

***Penstemon laricifolius* Hook. & Arn.
ssp. *exilifolius* (A. Nels.) D.D. Keck
(larchleaf beardtongue):
A Technical Conservation Assessment**



**Prepared for the USDA Forest Service,
Rocky Mountain Region,
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COVER PHOTO CREDIT

Penstemon laricifolius ssp. *exilifolius* (larchleaf beardtongue) by Earl Jensen, used with permission.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *PENSTEMON LARICIFOLIUS* SSP. *EXILIFOLIUS*

Status

Penstemon laricifolius ssp. *exilifolius* (larchleaf beardtongue) is a regional endemic of Colorado and Wyoming, and it is designated a sensitive species by the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). The taxon is not known outside of Region 2 except for one collection in Sublette County, Wyoming. At the time it was designated as sensitive, the NatureServe global rank for this subspecies was imperiled throughout its range (T2). The rank was revised to vulnerable throughout its range (T3) in 2005 incidental to this assessment. Also at the time it was designated as sensitive, it was ranked critically imperiled (S1) in Colorado and imperiled (S2) in Wyoming by the Colorado Natural Heritage Program and Wyoming Natural Diversity Database. As a result of new field information in both states, it has been re-ranked as imperiled (S2) in Colorado and vulnerable (S3) in Wyoming.

Penstemon laricifolius ssp. *exilifolius* is distinguished from *P. laricifolius* var. *laricifolius* primarily by flower color. It is accepted as a valid taxon in the current state floras and checklists. There are at least three mixed-color populations, including two in the Bighorn National Forest and one in Medicine Bow-Routt National Forest, and there are occasional pale color intermediates appearing in *P. laricifolius* ssp. *exilifolius* populations. Information on color variation and the distribution of the type subspecies is included in this assessment as it relates to *P. laricifolius* ssp. *exilifolius*.

Primary Threats

Penstemon laricifolius ssp. *exilifolius* is found in a range of dry, upland settings with no known widespread threats at present on National Forest System lands. Exotic species invasion by cheatgrass (*Bromus tectorum*) and other noxious weeds is the most serious potential threat, but invasions are limited at present. The presence and abundance of *P. laricifolius* ssp. *exilifolius* in previously graded road rights-of-way indicate a colonizing ability, but relative contributions of roadside colonies to population viability have not been evaluated to date. Elsewhere, *P. laricifolius* ssp. *exilifolius* taxon is subject to habitat fragmentation and housing development. Oil and gas development activity overlaps in western portions of its distribution, but there are no known threats to extant occurrences. Livestock grazing was previously identified as a threat in the sensitive species biological evaluation for the Medicine Bow-Routt National Forest, but a review of historic collection information and the results of recent surveys for this report suggest that livestock grazing as a form of herbivory has limited direct influence and may have positive and negative indirect influences.

Primary Conservation Elements, Management Implications and Considerations

This assessment represents the first compilation of distribution information for *Penstemon laricifolius* ssp. *exilifolius* in Region 2, including the documentation of large new occurrences on the Medicine Bow-Routt National Forest and additional survey results from the Arapaho and Roosevelt National Forests. Region 2 occurrences of *P. laricifolius* ssp. *exilifolius*, on National Forest System lands are at the upper elevations of its range, both at the core of its distribution (Medicine Bow-Routt National Forest and Arapaho and Roosevelt National Forests) and at the outlying limits of its distribution (Bighorn National Forest). At least 25 percent of extant occurrences (10 of 40) are on National Forest System lands. Therefore, conservation of *P. laricifolius* ssp. *exilifolius* by the USFS in Region 2 is a significant contribution to overall viability of the taxon.

Penstemon laricifolius ssp. *exilifolius* is a regional endemic taxon with its core distribution concentrated in an area of about 60 x 120 km. Endemic taxa of this extent may be vulnerable to stochastic events. *Penstemon laricifolius* ssp. *exilifolius* may be buffered from catastrophic disturbances by 1) a broad elevation range (5,640 to 9,600 ft.), 2) drought tolerance, as indicated by vigorous 2005 individuals despite the 2000-2005 drought event, 3) large numbers of individual plants at many of the occurrences that have been surveyed in detail, 4) outlying occurrences that span over 300 km beyond the core, and 5) persistence or colonizing ability under some forms and levels of disturbance.

On the other hand, occurrences of the taxon are concentrated at the lowest elevations on National Forest System lands where the likelihood of invasive weed establishment are greatest, land uses and exchange pressures tend to be greatest, and habitat fragmentation outside National Forest System boundaries may affect public lands. Maintaining or restoring sparsely vegetated native habitat is a critical element for conservation of the taxon. Two of the most important management needs for *Penstemon laricifolius* ssp. *exilifolius* within Region 2 are evaluating threats posed by prevailing land uses (i.e., livestock grazing) and assessing effects of road construction in and near native habitat. Meeting these needs requires monitoring trends of occurrences under these uses over time.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project of the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). *Penstemon laricifolius* ssp. *exilifolius* (larchleaf beardtongue) is the focus of an assessment because it is designated a sensitive species in USFS 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 its distribution. A sensitive species may require special management, so knowledge of its biology and ecology is critical.

Goal

Species conservation assessments are produced as part of the Species Conservation Project to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on 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. Instead, 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). Additionally, the assessment cites management recommendations for related taxa and provides a reference to promote species conservation on National Forest System lands (Blankenship et al. 2001).

Scope

This assessment examines the biology, ecology, conservation status, and management of *Penstemon laricifolius* ssp. *exilifolius* throughout its range, which is almost entirely limited to Region 2. It occurs in north-central Colorado and eastern Wyoming, in addition to one collection in western Wyoming. The 2004-2005 field survey records represent the most detailed documentation of the taxon. Collection labels represent the most consistent and extensive documentation. In producing the assessment, refereed literature, non-refereed literature, herbarium documentation, and other sources were also reviewed. This assessment also

selectively draws from the literature on research in the *Penstemon* genus and related genera.

Penstemon laricifolius ssp. *exilifolius* is accepted as a valid taxon in the current state floras and checklists (Nelson and Hartman 1994, Dorn 2001, Hartman and Nelson 2001, Weber and Wittmann 2001), and it is treated as such in this document. The status of mixed-color populations within *P. laricifolius* ssp. *exilifolius* and the associated relationship between *P. laricifolius* ssp. *exilifolius* and *P. laricifolius* ssp. *laricifolius* have been questioned. Genetic studies of color variations and mixed-color populations using modern techniques have not been conducted. Therefore, this report addresses color variation of *P. laricifolius* ssp. *exilifolius*, the contrasting distribution of *P. laricifolius* ssp. *laricifolius*, and a literature review of flower color as a basis for taxonomic distinction in the *Penstemon* genus.

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 taxon status data to produce a robust analysis. The data and analyses presented in this assessment on *Penstemon laricifolius* ssp. *exilifolius* in Region 2 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.

Publication on the World Wide Web

To facilitate their use in the Species Conservation Project, species assessments are being published on the USFS Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More importantly, it facilitates their revision, which will be accomplished based on guidelines established by USFS Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This assessment of *Penstemon laricifolius* ssp. *exilifolius* was reviewed through a process administered by the Center for Plant Conservation, employing 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

Federal Status

Penstemon laricifolius ssp. *exilifolius* is a regional endemic that is restricted to two states in Region 2, Colorado and Wyoming. It is currently designated a sensitive species in Region 2 where it occurs on the Medicine Bow-Routt and Bighorn national forests in Wyoming and the Arapaho and Roosevelt National Forests in Colorado (**Table 1**; USDA Forest Service

2003a). Most extant occurrences in both states are on private lands, lands managed by the Bureau of Land Management (BLM), or on state lands. The taxon does not have management status outside of National Forest System lands.

Natural Heritage Program Ranks

NatureServe (formerly the heritage division of The Nature Conservancy) and the network of natural heritage programs assigned *Penstemon laricifolius* a global rank of G4, indicating that the species is potentially secure throughout its range, usually with more than 100 occurrences rangewide. The subspecies *P. laricifolius* ssp. *exilifolius* was originally ranked T2Q, meaning that it was considered imperiled because of rarity (often 6 to 20 extant occurrences) or because of factors making it vulnerable to extinction. The “Q” indicates that questions exist regarding its taxonomic validity (see the discussion provided with the non-technical description below). There are no published critiques of the subspecies’ taxonomic validity, and the question denoted by “Q” has been removed from its rangewide rank. A separate rank change has been instituted as a result of recent surveys in Colorado and Wyoming, re-assigning the global rank for the

Table 1. Conservation status and ranks of *Penstemon laricifolius* ssp. *exilifolius*.

Listing	Status	Rank
USDA Forest Service Region 2 Sensitive Species List ¹	Sensitive	
U.S. Fish and Wildlife Service Endangered Species Act	Not listed	
NatureServe Global Ranking ²		Secure (G4T3)
Colorado Natural Heritage Program ²		Imperiled (S2)
Wyoming Natural Diversity Database ²		Vulnerable (S3)

¹USDA Forest Service. 2003. Forest Service Manual, Title 2600 - Wildlife, Fish and Sensitive Plant Habitat Management; Region 2 Supplement 2900-2003-1.

²Heritage Ranks: Colorado Natural Heritage Program and Wyoming Natural Diversity Database use a standardized ranking system originally developed by the Nature Conservancy and its network of natural heritage programs (now called NatureServe) to assess the global and statewide abundance and the probability of extinction of each plant and animal species, subspecies, and variety. The global and state-rank codes are as follows:

G Global rank: rank refers to the rangewide status of a species.

S State rank: rank refers to the status of the taxon in Wyoming and Colorado. State ranks differ from state to state.

Each taxon is ranked on a scale of 1-5 from most to least vulnerable to extirpation.

1 Critically imperiled because of extreme rarity (often known from 5 or fewer extant occurrences or very few remaining individuals) or because some factor of a species’ life history makes it vulnerable to extinction.

2 Imperiled because of rarity (often known from 6-20 occurrences) or because of factors demonstrably making a species vulnerable to extinction.

3 Rare or local throughout its range or found locally in a restricted range (usually known from 21-100 occurrences).

4 Apparently secure, although the species may be quite rare in parts of its range, especially at the periphery.

5 Demonstrably secure, although the species may be rare in parts of its range, especially at the periphery.

H Known only from historical record(s).

subspecies as T3 (vulnerable) based on 40 extant occurrences, which include occurrences with large numbers and few threats.

Penstemon laricifolius ssp. *exilifolius* was originally assigned a state rank of S1 (critically imperiled) in Colorado. In 2004, it was documented to be more common than previously known, and its state rank was revised to S2 (imperiled). The Colorado Natural Heritage Program tracks it as a species of concern due to its limited distribution in the state. In Wyoming, this taxon was originally ranked S2 (imperiled), but it was not tracked until 2003, when it was designated as sensitive in Region 2 (USDA Forest Service 2003a). Surveys in 2005 found the taxon to be more common than previously known. It is now ranked S3 (vulnerable) based on 40 extant occurrences, and its status as a species of concern in Wyoming is under review.

State Protection

There is no state legislation or policy protecting rare plant species in Colorado or Wyoming.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

In Region 2, *Penstemon laricifolius* ssp. *exilifolius* occurs on the Bighorn and Medicine Bow-Routt National Forest in Wyoming, and the Arapaho and Roosevelt National Forests in Colorado. It does not have sensitive species status on any other public lands in Colorado or Wyoming. Several USFS codes and regulations provide direction for activities on National Forest System lands: the Organic Administration Act of 1897 (16 U.S.C. 475), the Multiple Use - Sustained Yield Act of 1960 (16 U.S.C. 528), the National Forest Management Act of 1976 (16 U.S.C. 1600-1602, 1604, 1606, 1608-1614), the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701-1782, FSM 2729), the Forest Service Manual, and individual Forest Management Plans. The National Environmental Policy Act (NEPA) requires analysis of the environmental impacts of federal activities whether in wetlands or terrestrial settings.

A framework for addressing the status of *Penstemon laricifolius* ssp. *exilifolius* as a sensitive species was developed as part of the Medicine Bow-Routt National Forest Land Resources Management Plan (USDA Forest Service 2003b). This taxon has

been and is being addressed in allotment management plans (Proctor personal communication 2005) and has been addressed in a biological evaluation for a travel management plan (Roche 2005). There are no conservation strategies that address *P. laricifolius* ssp. *exilifolius*, but a Region 2 effects matrix discusses potential threats to this taxon (Proctor personal communication 2005). Several Colorado sites where the taxon occurs, including the Chimney Rock area that includes lands on the Arapaho and Roosevelt National Forests, are identified by the Colorado Natural Heritage Program as priority conservation areas (Doyle et al. 2005), a designation that has no regulatory status.

Biology and Ecology

Classification and description

Systematics and synonymy

Scientific Name: *Penstemon laricifolius* Hook. & Arn. ssp. *exilifolius* (A. Nels.) D.D. Keck (Keck 1937). Subspecies holotype: USA: Wyoming, Albany County, “Dry stony plateaus: Halleck Cañon”, 6 July 1900, *A. Nelson #7460* (Rocky Mountain Herbarium [RM]; with isotypes at Carnegie Museum of Natural History Herbarium [CM], Agriculture and Agri-Food Canada Herbarium in Ottawa [DAO], Gray Herbarium [GH], Botanische Staatssammlung München [M], New York Botanical Garden [NY], Suzhou University [SU], and the Smithsonian Institution [US]).

Common Name: larchleaf beardtongue, larchleaf penstemon; also called Nelson larchleaf penstemon [after Aven Nelson], as cited by B.E. Nelson (1984). The specific epithet “*laricifolius*” refers to the leaves resembling larch needles, and the subspecific epithet “*exilifolius*” pertains to leaves that are small, thin, and slender.

Both subspecies of *Penstemon laricifolius* are given the same common name in the USDA Plants Database (2005). The Wyoming Natural Diversity Database (2005) refers to *P. laricifolius* ssp. *exilifolius* as “white larch-leaf beardtongue” to distinguish it from the purple-flowered subspecies.

Family:

Scrophulariaceae (Figwort family) in the broad sense.

Plantaginaceae (Plantain family) in the narrow sense; based on recent revisionary taxonomic research (Albach et al. 2005).

Synonyms:

Penstemon exilifolius A. Nels.

Penstemon laricifolius Hook. & Arn. var.
exilifolius (A. Nels.) Payson.

Note: Variety is the only infraspecific rank recognized by Dorn (2001) in accordance with Article 4 of the International Code, in which the rank of subspecies is reserved for groups of more than two related varieties when relationships are presented (Greuter et al. 1994).

Phylogenetic relationships

The genus *Penstemon* contains about 275 species, primarily centered in western North America (Hitchcock et al. 1969, Cronquist et al. 1984, Wolfe et al. 2002). The diversity of the *Penstemon* genus may represent a post-Tertiary evolutionary radiation, involving adaptation to different pollinators, hybridization and hybrid speciation, and accompanying adaptations to fragmented habitats (reviewed in Wolfe et al. 2002). Taxonomists have divided this morphologically diverse genus into subgenera and sections between the genus and species levels (Holmgren 1979).

Rydberg (1906) first recognized *Laricifolii* as a discrete group in the *Penstemon* genus without assigning it a taxonomic rank. Pennell (1920) recognized two infrageneric levels, subgenus and section, placing *P. laricifolius* in the subgenus *Penstemon* and treating *Laricifolii*, among the other unranked names of Rydberg, as section *Laricifolii* in his monograph. Keck (1937) proposed new section names, including the section *Ericopsis*. He also added another subdivision, the subsection, and placed *P. laricifolius* into the subsection *Ericopsis* as a monotypic member. *Penstemon laricifolius* has not been addressed in more recent taxonomic works, so section placement is unresolved. The *Intermountain Flora* (Cronquist et al. 1984), as based on Holmgren (1979), may provide a framework even though there is no new treatment of the species in the flora. Holmgren (1979) recognized two infrageneric levels, retaining the subgenus *Penstemon* and the section *Caespitosi* (Rydb.) Pennell. The *Caespitosi* section includes the two species with closest superficial resemblance to *P. laricifolius*; these are *P. abietinus* (firleaf penstemon) and *P. linarioides* (toadflax penstemon). These two species differ from *P. laricifolius* in having prostrate old stems rather than a branched caudex and not having basal clusters of needle-like leaves. In addition, the earlier treatments of Keck (including Keck 1937) have been charted to

represent the entire genus (Bennett and Keck 1953) and updated as a non-standard taxonomic reference for the American Penstemon Society (Bennett et al. 1987).

There is an unpublished report of a diploid number for *Penstemon laricifolius* on a specimen label ($2n = 16$; B. Hammel #57 RM). Many xeric *Penstemon* species appear to be diploids and have been the subject of studies of diploid hybrid speciation (Wolfe et al. 1998).

History of the taxon

The history of *Penstemon laricifolius* ssp. *exilifolius* is closely linked to that of *P. laricifolius* ssp. *laricifolius*. Both taxa have their centers of distribution in Wyoming, but in different parts of the state. In order to present the status of *P. laricifolius* ssp. *exilifolius* coherently, it is appropriate to address the distribution of both taxa.

The holotype for the species, *Penstemon laricifolius* Hook. & Arn., was collected from the "original Snake Country" by *W.F. Tolmie s.n.* (probably Tolmie's friend, John McLeod, a fur trapper) (Kew), and was published by Hooker and Arnott (1841). The vague location could refer to either Idaho or Wyoming, but the taxon "has not been rediscovered in Idaho if, indeed, the type came from within what are now the bounds of that state" (Keck 1937).

The first collections of *Penstemon laricifolius* ssp. *exilifolius* were made from the Laramie Plains in 1884 by C.S. Sheldon, by G.E. Osterhout in 1892, and by Aven Nelson in 1894 and 1895. The taxon was reported by Nelson as *P. laricifolius* Hook. & Arn. in the first report on the flora of Wyoming (Nelson 1896). He collected additional specimens, including a specimen from Halleck Canyon in the Laramie Mountains of Albany County, Wyoming on 6 July 1900, subsequently recognizing them as distinct from the published description of *P. laricifolius*. He elevated the taxon to species level, publishing *Penstemon exilifolius* A. Nels., with the Halleck Canyon specimen as the holotype (Nelson 1901).

In 1900, Nelson collected *Penstemon laricifolius* ssp. *laricifolius* from Sweetwater County (Point of Rocks). He recognized its relation with *P. exilifolius* and described it as a variety, *P. exilifolius* A. Nels. var. *desertus* A. Nels. in the same monograph (Nelson 1901).

Pennell (1920) synonymized *Penstemon exilifolius* var. *desertus* under *P. laricifolius*. He maintained *P. exilifolius* at the species level and added that it also differs from *P. laricifolius* by corolla length. Edwin Payson, a student of Aven Nelson, recognized the close relation of the two taxa and proposed a new combination of *P. laricifolius* Hook. & Arn. var. *exilifolius* (A. Nels.) Payson (Payson 1924). He noted:

“It seems quite impossible to separate *exilifolius* from *laricifolius* except varietally. The characters used by Pennell are surely very slight and are scarcely evident on comparison of the two forms. Color is, after all, the most important character, and were this not accompanied by geographic separation *exilifolius* would be deemed worthy of formal rank only. Plants of *laricifolius* with very pale flowers approaching the white of *exilifolius* have been observed. It is of interest to note that when Dr. Nelson described true *laricifolius* as a variety of *exilifolius* (supposing as he did, that *laricifolius* was a different plant) he considered that the two forms were distinct only varietally. His judgement is here confirmed” (Payson 1924).

In the *Penstemon* monograph by Keck (1937), he changed the taxonomic level to that of subspecies, proposing *P. laricifolius* Hook. & Arn. ssp. *exilifolius* (A. Nels.) D.D. Keck. He discussed the distinguishing characteristics in saying:

“As indicated in the key, these subspecies are morphologically separable by their flowers which differ in length, shape and color. Since the difference in length is not pronounced in much material from central Wyoming, and since the difference in shape is best observed when one has at hand material of both subspecies for comparison, it follows that color of the corolla is the easiest field character to use. Unfortunately this character is not always clear-cut: collections of subsp. *typicus* [*laricifolius*] have been made with pink corollas, not only in the region where the subspecies approach each other, but in Big Horn County. On the other hand, material with purplish flowers has been collected near Laramie (Nelson 10701 C, RM), definitely in the midst of subsp. *exilifolius*. For these reasons, I object to calling the two units

distinct species, although I believe they are excellent ecotypes” (Keck 1937).

Keck (1937) acknowledged that flower color is the easiest field character to use in separating *Penstemon laricifolius* ssp. *exilifolius* from *P. laricifolius* ssp. *laricifolius*. Other morphological differences and genetic differences using current biosystematic techniques have not been rigorously addressed for these two subspecies. The treatment at variety level is accepted in the current Wyoming flora, Wyoming checklist, and Wyoming species of concern list (Hartman and Nelson 1994, Dorn 2001, Wyoming Natural Diversity Database 2005) in keeping with the International Taxonomic Code (Greuter et al. 1994), while the treatment at subspecies level is accepted in the current Colorado flora (Weber and Wittmann 2001) and in the PLANTS Database (USDA Natural Resources Conservation Service 2005).

Burrell E. Nelson made the first pairs of collections representing markedly different purple and white flower colors at the same site in 1979 in Big Horn County (*B.E. Nelson #3422, #3423* RM). The first surveys of mixed-color populations of purple- and white-flowered *Penstemon laricifolius* were in 2005, in and near the Bighorn National Forest (Jensen personal communication 2005), including the site of the 1979 collections by B.E. Nelson. The two mixed populations are described by Earl Jensen:

Site 1 (Shell Canyon - Bighorn NF): The pink flowered plants were very numerous along the roadside cuts on the south side of the highway [north-facing slopes rising up from the highway], probably numbering in the thousands. There were only 15-20 white flowered plants in the population and they were found mostly at the top of the cut and mixed in with the pink. There were some plants that were not as pink as others and showed various gradations between pink to white.

Site 2 (Alkali Road - BLM): The population was probably about 90 percent white but intermixed within the population was various shades of pink flowers. We found them growing side by side and in some cases it even looked like we found pink to white within the same plant clump. In general, the pink flowers were not as pink as the Shell Canyon flowers.

In Medicine Bow-Routt National Forest, there were purple flowers found in one mixed population in White Rock Canyon (WY occurrence #037), which had a preponderance of white-flowered plants, fewer intermediate pink plants, and fewest purple-flowered plants. In addition, a small number of very pale pink-flowered plants were noted among white plants southeast of Lake Owen and at the south end of Sheep Mountain (WY occurrence #035). In addition, two-tone plants with deep pink or purple corolla lobes and a white base were collected in the Laramie Range (WY occurrence #011; *W. Fertig* #16108 RM). Each of the previously-mentioned occurrences with plants other than a pure white flower color are entered in the Wyoming Natural Diversity Database system as occurrences of *Penstemon laricifolius* ssp. *exilifolius* with notes that highlight the color variation (Wyoming Natural Diversity Database 2005).

It may be significant that two of the three definite mixed-color populations of *Penstemon laricifolius* having both white-flowered and purple-flowered individuals as well as pink intermediates are in canyon settings. They are the Shell Canyon occurrence on the Bighorn National Forest (WY occurrence #041) and the White Rock Canyon occurrence on the Medicine Bow-Routt National Forest (WY occurrence #037).

In turn, *Penstemon laricifolius* ssp. *exilifolius* is apparently present in the primary range of *P. laricifolius* ssp. *laricifolius*, as represented by one collection from both Sublette County and from western Carbon County in the general vicinity of collection stations for the type subspecies, but mixed-color populations have not been reported in these areas.

A review of potential explanations for color differences between *Penstemon laricifolius* ssp. *exilifolius* and *P. laricifolius* ssp. *laricifolius* is presented in the following paragraphs by reviewing cases in which flower color does or does not have taxonomic significance in the *Penstemon* genus. This discussion is cross-referenced in the text on taxonomic history, phylogenetic relations, and hybridization. Unfortunately, there has been no thorough evaluation of other *P. laricifolius* traits that may distinguish the two subspecies, including corolla shape, corolla length, anther and staminode characteristics, and leaf shape and surface.

Non-technical description

Penstemon laricifolius ssp. *exilifolius* is a perennial with several to numerous stems arising 10

to 20 (34) cm from a branched caudex. Leaves are numerous, narrowly linear to filiform, 15 to 25 mm long, and in dense, erect clusters on the caudex. Flowers are borne in a narrow inflorescence, few- to many-flowered; pedicels slender, sepals lanceolate and long-acuminate, with scarious margins; corolla white, greenish white, or light rose outside, somewhat abruptly inflated, 12 to 15 mm long; with glabrous anthers that dehisce their full length and at the suture; the sterile filament very stiffly and densely short-pubescent; inflorescence is a raceme with 1 (few) flowers per node and nodes that are slightly overlapping to remote (**Figure 1**, **Figure 2**; Nelson 1901, Nelson and Coulter 1909, Harrington 1954). $2n = 16$ (Recorded on collection label: *B. Hammel* #57 RM).

Flower color is the only distinction mentioned between *Penstemon laricifolius* ssp. *exilifolius* and the type subspecies in the current flora where they overlap, the latter having purple to pink flowers (Dorn 2001). The most detailed monographic descriptions are by Nelson (1901), Pennell (1920), and Keck (1937). Payson (1924) also reviewed the *Penstemon* species of Wyoming and affirmed the primacy of flower color in making a distinction at the variety level. Different authors cite different traits, and the most current evaluation of recognized differences is that by Keck (1937) who cites corolla length, corolla shape, and corolla color as diagnostic. A comparative table of published diagnostic characteristics is presented as reference (**Table 2**).

The existence of intermediate pale pink-flowered *Penstemon laricifolius* ssp. *laricifolius* was noted by Payson (1924), and cited by Keck (1937), who went on to note the presence of pinkish flowers of a *P. laricifolius* in the Laramie Basin in the middle of *P. laricifolius* var. *exilifolius* distribution. Not only are there intermediates and possible distribution overlaps between the two subspecies, but there are dual color populations. For that reason, information on *P. laricifolius* ssp. *laricifolius* and the genetic basis for flower color difference in the genus is added to the assessment.

It should be noted that there are complications that confound interpretation of flower color in *Penstemon laricifolius* ssp. *exilifolius*. First, the buds of *P. laricifolius* ssp. *exilifolius* often have purple or pink-colored tips on the outer corolla lobe before the flowers open (see cover photo). This developmental coloration phenomenon diminishes and often disappears by anthesis (Heidel personal observation). Second, the mature corolla color may persist with a two-tone flower color similar to the unopened flower bud, with white at the base and purple or pink at the tips (e.g., *W. Fertig*

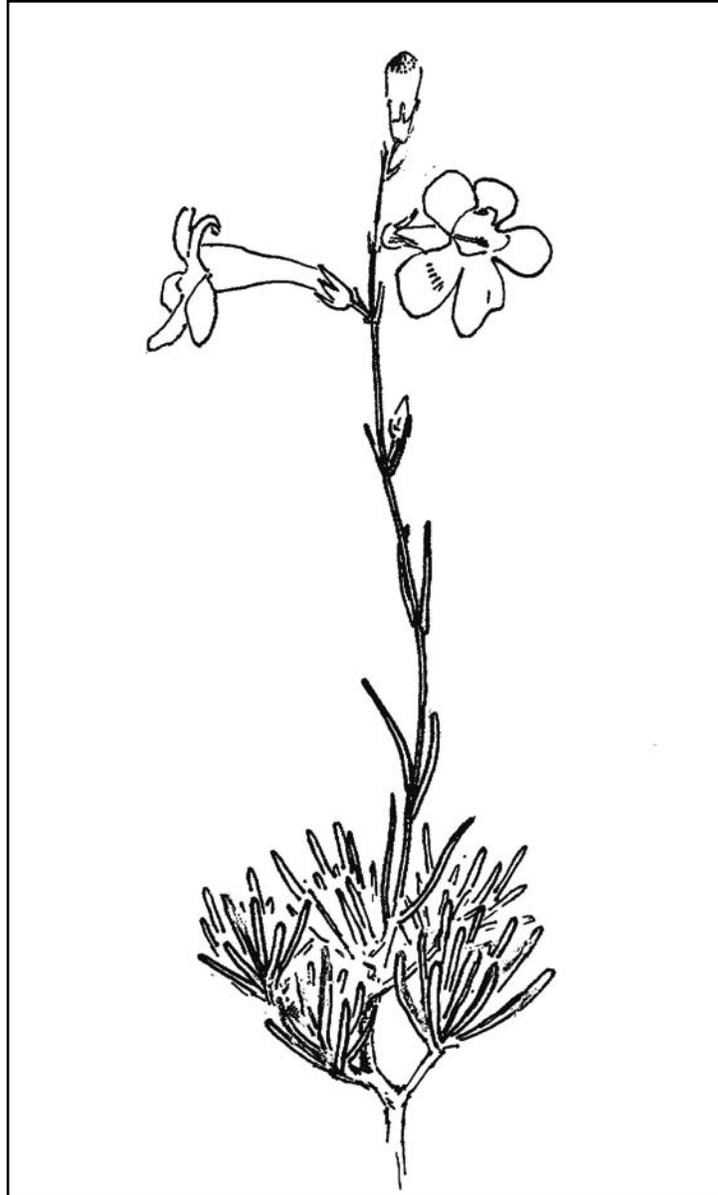


Figure 1. Illustration of *Penstemon laricifolius* ssp. *exilifolius*, by Bonnie Heidel.

#16108 RM). Third, the exterior of the mature corolla sometimes appears to have more color than the interior of the corolla tube as noted by Harrington (1954), sometimes highlighting veins or streaks on the outer surface. Fourth, there is also the appearance of greenish white flower colors as documented in specimens and reported by Harrington (1954). Interpretation is further complicated by the fact that color is not preserved in herbarium specimens, and the degrees of darkening as part of the drying effect may not be consistent between specimens. Unless otherwise stated, mention of flower color in this report refers to the prevailing color of mature flowers as noted in the field.

There are a few other examples of taxonomic distinctions in the *Penstemon* genus based primarily or exclusively on flower color. This is the case of the white-flowered *P. pratensis* (western whiteflower beardtongue), a Nevada endemic that closely resembles the widespread *P. rydbergii* (Rydberg's penstemon) in all but flower color, and may more appropriately be treated as a variety of the latter (Cronquist et al. 1984). It has a narrow, southern distribution by comparison with its widespread relative. The white-flowered *P. lentus* var. *albiflorus* (white handsome beardtongue) is another example; it has a much narrower distribution than the bluish-violet *P. lentus*



Figure 2. Photograph of *Penstemon laricifolius* ssp. *exilifolius* (WY occurrence #037), by Erin Foley, used with permission.

Table 2. Characteristics distinguishing *Penstemon laricifolius* ssp. *exilifolius* from *P. laricifolius* ssp. *laricifolius*.

	<i>Penstemon laricifolius</i> ssp. <i>exilifolius</i>			<i>Penstemon laricifolius</i> ssp. <i>laricifolius</i>		
	Nelson (1901)	Pennell (1920)	Keck (1937)	Nelson (1901)	Pennell (1920)	Keck (1937)
Flower color	White	White	White	Purple	Red-violet	Purple to pink
Corolla length (mm)	Corolla 12-15; lobes 6-7	Corolla throat 9-10; lobes 4-7	Corolla 12-15	—	Corolla throat 10-12; posterior lobes 3-4	Corolla 15-18
Corolla shape, inner hairs	Tubular- funnelform, obscurely pubescent in the throat	Corolla throat evidently inflated, evidently 2- lipped, the lobes spreading to 10-15 mm	More abruptly ampliate	Ventricose, pilose on the lip and throat	Corolla throat slightly inflated, slightly 2- lipped, the lobes spreading to less than 11 mm	Gradually ampliate
Staminode	Scarcely dilated, very stiffly and densely short- pubescent	Densely-bearded	—	Pilose	Slightly to moderately bearded	—
Anther sacs	—	Ovate-lanceolate	—	—	Linear-lanceolate	—
Leaf shape, surface	Subulate-pointed, glabrous leaves	—	—	Obtusish, shining leaves	—	—

var. *lentus* (handsome beardtongue) (Cronquist et al. 1984). These cases parallel that of *P. laricifolius* in that the more widespread taxon, possibly the progenitor, has corolla coloration. These cases differ from the relation between the two subspecies of *P. laricifolius* in that they do not have overlapping distributions or reports of intermediate flower coloration in populations of the white-flowered taxon.

In other cases of flower color variation in the *Penstemon* genus, flower color does not have taxonomic significance. These cases include albinism, genetic plasticity as expressed in a range of shades and hues, color phases, and low levels of genetic distinction found between races.

Distribution and abundance

Penstemon laricifolius ssp. *exilifolius* is a regional endemic of Colorado and Wyoming. It is concentrated in the Laramie Basin of Wyoming and the adjoining foothills. It is also in Colorado in the lower

reaches of the Laramie River Valley, which drains into and is contiguous with the Laramie Basin. *Penstemon laricifolius* ssp. *exilifolius* is sparingly distributed to the north, including outliers in the western foothills of the Big Horn Mountains (**Figure 3**). In total, 40 occurrences are extant (14 are historical) and 10 of the extant are on National Forest System lands (25 percent). There have been no efforts to relocate historical occurrences, almost all of which have vague location information and are on private ranches. Records of all processed occurrences and available abundance data through January 2006 are presented in **Table 3**.

In Colorado, *Penstemon laricifolius* ssp. *exilifolius* is known from 10 occurrences, many consisting of multiple colonies, with nine extant. Only one of the extant occurrences is on the Arapaho and Roosevelt National Forests as currently documented by the Colorado Natural Heritage Program (2005), but there are also two Arapaho and Roosevelt National Forests records that have yet to be integrated and entered as new occurrences or expansions of those above. McIntyre

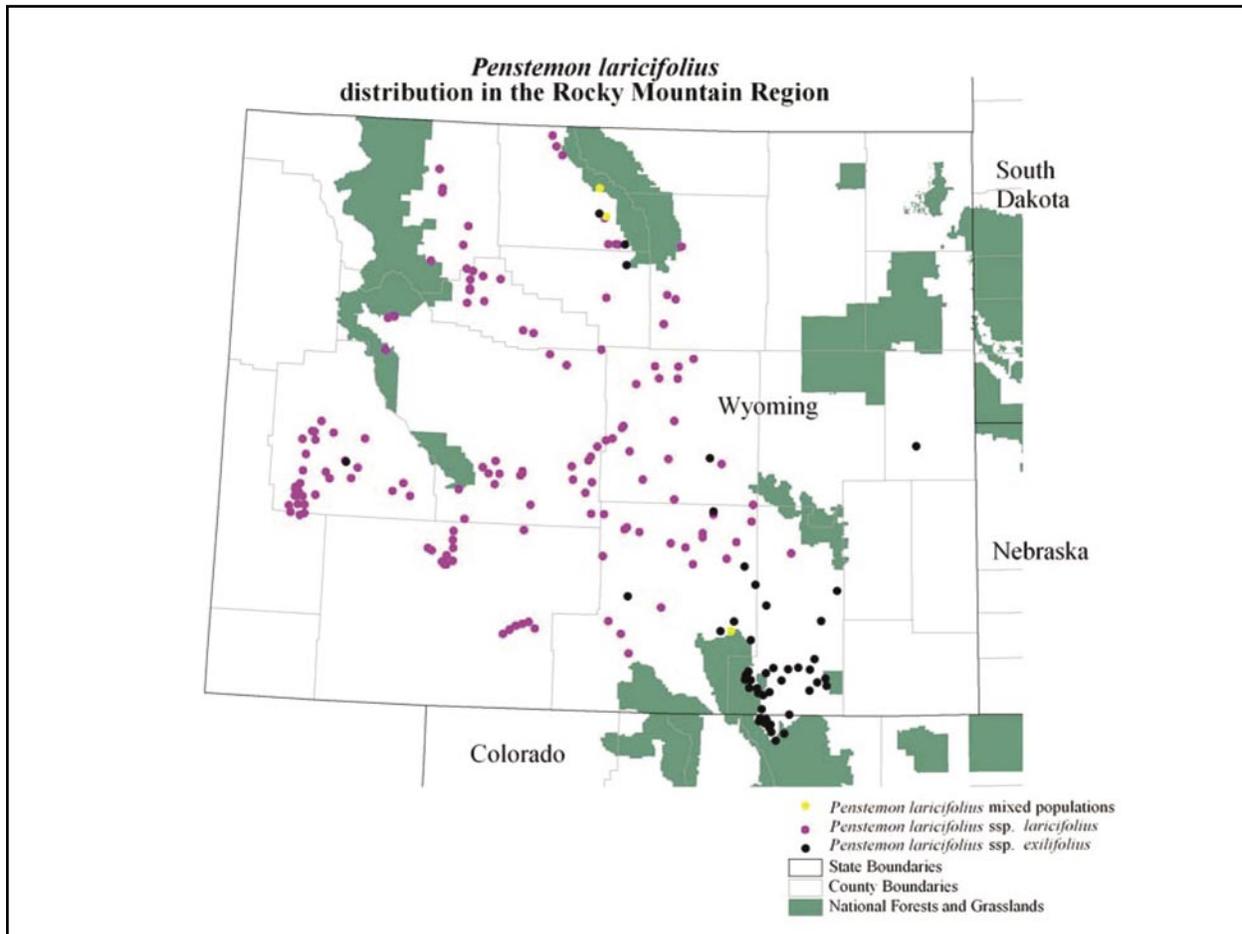


Figure 3. Distribution of *Penstemon laricifolius* ssp. *exilifolius* and *P. laricifolius* ssp. *laricifolius* in USDA Forest Service Region 2.

Table 3. Populations and habitats of *Penstemon laricifolius* ssp. *exilifolius* in Colorado and Wyoming. Those site names that are bold-faced are national forests of the Rocky Mountain Region. Hist=known only from historical records.

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Colorado								
Glendevy (001)	Larimer	Private	NA	1968 (hist)	2000	8,100	Not reported.	Not reported
Chimney Rock (002)	Larimer	Arapaho and Roosevelt National Forests; Bureau of Land Management (BLM); Private	10,000-15,000 (Sec. 19: 20,29,30)	2004	925	5,640-9,600 (Sec. 19: 8,800- 9,600)	Most abundant on barren slopes but also scattered within shrublands. On windswept sage plains and prairie knolls Sec. 19: Dry sagebrush slopes with red sandy soil, transitioning into higher elevation with white calcareous soil	<i>Artemisia triparita</i> , <i>Festuca idahoensis</i> , <i>Artemisia frigida</i> , <i>Chrysothamnus viscidiflorus</i> , <i>Muhlenbergia montana</i> , <i>Bouteloua gracilis</i> , <i>Eriogonum umbellatum</i> , <i>Purshia tridentata</i> , <i>Cercocarpus sp.</i> , <i>Tetradymia canescens</i> , <i>Krascheninnikovia lanata</i> , <i>Koeleria macrantha</i> , <i>Elymus lanceolatus</i> , <i>Stipa comata</i> , <i>Elymus smithii</i> , <i>Lupinus argenteus</i> , <i>Oxytropis sericea</i> , <i>Sedum lanceolatum</i> , <i>Antennaria sp.</i> , <i>Astragalus</i> sp. Sec. 19: <i>Lupinus argenteus</i> , <i>Oxytropis sericea</i>
Glendevy School (007)	Larimer	BLM; State of Colorado	NA	1996	115	7,940-8,520	Not in thick sagebrush or dense grasscover – only in more sparsely vegetated areas. Granite to sandstone; white, chalky clays to deep red and purple, fine sands.	<i>Artemisia tridentata</i> , <i>Cercocarpus montanus</i> , <i>Arenaria</i> sp., <i>Eriogonum sp.</i> , and grasses
La Garde Creek (008)	Larimer	BLM; State of Colorado Private	150	1996	7	7,960	North-facing, 40 degree slope of sandy, gravelly soils covered with river cobbles.	<i>Artemisia tridentata</i> , <i>Chrysothamnus sp.</i> , <i>Artemisia</i> sp., <i>Eriogonum</i> sp.
Stuck Creek (009)	Larimer	BLM	50-100	1996	7	8,390	Open, flat grassland in gravelly soils. Two track road through occurrence.	<i>Artemisia tridentata</i> , <i>Potentilla</i> sp., <i>Chrysothamnus</i> sp., <i>Eriogonum umbellatum</i> , <i>Artemisia frigida</i> , grasses
Little Hoinholz Lake (010)	Larimer	BLM Private	300	1996	31	7,920-8,000	Sagebrush plains surrounding reservoir. In relatively sparsely vegetated areas. North- facing slope of about 10 degrees.	<i>Artemisia tridentata</i> , <i>Chrysothamnus sp.</i> , <i>Astragalus</i> sp., <i>Eremogone</i> sp., <i>Gutierrezia sarothrae</i> , grasses

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Pete Creek (012)	Larimer	Private	50	1996	7	8,220-8,400	Flat roadside.	<i>Artemisia tridentata</i> , <i>Antennaria</i> spp., <i>Sedum lanceolatum</i> , <i>Chrysothamnus</i> spp.
Stuck Creek II (013)	Larimer	BLM; State of Colorado	1000+	1996	7	8,000-8,260	Grasslands in gravelly soils on 5-45 degree slopes, mostly in areas that are relatively barren (50% cover).	<i>Festuca idahoensis</i> , <i>Elymus spicatus</i> , <i>Artemisia tridentata</i> , <i>Artemisia</i> <i>frigida</i> , <i>Antennaria</i> sp., <i>Eriogonum</i> sp., <i>Pinus flexilis</i>
Pfister Draw (014)	Larimer	State of Colorado	Hundreds	2001	12	7,840	White, calcareous and red, sandy soils edging a wet draw, with red sandstone outcrops. Sagebrush plain.	<i>Artemisia tridentata</i> , <i>Agropyron</i> <i>cristatum</i> , <i>Eriogonum umbellatum</i> , <i>Chaenactis douglasii</i>
Woods Landing Road (015)	Larimer	BLM	5-10	2001	8	8,200	Calcareous, west-facing, crumbling roadside slope. Open, grassy, subalpine meadow.	<i>Ericameria parryi</i> var. <i>howardii</i>
TOTAL IN COLORADO 10 records: 9 extant, 1 historical								
Wyoming								
Alkali Road (001)	Big Horn	BLM Worland	High thousands	2005	NA	5,600-7,050	Rough breaks, roadside, and exposed, gravelly ridges.	<i>Cryptantha</i> sp., <i>Penstemon</i> sp., <i>Aster</i> sp.
Albany (002)	Albany	Private	NA	1913 (hist)	NA	unknown	Sunny granite slopes.	Not reported
Government Gulch (003)	Albany	Private	NA	1995	NA	7,700-7,850	Black sagebrush grassland. On reddish, sandy soil with limestone gravel.	<i>Artemisia nova</i>
State Route 487 (004)	Carbon	Private	NA	1986	NA	6,800	Not reported.	Not reported
Platte River Canyon (005)	Natrona	Private	NA	1947 (hist)	NA	5,250	Ledges of red sandstone bluff.	Not reported
Hwy 230 (006)	Albany	Private	NA	1993	NA	8,000	Plains.	<i>Comandra</i> sp., <i>Astragalus</i> sp., <i>Agropyron</i> sp.
Bighorn Basin (007)	Big Horn	BLM Worland	NA	2000	NA	6,300	Not reported.	<i>Artemisia</i> sp., <i>Chrysothamnus</i> sp.

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Mesa Road (008)	Sublette	BLM Pinedale	NA	1995	NA	7,200-7,280	Cobblestone hilltop edge with scattered sagebrush.	<i>Artemisia</i> sp.
Hallek Canyon (009)	Albany	BLM Rawlins	NA	1900 (hist)	NA	5,700-6,800	Not reported.	Not reported
Happy Jack (010)	Albany	Medicine Bow- Routt National Forest	NA	2005	NA	8,400-8,800	On ridge with pine and grass.	Not reported
Highway 30 (011)	Albany	Medicine Bow- Routt National Forest	NA	1995	NA	8,640	Cliffs and outcrops of shaley limestone in matrix of red sandstone.	<i>Artemisia tridentata</i> var. <i>vaseyana</i> , <i>Artemisia tripartita</i> , grasses
Rawlins (012)	Carbon	Private	NA	1942 (hist)	NA	6,000-7,000	Rock crevices on hill.	Not reported
Plumbago Canyon (013)	Albany	Private	NA	1935 (hist)	NA	7,300-7,900	Not reported.	Not reported
Manville (014)	Niobrara	State of Wyoming	NA	1995	NA	5,600	Chalky outcrop.	<i>Eriogonum flavum</i> , <i>Cryptantha</i> sp.
Chimney Rock (015)	Albany	Private	Common	1975	NA	7,500	In open ground. Red, sandy soil.	Not reported
Cooper Cove (016)	Carbon	Private	NA	1987	NA	7,400-8,400	Dry, gravelly soil in sagebrush-grassland.	Not reported
Wallace Creek (017)	Albany	Private	NA	1964 (hist)	NA	8,400	Western exposure, gravelly soil.	Not reported
Wagonhound (018)	Carbon	Wyoming Wildlife Habitat Management Unit	NA	2001	NA	7,600	On rocky flats within white-tailed prairie dog community.	<i>Artemisia nova</i> , <i>Artemisia tripartita</i> var. <i>rupicola</i> , <i>Haplopappus</i> sp., <i>Poa secunda</i> , <i>Phlox</i> sp., <i>Gutierrezia</i> <i>sarothrae</i> , grasses
Laramie airport (019)	Albany	Private	NA	1945 (hist)	NA	7,250	Along road.	Not reported
Pioneer Canal (020)	Albany	Private	NA	1989	NA	7,300	Sandy-silty soil on roadcut with scattered vegetation.	Not reported

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Como Ridge/ Aurora (022)	Albany/ Carbon	BLM Rawlins	NA	1899 (hist)	NA	6,700-7,200	Not reported.	Not reported
Sheep Mountain and Table Mountain (023)	Albany	Medicine Bow- Routt National Forest	396,000-415,000	2005	1251	7,400-8,100	Grassland on gravelly, exposed soil, often with large stones; calcium carbonate shell often observed on rocks. Highest numbers in wind-swept, sparsely vegetated, sometimes disturbed areas.	<i>Gutierrezia sarothrae</i> , <i>Astragalus tenellus</i> , <i>Astragalus adsurgens</i> , <i>Penstemon strictus</i> , <i>Eriogonum flavum</i> , <i>Oryzopsis contracta</i> , <i>Oryzopsis hymenoides</i> , <i>Elymus smithii</i> , <i>Elymus spicatus</i> , <i>Stipa comata</i> , <i>Koeleria macrantha</i> , <i>Lesquerella ludoviciana</i> , <i>Artemisia tripartita</i> , <i>Artemisia tridentata</i> var. <i>vaseyana</i> , <i>Comandra umbellata</i> var. <i>pallida</i> , <i>Chrysothamnus viscidiflorus</i> , <i>Arenaria hookerii</i> , <i>Cryptantha virgata</i> , <i>Cryptantha thysiflora</i> , <i>Artemisia frigida</i> , <i>Artemisia nova</i> , <i>Krascheninikovia lanata</i> , <i>Erysimum asperum</i> var. <i>arkansanum</i> , <i>Ericameria nauseosa</i> , <i>Chamaerhodos erecta</i> var. <i>parviflora</i> , <i>Oxytropis</i> sp., <i>Linum lewisii</i> , <i>Helianthella uniflora</i> , <i>Eriogonum elatum</i> , <i>Tetradymia canescens</i> , <i>Eriogonum microthecum</i> , <i>Sedum lanceolatum</i> , <i>Sphaeralcea coccinea</i> , <i>Gaillardia aristata</i> <i>Pinus flexilis</i> , <i>Artemisia tridentata</i>
Chalk Mountain (024)	Carbon	BLM Rawlins	NA	1978	NA	7,500	Not reported.	
Tensleep Canyon and Sand Draw (025)	Washakie	Bighorn National Forest; BLM Worland	87	2005	<1	5,000-6,050	Dry slopes. Calcareous sandstone.	<i>Artemisia</i> sp., <i>Juniperus</i> sp., <i>Opuntia</i> sp.
Laramie (026)	Albany	City of Laramie; State of Wyoming; Private	NA	2005	NA	7,100-7,200	Gentle slopes with <i>Elymus smithii</i> / <i>Gutierrezia sarothrae</i> grassland on red silt loam	<i>Elymus smithii</i> , <i>Sphaeralcea coccinea</i> , <i>Artemisia frigida</i> , <i>Atriplex canescens</i> , <i>Gutierrezia sarothrae</i>

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Millbrook (027)	Albany	Private	NA	1931 (hist)	NA	7,200	On rocky prairie with other cushion plants.	Not reported
Red Buttes (028)	Albany	Private	NA	1931 (hist)	NA	7,250-7,450	Red, gravelly knoll and dry fields.	Not reported
Deerwood (029)	Albany	Private	NA	1938 (hist)	NA	7,800-9,000	Prairie.	Not reported
BLM route 1117 (030)	Albany	BLM Worland	500	2004	6	6,360-7,600	Sparsely vegetated, steep cutbanks along road in loose, calcareous soil.	<i>Pinus ponderosa</i> , <i>Abies lasiocarpa</i> , <i>Senecio</i> sp., <i>Castilleja</i> sp., <i>Sedum lanceolatum</i> , <i>Arenaria hookeri</i> , <i>Penstemon aridus</i> , <i>Penstemon caryi</i> , <i>Berberis repens</i>
9th Street (031)	Albany	Albany County	Occasional	2003	<1	7,315	Windswept, sparsely vegetated flats of red, gravelly silt loam in roadside setting, with sagebrush steppe and cushion plants.	<i>Artemisia tripartita</i> , <i>Elymus elymoides</i> , <i>Stipa comata</i> , <i>Astragalus tenellus</i>
Twin Buttes Lake (032)	Albany	BLM Rawlins	Common/ Abundant	2005	NA	7,400	In dry, alkaline, sandy soil.	Not reported
Centennial (033)	Albany	Private	Common, copious	1926 (hist)	NA	8000	Dry, open flats and rocky, windswept flats.	<i>Artemisia pedatifida</i> , <i>Oxytropis sp.</i> , <i>Astragalus</i> sp., <i>Cryptantha</i> sp., <i>Muhlenbergia</i> sp., <i>Phlox</i> sp.
County Road 101 (034)	Carbon	Carbon County	180+	2005	4	7,880-8,120	Roadside grassland.	<i>Phlox</i> sp., <i>Astragalus bisulcatus</i> var. <i>major</i> , <i>Comandra umbrellata</i> var. <i>pallida</i> , <i>Cirsium aridum</i> , <i>Oryzopsis hymenoides</i> , <i>Gutierrezia sarothrae</i> , <i>Eriogonum exilifolium</i> , <i>Cirsium</i> sp., <i>Eriogonum flavum</i> , <i>Linum lewisii</i>

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Lake Owen (035)	Albany	Medicine Bow- Routt National Forest	30,970-31,040+	2005	114	8,040-8,480	Sagebrush grassland hillsides, some with scattered limber pine; in windswept, sparsely vegetated or disturbed areas, with sandy loam to a sandy clay loam soil texture. Slopes 0-19%, all aspects. Calcareous substrate.	<i>Castilleja sulphurea</i> , <i>Cirsium canescens</i> , <i>Artemisia frigida</i> , <i>Stipa comata</i> , <i>Eriogonum elatum</i> , <i>Cryptantha thrysiiflora</i> , <i>Tetradymia canescens</i> , <i>Eriogonum flavum</i> , <i>Antennaria</i> sp., <i>Oxytropis lamberti</i> , <i>Ericameria</i> sp., <i>Sedum lanceolatum</i> , <i>Paronychia sessiliflora</i> , <i>Chrysothamnus</i> sp., <i>Gutierrezia sarothrae</i> , <i>Calochortus nuttallii</i> , <i>Heterotheca</i> sp., <i>Crepis acuminata</i> , <i>Astragalus</i> sp., <i>Koeleria macrantha</i> , <i>Astragalus adsurgens</i> , <i>Elymus spicatus</i> , <i>Townsendia sp.</i> , <i>Chrysothamnus nauseosus</i> , <i>Artemisia tridentata</i> , <i>Oxytropis</i> sp., <i>Purshia tridentata</i> , <i>Elymus smithii</i> , <i>Cryptantha</i> sp.
Laramie River Overlook (036)	Albany	Medicine Bow- Routt National Forest; BLM Rawlins	240	2005	83	7,850-8,200	Sagebrush grassland hill.	<i>Artemisia nova</i> , <i>Artemisia frigida</i> , <i>Koeleria macrantha</i> , <i>Elymus scribneri</i> , <i>Eriogonum flavum</i> , <i>Oxytropis lamberti</i> , <i>Cryptantha virgata</i> , <i>Ericameria</i> sp., <i>Astragalus adsurgens</i> , <i>Castilleja sulphurea</i> , <i>Paronychia</i> sp.

Table 3 (cont.).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
White Rock Canyon (037)	Carbon	Medicine Bow- Routt National Forest	7220	2005	102	8,000-8,880	Sagebrush grassland ridges and steppes, with a sandy loam soil texture. Predominately found in more open areas with low vegetation density.	<i>Frasera speciosa</i> , <i>Sedum lanceolatum</i> , <i>Lupinus</i> sp., <i>Eriogonum elatum</i> , <i>Eriogonum flavum</i> , <i>Arenaria congesta</i> , <i>Pinus flexilis</i> , <i>Erigeron</i> sp., <i>Besseyia</i> sp., <i>Astragalus adsurgens</i> , <i>Tragopogon dubius</i> , <i>Heterotheca</i> sp., <i>Crepis acuminata</i> , <i>Comandra umbellata</i> var. <i>pallida</i> , <i>Cercocarpus montanus</i> , <i>Oxytropis sericea</i> var. <i>sericea</i> , <i>Antennaria</i> sp., <i>Calochortus nuttallii</i> , <i>Ericameria</i> sp., <i>Gutierrezia sarothrae</i> , <i>Artemisia frigida</i> , <i>Eremogone congesta</i> , <i>Tetradymia canescens</i> , <i>Stipa comata</i> , <i>Linum lewisii</i> , <i>Castilleja linariifolia</i> , <i>Galium boreale</i> , <i>Calochortus</i> sp., <i>Selaginella densa</i> , <i>Bromus inermis</i> , <i>Lewisia rediviva</i> , <i>Oxytropis</i> sp.
Centennial Work Station (038)	Albany	Medicine Bow- Routt National Forest	1250	2005	<1	8,380-8,695	Ridgetop to lower foothill slopes of rocky hillsides with pockets of exposed soil. Southeast aspect with a silt loam soil texture.	<i>Stipa comata</i> , <i>Koeleria macrantha</i> , <i>Tetradymia canescens</i> , <i>Helianthella uniflora</i> , <i>Elymus spicatus</i> , <i>Artemisia tridentata</i> , <i>Artemisia tripartita</i> , <i>Agropyron cristatum</i> Not reported
Weber Creek (039)	Albany	Private	NA	2004	NA	8,000	Sparse grass and forbs.	Not reported
Wyoming Hwy 130 (040)	Albany	State of Wyoming	NA	2004	NA	7,400	Gravelly roadside, sparsely vegetated.	<i>Melilotus officinalis</i> , grasses
Shell Falls (041)	Big Horn	Bighorn National Forest	15-20	2005	NA	5,600-6,300	On trail and most exposed upper slopes of relatively new, north-facing roadside cuts, 40-60% slopes.	Mixed in with ssp. <i>laricifolius</i>
Middle Fork Little Laramie River (042)	Albany	Private	150	2005	NA	8,140-8,260	Sagebrush grassland on calcareous clay.	<i>Artemisia tridentata</i> , <i>Chrysothamnus nauseosus</i> , <i>Selaginella densa</i> , <i>Stipa comata</i> , <i>Oxytropis</i> sp., <i>Comandra umbellata</i> , <i>Elymus smithii</i> , <i>Elymus spicatus</i>
Boulder Ridge (043)	Albany	Private	NA	1976	NA	8,340	Not reported.	Not reported

Table 3 (concluded).

Site name (Occurrence number)	County	Landowner	Estimated abundance	Year last seen	Extent (acres)	Elevation range (ft.)	General habitat description	Associated species
Wyoming Hwy. 287 (044)	Albany	Private	NA	1976	NA	7,310	Not reported.	Not reported
TOTAL IN WYOMING		44 records; 31 extant, 13 historical						
TOTAL RANGEWIDE		54 records; 40 extant, 14 historical						
TOTAL ON REGION 2 NATIONAL FOREST SYSTEM LAND		10 records; 9 extant, 1 historical						

Creek and above Stuck Creek on south and west sides of the valley, respectively (Richard Scully personal communication 2005). They are not represented in **Table 3** or tallies, but they are noted in distribution text for this assessment. The three records for *P. laricifolius* ssp. *exilifolius* on the Arapaho and Roosevelt National Forests (Canyon Lakes Ranger District) are on all three sides of the Laramie River Valley (south, east, and west). The Sand Creek occurrence (CO occurrence #002) has five separate locations recorded for it across three sections, and this is the only occurrence that is included in **Table 3**. In addition, there was a 1933 collection made on the Roosevelt National Forest (*B. Torgny* #T-9 RM) that is outside of current national forest boundaries.

In Wyoming, *Penstemon laricifolius* ssp. *exilifolius* is known from 44 occurrences, and at least 31 are extant. There are 13 historical occurrences, not including other historical collections within the Laramie Basin that have insufficient location information to assign to township. Nine of the extant occurrences are on National Forest System lands. Two occurrences are on the Bighorn National Forest (Painted Rock-Medicine Wheel Ranger District and Powder River Ranger District), where the taxon was documented for the first time in 2005 by Susan Bell, Earl Jensen, and Gary Lehnhoff. There are two occurrences on the Medicine Bow-Routt National Forest in the Pole Mountain Unit (Laramie Ranger District in the southern Laramie Range) where the national forest covers a limited area of habitat. The taxon has also been documented on private lands to the north and south (e.g., Fertig 1995). The largest number of occurrences and the largest size of occurrences known to date are on the Medicine Bow-Routt National Forest in the Medicine Bow Mountains. *Penstemon laricifolius* ssp. *exilifolius* is near, but not likely on, two other units of the Medicine Bow-Routt National Forest: the Laramie Peak Unit and the Thunder Basin National Grassland. In addition, a historical collection of *P. laricifolius* ssp. *exilifolius* was made in the vicinity of Albany, which is in the same township as extant occurrences on the Medicine Bow-Routt National Forest. Surveys have been conducted for at least two miles to the north without finding it there (Proctor personal communication 2005). It is likely that the historical collection was made outside of what is now National Forest System land because the collector, J. Francis MacBride, was working on an irrigation study, apt to be in the Centennial Valley. The five extant occurrences in the Medicine Bow Mountains are concentrated in five townships around the Centennial Valley and Sheep Mountain.

In addition to the ten currently recognized occurrences on National Forest System land, there are 18 occurrences on BLM-administered lands, several of which are extensions of the previously mentioned occurrences on USFS-administered lands.

The physiographic distribution of *Penstemon laricifolius* ssp. *exilifolius* is centered in the Laramie Plains and foothills of Albany County, Wyoming and the Laramie River Valley of northwest Larimer County, Colorado. The range extends to the adjoining Hanna Basin and Shirley Basin of Albany and Carbon counties, Wyoming. *Penstemon laricifolius* ssp. *exilifolius* is also known from isolated locales in the western foothills of the Big Horn Mountains in Big Horn and Washakie counties, Wyoming, and two isolated, historical collection records in the North Platte Valley north of Saratoga (Carbon County, Wyoming), a recent collection in the Hartville Uplift (Niobrara County, Wyoming), and one recent collection in the Green River Basin south of Boulder, Wyoming (Sublette County). There is a specimen of *P. laricifolius* from Montana that appears to be subspecies *exilifolius* (*W.E. Booth s.n.* RM, MONT; as reported in Wetherell 1959). However, subspecies *exilifolius* has not been reported in the Montana flora. The flower color of the dried specimen is pale pink if not white, and there are colored tips on the unopened buds for contrast, but white coloration of the mature flowers cannot be confirmed (Heidel personal observation). Montana botanists have been informed about this specimen.

The distribution of *Penstemon laricifolius* ssp. *exilifolius* has recently been documented in greater detail through the floristic surveys of the Rocky Mountain Herbarium (Hartman and Nelson 2002), the Larimer County biological inventory (Doyle et al. 2005), project reviews on the Medicine Bow-Routt National Forest (Proctor personal communication 2005), surveys conducted on the Medicine Bow-Routt National Forest for the Forest by Joy Handley and Erin Foley (Wyoming Natural Diversity Database), and surveys conducted on the Bighorn National Forest (Karow personal communication 2005). The 2005 surveys on the Bighorn National Forest documented *P. laricifolius* ssp. *exilifolius* for the first time on that National Forest. Recent surveys provided opportunities to locate and map the distribution of *P. laricifolius* ssp. *exilifolius* on National Forest System lands in particular.

One of the most intriguing locations for *Penstemon laricifolius* ssp. *exilifolius* is in Niobrara County north of Manville (*R.D. Dorn* #6244 RM), the

only known location east of the Laramie Mountains on an extension of the Hartville Uplift as vestige of the Laramide Orogeny. This location is consistent with the hypothesis that *P. laricifolius* ssp. *laricifolius* represents a paleoendemic.

By comparison with *Penstemon laricifolius* ssp. *exilifolius*, the distribution of *P. laricifolius* ssp. *laricifolius* is more widespread in total extent and in distribution on the National Forest System lands of Region 2 (**Figure 3**). *Penstemon laricifolius* ssp. *laricifolius* occurs on the Shoshone National Forest in the Absaroka, Owl, and Wind River ranges and on the Bighorn National Forest in the Big Horn Range, as well as at lower elevations in the foothills and basins of 11 Wyoming counties. Its overall distribution pattern arcs around the Greater Yellowstone Region at mid-elevations, and it is known from over 100 recent collections (Hartman and Nelson 2005). This taxon is not known from Colorado but extends north into Montana, in Bighorn and Carbon counties.

The distribution of *Penstemon laricifolius* ssp. *exilifolius* has limited overlap with the distribution of *P. laricifolius* ssp. *laricifolius*, as represented by Hartman and Nelson (2005). The latter occupies basins and foothills of the Greater Yellowstone Area and Big Horn Mountains, with scattered outliers on isolated escarpments and ancient ranges of south-central Wyoming. The only areas where both purple and white flowers are documented as sympatric are in the western foothills of the Big Horn Mountains and the northern end of the Medicine Bow Mountains, though there are intermediates reported elsewhere.

The subspecies of *Penstemon laricifolius* apparently sort out by setting if not by elevation, with *P. laricifolius* ssp. *exilifolius* concentrated in more open habitat at higher elevations compared to the forested, canyon setting of *P. laricifolius* ssp. *laricifolius*. Intermediates were present at two of the four recently surveyed Big Horn Mountains sites, in roadside settings, suggesting hybridization. The fact that intermediates were noted in early monographs (Payson 1924, Keck 1937) may indicate that this phenomenon is not an artifact of recent road construction, though neither monograph author was aware of the direct distribution overlap between the two subspecies.

Information on the abundance of *Penstemon laricifolius* ssp. *exilifolius* is not available for many collection stations. However, when Aven Nelson first collected *P. laricifolius* ssp. *exilifolius* in the 1890's, he characterized it as "abundant on stony ridges on

the Laramie Plains and their foothills" (Nelson 1896). It was also noted as "frequent in the region on stony slopes" on a 1914 collection label (*J.F. MacBride* #2782 RM). This characterization of its abundance and local distribution pattern appears to be valid today. As a result of 2005 surveys, it is known from at least seven extant occurrences on the Medicine Bow-Routt National Forest, and two of these occurrences had numbers estimated in the hundreds of thousands. While *P. laricifolius* ssp. *exilifolius* may be locally restricted to sparsely vegetated patches, each of these two occurrences occupies eight or more sections, and is distributed in up to 22 discrete colonies across the landscape. As part of occurrence specifications, occurrences were delimited by separation distances of at least 2 miles. In the case of the largest two occurrences, they are also separated by private land with an historic collection in the vicinity, and they might be part of one, giant occurrence complex. Estimates of the number of plants in each occurrence were made by counting discrete clumps in one or more areas, traversing occupied habitat, and then extrapolating. Where *P. laricifolius* ssp. *exilifolius* grows in highest densities, it can be difficult to distinguish individual plants, and estimates may be low.

Rangewide, there are at least four occurrences with numbers of individual plants above 10,000. Estimates are lacking to determine the magnitude of occurrence size for most records. In the Big Horn Mountains, the foothills occurrence of *Penstemon laricifolius* ssp. *exilifolius* was reported as having numbers in at least the "high thousands." Not only were plants numerous, but they were also many-stemmed and vigorous (**Figure 4**, **Figure 5**).

There are also reports of *Penstemon laricifolius* ssp. *exilifolius* occurrences with few plants, and differences in habitat represent differences in density and frequency. On flat tableland of the Laramie Range, *P. laricifolius* ssp. *exilifolius* plants are fewer and the distribution is more restricted than on slopes with unconsolidated substrate even though the taxon is widespread in this setting. The special case of low numbers of *P. laricifolius* ssp. *exilifolius* where it overlaps with *P. laricifolius* ssp. *laricifolius* in the Shell Canyon of the Big Horn Mountains might represent suboptimal habitat for the former (Jensen personal communication 2005). It was estimated at 15-20 individuals, among 2000+ pink-flowered individuals (Jensen personal communication 2005). Second, some of the abundance estimates are based on the preliminary nature of the survey effort, or on the limited extent of habitat on public lands.

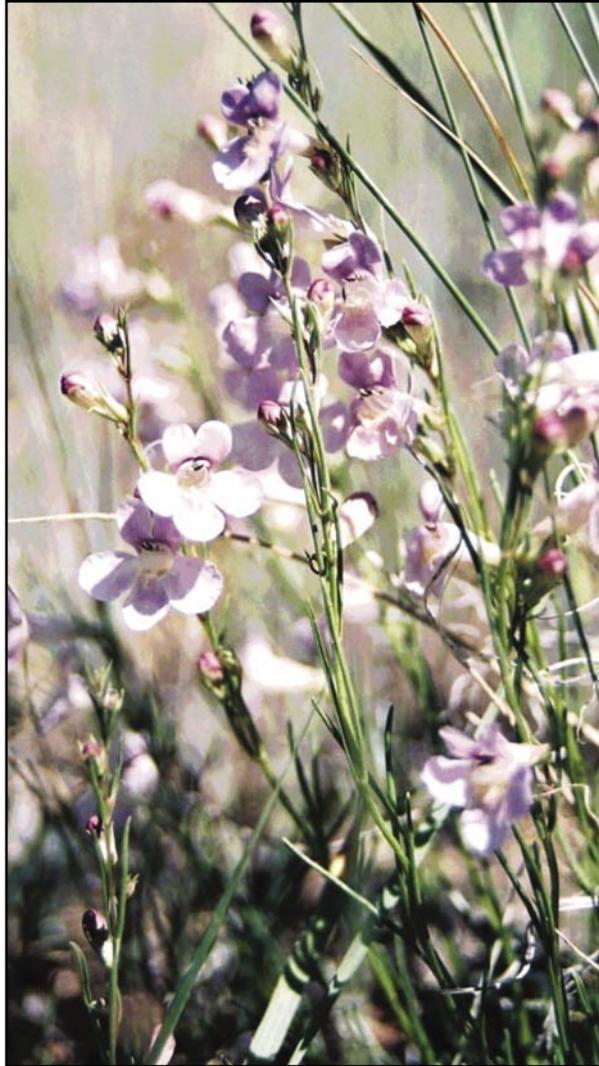


Figure 4. Photograph of pink intermediate flower color of *Penstemon laricifolius* ssp. *exilifolius* at White Rock Canyon on Medicine Bow-Routt National Forest (WY occurrence #037), in a mixed-color population with white-flowered and occasional purple-flowered plants (same location as [Figure 2](#)), by Erin Foley, used with permission.

In the Laramie Valley of Colorado, *Penstemon laricifolius* ssp. *exilifolius* is reported as abundant to common on the uplands among short-stature sagebrush and rabbitbrush (Scully personal communication 2005).

Population trend

Long-term trend data are unavailable for most occurrences of *Penstemon laricifolius* ssp. *exilifolius* in Colorado and Wyoming. Some extant Wyoming occurrences have been found with native vegetation near historic collection areas, suggesting that the taxon can persist over the long term. While there are no known cases where it has been extirpated, historic location information is often inadequate to prove extirpation.

In some cases, the taxon is closely associated with zones of disturbance, suggesting local expansions and increases in numbers. One of the highest local densities was found at a site on the Medicine Bow-Routt National Forest that appears to have been graded for parking highway construction vehicles (surveyed in 2005 on Sheep Mountain by Erin Foley, Bonnie Heidel, and John Proctor). The parking area habitat was surrounded by extensive, intact habitat where *P. laricifolius* ssp. *exilifolius* was present in lower densities. At least nine of the total records are from roadside rights-of-way or include segments of the occurrence in rights-of-way. It is not known how many of these represent settings that were essentially scraped of all vegetation or how many represent unaltered settings. This issue warrants further investigation in determining whether the taxon



Figure 5. Photograph of a vigorous *Penstemon laricifolius* ssp. *exilifolius* plant with pale pink flower color at Alkali Road (WY occurrence #001), by Earl Jensen, used with permission.

can persist despite grading and blading. *Penstemon laricifolius* ssp. *exilifolius* is clearly concentrated in the road rights-of-way in at least two occurrences in the Big Horn Mountains. In one extreme case, on BLM land below Bighorn National Forest, Earl Jensen noted that:

Penstemon laricifolius ssp. *exilifolius* was found along a nine mile stretch of the road, numbering into the very high thousands of plants. At times it looked like *Cerastium* [mouse-ear chickweed] covering the ground. These plants were found especially along the road cuts and disturbed areas but were also found along the gravelly exposed ridges and followed the ridges as far as we could see.” (Earl Jensen personal communication 2005.)

The taxon’s local abundance on a newly graded habitat would seem to indicate recent colonization events. The contributions of disturbed habitat to the long-term viability of *Penstemon laricifolius* ssp. *exilifolius* is not known, but the taxon’s persistence on rocky uplands appears more likely than in periodically manipulated roadsides. High fecundity but local extirpation has been documented for other species of *Penstemon* monitored in a roadside setting compared with native settings (Shelly and Heidel 1995).

Recent data on *Penstemon laricifolius* ssp. *exilifolius* abundance, around the Laramie Basin in

the core of its distribution, were gathered during what remains part of the longest drought episode in the 110 years that meteorological records have been recorded (USDI National Oceanic and Atmospheric Administration 2005a). Trends under drought conditions are unknown, but this taxon’s apparent resilience to drought indicates resilience to at least some climate adversities. The Big Horn Basin, by comparison, is not in a drought cycle, and the distribution of *P. laricifolius* ssp. *exilifolius* across different climate regimes may confer additional resilience.

Habitat

The habitat of *Penstemon laricifolius* ssp. *exilifolius* is dry, rocky, gravelly or sandy slopes, ridgetops, and upland flats of intermontane basins, foothills, and lower montane elevations (Harrington 1954, Nelson 1984). The prevailing vegetation at most occurrences is either sparse grassland or shrubland (**Figure 6**, **Figure 7**), but the taxon is also present on barrens and in open woodlands or at woodland margins (**Figure 8**). A review of available habitat information (**Table 3**) suggests that *P. laricifolius* ssp. *exilifolius* occupies a wide range of habitat conditions, though all settings have limited vegetation cover and dry, thin soils weathered directly above shallow bedrock (Entisols or Inceptisols). The bedrock includes widespread late Paleozoic and early Mesozoic sedimentary formations



Figure 6. Sparse grassland habitat of *Penstemon laricifolius* ssp. *exilifolius* on the Medicine Bow Mountains (WY occurrence #035), by Erin Foley, used with permission.



Figure 7. Sparse grassland habitat of *Penstemon laricifolius* ssp. *exilifolius* in the Laramie Valley (CO occurrence #002), by Georgia Doyle, used with permission.

of marine origin in Wyoming, and late Mesozoic to early Cenozoic sedimentary formations in Colorado. Topographically, most but not all, habitats are in high, exposed, windswept settings. Elevation of the northern occurrences and most other outlying occurrences are generally lower than the southern occurrences that

represent the center of its range; northern occurrences are found from 5,000 to 7,600 ft., and southern occurrences range from 5,640 to 9,600 ft. The common denominators in habitat requirements are represented in **Figure 9**.

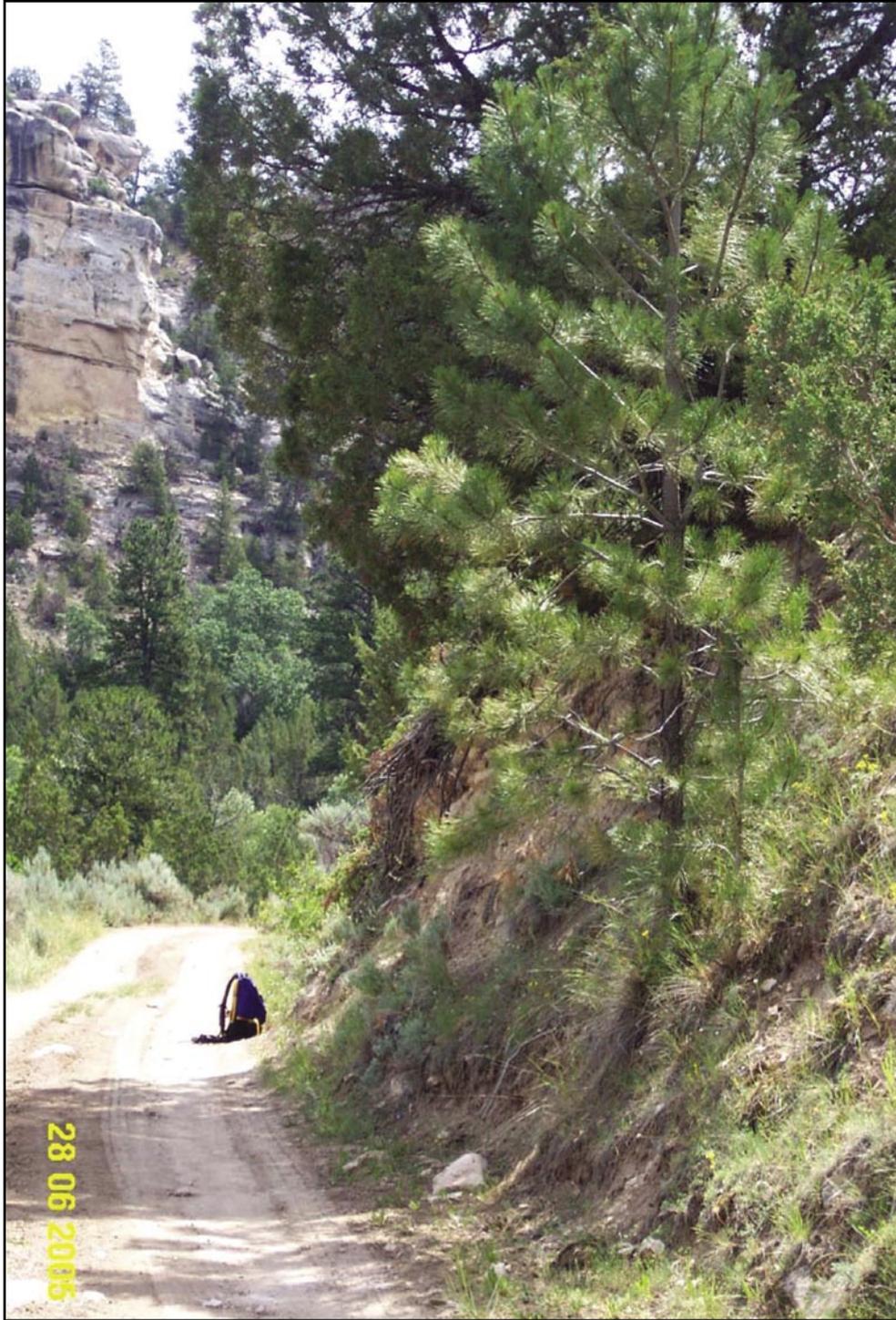


Figure 8. Semi-wooded habitat of *Penstemon laricifolius* ssp. *exilifolius* in ponderosa pine openings and roadside embankments of Sand Draw, a Big Horn Mountains canyon setting (WY occurrence #025), by Susan Bell, used with permission.

In the Laramie River Valley of Colorado, *Penstemon laricifolius* ssp. *exilifolius* occurs across an array of topographic settings where sagebrush grows in residual soils derived from sedimentary rocks of Tertiary and Cretaceous sedimentary units, including

the North Park formation, Pierre shale, Niobrara formation, and red beds. It has its widest known elevation breadth in the Laramie Valley, extending from 5,640 to 9,600 ft. The taxon reaches the Arapaho and Roosevelt National Forests at Sand Creek Pass on the

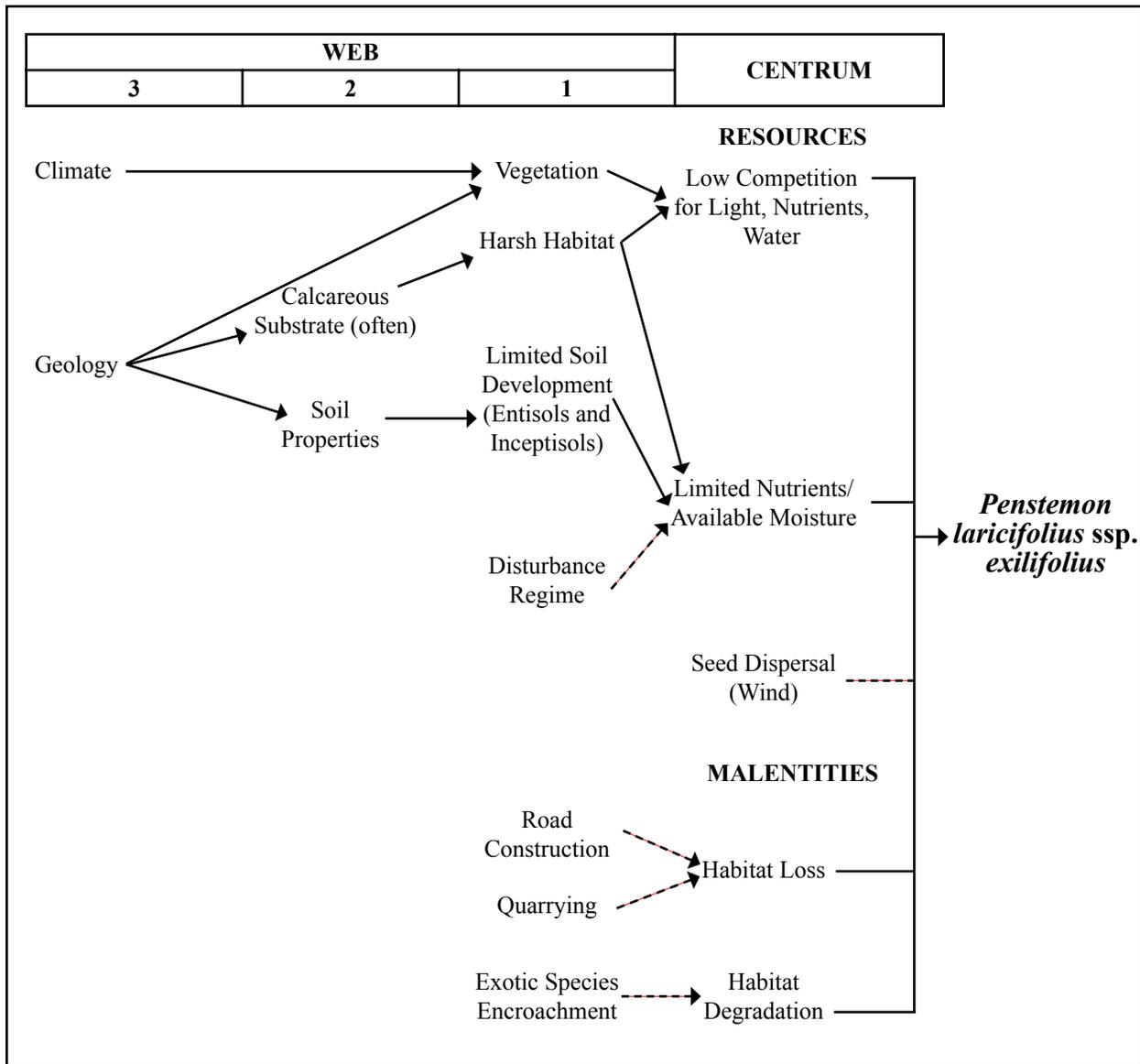


Figure 9. Envirogram of key resources and malentities for *Penstemon laricifolius ssp. exilifolius*.

east side of the valley, and west of Holnholz Lakes on the west side of the valley. The vegetation is typically an *Artemisia-Chrysothamnus* (sagebrush-rabbitbrush) community. *Penstemon laricifolius ssp. exilifolius* was found in the course of seeking residual soil settings to search for two other species, *Eriogonum exilifolium* (dropleaf buckwheat) and *Phacelia formosula* (North Park phacelia) (Scully personal communication 2004).

In the Laramie Range of Wyoming, *Penstemon laricifolius ssp. exilifolius* is only known from the western margin of the Pole Mountain Unit, on gravelly tablelands overlying the Casper formation, in sparsely vegetated settings at 8,400 to 8,800 ft. Dominant or co-dominant grass species include *Elymus*

spicatus (bluebunch wheatgrass), *Koeleria macrantha* (junegrass), *Poa secunda* (Sandberg's bluegrass), and *Festuca idahoensis* (Idaho fescue). The dominant or co-dominant sagebrush species, where present, include *Artemisia tripartita* (bird's-foot sage), *A. tridentata* (big sagebrush), and *A. frigida* (fringed sagewort), sometimes with widely scattered *Pinus flexilis* (limber pine). Commonly associated forb species include *Sedum lanceolatum* (spearleaf stonecrop), *Linum* spp. (flax), *Arenaria* spp. (sandwort), and *Erigeron* spp. (fleabane). The Casper formation is a late Paleozoic marine formation composed of sandstone and siltstone, including red beds, and is the only Laramie Range bedrock with high calcium carbonate concentration. *Penstemon laricifolius ssp. exilifolius* is absent from

the prevailing Sherman Granite formation and from areas of the Casper formation with over 60 percent vegetation cover.

In the Medicine Bow Mountains of Wyoming, *Penstemon laricifolius* ssp. *exilifolius* is in foothills and montane zones of the Medicine Bow-Routt National Forest, from 7,400 to 8,880 ft. It is most commonly located on exposed, convex ridges, hilltops, or rims (**Figure 6**). However, occurrences or colony subsets are also on level slopes and, in some cases, concave slopes. It was often adjacent to stands of *Pinus flexilis*, and consistently in grassland or sagebrush shrubland habitat. The dominant sagebrush species included *Artemisia tridentata*, *A. tripartita*, *A. frigida*, and at one location, *A. nova* (black sage). Dominant or co-dominant grass species include *Elymus spicatus*, *E. smithii* (western wheatgrass), *Koeleria macrantha*, and *Stipa comata* (needle-and-thread). Commonly associated forbs include *Astragalus laxmannii* var. *robustior* (prairie milkvetch), *Castilleja linariifolia* (Wyoming Indian paintbrush), *C. sulphurea* (sulphur Indian paintbrush), *Eriogonum elatum* (tall woolly buckwheat), *Gutierrezia sarothrae* (broom snakeweed), *Oxytropis lambertii* (purple locoweed), and *Sedum lanceolatum*. In the Medicine Bow Mountains surveys conducted in areas mapped with carbonate soils were effective except southwest of Arlington, where the soils differed from those at previously observed occupied habitat (Foley personal communication 2005). *Penstemon laricifolius* ssp. *exilifolius* was absent from areas that were not derived from calcareous sedimentary bedrock and had over 60 percent vegetation cover. The surface of occupied sites usually had conspicuous cover of loose gravel. Although the habitat was described as “sunny granite slopes” for the historic collection from “New Albany” (*J.F. MacBride* #2449 RM), there were no occurrences found on granite in recent surveys.

The Laramie Basin lies below USFS boundaries like the bottom of a bathtub between the Laramie Range and the Medicine Bow Mountains, with large parts of the basin exposed as rock outcrop mainly at the southern end and the rest buried in Quaternary alluvium. There have been no systematic surveys of *Penstemon laricifolius* ssp. *exilifolius* in the Laramie Basin. *Penstemon laricifolius* ssp. *exilifolius* is found there in habitats not represented in the adjoining ranges. For example, one of the early Laramie Basin collections indicated that it was “robust on selenium plains” (*B.E. Nelson* #3196 RM).

In the Big Horn Mountains of Wyoming, *Penstemon laricifolius* ssp. *exilifolius* is only known

from the western slope at 5,000 to 7,600 ft. The vegetation includes ponderosa pine forest, Utah juniper scrub, sagebrush steppe, and roadcut disturbances within such vegetation (**Figure 8**, **Figure 10**). Most of the occurrences are on Tensleep and Amsden formations, but the south end of the Alkali Road occurrence is on Chugwater and Goose Egg formations. The northern part of the Tensleep occurrence is on Madison Limestone and Darby formations. The Shell Canyon occurrence is on landslide deposits in a canyon setting derived from the previously mentioned formations (Karow personal communication 2005). The Big Horn Mountains formations are Carboniferous and Permian marine deposits with some calcium carbonate strata, particularly in the extensive limestone and dolomite deposits of the Madison and Darby formations. Occurrences are also found in intervening landscapes between the Big Horn Mountains and the Medicine Bow Mountains, all lower than 6,000 ft.

The climate at meteorological monitoring stations across the range of *Penstemon laricifolius* ssp. *exilifolius* distribution is arid (USDI National Oceanic and Atmospheric Administration 2005b). Temperatures and precipitation are lower at the southern end of the taxon’s distribution than at the northern end, corresponding to higher elevation to the south (**Table 4**). Average annual precipitation varies from at least 29.29 to 36.02 cm (11.53 to 14.18 inches). Each of the three meteorological monitoring stations across the range of *P. laricifolius* ssp. *exilifolius* has peak precipitation in different months, but the only pronounced difference is the earlier, heavier mean monthly precipitation level at the Big Horn County station compared to the Albany County stations. It should be noted that the Big Horn station at Tensleep 4NE is not within occupied habitat but over 300 m (1,000 ft.) lower in elevation. Data from the pair of stations at Laramie and Centennial point to the local contrasts in basin and foothills settings, in which there is added precipitation and lower temperatures in the foothills setting. The latter data are more representative of occupied habitat conditions on the Medicine Bow-Routt National Forest and the Laramie River Valley in Colorado.

Although *Penstemon laricifolius* ssp. *exilifolius* and *P. laricifolius* var. *laricifolius* have morphological distinctions, they occupy similar substrates and settings (derived from sedimentary marine deposits dating back to the time of the ancestral Rocky Mountain uplift). In general, the habitat of the more common, type variety differs in being at lower elevations.



Figure 10. Roadside setting of *Penstemon laricifolius* ssp. *exilifolius* in the Big Horn Mountains (WY occurrence #001), by Earl Jensen, used with permission.

Reproductive biology and autecology

Reproduction

Penstemon laricifolius ssp. *exilifolius* flowers from June to early August, depending on location, elevation, and climate conditions. The earliest collection of flowering specimens in the Big Horn Mountains is 5 June in 2000 (*R.D. Dorn* #8271 RM). The earliest collection date of flowering specimens from southeastern Wyoming and adjoining Colorado is 16 June in 1959, collected at Twin Buttes in the Laramie Basin (*V.J. Wetherell* #59 RM). It takes about 2 weeks from the time the earliest buds appear until flowers open, as indicated by the phenology documented in Sand Draw of the Big Horn Mountains by Susan Bell's survey (photographs taken 6 June, 16 June, and 28 June of 2005). Surveys for this taxon in the Medicine Bow-Routt National Forest began in the second week of July 2005, which was within the first half of the flowering period. It appears as though all specimens from the Big Horn Mountains at Rocky Mountain Herbarium and Bighorn National Forest Herbarium are in flower at least 2 weeks earlier than elsewhere in its range. Flowering is indeterminate, from the base to the apex of the inflorescence, and may be prolonged in moist years and curtailed in drought years. *Penstemon laricifolius*

ssp. *exilifolius* reproduces exclusively by seed, and fruits are produced from July into August.

Penstemon laricifolius ssp. *laricifolius* appears to flower earlier than *P. laricifolius* ssp. *exilifolius*, except in the Big Horn Mountains where the distribution of the two subspecies overlap. Flowering phenology is more or less synchronous where they are sympatric. A change in pollinators is a major factor in flower evolution within many plant families and genera, including evolution in flower size, form, pigmentation, and rewards (Grant and Grant 1965, Stebbins 1974). Most taxa in the Scrophulariaceae studied to date have adaptations that encourage cross-fertilization (Kampny 1995). Different taxonomic groups in the *Penstemon* genus are adapted to pollination by various genera and families of Hymenoptera (bees and wasps), as well as to hummingbirds (Crosswhite and Crosswhite 1966). More recent research into pollen presentation theory proposes that the *Penstemon* genus, with its array of anther structures, has evolved divergent pollination syndromes to favor pollinators with differential rates of pollen removal and deposition (Thomson et al. 2000).

Tepedino collected pollination information (unpublished) for *Penstemon laricifolius* ssp. *exilifolius* from two locales in the Laramie Basin and a ridge in

Table 4. Climate of *Penstemon laricifolius* ssp. *exilifolius* habitat as represented at three meteorological stations.

	Annual precipitation cm (in.)	Mean May precipitation cm (in.)	Mean June precipitation cm (in.)	Mean July precipitation cm (in.)	Average maximum temperature °C (°F)	Average minimum temperature °C (°F)
Laramie (1915-1961) @ 2198 m (7211 ft.) [Laramie Basin]	29.29 (11.53)	3.86 (1.52)	3.33 (1.31)	4.57 (1.80)	12.17 (53.9)	0.89 (30.4)
Centennial 1N (1948-2004) @ 2481 m (8140 ft.) [Foothills of Medicine Bow Mountains]	36.02 (14.18)	4.19 (1.65)	3.56 (1.40)	3.89 (1.53)	11.72 (53.1)	-2.39 (27.7)
Tensleep 4NE (1964-2005) @ 1463 m (4800 ft.) [Foothills of Big Horn Mountains]	32.89 (12.95)	5.59 (2.20)	5.23 (2.06)	2.46 (0.97)	16.11 (61.0)	1.56 (34.8)

adjoining semi-forested foothills (Tepedino personal communication 2005). Twenty-eight species of bees representing four families were collected on flowering *P. laricifolius* ssp. *exilifolius* plants during repeated visits made throughout the 4 to 5 week flowering period and repeated over 3 years (**Table 5**). Tepedino considers the bees likely pollinators of *P. laricifolius* ssp. *exilifolius* (Tepedino personal communication 2005). Only four of the 28 insect species that pollinate *P. laricifolius* ssp.

exilifolius plants are shared between the two study sites that are only 45 km (28 miles) apart, but differ about 314 m (1,030 ft.) in elevation.

There are no data on *Penstemon laricifolius* ssp. *exilifolius* fruit and seed production per plant. There are preliminary notes on abortion among *P. laricifolius* ssp. *exilifolius* flowers based on examination of herbarium specimens collected in 2005 on the Bighorn National

Table 5. Bees collected from *Penstemon laricifolius* ssp. *exilifolius*. Source: Vince Tepedino, unpublished data from 1974-1976, relayed in personal communication 2005.

Species	Family ^[1]	Study Area	
		Laramie Basin site	Boulder Ridge site
		Collected July 9 - Aug 4, 1974-1976	Collected July 16 - Aug 7, 1974-1976
<i>Andrena costillensis</i>	Andrenidae	—	X
<i>Anthidium tenuiflorae</i>	Megachilidae	X	
<i>Anthophora albata</i>	Apidae	X	
<i>Ashmeadiella gillettei</i>	Megachilidae	X*	
<i>Bombus appositus</i>	Apidae		X*
<i>Bombus bifarius</i>	Apidae		X*
<i>Bombus centralis</i>	Apidae		X
<i>Bombus fervidus</i>	Apidae	X	
<i>Bombus flavifrons</i>	Apidae		X
<i>Bombus huntii</i>	Apidae	X	X*
<i>Bombus nevadensis</i>	Apidae	X	X
<i>Bombus occidentalis</i>	Apidae		X
<i>Bombus rufocinctus</i>	Apidae		X
<i>Ceratina nanula</i>	Apidae	X*	X
<i>Ceratina neomexicana</i>	Apidae	X*	
<i>Dialictus pruinosus</i>	Halictidae	X	
<i>Dialictus pruinosiformis</i>	Halictidae	X	
<i>Halictus confusus</i>	Halictidae	X	
<i>Nomadopsis zebrata</i>	Andrenidae	X	
<i>Osmia brevis</i>	Megachilidae		X
<i>Osmia bruneri</i>	Megachilidae	X	
<i>Osmia giliarum</i>	Megachilidae	X*	X
<i>Osmia integra</i>	Megachilidae	X	
<i>Osmia (monilosmia) sp. #1</i>	Megachilidae	X	X
<i>Osmia sculleni</i>	Megachilidae	X	
<i>Perdita "bispicata" (ms name, not legit)</i>	Andrenidae	X	
<i>Pterosarus didirupa</i>	Andrenidae		X

^[1]Andrenidae is a family of solitary bees
 Apidae is a family that includes bumblebees, honeybees and stingless bees
 Halictidae is a family of mostly solitary bees
 Megachilidae is a family of solitary bees

^[2]Those species present marked by asterisks were most abundant on the flowers

Forest (Heidel personal observation 2005). The incidence of aborted flowers appears to be time-sensitive, appearing among terminal flowers or secondary axillary flowers that had growth curtailed under late-season conditions (e.g. *E. Jensen and G. Lehnhoff s.n.* BNF Herbarium). The presence of aborted *P. laricifolius* ssp. *exilifolius* flowers among the proliferant flowering of this taxon in 2005 needs additional data from other years and sites to interpret.

There are few comparative studies on pollination biology of related *Penstemon* taxa differing in flower color. Among the exceptions is the pollination research on *P. bicolor* with a pale yellow subspecies (*P. bicolor* ssp. *bicolor*) and a fuchsia subspecies (*P. bicolor* ssp. *roseus*). Initial research suggests that *P. bicolor* ssp. *roseus* has higher levels of autogamy than *P. bicolor* ssp. *bicolor* though there was no distinct difference in pollination vectors (Glenné 2003).

Dispersal mechanisms

Penstemon laricifolius ssp. *exilifolius* seeds are likely to be dispersed by gravity and wind. Each capsule produces seeds that are released passively when the capsule dehisces from the top down. The seeds are lanceolate, flattened in outline, and slightly winged at the upper margins (Heidel personal observation; *E. Jensen and G. Lehnhoff s.n.* BNF Herbarium; specimen from Alkali Creek).

Hybridization

Hitchcock et al. (1969) note that “many species of *Penstemon* are poorly defined, and taxa which superficially look very different sometimes hybridize freely in nature.” There are no reports of hybridization involving *P. laricifolius* ssp. *exilifolius* in the published or unpublished literature.

There are three surveys of mixed-color populations of *Penstemon laricifolius*, two by Earl Jensen and Gary Lehnhoff in the Big Horn Mountains, and one by Erin Foley in the Medicine Bow Mountains, that might represent hybridization of the two *P. laricifolius* subspecies. The mixed-color populations are represented by both white and purple flowers, as well as a gradation of intermediates.

Phenotypic plasticity

Phenotypic plasticity is demonstrated when members of a taxon vary in morphology, phenology, or other attributes, with change in light intensity, latitude,

elevation, or other environmental characteristics. It is not known if flower color of *Penstemon laricifolius* is influenced in any measure by environment. The published literature does not contain documentation of color ecotypes in the *Penstemon* genus.

The phenology of *Penstemon laricifolius* ssp. *exilifolius* may vary with latitude. The first documentation of ecotypes in the *Penstemon* genus with genetically-based phenology differences that varied with latitude and elevation was made by Clausen et al. (1940).

In *Penstemon laricifolius* ssp. *exilifolius*, plant vigor and flowering stem production appear to vary with spring moisture. Observations made at an occurrence near Laramie in consecutive years indicated that the number of flowering stems vary greatly depending on spring moisture levels (Heidel personal observation). Even more extreme, individuals with over 100 flowering stems were photographed in Big Horn County after an unusually wet spring at the heels of a drought cycle (**Figure 5**). This phenotypic response is a function of environmental conditions.

Life history

Penstemon laricifolius ssp. *exilifolius* is an iteroparous perennial with few to many clusters of linear leaves on the branched caudex. The basic life history stages of *P. laricifolius* ssp. *exilifolius* include seed, seedling, and mature plant stages (vegetative and flowering phases; **Figure 11**). The age of individual plants cannot be determined except at seedling stages. The number of years required for a seedling to develop into a flowering plant is not known. It is likely that established plants usually flower in consecutive years, but they may transition between flowering and non-flowering states in adverse conditions. The mean and maximum longevity are not known, but the taxon is characterized as “long-lived” under cultivation (Lindgren and Wilde 2003).

Penstemon laricifolius ssp. *exilifolius* is characterized as a taxon that needs spring moisture to bloom (Lindgren and Wilde 2003). Seeds germinate after 8 to 12 weeks of cold moist stratification (Lindgren and Wilde 2003). The taxon germinates when stratified and then seeded in spring, barely covered, at 13 to 18 °C (Rock Garden Plant Database 2005). This is consistent with research into the germination requirements of Intermountain taxa of *Penstemon*, which suggests seeds of most taxa of *Penstemon* are dormant at dispersal and require a period of moist chilling in order to germinate.

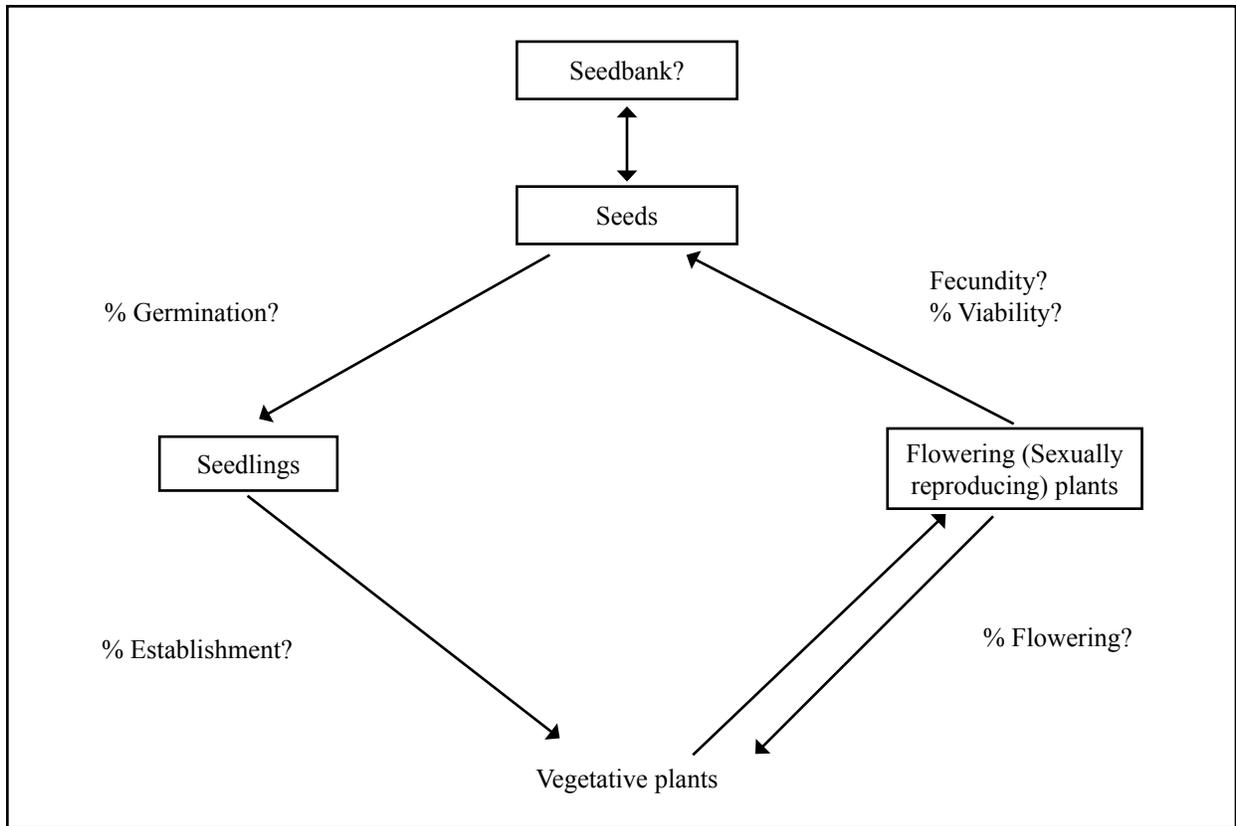


Figure 11. Life cycle diagram for *Penstemon laricifolius* ssp. *exilifolius*.

Those taxa of *Penstemon* from habitats with severe winters, as found in the range of *P. laricifolius* ssp. *exilifolius*, require long chilling periods (Meyer and Kitchen 1994, Meyer et al. 1995). Delayed germination of seeds beyond one year can result in a seed bank, which provides a stable seed source in spite of environmental conditions that may be unfavorable for seed germination for many years (Rees 1994). Data on flower fecundity, seed viability, and seed germination rates are not available.

Greenhouse data suggest that under field conditions, *Penstemon laricifolius* ssp. *exilifolius* germinates in the spring. Germination is likely limited to suitable microhabitat with adequate moisture and low cover. There are no reported observations of seedlings incidental to surveys and collections, but the small, needle-like leaves of seedlings may be overlooked. Data on establishment rates are not available.

It appears likely, but remains to be demonstrated, that flowering stem buds form in spring, so spring conditions help to determine how many and which clusters produce shoots or remain vegetative. Individuals may differ in the number of caudex branches, numbers of flowering stems per caudex branch, and the numbers

of leaf clusters arising from the branched caudex, but these are not known to indicate age.

At a few occurrences where surveys have been conducted, both flowering and non-flowering plants have been reported. This term has not been used consistently to refer to non-reproductive plants (as compared to immature flowering plants or plants past flowering). Non-flowering plants are easily overlooked, so this could affect occurrence estimates. Data on flowering levels over time and between occurrences are not available.

Community ecology

Disturbance regimes

Existing data on the disturbance regimes of *Penstemon laricifolius* ssp. *exilifolius* habitat do not cover the ramifications of different levels and frequencies of disturbance or the life history stages that are most strongly influenced. The poorly developed soils and sparse vegetation suggest that these may be seral habitats. Although forage and fuels for fire are limited, there is expected to be a natural disturbance regime associated with grazing and fire. Occurrences

are capable of colonizing, if not persisting, in prairie dog towns and under different grazing conditions that remain to be characterized. Occurrences also are capable of colonizing disturbed roadside areas, especially if competing vegetation is unable to become re-established. Natural disturbance regimes in *P. laricifolius* ssp. *exilifolius* habitat may also include frost action and associated weathering, and erosion by wind and water.

Competition

In general, the *Penstemon* genus is one of many large genera centered in western North America composed of drought-resistant perennials (Stebbins 1974). The indeterminate raceme enables individual *Penstemon* plants to form few or many flowers depending upon the length of the favorable season (Stebbins 1974). *Penstemon laricifolius* ssp. *exilifolius* is particularly adapted to a harsh environment. The filiform to linear leaf shape represents a drought adaptation in which the underside of the narrow leaf, with stomates, rolls inward to reduce evapotranspiration. The linear leaves may also be an adaptation for maximizing photosynthetic activity while reducing heat stress. *Penstemon laricifolius* ssp. *exilifolius* flowers during high summer temperatures, necessitating heat tolerance. The subspecies epithet “*exilifolius*” refers to its needle-like leaves, and other associated species have needle-like leaves, including other regional endemics with the same epithet (*Eriogonum exilifolium*). Keck (1937) referred to both subspecies of *P. laricifolius* as xerophytic cushion plants.

Penstemon laricifolius ssp. *exilifolius* occurs in sparsely vegetated grassland, shrubland, and open woodland habitat, because of either the decreased competition or the greater light availability. There is no direct information on the competitive ability of this taxon, but the previously mentioned information on the disturbance regimes of its habitat and adaptations for a stressful environment are consistent with a pattern of a stress-tolerant taxon of low competition habitat, in the sense of Grime (2001).

Penstemon laricifolius ssp. *exilifolius* is often found in an array of sparsely vegetated habitats that include bunchgrasses, which form tight clumps that tap nutrient and water resources in the immediate vicinity but leave large areas of unoccupied habitat. It is sometimes found in habitats that are dominated or co-dominated by rhizomatous grasses that are so sparse that there is no sod formation (Figure 7). In either case, the resulting vegetation patterns are patchy,

and the intervening spaces are suited to taxa that are poor competitors. These communities occupied by *P. laricifolius* ssp. *exilifolius* include sparse climax communities as well as seral communities. The seral settings include old gopher mounds, undeveloped roadbeds, and road cuts, which may reflect a lack of competition or the colonizing ability of *P. laricifolius* ssp. *exilifolius*.

Herbivory

At least two of the historic collections were made as part of range studies in the 1930's, and in both cases, the forage value of the taxon was placed in the lowest category (“none” or “low”; depending on the format of the collection label). In addition, *Penstemon laricifolius* ssp. *exilifolius* was described as “common on heavily grazed fields” in a historical collection in the Laramie Plains (*P.L. Ginter #7508* RM). It is interesting that the taxon was recently collected in a prairie dog town (*W. Fertig #19670* RM), a setting of intense herbivory that tends to favor short stature vegetation and taxa that tolerate or deter herbivory. Other members of the genus are known to be palatable, but the persistence of *P. laricifolius* ssp. *exilifolius* in a prairie dog town may indicate unpalatability. In any case, the diminutive leaves and short stature of this taxon indicate that it provides little forage.

There has been one observation of disease incidental to reviewing specimens collected on Bighorn National Forest in which a capsule had seeds blackened by smut (Heidel personal observation 2005). It is not known if smut is a frequent disease problem in all fruits or throughout the population, but it may have been more common in the relatively wet growing season of 2005 compared to other years.

Endemism

There are areas and locales of high endemism among the various settings occupied by *Penstemon laricifolius* ssp. *exilifolius*. One of these areas, the Laramie River Valley Shale Outcrops, is one of the two highest priority Potential Conservation Areas in Larimer County based on its high concentration of globally rare species (Doyle et al. 2004), including “an abundance” of *P. laricifolius* ssp. *exilifolius*. The Laramie River Valley Shale Outcrops include BLM, state, and private lands. *Penstemon laricifolius* ssp. *exilifolius* also occurs with *Phacelia c.f. formosula* (North Park phacelia), a federally listed, endangered species that is endemic to Colorado, in the same upland areas of this location. However, *P. laricifolius* ssp. *exilifolius* occupies a

much wider array of habitats in the same general area. It also occurs with at least four other state and regional endemic plant species at one or more other locations. Associated endemics include:

*Eriogonum exilifolium** (Laramie River valley and Medicine Bow Mountains of Colorado and Wyoming)

*Machaeranthera coloradoensis** (Colorado tansy-aster) (Medicine Bow Mountains of Colorado and Wyoming)

Oenopsis wardii (Ward's false goldenweed) (Laramie River valley and Medicine Bow Mountains of Colorado and Wyoming)

*Penstemon caryi** (Cary's beardtongue) (Big Horn Mountains, only one site in Wyoming)

Phacelia c.f. formosula (North Park phacelia) (Laramie River Valley, only in Colorado)

Of these species, three are designated as sensitive (USDA Forest Service 2003a; noted with asterisks in the preceding text). The *Phacelia formosula* material found in association with *Penstemon laricifolius* ssp. *exilifolius* is currently being verified; it either represents this taxon, which is federally listed as Endangered, or an undescribed taxon (Handwerk personal communication 2005). In Colorado, the taxon *P. laricifolius* ssp. *exilifolius* is much more of a habitat generalist whereas the other rare species with which it sometimes occurs are narrow habitat specialists (Scully personal communication 2005). This appears to be the case in Wyoming as well.

Mycorrhizal relationships

No research on the mycorrhizal relationships of *Penstemon* subsection *Caespitosi* or *Ericopsis* has been published.

CONSERVATION

Penstemon laricifolius ssp. *exilifolius* is a regional endemic with over 75 percent of all extant occurrences concentrated in an area of 60 x 120 km (37 x 74 miles), and it is almost entirely restricted to Region 2. It is concentrated on low elevation public lands and adjoining private lands. Thus, its conservation status in Region 2 weighs heavily in determining its status overall.

Recent surveys of *Penstemon laricifolius* ssp. *exilifolius* throughout its range did not identify threats or find evidence of declines despite past disturbances in its habitats. Thus, the information in the following section focuses on vulnerabilities. It draws from a compilation of current land use information and inventory of known and suspected disturbances and makes inferences. The potential malentities for *P. laricifolius* ssp. *exilifolius* are represented in **Figure 9**.

Threats

Invasion of its habitat by noxious weeds and other exotic species is among the most pervasive of potential threats to *Penstemon laricifolius* ssp. *exilifolius* even though occurrences have not been reported in direct association with any exotic species. Invasive species may expand under natural conditions or be introduced as part of management actions or disturbances, so they may be a factor in each of the other potential threats identified in this section. Cheatgrass is expanding its distribution in the Laramie Basin and foothills, and both Dalmatian toadflax (*Linaria dalmatica*) and spotted knapweed (*Centaurea maculosa*) are also expanding. Although leafy spurge (*Euphorbia esula*) is less common, it is at least as serious a threat if it has the potential to spread into *P. laricifolius* ssp. *exilifolius* habitat. The direct competition of these species or their effects on the fire regime could both influence *P. laricifolius* ssp. *exilifolius*. In addition, yellow sweetclover (*Melilotus officinale*) was found in association with *P. laricifolius* ssp. *exilifolius* at a Laramie Basin roadside setting (Handley personal observation 2005). This nitrogen-fixing exotic requires moisture to become established, and while it might be able to spread into some roadside habitat of *P. laricifolius* ssp. *exilifolius*, moisture may limit its potential to affect vegetation structure and competition. At present, the most widespread non-native species in this taxon's habitat are annuals like desert alyssum (*Alyssum desertum*).

The habitat of *Penstemon laricifolius* ssp. *exilifolius* is used mainly as rangeland for livestock grazing, but grazing is not known to pose a direct threat to this taxon. Rangeland vegetation emphasis is the prevailing management objective for the landscapes supporting all occurrences on the Laramie District of the Medicine Bow-Routt National Forest except on the Pole Mountain Unit, which is managed for recreation (USDA Forest Service 2003b, Proctor personal communication 2005). The Sand Draw occurrence is likewise managed mainly as rangeland on the Bighorn National Forest while the Shell Falls occurrence lies within a scenery

management area under the current plan (USDA Forest Service 2005, Karow personal communication 2005). The Sand Creek area on the Arapaho and Roosevelt National Forests is managed primarily for natural resources (Forested Flora and Fauna Management Areas), and it receives limited use as part of a large grazing allotment (Popovich personal communication 2005). Also on the Arapaho and Roosevelt National Forests, grazing and dispersed camping occur on the west side of the Laramie River along Forest Service Road 200 (Scully personal communication 2006) in an area managed for Forest Products and Dispersed Recreation (Carsey personal communication 2006).

Signs of grazing or browsing on *Penstemon laricifolius* ssp. *exilifolius* plants are not known from surveys, observations, or specimen reviews. Higher levels of grazing in the dry, upland habitat is generally less likely after flowering than during or before. The absence of grazing evidence may be because the taxon has low forage value, occupies habitats that have limited grazing use, or has low palatability. As described in the previous discussion of herbivory, at least two of the historic collections were made as part of range studies in the 1930's, and in both cases, the forage value of the taxon was placed in the lowest category of range utilization ("none" or "low"; depending on the format of the collection label). In addition, *P. laricifolius* ssp. *exilifolius* was described as "common on heavily grazed fields" in an historical collection in the Laramie Plains (*P.L. Ginter #7508* RM). Despite the presence of *P. laricifolius* ssp. *exilifolius* under a range of conditions that includes heavy grazing, in whatever sense the term was used by previous researchers, there may be successional change associated with grazing that reduces habitat suitability for the taxon, weed introduction, or land use practices associated with rangeland management, such as stock dam construction and salt block placement, that pose immediate threats on a limited scale.

The western occurrences of *Penstemon laricifolius* ssp. *exilifolius* that are in or near the Hanna Basin and western Laramie Basin in Wyoming are in an area of current oil and gas leasing activity. These occurrences are in relatively low elevation basin settings, outside of USFS boundaries, and represent both recent and historic collections. The potential for expansions of oil and gas leasing activity across its core distribution is not known. Its distribution does not overlap with known reserves of coalbed methane and oil shale.

Road construction and quarrying may also impact habitat of *Penstemon laricifolius* ssp. *exilifolius*,

particularly where the development parallels its habitat (e.g., a road that follows occupied ridgeline habitat, as shown in **Figure 10**). One of the more important management questions in determining species vulnerability is the net effect of road construction in and near native habitat. Seven or more occurrences of *P. laricifolius* ssp. *exilifolius* are in or along roads, but they are not necessarily restricted to the road corridor. The presence and abundance of *P. laricifolius* ssp. *exilifolius* in previously-graded road rights-of-way indicate a colonizing ability, while the threats posed by other roadside management practices, such as blading or herbicide spraying, are undetermined. In the Bighorn National Forest at Shell Canyon (US Hwy 14), the taxon was locally restricted to the right-of-way corridor. In one Medicine Bow Mountains survey, *P. laricifolius* ssp. *exilifolius* was found in extremely high densities of 10 to 20+ plants per square meter on a flat that had been graded for parking highway construction equipment (Heidel, Proctor, and Foley personal observation 2005). In another Medicine Bow Mountains survey, *P. laricifolius* ssp. *exilifolius* was present in the ruts and inner vegetated band of an undesignated two-track road. Most roadside occurrences have not been systematically surveyed beyond the right-of-way, but *P. laricifolius* ssp. *exilifolius* was analyzed in the Snowy Range travel management decision (Roche 2005).

All private lands are potentially threatened by development and fragmentation, including housing development, as noted in the information compiled to assign a global rank to *Penstemon laricifolius* ssp. *exilifolius* by Colorado Natural Heritage Program (1998) and updated by Wyoming Natural Diversity Database (2005). The persistence of *P. laricifolius* ssp. *exilifolius* under habitat fragmentation is evident at a small, undeveloped, municipal park ringed by residential developments within Laramie city limits. However, the municipal park site is slated for conversion to a developed recreational area (Roche personal communication 2005), and native vegetation will be eliminated.

Penstemon laricifolius ssp. *exilifolius* was documented in the Big Horn Mountains at the site of a wildfire that burned through ponderosa pine forest 16 years earlier (Karrow personal communication 2004), so it appears to be able to survive fire, colonize after fire, or escape fire by occupying sparse vegetation that does not carry fire. In the Medicine Bow Mountains, prescribed burns were carried out prior to surveys of *P. laricifolius* ssp. *exilifolius* below Lake Owen in 2005. Big sagebrush shrubs were preferentially burned in the treatment (Proctor personal communication

2005). *Penstemon laricifolius* ssp. *exilifolius* is not typically found under shrub cover and escaped prescribed burn spot treatments that directly burned its habitat (**Figure 12**). It would be interesting to see if *P. laricifolius* ssp. *exilifolius* becomes established in the openings created by fire if the settings are otherwise suited as potential habitat (Foley personal communication 2005). Experimental prescribed burn treatments of *P. laricifolius* ssp. *exilifolius* habitat are under consideration in the Iron Mountain fuel treatment area of the Medicine Bow Mountains, where a small occurrence segment of *P. laricifolius* ssp. *exilifolius* in

short shrub vegetation may be burned along with tall shrub vegetation steppe directly across from it (Proctor personal communication 2005).

The *Penstemon* genus includes some of the most beautiful native plants, widely regarded for their horticultural value (Hitchcock et al. 1969). *Penstemon laricifolius* ssp. *exilifolius* in particular has been described as “not showy, but totally charming with tiny tufts of grass-like foliage and many stems of full-faced, delicate flowers and deeper colored buds rising to 12” or less” (Lindgren and Wilde 2003). It is also featured



Figure 12. *Penstemon laricifolius* ssp. *exilifolius* among spot treatments in a prescribed burn (WY occurrence #035), by Erin Foley, used with permission.

in the Rock Gardeners Plant Guide (2005). There are no other known or suspected consumptive uses of this taxon for commercial, recreational, scientific, or educational purposes.

Conservation Status of *Penstemon laricifolius* ssp. *exilifolius* in Region 2

The core of *Penstemon laricifolius* ssp. *exilifolius* distribution is centered on the Laramie Basin (Albany County, Wyoming) and the contiguous Laramie River Valley (in a corner of Larimer County, Colorado). National forests border the core distribution on three sides, with the Arapaho and Roosevelt National Forests at the south end, and the Medicine Bow-Rout National Forest, including the Laramie and Medicine Bow Mountains, on the east and west margins. It has intermittent distribution to the north and west, including Bighorn National Forest at its northernmost extent. Region 2 harbors parts or all of 10 extant occurrences, representing 25 percent of the 40 extant occurrences presently known, including the two largest known occurrences. Each national forest unit makes a unique contribution at the upper elevations of the taxon's distribution, representing biogeography and habitat differences.

The species does not have special management status elsewhere in its distribution, which includes public lands administered by four BLM field offices (Pinedale, Rawlins, and Worland field offices of Wyoming, and the Kremmling Field Office of Colorado), nor does it have special management status on state trust lands of Colorado or Wyoming.

Penstemon laricifolius ssp. *exilifolius* has a limited distribution with its core concentrated in an area of about 60 x 120 km (37 x 74 miles). Taxa that are endemic to this extent may be vulnerable to stochastic events. However, *P. laricifolius* ssp. *exilifolius* has an elevation range of 5,640 to 9,600 ft. in its core; it appears to have flourished in the wake of the 2000 to 2005 drought event in its core; many of the occurrences surveyed in detail appear to be very large; and beyond its core distribution, it has diffusely distributed outliers spanning over 300 km (186 miles) farther.

Information is lacking on the influences of land management practices on *Penstemon laricifolius* ssp. *exilifolius* viability on National Forest System land in Region 2. It is very likely that this taxon and its habitat are vulnerable to weed encroachment. As a species that is concentrated at the lower elevations of the national forests where it occurs, it may also be influenced by

habitat fragmentation or pressure to be included in land exchanges for development.

Management of *Penstemon laricifolius* ssp. *exilifolius* in Region 2

Implications and potential conservation elements

The primary elements necessary to maintain viable populations of *Penstemon laricifolius* ssp. *exilifolius* are management of its upland habitat in current, topo-edaphically induced conditions of low native vegetation cover. There is an emerging body of information documenting the distribution of *P. laricifolius* ssp. *exilifolius* across a wide range of settings (e.g., elevation range and geographic range) that suggests this taxon has a broad ecological amplitude, so this management directive may need to be tailored to each landscape where the taxon occurs.

Grazing and prescribed burning may be neutral or beneficial for *Penstemon laricifolius* ssp. *exilifolius* in reducing competition and possibly, in seedling establishment, if these disturbances do not change the environment to foster competitive ruderal species and exotic species, or if the associated water developments and fire breaks are not constructed in occupied habitat. Any stocking or prescribed burning action that deviates from existing management practice might be considered an opportunity to evaluate species' management response, as in the case of a prescribed burn being considered in the Medicine Bow National Forest (Proctor personal communication 2005).

The majority of *Penstemon laricifolius* ssp. *exilifolius* occurrences in Region 2 are in accessible settings at National Forest System land perimeters, and fall within multiple-use management areas. The threats of weed invasion and habitat fragmentation tend to be concentrated in these low elevation perimeter zones. The most serious of these noxious weeds include spotted knapweed, leafy spurge, and Dalmatian toadflax, all of which are present in the same counties and elevations as *P. laricifolius* ssp. *exilifolius*. Noxious weed control is an important measure to prevent roadside weed colonies from becoming established in the landscape.

Many *Penstemon laricifolius* ssp. *exilifolius* occurrences extend into roadside rights-of-way. Grading and indiscriminate noxious weed spraying may affect them. Salvage techniques have not been implemented to date.

Finally, the low-elevation, scattered National Forest tracts where *Penstemon laricifolius* ssp. *exilifolius* occurs are among the areas most likely to be proposed for land exchanges by developers.

Tools and practices

Species inventory

Inventory of *Penstemon laricifolius* ssp. *exilifolius* is incomplete in the Bighorn and the Arapaho and Roosevelt national forests, and in portions of the Medicine Bow-Routt National Forest at low elevations along part of the east side of the Medicine Bow Mountains with no public access. There are no historic collection sites on National Forest System land that need surveys.

Although *Penstemon laricifolius* ssp. *exilifolius* was included in multi-species surveys in Colorado as early as 1996 (Kettler et al. 1996), surveys are incomplete. It was also addressed in floristic documentation (Hartman and Nelson 2002) and incidentally in more recent multi-species surveys (Doyle 2005).

Habitat inventory

The first year of botany surveys for *Penstemon laricifolius* ssp. *exilifolius* on the Bighorn and Medicine Bow-Routt National Forests was in 2005. Results suggest that the highest likelihood for finding new occurrences is by targeting large areas mapped as geological formations with limestone or dolomite parent material, and surveying sparse upland settings within these formations. This targeting might be conducted systematically by use of digitized surface geology information in combination with digital orthophotographs and maps to determine access. In the Medicine Bow Mountains, geologic maps of carbonate surface geology based on Love and Christiansen (1984) have been used with geographic information system (GIS) technology in combination with aerial photographs to identify potential habitat. The technique worked well, except in one limestone area near Arlington where *P. laricifolius* ssp. *exilifolius* does not occur (Foley personal communication 2005). There are large areas of calcium carbonate bedrock in the Big Horn Mountains, and the known occurrences correspond with Amsden, Chugwater, Darby, Goose Egg, Madison Limestone, and Tensleep formations (Karow personal communication 2005).

In the Laramie River Valley of Colorado, *Penstemon laricifolius* ssp. *exilifolius* is mainly on the highly calcareous Niobrara formation, which includes some limestone. However, *P. laricifolius* ssp. *exilifolius* also occurs on non-calcareous soils formed on the Tertiary North Park formation.

Population monitoring

Trend information is lacking for *Penstemon laricifolius* ssp. *exilifolius* in Region 2. The most compelling case for monitoring populations of *P. laricifolius* ssp. *exilifolius* is in evaluating response to management actions and disturbance. The handbook on plant monitoring (Elzinga et al. 1998) provides sound experimental design suggestions and a framework for developing monitoring objectives in measurable terms.

Livestock grazing is the prevailing land use in *Penstemon laricifolius* ssp. *exilifolius* habitat and its effects have only begun to be addressed. It may be possible to make inferences that take the place of monitoring or set the stage for monitoring, by referring to the *P. laricifolius* ssp. *exilifolius* survey results that address distribution and size on Medicine Bow-Routt National Forest, and comparing allotment history and fenceline contrasts. It may also be possible to make inferences by comparing *P. laricifolius* ssp. *exilifolius* distribution and abundance with the relative covers of increaser and decreaser species. It may be possible to evaluate the influence of grazing by comparing the relative numbers and stem production of *P. laricifolius* ssp. *exilifolius* in a small enclosure as simple as a cage.

Several *Penstemon laricifolius* ssp. *exilifolius* occurrences are restricted to, or have large population numbers in, road rights-of-way. The net effects of road construction and rights-of-way management practices, and the contribution of roadcut occurrences to the taxon's viability, have yet to be determined. A baseline monitoring program would ideally follow colonies of roadside settings paired with colonies in similar, if not contiguous, native habitat; and also evaluate responses before-and-after management treatment. Additional information on past disturbance events may aid in interpreting trend data. It would be ideal to isolate the prospective right-of-way practices like grading, blading, and herbicide application to evaluate their effects separately.

The secondary need for monitoring populations of *Penstemon laricifolius* ssp. *exilifolius* is to document

life history and to identify life history stages that are pivotal in maintaining population numbers.

Seed banking

Lindgren and Wilde (2003) have developed techniques for propagating *Penstemon laricifolius* ssp. *exilifolius* from seed. The taxon has not been added to botanic garden accessions to date. If the USFS were to pursue seed-banking, it would be appropriate to include material from across the north to south limits of its distribution as represented by the three national forests on which it occurs.

Habitat monitoring

The most compelling case for monitoring habitat of *Penstemon laricifolius* ssp. *exilifolius* is in conjunction with evaluating the response of the taxon to management actions and disturbance (see Population monitoring).

Beneficial actions

Weed prevention and control actions are beneficial. Most other existing management actions in *Penstemon laricifolius* ssp. *exilifolius* habitat, including grazing and prescribed burning, cannot be categorized as unequivocally beneficial or detrimental without a baseline for comparison and without considering the setting and details of implementation.

Locales with high concentrations of sensitive species and large occurrences of *Penstemon laricifolius* ssp. *exilifolius* may be appropriate to consider for a special management status. The Laramie River Shale Outcrops of Larimer County, Colorado (Doyle et al. 2005) would be an excellent location for special designation. In this and other low-elevation places, the taxon occurs with up to three other sensitive species.

A compilation of information on *Penstemon laricifolius* ssp. *exilifolius* beneficial management actions would ideally be pooled and exchanged between the three national forests to refine information needs and to build on the cumulative expertise in advancing management of the taxon in Region 2.

Information Needs

This report represents the results from the first year that *Penstemon laricifolius* ssp. *exilifolius* was surveyed on the Bighorn and the Medicine Bow-Rout national forests. More concerted survey is needed on the

Arapaho and Roosevelt National Forests. The number and sizes of occurrences presented in this assessment are likely to represent incomplete information. This places a premium on conducting surveys in project reviews where there is suitable habitat.

A fundamental information need for *Penstemon laricifolius* ssp. *exilifolius* is evaluation of its colonizing ability and the net effect of disturbance on population viability, particularly as it involves mechanical disturbance such as road construction. This information gap involves species monitoring and habitat monitoring and is a major consideration in determining the degree to which road construction poses a threat.

Taxonomic research is needed for *Penstemon laricifolius* ssp. *exilifolius* as context for species conservation. At a minimum, it would provide guidance for understanding mixed color populations if not the implications and origin of color differences. Field observations on color variation within colonies or sets of colonies might be collected systematically on a larger scale. To test the significance and genetic basis of flower color, it would be worthwhile to grow both subspecies under a range of climate conditions in the greenhouse, simulating the range of growing season conditions across their respective distributions in the manner of Clausen et al. (1940). Finally, to analyze the significance of flower color, it would be useful to conduct genetic research using modern systematic analysis. Pilot genetics work is underway in the laboratory of Dr. C. A. Buerkle at the University of Wyoming; this research includes both white-flowered and pink-flowered material of *P. laricifolius* collected in the Big Horn and Medicine Bow mountains as well as in the Laramie Range.

To help frame the hypotheses on the adaptive value of flower color, parallel pollination research on *Penstemon laricifolius* ssp. *laricifolius* is needed, analogous to that conducted on *P. laricifolius* ssp. *exilifolius* (**Table 5**). It would be particularly insightful to study pollinator preferences in the mixed color populations. Pollinator guilds may be associated with flower color differences. Related *Penstemon* taxa in other groups with the same diploid chromosome number have been determined to represent pollinator-adaptation and accompanying habitat differentiation (Straw 1966). Bee color preferences are very poorly known except for honeybees and bumblebees (Tepedino personal communication 2005). Tepedino (personal communication 2005) also noted that bumblebees in particular prefer the blues and purples but are not so partial to white. Pan-trapping experiments show that

some solitary bee species actually prefer yellow, others white, and some blue. There is no simple rule, and bees can quickly learn about sources for sugar and protein.

Whatever the genetic nature of flower color differences, there may be other adaptive values, such as that associated with the difference in heat absorption and reflectance between flowers of different color, but which are otherwise similar. It may be significant that

the flowering of *Penstemon laricifolius* ssp. *exilifolius* is generally later in the heat of the summer compared to *P. laricifolius* ssp. *laricifolius*. Pleiotropy is a phenomenon in which a gene associated with flower color has more than one, apparently independent, phenotypic effect (e.g., Nobs and Hisey 1958, Bradshaw et al. 1995). The three national forests where *P. laricifolius* ssp. *exilifolius* occurs represent unsurpassed laboratories for evaluating and maintaining such evolutionary adaptations.

DEFINITIONS

- Albinism** – a genetically-induced absence or deficiency in pigmentation
- Ampliate** – enlarged, dilated
- Anther sacs** – pollen-bearing units
- Anthesis** – the period of flowering
- Anthocyanin** – a blue, purple, or red vascular plant pigment
- Calcareous** – containing calcium carbonate
- Capsule** – a dry, dehiscent fruit
- Caudex** – the persistent woody root crown from which new stems arise each year, at or below ground level
- Corolla** – all of the petals of a flower, collectively
- Dehisce** – to burst or split open at maturity
- Dolomite** – metamorphic rock composed of calcium magnesium carbonate
- Dominant** – [as in genetic trait] the tendency of the phenotypic traits controlled by one allele (dominant) to be expressed over traits controlled by other alleles (recessive) at the same locus
- Dominant** – [as in vegetation structure] the extent to which a given species predominates in a community because of its size, abundance, or coverage, and affects the fitness of associated species.
- Ecotype** – a race or infraspecific group having distinctive characters that result from the selective pressures of the local environment
- Extant** – currently known to exist; seen since 1975
- Extirpation** – extermination of the population(s) of a given species from an area
- Filiform** – thread-like
- Glabrous** – smooth, lacking hairs
- Graminoid** – pertaining to grasses, sedges, or rushes
- Heterozygous** – a diploid individual formed by the fusion of gametes carrying different alleles at a given locus
- Holotype** – the single specimen used in defining a taxonomic group in the original published description
- Homozygous** – a diploid individual with identical alleles at the two homologous loci of a chromosome pair
- Hymenoptera** – the insect order that includes the ants, bees, wasps, and sawflies
- Isotype** – duplicate of a holotype from the single collection that contained the holotype
- Iteroparous** – having repeated reproductive cycles within the lifetime of an individual
- Neoendemic** – an endemic species having a limited geographical range attributable only to its recency of origin
- Paleoendemic** – a species with a limited geographic range of considerable evolutionary age
- Perennial** – a plant that normally lives for more than two seasons
- Phenotypic plasticity** – the capacity for marked variation in the morphology of an organism because of environmental influences
- Pilose** – with long, straight, rather soft, spreading hairs
- Pleiotropy** – expression of a gene that has more than one, apparently independent, phenotypic effect
- Polyploid** – having more than two sets of homologous chromosomes

Protogynous – having the female flower parts develop first

Pubescent – covered with hair

Race – an infraspecific category characterized by conspicuous physiological, biological, geographical, or ecological properties

Raceme – elongate inflorescence with pedicelled flowers arising from the bottom upward on an unbranched axis

Rank – NatureServe and the Natural Heritage Program use a ranking system (Internet site: <http://www.natureserve.org/explorer/granks.htm>). A rank of “G4T3” indicates that *Penstemon laricifolius* ssp. *exilifolius* is “potentially secure globally” at the species level, though the subspecies may be vulnerable. A rank of “S2” indicates that it is imperiled at the state (subnational) level because it is very rare or local, or because of some other factor(s) making it very prone to extirpation from the state. A rank of “S3” indicates that it may be vulnerable at the state (subnational) level.

Recessive – an allele that is not expressed in the phenotype except when homozygous

Regional endemic – restricted to a limited geographic area, e.g., used in Wyoming to refer to distribution patterns that span state lines for a species occupying a total range that is smaller than the land area of the state

Scariosus – dry, thin, membranous, and translucent

Seral – pertaining to a stage of succession

Staminode – a sterile stamen

Stress-resistant – able to survive exposure to an unfavorable environmental factor

Ventricose – inflated or swelling out on one side only

Xerophytic – adapted to life in dry places

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