# *Lesquerella parvula* Greene (pygmy bladderpod): A Technical Conservation Assessment

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

**March 21, 2006**

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Peer Review Administered by
Center for Plant Conservation

O'Kane, Jr., S.L. (2006, March 21). *Lesquerella parvula* Greene (pygmy bladderpod): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/lesquerellaparvula.pdf [date of access].

## ACKNOWLEDGMENTS

Sandy Friedley of Ecosphere Environmental Services kindly contacted herbaria and obtained data from the Wyoming Natural Diversity Database. My colleague, Ihsan A. Al-Shehbaz, of the Missouri Botanical Garden, has been instrumental in forming my interpretations of the taxonomy of *Lesquerella/Physaria*. Ben Franklin, of the Utah Natural Heritage Program, obtained information from the University of Utah Herbarium. My graduate student, Ben Grady, supplied some of the DNA sequencing data used in this report. John Proctor, forest botanist with the Medicine Bow-Routt National Forest, kindly provided photographs and information concerning potential impacts to *L. parvula* on the Medicine Bow National Forest.

## AUTHOR'S BIOGRAPHY

Steve L. O'Kane, Jr. is an associate professor of biology at the University of Northern Iowa. Dr. O'Kane worked as the Inventory Coordinator/Botanist of the Colorado Natural Heritage Inventory in the mid-1980's and held seasonal positions in Alaska, Utah, and Colorado working for the USDA Forest Service, the Bureau of Land Management, and the Soil Conservation Service. Dr. O'Kane earned his M.S. degree from the Department of Biology and his B.S. degree from the Department of Range Science, both at Colorado State University. He obtained a Doctorate in Population and Evolutionary Biology from Washington University in St. Louis for his studies of the genus *Lopezia* (Onagraceae). He pursued post-doctoral research at the Missouri Botanical Garden in the genus *Arabidopsis* (Brassicaceae). Current studies focus on the molecular and traditional systematics of the plant family Brassicaceae, especially in *Lesquerella*, which he recently transferred to *Physaria*. Dr. O'Kane is also involved in the Flora of the San Juan Basin Project in the Four Corners area of Colorado, New Mexico, Utah, and Wyoming.

## COVER PHOTO CREDIT

*Lesquerella parvula* (pygmy bladderpod) growing on a sandy ledge near Manilla, Utah and Flaming Gorge Reservoir. Photograph by the author.

# SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *LESQUERELLA PARVULA*

## *Status*

Approximately 50 known occurrences of *Lesquerella parvula* (pygmy bladderpod) are located in two disjunct areas, north-central Colorado and southwestern Wyoming/northeastern Utah. The majority (28) of these occurrences are likely on private land. Approximately 10 occurrences are located in Colorado, with one likely on the Arapaho-Roosevelt National Forest. There are approximately 21 occurrences in southwestern Wyoming, which straddles USDA Forest Service (USFS) Region 2 and Region 4; one of these Wyoming occurrences is likely on the Medicine Bow National Forest (Region 2). Seven occurrences are completely or partially on lands managed by the Bureau of Land Management in Wyoming. In Utah, 10 occurrences are located on Region 4 National Forest System lands, and three occurrences are located within the Flaming Gorge National Recreation Area. No population estimates are available for *L. parvula*. Even in habitat patches where the species is most abundant, it is a minor component of the plant community. There are no population trend data, and no inferences of population trend are provided.

No federal protected areas have been designated that include the conservation of this species or its habitat as an explicit goal. One occurrence on Bureau of Land Management public lands is located on Cedar Mountain, Wyoming, in an Area of Critical Environmental Concern that was established for another plant species, *Thelesperma pubescens*. Because the two species occupy similar habitat, it is likely that management favoring *T. pubescens* would also benefit *Lesquerella parvula*.

NatureServe has assigned *Lesquerella parvula* a global rank of vulnerable with uncertainty (G3?Q), as there was some taxonomic uncertainty about whether the taxon should be recognized as a species or a variety. In Region 2, the Wyoming Natural Diversity Database ranks *L. parvula* as imperiled (S2), and it is not ranked (SNR) by the Colorado Heritage Program, which does not track the species. In Region 4, the Utah Natural Heritage Program ranks *L. parvula* as imperiled (S2). *Lesquerella parvula* is not designated a USFS sensitive species by either Region 2 or Region 4. For Region 2, it is included on the list of species for which insufficient information was available to make a determination regarding whether the species warranted sensitive status.

## *Primary Threats*

*Lesquerella parvula* is a relatively rare species, with only about 50 known occurrences and low population numbers. It is also an endemic species, found in only two disjunct areas, north-central Colorado and southwestern Wyoming/northeastern Utah. These two factors raise concerns about the viability of this species. *Lesquerella parvula* is also at risk environmentally from climate change. Management activities that may threaten the species include impacts to occurrences or habitat from grazing, non-native species, wildfire or prescribed fire, and off-road vehicles.

## *Primary Conservation Elements, Management Implications and Considerations*

As a relatively rare species, *Lesquerella parvula* would be impacted by those activities that directly impact individuals or that result in habitat fragmentation. However, nothing is known about this species' response to disturbance (environmental or anthropogenic). Priorities for determining conservation elements include inventory for additional occurrences; investigation into the species' response to disturbance; determination of threats; development and implementation of monitoring to identify population trends; development and implementation of demographic monitoring; investigation into habitat requirements and interactions with the surrounding plant community; and investigation into pollinators, seed germination, seedling establishment, fruiting success, and dispersal.

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# INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Lesquerella parvula* (pygmy or narrow-leaved bladderpod) is the focus of an assessment because it is a possible species of viability concern in Region 2 due to its limited distribution and the limited number of known occurrences. Species of concern may require special management, so knowledge of their biology and ecology is critical. This assessment may help to clarify the status of *L. parvula* and whether it should be considered for sensitive species status.

Although this report was prepared for USFS Region 2, it addresses the biology and ecology of *Lesquerella parvula* throughout its range, which straddles the border between USFS Regions 2 and 4 (Intermountain Region). The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. This introduction defines the goal of the assessment, outlines the scope, and describes the process used in its production.

## *Goal of Assessment*

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, and conservation status of certain species based on available scientific knowledge. In this assessment, however, some new data are provided. 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. Instead, it provides the ecological background upon which management can be based and focuses on the consequences of changes in the plant's environment that result from management decisions and their implementation.

## *Scope and Information Sources*

This assessment examines the biology, ecology, conservation status, and management of *Lesquerella parvula* with specific reference to the geographic and ecological characteristics of its range in the USFS Rocky Mountain and Intermountain Regions. Although some of the literature on the species may originate from field and laboratory investigations outside the region, this document places that literature in the ecological of the central Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *L. parvula* in the context of the current environment. The historical environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. While there are no refereed publications devoted entirely to *Lesquerella parvula*, it is mentioned in a variety of sources. The refereed and non-refereed literature on the genus *Lesquerella* and its included species is somewhat more extensive and includes many endemic or rare species. Not all publications that include information on *L. parvula* or other *Lesquerella* species are referenced in this assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Given the paucity of refereed material directly pertaining to *L. parvula*, non-refereed publications or reports were used in the assessment, but these were regarded with greater skepticism. Information for this assessment has been gathered mainly from six sources:

1. Herbarium records from the University of Colorado Herbarium (COLO), University of Northern Iowa (ISTC), California Academy of Science (CAS), Grey Herbarium, Harvard (GH), New York Botanical Garden (NY), Field Museum (F), Brigham Young University (BRY), Rocky Mountain Herbarium (RM), Missouri Botanical Garden (MO), Vascular Plant Herbarium, Agriculture Canada (DAO), Natural History Museum, London (BM), Dudley Herbarium, Stanford University (DS), University of Idaho (ID), University of Montana (MONTU), Utah State University (UTC), University of California, Berkeley (UC), and Marion Ownbey Herbarium, Washington State University (WS).

2. Herbarium records reported to the author from the University of Utah by the Utah Natural Heritage Inventory.

3. "Element Occurrence Records" from the Wyoming Natural Diversity Database.

4. Literature sources, especially (Rollins 1939a, b, 1955, 1988, 1993; Rollins and Solbrig 1973).

5. Published and not-yet-published laboratory and herbarium research conducted by Steve L. O'Kane, Jr. and, in part, by Ihsan Al-Shehbaz of the Missouri Botanical Garden (e.g., Al-Shehbaz and O'Kane 2002, O'Kane and Al-Shehbaz 2002, O'Kane 1999, O'Kane and Al-Shehbaz 2004).

6. Field work on *Lesquerella parvula* conducted by O'Kane in June 1996 and August 1999.

### *Treatment of Uncertainty*

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

From necessity, descriptive elements of this report rely largely on inductive logic (observations lead to hypotheses [e.g., because the species grows in areas receiving between *x* and *y* inches of precipitation, that is the preferred range of precipitation]). Any conclusions reached concerning environmental impacts, however, rely on deductive reasoning (hypotheses lead to particular predictions [e.g., if the climate gets drier, then the species will not be able to exist where it currently does]). Another example of deductive reasoning would be that because grazing removes photosynthetic tissue, grazing could potentially weaken a plant. Uncertainty resides most potently, at least in this analysis, in conclusions drawn from deductive reasoning, primarily because the test (experiment) has not been done. For example, no one has tested (or would want to) whether overgrazing would impact the reproductive capacity of natural populations of the species. While well-executed experiments represent a "strong" approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are here accepted as sound approaches to understanding and are used in the syntheses for this assessment.

### *Publication of Assessment on the World Wide Web*

To facilitate the use of species assessments produced by the Species Conservation Project, they are being published on the Region 2 World Wide Web site (see www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More importantly, Web publication facilitates revision of the assessments, 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 assessment 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*

*Lesquerella parvula* occurs on both private and public lands in two disjunct areas in north-central Colorado and southwestern Wyoming/northeastern Utah (**Table 1**). Within Colorado, one occurrence of *L. parvula* is likely to occur on the Arapaho-Roosevelt National Forest while nine are probably located on private land. In Wyoming land ownership of some of the occurrences has been verified, as reported in nine Element Occurrence Records (EORs) of the Wyoming Natural Diversity Database. One occurrence is located on the Medicine Bow National Forest (Region 2). Four Wyoming occurrences are entirely in the Rock Springs Resource Area (RA) of the Bureau of Land Management (BLM); one is on both the Rock Springs RA and State of Wyoming land; one straddles the Rock Springs RA–Kemmerer RA boundary; one is on the Kemmerer RA; ownership of the land where one occurs is unknown.

**Table 1.** Locations of known occurrences of *Lesquerella parvula*.

| State | Surface Management[1] | Data Source (Herbaria acronyms as given in Holmgren et al. 1990)[2] |
|---|---|---|
| Colorado | Arapaho-Roosevelt NF | Ripley & Barneby 10489 (CAS, GH, NY) |
| Colorado | Private | Mulligan & Mosquin 2767 (DAO) |
| Colorado | Private | Salywon & Dierig 3110 (ISTC); Rollins 7946 (COLO) |
| Colorado | Private | Rollins 7946 (COLO, F, BM, BRY) |
| Colorado | Private | Osterhout 3260 (DS, RM) |
| Colorado | Private | Patterson 1876 Holotype: ND-G; Isotypes F, MO, NY, GH, US; O'Kane & O'Kane 4551 (ISTC) |
| Colorado | Private | O'Kane & O'Kane 4553 (ISTC) |
| Colorado | Private | Weber & Dahnke 17835 (COLO) |
| Colorado | Private | Ripley & Barneby 10487 (GH, NY) |
| Colorado | Private | O'Kane & O'Kane 4554 (ISTC) |
| Utah | Private | Harrison & Nisson 8784 (BRY) |
| Utah | Ashley NF | Holmgren & Holmgren 5046 (COLO, ID) |
| Utah | Ashley NF | Harrison & Larsen 7892 (MO) |
| Utah | Wasatch NF | Rollins & Rollins 79145 (F) (GH) |
| Utah | Wasatch NF | Rollins & Rollins 8659 (UTC, NY, BM, MONTU); Rollins & Rollins 79145 (NY) |
| Utah | Wasatch NF | M.D. Windham 2723 (UT) |
| Utah | Wasatch NF | Neese & Welsh 7856 (UTC) |
| Utah | Wasatch NF | O'Kane 3781 (ISTC, GH) |
| Utah | Wasatch NF | M.A. Franklin 7373 (BRY) |
| Utah | Wasatch NF | Huber & Plunkett 138 (NY) |
| Utah | Flaming Gorge NRA | R.C. Barneby 14,375 (CAS) |
| Utah | Ashley NF | S. Goodrich 25184 (BRY) |
| Utah | Private | Rollins & Rollins 8662 (NY) |
| Utah | Flaming Gorge NRA | Barneby 14375 (CAS, NY); Holmgren & Holmgren 5046 (NY) |
| Utah | Flaming Gorge NRA | Ripley & Barneby 7910 (NY) |
| Utah | Private | Holmgren & Tillet 9515 (NY, UC, UTC) |
| Utah | Private | J. Scott Peterson & Elizabeth Neese 740 (CS) |
| Utah | Private | R.C. Barneby 13,177 (CAS) |
| Utah | Private | O'Kane 3782 (ISTC) |
| Wyoming | BLM Rock Springs Field Office/State of Wyoming | WYNDD Record 009; Refsdal 1426 (RM) |
| Wyoming | BLM Rock Springs Field Office | WYNDD Record 007; Refsdal 557 (RM) |
| Wyoming | Private | Rollins & Munoz 2902 (DS) |
| Wyoming | Private | Rollins & Rollins 8664 (NY); Rollins & Rollins 8665 (UTC, NY, GH) |
| Wyoming | Private | Rollins 5133 (GH) |
| Wyoming | Private | Reed Rollins 3079 (DS) |
| Wyoming | Medicine Bow NF W | WYNDD Record 002; Location approximate; Osterhout 1104 (RM); Nelson 16205 (RM) |
| Wyoming | Private | Reed Rollins 1686 (DS) |
| Wyoming | Private | Rollins 1686 (DS, GH, MO, NY, UC, UTC, WS) |
| Wyoming | BLM Rock Springs Field Office | Reed Rollins 2302 (DS, GH) |

**Table 1 (concluded).**

| State | Surface Management[1] | Data Source (Herbaria acronyms as given in Holmgren et al. 1990)[2] |
|---|---|---|
| Wyoming | Private | WYNDD Record 006; Refsdal 507 (RM); Rollins 1684 (RM, NY, GH, WS) |
| Wyoming | Private | Refsdal 507 (UTC) |
| Wyoming | BLM Kemmerer Field Offices | WYNDD Record 010; Heidel s.n. (RM) |
| Wyoming | BLM Rock Springs Field Office | Fertig 18369 (NY) |
| Wyoming | BLM Rock Springs/Kemmerer Field Offices | Rollins & Rollins 8667 (NY) |
| Wyoming | BLM Rock Springs Field Office | WYNDD Record 001; Goodrich & Atwood 17192 (BYU, RM) |
| Wyoming | Private | S. Goodrich & D. Atwood 17192 (GH) |
| Wyoming | Private | WYNDD Record 008; Fertig 14898, 14907, 14909 (RM); Refsdal 704, 992 (RM) |
| Wyoming | Private | WYNDD Record 003; Christenson 156 (RM); Aldrich 384 (RM) |
| Wyoming | Private | WYNDD Record 005; Dueholm 10422 (RM) |
| Wyoming | Private | Rollins & Rollins 8673, 8674 (NY, GH) [Probably Sage Creek Mtn., NOT Hickey Mtn. as given on the label] |

[1]**NF** = National Forest and **NRA** = National Recreation Area

[2]**Herbaria acronyms**:

| | |
|---|---|
| (BM) | Natural History Museum, London |
| (BRY) | Brigham Young University |
| (CAS) | California Academy of Science |
| (COLO) | University of Colorado Herbarium |
| (DAO) | Vascular Plant Herbarium, Agriculture Canada |
| (DS) | Dudley Herbarium, Stanford University |
| (F) | Field Museum |
| (GH) | Grey Herbarium, Harvard |
| (ID) | University of Idaho |
| (ISTC) | University of Northern Iowa |
| (MO) | Missouri Botanical Garden |
| (MONTU) | University of Montana |
| (NY) | New York Botanical Garden |
| (RM) | Rocky Mountain Herbarium |
| (UC) | University of California, Berkeley |
| (UTC) | Utah State University |
| (WS) | Marion Ownbey Herbarium, Washington State University |

Currently, *Lesquerella parvula* has no official status with any federal, state, or local agency (**Table 2**). It has a global heritage status rank of G3?Q (vulnerable to extirpation or extinction with distinctiveness of this entity as a taxon at the current level listed as questionable), a state heritage status rank of S2 (imperiled) in Wyoming and Utah, and it is not ranked (SNR) in Colorado (**Table 2**; NatureServe Explorer 2004).

## *Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies*

*Lesquerella parvula* is not listed as threatened, endangered, sensitive, or species of special concern by any federal or state agency. It was not listed as a sensitive species by USFS Region 2 on the 1993 Species list (USDA Forest Service 2002), and it is not included

**Table 2.** Status of *Lesquerella parvula* at global, national, federal, and state levels.

| Status | Source of Ranking | Rank |
|---|---|---|
| Global | NatureServe Explorer (2004) | G3?Q – vulnerable to extirpation or extinction (G3), status not exact (?), questionable taxonomy (Q) |
| | National NatureServe Explorer (2004) | N? – status not determined |
| Federal | U.S. Fish and Wildlife Service | not listed |
| | USDA Forest Service Region 2 | not listed – insufficient information for determination[1] |
| | USDA Forest Service Region 4 | not listed |
| | Bureau of Land Management | not listed |
| State | Wyoming Natural Diversity Database | S2 – imperiled |
| | Colorado Natural Heritage Program | SNR - not currently ranked |
| | Utah Natural Heritage Program | S2 – imperiled |

[1]Species Conservation Project: Species Evaluations and Rationales. Website: http://www.fs.fed.us/r2/projects/scp/evalrationale/index.shtml.

as a sensitive species on the 2005 list due to insufficient information (USDA Forest Service 2005). The species is not currently the focus of any special management with the exception of the occurrence that straddles the BLM Rock Springs–Kemmerer Resource Areas. This occurrence is located on Cedar Mountain in the Special Status Plant Area of Critical Environmental Concern that was established, in part, because it contains the BLM Special Status plant *Thelesperma pubescens* (USDI Bureau of Land Management 1997). Because the two species occupy similar habitats, it is likely that management favoring *T. pubescens* would also favor *L. parvula*. Should *L. parvula* prove to be at risk, however, additional measures would likely be needed to ensure its survival in a significant portion of its limited range.

## *Biology and Ecology*

### Systematics and classification

H.N. Patterson apparently first discovered this species on July 29, 1876, on the "summit of Mt. Bross, Middle Park," Grand County, Colorado. Greene (1901) originally described the material collected by Patterson as *Lesquerella parvula*. Payson (1922) continued to recognize the taxon at the species level in his monograph of the genus. Rollins and Shaw (1973) decided that the taxon was better recognized at the subspecific level as *L. alpina* ssp. *parvula*. Welsh and Reveal (1978) concurred that the taxon should be recognized at the infraspecific level, but they thought the varietal rank more appropriate, *L. alpina* var. *parvula*. After further field work and study, Rollins (1993) reversed his previous conclusions and again recognized *L. parvula* at the species level.

So things remained until O'Kane began his studies in the genera *Lesquerella* and *Physaria* of the Brassicaceae (Cruciferae) family. As early as Payson's monograph (1922), there was doubt that these two genera could be justified as distinct. In Payson's words, "so striking, indeed, is this similarity that one is a little perplexed at times to know to which genus a given plant should be referred." Even Rollins and Shaw (1973) state, "the bridge connecting the two genera is nearly complete." As of yet unpublished studies by O'Kane using DNA sequences of ribosomal DNA have shown conclusively that the genus *Physaria* evolved from within the genus *Lesquerella*. In other words, *Lesquerella* is paraphyletic. In light of the fact that *Lesquerella* contains many more species than does *Physaria*, O'Kane et al. (1999) proposed that the species of *Physaria* be transferred to *Lesquerella*. Upon rejection of this proposal, O'Kane and Ihsan-Al-Shehbaz made the more numerous transfers from *Lesquerella* to *Physaria* (Al-Shehbaz and O'Kane 2002, O'Kane and Al-Shehbaz 2002).

The question remains as to whether the entity should be recognized as an infraspecific taxon of *Lesquerella* (now *Physaria*) or at the specific rank. In gross morphology, the taxon resembles *L. alpina* (*P. reediana*) and its allies such as *L. subumbellata* and *L. condensata* (*P. nelsonii*). In preparation for this report, O'Kane obtained additional DNA sequences of *L. parvula* and added them to a growing analysis of the genus (O'Kane unpublished). This work produced the surprising result that indicated that *L. parvula* is not necessarily closely related to *L. alpina* and its allies. **Figure 1** shows a pruned phylogenetic tree generated from this *preliminary* study, which illustrates *L. parvula*'s relationship to these species. Note that *L. parvula* is in a group distinct from *L. reediana* (*L. alpina*).

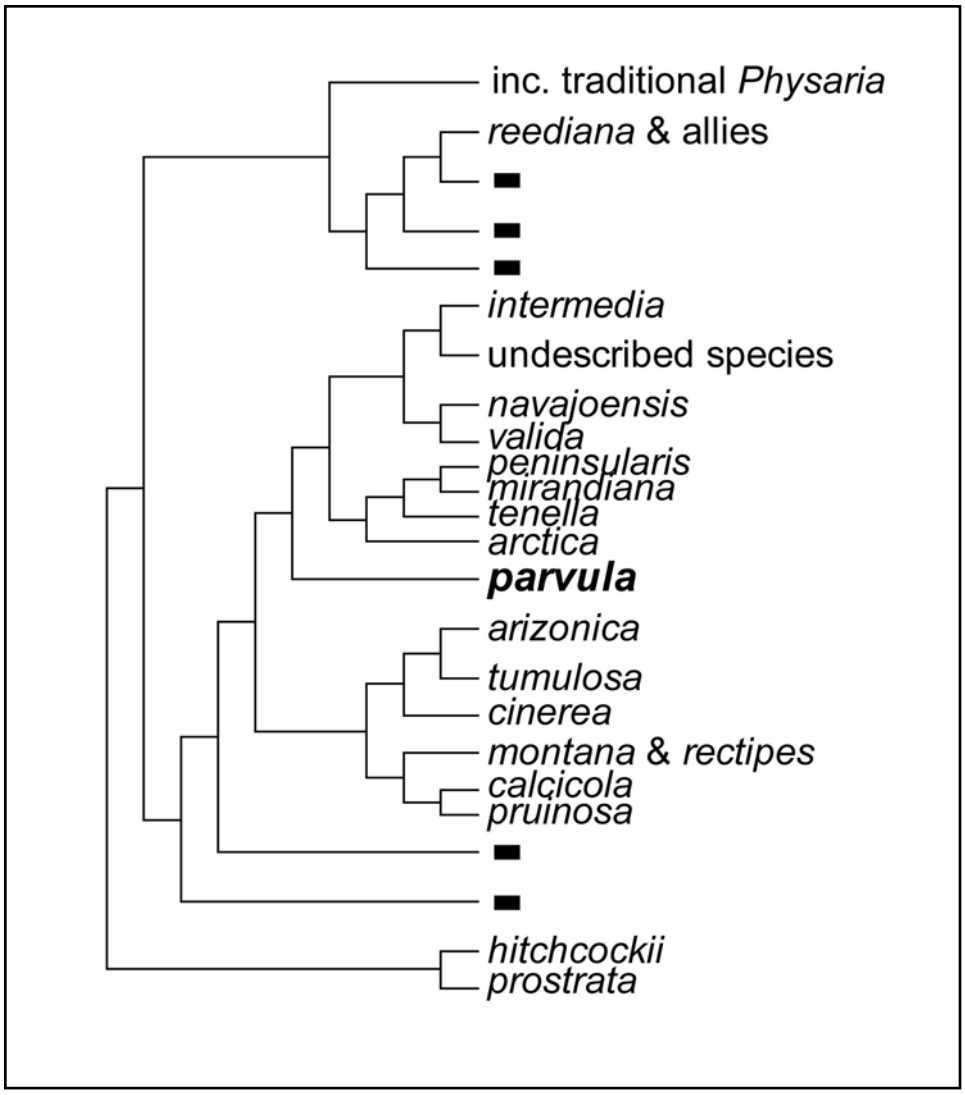


**Figure 1.** The phylogenetic neighborhood of *Lesquerella parvula*. The tree is from a Bayesian analysis of DNA sequences. Filled rectangles represent several species.

In conclusion, the species originally discovered by Patterson is best named *Physaria parvula* (Greene) O'Kane & Al-Shehbaz (*Lesquerella parvula* [Greene] in this report and in the PLANTS database). **Table 3** summarizes the classification of the species. As currently circumscribed, the genus *Physaria* contains 103 species (Al-Shehbaz and O'Kane 2002, O'Kane and Al-Shehbaz 2004) and numerous infraspecific taxa and excludes the auriculate-leaved species previously in *Lesquerella* from the southeastern United States that are currently placed in the genus *Paysonia* (O'Kane and Al-Shehbaz 2002).

## Species description

*Lesquerella parvula* is a small, densely pubescent, caespitose (tufted) perennial. The more windswept and harsh the site, the more condensed and tufted individual plants become. The plant is essentially entirely covered with 4– to 7–rayed stellate trichomes, which cause it to appear grey-green in color. The caudex, at least in older plants, is branched and resides just below the soil surface. Stems can be few to many, 3 to 15 cm (1.2 to 5.9 inches) tall, and are unbranched except for the pedicels leading to flowers and fruits. Stems arise from a tuft of basal leaves. The numerous basal leaves and the few stem leaves are nearly unique in the genus, being 1 to 3 cm (0.4 to 1.2 inches) long and linear, 1 to 2 mm (0.04 to 0.08 inches) wide with not even a hint of differentiation between the petiole and the blade. There are four sepals, greenish yellow and pubescent; petals are deep yellow, narrowly clawed, and 5 to 6 mm (0.20 to 0.24 inches) long. The four petals project straight out of the flower or reflex slightly; they seem not to become strongly

**Table 3.** Classification of *Lesquerella parvula*.

| | |
|---|---|
| **Family:** | Brassicaceae Burnett |
| | **Synonym:** Cruciferae A. L. Jussieu |
| **Genus:** | *Physaria* (Nuttall Ex Torrey & A. Gray) A. Gray |
| | **Synonym:** *Lesquerella* Watson |
| **Species:** | *Physaria parvula* (Greene) O'Kane & Al-Shehbaz |
| | **Synonyms:** *Lesquerella parvula* Greene; *Lesquerella alpina* (Nuttall ex Torrey & A. Gray) S. Watson ssp. *Lesquerella parvula* (Greene) Rollins & Shaw; *Lesquerella alpina* (Nuttall ex Torrey & A. Gray) S. Watson var. *parvula* (Greene) Welsh & Reveal |
| **Verncular Name:** | narrowleaved bladderpod |
| **Type:** | United States. Colorado. Grand County. Summit of Mt. Bross, Middle Park, 1901, *Patterson 1876* (holotype: ND-G; isotypes F, MO, NY, US) |

reflexed or bent at maturity giving the flower a "closed" appearance. The fruiting pedicels curve upward or often become sigmoid (S–shaped). The fruits (siliques) are erect, 3.5 to 4.5 mm (0.14 to 0.18 inches) long, with a relatively long style 2 to 4 mm (0.08 to 0.16 inches) long, and are ovoid to longer than broad with an acute apex that is slightly flattened on the margins. Ovules are two to four per locule, but in specimens examined by O'Kane mature fruits contain only two seeds, one per locule. Seeds are brown, wingless, and form a thin mucilaginous halo when wetted. Chromosome numbers are $n = 5, 10$; $2n = 10$. **Figure 2** shows a plant in flower. The photograph in **Figure 3** illustrates a plant in fruit.

Due to its very narrow leaves, this species is not likely to be confused with any other species of *Lesquerella* in the area. *Lesquerella* intermedia of southern Utah, northern Arizona, and northwestern New Mexico also has narrow leaves, but it does not grow anywhere near *L. parvula*. Occasionally an individual of *L. alpina* ssp. *alpina* has leaves nearly this narrow and could possibly be found growing in the area. The leaves of *L. alpina*, however, are never truly linear; rather they can be narrowly spatulate. Upon close examination (20–30X), the trichomes of *L. alpina* have rays that are slightly fused at the base, whereas *L. parvula* has rays that are distinct to the base. *Lesquerella condensata* also grows in the region, but this species is very diminutive and compact and has obvious widely-spreading trichomes on the siliques that make them look minutely fuzzy.

## Distribution and abundance

*Lesquerella parvula* is found primarily in the Wyoming Basin Ecoregion, with a few records also found in the Wasatch-Uintah Mountains Ecoregion (U.S. Environmental Protection Agency 2003). Occurrences on the eastern-most edge of its range in Colorado may be in the Southern Rocky Mountains Ecoregion. Distribution is based on careful mapping of herbarium specimens. Land ownerships of the Colorado, Wyoming, and Utah occurrences (specimen collections) are given in **Table 1**. This provides general information as to location but requires on-site verification.

All known occurrences are in one of two disjunct groups: in north-central Colorado and southwestern Wyoming/northeastern Utah (**Figure 4**). No information is available as to why the occurrences are disjunct. However, the intervening area has large stretches of habitat that are drier than the areas occupied by *Lesquerella parvula*.

There are approximately 21 occurrences in Wyoming (one likely on the Medicine Bow National Forest and seven completely or partially on lands managed by the BLM). Of the approximately 10 occurrences in Colorado, one is likely on the Arapaho-Roosevelt National Forest while the other ownerships are unresolved. Within Utah, approximately seven of the 19 known occurrences are on the Wasatch National Forest, and three occurrences are on the Ashley National Forest. Three Utah occurrences are in the Flaming Gorge National Recreation Area. Additional occurrences are likely to be found with intensive field surveys.

Based on observations (O'Kane), the species is never abundant, even locally. Even in those habitat patches where the species is most abundant, it is a minor component of the community, growing in the most barren areas between rocks and other plants. No occurrence censuses are available, and records from the Wyoming Natural Diversity Database (2004) describe occurrence densities as "local" or "low" at known sites.

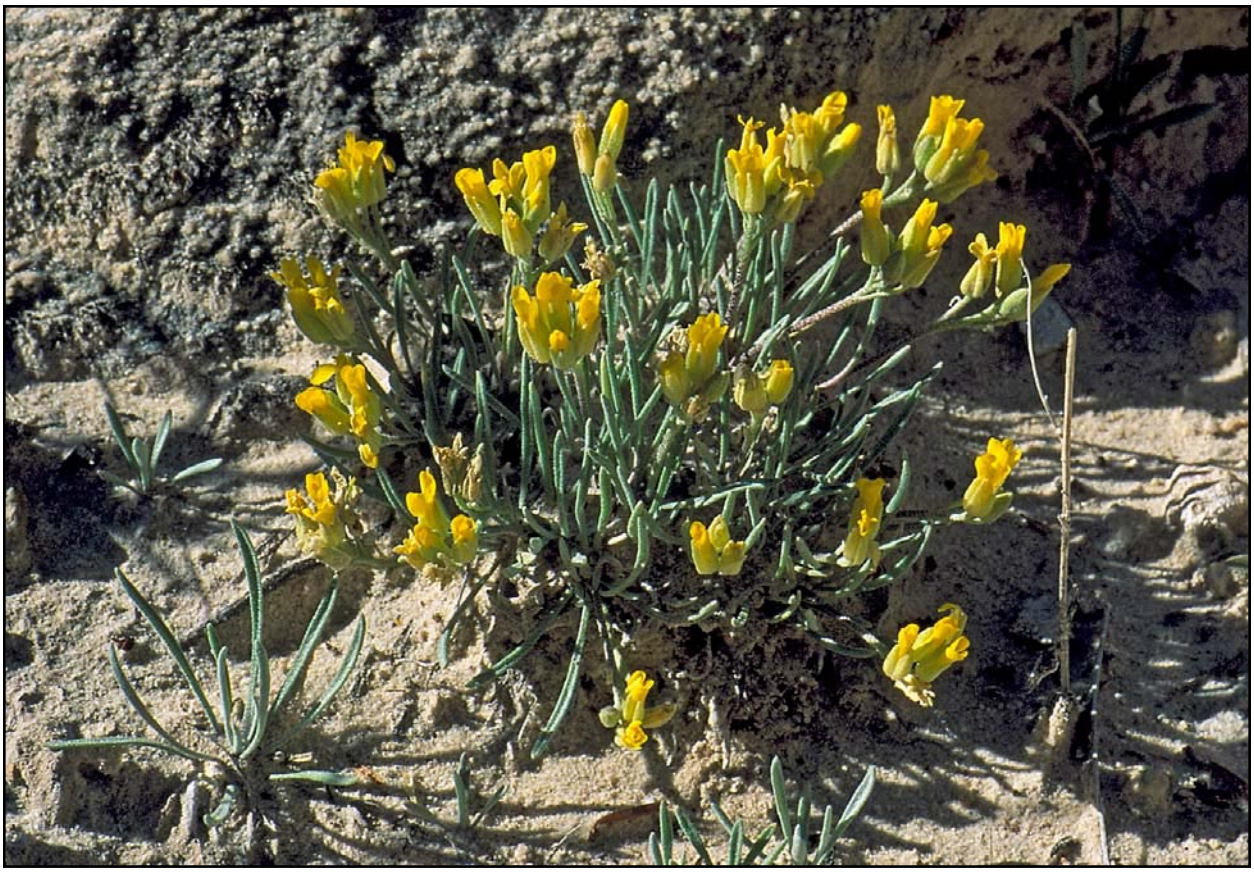

**Figure 2.** *Lesquerella parvula* in flower. Seedlings and young plants are seen below and to the left of the mature plant. Photo taken 3 June 1996 in northeastern Utah by the author.

## Population trend

No data are available to indicate whether the known occurrences of *Lesquerella parvula* are experiencing fluctuations in survival or recruitment. A few historical occurrences were relocated in 1996 and 1999. However, these sites were relocated with the intention of obtaining study material and not to obtain census information.

## Habitat

*Lesquerella parvula* is principally a plant of sagebrush and mountain shrub communities, where it occupies the open areas between other plants. Some localities, especially on knoll-tops and ridges, are windswept and fairly barren. In the Colorado portion of its range, the species ranges in elevation from 2,280 to 2,750 m (7,500 to 9,000 ft.) and occurs on slopes, ridges, and seleniferous knolls with sagebrush (*Artemisia tridentata* and *A. frigida*). Species of *Chrysothamnus* (rabbitbrush), *Purshia* (bitterbrush), and *Elymus* (wheatgrass) may also be present. In southwestern Wyoming and northwestern Utah, the species also occupies knolls, slopes, and ridges at elevations on average slightly lower than in Colorado (1,830 to 2,700 m [6,000 to 8,900 ft.]). *Lesquerella parvula* in this area typically occurs with one or more species of *Juniperus* (juniper), *Artemisia*, *Chrysothamnus*, and *Amelanchier* (serviceberry). One record mentions the presence of *Pseudotsuga menziesii* (Douglas-fir). A record from Wasatch County, Utah is given as "10,400 ft elev., exposed windswept ridges" (*S. Goodrich 14599*, BYU). *Lesquerella parvula* is never a community dominant.

**Figure 5** and **Figure 6** summarize the monthly precipitation and temperature data from three climate stations in the range of the species (Hot Sulphur Springs, Colorado; Grand Lake SW, Colorado; and Manilla, Utah). Data are available on-line from the Western Regional Climate Center (http://www.wrcc.dri.edu/index.html). At all localities, there are two precipitation peaks, one in May, and another in July and August. It appears that the bulk of precipitation, then, is in the form of rain. The temperature peaks in July during the wettest part of the summer. These data indicate that the

**Figure 3.** *Lesquerella parvula* in fruit. In this specimen the sigmoid pedicels are clearly visible as is the linear shape of the leaves. Photo taken 12 August 1999 in north-central Colorado at the type locality by the author.

Utah occurrences receive somewhat less precipitation and have somewhat higher temperatures than do the Colorado occurrences.

## Reproductive biology, ecology, and demography

No specific studies on the reproductive biology, ecology, or demography of *Lesquerella parvula* have been conducted. Statements about the species, then, are presumptive and are based primarily on the general literature for the genus, especially the most complete modern monograph (Rollins and Shaw 1973), and on personal observations of this and many other species of the genus. Given that *L. parvula* is perennial and can inhabit harsh sites that other plants apparently cannot tolerate, it can be characterized as a stress-tolerant species (Grime 1979, Barbour et al. 1999).

While sporophytic, self-incompatibility is known and probably common in the genus (Bateman 1955, Sampson 1958, Dierig et al. 1996); self-compatibility is also present. It is not known whether this species is self-compatible. Interspecific hybridization is believed to be uncommon (Rollins 1954, Rollins 1957, Rolllins and Shaw 1973, Rollins and Solbrig 1973), but molecular data show that at least some species are the product of past allopolyploidy (O'Kane unpublished); at present, however, these data do not indicate interspecific hybridization in *Lesquerella parvula*. O'Kane's observations on pollinators mirror those of Rollins and Shaw (1973) for the genus as a whole: plants are visited by various insects, but mostly by bees, flies, and butterflies. **Figure 7** illustrates a generalized life cycle for the species including its phenology. Members of the genus do not propagate asexually but live for an extended period of time; this strategy allows populations to survive periods of poor seed set and/or germination.

Although the number of ovules per locule ranges from two to four (Rollins 1993), it has been observed that mature fruits contain only one seed per locule (i.e., two seeds per fruit; O'Kane personal observation 2005). A typical plant has approximately 75 mature fruits, which may yield 150 seeds per plant. Seed set is probably higher, as was shown for *Physaria fendleri* (Roll et al. 1997), when population densities are higher.

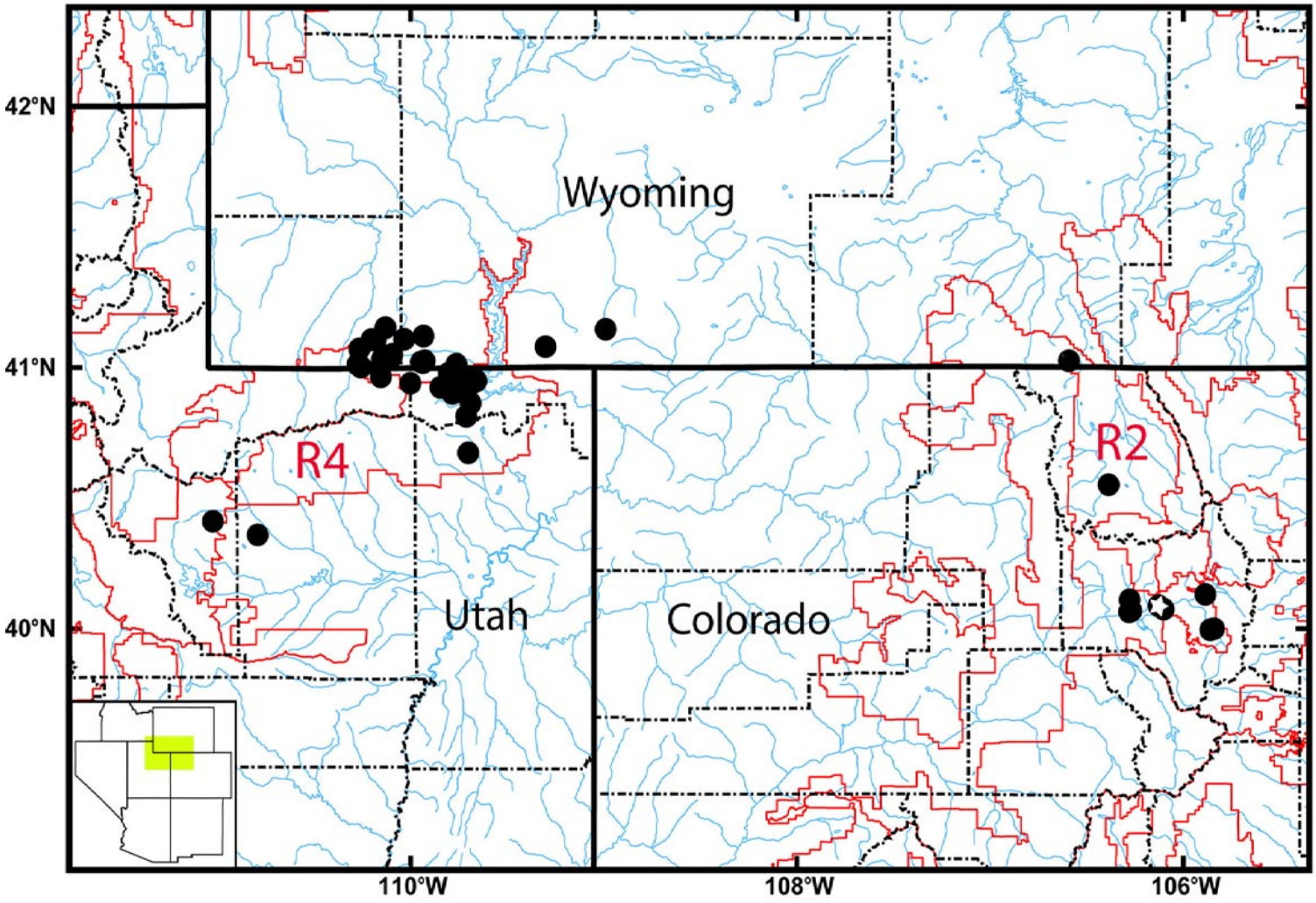


**Figure 4.** Known locations for *Lesquerella parvula*. The location marked with a white star is the type locality. Red lines indicate administrative boundaries of national forests in USDA Forest Service Region 2 and 4; dashed lines are county boundaries; the wide line indicates state boundaries; and blue lines are drainages.

This is likely a result of enhanced pollinator attraction. Germination percent for wild *Lesquerella ludoviciana* has been reported as 20 to 66 percent (Beach et al. 2001). If *L. parvula* falls within this range, then approximately 30 to 99 viable seeds may be produced per plant per season. Longevity in the seed bank, however, is unknown. Curiously and unexpectedly, in a study of seed banks of *P. fendleri*, seeds in the soil had *less* genetic heterozygosity than did living, surface plants (Cabin et al. 1998).

Under natural conditions, mortality is probably low for vegetative, flowering, and fruiting plants. Most mortality is seen in seeds and seedlings. Seed losses are from several sources. Some seeds are not viable to begin with. Some are probably lost to seed predators. Others may be removed from the site into unsuitable habitat through wind, water, or animal activity. Other seeds may be dispersed into nearby, suitable habitat; in *Lesquerella fendleri*, nearly all seeds from a given plant remain within 1 m (3.3 ft.) of the maternal plant (Cabin 1996). Surviving seeds either enter the seed bank or soon germinate. The bulk of seeds entering the seed bank are eventually lost to "old age"; however, Cabin (1996) found that *L. fendleri* seeds can persist in a viable condition for at least three years in the soil. Some small percentages of those that seeds germinate eventually enter the breeding population. Few young reproductive plants are seen in natural populations.

O'Kane (personal observation 2005) tested the seeds of this *Lesquerella parvula* for the presence of mucilage upon wetting and found that each seed forms a small halo of mucilage after a few hours of imbibing

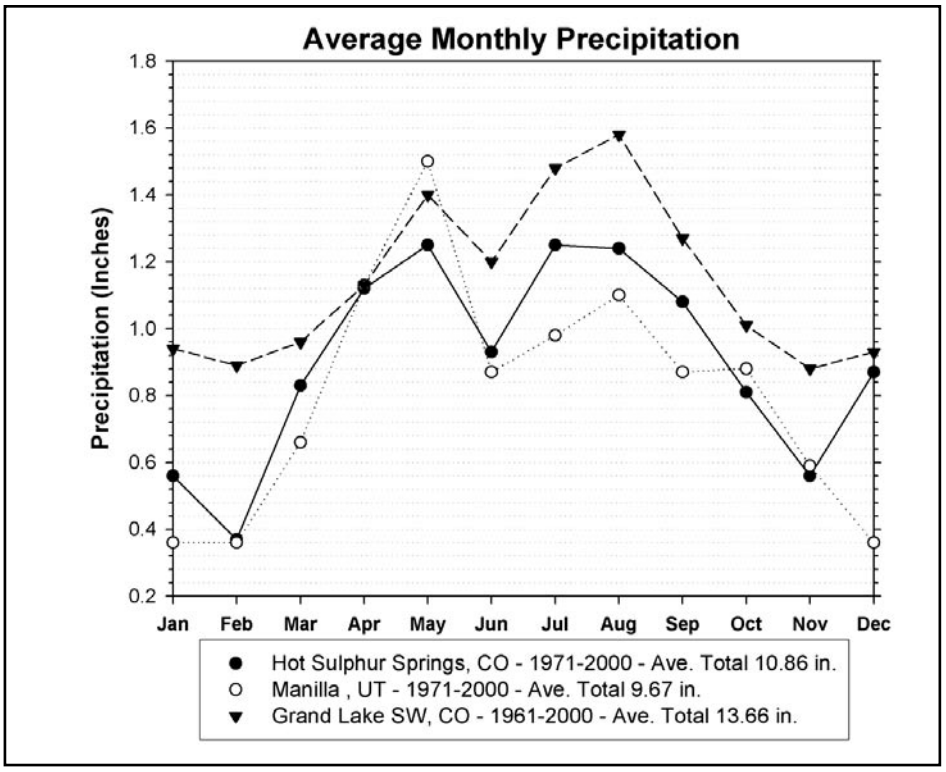


**Figure 5.** Average monthly precipitation for three climate stations within the range of *Lesquerella parvula*.

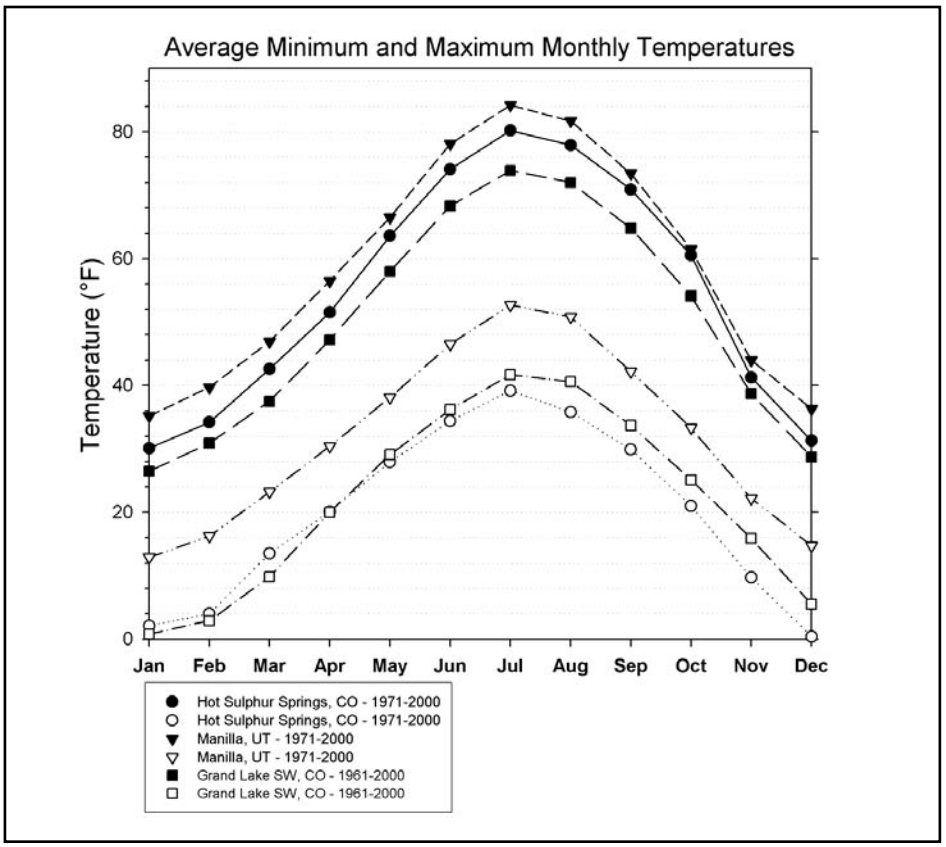


**Figure 6.** Average minimum and maximum monthly temperatures for three climate stations within the range of *Lesquerella parvula*.

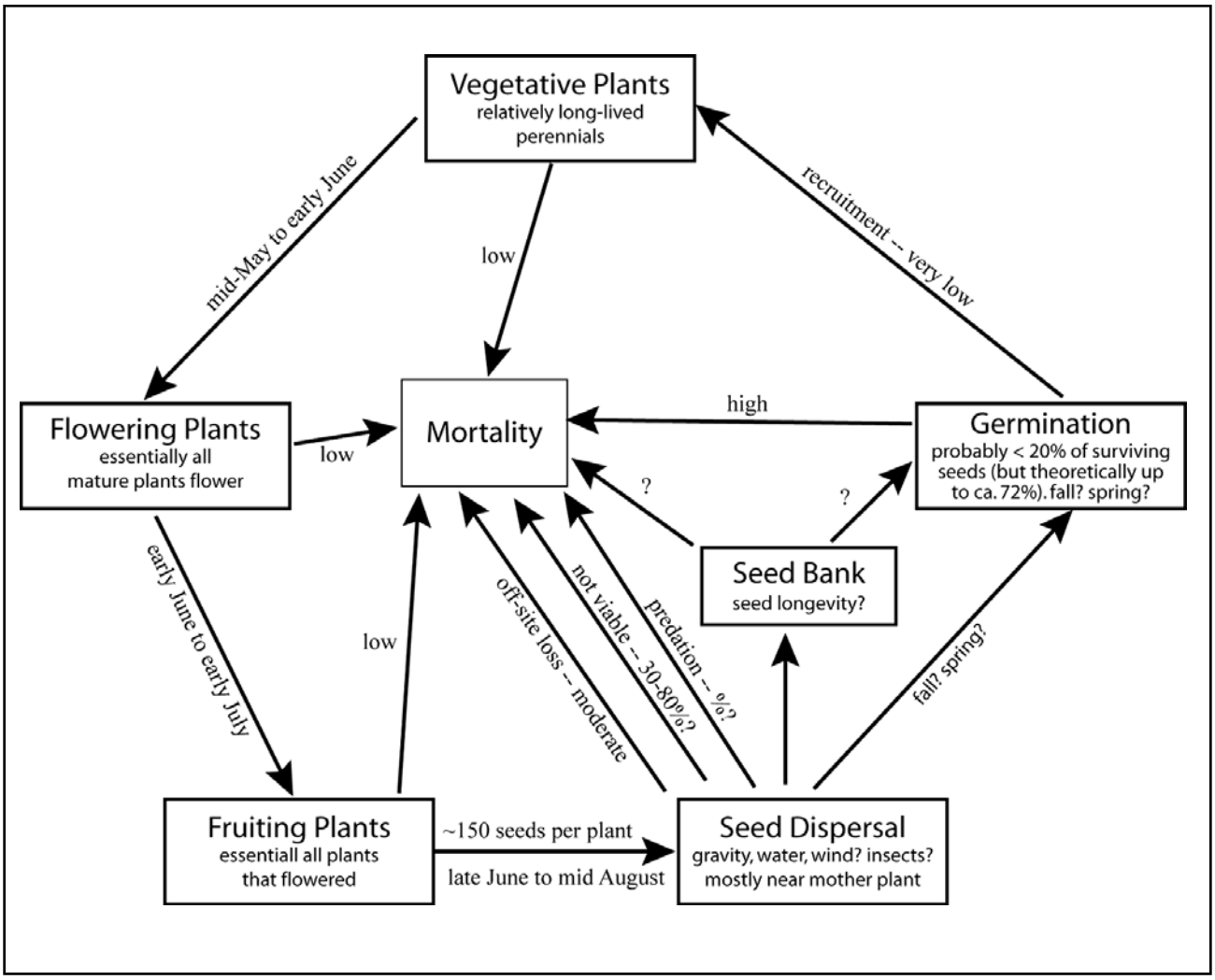


**Figure 7.** Generalized life cycle for *Lesquerella parvula*.

water. Of those members of the genus that inhabit the most inhospitable sites, especially those that occupy slopes, nearly all have this mucilage coat. Presumably, the mucilage is an adaptation for both water absorption/ retention through the hygroscopic nature of the mucilage and as a mechanism to remain on-site. The mucilage coat is sticky and will readily adhere to the substrate, eventually gluing the seed in place as the soil dries out.

**Figure 8** presents an envirogram (Andrewartha and Birch 1984) constructed to represent the biotic and abiotic factors impinging on the growth, reproduction, and establishment of *Lesquerella parvula*. Moving from right to left in this flow chart are factors that directly affect the species to those that have indirect impacts. For example, plants do not respond to regional climate, but they do respond to soil moisture that is, in part, affected by regional climate. Mycorrhizal relationships are not indicated on the diagram because members of the plant family Brassicaceae are unusual in that no mycorrhizal relationships have been reported (Paszkowski et al. 2002).

A Population Viability Analysis (PVA) is a rigorous quantitative analysis that uses demographic data to predict the future status of a given species. One result of a PVA that can provide useful information for management purposes is the minimum viable population (MVP), or the minimum population size necessary to have an acceptably low extinction probability. It has been suggested that demography is of more immediate importance than genetics in determining the MVP of a plant population (Landes 1988, Menges 1991). Menges (1991) suggests that if a plant population is able to buffer environmental stochasticity, then the population will be sufficient to protect its genetic integrity. A literature search for Population Viability Analysis

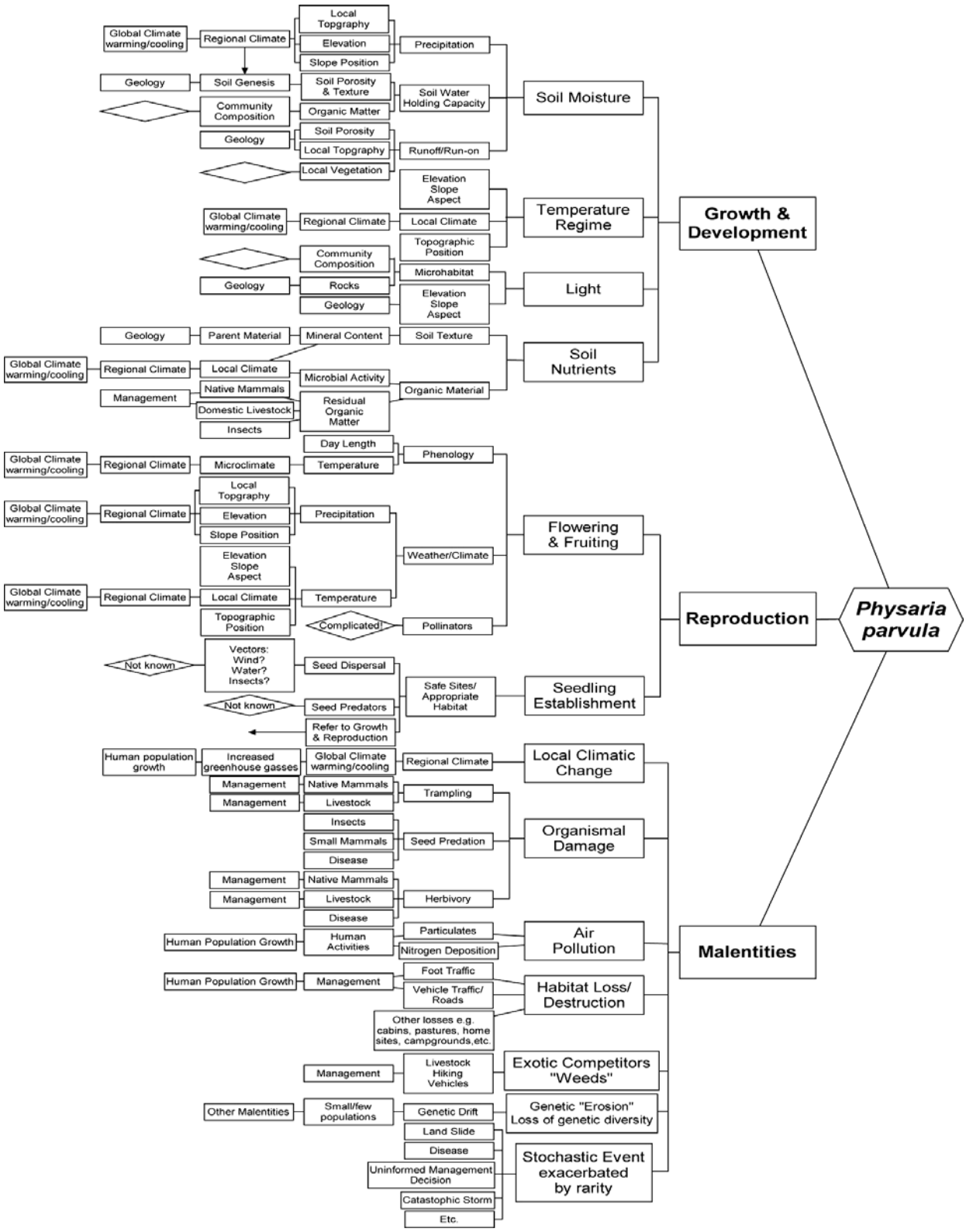


**Figure 8.** A generalized envirogram for *Lesquerella parvula*.

(PVA) models for this species was performed. No PVA has been accomplished or MVP has been determined for *Lesquerella parvula* at this time.

# CONSERVATION

## *Threats*

Given that there are no completed, in-depth surveys for *Lesquerella parvula*, it is difficult to ascertain specific threats. Potential threats, therefore, are primarily based on direct and indirect changes in local conditions that can be deduced from the envirogram presented in **Figure 8** and from the major threats that have been identified for other rare species (Wilcove et al. 1998).

### Rarity and "Genetic Erosion"

Rabinowitz (1981, Rabinowitz et al. 1986) developed a classification of seven forms of rarity based on a species' geographic range (narrow vs. wide), habitat specificity (restricted vs. broad), and local population size (somewhere large vs. everywhere small). *Lesquerella parvula* occupies a relatively restricted range centered on two areas: north-central Colorado and southwestern Wyoming/northeastern Utah. Its geographic range is "narrow." The species occupies only a small fraction of the habitats in its geographic range, and even there only on the most barren spots. Habitat specificity, then, is "restricted." In no cases are local occurrence sizes large. Population size is therefore "everywhere small." Many species are known that have yet smaller ranges and yet smaller population sizes. In **Figure 9**, the species' rarity is plotted in a three dimension space with range, habitat specificity, and local population size as the three axes.

Its own rarity should be considered a threat to *Lesquerella parvula* in that stochastic phenomena can drastically affect a species. A landslide, a local disease, an uninformed management decision, natural fluctuations in demography, insufficient pollinator attraction, to name but a few possibilities, can all lead to the loss of one or more populations. This phenomenon has been called "Rarity Unto Death" (Quammen 1996).

Small population size *may* lead to a loss of genetic diversity through genetic drift, which is yet another stochastic phenomenon associated with rarity (Ellstrand and Elam 1993). However, it should be noted that rare species are not necessarily genetically depauperate (Stebbins 1980, Karron 1991, Gitzendanner and Soltis 2000). If, however, genetic diversity is compromised, some rare plants are known to be negatively affected in the areas of reproduction and survival (Fenster and Dudash 1994, Weller 1994). The current status of this species' genetic heterozygosity is not known. Consequently, it is not known whether *Lesquerella parvula* is a species in which low genetic diversity is a chronic condition or if it is one in which erosion of diversity could have drastic effects.

### Prescribed or natural fire

The effects of fire are known to be variable and spatially heterogenous, depending on a myriad of factors such as placement of perennating buds, community composition, time of day, water status, and exotic species invasion following fire (Brown and Smith 2000). A bibliography of fire effects on threatened and endangered species can be found in Hessl and Spackman (1995) and on plant species in general in Brown and Smith (2000). No references specifically concerning *Lesquerella parvula* were identified in these or any publications examined. **Table 4** lists general mechanisms that enable plants to survive fire (Steuter and McPherson 1995), but there is no information specifically concerning *L. parvula*'s response to fire at any life stage.

*Lesquerella parvula* occupies relatively barren areas and is a hemicryptophyte, so fire is not likely to be a large direct threat. On the Medicine Bow National Forest, an occurrence of this species is located in a sparsely vegetated plant community with other "cushion plants", so the potential of direct impacts from fire are low (Proctor personal communication 2004). Fireline access and construction activities could directly impact individuals or populations through destruction of individual plants or habitat fragmentation. Vegetation changes following fire in areas adjacent to *L. parvula* occurrences could have indirect effects including the invasion of exotic species (including cheatgrass [*Bromus tectorum*]) (D'Antonio and Vitousek 1992, Fagan et al. 1999).

Many species of *Physaria/Lesquerella* grow well in disturbed areas in or adjacent to natural populations (Rollins and Shaw 1973), suggesting that they will tolerate at least some disturbance and that disturbance, including fire, may be important in opening new seedling establishment sites in communities otherwise closed due to plant competition or litter cover. The authors' observation is that *Physaria/Lesquerella* spp. seedlings tend not to become established amongst heavy ground cover of plants or organic matter. Disturbance that opens colonization sites can promote seedling

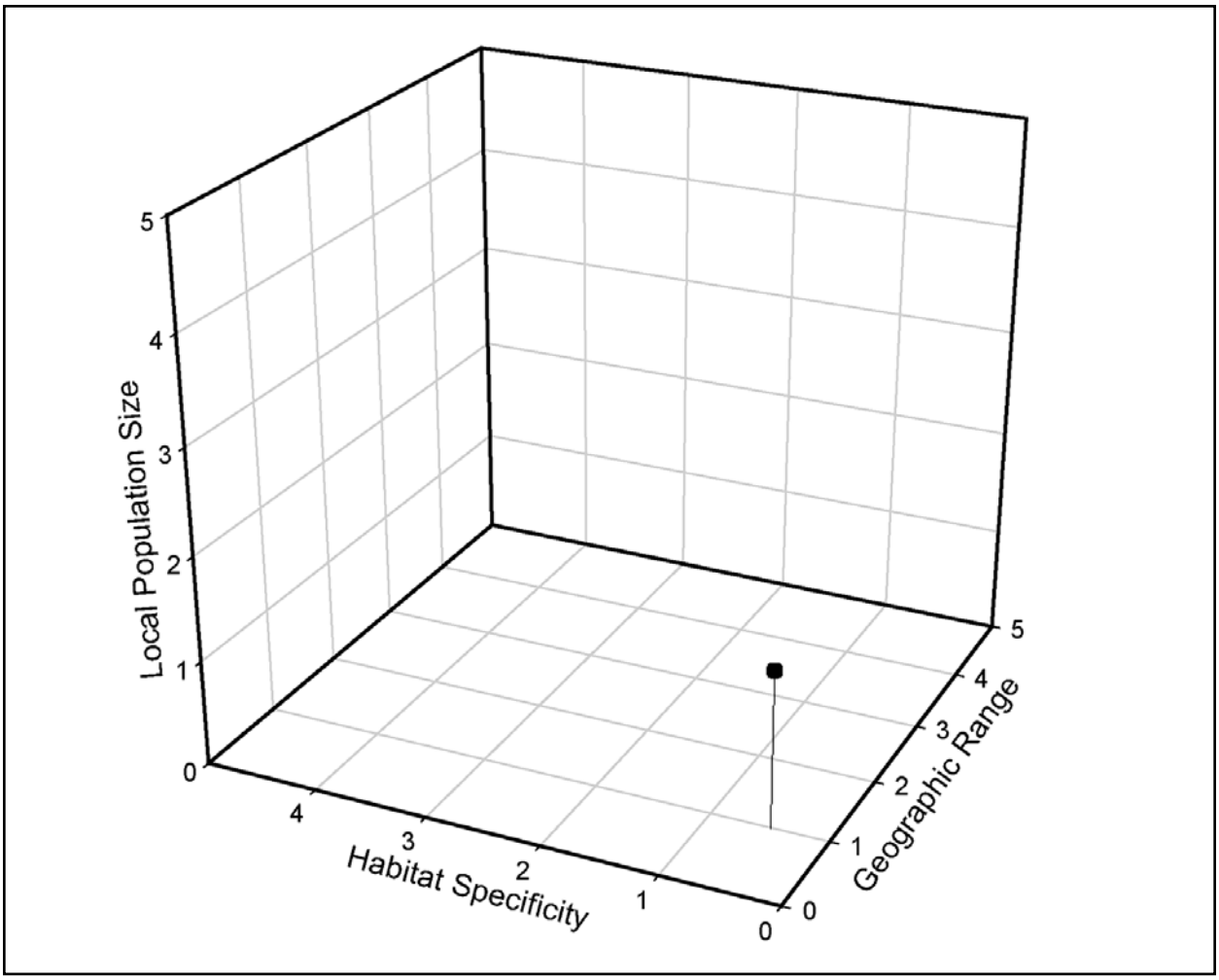


**Figure 9.** Rarity of *Lesquerella parvula* as a function of geographic range, habitat specificity, and local population size. Axes should be considered as scalars, and a range was arbitrarily chosen from 0 (small or specific) to 5 (large or wide).

establishment. Therefore, disturbance may be enough to clear areas for establishment, but duration and intensity should not be such that the seedlings and adults are injured or destroyed. Seeds likely remain in the soil for a number of years, so timing is not absolutely critical; having establishment sites available after seed ripening, of course, is desirable. Like *L. gracilis* in Texas and Oklahoma, *L. parvula* does spread with disturbance, but species of *Physaria/Lesquerella* are rarely aggressive colonizers and do not take over disturbed sites. Because *L. parvula* is not a forest species, fire suppression that leads to tree encroachment may negatively impact occurrence size and persistence in those occurrences that are adjacent to stands of trees.

## Livestock grazing

As a member of the mustard family (Brassicaceae), all members of which contain glucosinolates (Rodman 1991), *Lesquerella parvula* is not likely to be palatable to livestock. In addition, the foliage of this species is not abundant and resides close to the ground, a growth form that makes the plant less desirable forage species. Seedlings of *L. parvula* appear to be most often found in naturally occurring, small openings (**Figure 2**), so a low level of grazing might actually benefit the species by opening sites for seedling establishment. However, no quantitative monitoring data are available to support this hypothesis. Grazing could indirectly impact individuals or habitat through by increasing erosion or soil compaction, or by opening habitat for exotic species (**Figure 10**).

Cattle form trails or bovine terraces (Trimble and Mendel 1995) that may result in erosion and habitat fragmentation. Soils in the vicinity of the occurrence on the Medicine Bow National Forest appear highly erosive and impacts from cattle trails through this

**Table 4.** Mechanisms of plants at different life stages that enable them to survive fire.

| Life stage | General response | Mechanisms |
|---|---|---|
| Seeds | Avoidance | Burial |
| | Resistance | Insulative seed coat; protective tissue around fruit |
| | Stimulus | Increased germination; mortality of established neighbors |
| Juveniles | Avoidance | Rapid growth to resistance (protected) size |
| | Resistance | Aboveground buds protected by insulative plant tissue; belowground buds protected by soil |
| | Stimulus | Rapid growth of resprouts |
| Adults | Avoidance | Life cycle shorter than fire-return interval; flowing and fruiting phenology out of phase with fire season; suppression of understory fine fuel production |
| | Resistance | Thick, platy, corky, fissured bark; aboveground buds protected by insulative plant tissue; belowground buds protected by soil |
| | Stimulus | Rapid growth of resprouts; fire-obligate flowering; increase flowering (?) |

**Figure 10.** Cattle utilizing *Lesquerella parvula* habitat on the Medicine Bow National Forest in Big Creek Park in the Upper North Platte River Allotment. Photo by John Proctor.

sparsely vegetated habitat could occur (Proctor personal communication 2004). The low porosity of trails can result in a low infiltration rate, resulting in concentrated runoff that creates gullies (Rostagno 1989). Formation of these cattle trails potentially can cause hydrologic disruption of the site and result in habitat fragmentation of microhabitats in which *Lesquerella parvula* occurs (Stuth 1991). Trampling increases soil compaction and erosion by breaking the aggregate structure due to the force applied by hooves thereby reducing pore space and decreasing infiltration and percolation. These impacts may increase runoff and encourage erosion (Stuth 1991, Trimble and Mendel 1995). The degree of impact associated with trampling depends on soil type, soil water content, seasonal climate conditions, and vegetation type.

*Lesquerella parvula* is generally found far from water sources, in areas with little available forage. Water developments (e.g., stock ponds, pipelines for

water supplies) for cattle could negatively impact *L. parvula*. Water sources are the principal focus around which cattle orient their travel patterns and foraging strategies. Optimum grazing area for cattle is defined by a circle whose radius is generally not over 1.6 km (1 mile) from the water source (Stuth 1991). Various types of pipelines potentially could fragment habitats or disrupt individuals in the community. No information was available regarding exact locations of stock water developments in relation to occurrences of *L. parvula*.

The occurrence on the Medicine Bow National Forest in Region 2 is located in Big Creek Park in the Upper North Platte River Allotment. This allotment is currently active, but the pasture in which *Lesquerella parvula* is located is on a deferred rest rotation. Monitoring is proposed for this and other plants of concern found in the Big Creek pasture of the Upper North Platte River Allotment (Proctor personal communication 2004).

### Recreation

It is reasonable to assume that some forms of recreation could potentially impact *Lesquerella parvula*. Hiking is likely to have little or no effect due to the distance between occurrences and areas typically used for this purpose. Unregulated off-highway vehicle (OHV) use could conceivably damage some occurrences by increasing the spread of noxious and invasive weeds and by directly impacting individual plants or their habitats (**Figure 11**). Documented illegal OHV use has impacted individuals on the Medicine Bow National Forest. Measures are being evaluated to discourage travel in this particular location (Proctor personal communication 2004). A revised travel management policy on the Medicine Bow National Forest has been implemented to restrict all forms of motorized vehicles (excluding snowmobiles) to designated routes (USDA Forest Service 2000). Occurrences that may exist on private land could be damaged by the construction of vacation homes, especially given the proximity of some occurrences to Flaming Gorge Reservoir.

### Non-native species

*Lesquerella parvula* prefers open spots in the communities it inhabits, and because invasive non-native plants also often favor open sites in the communities where they occur, the species could

**Figure 11.** Off-Highway vehicle use occurring in *Lesquerella parvula* habitat on the Medicine Bow National Forest. Photo by John Proctor.

benefit from efforts to limit the spread or introduction of non-native species. Musk thistle (*Carduus nutans* L.) has been observed adjacent to roadsides in the vicinity of the occurrence on the Medicine Bow National Forest (**Figure 12**). Individuals plants were hand pulled from these locations. The presence of non-native species is being monitored by forest personnel, and treatments will be recommended if conditions dictate that control is needed (Proctor personal communication 2004). No other information was identified that indicated that there is current exotic species control in areas where *L. parvula* occurs.

### Climate change

Changing climate (e.g., global warming) could have a strong effect on *Lesquerella parvula* (**Figure 8**). The area in which this species is found is likely to become both drier and warmer in the future (U.S. Environmental Protection Agency 1997), in which case *L. parvula* would have to move, cope, or become extinct. Changes in pollinator timing and availability or in plant phenology could also negatively affect this species (McCarty 2001, Grossman 2004, Thomas et al. 2004). For example, if the plant flowers earlier in the season when pollinators are not available, seed set could be drastically lowered. It is conceivable, though, that climate change could *enhance* the species' available habitat by reducing tree cover and by increasing the amount of open ground available for seedling establishment. While this is not likely, no detailed ecological studies have been conducted that thoroughly examine the habitat requirements and preferences of this species.

### Road construction and maintenance

Numerous *Lesquerella parvula* occurrences are located near state, county, and USFS roads and other possible travel routes. Road modification may present a potential threat to some occurrences on either public or private lands by increasing the introduction of exotic species, removing individuals, or fragmenting habitat. Road maintenance including grading of ditches, herbicide use, realignments, installation of cattle guards, and other maintenance activities could affect the viability of several occurrences. On the Medicine Bow National Forest, road construction and maintenance may have impacted individuals on the road shoulder and on turnouts (Proctor personal communication 2004).

**Figure 12.** Musk thistle occurring in *Lesquerella parvula* habitat on the Medicine Bow National Forest. Photo by John Proctor.

### Other threats

Nitrogen emissions from fixed, mobile, and agricultural sources have increased dramatically along the Front Range of the Rocky Mountains (Baron et al. 2000). Possible effects of nitrogen deposition on a terrestrial ecosystem include premature abscission of pine needles, alteration of mycorrhizal fungi, loss of lichen communities, enhancement of non-native species invasions, and alteration of fire cycles by increasing fuel loads (Fenn et al. 2003). Increased nitrogen may provide a long-term potential threat or benefit.

## *Conservation Status of Lesquerella parvula in Region 2*

*Lesquerella parvula* is a relatively rare species endemic to two areas, one in north-central Colorado and another in southwestern Wyoming and northeastern Utah (O'Kane personal observation 2005). There are no established demographic monitoring sites for this species, nor have records been maintained noting changes in population size at any of the known occurrences. No inferences about population trend for this species can be made at either the scale of individual populations or rangewide. Due to the lack of data, no inferences can be made concerning the temporal pattern of abundance at any spatial extent.

Our knowledge concerning the habitat capability and ecology of *Lesquerella parvula* is limited. Known populations occupy windswept montane habitat types. No empirical data are available describing ecological strategies for this species. As stated above in the Threats section, the concern for the viability of this species reflects its limited abundance, its specialized habitat requirements, and the ecological characteristics that may make it vulnerable to habitat loss and degradation. The Wyoming Natural Diversity Database Wyoming State Abstract states that *L. parvula* is a regional endemic and lists the conservation status as "Medium" (Wyoming Natural Diversity Database 2004). Field work is necessary to adequately determine (1) if the species should be given special status and (2) how it should be managed.

Within its habitats of occurrence, which are treeless and in the montane zone, *Lesquerella parvula* appears to be somewhat of a generalist as it occurs over a range of elevations and soil types, and is found in a variety of plant associations. Typically, this taxon occupies the open areas between other plants. Some localities, especially on knoll-tops and ridges are windswept and fairly barren. This species may have specific requirements for the microhabitats it occupies, and study of these could provide the tools for its protection.

Populations of *Lesquerella parvula* may be at risk from environmental or demographic stochasticity due to the small size of the populations. Seedling recruitment may be a factor limiting population growth. However, there are no identified specific mutualisms including mycorrhizal partners, pollinators, or dispersers, and no investigations have been conducted concerning these mutualisms.

There is little direct evidence to indicate whether or not specific populations of *Lesquerella parvula* are at risk. The discussion in the preceding paragraphs indicates that perhaps several potential threats may impact *L. parvula*. Evaluation of the effects of management on species fitness has not been conducted.

## *Potential Management of Lesquerella parvula in Region 2*

### Implications and potential conservation elements

As stated above in the Threats section, the concern for the viability of this species reflects its limited abundance, its specialized habitat requirements, and the ecological characteristics that may make it vulnerable to habitat loss and degradation. Protection of population numbers and the habitat in which they occur are elements necessary for maintaining the viability of *Lesquerella parvula* on National Forest System lands in Region 2.

If the species should be given special status, management would have to consider, at a minimum, impacts from changes in grazing regimes, prescribed fires, and the use of off-road vehicles. Those activities that directly impact individuals or this species' habitat, introduce exotics, or increase erosion need to be evaluated. If the species requires special management consideration, it is likely that most effective efforts would need to be coordinated among the USFS, the BLM, and private land holders.

As a relatively rare species (low population estimates and low numbers of occurrences), *Lesquerella parvula* would be impacted by those activities that directly impact individuals or result in habitat fragmentation. However, nothing is known about this

species' response to disturbance (both environmental and anthropogenic). Priorities for determining conservation elements include:

- ❖ inventory for additional occurrences
- ❖ investigate the species' response to disturbance
- ❖ determine threats
- ❖ develop and implement a monitoring program to identify population trends
- ❖ investigate the habitat requirements of this species and its interactions with the surrounding plant community
- ❖ investigate pollinators, seed germination, seedling establishment, fruiting success, and dispersal of this species.

### Tools and practices

Since its discovery in 1876, most reports for *Lesquerella parvula* are the product of general botanical exploration, except for some efforts by the Wyoming Natural Diversity Database in southwestern Wyoming and by O'Kane in the course of collecting for a taxonomic treatment of the genus. Surveys are needed to identify additional occurrences, and monitoring of plots may be initiated, if deemed necessary, based on the range and number of populations (Elzinga et al. 1998). Since little is known about the extent of this species' distribution, its abundance, or trend, it is difficult to design a specific monitoring protocol for *L. parvula*. Population and habitat monitoring, if needed, will help to establish or clarify the demography, reproductive requirements, limiting factors, and habitat requirements of this species.

## *Information Needs*

*Lesquerella parvula* is a species of primarily mountain brush communities in north-central Colorado and disjunctly in southwestern Wyoming and northeastern Utah near Flaming Gorge Reservoir. Little is know about the species other than its general range, evolutionary relationships, and cursory habitat information. Field studies are needed to identify additional occurrences, boundaries of occurrences only known from herbarium specimens, and potential threats, if any. Likewise, monitoring studies are needed to identify population trends and basic information on survival and recruitment and to obtain quantitative information on its habitat requirements and the surrounding community. If specific conservation management of the species is deemed necessary, information on pollinators, seed germination, seedling establishment, herbivory by insects, livestock and native mammals, fruiting success, and dispersal will be needed, as well as field studies/monitoring to obtain information on impacts to the species from management activities.

# DEFINITIONS[1]

**Allopolyploidy –** an increase (usually doubling) in the number of chromosomes by incorporating the chromosomes from two or more species.

**Auriculate –** when referring to leaf bases, means that in a sessile leaf the leaf base extends beyond the stem forming two "ears" (auricles).

**Blade –** the widened, expanded portion of a leaf.

**Caespitose –** tufted.

**Disjunct –** having populations separated by a large area not containing the species.

**Endangered species –** any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of the Endangered Species Act would present an overwhelming and overriding risk to man.

**Endemic –** limited to a particular area.

**Hemicryptophyte –** a plant having its growing points very near or just below the ground.

**Infraspecific –** below the rank of species, i.e. variety or subspecies.

**Interspecific –** between species.

**Ovule –** an unfertilized seed.

**Paraphyletic –** describing a taxonomic group that does not contain all of the descendants of its most recent common ancestor.

**Pedicel –** the stalk that upholds a single flower or fruit.

**Petiole –** the stalk that upholds a leaf.

**Phylogeny –** evolutionary history, usually depicted as a branching diagram.

**Population –** in general terms, the members of a species living in an area. More specifically, the individuals of a species that can freely interbreed.

**Pubescent –** having trichomes.

**Seleniferous –** containing high amounts of the element selenium.

**Self-compatible –** able to produce viable seeds from the pollen from the same plant.

**Self-incompatibility –** not able to produce viable seeds from pollen from the same plant.

**Silique –** the dry, two-locular fruits of the Brassicaceae. Distinctive in having a septum spanning a rim (replum), in having parietal placentae, and in dehiscing (usually) by the two valves falling free of the replum.

**Spatulate –** narrow but somewhat wider at the apex.

**Sporophytic self-incompatibility –** self-incompatibility determined by the genotype of the parent plants, rather then by the genotype of the gametes (gametic self-incompatibility).

**Stellate –** star-shaped with rays spreading from a central portion.

**Threatened species –** any species which is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range.

**Taxon –** a taxonomic level, e.g., subspecies, species, genus, family.

**Trichome –** a plant "hair." In *Lesquerella/Physaria*, these hairs are typically stellate (with branches radiating from a central point).

[1]Definitions according to Lincoln et al. 1982

# REFERENCES


Al-Shehbaz, I.A. and S.L. O'Kane, Jr. 2002. *Lesquerella* is united with *Physaria* (Brassicaceae). Novon 12:319-329.

Andrewartha, H.G. and L.C. Birch. 1984. The Ecological Web. More on the distribution and abundance of animals. University of Chicago Press, Chicago, IL.

Barbour, M.G., J.H. Jack, H. Burk, W.D. Wanna D. Pitts, F.S. Frank S. Gilliam, M.W. Mark, and W. Schwartz. 1999. Terrestrial Plant Ecology. Third edition. Addison Wesley Longman, Menlo Park, CA.

Baron, J.S., H.M. Rueth, A.M. Wolfe, K.R. Nydick, E.J. Allstott, J.T. Minear, and B. Moraska. 2000. Ecosystem responses to nitrogen deposition in the Colorado Front Range. Ecosystems 3:352-368.

Bateman, A.J. 1955. Self-incompatibility systems in angiosperms III. Cruciferae. Heredity 9:53-68.

Beach, S.E., J.M. Coons, H.R. Owen, B.L. Todd, and M.A.L. Smith. 2001. Germination of *Lesquerella ludoviciana* as affected by seed age. Page 46 *in* Proceedings of Botanical Society of America meetings at Albuquerque, NM.

Brown, J.K.M. and J.K. Smith. 2000. Wildland fire in ecosystems: effects of fire on flora. USDA Forest Service, Ogden, UT.

Bureau of Land Management. 1997. Record of Decision and Green River Resource Management Plan. Bureau of Land Management Rock Springs District, Rock Springs, WY.

Cabin, R.J. 1996. Genetic comparisons of seed bank and seedling populations of a perennial desert mustard, *Lesquerella fendleri*. Evolution 50:1830-1841.

Cabin, R.J., R.J. Mitchell, and D.L. Marshall. 1998. Do surface plant and soil seed bank populations differ genetically? A multipopulation study of the desert mustard *Lesquerella fendleri* (Brassicaceae). American Journal of Botany 85:1098-1098.

D'Antonio, C. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 3:63-87.

Dierig, D.A., T.A. Coffelt, F.S. Nakayama, and A.E. Thompson. 1996. *Lesquerella* and Vernonia: oilseeds for arid lands. Pages 347-354 *in* J. Janick, editor. Progress in New Crops. ASHS Press, Alexandria, VA.

Ellstrand, N.C. and D.R. Elam. 1993. Population genetic consequences of small population size: implications for plant conservation. Annual Review of Ecology and Systematics 24:217-243

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations. Bureau of Land Management, Denver, CO.

Fagan, W.F., R.S. Cantrell, and C. Cosner. 1999. How habitat edges change species interactions. American Naturalist 153:165-182.

Fenn, M.E., J.S. Baron, E.B. Allen, H.M. Rueth, K.R. Nydick, L. Geiser, W.D. Bowman, J.O. Sickman, T. Meixner, D.W. Johnson, and P. Neitlich. 2003. Ecological effects of nitrogen deposition in the western United States. Bioscience 53:404-420.

Fenster, C.B. and M.R. Dudash. 1994. Genetic consideration for plant population restoration and conservation. Pages 34-62 *in* M.L. Bowles and C.J. Whelan, editors. Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation. Cambridge University Press, Cambridge, MA.

Gitzendanner, M.A. and P.S. Soltis. 2000. Patterns of genetic variation in rare and widespread plant congeners. American Journal of Botany 87:783-792.

Greene, E.L. 1901. Studies in the Cruciferae-IV. 1. New species of *Lesquerella*. Pittonia 4:307-311.

Grime, J.P. 1979. Plant Strategies and Vegetation Processes. John Wiley & Sons, Ltd., Bath, U.K.

Grossman, D. 2004. Spring forward. Scientific American 290:84-91.

Hessl, A. and S. Spackman. 1995. Effects of Fire on Threatened and Endangered Plants: An Annotated Bibliography. USDI, National Biological Service, Information and Technology Report 2. The Nature Conservancy, CO.

Holmgren, P.K, N.H. Holmgren, and L.C. Barnett. 1990. Index Herbariorum. Part I: Herbaria of the World. New York Botanical Garden, Bronx, NY.

Karron, J.D. 1991. Patterns of genetic variation and breeding systems in rare plant species. *In*: D.A. Falk and K.E. Holsinger, editors. Genetics and Conservation of Rare Plants. Oxford University Press, Oxford, U.K.

Landes, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1460.

Lincoln, R.J., G.A. Boxshall, and P.F. Clark. 1982. A Dictionary of Ecology, Evolution, and Systematics. Cambridge University Press, Cambridge, MA.

McCarty, J.P. 2001. Ecological consequences of recent climate change. Conservation Biology 15:320-331.

Menges, E.S. 1991. The application of minimum viable population theory to plants. Pages 45-61 *in* K.E. Holsinger, editor. Genetics and Conservation of Rare Plants. Oxford University Press, New York, NY.

NatureServe Explorer. 2004. An online encyclopedia of life [web application]. Accessed at http://www.natureserve.org/explorer on 10 September 2004.

O'Kane, S.L., Jr. 2005. Associate Professor of Biology, University of Northern Iowa, IA. Personal Observation.

O'Kane, S.L., Jr. 1999. *Lesquerella navajoensis* (Brassicaceae), a new species of the *L. hitchcockii* Complex from New Mexico. Madroño 46:88-91.

O'Kane, S.L., Jr. and I.A. Al-Shehbaz. 2002. *Paysonia*, a new genus segregated from *Lesquerella* (Brassicaceae). Novon 12:379-381.

O'Kane, S.L., Jr. and I. Al-Shehbaz. 2004. The genus *Physaria* (Brassicaceae) in South America. Novon 14:196-205.

O'Kane, S.L., Jr., I.A. Al-Shehbaz, and N.J. Turland. 1999. Proposal to conserve the name *Lesquerella* against *Physaria* (Cruciferae). Novon 48:163-164.

Paszkowski, U., S. Kroken, C. Roux, and S.P. Briggs. 2002. Rice phosphate transporters include an evolutionarily divergent gene specifically activated in arbuscular mycorrhizal symbiosis. Proceedings of the National Academy of Science, USA 99:13324-13329.

Payson, E.B. 1922. A monograph of the genus *Lesquerella*. Annals of the Missouri Botanical Garden 8:103-236.

Platt, J.R. 1964. Strong inference. Science 146:347-353.

Proctor, J. 2004. Forest botanist, Medicine Bow-Routt National Forest, WY. Personal communication.

Quammen, D. 1996. The Song of the Dodo: Island Biogeography in an Age of Extinctions. Scribner, New York, NY.

Rabinowitz, D. 1981. Seven forms of rarity. Pages 205-217 *in* H. Synge, editor. The Biological Aspects of Rare Plant Conservation. John Wiley & Sons. New York, NY.

Rabinowitz, D., S. Cairns, and T. Dillon. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. Pages 182-204 *in* M.E. Soulé, editor. Conservation Biology. The Science of Scarcity and Diversity. Sinauer Assoc., Inc., Sunderland, MA.

Rodman, J.E. 1991. A taxonomic analysis of glucosinolate-producing plants. I. Phenetics. Systematic Botany 16:598-618.

Roll, J., R.J. Mitchell, R.J. Cabin, and D.L. Marshall. 1997. Reproductive success increases with local density of conspecifics in a desert mustard (*Lesquerella fendleri*). Conservation Biology 11:738-746.

Rollins, R.C. 1939a. The Cruciferous genus *Physaria*. Rhodora 41:392-415.

Rollins, R.C. 1939b. Studies in the genus *Lesquerella*. American Journal of Botany 26:419-421.

Rollins, R.C. 1954. Interspecific hybridization and its role in plant evolution.

Rollins, R.C. 1955. The auriculate-leaved species of *Lesquerella* (Cruciferae). Rhodora 57:241-264.

Rollins, R.C. 1957. Interspecific hybridization in *Lesquerella* (Cruciferae). Contributions from the Gray Herbarium 181:1-40.

Rollins, R.C. 1988. A population of interspecific hybrids of *Lesquerella* (Cruciferae). Systematic Botany 13:60-63.

Rollins, R.C. 1993. The Cruciferae of Continental North America. Stanford University Press, Stanford, CA.

Rollins, R.C. and E.A. Shaw. 1973. The genus *Lesquerella* (Cruciferae) in North America. Harvard University Press, Cambridge, MA.

Rollins, R.C. and O.T. Solbrig. 1973. Interspecific hybridization in *Lesquerella*. Contributions from the Gray Herbarium 203:3-48.

Rostagno, C.M. 1989. Infiltration and sediment production as affected by soil surface conditions in a shrubland of Patagonia, Argentina. Journal of Range Management 42(5):382-385.

Sampson, D.R. 1958. The genetic of self-incompatibility in *Lesquerella densipila* and in the F1 hybrid *L. densipila* x *L. lescurii*. Canadian Journal of Botany 36:39-56.

Stebbins, G.L. 1980. Rarity of plant species: a synthetic viewpoint. Rhodora 82:77-86.

Steuter, A.A. and G.R. McPherson. 1995. Fire as a physical stress. Pages 550-579 *in* D.J. Bedunah and R.E. Sosebee, editors. Wildland Plants: Physiological Ecology and Developmental Morphology. Society for Range Management, Denver, CO.

Stuth, J.W. 1991. Foraging behavior. Pages 65-83 *in* R.K. Heitschmidt and J.W. Stuth, editors. Grazing Management: An Ecological Perspective. Timber Press, Portland, OR.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F. de Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips, and S.E. Williams. 2004. Extinction risk from climate change. Nature 427:145-148.

Trimble, S.W. and A.C. Mendel. 1995. The cow as a geomorphic agent—a critical review. Geomorphology 13:233-253.

U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. 2003. Level III Ecoregions of the Continental United States.

U.S. Environmental Protection Agency. 1997. Climate change and Colorado. EPA 230-F-97-008f. U.S. Environmental Protection Agency, Washington, DC.

USDA Forest Service. 2000. Medicine Bow National Forest and Thunder Basin National Grassland Forest-wide Travel Management Plan, Laramie, WY.

USDA Forest Service. 2002. Regional Forester's Sensitive Species List, USDA Forest Service, Rocky Mountain Region [Online]. Accessed at http://roadless.fs.fed.us/documents/feis/data/sheets/summspd/tes_supp/r2_ssspecies.pdf on 27 February 2006.

USDA Forest Service. 2003. Response to species-specific comments on draft R2 sensitive plant list. Document of 13 August 2003. Accessed at http://www.fs.fed.us/r2/projects/scp/comments/plantcomments.pdf on 14 January 2005.

USDA Forest Service. 2005. Regional Forester's Sensitive Species List, USDA Forest Service, Rocky Mountain Region [Online]. Accessed at http://www.fs.fed.us/r2/projects/scp/sensitivespecies/index.shtml on 27 February 2006.

Weller, S.G. 1994. The relationship of rarity to plant reproductive biology. Pages 90-117 *in* M.L. Bowles and C.J. Whelan, editors. Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation. Cambridge University Press, Cambridge, MA.

Welsh, S.L. and J.L. Reveal. 1978. Utah flora: Brassicaceae (Cruciferae). Great Basin Naturalist 37:279-365.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.

Wyoming Natural Diversity Database. 2004. State species abstract: *Lesquerella parvula* (narrowleaved bladderpod). Accessed at http://uwadmnweb.uwyo.edu/WYNDD/Plants/state_spp_abstracts/L/Lesquerella_paysonii.pdf on 20 September 2004.