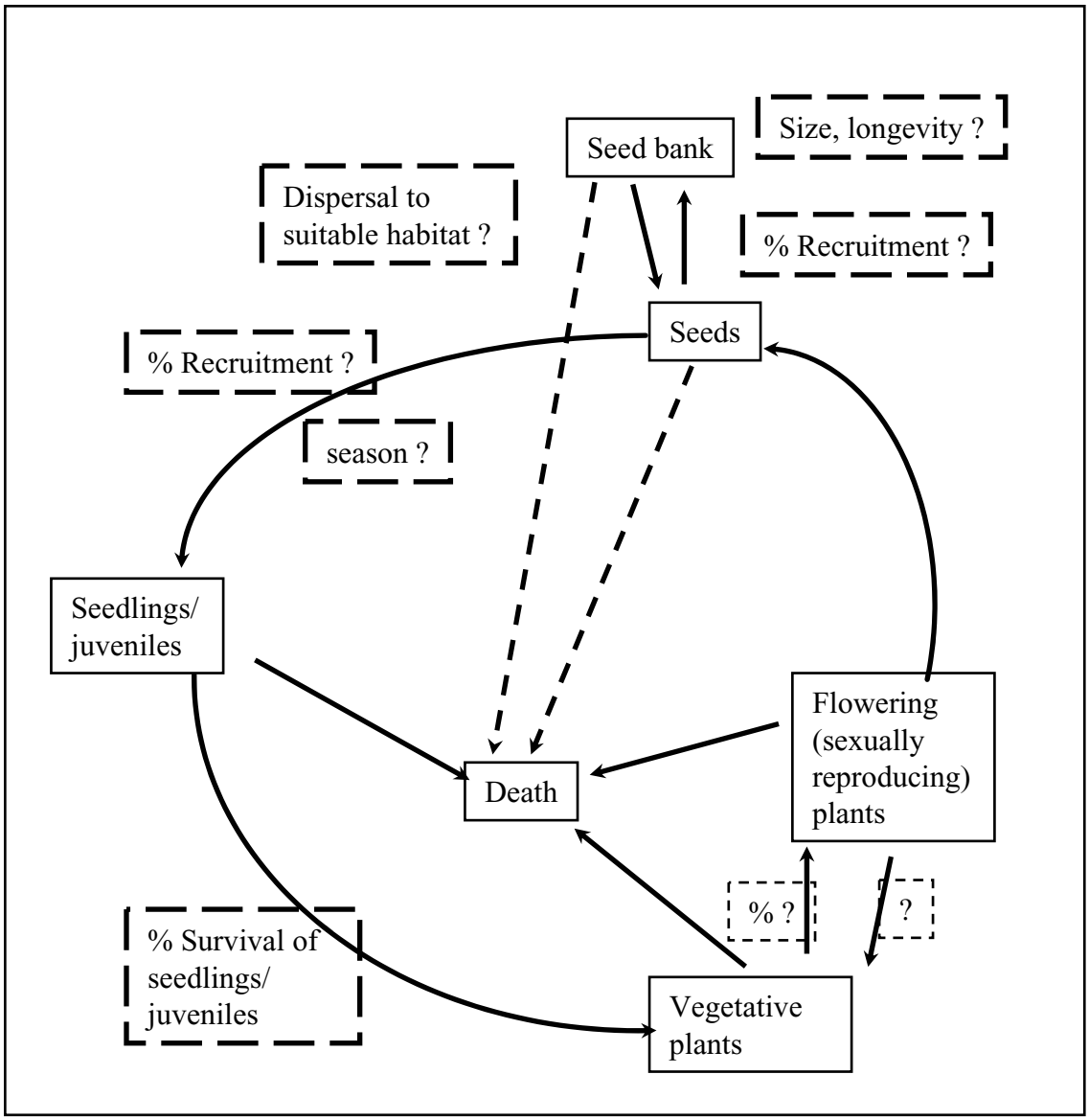


Figure 7. Life cycle diagram for *Physaria saximontana* var. *saximontana*.

relatively low degree of genetic variation, suggesting a species has not had a wider range historically. Other species may exhibit a high level of genetic variation, which suggests a wider historical geographic range. A high degree of genetic variation tends to offer population stability benefits, but in the event of a population crash, a species may still be hard hit because of inbreeding depression if numerous recessive alleles are present.

Gene flow between populations may be limited given the relative isolation of various *Physaria saximontana* var. *saximontana* populations across the landscape. In general, the probability of seed and other propagule dispersal decreases rapidly as distance from the source increases (Glenn-Lewin and van der Maarl 1992). As a result, long distance dispersal events are rare. On the other hand, the likelihood of *P. saximontana* var. *saximontana* dispersal is enhanced by the inherent morphological adaptations of the fruit that facilitate wind transport, coupled with a windy environment such as is found in central Wyoming. However, the reports of clusters of numerous seedlings in the vicinity of established plants suggest much of the propagule dispersal may be highly localized. It is not known how important or effective geneflow is for maintaining healthy levels of heterozygosity. Cross pollination within individual colonies and between nearby populations may help to maintain some degree of genetic diversity. The pollination ecology and genetic diversity of *P. saximontana* var. *saximontana* have not

been documented to date, and it is unclear to what degree geographically separate groups of individuals are demographically linked or how this relates to the resulting population structure and genetic diversity of the species as a whole.

As a habitat specialist exhibiting a preference for sparsely vegetated sites, often in coarse poorly developed soils, population sizes of *Physaria saximontana* var. *saximontana* are naturally limited by availability of habitat. Since not all apparently suitable habitat is occupied, other limiting factors apparently exist but are unknown at this time. The distribution and physiognomy of habitat for *P. saximontana* var. *saximontana* imposes constraints on population growth at a variety of scales. Although *P. saximontana* var. *saximontana* may be capable of occupying a broader range of habitat, it may not be able to successfully compete in areas with more favorable conditions and more developed plant communities or competitive species. Habitat fragmentation may impact pollinator populations and limit effective ranges of pollen transfer since pollinator-mediated pollen dispersal is generally limited by flight distances of pollinators.

Community ecology

Physaria saximontana var. *saximontana* is associated with dry, sparsely vegetated cushion plant and desert shrub communities (Wyoming Natural Diversity Database 2003b). Associated species that have been documented in Element Occurrence Records are listed in **Table 3** (Wyoming Natural Diversity Database 2003b). Dominant species/community types that were frequently reported from EOR's include *Juniperus osteosperma-Elymus spicatus* (Utah juniper-bluebunch wheatgrass), *Artemisia nova-Elymus spicatus* (black sagebrush-bluebunch wheatgrass), *Artemisia tridentata* var. *vaseyana-Elymus spicatus* (mountain big sagebrush-bluebunch wheatgrass), *Artemisia tridentata* (big sagebrush), *Juniperus scopulorum*, and *Pinus flexilis* (Wyoming Natural Diversity Database 2003b). In general, most of these vegetation types are wide ranging, and limiting factors for suitable habitat for *P. saximontana* var. *saximontana* such as geologic strata or unique soils are not known.

There are no known competitive, mutualistic, or symbiotic relationships associated with *Physaria saximontana* var. *saximontana*, including any specific interactions with other native or introduced species. However, *P. saximontana* var. *saximontana* may be associated with other rare endemics in the Wind River Basin south of the Wind River Indian Reservation including *Phlox pungens* (reported from five EOR's) and *Lesquerella* (*Physaria*) *fremontii* (reported from two EOR's). There are no known parasitic or disease relationships associated with *P. saximontana* var. *saximontana*.

Herbivory probably plays a very minor role in the ecology of *Physaria saximontana* var. *saximontana*, as the plant does not appear to be grazed or browsed by livestock, deer, or antelope, even where populations are accessible (Budd personal communication 2003). Predation or other utilization by small mammals and insects is possible, but there have been no observations of this reported to date.

There is no information on competitors for biotic and abiotic resources with *Physaria saximontana* var. *saximontana*. If competitive interactions are important in the autecology of *P. saximontana* var. *saximontana*, some of the associated species cited in **Table 3** are the most probable competitors. However, stress-tolerant species, such as *P. saximontana* var. *saximontana*, do not typically need to be good competitors, since they are adapted to stress regimes that tend to limit aggressively competitive species. There have been no reports in the literature or other observations of parasite or disease attack on *P. saximontana* var. *saximontana*.

An envirogram is a graphic representation of the environmental variables that influence a species and its chance of reproduction and survival. Envirograms have generally been used for animal species, but they may also be applied to plant species (Andrewartha and Birch 1984). Components that are thought to directly impact *Physaria saximontana* var. *saximontana* are listed under the centrum, and the web is comprised of indirectly acting components (**Figure 8** and **Figure 9**). As noted previously, sufficient information to make a comprehensive envirogram is lacking for *P. saximontana* var. *saximontana*. The envirograms in **Figure 8** and **Figure 9** are intended to outline some of the known or suspected major components that directly impact the species and also include some speculative factors that may be tested in the future (i.e., dashed boxes). As noted, the lack of direct studies on this taxon increases reliance on observations and inference as a basis for forming opinions.

CONSERVATION

Threats

The greatest threats to *Physaria saximontana* var. *saximontana* across its range are probably environmental stochasticity and natural catastrophes, with the most

Table 3. Species associated with *Physaria saximontana* var. *saximontana*, from Element Occurrence Records from Wyoming Natural Diversity Database (2003b). Nomenclature follows that of Dorn (2001). * = frequent associate with *P. saximontana* var. *saximontana* (i.e., listed at least twice). R = rare plant tracked by the WYNDD. ? = varietal status not listed in EOR.

Arenaria hookeri	*	*Juniperus scopulorum*	
Artemisia nova		*Juniperus* spp.	
Artemisia tridentata	*	*Lesquerella alpina*	
Artemisia tridentata var. *vaseyana*		*Lesquerella fremontii*	* R
Astragalus convallarius		*Lesquerella* spp.	
Astragalus shortianus		Lupinus argenteus	*
Astragalus tenellus		*Minuartia nuttallii*	
Astragalus spp.	*	*Oenothera cespitosa*	
Balsamorhiza incana		*Oryzopsis hymenoides*	*
Chrysothamnus viscidiflorus	*	*Penstemon laricifolius*	*
Cleome serrulata		*Penstemon paysoniorum*	
Cryptantha celosioides	*	*Phacelia hastata*	
Cryptantha spp.		*Phlox hoodii*	
Cymopterus terebinthinus		*Phlox muscoides*	*
Descurainia incana var. *incana*		Phlox pungens	* R
Elymus elymoides		*Physaria acutifolia*	*
Elymus spicatus	*	*Physaria didymocarpa*	* R ?
Eriogonum brevicaule	*	*Pinus flexilis*	
Eriogonum spp.		*Platyschkuria integrifolia*	
Gaura coccinea		*Psoralidium lanceolatum*	
Haplopappus multicaulis	*	*Purshia tridentata*	
Haplopappus nuttallii		*Senecio canus*	
Hymenopappus filifolius		*Stephanomeria* spp.	
Hymenopappus polycephalus		*Stipa comata*	*
Ipomopsis spicata		*Stipa spicatus*	
Juniperus osteosperma	*	*Townsendia spathulata*	

foreseeable range-wide threats being prolonged weather-related variability and potential climate change. The primary threats to individual populations are likely to result from human-related activities including off-road vehicle (ORV) activity and surface disturbance activities associated with road and pipeline construction, and mineral, oil, and gas exploration (Fertig 1992, Fertig 1997, Fertig 2000, Mills and Fertig 2000, Welp et al. 2000). Threats posed by livestock and non-motorized recreational activities, such as hiking, are generally expected to be minor, although it is unknown if livestock grazing in nearby areas may adversely impact pollinator populations that are important for *P. saximontana* var. *saximontana*. Development, including road construction and residential development, may pose a threat to occurrences of *P. saximontana* var. *saximontana* on private land. Particular potential threats to occurrences on the Shoshone National Forest include mineral, oil, and gas exploration, livestock grazing, and non-motorized recreational activities.

Since *Physaria saximontana* var. *saximontana* is a long-lived, stress-tolerant, slow-growing perennial, it is likely that populations and habitat quality would be negatively impacted by high disturbance activities such as road construction, resource development, and residential development. It is also likely that it would respond poorly to heavy physical disturbance from heavy livestock or recreational use. However, there has been no documentation of adverse impacts to, or extirpation of, known populations of *P. saximontana* var. *saximontana* by natural events or human activities.

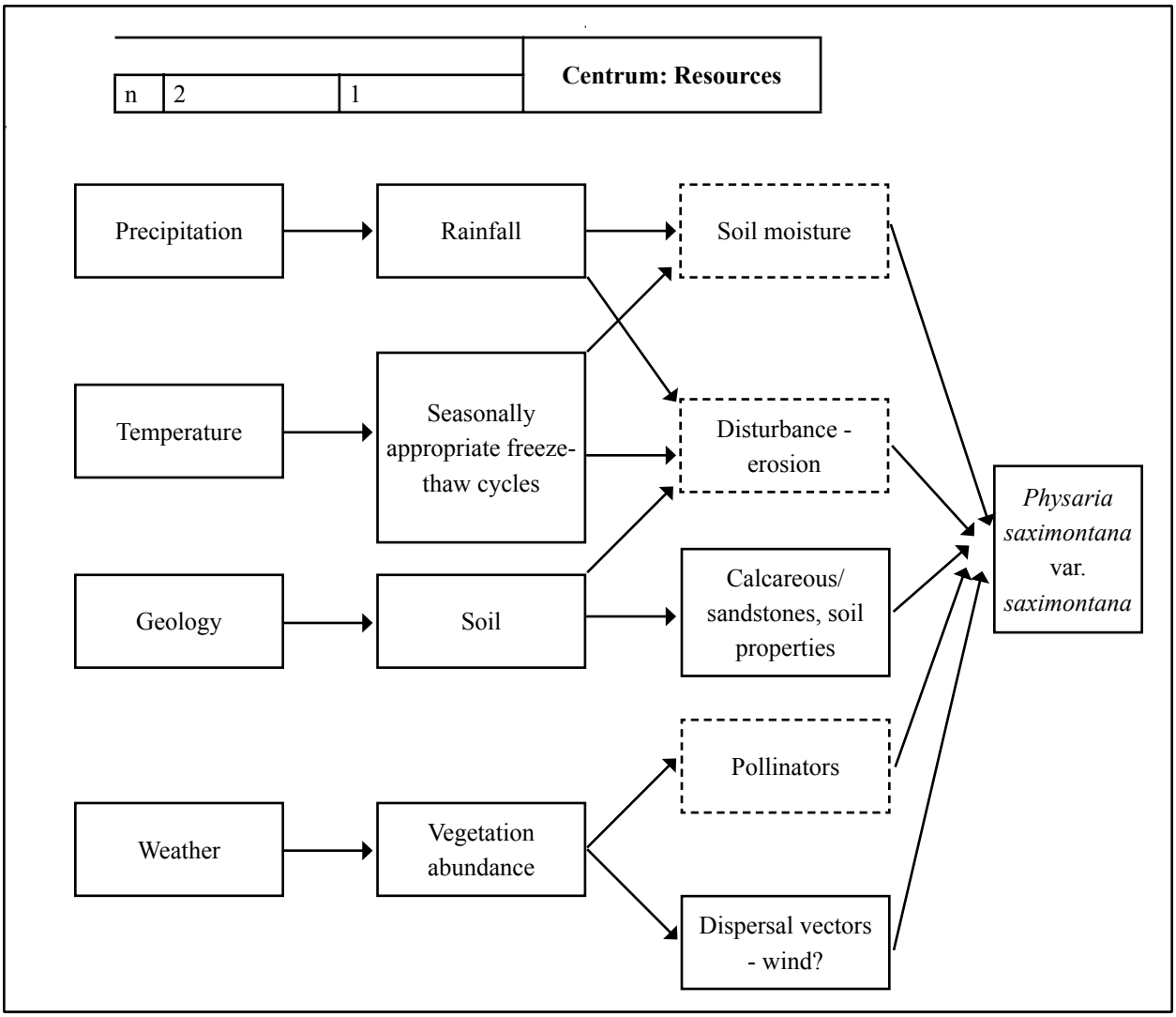


Figure 8. Envirogram outlining the resources of *Physaria saximontana* var. *saximontana*.

Human-related threats to *Physaria saximontana* var. *saximontana* are generally low on public lands, with the two occurrences on the Shoshone National Forest presently subject to a low level of threat. Most (i.e., 12 of 21) of the occurrences occupy inaccessible or infrequently visited sites on BLM land (Carroll personal communication 2003), with the largest BLM occurrence extending onto The Nature Conservancy's Red Canyon Ranch Preserve. Two BLM populations, including a portion of the largest occurrence of 10,000 or more individuals, are afforded additional protection due to their location on lands managed by The Nature Conservancy and the BLM's Beaver Rim and Red Canyon ACEC's (Bureau of Land Management 1987, Fertig 2000, Carroll personal communication). Although the BLM ACEC's are not managed specifically for *P. saximontana* var. *saximontana*, the increased management focus associated with the ACEC designation, as well as Wyoming BLM's listing of *P. saximontana* var. *saximontana* as a sensitive species, may provide a heightened level of awareness and protection for the plant, including the need for pre-project surveys through occupied or potential habitat (Bureau of Land Management 2001b). The Nature Conservancy's Red Canyon Ranch Preserve does not manage specifically for *P. saximontana* var. *saximontana* either, but it relies on general awareness of *P. saximontana* var. *saximontana*'s presence and rarity and prohibits development in areas where the plant is known to occur (Budd personal communication 2003).

Physical destruction associated with ORV recreation is one of the more likely threats for the known occurrences of *Physaria saximontana* var. *saximontana* on public lands. Most populations on BLM land, however, are remote, and the physiography of most of

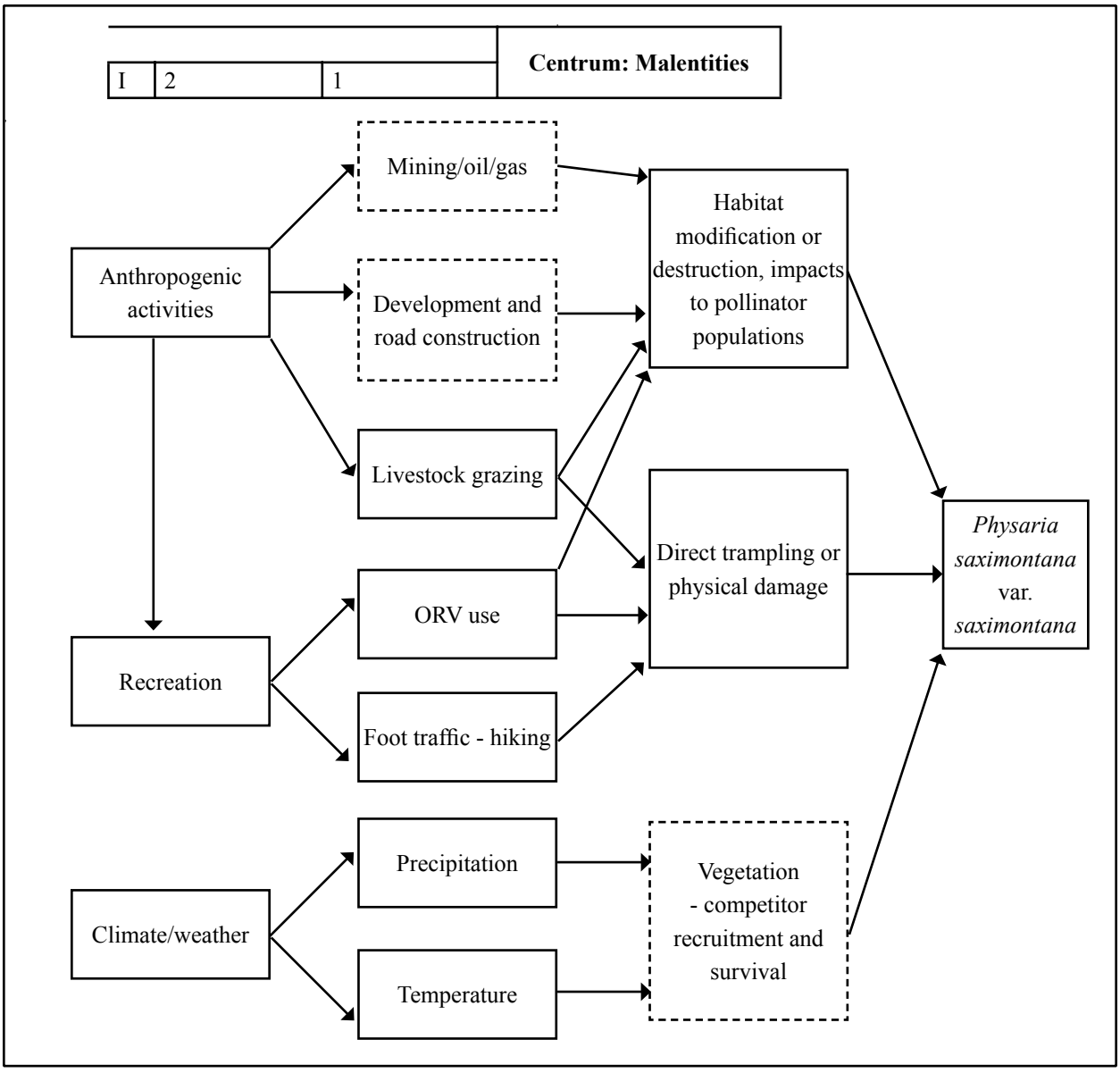


Figure 9. Envirogram outlining the malentities of *Physaria saximontana* var. *saximontana*.

these sites does not lend itself well to exploitation for motorized recreation (Carroll personal communication 2003). Non-motorized recreation, such as mountain-biking, may pose a minor threat to some populations on BLM land (Budd personal communication 2003). The Shoshone National Forest occurrences are also minimally threatened by ORVs, as they are not located in the vicinity of any existing roads and ORV use is not permitted on existing trails in the vicinity.

Resource extraction is a potential threat, mainly for occurrences that might be affected by surface disturbances such as physical removal or burial of populations in conjunction with mineral extraction and oil and gas activities. BLM lands supporting *Physaria saximontana* var. *saximontana* have not experienced increased oil and gas development in recent years and mineral development is also unlikely (Carroll personal communication 2003). The potential for resource extraction in the vicinity of known occurrences on the Shoshone National Forest is unknown (Houston personal communication 2003).

Roads might threaten occurrences of *Physaria saximontana* var. *saximontana* largely through direct physical disturbance and indirectly by causing erosion and negative erosional effects (e.g., increased sedimentation). In highly out-crossing species (such as

other known *Physaria*, and presumably *P. saximontana* var. *saximontana*), roads and trails might also serve as barriers to pollinators and disrupt effective geneflow. New road construction or right-of-way management and road widening projects may have detrimental effects on the habitat and or threaten occurrences of *P. saximontana* var. *saximontana* if they occur in the immediate vicinity or through occupied or potential habitat. Habitat fragmentation may adversely impact pollinator access to various populations and restrict geneflow. Populations in the vicinity of roads may also be vulnerable to other indirect impacts, such as dust coating of stigmatic surfaces. Road-related issues do not pose a threat to USFS Region 2 occurrences at present.

Herbivory does not appear to pose a significant direct threat to *Physaria saximontana* var. *saximontana*, as it does not appear to be palatable to domestic livestock or native ungulates. Plants that are accessible to cattle on the Red Canyon Ranch Preserve do not appear to be adversely affected (Budd personal communication 2003). The Nature Conservancy does not fence areas supporting *P. saximontana* var. *saximontana*, but the site steward noted that it does not appear to be palatable, as "nothing touches it" (Budd personal communication 2003). Additionally, few other occurrences are in accessible terrain, and grazing is not occurring at many locations for this species on BLM land (Carroll personal communication 2003). Heavy trampling is unlikely to be well tolerated by *P. saximontana* var. *saximontana*, but it does not appear to pose a tangible threat at present due to the relative absence of livestock from its occupied habitat, even in areas where livestock grazing occurs in the immediate vicinity. The two populations on the Shoshone National Forest are in active cattle grazing allotments, but they are also likely subject to a low threat from grazing, primarily due to *P. saximontana* var. *saximontana*'s apparent low palatability. In addition, these occurrences (as with most other occurrences) are on sparsely vegetated or talus slopes where cattle would not be expected to congregate or forage, thereby further reducing the potential for trampling. Although there is apparently some historic allotment monitoring data, there is reportedly no recent data and it is unknown how directly the historic data may pertain to *P. saximontana* var. *saximontana* occurrences or suitable unoccupied habitat (Houston personal communication 2003). As a result, it is not possible to directly assess specific impacts to date (Houston personal communication 2003). Future changes in stocking rates or placement of water developments, salt blocks, and other activities that concentrate livestock may increase the potential for impacts if locations are in the vicinity of the Torrey Lake or Fossil Hill occurrences.

A significant indirect threat from grazing in the general area is the possibility of negative impacts to pollinators. Degradation of adjacent areas via livestock herbivory and trampling may damage important ecological linkages with surrounding areas and negatively affect pollinator populations, nectar sources, and movement corridors. Knowledge of the active season and foraging range for the native pollinators of *P. saximontana* var. *saximontana* would enable studies to assess potential impacts to the seasonal continuity of nectar resources. It is likely that as other plants in the area flower over the summer, they support native pollinator populations important for *P. saximontana* var. *saximontana*. Livestock grazing may adversely impact these nectar sources, thereby reducing the vigor of pollinator populations on a localized basis.

There is no evidence to suggest that *Physaria saximontana* var. *saximontana* interacts specifically with any exotic species in Region 2, and exotic species do not appear to pose an appreciable threat at present. None of the Wyoming state or county-listed noxious weeds or the invasive species, *Bromus tectorum*, are noted in any natural heritage program data sheets. The threat of *B. tectorum* invading the talus, open, shale/gravelly habitat characteristic of most *P. saximontana* var. *saximontana* populations on BLM lands is minimal (Herren personal communication 2003). It is possible that new exotic species could arrive that favor the habitat for *P. saximontana* var. *saximontana* in the future.

Although many populations on BLM land are reportedly in remote locations that are not generally accessed for hiking (Carroll personal communication Carroll 2003), the only known USFS Region 2, EOR 006 at Torrey Lake and EOR 019 at Fossil Hill, are both in the vicinity of popular hiking trails on the Shoshone National Forest. No evidence of damage to either population has been reported, and assuming that the species is somewhat tolerant of light to moderate disturbance, it is likely to adequately withstand impacts of dispersed, infrequent sources of disturbance such as occasional hiking or scrambling through known occurrences (Wyoming Natural Diversity Database 2003b). It is possible that off-trail hiking in concentrated areas could be damaging to Shoshone National Forest occurrences in the future.

Since the species does not occur in forested areas, timber harvest and blowdown are not significant threats.

There are no known commercial uses for *Physaria saximontana* var. *saximontana*. Other Brassicaceae have

a long history of human use as remedies for various maladies, but there are no specific medicinal uses reported for the genus *Physaria* or for *P. saximontana* var. *saximontana*. Due to its small population size, *P. saximontana* var. *saximontana* would be vulnerable to potential impacts from harvesting wild populations if it became sought after for any reason. Over-collection for scientific purposes, particularly in small populations, is also a potential threat. In general, however, present threats posed by over-utilization for commercial, scientific, or educational purposes are minimal.

Global climate change as a result of elevated atmospheric carbon dioxide levels is likely to increasingly impact ecosystems and plant communities in the near future. Climatic-induced changes to environmental variables such as temperature, and seasonality and amount of precipitation may directly impact individual plant species and ecosystem processes such as nutrient cycling. Climate modeling for Wyoming suggests that average temperatures may increase by 4 to 5 °F from spring through fall, and 6 °F in the winter by 2100 (U.S. Environmental Protection Agency 1998). It has been estimated that increased temperatures in the Rocky Mountain Region of Colorado may cause vegetation zones to climb 350 feet in elevation for every one degree F of warming (U.S. Environmental Protection Agency 1997). Seasonal precipitation patterns may be altered, with predictions for a precipitation increase of 10 percent in spring and fall, and 30 percent in winter by 2100 (U.S. Environmental Protection Agency 1998). Precipitation during the summer months is projected to decrease slightly (less than 10 percent) (U.S. Environmental Protection Agency 1998). Seasonal shifts in precipitation may also affect plant reproduction and recruitment by reducing seedling survival. Effects specific to *Physaria saximontana* var. *saximontana* and its habitats are difficult to project; although the plant's morphological adaptations to an arid environment may be beneficial for its future survival.

The tolerance of *Physaria saximontana* var. *saximontana* to heavy metals and other pollutants has not been investigated.

The effects of fire and fire suppression on habitat quality are unknown. Given the sparse vegetation in sites occupied by *Physaria saximontana* var. *saximontana*, the role of fire in these habitats is probably minor, and many of the species that occupy these areas are likely not fire adapted. However, ecosystem processes in the surrounding rangelands and forests may directly or indirectly affect *P. saximontana* var. *saximontana* and its habitat quality, and fire might be important in the maintenance of these processes.

Existing and potential habitat on the Shoshone National Forest and BLM lands remains mostly intact and does not appear to be seriously threatened at this time. Although there has been no analysis of the effects of various management practices on the habitat of *Physaria saximontana* var. *saximontana*, some inferences can be made based on the nature of these habitats. In general, the remote, rugged terrain that provides habitat for *P. saximontana* var. *saximontana* is probably somewhat resilient to impacts that might cause light or moderate disturbance (e.g., infrequent recreational use). The sparsely vegetated areas can probably withstand occasional human visitation without severe effects, although frequent or moderate-to- heavy use, particularly by ORV's, would likely degrade these sites. On most federal land areas occupied by *P. saximontana* var. *saximontana*, current management appears to support the long-term viability of these populations and their habitat, but management changes might be necessary if human use of areas supporting populations of *P. saximontana* var. *saximontana* increases or changes. Potential indirect effects on habitat quality for *P. saximontana* var. *saximontana* caused by fragmentation (e.g., reduce vigor of pollinator populations, etc.,) are less clear. The impact of these actions on habitat quality for *P. saximontana* var. *saximontana* depends largely on the importance of ecological connectivity between populations, which is not known.

In summary, global climate and weather variation poses the greatest threat to the species across its range. No adverse impacts to individuals and populations of *Physaria saximontana* var. *saximontana* resulting from various management-related activities have been reported to date. However, *P. saximontana* var. *saximontana* populations may be vulnerable to impacts from a variety of threats, primarily ORV use, livestock grazing, disturbance from road construction, and residential, oil, gas, or mineral development. BLM lands supporting *P. saximontana* var. *saximontana* have not experienced increased oil and gas development in recent years. Livestock grazing generally does not pose a significant direct threat due to the rugged terrain typically occupied by the plant (Carroll personal communication 2003). However, possible adverse impacts to local pollinator populations in adjacent grazed areas have not been assessed. The seven populations on private lands (including the Wind River Indian Reservation) remain at risk of residential development or road construction. The potential for increased

recreational ORV use in the remote areas that support *P. saximontana* var. *saximontana* may result in increased threats on BLM lands in the future. Populations on the Shoshone National Forest are presently subject to minor threats of trampling or localized physical disturbance by livestock and non-motorized recreational activities, such as hiking. Depending on future management direction and proposals for resource development, populations on the Shoshone National Forest may be threatened in the future by ORV's, road construction, and oil, gas, or mineral development although none of these activities presently occur in the vicinity of the two known occurrences.

Conservation Status of the Species in Region 2

There is no evidence that the distribution or abundance of *Physaria saximontana* var. *saximontana* is changing within USFS Region 2, which encompasses the total global range of this narrow endemic plant. Its rarity is apparently the result of a naturally small number of occurrences across a narrow geographic range. Persistence and sustainability of *P. saximontana* var. *saximontana* may rely on relatively long-lived mature individuals. Management practices that allow for increased frequency or intensity of disturbance, or additional types of disturbance, may adversely affect population viability.

Although there are no population trend monitoring data for this taxon, most populations of *Physaria saximontana* var. *saximontana*, including the two on the Shoshone National Forest, appear stable based on observations during collection of WYNDD EOR data, and no specific impacts to existing populations have been noted to date (Wyoming Natural Diversity Database 2003a, 2003b). Based on anecdotal observations, The Nature Conservancy's Red Canyon Ranch Preserve population may even be increasing (Budd personal communication 2003). Although some fairly good data on distribution are available, these are largely qualitative or include only rough population estimates. In addition, many populations have not been visited since their discovery to assess or re-assess their status.

The high variation in population size and density documented thus far in populations across its range suggests that habitats vary substantially in their capacity to support *Physaria saximontana* var. *saximontana*. However, the underlying ecological reasons for this variation are unknown and difficult to speculate on until research reveals more details of the relationships between *P. saximontana* var. *saximontana* and its habitat. As a poor competitor, marginal habitats for *P. saximontana* var. *saximontana* include sites where competitive pressure from other species is more intense. This is a typical distribution pattern for a stress-tolerant species (Grime 2001).

Recent habitat modeling has identified potential habitat for *Physaria saximontana* var. *saximontana*, including areas along the eastern flank of the Wind River Mountains on the Shoshone National Forest (Fertig and Thurston 2003). This modeling was based "on the assumption that correlations exist between the presence/absence of a species and selected climate, topographic, substrate, and land cover variables" (Fertig and Thurston 2003). Critical modeling factors for *P. saximontana* var. *saximontana* included bedrock geology, surficial geology, relief, landcover, and total precipitation for July. Positive classification tree terminal nodes for bedrock geology descriptors include Cretaceous shale and Paleocene deposits. Positive classification tree terminal nodes for surficial geology descriptors include 1) bedrock and glacial bedrock including hot spring deposits and volcanic necks; mixed with scattered deposits of eolian, grus (coarse-grained granitic material), slopewash, colluvium, residuum, glacial, and alluvium; 2) landslide mixed with scattered deposits of slopewash, residuum, Tertiary landslides, and bedrock outcrops; landslides too small and numerous to show separately; and 3) slopewash and colluvium mixed with scattered deposits of slopewash, residuum, grus, glacial, periglacial, alluvium, eolian, and/or bedrock outcrops. Positive classification tree terminal nodes for landcover descriptors include human disturbed, juniper woodland, big sagebrush, and shrub dominated riparian (Fertig and Thurston 2003).

Based on these modeling efforts, potential habitat on the Shoshone National Forest is restricted to a narrow zone along foothill lowlands on the northeast flank of the Wind River Range (Fertig and Thurston 2003). Similar potential habitat is expected to occur on portions of the adjacent Wind River Indian Reservation (Fertig and Thurston 2003).

As a narrowly ranging endemic that is tightly bound to its limited habitat, populations of *Physaria saximontana* var. *saximontana* may be especially vulnerable to habitat change or other changes in the environment. While there is no evidence to suggest the species' habitat is declining or that current management is otherwise placing demands on the species, the taxon's existing habitat may become less suitable as climate change continues. The taxon's vulnerability is likely related to its high specificity for sparsely vegetated

habitats with poorly developed soils within a narrow geographic range. If it is an obligate out-crosser, as most other *Physaria* species are, it is also vulnerable to impacts that affect its pollinators. The lack of exotic species in *P. saximontana* var. *saximontana* populations suggests competition from exotic species is unlikely, although new exotic species are arriving all the time and may pose problems in the future.

The relatively concentrated nature of *Physaria saximontana* var. *saximontana* populations over a fairly narrow geographic range suggests it may be susceptible to demographic or environmental stochasticity. However, other observations suggest it may not be highly vulnerable to habitat or environmental change. As a long-lived, stress-tolerant perennial, *P. saximontana* var. *saximontana* may be buffered somewhat from the effects of short-term environmental stochasticity such as periodic drought. The several thousand foot elevation range of *P. saximontana* var. *saximontana* may also buffer it somewhat from the anticipated climate change impacts that may affect low elevation populations most severely. In addition, inherent morphological adaptations to hot arid conditions may enable low elevation populations to persist, unless increases in winter or spring precipitation alter the level of competition with other plant species.

Since other *Physaria* species are generally colonizers, the regeneration niche for *P. saximontana* var. *saximontana* may also require naturally disturbed areas (i.e., scree and other slopes) to some extent, although this is not known and is not strongly suggested by natural heritage program records.

The minimum viable population size is not known for *Physaria saximontana* var. *saximontana*, but even small populations may still be viable and of conservation importance. Any loss of existing populations may result in decreased genetic diversity and disturb metapopulation dynamics, although the population's genetic structure is unknown at any scale.

There is no strong evidence that any populations in Region 2 are at risk. Habitats occupied by *Physaria saximontana* var. *saximontana* are not well suited to many human uses, and consequently they are not generally at risk as a result of land management practices. In general, populations of *P. saximontana* var. *saximontana* on public lands appear relatively secure at present, mainly because they are in remote, infrequently visited areas, and because they do not occur in areas where resource extraction is likely. The steep, sparsely vegetated badlands, mesas, and escarpments on which this species typically grows are not often sought after for recreation activities at present and are not favorable sites for residential or commercial development. Increased human visitation to occurrences of *P. saximontana* var. *saximontana* is not likely to be a major threat on a range-wide basis, but the ever-increasing popularity of ORV's, as well as road construction and oil, gas, and mineral exploration or extraction may place individual populations at risk in the future. There is some risk due to development of *P. saximontana* var. *saximontana* populations on private land. Development and livestock grazing also have the potential to impact pollinator species on a local scale by reducing nectar resources in the area or through habitat fragmentation.

The Shoshone National Forest population near Torrey Creek is near a hiking trail in the vicinity of a campground, while the Fossil Hill population is also near a hiking trail. These populations may be vulnerable to expansion of recreational activities or increased recreational visitation. Both of the Shoshone National Forest populations are within active cattle allotments and may be adversely impacted by changes in grazing management practices, stocking rates, or locations of water developments. The Fossil Hill population contained only 10 plants during the initial survey and may be especially vulnerable to the effects of trampling if cattle access the area frequently. ORV use is prohibited on the Shoshone National Forest and consequently should not pose a threat to known occurrences, unless violations occur.

Habitat for *Physaria saximontana* var. *saximontana* on BLM lands is potentially vulnerable to management related multiple-use activities such as ORV use, road construction, mining, and oil and gas exploration, livestock grazing, and non-motorized recreation.

Pre-project right of way surveys would help to minimize impacts to populations that have not been identified to date. Thirteen occurrences have not been visited and assessed in the last 10 years. If these populations remain extant today, they will need to be relocated before they can benefit substantially from any conservation actions on behalf of the species. As a result, these populations are at risk simply due to the lack of knowledge regarding their status.

Management of the Species in Region 2

Implications and potential conservation elements

No specific management practices have been applied in Region 2 for *Physaria saximontana* var. *saximontana*. The biological, ecological, and natural history information available for *P. saximontana* var. *saximontana* is generally lacking and limits analysis specific to this section. The most current data available suggest *P. saximontana* var. *saximontana* is imperiled due to small population sizes and a small number of occurrences. Maintaining the genetic integrity of populations of *P. saximontana* var. *saximontana* is an important management consideration although there is presently no molecular data to assess genetic variation within or between populations and no research is actively underway (Hartman personal communication 2003). As a rare species, the loss of any population is significant and may result in the loss of important components of the genetic diversity of the species. It is possible that populations near the limits of the taxon's range (e.g., the two occurrences on the Shoshone National Forest) and populations in more extreme habitats have alleles not present in other populations, so loss of these populations might result in a significant loss of genetic diversity.

Preservation of sufficiently large areas that maintain the natural ecosystem processes and desired environmental conditions upon which *Physaria saximontana* var. *saximontana* depends will help to minimize impacts by human activities and secondary effects, such as invasion by weedy species. Maintaining a high degree of ecological connectivity between populations will help to ensure preservation of corridors and other nectar resources for pollinators. It is unknown whether or not ecosystem processes essential to *P. saximontana* var. *saximontana* are functioning properly for known occurrences or across its range due to the lack of monitoring data and biological information specific to this taxon. Until a thorough understanding of the distribution and ecology of this taxon is developed, priorities on a global scale should focus on conserving known occurrences, especially those that support large populations that are in excellent condition and in which the surrounding landscape remains largely intact. The Wyoming BLM's designation of *P. saximontana* var. *saximontana* as a sensitive species and the location of the largest known populations in special management areas such as BLM's Beaver Rim and Red Canyon ACEC's and The Nature Conservancy's Red Canyon Ranch Preserve provide some measure of protection for the species going forward. Further research on the genetics, ecology, and distribution of *P. saximontana* var. *saximontana* will help to identify effective approaches to management and conservation on a global scale.

Priorities for USFS Region 2 include conserving the two known occurrences on the Shoshone National Forest, monitoring population trends, assessing the need for listing as a sensitive species, and conducting additional surveys as well as pre-project surveys for any future proposed surface disturbance activities in areas of occupied and potential habitat (i.e., foothill areas along the east flank of the Wind River Range). Collecting scientific data as noted in Tools and practices and Information Needs sections is also an important priority.

Considering the changes predicted in the global climate for the next 100 years, maintenance of a variety of habitat features and functional ecosystems across a range of higher elevations or latitudes may help to ensure *Physaria saximontana* var. *saximontana*'s long-term global viability. These efforts can be incorporated into preserve designs and conservation plans. Other proactive measures could include closures to ORV use in the vicinity of known populations that are most vulnerable to heavy visitation. Management approaches that focus on "steering" recreational activities such as hiking, climbing, and camping away from known populations would likely benefit the species, and may also be useful for managing occurrences on the Shoshone National Forest.

Tools and practices

The priorities for *Physaria saximontana* var. *saximontana* at this time include gathering more complete baseline data on distribution and population sizes. Related areas of interest include better characterization of habitat requirements and environmental factors that control its distribution and long-term population dynamics.

Past inventories on the Shoshone National Forest have generally been broad, typically involving inventories for a suite of species across a representative cross-section of the forest (Fertig 1998). This is a widely used approach for an initial survey and inventory effort. Some of the older EOR's lack important data such as population size and thorough habitat and associated species descriptions, especially for occurrences located on private land or the Wind River Indian Reservation. Most of the more recent EOR's, including those on the Shoshone National Forest, provide more

comprehensive data. To date there has not been a species specific habitat-level inventory conducted for *Physaria saximontana* var. *saximontana* aimed at providing a thorough documentation of occurrences on the Shoshone National Forest or across its range. This may be due to inadequate characterization and mapping of suitable habitat, as well as other priorities or lack of resources to perform the work. Comprehensive surveys of recently identified potential habitat areas would better define the known distribution on the Shoshone National Forest (Fertig and Thurston 2003).

Periodic follow-up surveys of occupied and potential habitat would verify continued presence of known populations and could identify new populations (e.g., resurvey potential habitat every 5 or 10 years). This information would provide insights as to whether occupied range and populations are increasing, holding steady, or decreasing.

Inventories for *Physaria saximontana* var. *saximontana* are complicated by the difficulty of field identification of the species and potential co-occurrence with similar species. Since mature fruits are essential for positive identification, any monitoring and environmental clearance surveys of new populations would be most accurate if conducted from mid-June to early August. Follow-up visits to known populations could be conducted earlier during the flowering period to better characterize pollination strategies and pollinators. Any monitoring efforts may be made more time-consuming by the presence of similar *Physaria*, such as *P. acutifolia* and *P. didymocarpa*. Contracting experts on this species to search for more occurrences and update historic records would contribute greatly to our knowledge of *P. saximontana* var. *saximontana*.

No population monitoring has been performed to date for *Physaria saximontana* var. *saximontana*. An appropriate initial monitoring approach would included collection of qualitative trend line data (e.g., estimation of population size by tallying the number of rosettes, flowering individuals, size of colony, etc.). This type of trend line data, perhaps coupled with photo point monitoring, may be used to assess the stability of existing populations through time (Elzinga et al. 1998). A monitoring program that addresses recruitment, seed production, plant longevity, and pollinators would generate data useful to managers and the scientific community. The interpretation of such data may be problematic initially, as no baseline data exists for this species in terms of year-to-year fluctuations, habitat specific variability, etc. However, such information would provide very useful insights. If a substantial decrease is observed between visits (e.g., arbitrarily defined as 25 percent or greater), more sophisticated follow-up monitoring approaches could be devised and implemented to better assess microsite environmental requirements and populations trends. This may also serve as a trigger to review management practices. Population monitoring efforts by the USFS could be coordinated with any BLM monitoring efforts to better assess trends for the taxon across its range.

As a first step, documentation of existing occurrences of *Physaria saximontana* var. *saximontana* utilizing GPS (global positioning system) technology to more precisely document sub-colony locations might be beneficial for coarse level monitoring and subsequent follow-up. A simple approach of estimating colony size and density, and mapping boundaries of the known colony (ies) using GPS, could provide important baseline data. Follow-up monitoring may be repeated every few (e.g., two to five) years. Due to the time demands of visiting many known occurrences, presence/absence monitoring of local population persistence should always be supplemented by population tallies or other estimation techniques that can typically be accomplished without much additional time.

Possible sampling approaches for more formal monitoring programs involving permanent reference plots might include randomly arranged systematic sampling or a stratified random design (Elzinga et al. 1998). In the first approach, sampling units might consist of transects with evenly spaced quadrats or standard nested frequency frames, with the first quadrat randomly placed along the transect. Elzinga et al. (1998) offer guidelines for determining optimal quadrat shape and size. Placement of the sampling units would be fixed for future monitoring. Data collection could consist of simple tallies or nested frequency data, possibly with subsets to include flowering individuals, non-flowering rosettes, and seedlings. Better insight into plant longevity, recruitment, and survival could be accomplished by marking *Physaria saximontana* var. *saximontana* plants using an aluminum tag or other field marker to track small-scale shifts over time, but this approach would be time intensive for data collection and analysis and would be most meaningful if site visits were scheduled every two or three years. Estimating cover and/or abundance of associated species within the plots described above could permit the investigation of interspecific relationships through ordination or other statistical techniques. Understanding environmental constraints on *P. saximontana* var. *saximontana* would facilitate the management of this species. Gathering data on edaphic characteristics (i.e., moisture, texture,

and soil chemistry if possible) from the permanent plots described above might be useful for analysis of species-environment relationships and would facilitate hypothesis generation for further studies of the ecology of this species.

A stratified random design might also be employed to establish the sampling units, particularly at locations where it is difficult to establish a linear transect due to the ruggedness of the site. Permanent plots could be selected within a habitat unit by randomly choosing UTM coordinates, and they could then be physically located using an accurate GPS unit. For future monitoring visits, a recreation grade GPS is usually suitable for relocating plots. If subsequent power analysis of data indicates that sample size is inadequate, it is easy to add more quadrats in this sample design. Disadvantages to this method include the difficulty in using GPS in narrow canyons.

Monumenting permanent reference plots may be challenging in sites occupied by *Physaria saximontana* var. *saximontana* since many tend to occur on steep slopes. Possible materials for monumenting permanent reference plots include partially buried, painted metal bars, spikes, or rebar, marked with identifying metal tags (Elzinga et al. 1998).

Detailed population monitoring, coupled with a collection of basic community ecology, autecology, and phenology data, will yield greater insights to a variety of factors including pollination ecology, variability in plant size, flowering period, seed set rate, reproduction rates, recruitment, lifespan, and seedling survival rates. These efforts could be conducted to varying degrees depending on the desired objectives and available resources.

Meaningful population trend data on a global scale could probably be obtained from monitoring a subset of known populations of *Physaria saximontana* var. *saximontana* on public land and on land managed by The Nature Conservancy. Selecting monitoring sites throughout the range of *P. saximontana* var. *saximontana* at a variety of substrates, elevations, and human usage patterns will provide more meaningful data regarding population trends and responses to stressors. Population trend monitoring on the Shoshone National Forest could include both known occurrences. The use of photo points for population and habitat monitoring is a powerful qualitative technique that can be done quickly in the field and may help to support and clarify patterns observed in quantitative data (Elzinga et al. 1998, Hall 2002). Including photo points as part of monitoring efforts would also facilitate the tracking of individuals (Elzinga et al. 1998).

Visiting populations in early summer while the plants are flowering would allow researchers to observe insect visitors, if it is determined that they play a crucial role in the breeding biology of *Physaria saximontana* var. *saximontana*. Measuring seed production would require another visit later in the summer.

Currently, habitat monitoring in the absence of *Physaria saximontana* var. *saximontana* individuals (i.e., monitoring of presently unoccupied habitat to verify on-going suitability and to assess potential adverse impacts to suitable habitat) cannot be effectively conducted due to the lack of specific, detailed knowledge of habitat requirements. However, expanded survey, inventory, and population monitoring may yield more precise characterization of high quality potential habitat and allow for meaningful monitoring of high quality un-occupied habitat in the future.

For sites that are occupied by *Physaria saximontana* var. *saximontana*, habitat monitoring could be conducted concurrently with population monitoring. Descriptions of habitat characteristics and condition in conjunction with population monitoring efforts will provide important information. This could be incorporated into the field forms used for the quantitative sampling regimen described above. If carefully selected environmental variables are quantified during monitoring activities, then they might help to explain observations of population change and to provide insights to essential specific habitat requirements. Habitat monitoring of known populations would also help alert managers of new impacts such as ORV impacts, weed infestations, and trampling. Changes in environmental variables might not cause observable demographic repercussions for several years, so re-sampling the chosen variables may help to identify underlying causes of population trends. Evidence of current land use practices and management are important to document while monitoring populations.

Management actions that reduce impacts to *Physaria saximontana* var. *saximontana* and its habitat will benefit the species. No populations are presently known to be in need of changes in management at this time. However, if any Shoshone National Forest occurrences are identified as “at risk” in the future through population trend monitoring efforts or changes in the level or intensity of potential threats, implementation of appropriate management actions could prevent the loss of populations.

Fire is unlikely to harm or to benefit *Physaria saximontana* var. *saximontana* directly since its open sparsely vegetated habitat does not have sufficient fuel loading to support fire, and fire is rare or nonexistent in its occupied habitat.

Livestock management practices that limit or prohibit grazing within occurrences of *Physaria saximontana* var. *saximontana* may benefit the species and local pollinator populations. The primary direct threat to *P. saximontana* var. *saximontana* from grazing is likely damage from trampling, with weed invasion posing a secondary, minimal threat at present. Livestock exclosures could be used to prevent horse and cattle grazing in occupied habitat if problems are anticipated for particular occurrences. Since habitat for *P. saximontana* var. *saximontana* is of very low forage value, it is unlikely that actions on behalf of *P. saximontana* var. *saximontana* will affect the grazing regime or have economic impacts. However, if grazing in adjacent areas is found to adversely affect pollinators important to *P. saximontana* var. *saximontana*, then future management changes might have negative economic impacts to grazing permittees.

Routing new trails and re-routing any existing trails around known occurrences are probably the best ways to reduce direct human impacts to *Physaria saximontana* var. *saximontana*. Since populations of *P. saximontana* var. *saximontana* probably remain to be documented, it would be appropriate to conduct surveys before implementing management actions within potential habitat.

No seeds or genetic material are currently in storage for *Physaria saximontana* var. *saximontana* in the National Collection of Endangered Plants, maintained by the Center for Plant Conservation (Grant personal communication 2003). Collection of seeds for long-term storage will be useful if future restoration work is necessary, as is possible with global climate change.

Although several occurrences of *Physaria saximontana* var. *saximontana* are located in BLM's Beaver Rim and Red Canyon ACEC's and part of the largest known population is protected in the Red Canyon Ranch Preserve owned and managed by The Nature Conservancy, no protected areas have been designated that include the conservation of the habitat or populations of this species as an explicit goal. Pursuit of conservation easements to protect populations on private land would add significant protection to some low elevation populations, although other low elevation populations are already protected. Protection of additional populations might further broaden the elevation range and habitat types protected for this species, which in turn will very likely help to maintain its genetic diversity.

Conservation measures adopted in the recovery plan for the Federally Listed species, *Physaria obcordata*, are generally applicable for *P. saximontana* var. *saximontana* (U.S. Fish and Wildlife Service 1993a). Some of these approaches, not yet implemented for *P. saximontana* var. *saximontana*, include designating special management areas such as ACEC's specifically for protection of important populations, initiating monitoring programs of select populations, studying pollination biology, and collecting seed material for storage in biodiversity repositories. Formal designation of *P. saximontana* var. *saximontana* as a USFS Region 2 sensitive species would provide for increased protection of the plant on USFS land.

Information Needs

Further species inventory work is among the top priorities for research on *Physaria saximontana* var. *saximontana*. Until its distribution and population size are better defined, it will not be possible to accurately assess the conservation needs and priorities for this species.

Although the entire global range of *Physaria saximontana* var. *saximontana* is in the Big Horn and Wind River basins of Wyoming, much suitable habitat within the general area remains to be searched. On a global distribution scale, further attempts to locate populations in Park County is warranted, mainly because extant populations are known to the south, and this area contains much apparently suitable habitat. All potential habitat has not been searched yet in Fremont and Hot Springs counties, where extant occurrences are located, or in the vicinity of the newly discovered occurrence in Carbon County. Other neighboring counties (e.g., Natrona County), where *P. saximontana* var. *saximontana* has not yet been found, may also warrant inventory work. There is a great deal of potential habitat on BLM land, but much of it is rugged and difficult to reach. Complex land ownership patterns can complicate search efforts due to the need for permission to access private land. However, search efforts during the 1990's were productive, particularly WYNDD surveys and those of graduate students at the University of Wyoming. On the Shoshone National Forest, there is not a lot of additional potential habitat that has not been surveyed (Fertig personal communication 2003). As

noted earlier, recently modeled potential habitat on the Shoshone National Forest is restricted to a narrow zone along the foothill lowlands on the northeast flank of the Wind River Range (Fertig and Thurston 2003). Similar potential habitat is expected to occur on portions of the adjacent Wind River Indian Reservation (Fertig and Thurston 2003). Revisiting and assessing the historic occurrences is also needed, especially those that have not been observed since the early 1980's. More refined habitat specificity data and recent modeling efforts will help focus future search efforts.

Very little is known about the population ecology of *Physaria saximontana* var. *saximontana*. Baseline population size estimates are available for about half of the occurrences, but there are no monitoring data with which to determine the population trend. Basic life history parameters need to be determined, from which the viability of populations can be inferred. Fortunately there was substantial work in the 1990's (cited above) that resulted in the location of about 10 new occurrences and provided basic information on populations size, associated species, and habitat of *P. saximontana* var. *saximontana*. Further work is needed to more rigorously quantify population size, to attempt to observe population trend, and to better characterize habitat requirements.

Autecological research is needed for *Physaria saximontana* var. *saximontana* to better define important habitat characteristics and to provide insight as to why many apparently suitable sites are not occupied. Ordination of species associations might identify community types/species closely associated with *P. saximontana* var. *saximontana*. Information on soil chemistry and nutrient relations might yield valuable insights into the ecological requirements of *P. saximontana* var. *saximontana*, which would improve opportunities for effective habitat monitoring and conservation stewardship of this taxon. Physiological ecology studies will help to determine what substrate characteristics are required by *P. saximontana* var. *saximontana*. This is valuable information in the event that a population needs to be restored and for refining models of the potential distribution of the species.

Longevity, rates of reproduction, dispersal, germination, establishment, and the effects of environmental variation and disturbance on these parameters have not been investigated in *Physaria saximontana* var. *saximontana*, limiting the assessment of various management options during project planning. There is no evidence of disturbance-related impacts to *P. saximontana* var. *saximontana*, but an assessment of potential livestock trampling and grazing impacts would verify anecdotal reports that direct threats from these activities are generally low. The possible role of fossorial rodents in the ecology (e.g., herbivory, soil movement, soil nutrients, soil hydrology, etc.) of *P. saximontana* var. *saximontana* has not been examined to date and should be the subject of future research.

Understanding the pollination and breeding ecology of *Physaria saximontana* var. *saximontana* would assist managers by determining the importance of pollinators for reproduction and population genetics. At this time, it is not known how management changes that affect insect visitors will affect *P. saximontana* var. *saximontana*. Another important area of research is assessing possible impacts of livestock grazing on pollinator populations in adjacent areas. Multi-year studies could determine if seed set and reproductive success of *P. saximontana* var. *saximontana* is suppressed by livestock in the general area.

While no invasive species concerns have been noted for *Physaria saximontana* var. *saximontana*, it can be assumed that management changes that promote the spread and abundance of *Bromus tectorum* or other invasive species in the vicinity of *P. saximontana* var. *saximontana* populations will be detrimental. Population monitoring efforts could include occurrences near areas that have been invaded by exotic species. This might allow for tracking of incipient weed encroachment, should it occur in the future, and would provide valuable ecological information and insights into appropriate management strategies.

There has been no research on the population ecology of *Physaria saximontana* var. *saximontana* to determine the importance of metapopulation structure and dynamics to the long-term persistence of *P. saximontana* var. *saximontana* at local or regional scales. Migration of seed and pollen, extinction, and colonization rates are unknown for *P. saximontana* var. *saximontana*, so analyses of local or regional population viability depend on observable trends in individual populations.

Population size has been estimated for some populations of *Physaria saximontana* var. *saximontana*, but not rigorously quantified. In addition, existing knowledge of the distribution of the species is undoubtedly incomplete, and there is no data pertaining to growth, survival, and reproduction rates. As a result, additional field data is necessary before local and range-wide persistence can be assessed with demographic modeling techniques.

There has been no monitoring of *Physaria saximontana* var. *saximontana* populations, but a variety of methods are available that would provide meaningful insights to population trends, including several approaches discussed herein. Collecting information about life history stages can also be useful for slow-growing, long-lived species such as *P. saximontana* var. *saximontana*. For instance, it is not known how many years are required to reach reproductive maturity or how long individuals may live.

Propagation studies were conducted for other *Physaria* species during the early 1990's, but it is unclear how applicable they may be for *P. saximontana* var. *saximontana*, and no attempts have been made to restore populations of *P. saximontana* var. *saximontana* (Grant personal communication 2003).

Collection of additional baseline habitat and community ecology data for existing and future occurrences could provide a better understanding of the absolute habitat requirements and improve the scientific basis for management of *Physaria saximontana* var. *saximontana* in Region 2. This includes collection of detailed eco-data, such as cover class estimates of all associated species, bare ground, soil texture classes, canopy cover, and detailed phenologic data for *P. saximontana* var. *saximontana* (e.g., time of seedling emergence, biomass, flowering period, seed set, ripening, and germination, seedling survival rates, longevity of individual plants, years to reproductive maturity, etc.).

Understanding the genetic structure and demographics of *Physaria saximontana* var. *saximontana* is among the top research priorities for this species on a global scale. An assessment of genetic diversity within and between existing populations would provide valuable insights to metapopulation stability and resilience to stochastic events and future environmental change. Demographic research would have great value for management and conservation purposes. If populations are robust and contain healthy levels of genetic diversity, then demographic studies would help to determine how to maintain them via proper management. If they are not genetically diverse, then awareness of the problem through demographic research would permit development of appropriate management guidelines to address genetic concerns. Some key questions to address include 1) Are populations stable? 2) Do peripheral populations, such as those on the Shoshone National Forest, contain unique alleles? and 3) What is the minimum viable population size for *P. saximontana* var. *saximontana*? Molecular data would reveal much about the population genetics of individual populations as well and might be suggestive of historic distribution patterns.

Genetic studies (e.g., protein analysis, DNA analysis), including an evaluation of phylogenetic relationships with other western *Physaria* might yield useful information. Demographic and genetic analysis of *P. saximontana* var. *saximontana* in relation to other rare local *Physaria* endemics that may reportedly co-occur with *P. saximontana* var. *saximontana*, (i.e., *Lesquerella* (*Physaria*) *fremontii*) might also provide important scientific insights and valuable management information.

The response of *Physaria saximontana* var. *saximontana* to human impacts and disturbance has not been studied. Gaining practical knowledge of how to best manage populations of this species is important to anticipate potential impacts of existing and future land use patterns.

There is presently no research in progress on this taxon. As noted above, basic areas of study that are needed include demography, conservation genetics, pollen cytology, molecular cytogenetics, floral biology, seed viability, and species-environment relationships, including responses to disturbance. Such information would have significant relevance to the conservation and management of *Physaria saximontana* var. *saximontana*.

DEFINITIONS

Aneuploidy — a change in chromosome number amounting to a gain or loss of less than a full set. Often the result of uneven translocation of chromosome arms (Walters and Keil 1996).

Colpi — longitudinal furrows on pollen grains. Grains with three colpi are termed tricolpate (Rollins and Shaw 1973).

Decumbent — reclining or lying on the ground, but with the tip ascending (Walters and Keil 1996).

Monophyletic — in cladistic analysis, a natural taxonomic group composed of ancestral species and *all* of its descendents. Cladistics is a type of analysis of phylogenetic relationships in which taxa are grouped on the basis of shared, derived features. (Walters and Keil 1996).

Paraphyletic — a taxonomic group that includes an ancestral group and some, but not all, of its descendents. In cladistic analysis, such a group is rejected in favor of monophyletic taxa (Walters and Keil 1996).

Parietal placentation — a placentation type found in compound ovaries in which the placental areas are attached to the side walls of the ovary (Walters and Keil 1996).

Polyphyletic — a non-natural taxonomic group hypothesized to have originated from two or more different evolutionary lines; the most recent common ancestor of the two lineages is excluded from the group. Such a taxonomic grouping is generally rejected when it is demonstrated to be polyphyletic and the component taxa are reorganized into monphyletic groups (Walters and Keil 1996).

Polyploid speciation — the origin of a new species through hybridization of two parent taxa followed by doubling of the chromosomes in the offspring. The original hybrid is often highly sterile, but the doubling of the chromosomes restores fertility and genetically isolates the hybrid from both parents (Walters and Keil 1996).

Prostrate — a general term for lying flat on the ground (Walters and Keil 1996).

Pubescent — bearing plant hairs (trichomes) (Walters and Keil 1996).

Replum — the persistent membranous septum in a silique or silicle (Walters and Keil 1996).

Tetradynamous — a condition of the stamens in most Brassicaceae in which four stamens have long filaments and are alternate with the petals, and two stamens have short filaments and are opposite the petals (Walters and Keil 1996).

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