

Armeria maritima (P. Miller) Willdenow
ssp. *sibirica* (Turczaninov ex Boissier) Nyman
(Siberian sea thrift):
A Technical Conservation Assessment



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Barry C. Johnston, Botanist
Grand Mesa–Uncompahgre–Gunnison National Forests
216 N. Colorado St.
Gunnison, CO 81230-2197

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AUTHOR'S BIOGRAPHY

Barry C. Johnston has a B.S. degree in Engineering Physics, from the University of Colorado, Boulder (1966), and a Ph.D. in Biology (Botany and Ecology) from the same university in 1980. His Ph.D. thesis was a population and taxonomic study of three sections of the plant genus *Potentilla* (Rosaceae) in western North America. He worked for the USDA Forest Service as a seasonal-temporary botanist from 1976-1980, conducting field studies of rare plant populations throughout the Southwestern Region (1976) and Rocky Mountain Region (1977-1980). He was employed as an ecologist by the Rocky Mountain Region 1981-1989, for that time also doing the work of Regional Botanist. During that time, he was active working on writing documents for the first round of forest plans in this region, especially direction for biodiversity, riparian areas, Research Natural Areas, other special areas, and plant species.

In 1989, he moved to Gunnison to work for the Forest Service on an ecological classification of the Gunnison Basin, which was published in 2001. Since then, he has worked on various projects, including weeds, problems of aspen regeneration, biological evaluations and assessments, inventory and monitoring for Gunnison sage grouse, a field guide to sedges of the Rocky Mountain Region, watershed assessment, the BLM's National Resource Inventory, monitoring and inventory of riparian areas and wetlands, and monitoring forested sites to prevent catastrophic wildfire in the Front Range of Colorado.

Selected publications include Proposed and Recommended Endangered and Threatened Plant Species of the Forest Service, Rocky Mountain Region (1979), Plant Associations of Region Two (Third Edition, 1987), Multiple Factors Affect Aspen Regeneration on the Uncompahgre Plateau, West-Central Colorado (2001), Ecological Types of the Upper Gunnison Basin (2001), Field Guide to Sedges of the Rocky Mountain Region (2001), and *Ptilagrostis porteri*: A Technical Conservation Assessment (2006). He has also authored numerous species evaluations and reports.

COVER PHOTO CREDIT

Armeria maritima ssp. *sibirica* (Siberian sea thrift). Photograph by author.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *ARMERIA MARITIMA* SSP. *SIBIRICA*

Status

Armeria maritima ssp. *sibirica* (Siberian sea thrift) is found in Colorado and northeastern Utah, where it is disjunct from its primary range across northern Canada. USDA Forest Service (USFS) Rocky Mountain Region (Region 2) has designated *A. maritima* ssp. *sibirica* a sensitive species. NatureServe ranks the species and subspecies globally secure (G5/T5). The Colorado Natural Heritage Program ranks the taxon critically imperiled (S1), and the Utah Natural Heritage Program has recently assigned it the same rank in that state.

There are only three known occurrences of *Armeria maritima* ssp. *sibirica* in Region 2, and these are all within Colorado; the total number of plants known in Region 2 is less than 1,000. There are two known occurrences of *A. maritima* ssp. *sibirica* in Utah, probably totaling fewer than 1,000 individuals. Based on a few monitoring results over more than 25 years, it appears that *A. maritima* ssp. *sibirica* habitats and populations in Region 2 are stable in quantity and quality.

There are a few informal, local efforts to propagate *Armeria maritima* ssp. *sibirica*, but the taxon is apparently not conserved in seed banks or by other conservation-storage means.

Primary Threats

Currently, the primary potential threats to *Armeria maritima* ssp. *sibirica* in Region 2 are unauthorized vehicle use, global warming, and air pollution, in order of decreasing priority. Unauthorized vehicle use is present in small quantities at two sites, but effects on occurrences of *A. maritima* ssp. *sibirica* or its habitats have not been observed. Although effects of global warming and air pollution are evident elsewhere in the Rocky Mountains, and are predicted to affect rare plants in the alpine zone significantly, the predicted effects have so far not become evident at *A. maritima* ssp. *sibirica* sites. Most atmospheric scientists project effects on alpine sites to increase. Road construction at one site several decades ago presumably destroyed a small part of the population, but the remainder of the population is apparently stable. Currently, livestock grazing does not occur on any of the Region 2 sites, nor has there been any for over 20 years; there is no evidence of significant effects by livestock grazing before that. Future minerals exploration and development, future road or trail construction and maintenance, or increased foot travel could pose additional threats to this taxon and its habitats.

Occurrences of this taxon in Region 2 are few and small, suggesting the possibility of significant decline following small changes in its environment, but occurrences do not appear to be declining now.

Primary Conservation Elements, Management Implications and Considerations

Armeria maritima ssp. *sibirica* is a sensitive species in Region 2, and as such it is protected under two current forest plans. In those plans, resource managers are prevented from making any decision that would negatively affect this taxon's viability on the given national forest. However, changes now beginning on one of these forests, and possibly extending to both, would drop *A. maritima* ssp. *sibirica* from consideration as a species of concern. The implications of these changes are uncertain for this taxon, but they will likely lead to decreased protection.

Current laws and regulations are adequate to conserve *Armeria maritima* ssp. *sibirica* in the Region 2 against most threats, but not the effects of global warming and air pollution. Enforcement of the current laws and regulations is probably inadequate in the face of increasing unauthorized off-road vehicle use.

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EDITORS: Beth Burkhart, Kathy Carsey and Janet Coles, USDA Forest Service, Rocky Mountain Region

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Armeria maritima* ssp. *sibirica* (Siberian sea thrift) is the focus of an assessment because it is a rare taxon disjunct in the Rocky Mountains in Colorado, and because it has been designated a sensitive species by the Regional Forester of Region 2 (USDA Forest Service 2005b). 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 (Forest Service Manual 2670.5 [19]). A sensitive species may require special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology, ecology, conservation, and management of *A. maritima* ssp. *sibirica* throughout its range in the Rocky Mountain Region.

Goal

Species assessments produced as part of the Species Conservation Project are designed to provide forest managers, 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). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

The primary goal of this assessment is to provide natural resource managers and decision-makers with information on *Armeria maritima* ssp. *sibirica* necessary to manage this taxon on public lands. An associated goal is to bring together and summarize all known information about *A. maritima* ssp. *sibirica* to facilitate status determinations for this taxon.

Scope

This assessment examines the biology, ecology, conservation status, and management of *Armeria maritima* ssp. *sibirica* in Region 2. Although some of the literature relevant to the taxon originates from field investigations outside the region, this document places that literature in the ecological and social contexts of the southern Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *A. maritima* ssp. *sibirica* in the context of the current environment rather than under historical conditions.

In producing this assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. An effort was made to consider and cite all documents and other sources relevant to the goals. Many reports or non-refereed publications on rare plants are 'works-in-progress' or isolated observations on phenology or reproductive biology, and are thus reliable sources of information in spite of not being formally published. Unpublished data (e.g., state natural heritage program records, herbarium records, USFS monitoring projects) were important in estimating the geographic distribution and population sizes of this taxon. These data required special attention because of the diversity of persons and methods used in collection. Records associated with locations at which herbarium specimens had been collected at some point in time were weighted with more significance than observations only.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are 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 critical experiments in naturally occurring ecosystems, especially when those ecosystems are subject to historical and ongoing use and management. Therefore, while well-executed experiments represent the strongest approach to developing knowledge, alternative methods, such as observations, inference, good thinking, and models must be relied on to guide

the understanding of features of biology. In fact, careful, unbiased observation and inference has been responsible for most scientific progress, especially in biology (Mueller-Dombois and Ellenberg 1974). In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

Publication of Assessment on the World Wide Web

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

Peer Review

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

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

In central Colorado and Utah, *Armeria maritima* ssp. *sibirica* is disjunct* from its primary range. The next nearest locations of the species *A. maritima* are on the coasts of California, Oregon, Washington, British Columbia, and northern Saskatchewan (Argus 1999, Lefèbvre and Vekemans 2005); the next nearest locations of subspecies *sibirica* are in the Northwest Territories, Nunavut, and the south coast of Hudson Bay (Hitchcock et al. 1959, Hultén 1964, 1968, Argus 1999).

Armeria maritima ssp. *sibirica* is not federally listed as threatened or endangered, nor is it currently a candidate for listing (USDI Fish and Wildlife Service 2005). The species and subspecies do not qualify for

protection under the federal Endangered Species Act of 1973 because they are apparently abundant and secure in parts of their ranges. *Armeria maritima* ssp. *sibirica* is rated as sensitive by Region 2 (USDA Forest Service 2005b), where there are three known occurrences in Colorado. NatureServe gives the species *A. maritima* and the subspecies *A. maritima* ssp. *sibirica* ranks of G5 and T5, respectively. These ratings mean that the species and subspecies are globally demonstrably secure but may be rare in parts of their ranges.

The state of Colorado does not have legislation or regulations protecting any plant species (except the state flower, *Aquilegia coerulea*). The Colorado Natural Heritage Program ranks *Armeria maritima* ssp. *sibirica* as S1, which means that the subspecies is critically imperiled in the state, with typically 6 to 20 occurrences. The Utah Natural Heritage Program (Franklin personal communication 2005) has recently given this taxon the same rank in that state. Heritage Program ranks do not carry any legal status.

Armeria maritima ssp. *sibirica* apparently has stable, secure populations throughout most of its range, but it is considered Endangered in Finland (Finnish Ministry of the Environment 2004). *Armeria maritima* ssp. *interior* (Athabasca thrift) is considered a Special Concern Species in Canada (Canadian Wildlife Service 2005). *Armeria scabra* (sea pink; possibly synonymous with *A. maritima* ssp. *sibirica*) is considered "Rare, with limited distribution" in the central and northern Ural Mountains in Russia (Taksaeva 1998).

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Within Region 2, *Armeria maritima* ssp. *sibirica* is a sensitive species and has been since the Sensitive Species List was first published in 1994. This means that a biological evaluation must be written for every USFS action for which environmental analysis is required under the National Environmental Policy Act, if the proposed activity might occur in or near *A. maritima* ssp. *sibirica* habitat or might potentially impact its populations or individual plants (USDA Forest Service 2005b). The botanist writing the Biological Evaluation must make a determination of impact of the project on the taxon, choosing one of the following (USDA Forest Service 2005b):

* Definitions of selected terms can be found in the **Definitions** section below.

- ❖ no impact
- ❖ beneficial impact
- ❖ may adversely impact individuals, but not likely to result in a loss of viability in the planning area, nor cause a trend toward federal listing
- ❖ likely to result in a loss of viability in the Planning Area, or in a trend toward federal listing.

Although the last determination in the above list is technically possible, in the author's experience, USFS decision makers (i.e., District Ranger, Forest Supervisor, Regional Forester) generally avoid that determination by changing or mitigating the proposed action to result in another determination.

The last few months have seen the beginnings of a change in policy on national forests. The new policy follows changes in the regulations involving forest planning (USDA Forest Service 2005a). National forests (e.g., White River National Forest) that revised their forest plans before 2005 used the 1983 regulations and included sensitive species in their revision. However, national forests just beginning their forest plan revisions are allowed to choose whether they will operate under the 1983 regulations or the 2005 regulations. The Pike and San Isabel National Forest has chosen to complete its forest plan revision under the 2005 regulations, which do not consider sensitive species. Instead, under the 2005 regulations, two new concepts will apply: *species-of-concern* and *species-of-interest* (USDA Forest Service 2006a). *Armeria maritima* ssp. *sibirica* would not be admitted as a *species-of-concern* because it is ranked G5T5 (NatureServe 2006). Therefore, the taxon would not be considered in every project as sensitive species were. However, the taxon could still be chosen as a species-of-interest and special forest plan language written to protect it.

Armeria maritima ssp. *sibirica* was identified as a Species of Viability Concern in the forest plan for the White River National Forest. In the document, managers are instructed to survey for plant species of viability concern in identified areas prior to any activities that might impact them, including *A. maritima* ssp. *sibirica* in suitable alpine areas. Managers are also advised to avoid disturbances that would significantly affect species viability or trend the species towards federal listing (USDA Forest Service 2002, p. 2-24).

For the two occurrences on the White River National Forest, *Armeria maritima* ssp. *sibirica* will continue to be protected by the special plan language quoted above and by the necessity to consider the taxon in every project that might possibly affect it or its habitat. However, the occurrence on the Pike National Forest will be treated differently, possibly including special language in the revised forest plan to help protect it. After the revised forest plan is approved, however, *A. maritima* ssp. *sibirica* will be neither a sensitive species nor a species-of-concern on the Pike National Forest, so it likely will not be considered as a special species in projects on that forest.

One of the largest *Armeria maritima* ssp. *sibirica* populations in Colorado is wholly contained within the Hoosier Ridge Research Natural Area (RNA), in which no motor vehicles or developed trails are allowed. The RNA is on both the Pike and Arapaho national forests, and while the occurrence of *A. maritima* ssp. *sibirica* is entirely on the Arapaho side, it is managed by the White River National Forest. This taxon is cited as one of the justifications for the establishment of the Hoosier Ridge RNA, but as far as is known, there are no management objectives and no management plans for this RNA. In the White River National Forest Plan, the Hoosier Ridge RNA was assigned to Management Area 2.2, within which the following activities are generally not allowed: timber harvest, motorized recreation, mechanized recreation, livestock grazing, minerals location, new roads and trails, and developed recreation. "RNAs are managed to maintain natural, relatively pristine, or pre-settlement conditions by allowing ecological processes to prevail with minimal human intervention" (USDA Forest Service 2002, pp. 3-20 through 3-25).

There are no conservation strategies or plans specifically for *Armeria maritima* ssp. *sibirica* in Region 2.

Adequacy of current laws and regulations

In general, current laws and regulations are sufficient to conserve *Armeria maritima* ssp. *sibirica* on the White River National Forest because there is special language in that forest plan and an RNA which provides some protection for the taxon. The taxon will remain a sensitive species on the White River National Forest, so it must be considered in every project possibly affecting it.

The situation is less certain on the Pike National Forest. Currently, *Armeria maritima* ssp. *sibirica* is

protected on the Pike and San Isabel National Forests because it remains a sensitive species there. However, if current USFS policy continues, *A. maritima* ssp. *sibirica* will not have sensitive species or species-of-concern status on that national forest under the revised forest plan, which is due to be approved in the next twelve to eighteen months. When that happens, *A. maritima* ssp. *sibirica* will no longer have legal and regulatory support sufficient to conserve it in the Rocky Mountain Region.

Current laws and regulations are probably sufficient to conserve *Armeria maritima* ssp. *sibirica* against mineral exploration and development at the two sites where those activities are allowed (#2 and #3 in **Table 1**). There are no current proposals for those activities in these areas, and given the mineralogy of those sites, such activities are unlikely. However, current laws and regulations, including their enforcement, are inadequate to conserve *A. maritima* ssp. *sibirica* in Region 2 against the effects of climate change, including global warming and nitrogen deposition.

Adequacy of enforcement of current laws and regulations

Current enforcement of these laws, regulations, and other restrictions is apparently not sufficient to protect *Armeria maritima* ssp. *sibirica* in Region 2 against all threats. Vehicles are still accessing the Hoosier Ridge RNA and most managers expect vehicle pressure in this area to increase. There is nothing to prevent vehicles from leaving the roads in the Radical Hill area, but they have not done so in recent years.

Biology and Ecology

Classification and description

Systematics, synonymy, and history

Most botanists put *Armeria maritima* ssp. *sibirica* in the Plumbaginaceae (the thrift family (Lledó et al. 1998, Lefèbvre and Vekemans 2005)). Weber and Wittmann (2001a, 2001b) place *Armeria* in the Limoniaceae. **Table 2** is a summary of the classification of this taxon.

C.W.T. Penland of Colorado College discovered the taxon in Colorado and the Rocky Mountains in July 1935 (Lawrence 1947); he called the Colorado plants *Statice arctica* var. *coloradense*, but never published that name. Harrington (1954) called these plants *Armeria labradorica*, a species that was then thought

to occur across Canada and from northern Scandinavia to the Bering Strait. Hultén (1964) called the taxon *A. maritima* ssp. *labradorica*, later changing the name to *A. maritima* ssp. *arctica* (Hultén 1968), while admitting that the species complex is complicated and difficult to assess.

After several trips to Siberia, William A. Weber accepted Hylander's (1945) treatment. Hylander included the Colorado occurrences within *Armeria scabra* Pallas ssp. *sibirica* (Turczaninov) Hylander, with disjunct occurrences in the central Rocky Mountains and east-central Siberia. Subspecies *sibirica* was first described (as a species) by the Russian botanist Turczaninov in 1803, based on specimens from western Siberia.

In Colorado, *Armeria maritima* ssp. *sibirica* has been known by a variety of names, depending upon how authors felt the Colorado plants fit into the complicated global taxonomy and as opinions of classification within *Armeria* changed. **Table 3** illustrates some synonyms for *A. maritima* ssp. *sibirica*.

Armeria maritima ssp. *sibirica* is usually known in Colorado as *A. scabra* ssp. *sibirica* (Baker 1959, Hultén 1964, Spackman et al. 1999, Weber and Wittmann 2001a, 2001b, Weber 2003); the author and other botanists agree with this name (for example, Aiken et al. 2003); other botanists believe it should be called *A. maritima* ssp. *sibirica* (Lefèbvre and Vekemans 1995) or *A. maritima* ssp. *labradorica* (Hultén 1968). There is a wide variety of opinions about taxonomy and distribution of this taxon. For the purposes of this document, this taxon will be called *A. maritima* ssp. *sibirica*, following the recent treatment in Flora of North America (Lefèbvre and Vekemans 2005).

This taxonomic uncertainty indicates there is a need for detailed taxonomic work to place the Colorado and Utah populations in a world-wide context. Populations in Colorado and Utah are widely disjunct and at the edge of the range of *Armeria maritima* ssp. *sibirica*, which normally would suggest that they are a unique genotype; but populations of *A. maritima* ssp. *sibirica* have a high degree of self-pollination and are often relatively uniform genetically and morphologically (Baker 1959, 1966, Lefèbvre 1970, Vekemans et al. 1990).

Armeria maritima is only occasionally offered as a garden plant in Colorado, but species from other genera in the family are fairly common in cultivation, especially species of *Statice* and *Limonium* (sea-

Table 1. Known sites for *Armeria maritima* ssp. *sibirica* in the Rocky Mountains of Colorado and Utah.

Site No.	Site Name	State	County	Manager	Protected Area	Discovered	Last Visited	Elevation (ft.)	Aspect	Slope	Habitat Notes	Associated Plant Species ^a	Geology ^b
1	Hoosier Ridge	Colorado	Summit	Arapaho National Forest **, Dillon Ranger District	Hoosier Ridge RNA	C.W.T. Penland, 1935	2004	12,000-12,450	NNW-NW	50-60% (1978) 4-25% (2004)	North side of Hoosier Ridge, moderately-steep tundra slope on flat side of ridge	<i>Acomastylis rossii</i> , <i>Artemisia scopulorum</i> , <i>Besseyia alpina</i> , <i>Bistorta bistortoides</i> , <i>B. vivipara</i> , <i>Cerastium beeringianum</i> , <i>Gentianodes algida</i> , <i>Papaver kluanense</i> , <i>Phleum commutatum</i> , <i>Poa alpina</i> , <i>Saxifraga rhomboidea</i> , <i>Smelowskia calycina</i> , <i>Trifolium nanum</i>	Tertiary and Cretaceous intrusive rocks of Laramide age (close to limestones)
2	Radical Hill	Colorado	Summit	Arapaho National Forest **, Dillon Ranger District	None	D. Havig & B. Johnston, 1977	2004	12,360-12,580	NNW	2% (1977) 5-12% (2004)	Flat ridge top, usually in dense tundra or in microsites in small depressions between rockier lobes and stripes on slope	<i>Acomastylis rossii</i> , <i>Anemone parviflora</i> , <i>Artemisia pattersonii</i> , <i>Bistorta bistortoides</i> , <i>B. vivipara</i> , <i>Castilleja occidentalis</i> , <i>Pedicularis parryi</i> , <i>Poa alpina</i> , <i>Polemonium viscosum</i> , <i>Trisetum spicatum</i>	Precambrian metamorphic rocks, mostly gneiss
3	Missouri Mine	Colorado	Park	Pike National Forest *, South Platte Ranger District	None	B. Johnston, 1977	1977	11,800-12,000	NE	30-55%	Bottom of steep, willow-covered gully; beside dry brooklet channel in spongy organic soil of steep E-facing willow-sedge swale	<i>Saussurea weberi</i>	Precambrian metamorphic rocks, mostly gneiss
4	Gilbert Peak	Utah	Summit	Wasatch-Cache National Forest	None	D. Hill & E. Hill, 08-13-1999	2004	12,550	NNE	Not recorded	Expansive tundra meadow heavily grazed by sheep	None recorded	Precambrian

Table 1 (concluded).

Site		Protected			Elevation			Associated Plant					
No.	Name	State	County	Manager	Area	Discovered	Last Visited	Elevation (ft.)	Aspect	Slope	Habitat Notes	Species ^a	Geology ^b
5	Kabell Ridge	Utah	Summit	Wasatch-Cache National Forest	None	G. Brown & S. Goodrich, 2004	11-Aug-2004	11,460	NW	10%	Convex ridge top. <i>Armeria</i> 10% cover	<i>Bistorta vivipara</i> , <i>Carex nova</i> , <i>C. saxatilis</i> , <i>C. scirpoidea</i> , <i>Deschampsia cespitosa</i> , <i>Juncus triglumis</i> , <i>Pedicularis groenlandica</i> , <i>Salix planifolia</i> , <i>Silene acaulis</i>	Precambrian

* Plant species names after Weber and Wittmann (2001a).

^a Hintze (1974), Tweto (1979), Green (1995).

** Administered by the White River National Forest.

† Close (about 30 m) to private (patented) land.

Table 2. Classification of *Armeria maritima* ssp. *sibirica*. After USDA Natural Resources Conservation Service 2006.

Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Caryophyllidae
Order	Plumbaginales
Family	Plumbaginaceae – Leadwort family
Genus	<i>Armeria</i> (DC.) Willdenow
Species	<i>Armeria maritima</i> (P. Miller) Willdenow
Subspecies	<i>Armeria maritima</i> (P. Miller) Willdenow ssp. <i>sibirica</i> (Turczaninov ex Boissier) Nyman

Table 3. Partial synonym list for *Armeria maritima* ssp. *sibirica*. Bold type indicates the currently accepted name.

Name	Year of Publication	Type Location	Reference(s)
<i>Armeria scabra</i> Pallas	1802	Northern Asia	Czerepanov 1995, Aiken et al. 2003
<i>Armeria vulgaris</i> Willd. f. <i>arctica</i> Chamisso	1831	Unalaska, AK	Chamisso 1831
<i>Armeria maritima</i> (P. Miller) Willdenow ssp. <i>arctica</i> (Chamisso) Hultén	1948		Hultén 1968
<i>Armeria labradorica</i> Wallring	1844	Labrador	Harrington 1954, Czerepanov 1995
<i>Armeria maritima</i> (P. Miller) Willdenow var. <i>labradorica</i> (Wallring) Lawrence	1940		Lawrence 1947, Hitchcock and Cronquist 1973
<i>Armeria maritima</i> (P. Miller) Willdenow ssp. <i>labradorica</i> (Wallroth) Hultén	1948		Porsild 1957, Hultén 1968
<i>Armeria sibirica</i> Turczaninov	1848	Siberia	Raven 1963
<i>Armeria maritima</i> (P. Miller) Willdenow var. <i>sibirica</i> (Turczaninov) A. Blytt	1874		Lawrence 1947, Welsh 1974
<i>Armeria maritima</i> (P. Miller) Willdenow ssp. <i>sibirica</i> (Turczaninov) Nyman	1881		Pinto da Silva 1972, Lefèbvre and Vekemans 1995, Lefèbvre and Vekemans 2005, USDA Natural Resources Conservation Service 2006
<i>Armeria scabra</i> Pallas ssp. <i>sibirica</i> (Turczaninov) Hylander	1945		Hylander 1945, Hultén 1964, Spackman and others 1999, Weber and Wittmann 2001a, Aiken et al. 2003, Weber 2003

lavender; Bailey 1949). Species of *Armeria* are cultivated in Utah as well as in other parts of the world (Welsh et al. 1993, Soppe 2005).

Species description

The following is a description of *Armeria maritima* ssp. *sibirica* as it occurs in Colorado and Utah, derived from the descriptions in Lawrence 1947, Harrington (1954), Porsild 1957, Hitchcock et al. (1959), Hultén (1968), Hitchcock and Cronquist (1973), Welsh (1974),

Weber and Wittmann (2001a, 2001b), and Lefèbvre and Vekemans (2005). Technical terms can be found in the **Definitions** section.

Perennial plants, acaulescent, caespitose, from a woody branched taproot, 5 to 20 cm tall. Leaves in a basal rosette, sessile, purplish–green, narrowly linear, folded, somewhat succulent, 3 to 10 cm (usually <6 cm) long and up to 1.8 mm wide, decumbent to ascending at base, the acute tips arching upward. Inflorescence scapose, flowers in groups of 3 to 5 subtended by an

involucre of papery bracts, outer bracts about one-half as long as the inner ones; inner bracts obtuse. Groups of flowers clustered in a head. Head globose to obolespheroidal, 1 to 2 cm wide, with 15 to 20 flowers, subtended by fused, reflexed bracts in a sheath on the scape below the flower cluster. Flowers perfect, radially symmetric, monomorphic. Calyx tubular, of five partially united sepals, scarious and pubescent, papery. Petals five, longer than the calyx, united, bright pink at first, turning white and becoming papery as the season progresses. Stamens five, opposite the petals and adnate to their bases. Ovary superior, 1-celled, 1-ovuled. Styles five, slightly united at base. Fruit a 1-seeded indehiscent nut (utricle), enclosed in persistent papery calyx. Pollen coarsely reticulate (Nowicke and Skvarla 1979). Chromosomes $2n = 18$ for *Armeria scabra* (including *A. maritima* ssp. *labradorica* and *A. maritima* ssp. *sibirica*) (Aiken et al. 2003). Other subspecies also $2n = 18$ (Lefèbvre and Vekemans 2005).

Armeria maritima ssp. *sibirica* in flower is not easily confused with anything else in its habitat. Its spherical cluster of bright pink flowers on a scape and fused bracts below the cluster are distinct (**Figure 1**, **Figure 2**, and **Figure 3**). Even after the flowers have faded, the dry cluster is still distinctive, though not as visible as the pink flowers. Cultivated relatives of this plant are prized in arrangements of dry flowers (Bailey 1949). In their vegetative state, without scapes or flowers, the plants are almost impossible to distinguish from the grasses among which they grow; this may

have contributed to underestimates of abundance in some years.

Distribution and abundance

The global distribution of *Armeria maritima* ssp. *sibirica* extends from northern Yukon through most of the Northwest Territories and Nunavut, northern Québec, Labrador, northern Newfoundland, and the northeast Atlantic coast of Québec, in the Canadian Arctic Archipelago, and the western and eastern coasts of Greenland, along the Arctic coast from Chukotsk across northern Russia to northern Finland, Sweden, and Norway (**Figure 4** and **Figure 5**). Disjunct occurrences appear in the Gorno-Altai and Altai Mountains near where Siberia, Mongolia, and China meet, the central Ural Mountains in Russia, the north coast of Greenland, the south shore of Hudson Bay, central Colorado and northeastern Utah (**Figure 6**), and the southern Andes Mountains in Chile and Argentina.

Populations in the Andes of South America are thought to belong to *Armeria maritima* ssp. *sibirica*, based on reports by Raven (1963) and Lefèbvre and Vekemans (1995) that the plants cannot be distinguished from *A. maritima* ssp. *sibirica* of Arctic North America (also see Reiche 1911, Coulaud et al. 1999, Nuñez et al. 1999).

A closely related subspecies, *Armeria maritima* ssp. *interior*, is endemic to the shores of Lake Athabasca

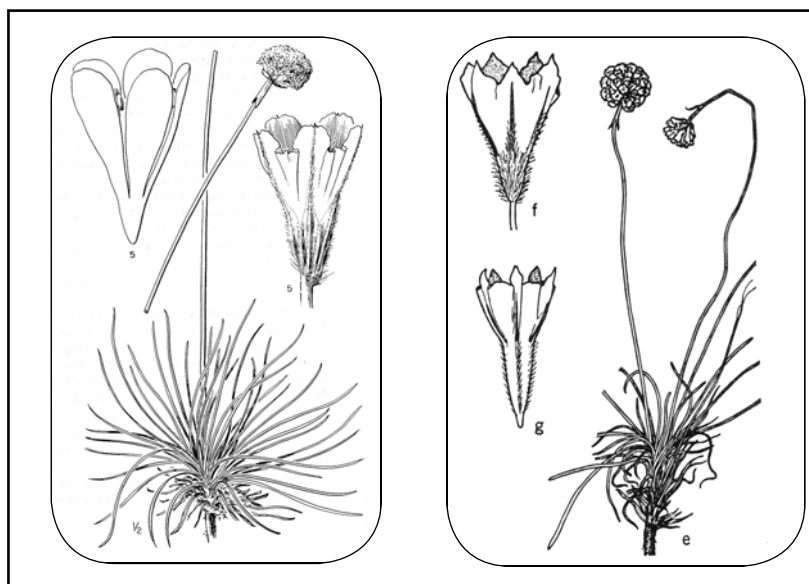


Figure 1. Drawings of *Armeria maritima*. Left illustration from Vascular Plants of the Pacific Northwest (Hitchcock et al. 1959). Illustration by Jeanne R. Janish. Used with permission of the University of Washington Press. Right illustration from Illustrated Flora of the Canadian Arctic Archipelago (Porsild 1957). Used with permission of the Canadian Museum of Nature.



Figure 2. A typical view of *Armeria maritima* ssp. *sibirica* in Colorado. The stripes on the frame are 10 cm long, and the frame is made of ½ inch outside-diameter pipe. Photograph by the author, July 27, 2004.

in northern Saskatchewan (Argus 1999, Lefèbvre and Vekemans 2005), with a distribution disjunct from the main distribution of *A. maritima* ssp. *sibirica*. Other subspecies of *A. maritima* occur in coastal Alaska south to southern California, on the northeast coast of Asia south to Kamtchatka and the north coast of the Sea of Okhotsk, in Iceland and south Greenland, on the coasts of southwestern Norway and the Baltic Sea, along the coasts of the North Sea and Atlantic Ocean south to northern Spain, on the coasts and in the mountains of England, Scotland, and eastern Ireland, in the mountains of Spain, central Europe, and southern Poland, and in southern Sakhalin (**Figure 4**, Hylander 1945, Baker 1959, Hultén 1964, 1968, Nieto Feliner 1997, Argus 1999, and Lefèbvre and Vekemans 1995, 2005).

In Colorado, *Armeria maritima* ssp. *sibirica* is known from three occurrences, all in the alpine zone (**Table 1**). Two of these are in Summit County, on the Dillon Ranger District of the Arapaho National Forest

(administered by the White River National Forest); the third is in Park County on the South Platte Ranger District of the Pike National Forest (**Figure 7**). This taxon has been considered very rare ever since these populations were discovered. Weber and Wittmann (2001a) say the subspecies “is so extremely restricted that it should never be collected unless to document a new locality.”

The occurrence on Hoosier Ridge in the White River National Forest (#1 in **Table 1**) was discovered in the 1930s by C. William T. Penland, a botanist from Colorado College in Colorado Springs. This locality was thought to be the only occurrence in Colorado until 1977, when Dennis Havig of the USFS and the author discovered two more occurrences near Radical Hill, about 15 miles to the northeast of Hoosier Ridge. These are still the only three native occurrences of this taxon known from Region 2.



Figure 3. A close-up view of an *Armeria* plant. Photograph by the author, July 26, 2004.

Two other occurrences in the Rocky Mountains have been reported from the Uinta Mountains of Summit County, Utah. Both occurrences are on the Wasatch-Cache National Forest. One occurrence (#4 in **Table 1**) is known from an herbarium specimen collected in August 1999. The other Utah location (#5 in **Table 1**) was discovered by Garry Brown of Brigham Young University and Sherel Goodrich of the Ashley National Forest in 2004 (Brown personal communication 2005).

Population trend

Population counts or estimates of the five Rocky Mountain occurrences of *Armeria maritima* ssp. *sibirica* are shown in **Table 4**. The author inventoried both of the larger Colorado occurrences in the period 1977 to 1978 and in 2004, and though both appear to be increasing, there are still fewer than 1,000 individuals known in Colorado.

Data derived from triangulation mapping in 1977 and global positioning system (GPS) techniques

in 2004 indicate that the Hoosier Ridge occurrence moved about 100 m northeast in the 27 years between these observations. There are about 12 to 15 plants in the overlap between the 1977 and 2004 occurrence boundaries (Johnston 2004). This occurrence moved in the direction of prevailing winds in this area (southwest to northeast), which may explain the shift.

Much potential habitat for *Armeria maritima* ssp. *sibirica* has been searched unsuccessfully over the last 60 to 70 years, both on National Forest System lands and on private lands in Colorado. For an alpine plant, *A. maritima* ssp. *sibirica* is fairly easy to spot with its bright-pink flower heads. Despite these searches, more occurrences may yet be discovered.

Habitat

Microhabitat

In Colorado, *Armeria maritima* ssp. *sibirica* plants occur on a wide variety of microsites, including

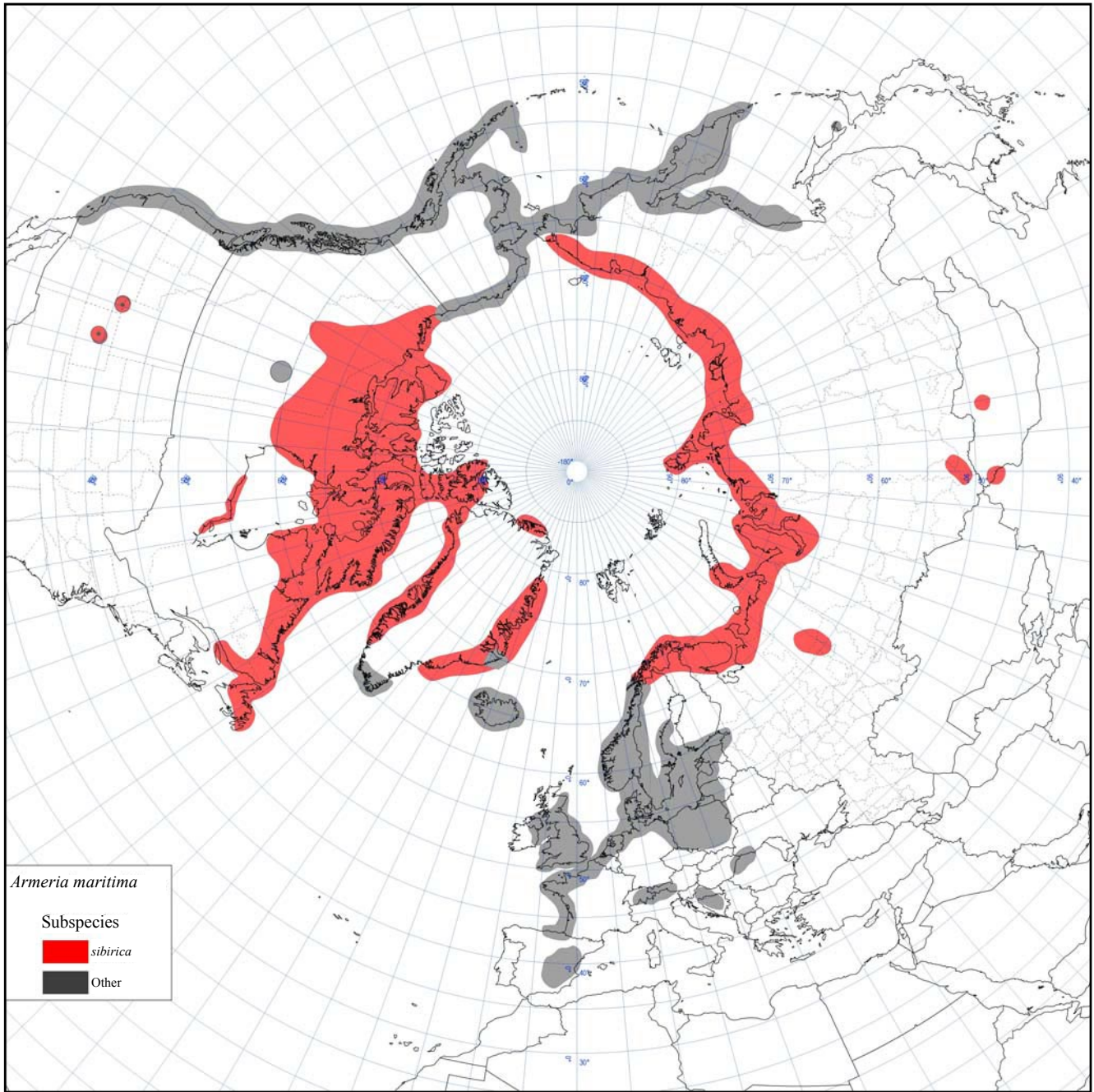


Figure 4. The global distribution of *Armeria maritima*. Not pictured are occurrences in the mountains of South America (Coulaud et al. 1999, Nuñez et al. 1999). The gray dot in northern Saskatchewan is *A. maritima* ssp. *interior*. After Hylander 1945, Baker 1959, Hultén 1964, 1968, Nieto Feliner 1997, Argus 1999, and Lefèbvre and Vekemans 1995, 2005.

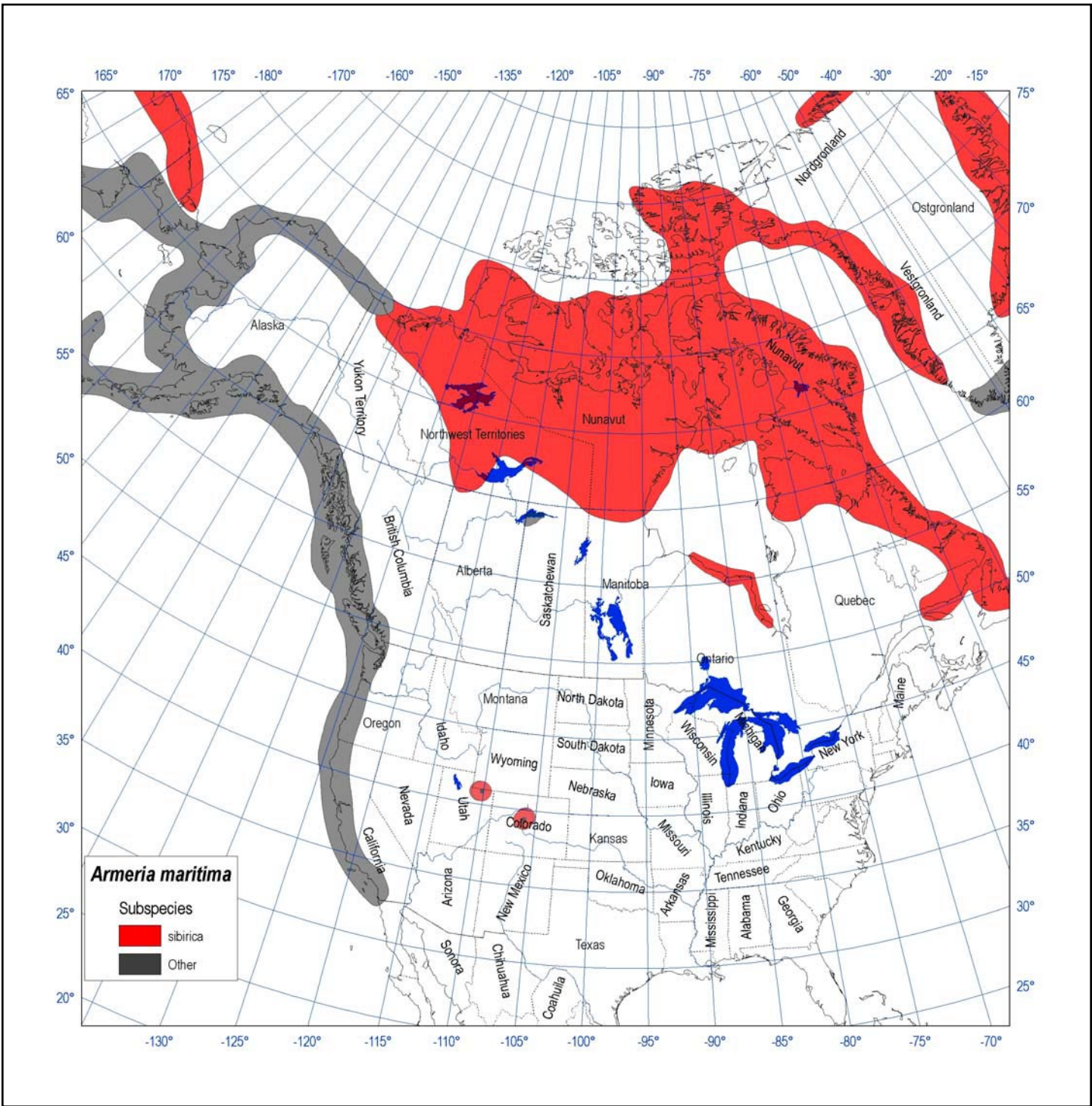


Figure 5. The distribution of *Armeria maritima* in North America. After Hylander 1945, Baker 1959, Hultén 1964, 1968, Nieto Feliner 1997, Argus 1999, and Lefèbvre and Vekemans 1995, 2005.

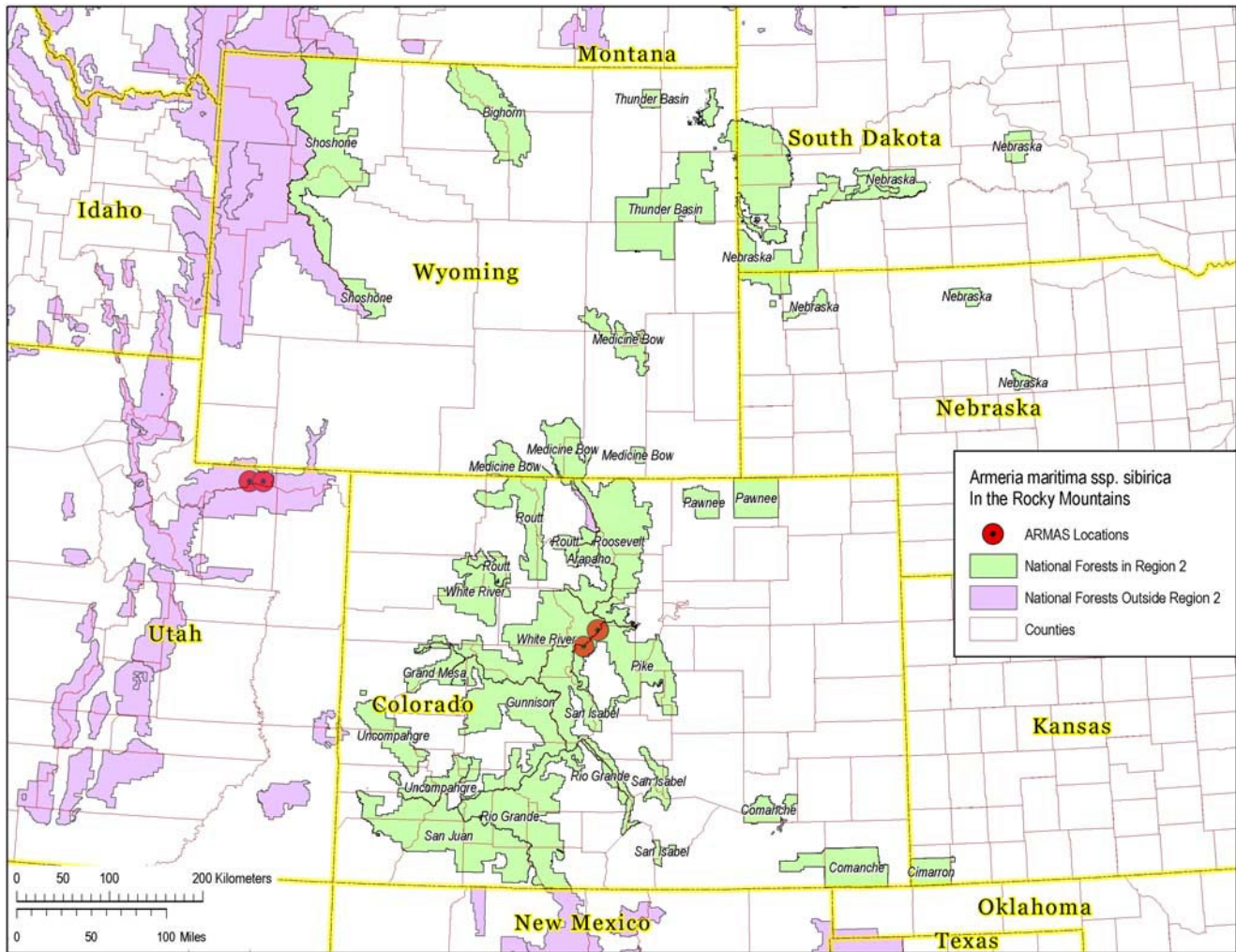


Figure 6. The range of *Armeria maritima* ssp. *sibirica* in the Rocky Mountains. National Forest System lands of the USDA Forest Service Rocky Mountain Region are in green. States of the Rocky Mountain Region include Wyoming, South Dakota, Nebraska, Kansas, and Colorado.

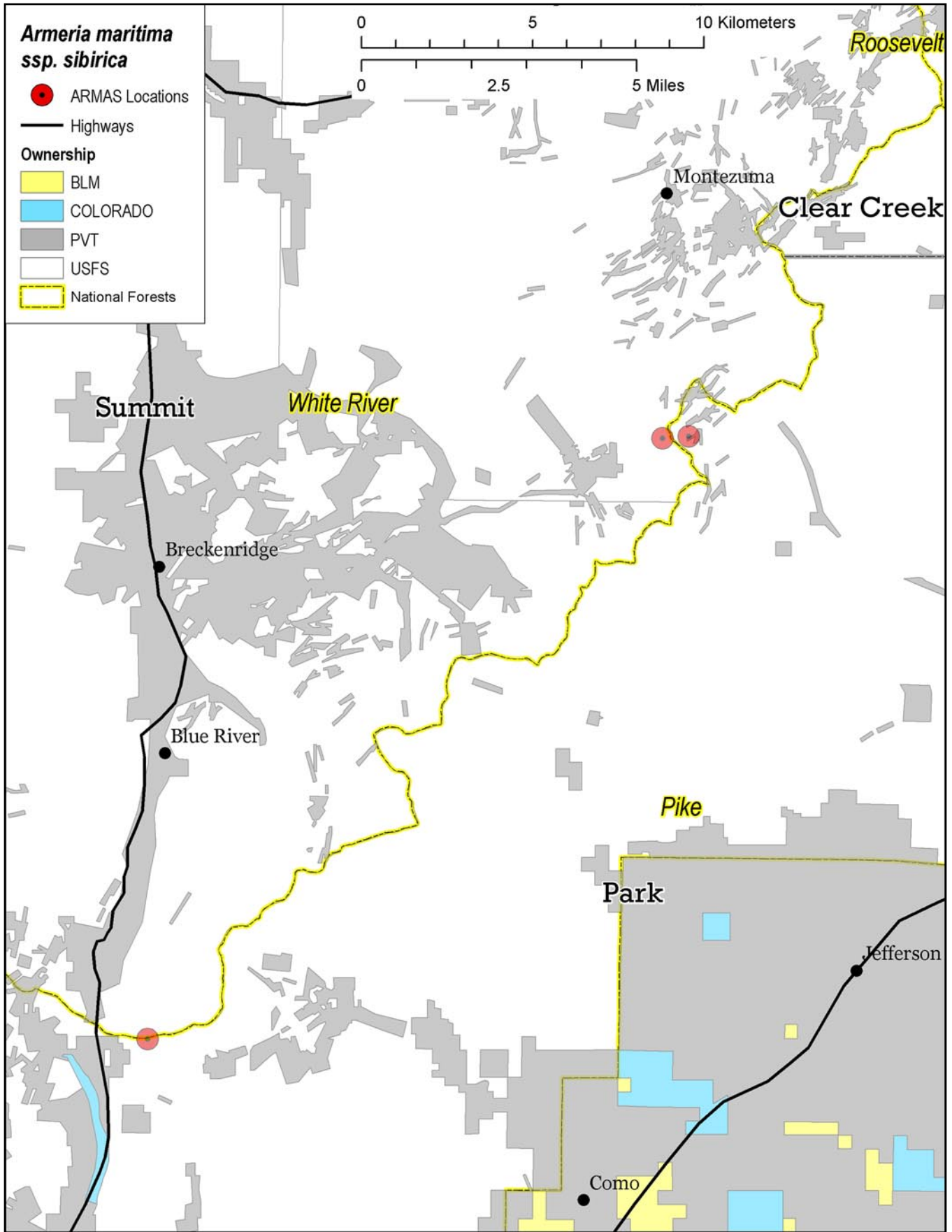


Figure 7. The distribution of *Armeria maritima* ssp. *sibirica* in Summit and Park counties, Colorado (Johnston 1977, Spackman et al. 1999, Johnston 2004, Colorado Natural Heritage Program 2005b).

Table 4. Population counts or estimates for *Armeria maritima* ssp. *sibirica* in the Rocky Mountains of Colorado and Utah.

Site No.	Site Name	Population Counts or Estimates				
		1975	1977-78	1992	1997	2004
1	Hoosier Ridge	±100	186			507
2	Radical Hill		321		±120	337
3	Missouri Mine		12	40		(40) [†]
4	Gilbert Peak					
5	Kabell Ridge					± 300

[†] Interpolated from 1992.

dense *Acomastylis rossii*–*Deschampsia cespitosa* (Ross’ avens-tufted hairgrass) tundra, edges of *Dryas octopetala* (eightpetal mountain-avens) solifluction lobes, in early snowmelt courses, and dense *Carex rupestris* (curly sedge) tundra (Johnston 1977, 2004, Colorado Natural Heritage Program 2005b). Total live vegetation cover estimates (Daubenmire 1959, 1968) vary from about 60 percent to 150 percent (complete cover). In some places, medium gravel to coarse gravel (5 to 75 mm diameter, see USDA Natural Resources Conservation Service 1998) covers 20 to 30 percent of the ground.

There are a few rare plant associates, but most of the dominant species in Rocky Mountain *Armeria maritima* ssp. *sibirica* sites are common alpine plants (**Table 5**). However, the Hoosier Ridge locality has many other rare plants (**Table 6**). Microhabitat does not appear to limit the distribution of *A. maritima* ssp. *sibirica*. In the one site in Utah where ecological measurements were made, somewhat different associates were recorded (**Table 5**). This supports the idea that microhabitat may not be limiting on *A. maritima* ssp. *sibirica*.

Macrohabitat

The sites for *Armeria maritima* ssp. *sibirica* in Colorado and Utah range from 11,460 to 12,800 feet (3,490 to 3,900 m) in elevation, from west-northwest to northeast aspect, and 2 to 60 percent slope (**Table 1**). The three Colorado occurrences are in alpine sites (**Figure 8** and **Figure 9**). Different geological substrates underlie otherwise similar habitats for the three Colorado occurrences, so it is unlikely geology is limiting these populations. The Hoosier Ridge site (#1 in **Table 1**) could have calcareous soil, but the Radical Hill (#2 in **Table 1**) and Missouri Mine (#3 in **Table 1**) sites are unlikely to be calcareous. As far as is known, soils have not been mapped for the areas containing the Colorado occurrences of *A. maritima* ssp. *sibirica*.

Although calcareous soils are not necessary for *Armeria maritima* ssp. *sibirica*, *A. maritima* thrives in calcareous soils. The taxon “often occurs in edaphically peculiar situations: heavy-metal contaminated sites on natural outcrops or on deposits from industrial mining, serpentine bedrock, and salt marshes” (Coulaud et al. 1999). There is no indication that the soils in the Colorado and Utah occurrences are unusual. *Armeria maritima* appears to be less of a calciphile in more northern locations in Scotland (Woodell and Dale 1993).

Comparing Colorado habitats for *Armeria maritima* ssp. *sibirica* with its habitats on sea shores is probably not appropriate. Habitats for occurrences of *A. maritima* ssp. *sibirica* in Russia are reported as stony tundra near sea coasts and in high mountains of Arctic regions near the Siberian coast, and alpine meadows in Finland and the Ural Mountains (Soppe 2005, Lawrence 1947, Finnish Ministry of the Environment 2004). Habitats in southern Siberia, Mongolia, and northwest China are unknown. Habitats for disjunct *A. maritima* ssp. *sibirica* occurrences on the south shore of Hudson Bay in northern Ontario also occupy relatively stable portions of coastal dune complexes (Bakowsky 2000). *A. maritima* ssp. *sibirica* populations in the Canadian Arctic islands are also on sea shores and sand dunes, but sometimes on “compact tundra” on higher-elevation slopes with *Dryas octopetala*, one of the Colorado associates (Aiken et al. 2003).

In the Andes Mountains of Chile and Argentina, *Armeria maritima* (probably ssp. *sibirica*, see Raven 1963, Lefèbvre and Vekemans 1995) occurs in alpine cushion-plant communities near timberline (Nuñez et al. 1999), with dominant plant species that are unique to South America, not related to associated plants in the Colorado or Utah occurrences. Geology and soils are not reported. Other occurrences of *A. maritima* are found along the coastlines and in the Falkland Islands, Islas Malvinas (Baker 1959) – these are likely subspecies different from *A. maritima* ssp. *sibirica*.

Table 5. Plants associated with *Armeria maritima* ssp. *sibirica* in Colorado and Utah.

Species Name	Common Name ¹	CO	UT	Code ²
<u>Subshrubs</u>				
<i>Dryas octopetala</i>	alpine dryad	X		DROC
<i>Salix planifolia</i>	planeleaf willow		X	SAPL2
<u>Graminoids</u>				
<i>Carex nova</i>	new sedge		X	CANO3
<i>Carex rupestris</i>	curly sedge	X		CARU3
<i>Carex saxatilis</i>	russet sedge		X	CASA10
<i>Carex scirpoidea</i>	northern singlespike sedge		X	CASC10
<i>Deschampsia cespitosa</i>	tufted hairgrass	X	X	DECE
<i>Juncus triglumis</i>	threehulled rush		X	JUTR4
<i>Poa alpina</i>	alpine bluegrass	X		POAL2
<i>Trisetum spicatum</i>	spike trisetum	X		TRSP2
<u>Forbs</u>				
<i>Acomastylis rossii</i>	alpine avens	X		ACROT
<i>Anemone parviflora</i>	arctic anemone	X		ANPA
<i>Artemisia scopulorum</i>	alpine sagebrush	X		ARSC
<i>Bistorta bistortoides</i>	American bistort	X		BIB15
<i>Bistorta vivipara</i>	viviparous bistort	X	X	BIVI2
<i>Castilleja occidentalis</i>	western paintbrush	X		CAOC4
<i>Erigeron pinnatisectus</i>	pinnate fleabane	X		ERPI6
<i>Gentianopsis thermalis</i>	Rocky Mountain fringed gentian	X		GETH
<i>Papaver kluanense</i> *	alpine poppy	X		PAKL
<i>Pedicularis groenlandica</i>	elephant head		X	PEGR2
<i>Pedicularis parryi</i>	Parry lousewort	X		PEPA3
<i>Polemonium viscosum</i>	sky pilot	X		POVI
<i>Saussurea weberi</i> **	Weber's saw-wort	X		SAWE
<i>Silene acaulis</i>	moss campion		X	SIAC
<i>Smelowskia calycina</i>	alpine smelowskia	X		SMCA

¹Plant species names follow Weber and Wittmann (2001a, 2001b).

²USDA Natural Resources Conservation Service (2006).

*Species tracked by Colorado Natural Heritage Program (see **Table 6**).

**Sensitive Species (USDA Forest Service 2005b).

Occurrences of *Armeria maritima* ssp. *interior* (Athabasca thrift) are “on gravel pavements within areas of active sand dunes ... and in moist interdunal depressions” on the south shore of Lake Athabasca in northern Saskatchewan (Argus 1999). *Armeria maritima* ssp. *californica*, which occurs in California and southern Oregon, is a member of coastal shrubland communities. It sometimes is a halophyte (Coulaud et al. 1999, Calflora 2005). *Armeria maritima* ssp. *maritima* is considered a halophyte in most of its coastal European range (Cooper 1997), but some inland populations are just as salt-resistant and heavy-metal-resistant as the salt marsh and metal mine populations (Köhl 1997a, 1997b). It also occurs on a wide variety of rock types in

upland sites in the mountains of England and Scotland, (e.g., limestone, lead-zinc soils of old mine tailings, quartzite scree, limestone, and serpentine), some of which are calcareous and some are not (Hultén 1964, Proctor 1971, Woodell and Dale 1993).

In some salt marsh communities in central Europe, *Armeria maritima* was found to be colonized by the arbuscular mycorrhiza *Glomus* (Hildebrandt et al. 2001). Some scientists have reported that mycorrhizal colonization is one mechanism for increasing the tolerance of plants such as *A. maritima* to heavy metals and salt (Hall 2002). It is not known whether Colorado or Utah occurrences are colonized by mycorrhizae.

Table 6. Plants of concern known from the Hoosier Ridge area in Colorado.

Species Name*	Code ⁺	Common Name(s)	Rank [†]	Federal Status
<i>Aquilegia saximontana</i>	AQSA	Rocky Mountain columbine	G3 / S3	
<i>Askellia nana</i>	ASNA5	dwarf hawksbeard, dwarf alpine hawksbeard	G5 / S2	
<i>Aster alpinus</i> var. <i>vierhapperi</i>	ASALV	alpine aster, Vierhapper's aster	G5T5 / S1	
<i>Astragalus bodinii</i>	ASBO	Bodin milkvetch	G4 / S2	
<i>Astragalus molybdenus</i>	ASMO8	Leadville milkvetch	G3 / S2	
<i>Botrychium echo</i>	BOEC	reflected moonwort, reflected grapefern	G3 / S3	
<i>Botrychium minganense</i>	BOMI	Mingan's moonwort	G4 / S1	
<i>Botrychium simplex</i>	BOSI	least moonwort, little grapefern	G5 / S1	
<i>Braya humilis</i>	BRHU	alpine braya, low northern-rockcress	G5 / S2	
<i>Cystopteris montana</i>	CYMO3	mountain bladder fern	G5 / S1	
<i>Delphinium ramosum</i> var. <i>alpestre</i>	DERAA	Colorado larkspur	G2 / S2	
<i>Draba borealis</i>	DRBO	northern rockcress, boreal draba	G4 / S2	
<i>Draba crassa</i>	DRCR	thick-leaf whitlow-grass, thickleaf draba	G3 / S3	
<i>Draba exunguiculata</i>	DREX3	clawless draba	G2 / S2	USFS Sensitive
<i>Draba fladnizensis</i>	DRFL	arctic draba, Austrian draba	G4 / S2S3	
<i>Draba grayana</i>	DRGR3	Gray's Peak whitlow-grass, Gray's draba	G2 / S2	USFS Sensitive
<i>Draba oligosperma</i>	DROL	woods draba, fewseed draba	G5 / S2	
<i>Draba porsildii</i>	DRPO2	Porsild's whitlow-grass, Porsild's draba	G3G4 / S1	
<i>Draba streptobrachia</i>	DRST5	Colorado divide whitlow-grass, alpine tundra draba	G3 / S3	
<i>Eutrema penlandii</i>	EUPE10	Penland alpine fen mustard, Penland's eutrema	G1G2 / S1S2	Endangered
<i>Ipomopsis globularis</i>	IPGL	globe gilia, Hoosier Pass ipomopsis	G2 / S2	USFS Sensitive
<i>Oxytropis parryi</i>	OXPA2	Parry's crazy-weed, Parry's oxytrope	G5 / S1	
<i>Parnassia kotzebuei</i>	PAKO3	Kotzebue's grass-of-Parnassus	G4 / S2	USFS Sensitive
<i>Phippsia algida</i>	PHAL	snow grass, icegrass	G5 / S2	
<i>Physaria alpina</i>	PHAL10	Avery Peak twinpod	G2? / S2?	
<i>Ranunculus gelidus</i>	RAGE	tundra buttercup, ice cold buttercup	G4G5 / S2	USFS Sensitive
<i>Saussurea weberi</i>	SAWE	Weber saussurea, Weber's saw-wort	G2G3 / S2	
<i>Townsendia rothrockii</i>	TORO	Rothrock Townsend-daisy	G2 / S2	

* Plant names after Weber and Wittmann (2001a, 2001b).

+ Plant codes from USDA Natural Resources Conservation Service (2006).

† Ranks from Colorado Natural Heritage Program (2005a, 2005b).

Reproductive biology and autecology

Colorado occurrences. I have observed bees and flies on flowers in Colorado.

Phenology

In Colorado, the perfect flowers of *Armeria maritima* ssp. *sibirica* begin to open in early July, and reach full anthesis about the third week in July. Plants in the same occurrence apparently flower together, and not at all in some years. As far as I know, no one has studied pollen viability, seed viability, or germination in

In Britain, *Armeria maritima* ssp. *maritima* may flower for one to three weeks. "On maturity, each flower opens and is receptive to pollen for a single day," though several flowers in a head may be open on any given day (Woodell and Dale 1993). These observations were made on obligate outbreeding coastal populations. The seed bank in these self-incompatible



Figure 8. Habitat at one of two large Colorado occurrences, Hoosier Ridge (#1 in [Table 1](#)). Photograph by the author, July 26, 2004.



Figure 9. Habitat at the other large Colorado occurrence, Radical Hill (#2 in [Table 1](#)). Photograph by the author, July 27, 2004.

salt marsh populations is typically small (Ungar and Woodell 1996).

Genetics

Nothing is known about pollinators, pollen viability, seed production and viability, seed dispersal, or genetics of the Colorado and Utah populations. Even though the chromosome number is constant throughout *Armeria maritima* ($2n = 18$), the breeding system is highly variable, ranging from self-incompatible to autogamous. Pollen varies according to the breeding

system, with smaller pollen associated with autogamous populations (Vekemans et al. 1996). Polyploidy and apomixis are unknown in the genus *Armeria* (Nieto Feliner et al. 2004).

In the European portion of the *Armeria maritima* species complex, there are two morphological expressions of the supergene controlling pollen morphology: “one morph is heterozygous having ‘cob’ stigma ... and closely reticulate pollen; the other morph is homozygous with a papillate stigma and finely reticulate pollen” (Baker 1966, Vekemans et al.

1990, also see Lefèbvre 1970). This heteromorphism is an efficient method for ensuring self-incompatibility (Baker 1966, Aguilar et al. 1999a, Aguilar et al. 1999b). In the most ‘primitive’ situation, a population has both morphs in about equal abundance, “from which monomorphic populations are derived in response to pollinator-poor ... environments and/or establishment after long-distance dispersal.” Self-fertilization thus occurs in some metal-tolerant populations of *A. maritima* (Lefèbvre 1970, Lefèbvre and Mortimer 1984).

Armeria maritima ssp. *sibirica* plants are self-compatible, autogamous, and monomorphic (Baker 1959, 1966, Vekemans et al. 1990). The flowers of *A. maritima* ssp. *sibirica* are smaller and produce fewer pollen grains than other subspecies (Baker 1966). In northern Fennoscandia, “monomorphic [ssp. *sibirica*] and dimorphic [ssp. *maritima*] populations inhabit contrasted ecological situations: dimorphic populations are only found along the coast, while monomorphic populations are confined to tundra on calcareous mountains where pollinators are scarce” (Vekemans et al. 1990).

All New World *Armeria* are self-compatible and monomorphic, with a papillate stigma and coarsely reticulate pollen, except for a few populations in south Greenland (Baker 1959, Lefèbvre and Vekemans 1995). This self-compatibility makes it more likely that plants will become established after long-distance dispersal (Baker 1967). However, the coastal California plants (*A. maritima* ssp. *californica*) are partially dioecious and have some outcrossing ability, even though they remain self-compatible, and they have showier flowers (Baker 1966, Baker 1984). An extensive analysis of the results of crosses between *A. maritima* ssp. *californica* and several other taxa appear in Baker (1966).

In European populations of *Armeria maritima*, genetic variation within populations is high, and is positively correlated with the size of populations. Gene dispersal within populations is relatively high (Lefèbvre 1974, Weidema et al. 1996). The genetic makeup of Rocky Mountain populations of *A. maritima* ssp. *sibirica* is unknown, but if as hypothesized (see History section) these populations all are the result of ancient long-distance dispersal, then there may be few genetic connections among them. If this is true, genetic variability in Rocky Mountain populations may be low, although that has not been measured in Region 2 or in any other disjunct population.

Life history

Colorado populations appear to be monomorphic, with a papillate stigma (pollen morphology unknown), fitting the model described by Vekemans et al. (1990) for populations in pollinator-poor environments or those established after long-distance dispersal. The Colorado plants are apparently mostly self-compatible, with self-compatibility thought to have given the plants an ability to establish after an ancient dispersal event (Baker 1967). The degree to which Colorado plants outcross is not known.

Resistance to weather and grazing

Some populations and subspecies of *Armeria maritima* have been reported to be drought-tolerant and cold-hardy; the plants of some populations appear to be tolerant of calcareous soil or serpentine (Woodell and Dale 1993). In many situations, the plants are resistant to grazing by cattle, domestic sheep, and rabbits (Gillham 1955, Woodell and Dale 1993).

Demography

Little is known about the demography or life history of *Armeria maritima* ssp. *sibirica* in the Rocky Mountains. Although life history information is available for other taxa in the *A. maritima* complex, observations of other subspecies in distant localities are doubtfully appropriate to Rocky Mountain populations. **Figure 10** is a hypothetical life history of *Armeria maritima* ssp. *sibirica* in Colorado and Utah.

The lifespan of plants of *Armeria maritima* ssp. *interior* (disjunct in northern Saskatchewan) has been estimated at three to five years, with a generation time of “perhaps 2-3 yrs” (Argus 1999). The Hoosier Ridge population (#1 in **Table 1**) has been observed to have moved over a period of 26 years, with an overlap of less than 1 percent of the population (Johnston 2004). This suggests that the lifespan of *A. maritima* ssp. *sibirica* in Colorado is about the same as *A. maritima* ssp. *interior* or slightly longer, perhaps four to eight years.

Other than simple counts of plant numbers (**Table 4**), no demographic data have been collected that could be used in population or viability analyses. Seeds and seedlings have not been observed, although they must be present. It is not known whether smaller, non-flowering plants are young plants or plants that did not flower in a particular year for unknown reasons.

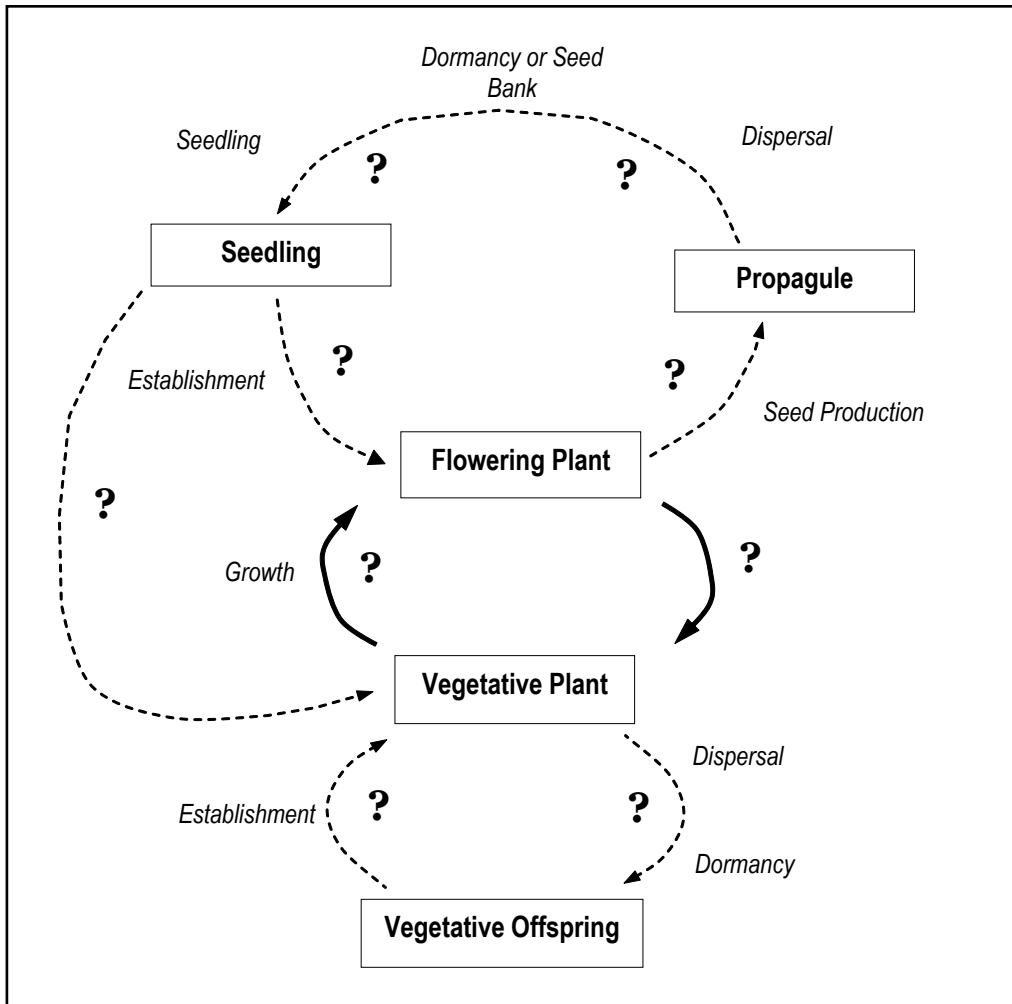


Figure 10. Hypothetical life history diagram of *Armeria maritima* ssp. *sibirica* in Colorado and Utah. Information available for this species is insufficient to create a more specific diagram. Dotted lines indicate uncertain phases of the life cycle. Rates of growth, dispersal, and seed production are unknown (shown by “?”). After Grime 2002 and Beatty et al. 2004.

The seed bank has not been studied anywhere in the distribution of *Armeria maritima* ssp. *sibirica*, so details of the seed bank are unknown for Colorado and Utah occurrences. Drawing inferences from studies of the seed bank of a different subspecies occupying coastal salt marshes (e.g., Ungar and Woodell 1996) may not be appropriate.

Armeria maritima ssp. *sibirica* has an inexplicably restricted distribution in Colorado and Utah, occurring on common habitat types but absent from most examples of these habitats. One explanation might be that few viable propagules are produced (possibly due to reduced pollen viability), and that those propagules disperse only a short distance and are short-lived. Germination may also be limited. However, the taxon has been reported as “amazingly amenable to cultivation” (Rocky Mountain Rare Plants 2005).

It is possible that after one or more of these populations became established in prehistoric times, the plants became restricted in pollen viability, seed production, seed viability, germinability, or dispersal (or all of these). The sites might be deficient in required nutrients or habitat elements, or the plants responded to the new environment by nearly shutting down reproduction. Then the probability of establishing new populations derived from these pioneers would be very small. If the regional conditions making the original pioneer long-distance dispersal possible have changed, then the probability of another long-distance dispersal event may also be very small (Weber 2003). Most or all of the known occurrences in Colorado and Utah may be derived from ancient long-distance dispersal, rather than dispersal within Region 2.

Community ecology

In the two largest Colorado occurrences (#1 and #2 in **Table 1**), plants are associated with mesic alpine tundra dominated by *Deschampsia cespitosa* and *Acomastylis rossii* communities that are relatively well-vegetated compared with other alpine sites (Johnston 1977). Associated plant species are for the most part common alpine plants, found together in thousands of other similar sites in the alpine of Colorado and elsewhere (**Table 5**). The Utah occurrences are also associated with plants common to the north slope of the Uinta Mountains (Brown personal communication 2005). The Hoosier Ridge occurrence (#1 in **Table 1**) contains more rare plants than most areas of the Rocky Mountains (**Table 6**).

There is nothing distinctive (that we have yet been able to discern) about the habitat of *Armeria* at these three sites, yet many people have searched in vain for *Armeria* in hundreds of similar alpine areas throughout Colorado and elsewhere. One possibility is that the plants in these populations of *Armeria* have very restricted dispersal capabilities, but the pollen is reportedly reticulate and the propagules (fruit and the persistent papery calyx) would be easily carried by wind or animals. It is also possible that few viable seeds are produced. However, no one has studied pollen, seed dispersal, or germinability at the Colorado or Utah sites.

Environmental factors limiting the species

From what we know about *Armeria maritima* ssp. *sibirica* in the Rocky Mountains, there are few factors limiting the germination or growth of individuals, or that might limit its distribution. Comparable information is also lacking for other portions of its distribution. Geological substrate, soil chemistry, and soil morphology all appear not to be critical or limiting.

From the distribution of *Armeria maritima* ssp. *sibirica*, the plants in Colorado apparently require a continuously cold climate, that in Colorado and Utah would occur only on north-facing slopes in the alpine zone. Some soil development is necessary, because the taxon is not found in the coldest high alpine (nival belt of Löve 1970). We can infer that the plants require full sun, for at least part of the day or part of the year (Baker 1959).

The effects of disturbance on plants of *Armeria maritima* ssp. *sibirica* are little known. The plants are

reportedly poorly palatable to herbivores (Johnston 1977, 2000, 2004, Brown personal communication 2005). The Hoosier Ridge occurrence apparently survived inadvertent clipping of a few plants by domestic sheep in the late 1970s, and one of the Utah populations is apparently thriving in an area experiencing moderately heavy grazing by domestic sheep (Brown personal communication 2005).

Apparently healthy plants of *Armeria maritima* ssp. *sibirica* occur in all-terrain vehicle tracks at the Hoosier Ridge site and on the edge of a road at the Radical Hill site. Plant density in these microsites is not apparently different from the undisturbed portions of the populations. From this we can infer that light occasional vehicle use might not be detrimental to the taxon. There is no evidence of trampling or soil compaction effects at any site, but there are no plants in the main part of the roadbed at Radical Hill, so moderate to heavy vehicle use or trail use is probably detrimental.

There are no reports or other evidence of diseases, predatory organisms, or mycorrhizae in *Armeria maritima* ssp. *sibirica* in Colorado or Utah or anywhere else in its range.

CONSERVATION

Use and Management of Armeria maritima ssp. *sibirica* Sites

The *Armeria maritima* ssp. *sibirica* occurrence on Hoosier Ridge (#1 in **Table 1**), is contained within the established Hoosier Ridge Research Natural Area. Rules governing the management and use of Research Natural Areas provide some protection for this occurrence, but vehicles have recently used this site. Motor vehicles and trail development are not permitted at Hoosier Ridge. There is a road leading from the summit of Hoosier Pass to a microwave tower at timberline on the White River side to the northwest of the site. This road is gated with a cable across it, with signs warning that the area is closed to motor vehicles. In spite of the signs, motorcycles and all-terrain vehicles sometimes skirt the cabled gate. I estimate that five or six vehicles per summer reach the *Armeria* site. There are also snowmobiles that go around the gate in the winter, but few reach the alpine because of rocks and vegetation blocking the route. I estimate that three to four snowmobiles reach the *Armeria* site each winter.

Quite a few hikers also access the Research Natural Area from Hoosier Pass. There are no established trails within the Research Natural Area, as

required by national policy. Most hikers trying to reach the top of Hoosier Ridge follow the county line (USFS boundary) along the skyline ridge, but a few probably cross the *Armeria* site each year because almost all the terrain is easy for a seasoned hiker.

About 100 yards east of the road gate, there is a sign (visible from the pass) notifying the public of the “Bemrose Ski Circus,” a circle route for cross-country skiers. This trail, managed by the Dillon Ranger District, goes through the trees below timberline into the head of Bemrose Creek to the northeast of the site. Few skiers likely get to the *Armeria* site, and skiers probably have little effect.

The Hoosier Ridge site has deep soils (for an alpine site), so it is sensitive to vehicle use. Vehicle use has had an apparent effect on soils within the site, increasing bare soil and rock cover. Light vehicle use has occurred after this area was established as a Research Natural Area. It is not known whether vehicle use has affected the *Armeria maritima* ssp. *sibirica* occurrence. Any type of motorized vehicle use is currently prohibited within the Research Natural Area.

Radical Hill

The Radical Hill site (#2 in **Table 1**) is close to a four-wheel-drive road, reachable over a choice of two very rough roads, five miles or more east of Breckenridge. These established routes are used regularly by four-wheel-drive vehicles in the summer and sometimes by snowmobiles in the winter (Connell personal communication 2000). The terrain is gentle and it would be easy to access the *Armeria* site from the road in summer or winter. The most recent documented visits by botanists to the site did not note any sign of off-road vehicle use in this area, but it is certainly possible. Part of the Radical Hill population is crossed by one of the four-wheel-drive roads. I have not observed any vehicle use off these roads in the vicinity of the *Armeria* occurrence, and such use is not allowed by USFS regulation.

There are no signs of any mining activity for at least several decades at the two largest *Armeria* sites on the White River National Forest or within adjacent areas.

Missouri Mine

This is a small site on the Pike National Forest, with a small occurrence of *Armeria maritima* ssp. *sibirica*. The occurrence is well away from any roads

or trails. There is no sign of past mining at this locality, but it is within 300 m of an old patented mine site, the Missouri Mine, that apparently has not been worked for 100 years or more.

The three *Armeria maritima* ssp. *sibirica* sites in Colorado have not been grazed by domestic livestock for at least 25 years, although there used to be sheep grazing in these alpine areas more than 30 years ago; all three areas are now closed to livestock grazing (USDA Forest Service 2002). About 20 years ago, the Pike National Forest side of Hoosier Ridge was part of a sheep grazing allotment. One year, the sheep were driven over the ridge to graze on the White River side and they grazed the flowering tops of the *Armeria* plants. There was apparently no damage to the population from the short period of time it was grazed; but we can infer that the plants are at least somewhat attractive to grazing domestic sheep. The plants are probably not palatable or attractive to cattle, because cattle rarely are attracted to pink flowers (personal observation).

Threats

Potential threats to *Armeria maritima* ssp. *sibirica* occurrences in Region 2 include off-road vehicle use, mineral exploration and development, climate change, and foot, horse, and mechanized travel. Of these, only off-road vehicle use is evident at the Colorado sites. The most important potential threats are off-road vehicle use and climate change, the former because it is evident at Colorado sites, and the latter because its effects are largely outside of the control of land and resource managers.

Off-road vehicle use

Off-road vehicle use is a potential threat to the Radical Hill population because vehicles could easily leave the roads that pass through the areas. Off-road vehicle use is prohibited by USFS regulations, although enforcement of these regulations is difficult on this remote stretch of road. There is no particular need for vehicles to leave the road in this area, because there are no obvious features or scenic views that would be better attained by leaving the road. This potential threat has not manifested itself at this location.

Several plants of *Armeria maritima* ssp. *sibirica* were seen on the fringes of the roadbeds within the Radical Hill population (personal observation). There is probably some damage to plants from regular use of these roads, but it is apparently minor, because plants in the roadbeds appeared healthy. As far as known, there

are no proposals to do reconstruction or maintenance of these roads or to build new ones in this area; doing so would probably be detrimental to the taxon.

The Hoosier Ridge occurrence of *Armeria maritima* ssp. *sibirica* shows evidence of use by vehicles, probably all-terrain vehicles, since the Research Natural Area was established (Johnston 2004). Vehicles are prohibited within the RNA and access is limited by barriers, but the barriers and enforcement are apparently not sufficient to prevent use. This represents a potential threat to this population, although the effects of vehicle use on plants of *A. maritima* ssp. *sibirica* have not been documented. The light use by hikers and snowmobiles this site receives is not currently a threat, because no evidence can be seen of these uses on the site.

Off-road vehicle use has been growing in recent years in the areas near the Colorado sites and rapidly approaches being out of control. The USFS has recognized unmanaged recreation use, including unmanaged off-road vehicle use, as one of the four threats to National Forest System lands (Bosworth 2003, USDA Forest Service 2006b).

Mineral exploration and development

Mineral entry is not allowed within the Hoosier Ridge Research Natural Area, which contains one entire occurrence of *Armeria maritima* ssp. *sibirica* (#1 in **Table 1**). The Hoosier Ridge Research Natural Area was established in 1995 in conjunction with a mineral withdrawal, but the USFS decision was immediately appealed and a lawsuit was brought against the USFS. In 1999, the court denied the litigants' claims and upheld the mineral withdrawal for the Research Natural Area.

The Radical Hill site (#2 in **Table 1**) is not protected from mineral exploration and entry (USDA Forest Service 2002). If mineral activity increases in the area where the taxon occurs, it could lead to increased ground disturbance, which would pose a threat to this occurrence and habitat. There is no indication of increased mineral-extraction activity in the area around the Radical Hill occurrence (**Table 1**, **Figure 9**) and none is planned as far as is known.

The Missouri Mine occurrence (#3 in **Table 1**) is near old mining activities mostly on private, patented land, but partly on the National Forest System land. Apparently the mining activity occurred in the 19th century and early 20th century. This area is not protected against mineral exploration and entry (USDA Forest Service 1983). If mineral activity increases in the

area where the taxon occurs, it could lead to increased ground disturbance, which would pose a threat to this occurrence and habitats. Mineral activity on private land is largely outside the control of the USFS.

Diseases and pests

No diseases or pests are known that might be predatory on or otherwise affect *Armeria maritima* ssp. *sibirica*, and no diseases or pests have been observed on plants of this taxon in Colorado or Utah. All plants observed by the author apparently have been healthy, although factors determining plant size and flowering are unknown. *Armeria maritima* ssp. *sibirica* sites are cold enough to exclude exotic plant species; usually none are seen in these sites.

Climate change and pollution

Most models of climate change indicate that under continued global warming, "some ecosystems that are already constrained by climate, such as alpine meadows in the Rocky Mountains, are likely to face extreme stress and disappear entirely in some places" (U.S. Department of State 2002). In these ecosystems, evapotranspiration is predicted to rise, climates will warm, and water will become less available to plants later in the growing season (Barnett et al. 2005). Because populations of *Armeria maritima* ssp. *sibirica* in the Rocky Mountains lack the ability to move to colder climates higher in elevation or latitude, they will be negatively impacted if such predictions are realized (Neilson et al. 2005).

Increases in inorganic nitrogen deposition have been detected in the Front Range of Colorado. There are noticeable effects on the alpine tundra, especially loss of litter under snow, leading to increased nitrogen retention in alpine tundra (Steltzer and Bowman 2005, Williams et al. 1998, Seastedt et al. 2004). This trend will likely continue and lead to declines in some alpine species; this may exacerbate the effects of global warming.

Foot, horse, and mechanized travel

There is light to very light use by people on foot, on horses, or on bicycles in the vicinity of the Colorado occurrences. Although these uses have had no discernable effects on *Armeria maritima* ssp. *sibirica* plants or their habitats, there are a lot of hikers and botanists that visit the sites, especially Hoosier Ridge; this may become a problem in the future. There is apparently very little foot travel at the Utah sites but

populations of *A. maritima* ssp. *sibirica* have a high degree of self-pollination and are often relatively uniform genetically and morphologically (Baker 1959, 1966, Lefèbvre 1970, Vekemans et al. 1990).

Effects of small population size

There are only three occurrences of *Armeria maritima* ssp. *sibirica* in Region 2, all of which are moderately small to small. Even though these occurrences appear to be stable, unforeseen changes in weather, patterns of use, or management could cause unexpected declines.

Conservation Status of *Armeria maritima* ssp. *sibirica* in Region 2

There are five known occurrences of *Armeria maritima* ssp. *sibirica* in the Rocky Mountains, three in Colorado and two in Utah, probably totaling fewer than 2,000 plants. In Region 2, there are three known occurrences of *A. maritima* ssp. *sibirica*, all in Colorado, containing fewer than 1,000 plants. *Armeria maritima* ssp. *sibirica* habitats and occurrences in Region 2 appear to be stable in quantity and quality at this time, but the small number of occurrences and individuals makes them especially vulnerable to accidents of land management, unforeseen diseases, or declines resulting from climate change.

The principal potential threats to *Armeria maritima* ssp. *sibirica* in Region 2 are unauthorized vehicle use and global warming. Only off-road vehicle use has become evident at the known occurrences. In the future, road and trail construction, road maintenance, or mineral exploration and development that might be planned without concern for this taxon and its habitats could pose a threat; none of these is planned as far as known. Increased foot travel through the known occurrences may also become a threat in the future.

The laws, regulations, and forest plan direction appropriate to *Armeria maritima* ssp. *sibirica* in Region 2 (USDA Forest Service 2002, 2005a) are sufficient to conserve this taxon against most threats, except the effects of global warming. However, enforcement will increasingly become a major challenge for this taxon and its habitats, as human populations and recreational demands continue to increase. We can expect there will be more unauthorized vehicle use in and around occurrences. The number of law enforcement personnel available on National Forest System lands continues to decline, and the number of situations to which they

must respond is increasing. Most of these have a higher priority than rare plant protection.

Although *Armeria maritima* and other species of *Armeria* are used in ornamental gardening in Russia and other cold countries (Soppe 2005), there is apparently little such use in the Rocky Mountain states. The author has seen *A. maritima* for sale in nurseries and garden shops; the plants were cultivars derived from one of the other subspecies, not ssp. *sibirica* (Bailey 1949). One local web site describes simple techniques for germinating *Armeria* from seed, apparently collected from the Hoosier Ridge populations of *A. maritima* ssp. *sibirica*, so there is some local interest in propagation of this taxon (Rocky Mountain Rare Plants 2005).

Management of *Armeria maritima* ssp. *sibirica* in Region 2

Management status

Armeria maritima ssp. *sibirica* is rated as sensitive in Region 2, and the Colorado Natural Heritage Program ranks it as G5T5/S1 (species and subspecies are “globally secure,” taxon is “critically imperiled” in the state). There are only three known occurrences of *A. maritima* ssp. *sibirica* in Region 2, all in Colorado, containing fewer than 1,000 plants. *Armeria maritima* ssp. *sibirica* habitats and populations in Region 2 appear stable in quantity and quality based on revisits of the known occurrences over a period of more than 25 years. Laws and regulations are adequate to conserve this taxon against most threats, except the effects of global warming. However, enforcement will be increasingly a major challenge for this taxon and its habitats. There are a few informal local efforts to propagate *A. maritima* ssp. *sibirica*, but the taxon is apparently not conserved in seed banks or by other conservation-storage means.

It is unknown how changes in the environment are affecting populations of *Armeria maritima* ssp. *sibirica* and their habitats on National Forest System lands in Region 2. These sites are no longer grazed by livestock, nor have they been grazed for more than 20 years. There is no residual evidence of significant effects by livestock grazing. Construction of the roads that now run through and adjacent to the Radical Hill population presumably destroyed a small part of the occurrence there, but the remainder of the occurrence has been stable over a span of more than 25 years. Vehicle use at the Radical Hill site apparently has never strayed from the roads. So far, effects have not been detected from the unauthorized

vehicle use at the Hoosier Ridge site, but monitoring has been limited. Although global warming is evident in the Rocky Mountains and is predicted to have significant effects on rare plants in the alpine zone, no effects on *A. maritima* ssp. *sibirica* and its habitats in Colorado have been detected to date. There is no evidence that current management of national forests in Region 2 is having any significant effect on *Armeria maritima* ssp. *sibirica* and its habitats.

Implications and potential conservation elements

All three occurrences of *Armeria maritima* ssp. *sibirica* in Region 2 are on National Forest System lands, so the responsibility for conserving this taxon in Region 2 lies with the USFS. Desired conditions of *A. maritima* ssp. *sibirica* in Region 2 include stable populations and stable, unmodified habitats. Avoidance of disturbance is critical, because plants of this taxon apparently depend on unmodified alpine tundra. Alpine tundra is difficult to revegetate or rehabilitate (Marr 1964, Brown et al. 1978, Johnson 1979).

Because there are few individuals and occurrences in Region 2, protecting known occurrences becomes critically important. The federal government is moving away from protecting species of local concern (such as *Armeria maritima* ssp. *sibirica*) and towards protecting species of global concern. If this trend continues, it could seriously impair the viability of *A. maritima* ssp. *sibirica* in Region 2. State and local regulations will become more important in the conservation of taxa such as *A. maritima* ssp. *sibirica*, and cooperation with states, counties, and municipalities will be indicated.

Tools and practices

A number of practices and tools would improve the conservation of *Armeria maritima* ssp. *sibirica* occurrences and habitats on National Forest System lands in Region 2:

- ❖ establish a seed bank for *A. maritima* ssp. *sibirica*
- ❖ propagate the taxon by seed and establish occurrences in other alpine sites
- ❖ protect known sites by Special Interest Botanical Area or other designations

- ❖ keep vehicles out of Hoosier Ridge Research Natural Area more effectively
- ❖ monitor plant numbers and health at all known sites (e.g., Elzinga et al. 1998)
- ❖ monitor vehicle use at all sites
- ❖ remind drivers to stay on the roads using off-site signing
- ❖ retain the taxon on the Regional Sensitive Species list.

As far as is known, no one has attempted any management practices specifically to improve or conserve *Armeria maritima* ssp. *sibirica*. There are no species conservation plans for this taxon.

Information Needs

A conservation plan for *Armeria maritima* ssp. *sibirica* would depend on careful management of vehicle use, especially at the Radical Hill site. It would also depend on management of mineral exploration and development at all known sites. Enforcement of forest plans and other local plans would be an important issue to discuss in developing a conservation plan for this taxon.

Information is lacking about pollinators, pollen viability, seed production and viability, seed dispersal, and genetics of the Colorado and Utah occurrences of *Armeria maritima* ssp. *sibirica*. Similarly, population dynamics, breeding structure of populations, germination, establishment, and detailed demography are all unknown and unstudied. Research studies of these topics would be helpful in developing a conservation plan for *A. maritima* ssp. *sibirica*, and productive for understanding the role of rare, disjunct species in alpine ecosystems.

The role of disturbance (both natural and human-caused), including vehicles and foot travel, in the ecology of *Armeria maritima* ssp. *sibirica* and its habitats, is largely unknown and unstudied.

Methods that might be used to restore *Armeria maritima* ssp. *sibirica* populations and habitat are largely unknown and unstudied. Restoration of alpine habitats had more attention in past decades (for example Marr 1964, 1979, Thilenius 1975, Brown et al. 1978).

DEFINITIONS

Acaulescent – “Without a stem, or the stem so short that the leaves are apparently all basal” (Harris and Harris 2001).

Acute – “Sharply pointed” (Hickey and King 2000).

Adnate – “United with a different part” (Hickey and King 2000).

Ascending – “Sloping or curving upwards” (Hickey and King 2000).

Autogamous – “Self-fertilized” (Harris and Harris 2001).

Biological Evaluation – “A documented Forest Service review of Forest Service actions in sufficient detail to: 1) comply with the requirements of the Endangered Species Act; 2) ensure that actions do not contribute to loss of viability of native or desired non-native plant or animal species, or cause a trend towards listing under the E[ndangered] S[pecies] A[ct]; and 3) provide a standard by which to ensure that endangered, threatened, proposed, and sensitive species and critical habitats receive full consideration in Forest Service decision-making” (USDA Forest Service 2005a, Section 2670.5).

Bract – “A reduced leaf or leaflike structure at the base of a flower or inflorescence” (Harris and Harris 2001).

Calcareous – “Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone” (American Heritage Dictionary 2000).

Calciphile – “A plant that prefers soils containing lime,” or alkaline soil (Hickey and King 2000).

Calyx – “The outer perianth, composed of free or united sepals” (Hickey and King 2000).

Cespitose (or caespitose) – “Growing in dense tufts” (Harris and Harris 2001).

Decumbent – “Reclining on the ground but with the tip ascending” (Harris and Harris 2001).

Dioecious – “Having male and female flowers on different plants of the same species” (Hickey and King 2000).

Disjunct – A species whose distribution in an area is widely separated from other parts of the distribution.

Edaphic – “Relating to the soil” (Hickey and King 2000).

Endemic – Restricted to a relatively small geographical area.

Globose – “Globe-shaped or spherical” (Harris and Harris 2001).

Halophyte – “A plant that grows in salty soil” (Harris and Harris 2001).

Herbaceous – A “flowering plant the aerial portion of whose stem is destitute of woody tissue” (Dayton 1950).

Heteromorphic – “Having two or more forms,” or morphs (Hickey and King 2000).

Heterozygous – “Having different alleles at one or more corresponding chromosomal loci” (American Heritage Dictionary 2000).

Homozygous – “Having the same alleles at a particular gene locus on homologous chromosomes (American Heritage Dictionary 2000).

Indehiscent – “Remaining closed at maturity” (Hickey and King 2000).

Inflorescence – “The flowering part of a plant; a flower cluster; the arrangement of the flowers on the flowering axis” (Harris and Harris 2001).

Involucre – “A whorl of bracts subtending a flower or flower cluster” (Harris and Harris 2001).

Linear – “Resembling a line; long and narrow with more or less parallel sides” (Harris and Harris 2001).

Monomorphic – “Having one or the same genotype, form, or structure” (American Heritage Dictionary 2000).

Morph – “One of various distinct forms of an organism or species” (American Heritage Dictionary 2000).

Morphology – “The science of form and structure” (Dayton 1950).

Mycorrhiza – “A symbiotic relationship between a fungus and the root of a plant” (Harris and Harris 2001).

Oblate – “Spheroidal and flattened at the poles” (Harris and Harris 2001).

Outcrossing – A condition when fertilization of one plant is due to the pollen of another plant.

Ovary – “The expanded basal portion of the pistil that contains the ovules” (Harris and Harris 2001).

Ovule – “A structure that, after fertilisation, develops into a seed” (Hickey and King 2000).

Papillate – “Beset with ... diminutive nipplelike or pimplelike protuberances” (Dayton 1950).

Perfect – A flower “with both male and female reproductive organs (stamens and pistil); bisexual” (Harris and Harris 2001).

Persistent – “Remaining attached ... after the function has been completed” (Harris and Harris 2001).

Petal – “An individual segment or member of the corolla, usually colored or white” (Harris and Harris 2001).

Propagule – “A structure, such as a seed or spore, that gives rise to a new plant” (Harris and Harris 2001).

Pubescent – Bearing hairs.

Radially – “Extending from a common centre” (Hickey and King 2000).

Reflexed – “Bent backward or downward” (Harris and Harris 2001).

Reticulate – “In the form of a network; net-veined” (Harris and Harris 2001).

Rosette – “A dense radiating cluster of leaves (or other organs), usually at or near ground level” (Harris and Harris 2001).

Scape – “A leafless ... main flower stalk, arising from the underground parts of a plant” (Dayton 1950).

Scapose – “With flowers born on a scape” (Harris and Harris 2001).

Scarious – “Thin, dry, and membranous in texture, not green” (Harris and Harris 2001).

Self-compatible – Describing a plant that is capable of fertilizing itself to produce viable seed. Many plants have some degree of self-compatibility.

Self-incompatible – Describing a plant that is not capable of fertilizing itself, or that fertilizing itself never produces viable seed.

Sensitive Species – In the Forest Service, “Those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by: a. Significant current or predicted downward trends in population numbers or density [or] b. Significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution” (USDA Forest Service 2005b).

Sepal – “A segment of the calyx” (Harris and Harris 2001).

Serpentine – “Loosely applied to minerals, rocks, soils, vegetation, and floras associated with ultramafic (ferromagnesian) substrates” (Kruckeberg 2002).

Sessile – “Attached directly, without a supporting stalk” (Harris and Harris 2001).

Spheroidal – “Almost spherical, but elliptical in cross section” (Harris and Harris 2001).

Stamen – “The male reproductive organ of a flower, consisting of an anther and filament” (Harris and Harris 2001).

Stigma – “The part (usually the tip and mostly sticky or hairy) of a pistil through which fertilization by the pollen grain is accomplished” (Dayton 1950).

Style – “The usually narrowed portion of the pistil connecting the stigma to the ovary” (Harris and Harris 2001).

Subtend – “To be below and close to, as a bract may *subtend* an inflorescence” (Harris and Harris 2001).

Supergene – A group of closely linked genes occupying a large chromosomal segment and frequently functioning as a genetic unit” (American Heritage Dictionary 2000).

Superior – “Attached above, as an ovary that is attached above the point of attachment of the other floral whorls” (Harris and Harris 2001).

Taxon (plural = taxa) – A unit in the taxonomic hierarchy, for example *Armeria maritima* ssp. *sibirica* is a taxon.

Tubular – “Cylindrical and hollow” (Hickey and King 2000).

Utricle – “A small, thin-walled, one-seeded, more or less bladderly-inflated fruit” (Harris and Harris 2001).

Vegetative – “Of or pertaining to the non-floral parts of the plant” (Harris and Harris 2001).

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APPENDIX

Plant Species Mentioned in the Text

Species Name*	Common Name	Code†
<i>Acomastylis rossii</i>	alpine avens	ACRO4
<i>Alchemilla alpina</i>	alpine lady's mantle, mountain lady's mantle	†
<i>Anemone parviflora</i>	Arctic anemone	ANPA
<i>Aquilegia coerulea</i>	Colorado columbine, blue columbine	AQCO
<i>Armeria maritima</i> ssp. <i>sibirica</i>	Siberian sea thrift, Arctic thrift, sea pink,	ARMAS
<i>Armeria labradorica</i>	Армерия арктическая (Arctic armeria), Армерия сибирская (Siberian armeria),	
<i>Armeria maritima</i> var. <i>labradorica</i>		
<i>Armeria maritima</i> ssp. <i>labradorica</i>		
<i>Armeria maritima</i> var. <i>sibirica</i>		
<i>Armeria scabra</i>		
<i>Armeria scabra</i> ssp. <i>labradorica</i>		
<i>Armeria scabra</i> ssp. <i>sibirica</i>		
<i>Armeria sibirica</i>		
<i>Armeria maritima</i> ssp. <i>interior</i>	Athabasca thrift	†
<i>Armeria maritima</i> ssp. <i>californica</i>	California seapink	ARMAC2
<i>Armeria maritima</i> ssp. <i>maritima</i>		†
<i>Artemisia scopulorum</i>	alpine sagebrush	ARSC
<i>Bistorta bistortoides</i>	American bistort	BIBI5
<i>Bistorta vivipara</i>	viviparous bistort	BIVI2
<i>Carex nova</i>	new sedge	CANO3
<i>Carex rupestris</i>	curly sedge	CARU3
<i>Carex saxatilis</i>	russet sedge	CASA10
<i>Carex scirpoidea</i>	northern singlespike sedge	CASC10
<i>Castilleja occidentalis</i>	western paintbrush	CAOC4
<i>Deschampsia cespitosa</i>	tufted hairgrass	DECE
<i>Dryas octopetala</i>	alpine dryad	DROC
<i>Erigeron pinnatisectus</i>	pinnate fleabane	ERPI6
<i>Festuca ovina</i>		†
<i>Gentianopsis thermalis</i>	Rocky Mountain fringed gentian	GETH
<i>Juncus triglumis</i>	threehulled rush	JUTR4
<i>Kobresia myosuroides</i>	kobresia, Bellardi bog sedge	KOMY
<i>Papaver kluanense</i>	alpine poppy	PAKL
<i>Pedicularis groenlandica</i>	elephant head	PEGR2
<i>Pedicularis parryi</i>	Parry lousewort	PEPA3
<i>Poa alpina</i>	Alpine bluegrass	POAL2
<i>Polemonium viscosum</i>	sky pilot	POVI
<i>Rhodiola rosea</i>	roseroot stonecrop	RHRO3
<i>Salix glauca</i>	grayleaf willow	SAGL
<i>Salix lanata</i>		†
<i>Salix planifolia</i>	planeleaf willow	SAPL2

APPENDIX (concluded).

Species Name *	Common Name	Code †
<i>Saussurea weberi</i>	Weber's saw-wort	SAWE
<i>Sibbaldia procumbens</i>	creeping sibbaldia, false-strawberry	SIPR
<i>Silene acaulis</i>	moss campion	SIAC
<i>Smelowskia calycina</i>	alpine smelowskia	SMCA
<i>Trisetum spicatum</i>	spike trisetum	TRSP2

* Following Weber and Wittmann 2001a, 2001b.

† Codes from USDA Natural Resources Conservation Service 2005; dagger in table indicates no entry in the database for this species because it only occurs outside the United States.

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