Eriophorum scheuchzeri Hoppe (white cottongrass): A Technical Conservation Assessment

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SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *ERIOPHORUM SCHEUCHZERI*

Status

The NatureServe Global rank for *Eriophorum scheuchzeri* (white cottongrass) is G5, which indicates that it is not vulnerable in most of its range, but it may be rare in parts of its range, particularly on the periphery. *Eriophorum scheuchzeri* is ranked critically imperiled (S1) by the Wyoming Natural Diversity Database, likely to be imperiled (S2?) by the Utah Conservation Data Center, and apparently secure (S4) by the Alaska Natural Heritage Program. The Montana Natural Heritage Program lists *E. scheuchzeri* as a plant species of potential concern. The Colorado Natural Heritage Program does not currently track or rank this species. In Canada, *E. scheuchzeri* is ranked critically imperiled (S1) by the Saskatchewan Conservation Data Centre, between critically imperiled and imperiled (S1S2) in Newfoundland, likely imperiled (S2?) in Manitoba, between imperiled and vulnerable (S2S3) in Ontario, vulnerable (S3) in Alberta, and apparently secure (S4) in British Columbia. It is not yet ranked (SNR) in Labrador, Northwest Territories, Nunavut, Quebec, and Yukon Territory. These ranks denote conservation status and have no regulatory authority. None of the USDA Forest Service (USFS) regions have designated *E. scheuchzeri* as a sensitive species. There are seven *E. scheuchzeri* occurrences known in Colorado and Wyoming, six in Region 2 and one in Region 4.

Primary Threats

Eriophorum scheuchzeri is an obligate wetland species with apparently restrictive microhabitat requirements. Therefore, activities and events that modify the hydrology of its habitat are especially detrimental. Habitat modification caused by recreation activities; urbanization; extraction of peat, minerals, oil, gas, and other natural resources; and livestock grazing is a primary threat to *E. scheuchzeri* throughout its range. Recreational use of habitat, ranging from foot traffic to off-road recreational vehicles including snowmobiles, may threaten some populations range-wide, including those on land managed by USFS Region 2. As the human population grows in areas within easy access to *E. scheuchzeri* habitat and as consequential recreational use of those areas increases, the impacts of recreation may become substantially more significant. While mineral and peat-mining activities may have impacted individual populations of *E. scheuchzeri* in the past, they are not currently perceived to be a significant threat to the known populations on land managed by USFS Region 2. Domestic livestock may have impacted the species and its habitat in some parts of its range, including that in Colorado and Wyoming. At the current time approximately half of the occurrences in Wyoming and Colorado are open to livestock grazing. Invasive weeds are not currently believed to be a concern at any of the known occurrence sites within Region 2 but may pose a threat in the future. Wet nitrogen deposition (acid rain) and air pollution are likely to change the composition of many alpine tundra communities. The specific consequences of pollution or changes in available nitrogen on *E. scheuchzeri* are unknown. Global warming is a potential threat to all species currently restricted to sub-alpine and alpine-tundra zones.

Primary Conservation Elements, Management Implications and Considerations

Eriophorum scheuchzeri is a circumboreal species with disjunct occurrences in the central and southern Rocky Mountains of North America, the alpine zones of the Alps in Central Europe, some mountain-tops in Asia, and on Mt. Daisetu in Hokkaiko, Japan. Even though *E. scheuchzeri* populations in North America are regarded as conspecific with those in Europe and Asia, the morphological variation among populations suggests that further examination of their genetic diversity is warranted. In the southern and central Rocky Mountains, *E. scheuchzeri* is an uncommon species growing at elevations above approximately 9,800 ft. (3,000 m) in relatively uncommon fen and bog communities that are vulnerable to modification. Maintenance of an appropriate hydrologic regime is critical to its survival. All seven *E. scheuchzeri* occurrences known in Colorado and Wyoming occur on National Forest System lands. Six of these occurrences are on land managed by USFS Region 2, and the remaining one is on land managed by USFS Region 4. Of the four occurrences in Colorado, two have been observed within the last decade. Of the three in Wyoming, one has been observed within the last decade, and one is likely to have been extirpated. *Eriophorum scheuchzeri* occurs in a wilderness area on the White River National Forest and also on the Shoshone National Forest, where it is afforded some protection from development activities. The status and population trends of *E. scheuchzeri* on National Forest System lands cannot be critically evaluated because there has been no occurrence monitoring and there are no detailed historical records. Designation of *E. scheuchzeri* as a USFS sensitive species would be a useful conservation tool for at least two reasons. Sensitive species designation requires that the taxon be reviewed during management planning. It also raises awareness of the species to botanists and ecologists and promotes the reporting of occurrences and the inclusion of *E. scheuchzeri* in research projects. Uncertainties associated with the identification of solitary-spikeleted Eriophorum specimens in Colorado need resolution. Specimens from approximately 24 occurrences reported to be *E. altaicum* var. *neogaeum* need to be examined in detail. Although *E. altaicum* var. *neogaeum* has been placed in synonymy with *E. chamissonis* in the 2002 edition of the Flora of North America, some specimens taken from known *E. altaicum* var. *neogaeum* occurrences in Colorado do not match the characteristics of *E. chamissonis* and may represent either *E. scheuchzeri*, another taxon (e.g., *E. altaicum*), or a hybrid.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). *Eriophorum scheuchzeri* (white cottongrass or Scheuchzer's cottongrass) is the focus of an assessment because it is a rare species within much of its range. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production. The broad nature of this report leads to some constraints on the specificity of information for particular locales. Also, completing the assessment promptly required the establishment of some limits concerning its geographic scope. This assessment addresses the biology and ecology of *E. scheuchzeri* throughout its range, within an emphasis on lands managed by USFS Region 2. Specific information for many locales, especially in Canada, Asia, and Europe, has not been reported. In many cases, such information either does not apply to Rocky Mountain occurrences, or it is unavailable.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, 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 information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, the assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope

This assessment examines the biology, ecology, conservation status, and management of *Eriophorum scheuchzeri* with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although the majority of the literature relevant to this species originates from field investigations outside the region, this document places that literature in the ecological and social context of the central Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *E. scheuchzeri* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis, but placed in a current context.

In producing the assessment, peer reviewed (refereed) literature, non-peer reviewed (non-refereed) publications, research reports, and data accumulated by resource management agencies were reviewed. Not all publications on *Eriophorum scheuchzeri* may have been referenced in the assessment, but an effort was made to consider all relevant documents. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed literature was used in the assessment when peer reviewed literature was unavailable. In some cases, non-refereed publications and reports should be regarded with greater skepticism. However, many non-refereed reports or publications on rare plants are reliable. Non-refereed publications on rare plants are often 'works-in-progress' or isolated observations on phenology or reproductive biology. For example, insufficient funding or manpower may have prevented work in subsequent years after the start of a project. One year of data is generally considered inadequate for publication in a refereed journal, but the initial report and data still provide a valuable contribution to the knowledge base of a rare plant species. Unpublished data (e.g., Natural Heritage Program and herbarium records) were important in estimating the geographic distribution and population sizes of this species. These data required special attention because of the diversity of persons and methods used in collection. Records that were associated with locations at which herbarium specimens had been collected at some point in time were weighted higher than observations only. Furthermore, completing the assessment promptly required that only current label information on herbarium specimens be analyzed, and no attempt was made to evaluate the accuracy of specimen identification.

Because there is relatively little information on *Eriophorum scheuchzeri* in the Rocky Mountains, observations on other *Eriophorum* species and on *E. scheuchzeri* in other geographic areas have been compared and related to the *E. scheuchzeri* occurrences in Region 2. However, for management planning purposes, it is unwise to rely solely on observations of potentially different ecotypes or of other species because their physiology, morphology, and ecology may be substantially different from one another (Grime et al. 1988).

Treatment of Uncertainty

Science is a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. The geologist T.C. Chamberlain (1897) recognized the difficulty in conducting critical experiments in geology and suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). Ecology is similar to geology in that experiments do not always produce clean results, and alternative approaches such as modeling, critical assessment of observations, inference, and good thinking are accepted approaches to understanding the natural world (Hillborn and Mangel 1997). Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

One element of uncertainty for this species lies in questions about the potential for mis-identification. In Wyoming, three *Eriophorum* species with solitary spikelets have been reported: *E. chamissonis*, *E. scheuchzeri*, and *E. callitrix*[1] (Dorn 2001). *Eriophorum chamissonis* and *E. scheuchzeri* are superficially very similar and may be mistaken for each other, especially if flowers are absent. In the most recent Colorado Floras, *E. altaicum* var. *neogaeum* is described as the only *Eriophorum* species with a solitary spikelet occurring in Colorado (Weber and Wittmann 2001a and 2001b). According to the most recent treatment of the *Eriophorum* genus, *E. altaicum* is a synonym of *E. scheuchzeri* (Ball and Wujek 2002). This must be clearly distinguished from *E. altaicum* var. *neogaeum*, which was placed in synonymy with *E. chamissonis* (Ball and Wujek 2002). Several specimens of *E. altaicum* var. *neogaeum* in the University of Colorado herbarium have since been annotated as *E. chamissonis*. However, *E. altaicum* var. *neogaeum* specimens have also been identified as *E. scheuchzeri*. It is clear that that the synonymy per se is not the source of uncertainty but that there is the potential for misidentification and mistakes when specimens at herbaria are automatically renamed without careful examination. Currently, there is a situation where there are *E. altaicum* var. *neogaeum* collections within Region 2 that do not have characteristics of *E. chamissonis* and might actually be *E. scheuchzeri* (Ladyman 2004). This dilemma could be resolved by careful review of herbarium material by a taxonomic expert in the genus *Eriophorum*.

Another element of uncertainty lies with inadequate information on the ecology and physiology of *Eriophorum scheuchzeri*. Where information for *E. scheuchzeri* is lacking, studies of other *Eriophorum* species have been referred to in this assessment in order to provide a baseline of information about the genus and to stimulate ideas for research specifically on *E. scheuchzeri*. However, it needs to be remembered that each *Eriophorum* species may have unique physiological characteristics and often occupies an ecological niche different to that of *E. scheuchzeri*.

Publication of Assessment on the World Wide Web

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (http://www.fs.fed.us/r2/projects/scp/assessments). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, Web publication facilitates revision of the assessments, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This assessment was reviewed through a process administered by the Society of Conservation Biology, 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.

[1]*Eriophorum callitrix* spelled *E. callithrix* in some early literature (Fernald 1905).

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Eriophorum scheuchzeri Hoppe is a rare member of the Cyperaceae, or Sedge Family. NatureServe and many state natural resource inventory programs use a system established by The Nature Conservancy to rank sensitive taxa at state, or subnational, (S) and global (G) levels on a scale of 1 to 5. A ranking of 1 indicates the most vulnerable and of 5 the most secure . These ranks carry no regulatory status. The NatureServe Global Heritage Status rank[2] for *E. scheuchzeri* is G5, which indicates that it is not vulnerable in most of its range although it may be rare in parts of its range, particularly on the periphery (NatureServe 2005). This rank was last reviewed in 1984 (NatureServe 2005). Typically there are considerably more than 100 occurrences and more than 10,000 individuals range-wide for a taxon to be ranked G5. Even though *E. scheuchzeri* has a globally secure ranking, it is rare and vulnerable to habitat loss in many parts of its range.

The Wyoming Natural Diversity Database (2005) ranks *Eriophorum scheuchzeri* critically imperiled (S1), and the Utah Conservation Data Center (NatureServe 2005) ranks it as likely to be imperiled (S2?). It is tracked by the Wyoming Natural Diversity Database (2005) but not by the Utah Conservation Data Center (Franklin personal communication 2005a). The Alaska Natural Heritage Program ranks it apparently secure (S4) (Lipkin personal communication 2003). It remains unranked and untracked by the Colorado Natural Heritage Program (2005). The Montana Natural Heritage Program (2005) regards *E. scheuchzeri* as a species of potential concern, but it remains unranked.

Eriophorum scheuchzeri occurs in the Intermountain (Region 4) and Rocky Mountain (Region 2) regions of the USFS. Currently, it not designated as a sensitive species by either region (USDA Forest Service 2003, Prendusi personal communication 2005, USDA Forest Service 2005).

The U.S. Fish and Wildlife Service designates *Eriophorum scheuchzeri* as an obligate wetland land species in all states in which it occurs in the United States (USDA Natural Resources Conservation Service 2005). An obligate wetland species "occurs almost always (estimated probability 99%) under natural conditions in wetlands" (USDA Natural Resources Conservation Service 2005).

In Canada, *Eriophorum scheuchzeri* is ranked critically imperiled (S1) by the Saskatchewan Conservation Data Centre (2004), between critically imperiled and imperiled (S1S2) in Newfoundland Island, likely imperiled (S2?) in Manitoba, between imperiled and vulnerable (S2S3) in Ontario, vulnerable (S3) in Alberta, and apparently secure (S4) in British Columbia (Manitoba Conservation Data Center 2005, NatureServe 2005). *Eriophorum scheuchzeri* was actively tracked by the Alberta Natural Heritage Information Center until 1998, when it was dropped from their active tracking list (Rintoul personal communication 2004). It is not yet ranked (SNR) in Labrador, Northwest Territories, Nunavut, Quebec, or Yukon Territory (NatureServe 2005).

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

No conservation strategies or management plans for *Eriophorum scheuchzeri* have been developed by any organization. Relatively few formal surveys have been conducted specifically for this taxon. Available reports and observations are usually incidental as part of surveys made for other projects. In addition, some location information associated with occurrences, especially on older herbarium labels, is sufficiently vague as to preclude knowing the precise location of the occurrence.

All of the *Eriophorum scheuchzeri* occurrences in Colorado, Wyoming, and Utah have been found on National Forest System lands (**Table 1**, **Table 2**). Therefore it appears that perpetuation of occurrences on National Forest System lands is critical to conservation of the taxon in these states. Within USFS Region 2, *E. scheuchzeri* occurrences have been reported on the Pike-San Isabel National Forest, the Gunnison National Forest, and the Rio Grande National Forest in Colorado and the Shoshone National Forest in Wyoming. Within USFS Region 4, it has been reported to occur on the Bridger-Teton National Forest in Wyoming and the Ashley and Wasatch-Cache national forests in the Uinta Mountains in Utah (Albee et al. 1988).

At the present time, two, and possibly three, occurrences within Region 2 appear to be relatively

[2]For definitions of ranking see Ranks in the **Definitions** section at the end of this document.

Table 1. Occurrences of *Eriophorum scheuchzeri* in Colorado and Wyoming.

State #	County	Management	Date observed	Locality	Habitat	Reproductive status and additional comments	Source of information[1]
CO 1	Park	Pike-San Isabel National Forest	20-Jul-00	In the Mosquito Range, on east slope of the Continental Divide. In the Horseshoe cirque area, off Forest Road 603 on north side, approximately 10 miles southeast of Leadville. Sub-occurrences distributed over three contiguous sections.	Alpine meadow in limestone cirques. Elevation 12,250-13,200 ft.	In flower and fruit.	*E.A. Holt #2443 with B. Madsen* RM.
CO 2	Eagle	Holy Cross Wilderness, White River National Forest	13-Aug-00	In the Sawatch Range, on west slope of Continental Divide. Along Fall Creek Trail 2001, between Lake Constantine and Lake Honky Dory, approximately 11 miles south of Minturn. Sub-occurrences distributed over three contiguous sections.	Above tree line in alpine meadow. Elevation 11,600-12,200 ft.	In flower and fruit.	*E.A. Holt #3865* RM.
CO 3	Gunnison	Gunnison National Forest	11-Aug-60	Rustler Gulch, a small alpine basin in the Elk Mountains. [Label details from UT specimen with same number reported from: Wet alpine basin above upper Tustlers Gulch, Gothic, 12,000 ft. alt.]	At the edge of the pool and over a large part of the bog.	In 1961, the year after the observation, "snow still covered the area in August and there was little chance before the first snowfall of the year that was likely in September" (Barrell 1969).	*J. Barrell #240-60* CS, UT; Barrell (1969). [A COLO specimen with the same collection number, but collected 18-Aug-1960, was later annotated *E. altaicum* var. *neogaeum* by W.A. Weber, 1983].
CO 4	San Juan	San Juan National Forest	21-Aug-55	Trail from South Mineral Campground to Ice Lake Basin, approximately 6 miles northwest of Silverton.	In sedge hammocks in pond in upper basin. Elevation 10,000-11,800 ft.	No information.	*W.A. Weber #9531 and J. Langenheim* UT [A COLO specimen with the same collection number was later annotated *E. altaicum* var. *neogaeum*].
WY 1	Fremont	Fitzpatrick Wilderness, Shoshone National Forest	17-Aug-1981, 13-Aug-1997	In Wind River Range. On Ink Wells Trail from Echo Lake to the intersection of Glacier Trail and Dinwoody Creek, approximately 17 miles south of Dubois. Sub occurrences in 3 sections separated by less than 10 km with intervening patches of apparently suitable habitat.	Lakeside and wet areas in pine spruce forest. Pine/spruce forest with wet areas and granite outcrops.	1981: Observed in fruit. 1997: Observed in fruit.	Wyoming Natural Diversity Database (2003); *D. Rosenthal #4001* 1997 RM.

Table 1 (concluded).

State #	County	Management	Date observed	Locality	Habitat	Reproductive status and additional comments	Source of information[1]
WY 2	Park	Shoshone National Forest	26-Jun-56	Timber Creek - approximately 2 miles southwest of the Timber Creek Ranger Station, Absaroka Range.	Alpine bog on level slope with organic soil.	In fruit. Reported as "scarce to rare" abundance. Also a remark was made that it had "low forage value"). CS* specimen annotated *E. altaicum* by W.A. Weber in 1991.Currently the area is an active cattle grazing allotment (Hicks personal communication 2005).	RM in Wyoming Natural Diversity Database (2003);. *R.K. Gierisch #1864* CS.
WY 2	Sublette	Bridger Wilderness, Bridger-Teton National Forest	22-Aug-1958	Titcomb Lakes, Fremont Peak area, north-central region of the Wind River Range.	Alpine wet meadows. Elevation 10,000-11,000 ft.	Annotated by A.E. Porsild 1960. Note: Fertig (1992) did not collect *E. scheuchzeri* during his extensive survey of the Wind River Range.	*C. Laing #s.n.* RM in Wyoming Natural Diversity Database (2003); Fertig (1992).

[1]Herbaria abbreviations (Holmgren and Holmgren 1998):

RM Rocky Mountain Herbarium at the University of Wyoming, Laramie, WY, USA.
UT Intermountain Herbarium at Utah State University, Logan, UT, USA.
COLO University of Colorado Herbarium, Boulder, CO, USA.
CS Colorado State University Herbarium, Fort Collins, CO, USA.

Table 2. Occurrences of *Eriophorum scheuchzeri* in Utah.

#	County	Management	Date observed	Locality	Habitat	Reproductive status and additional comments	Source of information[1]
1	Duchesne	Ashley National Forest	21-Aug-1967	Ottoson Basin, Uinta Mountains.	Subalpine meadow. Exposure south southwest. Slope 8 percent. Wet meadow. Elevation 11,500 ft.	Sheep grazing in area. Rare.	*J. Ludwig #940* UT
2	Duchesne	Ashley National Forest	10-Aug-1935	Kings Peak, Uinta Mountains.	No information	No information.	*Mr. Hess #s.n.* UT
3	Duchesne	Ashley National Forest	13-Aug-1960	Yellowstone Valley below Kings Peak.	Rather dry meadow. Elevation 12,000 ft.	Determined by L. Arnow.	*E.B.R. #s.n.* UT
4	Unreported	Ashley National Forest	Undated	Uinta Mountains.	Cold Bogs. Elevation 10,000 ft.	Determined by W.P. Cottam (no date or collector).	No collector or collection number UT
5	Duchesne	Ashley National Forest	30-Jul-1940	North end of Atwood Lake.	Dry hillside among rocks, willow-sedge association. Elevation 11,000 ft.	Identified by C.V. Morton.	*B.F. Harrison #10,088 and R.Liechty and N. Allen* UT

Table 2 (concluded).

#	County	Management	Date observed	Locality	Habitat	Reproductive status and additional comments	Source of information[1]
6	Duchesne	Ashley National Forest	24-Jul-1975	Above 1st Chain Lake in the Krebs Basin.	Subalpine meadow on drying shore of Island Lake.	No information.	*L.M. Shultz and J.S. Shultz #1760* UTC
7	Duchesne	Ashley National Forest	20-Aug-1996	Uinta Mountains, Uinta drainage, Gilbert Bench.	Alpine community, wet meadow.	Duplicate specimens: One specimen in fruit and one in flower.	*S. Goodrich, A. Huber, D. Prescott #25618* UTC
8	Summit	(Likely) Wasatch-Cache National Forest	04-Aug-1936	Uinta Mountains, Upper Henry's Forks Basin.	Wet sedge marshes, about lakes.	Common. In flower and fruit.	*B. Maguire, D.A. Hobson, R.R. Maguire #14332* UTC
9	Summit	(Likely) Wasatch-Cache National Forest	10-Aug-1936	Uinta Mountains, West Gunsight Pass, east Henry's Roaks [Forks] Basin.	About bog.	Abundant. In flower and fruit.	*B. Maguire, D.A. Hobson, R.R. Maguire #14568* UTC
10	Summit	(Likely) Wasatch-Cache National Forest	06-Aug-1936	Uinta Mountains, Shore Henry's Forks Lake.	No information.	In fruit.	*B. Maguire, D. H. Hobson, R.R. Maguire #14396* UTC
11	Summit	(Likely) Wasatch-Cache National Forest	25-Sept-1983	Uinta Mountains, large meadow east of South Burro Peak, between Bennion and Island lakes.	East facing slope. Soils derived from precambian quartzite; dominated by *Eriophorum* and *Carex aquatilis*; standing water.	In fruit.	*B. Neely and A. Carpenter #1911* UTC

[1]Herbaria abbreviations (Holmgren and Holmgren 1998):
UT Garrett Herbarium, University of Utah
UTC Intermountain Herbarium, Utah State University

secure because they are located on land management units designated as wilderness areas. Colorado occurrence 2 is in the Holy Cross Wilderness Area, Wyoming occurrence 1 is in the Fitzpatrick Wilderness Area, and Colorado occurrence 3 may be within the Maroon Bells Snowmass Wilderness Area (**Table 1**). In 1964, Congress passed the Wilderness Act (16 U.S.C. 1131-1136, 78 Stat. 890.) to protect pristine public lands by designating them as wilderness, where wilderness is defined in the law as "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions..." Although exceptions occur, the Wilderness Act prohibits commercial activities, motorized access, roads, bicycles, structures, and facilities within wilderness areas (Environmental Media Services 2001, USDI Bureau of Land Management and Office of the Solicitor 2001). USFS officials managing the wilderness area also have the discretion to limit the size of groups visiting it. Livestock grazing is permitted where it was customary prior to 1964.

Several *Eriophorum scheuchzeri* occurrences have been observed within national parks and preserves in Alaska, Canada, Europe, and the Russian Federation (**Table 3**, **Table 4**). By international standards, national parks are natural areas that have been set aside to

Table 3. Occurrences of *Eriophorum scheuchzeri* in national parks and reserves in North America (Information Center for the Environment 2004).

Country	Protected Area	Status of observation
USA	Aniakchak National Monument, Alaska.	Present.
USA	Bering Land Bridge National Preserve, Alaska.	Present.
USA	Gates of the Arctic National Park, Alaska.	Present.
USA	Katmai National Park and Preserve, Alaska.	Present.
USA	Noatak Biosphere Reserve, Alaska.	Present.
USA	Yukon-Charley Rivers National Preserve, Alaska.	Likely present.
USA	Bering Land Bridge National Preserve, Alaska.	Present (reported as var. *tenuifolium*).
USA	Denali Biosphere Reserve, Alaska.	Present (reported as var. *tenuifolium*).
USA	Katmai National Park and Preserve, Alaska.	Present (reported as var. *tenuifolium*).
USA	Kobuk Valley National Park, Alaska.	Present (reported as var. *tenuifolium*).
USA	Lake Clark National Park and Preserve, Alaska.	Present (reported as var. tenuifolium).
USA	Yukon-Charley Rivers National Preserve, Alaska.	Likely present (reported as var. *tenuifolium*).
Canada	Aulavik National Park, Northwest Territory.	Present.
Canada	Auyuittuq National Park.	Present.
Canada	Banff National Park.	Present.
Canada	Glacier National Park.	Present.
Canada	Jasper National Park.	Present.
Canada	Kluane National Park and Reserve.	Present.
Canada	Nahanni National Park Reserve.	Present.
Canada	Quttinirpaaq National Park Reserve, Ellesmere Island.	Present.
Canada	Sirmilik National Park, Bylot Island.	Present[1]
Canada	Tuktut Nogait National Park.	Present.
Canada	Ukkusiksalik National Park (proposed), Wager Bay.	Present.
Canada	Vuntut National Park.	Present.
Canada	Walker Bay Field Station.	Probably present.
Canada	Wapusk National Park.	Present.
Canada	Yoho National Park.	Present.

[1]Details on how this information was likely generated is in an "Overview of the ecological studies and monitoring conducted on Bylot Island by the Centre d'Études Nordiques" accessible online at: http://www.cen.ulaval.ca/bylot/intro.htm.

Table 4. Occurrences of *Eriophorum scheuchzeri* in national parks and reserves in Europe and Asia (Information Center for the Environment 2004).

Country	Protected Area	Status of observation	Abundance; known collection
Russia[1]	Baikalskiy Biosphere Reserve.	Present.	Common; museum specimen.
Russia	Barguzinskiy Biosphere Reserve.	Probably present.	Not reported.
Russia	Katunsky Biosphere Reserve.	Probably present.	Abundant; museum specimen.
Russia	Laplandskiy Biosphere Reserve.	Present.	Uncommon, with specimen in protected area.
Russia	Magadansky Zapovednik.	Present.	Common
Russia	Ostrov Vrangelya (Wrangel Island) Zapovednik.	Present.	Uncommon.
Russia	Pechoro-Ilychskiy Biosphere Reserve.	Probably present.	Not reported.
Russia	Taimyrsky Biosphere Reserve.	Present.	Abundant; museum specimen.
Russia	Tsentral'no-Sibirskiy Biosphere Reserve.	Present.	Uncommon, with specimen in protected area.
Germany[2]	Berchtesgaden Alps.	Present.	Uncommon, with specimen probably collected.
Sweden	Lake Torne Area.	Probably present.	Common.

[1]Russian Federation
[2]Federal Republic of Germany

protect and preserve the landscape features (Stadel et al. 1996, Eagles 2001). In many cases, the specifics of *E. scheuchzeri*'s abundance and current status are unknown. Apparently the taxon is not actively managed or singled out for protection in any area in which it occurs. In the United States and Canada, national parks are managed for their scenic or historical significance and are more geared to human recreation than are national forests or wilderness areas. Logging, mining, and other activities allowed in national forests are usually prohibited in these national parks (Canada National Parks Act 2000 c. 32, Environmental Media Services 2001, USDI Bureau of Land Management and Office of the Solicitor 2001). High recreation use in many national parks must often be balanced with the conservation of natural communities (Price et al. 1999). Depending upon the country, parks and preserves may be owned by private individuals or organizations and/or the state in Europe. Eighty-three percent of the Hohe Tauern National Park land on which *E. scheuchzeri* occurs in Austria is privately owned while the three Provincial Governments own 16 percent (International Union for Conservation of Nature and Natural Resources 2001). The current status of protection in the national parks in which *E. scheuchzeri* occurs in Russia is not clear because some of the parks may not have the infrastructure to accommodate and control its visitors (Travkina 2002). In addition, apparently insufficient regulation of the use of natural resources has led to the degradation of entire natural parks and sanctuaries in Russia (Yablokov 2001). Even though protections may be in place currently, some of the land in what are now national parks or reserves in China has also been severely degraded by overgrazing and other anthropogenic land use practices. Therefore, while the status of *E. scheuchzeri* populations in many national parks and preserves cannot be evaluated with the data available, they cannot be assumed to be uniformly secure.

Since *Eriophorum scheuchzeri* grows in wetlands, some occurrences may have received protection from development within the United States by the Section 404 regulatory program of the Clean Water Act (33 U.S.C. 1251 - 1376; Chapter 758; P.L. 845, June 30, 1948; 62 Stat. 1155; Comer et al. 2005). This program requires that a permit be obtained from the U.S. Army Corps of Engineers before any activity that moves even a small amount of earth into the "waters of the United States" is performed (U.S. Environmental Protection Agency 1977). Prior to 2001, a broad regulatory definition of "waters of the United States" was used that afforded federal protection for almost all of the nation's wetlands, including "isolated" wetlands and other intermittent waters (Legal Information Institute Undated). However, in 2001, the Supreme Court made the decision that Congress had not granted the U.S. Army Corps of Engineers jurisdictional Clean Water Act authority over "isolated" wetlands (Supreme Court of the United States 2001). A much narrower definition of what constitutes "waters of the United States" has been proposed. This new definition removes Clean

Water Act protection from "isolated" wetlands as well as non-navigable tributaries of traditionally navigable waters, intermittent and ephemeral streams, and waters that pass through human-made conveyances (Legal Information Institute Undated). Therefore, protection of many wetlands, and the species therein, will be subject only to individual state laws and local ordinances. It is possible that some *E. scheuchzeri* occurrences will be affected by the change in the interpretation of these provisions of the Clean Water Act since the current wetlands deemed as isolated may be extensive (Tiner et al. 2002).

Those *Eriophorum scheuchzeri* occurrences associated with substantial peat deposits in the United States, especially in the Rocky Mountains, may be protected in the future since peatlands may be placed within "Resource Category 1" of the U.S. Fish and Wildlife Service wetland mitigation policy (USDI Fish and Wildlife Service 1981). The criteria for habitat to be designated "Resource Category 1" is that the "habitat to be impacted is of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section" (USDI Fish and Wildlife Service 1993). Furthermore, "the mitigation goal for habitat in Resource Category 1 is no loss of existing habitat value" (USDI Fish and Wildlife Service 1993). Peatland formation is extremely slow in the Rocky Mountains, representing a unique and essentially irreplaceable resource (Cooper and MacDonald 2000, Chimner et al. 2002). Therefore, further development of peat mining, at least on land managed by federal agencies, is likely to be restricted (see Conservation Status of *Eriophorum scheuchzeri* in Region 2 section for further discussion).

Biology and Ecology

Classification and description

Systematics and synonymy

Eriophorum is a genus in the Cyperaceae, commonly known as the Sedge Family. There are approximately 25 species worldwide, and they typically grow in cool temperate, alpine, and Arctic regions of the Northern Hemisphere (Ball and Wujek 2002). Many species are found on the three continents of North America, Asia, and Europe. However, Ball and Wujek (2002) suggested that because there are differences in achene micromorphology and isozyme composition between some North American and Eurasian populations of certain species, the relationships between species on different continents should be investigated more thoroughly.

Eriophorum scheuchzeri was first described by David Heinrich Hoppe in 1800 (Hoppe 1800), and it has been maintained as a distinctive taxon since that time. However, the variation in morphology between different populations of single-spikelet *Eriophorum* plants across North America, Europe, and Asia has led to a wide range in interpretation of the material. The current taxonomic status of several occurrences of single-spikelet *Eriophorum* plants in the southern and central Rocky Mountains is uncertain.

Recently, Ball and Wujek (2002) placed the Asian taxon, *Eriophorum altaicum*, in synonymy with *E. scheuchzeri*. More than a century ago, *E. scheuchzeri* was observed to be similar to *E. altaicum*, but the two taxa were believed to have some constant morphological differences (Meinschausen 1900, Shishkin 1935). According to Meinschausen (1900), both *E. scheuchzeri* and *E. altaicum* have short anthers (0.5 to 1.0 mm), white bristles, long stolons, and fewer than seven basal glumes, but two specific characteristics separate the two species. The juvenile, immature, spikelet of *E. scheuchzeri* is spherical (globose) while that of *E. altaicum* is elongate, only becoming globose with age. The bristles of *E. scheuchzeri* are soft or pliant while those of *E. altaicum* are vertical or rigid. More recently, Novoselova (1994a) has maintained *E. altaicum* as an independent taxon in Asia, where it has been reported most frequently from northwest Russia. She has also tentatively referred the species described as *E. tolmatchevi* to *E. altaicum* var. *neogaeum* (Novoselova 1994a). Apparently height and robustness are also variable between *E. scheuchzeri* populations because these characteristics were used to differentiate a variety. *Eriophorum scheuchzeri* var. *tenuifolium* was described as being taller and more slender than variety scheuchzeri (Hultén 1968). Hultén (1968) suggested placing *E. altaicum* in synonymy with *E. scheuchzeri* var. *tenuifolium*. Ball and Wujek (2002) reported that, based on the North American specimens that they examined, *E. scheuchzeri* var. *tenuifolium* could not be differentiated.

In the treatment in the most recent Flora of North America (Ball and Wujek 2002), *Eriophorum altaicum* is a synonym of *E. scheuchzeri*, which they consider to be monotypic, whereas *E. altaicum* var. *neogaeum* is a synonym of *E. chamissonis*. Ball and Wujek (2002) also included *E. russeolum* within *E. chamissonis*.

Cayouette (2004) recently reviewed the taxonomy of the *Eriophorum russeolum*-*Eriophorum scheuchzeri* complex in North America, focusing on Canada and the eastern United States, and he interpreted the variation observed within this complex somewhat differently. His identification key includes characteristics of the medial fertile scales and achenes, which he argues are critical to differentiating between the various taxa (see **Appendix A** for the key Cayouette has developed). The *E. russeolum*-*E. scheuchzeri* material examined by Cayouette (2004) came from the Quebec-Labrador peninsula, Nunavut Territory, British Columbia, Manitoba, Ontario, Yukon, Northwest Territories, New Brunswick in Canada and Alaska, Minnesota, and Wisconsin in the United States. He also examined some specimens from the Rocky Mountains and realized that some were different from the boreal and arctic ones that he had examined (Cayouette personal communication 2006). Some of the material was closer to what the Russian specialist Novoselova (1994) calls *E. altaicum* (Cayouette personal communication 2006). Since insufficient Rocky Mountain material was available for an in-depth study, Cayouette (2004) limited his treatment to the *E. russeolum*-*E. scheuchzeri* complex as it occurred in Canada and the northeastern United States.

Cayouette (2004) concurred with the circumscription proposed by Novoselova (1993, 1994a) who followed Bondareva (1990) and subdivided *Eriophorum scheuchzeri* into two subspecies, subspecies *scheuchzeri* and subspecies *arcticum* (**Table 5**). *Eriophorum scheuchzeri* ssp. *scheuchzeri* is accepted as an arctic-alpine circumpolar taxon and covers both Arctic and Boreal zones in North America (Cayouette 2004). *Eriophorum scheuchzeri* ssp. *arcticum* apparently has a more restricted distribution in North America occurring principally in Arctic North America, but extending below the Arctic Circle in Alaska, Nunavut Territory, and Quebec. It also occurs in Greenland (Cayouette 2004). *Eriophorum scheuchzeri* ssp. *arcticum* has a wider distribution in Asia, and the type (apparently holotype) specimen is from Jenissejsk, in the Krasnoyarsk region of southern-central Russia (Novoselova 1994a). In addition to inter-continental differences, the morphological variation encountered between trans-continental *E. scheuchzeri* populations in central Asia has led Ali and Qaiser (2001) to suggest that the taxon is a candidate for more study in this area as well. Ali and Qaiser (2001) reported, without further explanation, that some plants collected within the extensive land mass from Yakutia (Sakha) above the Arctic Circle to as far south as Kirghisia (Kyrgyz Republic) have been named *E. scheuchzeri* ssp. *altaicum*, but they concluded that the status of subspecies *altaicum* in that region requires further study.

In current Central European literature (for example Hegi 1980, Wisskirchen and Haeupler 1998), synonyms for *Eriophorum scheuchzeri* are *E. capitatum* and *Scirpus leucocephalus*. An earlier flora by Hegi (1939) lists additional synonyms as *E. chamissonis* and *E. medium* (Kasperek personal communication 2005). This synonymy seems out of date (Kasperek personal communication 2005). However, the WSL (Swiss Federal Institute for Forest, Snow and Landscape Research) recognizes these as alternative names, and all occurrences of plants that have been identified with any of these three names have been listed under the name *E. scheuchzeri* in Switzerland (WSL 2005). However, rather than using the term "synonym" formally, it appears that they use it to mean "names under which specimens have been reported." According to the European Nature Information System (EUNIS 2004), *E. chamissonis* does not occur in the Alps, being restricted to Scandinavia and northern parts of the Russian Federation in Europe. In contrast to the United States Flora (Ball and Wujek 2002), the Flora Europea uses *E. russeolum* as the accepted name, and *E. chamissonis* is a synonym (Hegi 1980, Kasperek personal communication 2005).

However, the taxonomic positions of *Eriophorum russeolum* and *E. chamissonis* may still need to be fully resolved on a global basis. Novoselova (1993) restricted the range of *E. chamissonis* to North America (both western and eastern North America) and considered Russian material to be referable to *E. russeolum* ssp. *russeolum* or other species of the group. The investigation of Cayouette (2004) supports the concepts of Novoselova (1993, 1994a, 1994b). Based on Cayouette's examination of North American rhizomatous, solitary-spikelet *Eriophorum* specimens with orange-brown spikelets, it appears that *E. chamissonis* is present only in Alaska and British Columbia while *E. russeolum* ssp. *russeolum* occurs only in northeastern North America. Examination of material revealed that rhizomatous specimens with orange-brown spikelets in northeastern North America are highly variable and the variation includes typical and atypical *E. russeolum* ssp. *russeolum*, and also what is known in western Russia and northwestern Europe as *E.* x*medium*, the hybrid between *E. russeolum* ssp. *russeolum* and *E. scheuchzeri* ssp. *scheuchzeri* (Novoselova 1993, 1994a, Aiken et al. 1999). In addition to previously known taxa, Cayouette (2004) has also described a new nothosubspecies, *E.* x*medium* ssp. *album*, which occurs in northern Quebec and Nunavut. This taxon likely represents a hybrid between *E. russeolum* ssp. *leiocarpum* and

Table 5. Taxonomic notes on the three *Eriophorum* species with solitary spikelets that occur on National Forest System lands in USDA Forest Service Region 2. See Systematics and synonymy section for further discussion relevant to the taxonomy of *Eriophorum scheuchzeri*.

Binomial*	Synonym* according to Ball and Wujek (2002)	Additional taxonomic notes
Eriophorum scheuchzeri	---------	Two subspecies, ssp. *arcticum* and ssp. *scheuchzeri*, described by Cayouette (2004).
	E. altaicum	E. altaicum retained as unique taxon (Novoselova 1994a) and also accepted by ITIS (2005).
	E. scheuchzeri var. *tenuifolium*	Var. *tenuifolium* synonym of *E. scheuchzeri* (ITIS 2005). Hultén (1968) suggested placing var. *tenuifolium* in synonymy with *E. altaicum*.
	E. capitatum	None.
	E. leucocephalum	None.
	Scirpus leucocephalus	None.
Eriophorum chamissonis	-------------	Retained as a taxon distinct from *E. russeolum* (Cayouette 2004, Novoselova 1994a, ITIS 2005).
	E. altaicum var. *neogaeum*	Var. *neogaeum* accepted as unique taxon by ITIS (2005). Var. *neogaeum* referred to *E. tolmatchevi* (Novoselova 1994a).
	E. chamissonis var. *aquatilis*	None.
	E. rufescens	None.
	E. russeolum ssp. *rufescens*	Also synonym in ITIS (2005).
	E. russeolum ssp. *albidum*	Ssp. *albidum* retained as unique taxon by ITIS (2005); *E. chamissonis* var. *albidum* is synonym (ITIS 2005)
	E. russeolum ssp. *leucothrix*	None.
	E. russeolum var. *majus*	Var. *majus* is synonym of *E. russeolum* ssp. *russeolum* (Cayouette 2004).
Eriophorum callitrix	**None.**	**None.**

*Authorship:

E. chamissonis C.A. Meyer

E. chamissonis var. *albidum* (F. Nylander) Fernald

E. altaicum Meinshausen

E. callitrix Chamisso

E. chamissonis var. *aquatile* (Norman) Fernald

E. leucocephalum Boeck

E. rufescens Andersson

E. russeolum Fries ssp. *rufescens* (Andersson) Hylander

E. russeolum ssp. *albidum* F. Nylander

E. russeolum ssp. *leucothrix* (Blomgren) Hultén

E. russeolum var. *majus* Sommier

E. capitatum Host

E. scheuchzeri Hoppe

E. scheuchzeri var. *tenuifolium* Ohwi

Scirpus leucocephalus (Boeck.) T. Koyama

Eriophorum scheuchzeri ssp. *scheuchzeri* (Cayouette 2004). Interspecific hybridization is documented between several other *Eriophorum* taxa, including *E. angustifolium* x *E. chamissonis* and *E. angustifolium* x *E. vaginatum* (Kartesz 1994).

In summary, the taxonomic status of rhizomatous, solitary-headed *Eriophorum* taxa has been subject to various interpretations. The available literature on the subject suggests that further examination of more specimens by taxonomists may lead to different concepts of *E. scheuchzeri* being proposed in the future. Names, and synonyms, of the three *Eriophorum* taxa with solitary spikelets that have been reported to occur on land managed by USFS Region 2 are listed in **Table 5**. Authorships for the taxa are listed in the footnote to **Table 5**.

Taxonomic accuracy is very important in order to determine the rarity of a species and has a significant impact on the conservation value of individual occurrences. In Colorado, there are approximately 24 occurrences of a single-spikelet *Eriophorum* species that have been identified as *E. altaicum* var. *neogaeum* (Ladyman 2004). Potentially these may represent occurrences of *E. scheuchzeri*, some other taxon, or even a hybrid. Even if only a quarter of these occurrences turn out to be of *E. scheuchzeri*, the number of its occurrences in Colorado would double since there are only four currently known *E. scheuchzeri* occurrences (**Table 1**).

History of species

Species in the genus *Eriophorum* have been beset by multiple names, and the designation and revocation of synonyms seem the rule rather than the exception (Fernald 1905b, Shishkin 1935, Raymond 1954, Kartesz 1994). One of the principal causes of confusion is the similarity between many species and the range over which they occur. Raymond (1954) notes that most circumpolar species have been described in Asia, Europe, and North America under different names. In addition, many herbarium specimens have been repeatedly misidentified. This is probably because they resembled species that were described on another continent, but specimens with which they could be compared were not readily available.

Eriophorum scheuchzeri was first described from material collected from "Fuscher Tauern" in the Tyrol, Austria (Hoppe 1800). The holotype specimen was collected from this area (Hoppe 1800). The current location of the holotype specimen is uncertain, and it may be lost. The epithet "Scheuchzeri" was used to honor Johannes Jakob Scheuchzer (1684-1738), a scientist of diverse interests who published an important text on monocots in 1719 (Scheuchzer 1719, Hegi 1980). Meinschausen (1900) described *E. altaicum* from Dzhung, Alatau, which is a region bordering Xinjiang Province and Kazakstan south of the Altai Mountain range (Shishkin 1935). This area lies between Xinjiang Province in China and Mongolia (National Geographic Society 1999). To Russian botanists the specific epithet apparently, but erroneously, suggested that it came from the Altai region of west-central Russia (Shishkin 1935).

The lectotype of *Eriophorum altaicum* is in the New York Botanical Garden Herbarium (see **References** section for Internet address). This lectotype specimen was first identified as *E. chamissonis* var. *humile* and then annotated, apparently by N.L. Britton in the early 1900s, as *E. callitrix*. There are two specimens on the sheet, and the second specimen is identified as *E. chamissonis*, later annotated to *E. russeolum*. The origin of both specimens is less than clear. The specimen of *E. altaicum* is apparently from Sarchan in the Dzungar Alatau mountain range at the Eastern edge of the Altai Mountains on the border between southwestern Mongolia and Xinjiang province in China. This *Eriophorum* collection was widely distributed in Europe as well as North America (e.g., Kew Gardens in England and Paris, France), but apparently, just as the New York specimens, many herbaria received a mixture of several different species, which in some cases resulted in having two species on the same sheet (Raymond 1957).

Eriophorum scheuchzeri appears to have been found only relatively recently in the southern, central, and northern Rocky Mountains. It was reported from Alaska, Canada, and Europe in Britton's Flora published in 1901. This Flora reported that *E. scheuchzeri* was also found in Oregon. No record of an *Eriophorum* species with a solitary-spikelet is reported in the 1906 edition of the Flora of Colorado (Rydberg 1906). In 1964, Harrington reported three species of *Eriophorum* in Colorado, namely *E. gracilis*, *E. angustifolium*, and *E. chamissonis*. *Eriophorum chamissonis* was the only *Eriophorum* species with a solitary spikelet on each culm, and Harrington (1964) mentioned that only two specimens of this species existed at the time. In the most recent Colorado Floras by Weber and Wittmann (2001a and 2001b), *E. altaicum* var. *neogaeum* is described as the only *Eriophorum* species with a solitary spikelet occurring in Colorado. However, *E. scheuchzeri* does occur in this state and was reported to be part of the Colorado flora in 1955 (Weber 1955). The collection made by Weber (#*39531* UT) and Langenheim from San Juan County was likely to have been one of the first in Colorado. Penland's collection (#*1037* COLO), also from San Juan County, was earlier, in 1934, but its identity is uncertain. The original identification of this specimen was *E. gracile* Koch, which is also rare but has multiple spikelets per stem and is clearly distinguishable from *E. scheuchzeri*. In 1954, C.W.T. Penland revised his specimen's identity to *E. scheuchzeri* ("fide W.A. Weber 1954"). A further annotation in 1979 ("det. KMA") determined this specimen to be *E. altaicum* Meinsh. The specimen is now identified as *E. altaicum* var. *neogaeum* (University of Colorado Herbarium 2005).

Eriophorum scheuchzeri has been known from Wyoming since at least 1917 (Rydberg 1954). Few details of its occurrence in Montana are available (Dorn 1984, Lesica et al. 1984, Lesica and Shelly 1991, Hitchcock and Cronquist 2001), and it is not clear when it was first collected there. In Utah, collections from the Uinta Mountains apparently date from 1935 (**Table 2**).

Non-technical description

Eriophorum scheuchzeri is a perennial, grass-like plant with long-creeping rhizomes. The stems, or culms, are 5 to 70 cm (2 inches to 2.3 ft.) tall. The leaf blades are rolled and from 3 to 12 cm (1.2 to 4.7 inches) long. The leaf nearest the top of the stem is usually bladeless with a black tipped sheath. The flower head, which resembles a "cotton-ball" at maturity, is solitary on the stem apex (Ball and Wujek 2002).

Characteristics of the spikelet and structures wherein, particularly the scales, the anthers, the bristles, the stigmatic branches, and the achene (nutlet) are particularly important in distinguishing *Eriophorum scheuchzeri* (Cayouette 2004). In the Cyperaceae, the petals and calyx (perianth) of the flower are reduced to scales and bristles. The scales of *E. scheuchzeri* are of two types, depending upon their position in the flower. The medial ones are distinctively tapered toward the tip and are 0.3 to 1.6 mm (0.01 to 0.06 inches) wide at their mid-point (Cayouette 2004). The anthers of *E. scheuchzeri* are 0.35 to 1.0 mm (0.01 to 0.04 inches) long, the stigmatic branches are 0.3 to 1.5 mm (0.01 to 0.06 inches) long, and the white or whitish bristles are 1.0 to 2.5 cm (0.39 to 1 inch) long (Cayouette 2004). The achenes are approximately 0.5 to 0.85 mm (0.02 to 0.03 inches) wide, with either a glossy or dull surface and are colored a shade ranging from beige to darker reddish- or olive-pale brown (Cayouette 2004). The key proposed by Cayouette (2004) to identify the various rhizomatous *Eriophorum* taxa with solitary-spikelets that he examined in North America is reproduced in **Appendix A**.

During the initial flowering time, the hair-like bristles in the flowers are small and invisible from a distance but become a conspicuous silvery-white as the head matures. The fluffy bristles in the head account for the common names for *Eriophorum*, namely cottongrass, bog wool, cotton sedge, and Arctic Hare's foot sedge. Common names in other countries (e.g., wollgras in Germany and jonc à cotton in France) also refer to its woolly head. On the same theme, the Inuit name, pualunnguat, used in South Baffin means "imitation mittens" (Aiken et al. 1999).

The solitary spikelet on each stem differentiates *Eriophorum scheuchzeri* from the more common, sympatric species, *E. angustifolium*, which has multiple heads at the top of each stem. *Eriophorum callitrix*, another solitary-headed species that occurs in Wyoming, is very similar to *E. scheuchzeri* but lacks stolons or rhizomes. A line drawing and photograph of *E. scheuchzeri* are in **Figure 1** and **Figure 2** respectively.

References to technical descriptions, photographs, line drawings, and herbarium specimens

A technical description and line drawing of *Eriophorum scheuchzeri* are in Cronquist et al. (1977), Douglas et al. (2001), and Ball and Wujek (2002). A technical description, with colored photographs illustrating details of the morphology of spikelets, proximal and medial scales, and achenes is in Cayouette (2004). There are many other botanical texts that describe *E. scheuchzeri*. Floras specific to the southern and central Rocky Mountains that describe *E. scheuchzeri* include Britton (1901), Rydberg (1954), Dorn (1984, 2001), Scott (1995), and Welsh et al. (1993, 2003).

Descriptions of *Eriophorum scheuchzeri* are also in Fernald (1905a, 1950), Hegi (1980), Hitchcock et al. (1969), Hitchcock and Cronquist (2001), Hultén (1942, 1968), Huxley (1987), Klinkenberg (2004), Löve (1977), Ohwi (1965), Polunin (1940, 1959), Porsild (1951), Rasetti (1980), Scoggan (1950), Shishkin (1935), Tolmachev et al. (1996), and Wiggins and Thomas (1962). The texts of Löve, Huxley, and Klinkenberg also include line drawings of the taxon. This is not a complete list of books that describe this taxon, but these are a representative selection of some

Figure 1. Line drawing of *Eriophorum scheuchzeri*. Illustration by Robert H. Mohlenbrock (Courtesy Robert H. Mohlenbrock in USDA-NRCS PLANTS Database/USDA NRCS. 1992. Western wetland flora: Field office guide to plant species. USDA-NRCS West Region, Sacramento, California, USA).

Figure 2. Close-up photograph of the head of *Eriophorum scheuchzeri*. Photograph by Robert H. Mohlenbrock (Courtesy Robert H. Mohlenbrock in USDA-NRCS PLANTS Database/USDA NRCS. 1992. Western wetland flora: Field office guide to plant species. USDA-NRCS, West Region, Sacramento, CA).

of the publications available throughout its range. Some discrepancies between the descriptions in the different texts are likely due to local variations in morphology, hybridization, and also, in some instances, recognition of varieties or subspecies (Polunin 1940, Aiken et al. 1999; also see Systematics and synonymy section).

Distribution and abundance

Eriophorum scheuchzeri is a circumboreal species with disjunct occurrences in the southern and central Rocky Mountains in the United States, the alpine zones in the Alps, and the eastern Carpathians of central Europe (Ellenberg 1988, Ball and Wujek 2002, EUNIS 2004). *Eriophorum scheuchzeri* has been reported from Mt. Daisetu in Hokkaiko, Japan, where it was described as *E. scheuchzeri* var. *tenuifolium* (Ohwi 1965; see Systematics and synonymy section). In Asia, plants recorded from areas between Yakutia (Sakha) above the Arctic Circle to as far south as Kirghisia (Kyrgyz Republic) have been named *E. scheuchzeri* ssp. *altaicum* (Ali and Qaiser 2001). There are also some isolated records of *E. scheuchzeri* occurring in northern Pakistan and Kashmir (Ali and Qaiser 2001). However, Ali and Qaiser (2001) have indicated that the status of subspecies *altaicum* and the plants from disjunct locales in Pakistan, and presumably Kashmir, require further study.

In the 48 contiguous United States, *Eriophorum scheuchzeri* has been found in small, isolated locales in the high mountains of Montana, Utah, Colorado, and Wyoming (Cronquist et al. 1977, Dorn 1984, Dorn 2001, Hitchcock and Cronquist 2001). It has also been reported from Oregon (Britton 1901) and Washington (Ball and Wujek 2002). *Eriophorum scheuchzeri* is unlikely to occur in Oregon, and it is not recorded on the carefully researched Oregon vascular plant species checklist (Liston personal communication 2005, Oregon Vascular Plant Database 2005). No *E.*

scheuchzeri specimens from Washington could be found for this assessment to confirm the report of its occurrence in Washington (Burke Museum of Natural History and Culture 2004; see footnote in Table 6 for a list of additional herbaria checked for this report).

The pattern of its disjunct distribution suggests that *Eriophorum scheuchzeri* has survived in pockets of suitable habitat since the Pleistocene, or last "ice-age." Weber (2003) made a critical biogeographical review of the Middle Asian element in the southern Rocky Mountain flora. He concluded that the flora of the southern mountains, rather than being derived from, actually antedate those of the present-day Arctic and the Middle Asiatic. In addition, his deductions indicated that North American flora such as *Eriophorum* species were once distributed contiguously over a broad area involving connections between North America and Asia across the Arctic by way of Greenland, and that their present disjunctions are the products of extinction and attrition of ranges, not of any long-distance migration or dispersal mechanisms (Weber 2003).

Eriophorum scheuchzeri appears widespread but has highly variable abundance (see Systematics and synonymy section). In some parts of its range, for example around Lake Mitterberger, Tyrol, Austria (IBC 2005) and in Taymyr, Russia (Chernov and Matveyeva 1998), large and relatively homogenous stands have been observed. However, although it can be quite common and locally abundant in some parts of its range, especially in the Arctic, *E. scheuchzeri* appears to be usually less abundant than either *E. chamissonis* or *E. angustifolia* with which it is often sympatric (Forbes 2004). A specific example of this relative abundance is that, whereas *E. scheuchzeri* was mentioned as being present, *E. angustifolia* and two other sedge species made up 73 percent of standing biomass at a site in Alaska (Dennis et al. 1978). Within the confines of its wet habitat, it has been reported to be common in southeastern Yukon (Porsild 1951), British Columbia (Klinkenberg 2004), and Alberta (Alberta Natural Heritage Information Centre 2003) whereas in other parts of Canada it is rare (Saskatchewan Conservation Data Centre 2004). Outside of North America, it has been reported to be quite common in tarn habitats throughout Iceland (Wolseley 1979), northern parts of Scandinavian countries, and in northeastern Russia including the Kamtschatka peninsula (Koltzenburg personal communication 2002, Tolmachev et al. 1996). In certain parts of the Alps and the Eastern Carpathians in Europe, *E. scheuchzeri* is also quite common above the treeline (EUNIS 2004, Kasperek personal communication 2005). Its current or historic abundance and distribution in western China and southern Mongolia cannot be assessed with the information available. Perhaps significantly, it is not included in the national China Flora (Chien and Chun 1978). *Eriophorum scheuchzeri* is reported to be rare on Mt. Daisetu in Hokkaiko, Japan, and its status there is unknown (Ohwi 1965). The recent Flora of North America treatment considers *E. scheuchzeri* to range from Eurasia through Greenland, Canada, and southwards in the U.S. Rocky Mountains into Colorado (Ball and Wujek 2002). However, when evaluating global distribution and abundance, it is important to consider that it appears that more research is needed to determine if indeed the populations are actually conspecific across continents (Ball and Wujek 2002; see Systematics and synonymy section).

The distribution of *Eriophorum scheuchzeri* in North America is summarized in **Figure 3**. In the United States, it is most common in Alaska. Appropriately for a transcontinental species, *E. scheuchzeri* is reported from the Bering Land Bridge National Preserve, which is one of the most remote national park areas in the United States. Its abundance in this area is not reported, but it has been collected from this area as recently as 2003 (**Table 6**). Other areas in which it has been collected in Alaska are reported in **Table 6**. The tendency for collections to be spatially patchy and in clusters may reflect the species' actual distribution but may also reflect limited collecting activity and/or the accessibility of the terrain.

Eriophorum scheuchzeri is only infrequently encountered in the southern and central Rocky Mountains. It is known from three occurrences in Wyoming, one in each of Fremont, Park, and Sublette counties, and from four occurrences in Colorado, one in each of Eagle, Park, Gunnison, and San Juan counties, (**Table 1**). Six of these seven occurrences are on land managed by USFS Region 2. Two occurrences are on the Shoshone National Forest, and one on each of the Pike-San Isabel, the White River, the Gunnison, and the Rio Grande national forests (**Table 1**). The San Juan County occurrence in Colorado (Colorado occurrence 4 in **Table 1**) may have been that described by Heil and O'Kane (2004), but precise location information and details of its abundance were not reported. Therefore, there may be at least one additional *E. scheuchzeri* site in that county, which is not included in **Table 1**. Information on its abundance in Wyoming is unknown, but presumed to be low (Fertig 1998).

In USFS Region 4, one occurrence is on the Bridger-Teton National Forest, Wyoming. Also in

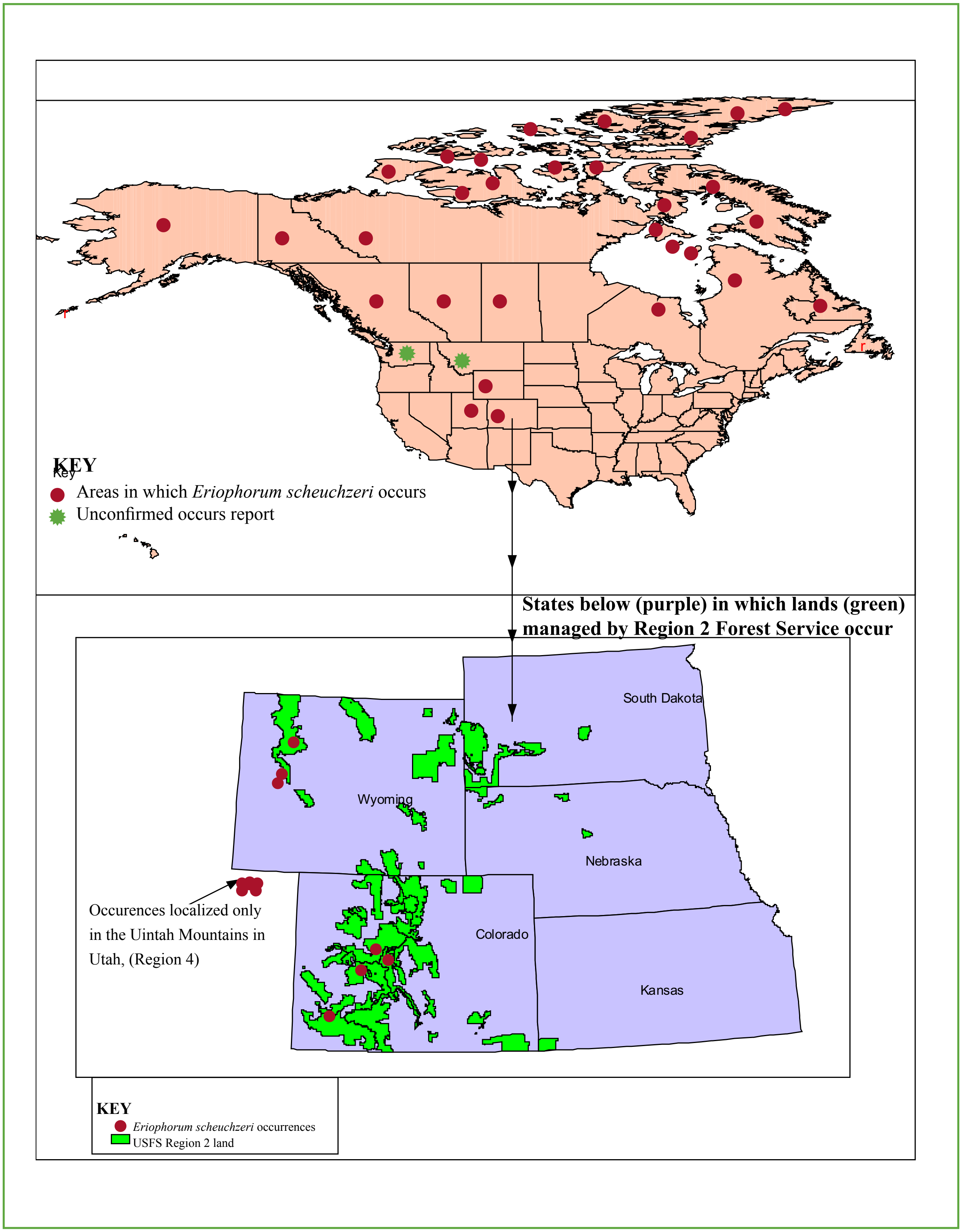

Figure 3. Distribution of *Eriophorum scheuchzeri* in North America (Data includes that from Aiken et al. 1999, Porsild and Cody 1980).

Table 6. Occurrences of *Eriophorum scheuchzeri* in Alaska[1].

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Shumagin Islands	Alaska Maritime National Wildlife Refuge	16-Jul-1995	Shumagin Islands, Simeonof Island.	Wet *Empetrum nigrum-Equisetum arvense* heath	*S.S. Talbot #198* ALA.
Aleutian Range	Aniakchak National Monument	18-Jul-1987, 21-Aug-1987	18-Jul-1987: Aleutian Range, Aniakchak Crater. 21-Aug-1987: Aleutian Range, Aniakchak Bay.	18-Jul-1987: Wet alluvium. 21-Aug-1987: Muddy river banks/stolen.	*K. Bosworth #136* 18- Jul-1987 ALA; *K. Bosworth #257* 21-Aug-1987 ALA.
Arctic Coastal Plain	Arctic National Wildlife Refuge	22-Jul-1970, 23-Jul-1970, 25-Jul-1972	22-Jul-1970: Arctic Coastal Plain, Beaufort Lagoon, Nuvagapak Pt. 23-Jul-1970: Arctic Coastal Plain, Raluk, Pingokraluk Lagoon. 1972: Beaufort Lagoon.	22-Jul-1970: Moist to wet gravel and sand.	*D. Murray #3194* 22-Jul-1970 ALA; *D. Murray #3210* 23-Jul-1970 ALA; *R.E. LeResche #s.n.* 1972 ALA.
Seward Peninsula	Bering Land Bridge National Park	24-Jun-1987, 06-Aug-2001, 08-Aug-2001, 05-Jul-2003	1987: Seward Peninsula Highlands, Serpentine Hot Springs. 06-Aug-2001 and 08-Aug-2001: Seward Peninsula, Cowpack Inlet 'Lagoon', N arm of Shishmaref Inlet, near Singeak (Sinik) shelter cabin and Kividlo (Qivaluaq) site. 2003: Seward Peninsula, Espenberg River, ca. 5 km inland from coast, vic. of channel between river and lagoon.	06-Aug-2001: wet meadows, above brackish zone. 08-Aug-2001: stabilized dunes and slacks, open herbaceous and *Empetrum* heath vegetation, growing in fresh water meadow. 2003: peaty mesotrophic marsh.	*S. Kelso #87-177* 1987 ALA; *C.L. Parker, R. Elven, and H. Solstad #11029* 6-Aug-2001 ALA, US NPS #BELA-00086; *C. Parker, R. Elven, and H. Solstad #11222* 8-Aug-2001 ALA, US NPS #BELA-00086; *C.L Parker, A .Batten, R. Elven, and H. Solstad #14437* 2003 US NPS #BELA-00090.
Seward Peninsula	No information	1936, 04-Jul-1951, 16-Jun-1954, 11-Aug-1966, 1980, 17-Jul-1984	1936: Nome, Seward Peninsula. 1951: Nome: West banks of Kukpowruk River; 10 miles from its mouth. 1954: Seward Peninsula Highlands, Dexter Road, Nome area. 1966: Seward Peninsula Highlands, Teller Road, <10 km east of Teller. 1980: Seward Peninsula, Cape Prince of Wales. 1984: Seward Peninsula, Kigluiak Mts., near Mt. Osborn, Crater Lake.	1966: With *Carex* spp. 1980: edge of road by old bridge, wet tundra.	*G.N. Jones #9000* 1936 WTU (2 specimens); *K.L. Chambers #099* 1951 WTU; *C.A. Heller #1070* 1954 ALA; *R. Pegau #85* 1966 ALA; *S. Kelso, J.W. Flock, and M.F. Colson #295* 1980 ALA; *E.F. Layser #3072* 1984 ALA.
Tanana Lowlands	Bonanza Creek Experimental Forest	28-Jul-1994	Tanana Lowlands, Bonanza Creek Experimental Forest, Stand LTER 0A	New exposed sand bar, first year of vegetation establishment, very open with scattered *Salix* seedlings, *Luzula*. *Eriophorum*, cover >1%, rare.	*L.A. Viereck #10413* ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Tanana Lowlands	No information	05-Jun-1964, 18-Jun-1964, 28-Jul-1965, 22-Jun-1972	05-Jun-1964: Tanana Lowlands, Tanana River near Shaw Creek Flats, Flood plain of the Tanana River. 18-Jun-1964. Tanana Lowlands, Tanana River, south of Fairbanks. 1965: Tanana Lowlands, Tanana River, below Nenana. 1972: Tanana Lowlands, Tanana Flats vicinity Salchaket Slough.	05-Jun-1964: recently exposed silt. 18-Jun-1964: Alluvium, early successional stage. 1965: fine river alluvium. 1972: riverbank.	*L.A. Viereck #7168* 5-Jun-1964 ALA; *L.A. Viereck #7199* 18-Jun-1964 ALA; *L.A. Viereck #7678* 1965 ALA; *D. Simpson #s.n.* 1972 ALA.
Sheshalik Spit	Cape Krusenstern National Monument	31-Jul-2001	Sheshalik Spit, northwest end, near Uhl summer camp.	Gravel beaches, inner lagoons, and old beach ridges, growing at wet margin of fresh water pond.	*C.L. Parker, R. Elven, and H. Solstad #10854* US NPS CAKR-00043.
Kodiak Archipelago	Chugach National Forest	20-Aug-1961, 13-Jul-1974, 13-Jul-1979, 19-Jul-1979	1961: Kenai Mts., Cooper Landing, Mile 49.5 Sterling Hwy, Quartz Cr. Forest Service. 1974: Chugach Mts., Cordova. 13-Jul-1979: Kodiak Archipelago, Afognak I., Danger City, mile 5.5 on road north of town. 19-Jul-1979: Prince William Sound, Whittier and vicinity.	1961: Wet roadside. 1974: Well lit marshes and other wet places. 13-Jul-1979: Bog, with sparganium, wet organic soil. 19-Jul-1979: Roadside.	*R. Clemson #s.n.* 1961 ALA; *B. Cumby #67* 1974 ALA; *J. Ver Hoef #97* 13-Jul-1979 ALA; *J. Jorgenson #W15* 19-Jul-1979 ALA.
Kodiak Archipelago	Chugach State Park	12-Jul-1984, 06-Aug-1985	1984: Eklutna Lake, margin of lake. 1985: Eklutna Lake, north end of lake.	1984: Muskeg with running water. 1985: Marshy clearing in poplar and birch forest.	*L.C. Marvin #1606* 1984 ALA; *L.C. Marvin #1952B* 1985 ALA.
Kodiak Archipelago	Fort Richardson Military Reservation	23-Aug-1994	Chugach Mts., North Campbell Creek Canyon-East Long Lake area, southeast margin of Long Lake.	Alpine, muddy lake margin.	*M. Duffy and J. Tande #1104* ALA.
Kodiak Archipelago	Kodiak National Wildlife Refuge	24-Jul-1990	Kodiak Island, Spiridon Pen, Chief Cove.	Margin of beaver dam.	*S.S. Talbot #88-X-8* ALA.
Kodiak Archipelago	No information	02-Aug-1978	Kodiak Archipelago, Ocean Bay, Sitkalidak Island.	Common.	*M.A. Hatch #502* (duplicate sheets) ALA.
Kodiak Archipelago	No information	24-Jul-1904, 27-Jul-1965, 30-Jul-1965	1904: Kodiak Island. 27-Jul-1965: Kodiak Island, Cape Chiniak, Cape Chiniak Road. 30-Jul-1965: Kodiak Island, Middle Bay.	27-Jul 1965: Bog. 30-Jul-1965: Bog transition.	*C.V. Piper #4493*1904 WTU; *B.J. Neiland #1365* 27-Jul-1965 ALA; *B.J. Neiland #1409* 30-Jul-1965 ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Chugach Mountains-Granite Range	Wrangell-St. Elias National Park and Preserve	21-Jul-1962, 16-Jul-1968, 04-Jul-1990, 28-Jul-1996a, 28-Jul-1996	1962: Twin Lakes, Nabesna Road, Mile 29 Nabesna Road, by Twin Lakes. 1968: Upper Skolai Valley. 1990: South side Granite Creek upstream from Jefferies Gulch. 1996a: Martin Creek upstream from major tributary coming in from south. 1996: East side Kiagna River.	1962: In stagnant pool. 1968: Bottomland along river. 1990: Small wetland near edge of alluvial fan built by small tributary. 1996a: In a few cm water on flooded silt bar of tributary stream. 1996: Wet sedge meadow on low terrace with small stream running through it, in muddy mineral soil near stream.	*M. Sharrock #s.n.* 1962 ALA; *R.W. Scott #2781* 1968 ALA; *A. Batten and M.H. Barker #96-361* 1990 ALA, US NPS #WRST-00104; *A. Batten and M.H. Barker #96-265* 28-Jul-1996a US NPS #WRST-00104; *A. Batten and M.H. Barker #96-231* 28-Jul-1996 US NPS #WRST-00104.
Chugach Mountains – Copper River	No information	02-Jul-1966, 16-Jul-1968, 08-Jul-1981	1966: Chitina, on west bank Copper River, above Fox Creek. 1968: Copper River Basin, Richardson Hwy. Sourdough Creek Campground. 1981: Chitina, Copper River bridge, Mile 35 Edgerton Hwy, Chitina River campground.	1966: Moist/dry habitat. 1968: Black spruce muskeg, with birch and willow. 1981: Sandy alluvium, shrub thickets and open.	*D.J. Riley #7* 1966 ALA; *S.L. Welsh and G. Moore #8258* 1968 ALA; *A.P. Khokhryakov, B.A. Yurtsev, and D. Murray #6098* 1981 ALA.
Alaska Range	Denali National Park and Preserve	19-Aug-1962, 23-Jul-2002	1962: Alaska Range, Botany Ridge, west of Mile 69 Park Road, Mile 68, Botany Ridge. 2002: Alaska Range, cirque above upper Coffee River.	1962: Tundra pond depression. 2002: In Enander sedge-cottongrass alpine wet meadow on, large-grained (gruss), light colored, saturated diorite alluvium.	*R. Richey #s.n.* 1962 ALA; *M. Duffy #MD02-113* 2002 ALA, US NPS #DENA-00521.
Alaska Range	Denali National Park	19-Aug-1954, 24-Jul-1956, 30-Jul-1956, 24-Aug-1963, 11-Aug-1964, 23-Jul-1998, 01-Jul-2000, 18-Aug-2000	1954: Mile 39 Denali Park Road, Sable Pass, just east of summit. 24-Jul-1956: Mt. Eielson (Copper Mtn), NW slope to summit. 30-Jul-1956: Wonder Lake. 1963: Mile 39 Denali Park Road, Sable Pass. 1964: Wonder Lake. 1998: Carlson Creek drainage, ridge between two forks of Carlson Creek, east of Muddy River. 01-Jul- 2000: Alaska Range, upper Swift Fork Kuskokwim River, floodplain on south side of river, 2.5 km S of VABM Swallow, 10 km N of Heart Mtn. 18-Aug-2000: Bench above confluence of Granite Cr. and Kahiltna Gl., pond on bench, W of Dutch Hills.	1963: Growing along stream.	*S.G. Smith #2577* 1954 ALA; *L.A. Viereck #1503* 24-Jul-1956 ALA; *L.A. Viereck #1625* 30-Jul-1956 ALA; *A. Murie #s.n.* 1963 ALA; *A. Murie #s.n.* 1964 AL; *A.C. Roland #3348* 1998 ALA, US NPS #DENA-00502; *C. Roland and C. Drake #4499* 1-Jul-2000 ALA, US NPS #DENA-00513; *C. Roland and A. Batten #4931* 18-Aug-2000 ALA, US NPS #DENA-00513.
Alaska Range	Denali National Preserve	17-Aug-2000	Alaska Range, Fourth of July Creek, valley between Yentna and Kichatna Rivers, beaver ponds in valley, 11 km west of Midway Lakes.	Scattered in wet area of floodplain.	*C. Roland and A. Batten #4865* ALA, US NPS #DENA-00513.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Alaska Range	Denali National Park	20-Jun-1967, 23-Jul-1967 28-Aug-1973	20-Jun-1967: Eagles Nest, Camp Denali. 23-Jul-1967: Camp Denali. 1973: Wickersham Dome Fire Research Area.	1967: No information. 1973: Bulldozed fireline, exposed mineral soil.	*S. Dickman #s.n.* 20-Jun-1967 WTU; *S. Dickman #s.n.* 23-Jul-WTU; *M.J. Foote #s.n.* 1973 ALA.
Alaska Range	Fort Greely Military Reservation	15-Jul-1998, 16-Jul-1998	15-Jul 1998: Alaska Range, Cannister Lake. 16-Jul-1998: Alaska Range, Granite Lakes.	15-Jul-1998: Nearly dry old lake bed, common on rocky organic muck, with *Carex* spp. 16-Jul-1998: Rocky lake margin, common on dry gravel, rocky organic muck, with *Carex* spp.	*M. Duffy # 8-181* 15- Jul-1998 ALA; *M. Duffy #98-218* 16-Jul-1998 ALA.
Yukon-Tanana Uplands	Fort Wainwright Military Reservation	30-Jun-1995, 17-Aug-1995	30-Jun-1995: Yukon-Tanana Uplands. South of Birch Hill Bluff. 17-Aug-1995: Tanana Lowlands, Wood River oxbow, west northwest of Wood River Buttes.	30-Jun-1995: Subarctic lowland wet sedge meadow, on mats of brown moss-fen peat over fluvial silt and gravel in permanently flooded depressions. 17-Aug-1995: Barren abandoned river channel, on nearly level moist seasonally flooded sand and silt.	*M. Duffy and J. Tande #95-430* 30-Jun-1995 ALA; *M. Duffy and J. Tande #95-939* 17-Aug-1995 ALA.
Yukon-Tanana Uplands	Steese National Conservation Area	06-Jul-1996	Yukon Fork of South Fork of Birch Creek headwaters, ridgetops and alpine slopes above headwaters.	Mica-schist bedrock with scattered marble outcrops, wet tussock tundra.	*C.L. Parker, A. Batten, and J. Herriges #6499* ALA.
Yukon-Tanana Uplands	Yukon-Charley Rivers National Park	02-Jul-2002, 22-Jul-2002	02-Jul-2002: Yukon-Tanana Uplands, bluff 2.2 km south of Coal Creek Camp. 22-Jul-2002: Yukon River valley, Eureka Creek, vicinity of pond 0.5 km E of mouth of Creek.	02-Jul-2002: South-facing bluff along road to Woodchopper, mesic areas and disturbed areas along road. 22-Jul-2002: Littoral zone of small shallow pond with well-established patches of Nuphar and wide ring of littoral vegetation.	*A. Larsen, B. Bennett, and M. Cook #02-1796* 02-Jul-2002 ALA, US NPS #YUCH-00184; *A. Larsen and A. Batten # 02-2302a* 22-Jul-2002 ALA, US NPS #YUCH-00184.
Yukon-Tanana Uplands	No information	15-Jul-1941	Yukon-Tanana Upland, Franklin, south Fork Fortymile River.	Wet riverbank.	*J.P. Anderson and G.W. Gasser #7293* ALA.
Yukon-Tanana Uplands	No information	27-Jun-1957, 09-Jul-1963, 18-Sep-1967	1957/1967: Yukon-Tanana Uplands, mile 100 & 101 Steese Highway. 1963: Yukon-Tanana Uplands, Belle Creek on Steese Highway.	1957: Roadside, wet ditch. 1963: Rodaside. 1967: Roadside ditch, moist habitat.	*S.G. Shetler #296-AF* 1957 ALA; *R.O. Stephenson #49* 1967 ALA; *D. Hatler #DH35* 1963 ALA.
Yukon-Tanana Uplands	No information	23-Jun-1956	Yukon-Tanana Uplands, Willow Creek on Elliott Highway.	Wet roadside.	*A.W. Johnson #3113* ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Brooks Range	Gates of the Arctic National Park and Preserve	25-Jul-1968, 25-Jun-1973, 23-Jul-1973, 20-Jul-2002 24-Jul-2002, 30-Jul-2002, 04-Aug-2002, 05-Aug-2002	1968: Unakserak River headwaters, Folly Lake. 25-Jun-1973: Nahtuk River, vicinity of confluence with Alatna River. 23-Jul-1973: Killik River Valley, Lake Kaniksrak. 20-Jul-2002: Endicott Mts., Chandler Lake, S shore. 24-Jul-2002: Killik River valley, vicinity mouth of Ivisak Creek on east bank of river. 30-Jul-2002: Arctic Foothills, Castle Mtn., northern ridge of summit area. 04-Aug-2002: Angayucham Mts., Fritts Mt., north-facing alpine cirque north of summit. 05-Aug-2002: At Igning River headwaters in broad north-northwest trending valley in Schwatka Mts.	1968: Rocky shore of lake, growing in water. 25-Jun-1973: Wet silt. 23-Jul-1973: Wet gravel of broad stream channels. 20-Jul-2002: Old beach ridges inland of active shoreline, emergent in depression behind old beach ridge. 24-Jul-2002: Semi-stabilized dunes, blowouts, moist sand and silt bars, growing on silt bars along river. 30-Jul-2002: Alpine dryas heath, cliffs, scree and meadows along drainages, growing in mud along creek margin. 04-Aug-2002: Snowbeds, screes and rocky heath, igneous substrate, growing in wet snowbed. 05-Aug-2002: Wet sedge meadows along stream.	*G. Staender and V. Staender #35* 1968 ALA; *D. Murray #3774A* Jun-1973 ALA; *D. Murray #4260* Jul-1973 ALA; *C.L. Parker, R. Elven, and H. Solstad #12156* 20-Jul-2002 ALA, US NPS #GAAR-00159; *C.L. Parker, B. Bennett, and N. Guldager #13035* 24-Jul-2002 ALA, US NPS #GAAR-00159; *C.L. Parker, R. Elven, B. Bennett, and N. Guldager #12892* 30-Jul-2002 ALA, US NPS #GAAR-00159; *C.L. Parker, R. Elven, and H. Solstad #13478* 04-Aug-2002 ALA, US NPS #GAAR-00159; *C.L. Parker and H. Solstad #13740* 05-Aug-2002 ALA, US NPS #GAAR-00159.
Brooks Range	No information	04-Aug-1973, 1979	1973: Imiaknikpak Lake, Killik River valley. 1979: Porcupine Lake.	1973: Pond margins. 1979: Sandy lake shores.	*D. Murray #4489, #4491* 1973 ALA; *K. Gustafson #s.n.* 1979 WTU.
St. Elias Mountains	Glacier Bay National Park and Preserve	10-Jul-1967	Goose Cove, Muir Inlet, Glacier Bay, top of knob-like hill.	Wet area in depression, poor drainage.	*F. Martin#148-67* ALA.
St. Elias Mountains	No information	20-Jul-2000	Takhin River valley, vicinity upstream of abandoned airstrip.	Floodplain, growing on moist silt bars.	*C.L. Parker, A. Batten, and D. Blank #9850* ALA.
Aleutian Range	Glacier Bay National Park	06-Aug-1954, 28-Jun-2003	1954: Aleutian Range, Broken Mtn., Valley of Ten Thousand Smokes, N slope. 2003: St. Elias Mtns., Lower Alsek R., 10 km SE of Novatak, E Brabazon, site 206.	1954: Pumicious sand. 2003: Margin of glacial lake, rare on saturated muddy soil in alder scrub on 0-5% slope, 100% vegetation cover.	*G.B. Schaller #s.n.* 1954 ALA; *M. Carlson and S.D. Gisler #03-108* 2003 ALA, US NPS #GLBA-00571.
Alaska Peninsula	Katmai National Park	24-Jul-1971, 17-Jul-2002	1971: Cold Bay. 2002: Alaska Peninsula, Mirror Lake, at ponds on northwest side of lake.	2002: Patchy, stoloniferous.	*M. Williams #2958* 1971 WTU; *A. Jansen, M. Carlson, and I. Pearse #02-197* 2002 US NPS #KATM-00305.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Kobuk River	Kobuk Valley National Park	24-Jul-1967, 20-Aug-1974, 26-Jun-2002	1967: Kobuk River Valley, Onion Portage. 1974: Kobuk River Lowlands, Great Kobuk Sand Dunes at Ahnewetut Creek. 2002: Kobuk River Valley, near Hunt River dunes.	1967: Wet tundra, organic soils, not forming tussocks. 1974: Wet sandy flats along creek. 2002: Wetlands complex within semi-stabilized dune complex, dominated by *Equisetum fluviatile* and *Carex utriculata*.	*C. Schweger #144* 1967 ALA; *C.H. Racine #833* 1974 ALA; *C.L. Parker, A. Batten, and S. Fowell #11561* 2002 US NPS #KOVA-00044.
Neacola Mountains	Lake Clark National Park and Preserve	11-Jun-1997	Neacola Mountains, North Upper Twin Lakes, north shore.	No information.	*P. Caswell #7993* ALA.
Neacola Mountains	Lake Clark National Park and Preserve	02-Jul-2001	Neacola Mts., Portage Lake, west shore.	Along Portage L. outlet stream, alone in water.	*P. Caswell and E. Laeger #01-235* US NPS #LACL-00119.
Upper Epizetka River valley	National Petroleum Reserve-Alaska	21-Aug-1980, 19-Aug-1984	1980: Kokolik Fire, upper Epizetka River valley. 1984: Arctic Coastal Plain, Icy Cape.	1980: Rolling *Eriophorum* tussock tundra with occasional thaw lakes and small streams, lightly burned wet meadow dominated by sedges, scattered *Salix planifolia* ssp. *pulchra*, abundant in plots, area burned in 1977. 1984: Sandy beach.	*L.A. Viereck # 0413* 1980 ALA; *S. Keller #1253* 1984 ALA.
Kuskokwim River valley	Noatak National Park	08-Jul-2001, 12-Jul-2001, 21-Jul-2003	08-Jul-2001: Middle Kugururok River valley, 12 km north of Lake Kaiyak. 12-Jul-2001: Anisak River valley, central area, northwest of Avingyak Hill. 2003: Central Noatak River valley, mouth of Porgo Creek, south side of river.	08-Jul-2001: Active river floodplain, medium-aged poplar stand and active sand-gravel bar, growing in wet sand-silt depression on bar. 12-Jul-2001: Gravel river floodplain, growing in wet silt. 2003: Sand-gravel bars and willow thickets on floodplain.	*C.L. Parker and C.R. Meyers #10598* 8-Jul-2001 ALA, US NPS #NOAT-00078; *C.L. Parker and C.R. Meyers #10729* 12-Jul-2001 ALA, US NPS #NOAT-00078; *C.L. Parker, R. Elven, and H. Solstad #14993* 2003 ALA, US NPS #NOAT-00084.
Kuskokwim River valley	No information	21-Aug-1949	Kuskokwim River valley, McGrath area.	In dried muskeg.	*W.H. Drury, Jr. #3122* ALA.
Selawik River valley	Selawik National Wildlife Refuge	29-Jul-1992	Selawik River valley, Nuteargowik River drainage.	Mesic sedge-grass herbaceous, 4-yr-old burned black spruce stand.	*M.J. Foote #5099* ALA.
Center Interior	Tetlin National Wildlife Refuge	07-Jul-1968	Deadman Lake, Mile 1249 Alaska Highway.	Black spruce muskeg.	*S.L. Welsh and G. Moore #7974* ALA.
Coast Mountains	Tongass National Forest	28-Jun-1962, 27-Jul-1993	1962: Auke Bay, near Mile 14 Glacier Hwy. 1993: Coast Mts., Goat Lake, 7 miles northeast of Skagway, mountain on E side of lake.	1993: West-facing slope, rock faces with pockets of vegetation.	*B.J. Neiland #579* 1962 ALA; *M.C. Stensvold #6016* 1993 ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Chikuminuk Lake	Wood-Tikchik State Park	15-Aug-1989, 04-Jul-1990	1989: Chikuminuk Lake, Mill Creek mouth vicinity. 1990: Nishlik Lake, S of E end of Lake.	No information.	*P. Caswell #s.n.* 1989 ALA; *P. Caswell #s.n.* 1990 ALA.
Yukon-Kuskokwim Delta	Yukon Delta National Wildlife Refuge	07-Jul-1921, 05-Jul-1928, 13-Aug-1963, 12-Jun-1979, 13-Jun-1980, Jun-1981, 24-Jul-1986	1921: Nunivak Island. 1928: Yukon-Kuskokwim Delta, Pastolik. 1963: Yukon-Kuskokwim Delta, Bethel. 1979: Yukon-Kuskokwim Delta, Newtok, Kealavik River north of Nelson I. 1980 and 1981: Nyac vicinity in Kilbuck-Kuskokwim Mts. 1986: Nunivak Island, Mekoryuk.	1928: Wet boggy tundra, with *Carex, Ledum*. 1979: Marsh. 1980: Silty soil beside road. 1981: Wet depression in low shrublands. 1986: Mekoryuk Road shoulders; sandy, wet soil.	*L.J. Palmer #182C* 1921 ALA; *W.B. Miller #77-C* 1928 ALA; *J.G. King #16* 1963 ALA; J.*D. Durst #27* 1980 ALA; *C. Rutherford #s.n.* 1981 ALA; *R.A. Sattler #96* 1986 ALA.
Nulato Hills	No information	15-Jul-1997, 02-Jul-1998	1997: Nulato Hills, near Debauch Mtn., ridges and bowls 2 km southeast of summit. 1998, two collections (a) and (b): Nulato Hills, North Fork Unalakleet River, lower portion of river.	1997: Wet sedge fen in alpine saddle. 1998a: Active river gravel bar, growing in wet silt. 1998b: Active river floodplain, growing in moist sand along river, meadow at edge of poplar-willow woodland.	*C.L. Parker, A. Batten, and J. Cole #7488* 1997 ALA; *C.L. Parker and R. Lipkin #7968* 1998a ALA; *C.L. Parker, A. Batten, and C. Roland #7993* 1998b ALA.
Prince William Sound	No information	01-Jan-1987 – 31-Dec-1987	Culross Island, Culross Bay area	Lake margin.	*N.R. Lethcoe #s.n.* ALA.
Afognak Island	No information	19-Jul-1991, 25-Jul-1992	1991: Afognak Island, Kazakof (Danger) Bay, east shore, vicinity of logging camp. 1992: Afognak Island, Paramanof Mountain.	1991: Wet roadside waste areas. 1992: Wet alpine seepage meadows and streamsides.	*C.L. Parker #2884* 1991 ALA; *C.L. Parker #3880* 1992 ALA.
Sparrevohn	US Air Force	27-Jun-1999, 28-Jun-1999	27-Jun-1999: Sparrevohn Long Range Radar Station (LRRS) Air Force Station and vicinity, road to Hook Creek. 28-Jun-1999: Sparrevohn LRRS Air Force Station and vicinity, along airstrip.	27-Jun-1999: Drainage ditch along road, common. 28-Jun-1999: Wet, rocky roadside.	*C.L. Parker, A. Batten, C.R. Meyers, and M.K. Raynolds #8674* 27-Jun-1999 ALA; *C.L. Parker, A. Batten, C.R. Meyers and M.K. Raynolds #8705* 28-Jun-1999 ALA.
Aialik Bay	No information	13-Jul-1979	Aialik Bay, Pederson Lagoon, Addison Creek.	Moist area along creek.	*B. Day and A. Hoover #44* ALA.
Alaska Peninsula	No information	15-Jun-2003	Iliamna Lake, northwest shore, 5 km north northeast of Grants Lagoon.	Ancient dunes vegetated with graminoid meadows, heath, and scattered tall shrubs, growing in wet lake margin.	*C.L. Parker #14169* ALA.
Alaska Peninsula	Alaska Peninsula	07-Aug-1952	Alaska Peninsula, Newhalen.	No information.	*R. Thomas #N-6-52* ALA.
Alaska Range	No information	01-Jul-1976	a) Richardson Hwy, Gunn Cr., Gunn Creek. Flats. b) Richardson Hwy, Gunn Creek.	a) Along creek in saturated sand-silt b) Along stream in saturated clay-silt sand (possibly duplicate specimens).	a) *J.F. Winters #s.n.* ALA; b) *J.F. Winters #s.n.* ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Alaska Range	No information	03-Jul-1962	Alaska Range, Dry Creek, 50 miles east of Healy	Seepage area and under alders.	*L.A. Viereck and K. Jones #5797* ALA.
Alaska Range	No information	07-Aug-1968, 01-31 Aug 1976	1968: Denali Highway, Mile 12. 1976: Alaska Range, Mile 31 Denali Hwy.	1976: Wet meadow on glacial outwash plain.	*M. Williams #2377* 1968 WTU; *J.C. Dawe #775* 1976 ALA.
Alaska Range	No information	13-Jul-2002	Alaska Range, ridge S of Max Lake.	Alpine wet meadow by rivulet.	*A. Batten and M.H. Barker #02-454* ALA.
Alaska Range	No information	10-Jul-1927	Alaska Range, Cantwell.	No information.	*L.J. Palmer #1881* ALA.
Alaska Range	No information	08-Jul-1970	Alaska Range, Sager's camp, on slopes below and north of Mt. McGinnis.	Mesic sites, alpine meadows.	*D. Murray#3073* ALA.
Alaska Range - Susitna River	No information	24-Aug-1956	Alaska Range, near West Fork Susitna River and West Fork Gl.	River bars and moraine.	*L.A. Viereck #1816* ALA.
Cook Inlet Lowlands - Susitna River	No information	07-Jun-1963	Cook Inlet Lowlands. East channel Susitna River. 10 km above mouth.	Moist flat sand with equisetum and grass.	*J.A. Erickson #3* ALA.
Susitna River	No information	13-Jul-1982	Susitna Valley, Mile 57 Parks Hwy, Little Susitna River.	In field along river.	*J. Fox # s.n.* ALA.
Aleknagik	No information	01-Jul-1965 – 31-Jul-1965	Aleknagik.	Wet lake beach.	*K. Roberson #363* ALA.
Aleutian Range	No information	01-Jul-1978 – 31-Jul-1978	Aleutian Range, between Chignik Lake and Black Lake	Mud flat along river bank.	*G. Weiler #35.5* ALA.
Anchorage	No information	19-Jul-1961	Anchorage, Tudor Road 1.6 km off Seward Hwy.	Low-lying wet area, with *Potentilla*.	*L. Bidlake #s.n.* ALA.
Pitmegea River	No information	11-Jul-1959	Arctic Alaska, west of Pitmegea River, approximately 12 km south of Cape Sabine.	Wet sandy meadow west of river.	*S.G. Shetler and K.J. Stone #3199* ALA.
Arctic Coastal Plain	No information	11-Aug-1984	Arctic Coastal Plain, Putuligayuk R. Estuary.	Standing water, bare mineral soil.	*S. Keller and K. Holmes #1198* ALA.
Arctic Slope	No information	13-Jul-1959	Arctic Slope, about 12 km southeast of Cape Sabine, Pitmegea R.	Wet sandy soil along river.	*S.G. Shetler and K.J. Stone #3300* ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Bristol Bay Lowlands	No information	27-Jul-1947, 04-Jul-1952, 12-Jun-1979, 15-Jul-2003, 16-Jul-2003, 17-Jul-2003, 21-Jul-2003	1947: Naknek. 1952: King Salmon. 1979: Snake River mouth, 24 km southwest of Dillingham. 15-Jul-2003: Vicinity of flats south of Ketok Mtn. 16-Jul-2003: King Salmon, Naknek River approx. 1 km downstream from USFWS bunkhouse. 17-Jul-2003: Lake west of Naknek across Kvichak River. 21-Jul-2003: Lake west of VABM Yenuk.	15-Jul-2003: In wet sphagnum with sparse *Eriophorum vaginatum* tussocks. 16-Jul-2003: In wet mud at edge of river, with *Carex lyngbyei*. 17-Jul-2003: In organic muck under 2-5 cm water on floating peat mat adjacent to lake. 21-Jul-2003: In wet sphagnum in *Sphagnum-Eriophorum* wet meadow in wet basin near lake.	*C.C. Hills #s.n.* 1947 ALA; *W.B. Schofield #1992* 1952 WTU; *D. Mesiar #DCM-14* 12-Jun-1979 ALA; *A. Batten and M. McWhorter #03-21* 15-Jul 2003 ALA; *A. Batten and M. McWhorter #03-44* 16-Jul-2003 ALA; *A. Batten and M. McWhorter #03-58* 17-Jul-2003 ALA; *A. Batten #03-189* 21-Jul-2003 ALA.
Coast Mountains	No information	16-Jun-1952, Aug-1955	1952: Coast Mts., Juneau airport. 1955: Juneau.	1952: Wet areas (possibly duplicate specimens).	*G.W. Argus #s.n.* 1952 ALA; *G.W. Argus #157* 1952 ALA; Unknown #s.n. 1955 WTU.
Delta Junction	No information	09-Jun-1951	Delta Junction, Mile 1422 Alaska Hwy, Mile 266 Richardson Hwy.	1951: Broad gravel roadside ditch.	*W.J. Cody #5069* ALA.
Nushagak Bay	No information	05-Jun-1993	Dillingham, between downtown and Windmill Hill.	No information.	*P. Caswell #s.n.* ALA.
Between Alaska Range and the Yukon-Tanana Upland	No information	16-Jul-1957	Gerstle River.	Wet silty roadside through black spruce.	*L.A. Spetzman #591* ALA.
South of St. Elias Mountains	No information	14-Jun-1949	Haines.	Mile 10 Haines Highway.	*A. Rude #77* ALA.
Homer	No information	25-Jun-1968, 28-Jun-1968	25-Jun-1968: Homer. 28-Jun-1968: Homer. Road to airport. Sterling Highway.	Moist soil next to lake.	*K. Roberson #246* 25-Jun-1968 ALA; *M. Williams #2232* 28-Jun-1968 WTU.
Innoko Lowlands	No information	05-Sep-1965	Innoko Lowlands, Holy Cross, west bank Walker Slough off Yukon R.	No information.	*E. Hulten # s.n.* ALA.
Kantishna River	No information	17-Jul-1964	Kantishna River adjacent to Bearpaw Mtn.	Floating sedge-equisetum bog, organic soil.	*L.A. Viereck #7313* ALA.
Kenai Peninsula	No information	05-Jul-1979	Kenai Lowlands, Lower Kenai River valley, Soldotna area.	Treeless sphagnum bog in 0 - 5 cm standing water.	*A. Batten #79-14* ALA.
Kenai Peninsula	No information	27-Jun-1951, 20-Jun-1962	1951: Seward. Near head of Resurrection Bay. 1962: Kenai Mts., Seward, Resurrection Bay area.	No information.	*J.A. Calder #5464* 1951 WTU; *L.J. Rowinski #s.n.* 1962 ALA.
Kenai Peninsula	No information	12-Jun-1980	Kenai Peninsula Mts., pipeline road from Big Indian Cr. to Little Indian Cr.	Disturbed areas along road mainly.	*E. Helmstetter #80-35* ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Kenai Peninsula	No information	14-Jul-1968	Kenai Peninsula, Clam Gulch.	Moist meadow.	*S.L. Welsh and G. Moore #8189* ALA.
Kilbuck Mountains	No information	12-Aug-2001	Kilbuck Mtns., Hot Springs Cr., ca. 6 km WNW of Mt. Hamilton, downstream ca. 3 km from hot springs source to creek.	Meandering, cold water portion of creek, beaver dammed, periodically flooded, growing in wet sandy soil of creek bed.	*D. Blank and M. McWhorter #01-92* ALA.
Kilbuck-Kuskokwim Mountains	No information	02-Jul-1985, 13-Jul-1985	02-Jul-1985 Kilbuck-Kuskokwim Mts., Flat. 13-Jul-1985 Kilbuck-Kuskokwim Mts., Flat	02-Jul-1985: airstrip and roadsides, wet depressions. 13-Jul-1985 Roadside just N of Willow Creek, Wet.	*C.L. Parker #1376* 02-Jul-1985 ALA; *C.L. Parker #1597* 13-Jul-1985 ALA.
Kilbuck-Kuskokwim Mountains	No information	26-Jul-1941, 19-Jun-1969, 05-Jul-1985	1941: Kilbuck-Kuskokwim Mts., Takotna. 1969: Kilbuck-Kuskokwim Mts., Yankee Cr. mining district. 1985: Kilbuck-Kuskokwim Mts., Discovery, ca. 5 km east of Flat.	1941: Wet. 1969: Swamp area. 1985: Dredge tailings, waste areas, moist.	*J.P. Anderson and G.W. Gasser #7409* 1941 ALA; *K.M. Reed #s.n.* 1969 ALA; *C.L. Parker #1452* 1985 ALA.
Kroto Lake	No information	09-Jul-1980	Kroto Lake, Petersville Road.	Peat bog.	*V.N. Siplivinsky #463* ALA.
Matanuska Valley	No information	06-Jul-1931	Matanuska Valley, Matanuska.	Wet soil.	*J.P. Anderson #842* ALA.
Mentasta Mountains	No information	07-Jun-2003	Mentasta Mts., Nabesna R., north margin of Mentasta Mtns.	River flloodplain and bars, common in sloughs and wet depressions of bars.	*B. Bennett and P. Loomis #03-329* ALA.
Robe River	No information	17-Jul-1974	Richardson Hwy, Robe River, approximately 11 km from Valdez on Richardson Hwy.	Open wet places, swampy river marsh.	*B. Cumby #97* ALA.
Akulik River	No information	24-Jul-1977	Mouth of Inglutalik and Akulik River.	Growing at pond edge with grasses.	*D.M. Troy #s.n.* ALA.
Anchor River	No information	03-Jul-1968	North Fork Anchor River Road.	Roadside bog.	*K. Roberson#286* ALA.
Nushagak-Big River Hills	No information	01-Jul-1999	Nushagak-Big River Hills, Cairn Mtn. vicinity, ca. 3 km southeast of summit.	Small drained lake basin, open sedge meadow, common.	*C.L. Parker, CR. Meyers, and M.K. Raynolds #8966* ALA.
Peters Hills	No information	17-Jul-1980	Peters Hills, near Peters Cr.	Alpine mossy bog.	*V.N. Siplivinsky #654* ALA.
Redoubt Bay	No information	01-Jan – 31-Dec-1981, 28-May-1981	Redoubt Bay, Big (Katnu) River Delta and vicinity.	01-Jan – 31-Dec-1981: Sandy soil. 28-May-1981: Sandy soil, bank of creek.	*T. Pogson #81-41* 01-Jan-1981 – 31-Dec-1981 ALA; *T. Pogson #81-11* 28-May-1981 ALA.

Table 6 (cont.).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Robinson Mountains	No information	13-Aug-2001, 06-Aug-2003	2001: Robinson Mts., ridge W of McIntosh Peak. 2003: Robinson Mts., ridge W of McIntosh Peak.	2001: Alpine ridge. 2003: In saturated muck beneath 2-4 cm of peat and living mosses (incl. *Sphagnum*) in fen dominated by *Eriophorum angustifolium* and *Carex saxatilis*, no standing water at this time.	*M.H. Barker and V. Pratt #s.n.* 2001 ALA; *M.H. Barker, A. Batten, K. Lynch #BG03-166* 2003 ALA.
Smith Lake	No information	22-Jun-1956	Smith Lake, 3 km northwest of College.	Very wet muddy site.	*G.W. Argus #428* ALA.
Tangle Lakes	No information	20-Aug-1953	Tangle Lakes, ridge due N of Tangle Lake.	Pure stand in water, bog.	*S.G. Smith #2045* ALA.
Umiat	No information	09-Jul-1952, 12-Aug-1964	1952: Umiat. 1964: Umiat. On the Colville River.	1964:Wet, heath tundra. (Det. B.Albee, 1984).	*G. Lindsa #2285* 1952 WTU; *C. White #s.n.* 1964 UT.
Southeast Alaska	No information	11-Jun-1997	Haines Burrough. North shore of Chilikat River, west of Haines airport.	No information.	*P.F. Zika #13118* WTU.
Barrow	Possibly Department of Defense, private and other	12-Jul-1950, 21-Jul-1950, 24-Jul-1950, 27-Jul-1950, 12-Aug-1950.	12-Jul-1950: One and a half miles southwest of Barrow Village. 21-Jul-1950: One mile inland from Rogers' Monument, 15 miles southwest of Barrow Camp. 24-Jul-1950: Along Elson Lagoon, 2.5 miles east of Barrow Base. 27-Jul-1950: About 1.5 miles south of Point Barrow Base. 12-Aug-1950: North shore of Iko Bay, 18 miles southeast of Barrow Base.	No information.	*I.L. Wiggins #12434* 12-Jul-1950 WTU; *I.L. Wiggins #12492* 21-Jul-1950 WTU; *H.J. Thompson #1197* 24-Jul-1950 WTU; *I.L. Wiggins #12516* 27-Jul-1950 WTU; *H.J. Thompson #1367* 12-Aug-1950 WTU.
North Slope	No information	16-Jul-1952, 22-Jul-1976, 14-Aug-1977, 05-Jul-1978	1952: North side of Meade River about 50 miles south of Barrow. 1976: Arctic slope district: 70 miles south of Point Barrow, near Eskimo village of Atkasook; 4.75 kilometers east of Meade River Camp. 1977: Atkasook. 1978: Atkasook. Meade River, 60 miles south of Barrow.	No information.	*G. Ward #1177* 1952 WTU; *V. Komarkova #407 with H. Hansell and K. Seabert* 1976 WTU; *J.C. Bergdahl #s.n.* 1977 WTU; *B.R. Vogel #s.n.* 1978 WTU.
Chichagof Island	No information	01-Jul-1982	Port Frederick. Neka River estuary.	No information.	*K.L. Labounty #295* WTU.
Talkeetna Mountains	No information	05-Aug-1956	Near summit of Hatcher Pass.	No information.	*J.H. Langenheim #4274* WTU.
Utukok River	No information	30-Jul-1952	Along Utukok River below Driftwood Creek about 10 miles due west of Meat Mountain.	No information.	*G.H. Ward #1346* WTU.
Oumalik	No information	18-Aug-1952	Lake at East Oumalik.	No information.	*G.H. Ward #1499* WTU.

Table 6 (concluded).

Region	Management	Dates observed	Location	Habitat and/or comments about occurrence	Source[1,2]
Northeast Alaska	No information	Jul-1984	Okpilak Valley, West Okpilak Lake.	No information.	*N.E. Grulke #1132 with D.J. Marrett* WTU.

[1] List of herbaria checked for this report. The majority of herbarium specimens are deposited at the University of Alaska herbarium (ARCTOS 2005). Herbaria abbreviations (Holmgren and Holmgren 1998):

- ALA University of Alaska, Fairbanks, AK, USA.
- COLO University of Colorado Herbarium, Boulder, CO, USA.
- CS Colorado State University Herbarium, Fort Collins, CO, USA.
- GH Gray Herbarium at Harvard University, Cambridge, MA, USA.
- HSC Humboldt State University Vascular Plant Herbarium, CA, USA.
- NY New York Botanical Garden Herbarium, Bronx, NY, USA
- RM Rocky Mountain Herbarium at the University of Wyoming, Laramie, WY, USA.
- US United States National Herbarium, Smithsonian Institution, Washington, DC, USA.
- UT Intermountain Herbarium at Utah State University, Logan, UT, USA.
- UTC Garrett Herbarium at the University of Utah, Salt Lake City, UT, USA.
- WTU Burke Museum and Herbarium of the University of Washington, Seattle, WA, USA.

[2] US NPS refers to the U.S. National Park Service.

Region 4, there are approximately 11 occurrences in the Uintah Mountains of Utah (**Table 2**). Since 1935, seven specimens have been collected from the Ashley National Forest and approximately four from the Wasatch-Cache National Forest (**Table 2**). *Eriophorum scheuchzeri* is found in Duchesne, Summit, Uintah counties in Utah (Welsh et al. 2003). It has been reported from Carbon County in Montana (Dorn 1984). However, no specimens have been located to verify the occurrences in Montana (Lesica and Shelly 1991), and there is no information on its status in Montana other than it is a taxon of potential concern in that state (Lesica et al.1984, Miller personal communication 2003, Montana Natural Heritage Program 2005).

Habitat for this species is relatively rare in the southern Rocky Mountains, but even within suitable habitat this species appears to naturally occur infrequently. Range-wide there has been mistaken identity between it and other species of *Eriophorum*. It is particularly confused with another solitary-headed taxon, *E. chamissonis*, which is more common. Because *E. scheuchzeri* has often been confused with other species of *Eriophorum*, occurrence reports that are not accompanied by collected specimens or, at least, photographs must be treated with some uncertainty. Although photographs do not permit taxonomic verification, they do permit confirmation that the specimen matches the macro identification characteristics. For example, flowering specimens of *E. gracile* would be readily distinguished from *E. scheuchzeri* by anyone familiar with both species.

Occurrence data has been reviewed and compiled from the Alberta Natural Heritage Information Center (2003), the Wyoming Natural Diversity Database (2003), ARCTOS (2005), the Colorado Natural Heritage Program, The Montana Natural Heritage Program, and ALA, COLO, CS, GH, HSC, NY, OSC, ORE, RM, UBC, US, UT, UTC, WILLU, and WTU (see Herbaria in **Definitions** section). Herbaria acronyms are according to Holmgren and Holmgren (1998). It must be noted that many records do not have precise location information, and errors may have been made in determining the exact number of occurrences; in some cases a site may have been revisited and designated a new occurrence, or discrete populations in the same general vicinity may have been estimated to be the same site.

Population trend

Observations in Canada, Russia, and Europe suggest that *Eriophorum scheuchzeri* plants persist in the same general area for many decades. In fact, *E. scheuchzeri* was first described from material collected from "Fuscher Tauern" in the Tyrol, Austria where occurrences can be found today (IBC 2005). However, in general, sites have rarely been revisited, and reports containing specific abundance data at any time are few. Therefore, there are insufficient data to critically determine the long-term population trends of *E. scheuchzeri* across its range, including that on National Forest System land in Region 2. Some *E. scheuchzeri* populations are likely to have been negatively impacted in the last century due to considerable habitat loss from fen and bog conversion, but specific losses cannot be confirmed. Large stands of *E. scheuchzeri* are apparently extant on all continents near the Arctic Circle and above the treeline in mountains of Central Europe.

On land managed by USFS Region 2, three of the five documented *Eriophorum scheuchzeri* occurrences have been observed since 1997 and are likely to be still extant (Colorado occurrences 1 and 2 and Wyoming occurrence 1 in **Table 1**). The current status of Colorado occurrences 3 and 4 and Wyoming occurrence 2 in **Table 1** are not known (Fertig 1998).

One *Eriophorum scheuchzeri* population may have been extirpated in Wyoming within the last 50 years (Wyoming occurrence 3 in **Table 1**). The occurrence reported in 1958 from Titcom Basin on the western slope of the Wind River Range in the Bridger-Teton National Forest has not been relocated (Fertig 1992). In addition, *E. scheuchzeri* was not found in other regions of the western slope of the Wind River Range that were examined during an extensive survey for rare plant species in 1990 and 1991 (Fertig 1992). Titcom Basin is an undeveloped, relatively remote area (**Figure 4**), and the reason why the *E. scheuchzeri* occurrence might have been extirpated is not known with certainty. It is possible that sheep grazing, mining, and/or recreation might have impacted the occurrence. Sheep grazed the area until about 1965, after which the allotment in Titcom Basin was closed to sheep grazing (Franklin personal communication 2005b). Historical mining activities may also have influenced its wetland habitat, but the extent to which they have actually done so is unknown. The only other management change in the last 50 years is an increase in recreational use. Titcom Basin is currently a very popular backpacking, climbing, and camping area (Franklin personal communication 2005b). No abundance data were associated with the original observation, and there is always the possibility that it is a small occurrence that has since been overlooked.

Figure 4. Habitat of *Eriophorum scheuchzeri* in the Titcom Basin, Wyoming. (Photograph courtesy of Barbara Franklin, Bridger-Teton National Forest, USDA Forest Service – Region 4).

The status of the *Eriophorum scheuchzeri* occurrences in the Uinta Mountains is not documented. *Eriophorum scheuchzeri* is not tracked by the Utah Natural Heritage Program (Franklin personal communication 2005a). Ten of the eleven documented collections were made over 20 years ago, and at the time of collection little indication of *E. scheuchzeri* abundance was given (**Table 2**).

Habitat

In the far north, *Eriophorum scheuchzeri* is found at sea level. Further south, it is found at elevations up to just over 4,000 m (13,000 feet) elevation, with latitude strongly influencing the elevation at which it grows. In the central and southern Rocky Mountains, *E. scheuchzeri* is reported at elevations between 3,045 and 4,025 m (9,990 and 13,205 ft.) in Colorado and Wyoming (**Table 1**) and 3,320 to 3,810 m (10,892 and 12,500 ft.) in Utah (Welsh et al. 2003). *Eriophorum scheuchzeri* is found to 1,800 m (5,905 ft.) in Norway (Huxley 1986), and it grows just below and above the treeline from approximately 1,500 to 2,900 m (4,900 to 9,514 ft.) in the Alps (Hegi 1980, Kasperek personal communication 2005, WSL 2005). *Eriophorum scheuchzeri* has been reported from 0 to approximately 1,921 m (0 to approximately 6,302 ft.) in Alaska and Canada (Porsild 1951, Klinkenberg 2004).

In the sub-alpine and alpine tundra zone of the central and southern Rocky Mountains, *Eriophorum scheuchzeri* occupies habitats that often support communities including other disjunct species that, like *E. scheuchzeri*, are likely to be relics from the last glacial stage of the Pleistocene (Weber 1960, Cooper 1991). Its habitat in the central and southern Rocky Mountains appears to be very similar to that where it is found elsewhere. It grows on level ground or on gentle slopes with up to a 20 percent incline. The slope shape is often described as slightly concave. It grows in open and, more rarely, partially shaded environments and apparently favors no particular aspect. *Eriophorum scheuchzeri* is commonly associated with species of *Carex* and moss, often being a principal member of sedge-moss and sedge-grass/moss meadow tundra (Ellenberg 1988, EUNIS 2004). *Carex aquatilis* is a common associate on both the coastal plains of North America and Siberia, and the mountain meadows in the Rocky Mountains. This suggests that it is most likely a part of the *Carex aquatilis*-*Carex utriculata* and *C. aquatilis* associations in Colorado (Carsey et al. 2003). Apparently because of their relative rarity, no *Eriophorum* species have been included in recent descriptions of wetland (Carsey et al. 2003) and alpine (Johnston and Huckaby 2001) vegetation communities in Colorado.

Eriophorum scheuchzeri is always found in water-saturated soils. It is a helophyte, growing in wetlands, fens, bogs, wet meadows, peatlands, marshy ground, along very wet stream-sides, riverbanks, lakeshores, and pond margins, in openings in alpine lodgepole pine and spruce fir, and tundra (**Table 1**, **Table 2**; Ball and Wujek 2002, Welsh et al. 2003). In Region 2, *E. scheuchzeri* habitat can be broadly defined as a Palustrine System (Cowardin et al. 1979). Within that system, the habitat falls in the Emergent Wetland Class, which is characterized by erect, rooted, herbaceous hydrophytes, and less frequently it falls in the Moss-Lichen Wetland Class. Cowardin et al. (1979) have developed those class descriptions based on life form, water regime, substrate type, and water chemistry to avoid the confusion often associated with more common and often less precisely defined terms like marsh, swamp, and bog. However, collectors have used the more familiar terms, such as bog, fen, and mire, when describing occurrence habitat. The difference between a bog and a fen is based upon the source of water and nutrients (see the **Definitions** section for the distinctions between a bog and a fen). Essentially, fens are generally nutrient-rich with a source of incoming water. They are usually on flat or gently sloping land and tend to be slightly concave. Bogs are nutrient-poor and acidic and have become raised above the influence of the water table by progressive peat accumulation. The condition of a bog is referred to as ombrotrophic, after the Greek words that translate as “rain food”. Bogs tend to be convex in shape. Fens may have low or high floristic diversity depending upon the conditions while a bog always has low floristic diversity. A poor fen may easily be mistaken for a bog in some circumstances.

Eriophorum scheuchzeri frequently grows in acid (pH 3.5 to 5.5) soils that can be primarily clay in the uppermost horizon, alluvial, sandy, or with high levels of gravel, but they always have a high level of organic matter usually described as humus, peat, fine organic, or sphagnum matter. Soils are hydric. In the Sunshine area of Banff National Park in Alberta, a significant correlation was found between plant community types and soil classification (Knapik et al. 1973). *Eriophorum scheuchzeri* favored poorly drained Gleysolic soils, in areas of runoff ponding and groundwater discharge (Knapik et al. 1973). These humic Gleysols often have a mottled subsurface horizon, which is likely to indicate seepage of oxygenated groundwater through the soils (Knapik et al. 1973). Range-wide, where geological association has been reported, granite and gneiss are the most common parent materials (Tweto 1978, Love and Christiansen 1985, Kasperek personal communication 2005). The character of groundwater entering a mire is heavily influenced by the regional geology, and groundwater flowing though granitic parent material is typically very nutrient-poor and slightly acidic, having a pH value of approximately 6.5 (Cooper and Andrus 1994, Chimner and Cooper 2003). However, when evaluating potential habitat, the possibility that plants may be found outside granitic areas needs to be considered because some occurrence location descriptions from Wyoming and Colorado indicate that *E. scheuchzeri* plants grow in soils that are derived from limestone, from other sedimentary, and also from volcanic rock (**Table 1**; Tweto 1978, Love and Christiansen 1985). This variation in geology suggests that *E. scheuchzeri* may be able to grow in a range of pH conditions.

It is not clear from the habitat descriptions if *Eriophorum scheuchzeri* is uniquely found in areas with open water in the Rocky Mountains. In Greenland, *E. scheuchzeri* prefers bog sites adjacent to open water, and in fact the proximity of open water is a characteristic of its typical habitat (Crawford 1983). Open water means free water, often “standing water.” However, functional “open water” may be difficult to determine for a non-specialist. Some of the least compact surface materials (e.g., peat, soil) become supersaturated in wet conditions so that the structure expands to admit intrusions of free water (Ingram 1983). This process, whereby the bulk density and hydraulic conductivity of the surface materials change, has been particularly associated with *Sphagnum*-*Eriophorum* microtopes that undergo seasonal variation in these properties (Ingram 1983).

Descriptions of *Eriophorum scheuchzeri* occurrence condition that were reported for occurrences in Colorado and Wyoming are listed in **Table 1**, and for the occurrences in Utah they are listed in **Table 2**. Detailed and relatively recent descriptions of *E. scheuchzeri* habitat outside of the central and southern Rocky Mountains include those provided by WSL (2005) for Switzerland, Ellenberg (1988) for central Europe, Chernov and Matveyeva (1998) for parts of Russia, and Klinkenberg (2004) for British Columbia.

Reproductive biology and autecology

Eriophorum scheuchzeri is a perennial species. It has long spreading rhizomes and is likely to propagate vegetatively. It also reproduces sexually. The chromosome number has been reported as 2n = 58 ± 2 from material collected from the vicinity of Bailey Point, Melville Island, Northwest Territories, Canada (Mosquin and Hayley 1966). Other studies have reported 2n = 60 (Aiken et al. 1999), 2n = 58, 60 (Bondareva 1990), and 2n = 58 (Löve 1977, Hegi 1980, Ball and Wujek 2002). Aneuploidy is not uncommon in the Cyperaceae (Grant 1981), and this condition of aneuploidy may at least partially explain the variable morphology observed between and even within populations of *E. scheuchzeri*.

Eriophorum scheuchzeri flowers are hermaphrodite. Flowering begins in late spring with fruiting occurring in summer (Fertig 2000a). The earliest that fruits have been reported in Wyoming is in June (Wyoming occurrence 2 in **Table 1**). In other parts of its range, its reproductive period has been reported to be from June to October (Huxley 1986). Timing of flowering and seed fill may be influenced by environmental conditions.

Members of the Cyperaceae share an unusual feature in their pollen formation process. Only one microspore in each tetrad develops into a functional pollen grain while the other three microspores degenerate (Grant 1981).

Eriophorum scheuchzeri pollination mechanisms are most likely similar to other *Eriophorum* species, which are wind pollinated. In general, wind-dispersed seeds move relatively short distances, and the main bulk of wind-borne seeds typically fall within 4 m (13 ft.) of the seed parent (Salisbury 1961, Silvertown 1987). Wind, rather than water, is the most common seed dispersal method amongst taxa that grow in mires and bogs (Moore 1982). One reason may be that water-flow rates in transitional mires might be unreliable, and in ombrotrophic bogs surface run-off water would primarily transport seeds to unsuitable areas rich in nutrients (Moore 1982).

Eriophorum scheuchzeri seeds undergo physiological dormancy (Baskin and Baskin 2001). Cold stratification was the trigger for breaking dormancy in another *Eriophorum* species, *E. latifolium*, where the length of the stratification period was 42 days and the optimum germination soil temperature was 22 °F (12 °C; Maas 1989). Such a mechanism would maximize the chances that the seedlings would encounter suitable growing conditions.

Observations in Canada suggest that the seed bank may be a significant source of viable seed. Bryophyte sod was brought into an area in Canada that had been severely disturbed by heavy tracked bulldozer-like vehicles (Streng 1999). After the restoration effort, no further disturbance occurred in this isolated region, and after 18 years the restoration plots were checked. Abundant *Eriophorum scheuchzeri* plants were blooming despite the fact that it was not present in any of the adjacent undisturbed areas of the meadow. It was concluded that *E. scheuchzeri* had germinated from seeds in the seed bank that had been contained in the bryophyte sod (Streng 1999). Thus, the seed bank is likely to be very important in re-establishing a population after extirpation of an original patch. This is a common strategy employed by taxa in unstable environments (Moore 1982). However, it is interesting to consider that the replacement patch may be genetically different from the original population. A study on *E. vaginatum* indicated that plants grown from seed in the seed bank differed from the established plants with regard to morphological, growth, and flowering characteristics. The differences were attributed to genetics and not apparently to any genetic deterioration in the old seeds (McGraw 1993). The reason for this observation was not clear. Seeds with different genetic composition may be prompted to germinate on different cues, and such diversity in the seed bank may provide a buffer to a changing environment.

Unlike some plants in which the physiologically active root system is a perennial structure, *Eriophorum* species have adventitious root systems that are repeatedly replaced by new roots. These roots arise from perennating rhizomes a short distance below the soil surface, often from points close to the buds from which aerial leaves and stems are formed (Ingram 1983). It is not clear if new roots are continuously produced throughout the growing season. For example, root production shows two maxima in *E. vaginatum*, the greatest production being in June and July when the roots grow most deeply and a lesser production of shallower roots during the winter (Wein 1973). The influence of soil temperature on *E. scheuchzeri* root growth is not well defined. Roots may be able to grow at relatively low temperatures because roots of some *Eriophorum* species (species not identified) have been reported to grow at soil temperatures below 5 °C (41 °F; Körner 2003).

As indicated in the Habitat section, *Eriophorum scheuchzeri* appears to occupy sites adjacent to open water (Crawford 1983). This situation may be related to a physiological requirement of the species. Lack of oxygen can promote toxic concentrations of metabolites to accumulate within the roots. Near open water the adventitious roots will be bathed by free water, and therefore the toxic metabolites will be able to rapidly dissipate by diffusion (Crawford 1983). This process may be particularly important because, at least for *E. angustifolium*, the internal oxygen supply will support root respiration for only one hour when plants are kept in the dark (Armstrong 1975). The aerenchyma tissue of *Eriophorum* species roots may provide an oxygen reserve (Williams and Barber 1961), but apparently it can only provide oxygen for very short term needs (Crawford 1983).

Studies in Alaska suggest that *Eriophorum scheuchzeri* uses photosynthate very efficiently and is therefore likely to be exceptionally well adapted to exploit short growing seasons common within its range. *Eriophorum scheuchzeri* had a two to three times higher concentration of chlorophyll (mg g dry wt–1) in the leaf blades, which are the primary photosynthetic organs, than in other aerial parts of the plant (Tieszen 1978). In addition, it has an unusually high proportion of its aboveground dry matter invested in its leaves; approximately 89 percent of all aboveground material was in the blades (Tieszen 1978).

Eriophorum scheuchzeri is a perennial species with a high proportion of assimilates directed toward sustaining vegetative vigor. That characteristic along with long habitat tenure is typical of a K-selected species with a stress-tolerant life strategy (MacArthur and Wilson 1967, Harper and White 1974, Grime et al. 1988). *Eriophorum scheuchzeri* is also likely competitive in low-nutrient bogs because certain nutrients are salvaged from dying tissues by translocation to the perennating organ, and the extensive, renewable root system must also provide a certain degree of dynamic foraging behavior (Dickinson 1983, Jonasson and Chapin 1985). Therefore, in some circumstances, *E. scheuchzeri* may have an intermediate strategy between stress-tolerator and stress-tolerant competitor, as has been reported for another *Eriophorum* species, *E. vaginatum* (Grime et al. 1988). This intermediate position is supported by the fact that large numbers of wind-dispersed seeds are produced, which is more characteristic of r-selected, or pioneer, species (Moore 1982).

Demography

Eriophorum scheuchzeri reproduces sexually by seed and asexually, or vegetatively, via rhizome production. It is not documented, although it is likely, that juveniles arising from rhizome nodes routinely break from the parent and live as independent individuals. The rhizomatous and adventitious root systems form a mat that can make differentiating between individuals difficult. The frequency with which seed germination occurs has not been documented for *E. scheuchzeri*. It is not clear as to how old the plant must be before flowering occurs. In northern Russia, results from dating *Dryas* woody tissue to estimate *E. vaginatum* age and growth suggested that the juvenile stage could last for 20 years and the generative stage from 40 to 60 years although discrete patches could remain active for over 100 years (Wein 1973).

Population sizes of *Eriophorum scheuchzeri* are quite variable. There is little information on its abundance in Region 2. However, occurrence records throughout its range suggest that less than 15 stems to several hundred (thousand), which can form an extensive, essentially monospecific stand, may comprise a population. In some cases, several small patches or "clumps" of plants that are separated by several tens of meters are distributed over several acres. In other instances, patches of less than $1m^2$ are found seemingly in isolation. Because of the highly rhizomatous growth habit, it is likely that small patches only represent a few, or possibly only one, genetically unique individual. Neither the patch dynamics nor the dynamics of individuals within patches have been investigated. Other than habitat availability, causes of the differences in occurrence size and their spatial distribution are unknown.

Estimation of a minimum viable population size is very complex and needs to be examined on a species-specific and population-specific basis since population dynamics (and extent of suitable habitat) also need to be considered (Franklin and Frankham 1998, Lande et al. 1998, Frankham 2003). The situation with a clonally propagating species, such as *Eriophorum scheuchzeri*, is additionally complicated because many apparent individuals are actually joined by a subterranean connection, and therefore an occurrence may be more vulnerable than the size of the aboveground extent of the population would suggest. Ramet and genet dynamics can differ greatly, and the minimum viable population size can vary widely according to the different proportions of genets or ramets that make up a population (Erikkson 1994, Damman and Cain 1998, Menges 2000).

No demographic studies on *Eriophorum scheuchzeri* have been undertaken, and transition probabilities between the different stages from seed germination to the flowering adult are unknown. Seedlings are seldom reported. The proportion of stems that flower and produce seed per year is also not known. Where abundance has been reported, it is the flowering stems that are typically counted or estimated. Whether this is solely because they are quite visible or because there are few stems that are not reproductive is not documented. There is no information to suggest the relative importance of asexual and sexual reproduction in the life history of *E. scheuchzeri*. It is reasonable to speculate that the rhizome organ is very important to the long-term sustainability of individuals within a population (Silvertown et al. 1993, Crone 2001). However, a certain level of fecundity is critical for providing seeds to the seed bank, which is likely to be particularly important in re-establishment of populations after disturbance (for example see Streng 1999). Patch size is most likely to reflect microhabitat conditions, but it is unknown if patch size reflects age. It is also not known if the rhizome system can undergo a prolonged dormancy period during unfavorable environmental conditions. Limits to population growth are also not well defined.

A simple life cycle model of *Eriophorum scheuchzeri* is described in diagrammatic terms (**Figure 5**). Heavy arrows indicate phases in the life cycle that appear most critical, and lighter weight arrows indicate the phases that may be less significant or unknown. The steps that particularly need to be clarified are noted by "?" at the appropriate arrow.

Community ecology

Eriophorum scheuchzeri grows in a wide variety of wet habitats including fens, bogs, wetlands, wet meadows, peatlands, marshy ground, along very wet stream-sides, riverbanks, lakeshores, and pond margins, in openings in alpine lodgepole pine and spruce fir, and tundra (see Habitat section). Within these habitat types, *E. scheuchzeri* typically inhabits relatively fertile sites that are subject to more natural disturbance than those colonized by some other *Eriophorum* species (Mark and Chapin 1989, McGraw and Chapin 1989, Cholewa and Griffith 2004).

The position of *Eriophorum scheuchzeri* in community succession is not precisely known. Plant succession is not a conspicuous feature of the arctic landscape and historically has not been greatly discussed (Bliss 1988). Many of the pioneer plant species become part of the stable, climax vegetation, which reduces the visual impacts associated with succession (Bliss 1988). However, since petroleum exploration and its development have occurred at many areas in the Arctic, succession subsequent to human-induced disturbance has been more evident (Bliss 1988). It appears that *Eriophorum* species are generally pioneers in areas that have experienced disturbance (Tallis 1984, Chernov and Matveyeva 1998). They may also be permanent pioneers in the sense that environmental conditions of their normal habitat may be unstable and successional development is stymied by external factors such as the rise and fall of tides, floods, or small mammal activity, specifically of lemmings in the Arctic (Chernov and Matveyeva 1998). However, some *Eriophorum* species are earlier colonizers than others. *Eriophorum angustifolium* appears to be a particularly early colonizer in Great Britain (Taylor 1983). In studies on the vegetational succession of bogs and fens in Great Britain, *E. angustifolium* was an earlier colonizer than the tussock-forming *E. vaginatum* (Moore and Bellamy 1974). After colonization by *E. vaginatum*, the diversity of both plant and animal species increased (Moore and Bellamy 1974). In Alaska, *E. scheuchzeri* and *Dupontia fisheri* are early colonizers while *E. angustifolium* and *Carex aquatilis* enter somewhat later and eventually predominate (Bliss 1988, Hinkel et al. 2003). The *E. scheuchzeri*/*D. fisheri*/*E. angustifolium*/*C. aquatilis* community on a poorly drained sandy area in Alaska shifted to dominance by *C. aquatilis* as organic matter accumulated (Bliss 1988).

Eriophorum species also show marked preferences for different habitat niches at the same location. For example in Finland, *E. russeolum* is one of the dominant species in the field layer whereas *E. vaginatum* is a dominant species at the bog margins (Ruuhijärvi 1983). Apparently *E. scheuchzeri* is similarly restricted to a narrow range of conditions within its habitat. In the Alps in central Europe, stands of *E. scheuchzeri* are quite precisely delineated and are most commonly found at the margins of small, acidic, still-water lakes that are above the treeline (Ellenberg 1988, Kasperek personal communication 2005). It tends to form a fringe at the edge of standing water, which is typically also occupied by *Sparganium angustifolium*, *Callitriche palustris*, and *Eleocharis* species (Ellenberg 1988). In turn, stands of *Carex nigra* form an outer

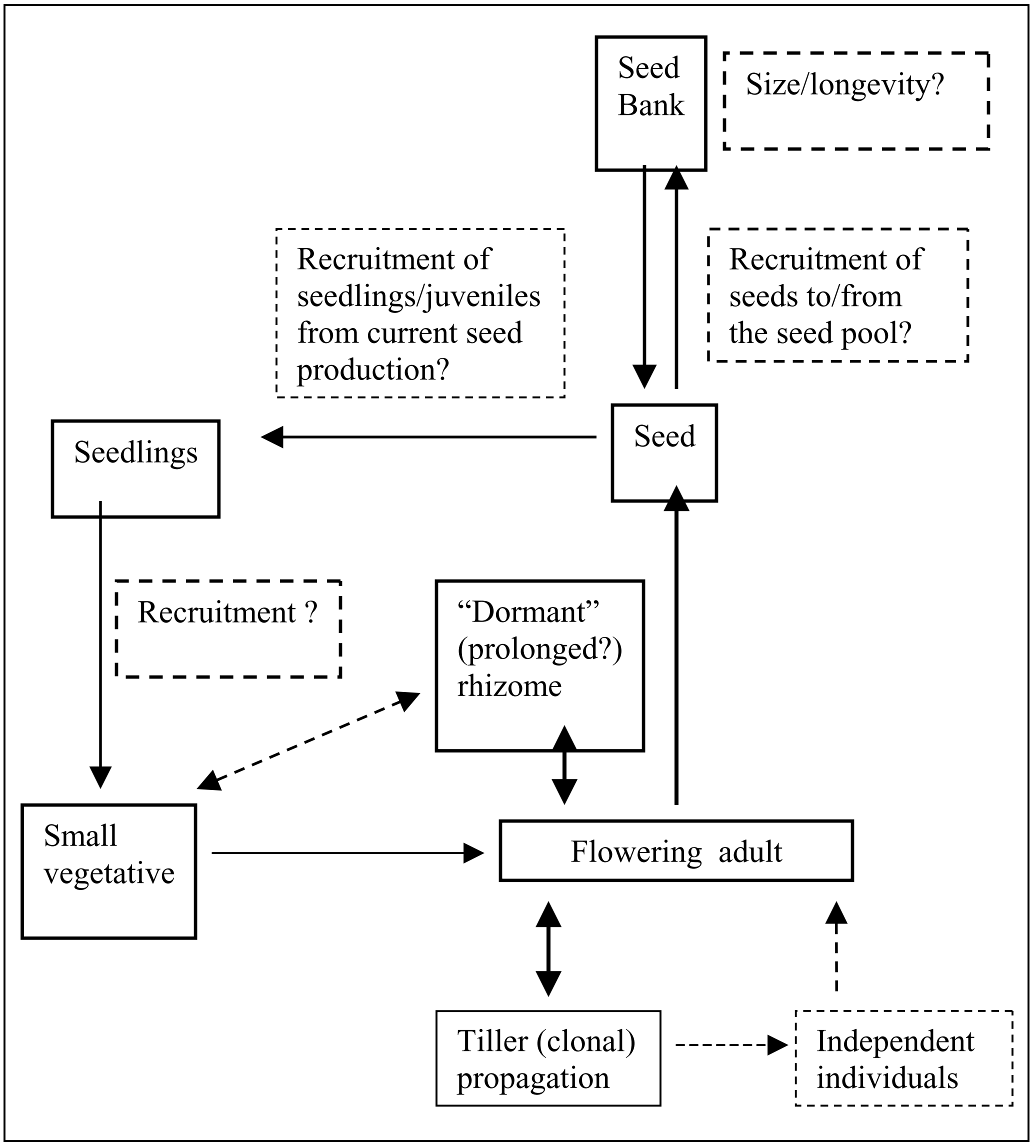

Figure 5. Life cycle diagram for *Eriophorum scheuchzeri*.

circle to that of *E. scheuchzeri* (Ellenberg 1988). The distribution may reflect local differences in mineral and nutrient availability since *E. scheuchzeri* generally occurs in relatively fertile sites (Mark and Chapin 1989, McGraw and Chapin 1989, Cholewa and McGriffith 2004). In Alaskan tundra, *E. scheuchzeri* also has a narrow range, being restricted to certain types of ponds and meadows where its distribution was influenced by soluble phosphate availability, hydrogen sulphide, and flowing water as well as moisture per se (Webber 1978). This is in contrast to *E. russeolum*, which was much more widely distributed and could tolerate a significantly wider range of conditions (Webber 1978). In Russia, stands of *E. scheuchzeri* have been noted to lack a substantial diversity of plant species and may approach being homogeneous for large areas within a patchwork of other stands that are also essentially monospecific (Chernov and Matveyeva 1998). *Eriophorum scheuchzeri* is morphologically typical of the vascular plant species that form such communities in the northern Russian peatlands, which tend to have long rootstocks and a non-compact growth habit (Chernov and Matveyeva 1998). However, when considering the amount of potential *E. scheuchzeri* habitat in the Rocky Mountains, it is important to consider that there may be geographical differences in habitat preferences. This phenomenon has not been well documented specifically for *E. scheuchzeri*, but *E. angustifolium* grows in both poor and rich fens but never in ombrotrophic bogs in Sweden whereas in the British Isles they grow in ombrotrophic as well as other fen sites (Sjörs 1983).

Interactions between *Eriophorum* species and wildlife have been reported. Waterfowl (species unreported) eat *E. scheuchzeri* achenes (U.S. Department of Agriculture Undated). Whether waterfowl thus contribute to its seed dispersal is not documented. In the Arctic, a variety of wildlife finds the vegetation of *Eriophorum* species to be palatable. *Eriophorum scheuchzeri* provides browse for muskoxen (*Ovibos moschatus*; Larter and Nagy 2001) and geese (*Chen caerulescens atlantica*; Beaulieau et al. 1996). A positive relationship was found between the proportion of sedge (*Carex* species and *E. scheuchzeri*) in muskox summer diet and muskox calf survival (Larter and Nagy 2001). Lemmings, particularly brown lemmings (*Lemmus sibiriens*), voles (*Microtus species*), bison (*Bison bison athabascae*), and caribou/reindeer (various subspecies of *Rangifer tarandus*) utilize *Eriophorum* species in North America (Krebs 1964, Wein 1973, Côté 1998, Crête et al. 2001, Forbes 2004, Gauthier 2004, Fischer and Gates 2005). Apparently for some animal species, *Eriophorum* use varies according to the season or growth stage since it was noted that *Eriophorum* shoots are specifically incorporated into the diet of red grouse (*Lagopus lagopus scoticus*) and ptarmigan (*Lagopus* species) in the spring, when the shoots are young and easily digested (Moss 1997). Often the particular species of *Eriophorum* found in the animal diet are lumped together or are not reported, and in general it is unclear how *Eriophorum* species differ in their palatability and digestibility. The observation, which was incidental to the goals of the study, that all 200 transplanted *E. scheuchzeri* tillers were consumed whereas those of *E. vaginatum* were untouched by tundra voles (*Microtus oeconomus*) suggests that *E. scheuchzeri* is particularly palatable, at least to voles (McGraw and Chapin 1989). Specific interaction between wildlife and *E. scheuchzeri* in the central and southern Rocky Mountains has not been examined. However, by comparison with *E. scheuchzeri* use in northern regions, it appears likely that *E. scheuchzeri* provides food for some animal species, such as pikas (*Ochotona princeps*) and ptarmigan.

In some parts of *Eriophorum scheuchzeri*'s range, beavers (*Castor canadensisis*) might have had a role in the maintenance of its habitat. These animals influenced the shaped, vegetation composition, and structure of many wetlands until recent times (Knight 1994, Schlosser 1995). In the 1800's, beavers were hunted almost to extinction throughout North America, from the Rocky Mountains through Canada, and the effect of their population reduction on wetland habitats is not known (Stohlgren 1998, Muller-Schwarze and Sun 2003).

The association between *Eriophorum* species and invertebrate animals may be highly complex and is likely to be an integral part of the chemistry of functioning wetlands. A wax-producing aphid, *Colopha compressa*, lives on the roots of some *Eriophorum* species (Wheatley et al. 1975, Clymo 1993). This wax, which is composed of paraffins, carbohydrates, and secondary amides, forms interlinked fibers that become a white-colored aggregate of up to 3 mm (0.12 inches) in diameter and can be found to depths of at least 6 m (19.7 ft.) within the peat substrate (Wheatley et al. 1975). These fibres are not always associated with roots since they remain deep in the peat horizons after the roots have disintegrated (Wheatley et al. 1975). Wheatley et al. (1975) speculated that the main reason for wax secretion by the aphid was to void excess carbohydrate ingested in its diet. The wax is also speculated to protect the aphid from predators, adverse environmental conditions, and disease (Smith 1999). The effects of the wax secretion or the impact of root colonization by the aphid on the *Eriophorum* plant is not known.

Wind-pollinated plant species are less likely than entomophilous species to be immediately recognized as having important arthropod associations. However, in many parts of the world *Eriophorum* species are specific food sources for many species of Lepidoptera larvae (Scott 1986, Klassen et al. 1989, Savela 2002). In the United Kingdom, *E. vaginatum* is critical to the life cycle of the large heath butterfly (*Coenonympha tullia*) of which the larval stage feeds on the tips of young growth (Joy and Pullin 1999).

Despite a substantial microflora around the roots, *Eriophorum* species often lack mycorrhizal infections (Dickinson 1983, Grime et al. 1988, Emmerton et al. 2001). Powell (1975) suggested that the long-branched roots that bear numerous large root hairs obviate the need for mycorrhizal associations. In Alaska, close association between roots of an *Eriophorum* species and rhizoids of a bryophyte, *Pogonatum* species, have been observed (Tieszen 1978). The species of *Eriophorum* in this study was not reported, and it was not clear what the physiological relationship was between the two species. Although moss and lichen cover may be high in *E. scheuchzeri*'s habitat, the associated bryophyte species have not been reported for the southern and central Rocky Mountain occurrences. Three boreal fen mosses, *Sphagnum contortum*, *Scorpidium scorpioides*, and *Paludella squarrosa*, were reported for either rich or poor-to-intermediate fens in the southern Rocky Mountains (Cooper 1991). Each of the three species has rarely been encountered in the continental United States, and it would be interesting to know more about the associations and interactions between such disjunct cryptogams and *Eriophorum* species in the Rocky Mountains.

The root system of *Eriophorum* species may have important ecological functions in the ecosystem in which it occurs. Root systems of *Eriophorum* species penetrate the substrate to depths of at least 1 m (3.3 ft.) (Moore and Bellamy 1974, Clymo 1983, Dickinson 1983, Ingram 1983). They therefore contribute by continuously altering the peat layers that were formed decades previously and influence the nutrient cycling in these layers. The adventitious roots also physically contribute to the fragmentation of material in the bog. Leaf bases of bog plants such as *Scirpus* are partially fragmented and *Sphagnum* leaves are often pierced by the adventitious roots of *Eriophorum* species (Dickinson 1983). Certain nutrients are translocated back into the perennating rhizome prior to litter fall at the end of each growing season (Moore and Bellamy 1974, Mitsch and Gosselink 1993; see Reproductive biology and autecology section). Therefore, nutrients are captured in the plants until death, and the disintegration of the rhizome likely plays a critical role in the nutrient budget of the system.

Eriophorum species may accumulate some metal pollutants as well as certain minerals (Goodman and Perkins, 1959, Clymo 1983). Copper, cadmium, aluminum, lead, potassium, insoluble ash, sodium, iron, and calcium were all found to be higher in peat derived from *E. vaginatum* than that from *Sphagnum cuspidatum* (Clymo 1983). There was also an indication that the accumulation of ions is selective because zinc levels were lower in *E. vaginatum* derived peat than that from S. cuspidatum derived peat. This may have particular significance in mineral mining areas where large stands of *Eriophorum* species could potentially become a repository for mining by-products and thus contribute to improving water quality. However, it needs to be noted that since the pollutants accumulate in the peat, during vegetative decomposition they might eventually re-enter and become active again in the ecosystem.

The ability to take-up and accumulate natural minerals and pollutants is likely to differ between the *Eriophorum* species. For example, nitrogen use efficiency was higher for *E. vaginatum* while nitrogen uptake efficiency was higher for *E. scheuchzeri* in both growth-chamber and field studies that examined the competitive ability of the two species under two levels of nitrogen fertilization (McGraw and Chapin 1989). Cholewa and Griffith (2004) have reported differences in the vascular system anatomy between species, which may result in differences in mineral uptake and accumulation. When the anatomy of overwintering corms of *E. vaginatum* and *E. scheuchzeri* were examined using histochemical and microscopy techniques, it was observed that *E. vaginatum* developed a ring of horizontally arranged xylem and phloem, in addition to axial amphivasal vascular bundles leading to the leaves, all of which were bordered by transfer cells (Cholewa and Griffith 2004). In addition, special groups of sclereids that functioned in both phloem and xylem transport were found at the base of the leaf traces and within the junctions of senescing roots (Cholewa and Griffith 2004). These distinct anatomical features were not observed in *E. scheuchzeri*, which produced a rhizome that consisted mainly of storage parenchyma cells within which collateral vascular bundles were centrally located and circularly arranged (Cholewa and Griffith 2004).

The role of disturbance in *Eriophorum scheuchzeri*'s life history has not been critically examined. Observations suggest that some undefined level of natural disturbance is advantageous to seedling establishment (McGraw and Chapin 1989). Vegetative expansion by rhizomes and stolons implies that there is a period of attachment between parent and offspring, and therefore frequent and severe soil disturbance may be detrimental. The fact that there appears to be a substantial seed bank suggests that populations could survive at least a limited amount of disturbance.

Considering the role of fire on a range-wide basis, much of the habitat of *Eriophorum scheuchzeri* is unlikely to experience fire or only likely to be exposed to fires having long return intervals. In years of average precipitation, wet habitat such as bogs and fens are usually too damp to burn. However, during drought years, bog surfaces can be dry enough to support fire (Flinn and Wein 1977, Dawson 1979, Sullivan 1994). In Quebec, the fire frequency for conifer bogs was estimated from stand age to be on the order of 100 to 200 years (Cogbill 1985). In addition, although fire return intervals are likely to be long, in some circumstances wildfires in adjacent conifer communities can impact fenland in western mountain environments (Ratchford et al. 2005). In the latter situation, the fens appear to experience a patchy burn pattern, which is likely to contribute to a spatially diverse vegetation pattern. Studies have indicated that the effect of fire on *Eriophorum* species, but not specifically *E. scheuchzeri*, depends on the severity of the burn (Tallis 1984). Fire apparently elicited *E. vaginatum* flowering, and a higher seed yield was harvested from burned areas than from unburned areas (Wein and MacLean 1973). The similarity between *E. scheuchzeri* and *E. vaginatum* with response to fire is unknown. However, it needs to be noted that *E. vaginatum* exhibits a wide variation in flowering and annual seed production, depending upon environmental factors and disturbance (Wein and MacLean 1973).

An envirogram is a graphic representation of the components that influence the condition of a species and reflects its chance of reproduction and survival. Envirograms have been used especially to describe the conditions of animals (Andrewartha and Birch 1984) but may also be applied to describe the condition of plant species. Those components that directly impact *Eriophorum scheuchzeri* make up the centrum, and the indirectly acting components comprise the web (**Figure 6**, **Figure 7**). Much of the information to make a comprehensive envirogram for *E. scheuchzeri* is unavailable. The envirograms in **Figure 6** and **Figure 7** are constructed to outline some of the major components known to directly impact the species and also include additional speculative factors. Dotted boxes indicate factors that are likely but not proven.

Resources that have been listed include water-saturated soils providing a suitable edaphic environment for adequate growth. Open water may be a specific resource as it may reduce the impact of toxic metabolite accumulation, and thus the availability of free water may be one of the factors that restrict localized population expansion (see Habitat and

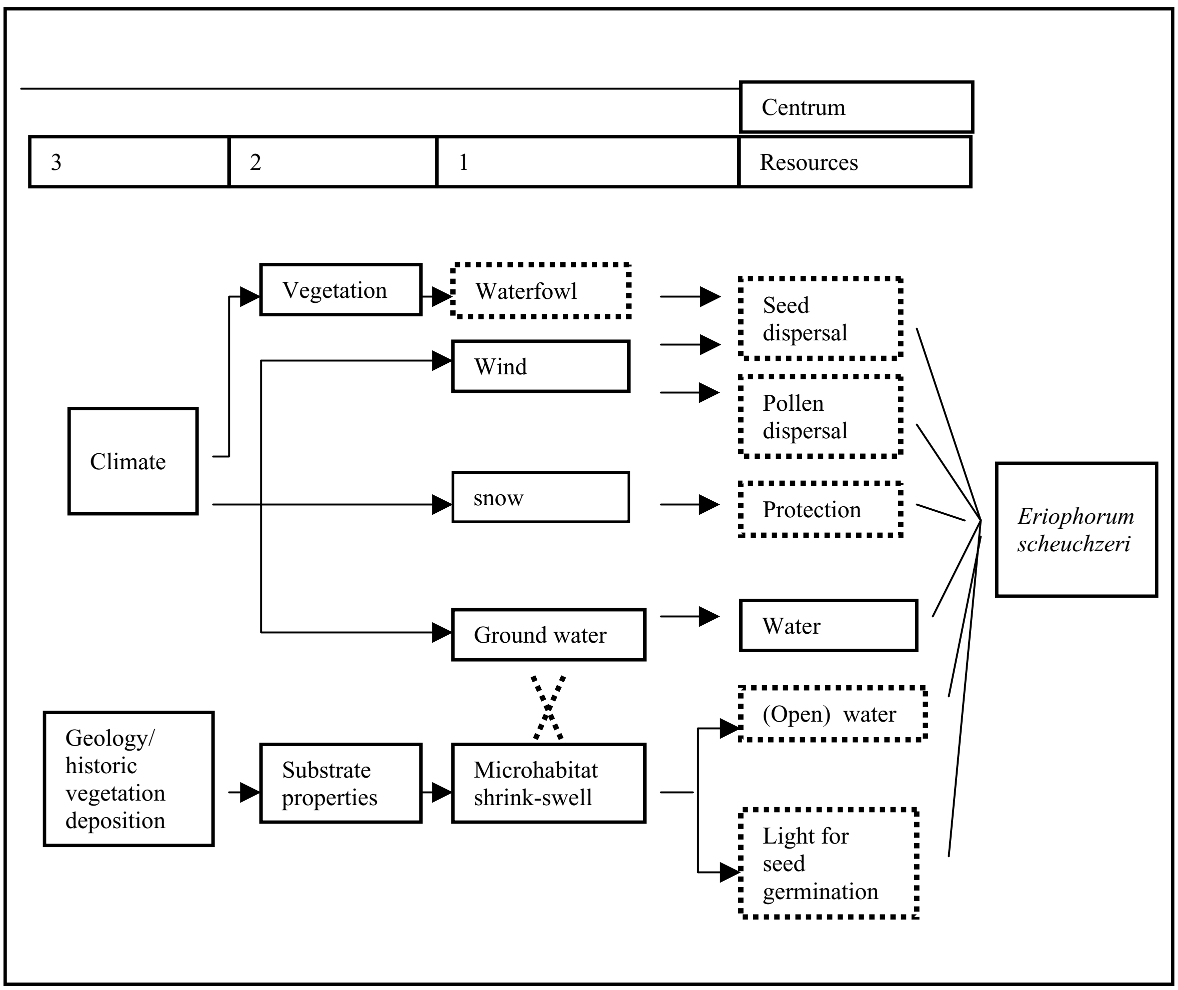

Figure 6. Envirogram of the resources of *Eriophorum scheuchzeri*. Dotted boxes indicate resources that are likely but not proven.

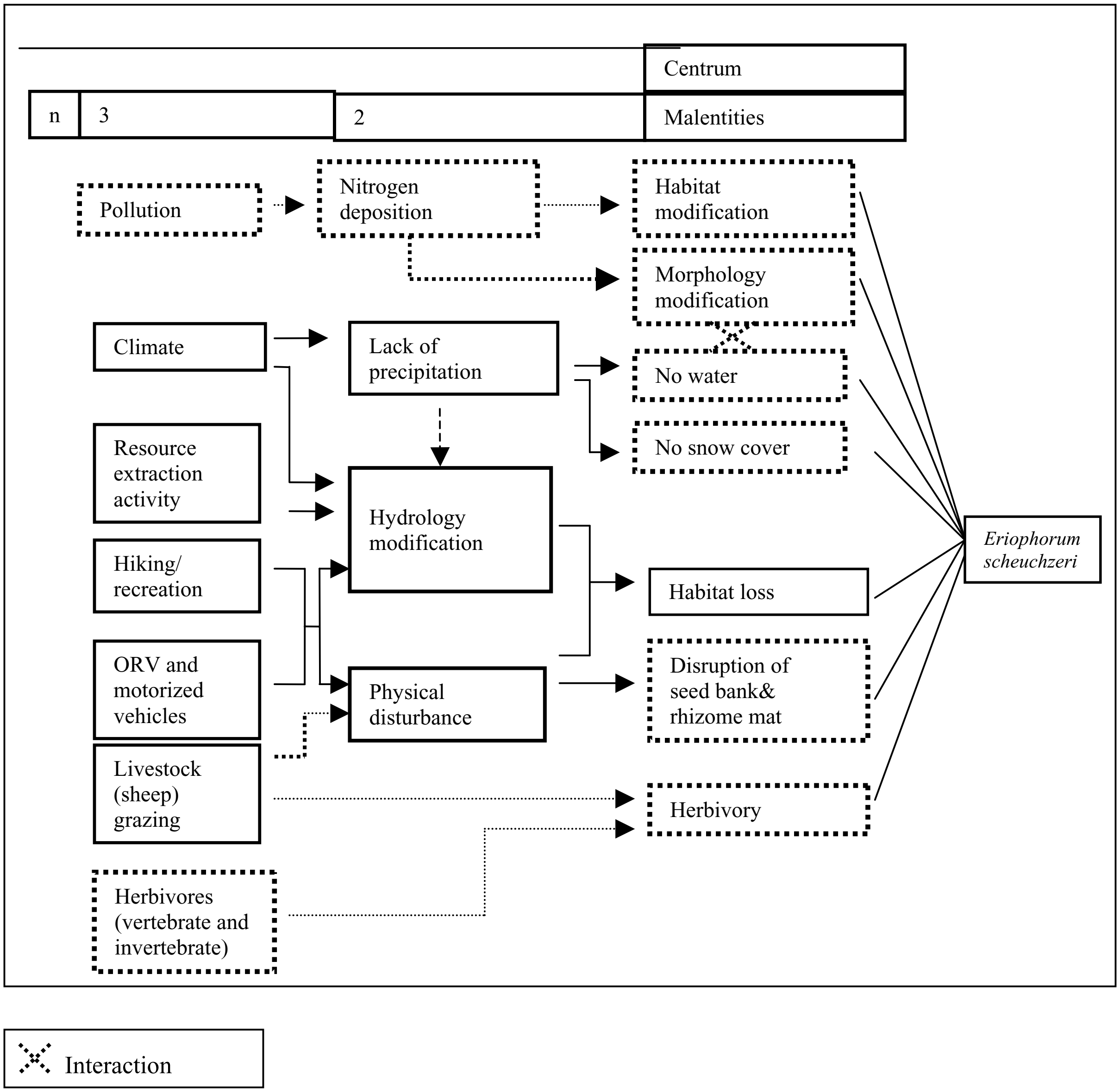

Figure 7. Envirogram outlining the malentities to *Eriophorum scheuchzeri*. Dotted boxes indicate malentities that are either likely but not proven.

Reproductive biology and autecology sections). Snow cover has been included because *Eriophorum angustifolium* exhibited positive responses to various measures of snow cover (Aiken et al. 1999). It was thought that snow cover reduces the rate of desiccation, protects plants from abrasion, and insulates them from low temperatures during the winter season. These properties are likely to apply to *E. scheuchzeri* as well. Fire or freeze/thaw disturbances are likely tolerated and may benefit seed germination; however, because the impact of fire on the life history of *E. scheuchzeri* is very speculative, it is not included in the envirogram. Some types of disturbance may also have a role in seed germination and the establishment of independent plants from rhizome nodes (see Reproductive biology and autecology and Demography sections). However, other than microswell of the substrate, disturbance is also omitted from the envirogram because of the lack of pertinent information.

CONSERVATION

Threats

The principle threats and potential threats to *Eriophorum scheuchzeri* appear to be related to habitat loss. *Eriophorum scheuchzeri* is restricted to bogs, fens, marshes, wetlands, and peatlands, which are all very susceptible to modification from anthropogenic activities, such as mining, petroleum development, livestock grazing, outdoor recreation, and water development projects (Forbes 2004). Vegetation has been destroyed or altered by construction activities for access roads, production sites, support infrastructure, borrow sites, as well as by contamination from discharges, waste, and spills (Forbes 2004). Recovery from disturbance is slow because of the short growing season and low annual production of nutrients. Loss of vegetation caused by disturbance also affects nutrient cycles and accelerates the rate of soil loss through erosion. In the United States, the imminent drilling for oil in the Arctic Wildlife Refuge (Efstathiou 2004, Cohen 2005) suggests that these otherwise protected occurrences (**Table 3** and **Table 6**) may become vulnerable to habitat modification.

Peatlands and wetlands are particularly vulnerable to modification from anthropogenic activities in most parts of the range of *Eriophorum scheuchzeri*. Although some peatland areas such as those in northern Canada and northern parts of Scandinavia are relatively remote and unmodified, in many other areas peatland losses are already substantial. Fifty-two percent of peatlands in Europe have been lost due to their conversion to agriculture or forestry and to peat mining (Chapman et al. 2003). The status of wetlands in the Rocky Mountains is not well defined because there has been a lack of systematic and integrated surveys (Stohlgren 1998), but wet habitats are accepted as being generally in decline throughout the central and southern Rocky Mountains (Knight et al. 2000, Chimner and Cooper 2003). Peatlands are understood to be particularly rare in the Rocky Mountains of Colorado and Wyoming (Chadde et al. 1998). However, results of a recent, extensive, systematic peatland inventory in the Medicine Bow National Forest (Heidel and Thurston 2004) suggest that areas occupied by peatlands in the Rocky Mountains of Wyoming and Colorado may have been underestimated in the past. Heidel and Thurston (2004) estimated that peatland habitat approached 1 percent of the land cover in the four areas surveyed, which totaled 96,079 acres, in the Medicine Bow National Forest.

Peat mining has not been as developed in the Rocky Mountains as it has in many other parts of the world, but evidence of local activities exists (Chadde et al. 1998, Cooper and MacDonald 2000). One documented example on USFS Region 2 land is in the Warren Lakes area on the White River National Forest in Colorado. In this area, several ditches ranging from two to over 10 feet wide were machine-dug many decades ago to extract peat (Cardamone personal communication 2002). Peat mining also occurred on private land in the 1980's in the Geneva Park area near the Pike San Isabel National Forest in Colorado (Center for Native Ecosystems et al. 2002). Peat mining affects edaphic conditions, microbial as well as non-vascular and vascular plant species composition, and the local hydrology of the sites (Chapman et al. 2003). Currently peat mining is less likely to be pursued on land managed by federal agencies in the Rocky Mountains since they may be classed within "Resource Category 1" of the U.S. Fish and Wildlife Service wetland mitigation policy (USDI Fish and Wildlife Service 1981; see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section). In the northern Rocky Mountains, private landowners and mining companies are apparently becoming more interested in exploiting peat for its commercial value (Chadde et al. 1998). Although peat mining can have devastating localized impact, especially if it happens to be at one of the areas where *E. scheuchzeri* occurs, on a global scale it represents only a relatively small part of continuing peatland losses (Chapman et al. 2003).

Mineral mining activities may also be a threat to some populations of *Eriophorum scheuchzeri*. Substantial habitat loss within Arctic wetlands from petroleum development, mineral and metal mining, and the associated atmospheric pollution is well documented in North America and Russia (Forbes 2004). The extent to which mineral mining activities on land managed by Region 2 have affected *E. scheuchzeri* populations has not been documented. The occurrences in the Horseshoe Cirque area (Colorado occurrence 1 in **Table 1**) on the Pike-San Isabel National Forest and northwest of Silverton on the Rio Grande National Forest (Colorado occurrence 4 in **Table 1**) are in regions where mining for metals has been particularly prevalent. In the past, the occurrence in the Dinwoody Lakes-Ink Wells area in the Fitzpatrick Wilderness in the Shoshone National Forest may also have been impacted by mining activity (Wyoming occurrence 1 in **Table 1**). The area is quite rich in mineral deposits; for example an 8 foot wide by 1,000 foot long vein that contained silver, copper, lead, and zinc is located near the Ink Wells, and other minerals including molybdenite were found in the Dinwoody Lakes area (USDA Shoshone National Forest 1986). Currently there is an operating plan for gold dredging in Dinwoody Creek (USDA Shoshone National Forest 1986). The potential impacts of this activity on the *E. scheuchzeri* occurrence have not been documented.

As well as physically disturbing the ground surface, mining activities can affect the hydrology of an area and may therefore indirectly impact *Eriophorum scheuchzeri* because it is an obligate wetland species with restricted habitat requirements. Another indirect, persistent consequence of metal mining is acid rock drainage (ARD), which flows from mine sites and tailing piles. Fens in many Colorado Rocky Mountain watersheds have been affected by ARD (Arp et al.1999). ARD water has a low pH and high concentrations of heavy metals and can pollute surface and ground waters associated with fens. Arp et al. (1999) found that pristine fens in the Rocky Mountains had litter decomposition rates comparable with boreal rich fens while polluted fens had decomposition rates comparable with boreal bogs and poor fens. They also found that ARD caused ecosystem-level responses in organic matter processing, decreases in peat accumulation rates, and most likely changes in nutrient cycling (Arp et al. 1999). These changes may well have long-term effects on fen primary and secondary production and on other functions that could impact the sustainability of *E. scheuchzeri* habitat.

Recreational activities are likely to pose a threat to some populations. Management of most protected areas must balance recreational use with conservation of natural and functioning plant communities (Price et al. 1999; see Management section). That is true for all national parks as well as lands managed by the USFS in the Rocky Mountains. In fact the type location of *Eriophorum scheuchzeri*, "Fuscher Tauern" (Hoppe 1800), has since been developed for its tourist attractions. The Titcomb Basin in the Bridger-Teton National Forest has become a very popular recreation area (see Population trend section). Also, the Ink Wells Trail and the Dry Creek Trail areas, within the Fitzpatrick Wilderness of the Shoshone National Forest (Wyoming occurrence 1 in **Table 1**), are primarily managed for a mix of semi-primitive and primitive recreation opportunities. In this area, there is one large-group, horse-supported campsite that is open to commercial outfitters (USDA Shoshone National Forest 1986). Even though boggy areas, by virtue of being wet, appear to be less susceptible to disturbance from hiking and outdoor activities that use motor vehicles and horses, both "unofficial" and "official" trails are often established at the edge of wetlands, which is where *E. scheuchzeri* most frequently grows.

Recreational off-road vehicle traffic, all-terrain vehicles (ATVs), and snowmobiles have gained popularity on federally managed lands in the United States within the last decade (e.g., ATV Source 1999-2004, OffRoadDirectory.net 2004). Meadows are particularly exposed to overuse by snowmobiles in winter. All mechanized forms of recreation can severely disturb vegetation, cause accelerated soil erosion, increase soil compaction, and add to pollution (Keddy et al. 1979, Aasheim 1980, Belnap 2002, Misak et al. 2002, Gelbard and Harrison 2003, Durbin et al. 2004). Seedlings, shrubs, and other exposed vegetation are commonly broken, and shallow roots and rhizomes can be crushed or damaged (Neumann and Merriam 1972, Ryerson et al. 1977). The potential for snow compaction due to recreational activities, especially snowmobiling, is another cause for concern. Snow compaction can cause considerable below-surface vegetation damage (Neumann and Merriam 1972). Significant reductions in soil temperatures, which retard soil microbial activity and seed germination, may also result from snow compaction (Keddy et al. 1979, Aasheim 1980). These impacts may be exacerbated by compaction of the underlying soil layers. Pollution may be a threat even in remote locations. A study sponsored the Colorado School of Mines, the National Park Service, and Public Counsel of the Rockies analyzed the chemical content of snow near a snowmobile route (Skid Marks Newsletter 2000, Ray 2001). It reported that "an unnatural level of pollution" and at least 20 hydrocarbon compounds, some toxic and carcinogenic, were located 50 feet above the snowmobile route. As mentioned previously, trails frequently run alongside, and in winter sometimes over, wetland areas. Because the presence of water may influence the distribution of pollutants in unexpected ways, the significance of this finding cannot be evaluated without further information.

Eriophorum scheuchzeri habitat is also vulnerable to expansion and new construction of ski resorts. Ski lifts or other structures can be designed and constructed to span or avoid wetlands, so modification of the hydrology of an area is likely to be the most difficult threat to manage. In particular, ski area access road networks can alter the hydrologic regime. Snow-making and snow redistribution activities associated with optimizing skiing conditions can result in a cascade of events that can negatively affect plant communities, soil structure and biology, and natural hydrologic regimes (Kattelmann 1985, Mosimann 1985, Fahey and Wardle 1998, Pickering et al. 2004).

Housing development is also a potential threat to some wetland habitat, especially near urban centers in well-populated areas of Colorado. Mountain homesites are becoming very popular as urban populations grow, and wetlands may be threatened by homesite development. Even if the wetland itself is avoided, nearby housing developments can alter the hydrologic regime, contaminate groundwater, and increase recreational activities that can lead to disturbance of wetland vegetation. Since 2001, the U.S. Army Corps of Engineers no longer regulates development in isolated wetlands in the United States (Guzy and Anderson 2001, Kusler 2001a; see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section). States vary with respect to the laws protecting isolated wetlands, and some counties have no regulations regarding development in or around isolated wetlands (Kusler 2001b). This state-by-state and county-by-county variability makes wetland protection a concern.

Use of *Eriophorum* species by domesticated herbivores may be limited (Mason and Standen 1983, Erhard 1994). It is not clear as to how palatable sheep find *Eriophorum* species. In Scotland, sheep were reported to specifically graze *Eriophorum* species (Wein 1973). In contrast, sheep did not appear to utilize the *Eriophorum* community substantially in England (Mason and Standen 1983). Erhard (1994) reported little significant use of *Eriophorum* species in the Rio Grande National Forest and suggested that one reason is the extremely wet conditions where they grew in those particular areas. In all areas, the availability of alternative forage, the particular *Eriophorum* species, or even the breed of sheep may affect the behavior of the herbivores. One study on *E. scheuchzeri* suggests that some level of grazing is likely tolerated, at least in the short term. Beaulieau et al. (1996) studied the response of *E. scheuchzeri* to snow geese (*Chen caerulescens atlantica*) grazing in the Arctic. The grazed plants compensated for the loss of leaves and maintained production of leaves and tillers (biomass) to a level similar to the ungrazed plants. However, this compensation response resulted in reduced belowground reserves to levels that were likely to be deleterious if grazing was repeated over successive years. Beaulieau et al. (1996) concluded that grazing was not beneficial but that the plants responded in such a way to minimize damage. Another study that utilized permanent exclosures to monitor vegetation changes concluded that snow geese grazing reduced *Eriophorum* (*E. scheuchzeri* and *E. angustifolium*) production, which led to a shift in plant species community composition and resulted in a dominance by grasses, such a *Dupontia fisheri*, in areas chronically grazed by geese (Gauthier et al. 2004).

Wyoming occurrence 2 (**Table 1**) is within an active cattle-grazing allotment on the Shoshone National Forest (Hicks personal communication 2005). Since there has been no long-term monitoring of this site, the impacts of livestock grazing on the occurrence are not known. It also needs to be remembered that persistence of a taxon per se is not proof that the taxon is unaffected by an activity. A decrease in reproductive output, a shift from sexual reproduction to vegetative reproduction, and/or a change in the belowground population size are all potential reactions that are not considered in a simple observation of persistence. The specific interactions between domesticated cattle and *Eriophorum scheuchzeri* have not been documented. The response of *E. scheuchzeri* to aboveground matter loss might be the same, irrespective of herbivore, but this cannot be assumed. Similarly, since it is unlikely that livestock forage and use vegetation in the same way as other bovine herbivores, such as musk oxen (see Community ecology section), such extrapolations would also be subject to error.

In addition to herbivory, livestock grazing can directly impact on *Eriophorum scheuchzeri* habitat. In general, livestock grazing in riparian areas has been found to negatively affect water quality and seasonal quantity, hydrology, riparian zone soils, and streambank vegetation (Belsky et al. 1999). Trails created from livestock movement patterns can alter surface water flows, thus altering landscape hydrology (Fredrickson 2004). Inappropriate livestock grazing can also compact soil and change vegetation composition and structure, which can lead to drying of meadows (Nicholoff 2003). Livestock also contribute to the spread of invasive weeds by carrying seed on their hair and feet and dispersing seed after ingestion (Sheley and Petroff 1999).

Habitat invasion by aggressive weedy plant species is a potential threat. However, *Eriophorum scheuchzeri* appears relatively more able to withstand competition by invasive weeds due to its tall and rhizomatous growth habit and high-elevation habitat preferences. In addition, the water-saturated bog and mire habitats in which this species occurs often support relatively little biodiversity, suggesting that they may not be easy to invade (Chernov and Matveyeva 1998). On the other hand, there are clearly niches within that habitat that have relatively higher fertility, are colonized by *E. scheuchzeri*, and may be more vulnerable to invasion (see Community ecology section). Several species appear to pose a potential threat at the current time. Reed canary grass (*Phalaris arundinaceae*) is a species that spreads aggressively and is commonly observed in peatlands in the northern Rocky Mountains (Chadde et al. 1998). In the same area, Canada thistle (*Cirsium arvense*) will invade peatlands following disturbances such as wheel ruts or fire (Chadde et al.

1998). At the present time invasive species have not been reported in habitat occupied by *E. scheuchzeri* within Region 2. However, several invasive species, for example exotic thistles such as teasel (*Dipsacus* sp.), purple loosestrife (*Lythrum salicaria*), and oxeye daisy (*Chrysanthemum leucanthemum*), have invaded wetland regions at lower elevations in the southern and central Rocky Mountains. New invasive species, which may find a niche in higher elevation wetland habitats, are potentially being continuously introduced into the United States.

Interspecific hybridization is documented between several *Eriophorum* taxa (see Systematics and synonymy section). Hybridization between *E. scheuchzeri* and *E. chamissonis* appears to occur in the Canadian Arctic (Aiken et al. 1999). The hybrid *E. russeolum* x *E. scheuchzeri* is known by the name *E.* x*medium* in northern Europe (Novoselova 1993, 1994a, Aiken et al. 1999, Cayouette 2004). However, the frequency with which hybridization occurs is unclear, and in the case of *E. scheuchzeri*, chromosome number may influence hybrid success. The chromosome number of *E. angustifolium*, *E. chamissonis*, and *E. vaginatum* is 2n = 58 (Grime et al. 1988, Ball and Wujek 2002) whereas some *E. scheuchzeri* populations can be comprised of aneuploids: 2n = 60 (Aiken et al. 1999), or 2n = 58 ± 2 (Mosquin and Hayley 1966). Considering these differences, there is the potential that the chromosomes will not be homologous thereby being unable to pair successfully during meiosis (Grant 1981). Threats associated with hybridization may be a particular concern if non-local *E. scheuchzeri* plants are introduced (Hufford and Mazer 2003).

Eriophorum species can be used successfully in restoration projects (Gorham and Rochefort 2003). However, the use of seed from non-local *Eriophorum* species in areas where *E. scheuchzeri* is native does raise the potential for genetic modification, or "dilution," of locally adapted genotypes by genotypes originally adapted to another region (Lesica and Allendorf 1999, Hufford and Mazer 2003). For example, introduced genotypes may have particularly high fecundity and may be physiologically robust but not have the genetic composition to be resistant to environmental or biological (e.g., disease or insect infestation) events that occur periodically (perhaps decades apart) in the local area. Genetic contamination may pose a threat although, because of the slow growth and apparent low turnover of individuals, the effects would be a long time in becoming apparent.

The threats from genetic stochasticities are unknown. Without detailed genetic studies, it is difficult if not impossible to predict the genetic vulnerability of *Eriophorum scheuchzeri* populations. One consequence of aneuploidy can be a reduction in the robustness of some aspect of an individual's physiology (Allard 1960). In addition, small, isolated populations can be genetically depauperate as a result of changes in gene frequencies due to inbreeding, founder effects, or bottlenecks (Barrett and Kohn 1991, Menges 1991). "A bottleneck is a sharp reduction in the number of individuals of a species in a particular place or time" (Barrett and Kohn 1991). If a numerical reduction is accompanied by a substantial loss in the genetic diversity, the term genetic bottleneck can be applied (Barrett and Kohn 1991).

Similarly, few comments can be made on the influence of demographic stochasticity on *Eriophorum scheuchzeri* population sustainability because there is no information on the survival probability of individuals at any given life-stage or age (see Demography section). Demographic stochasticity refers to chance events independent of the environment that may affect the reproductive success and survival of individuals, which in very small populations have an important influence on the survival of the whole population (Kendall and Fox 2002). Demographic stochasticity, for example variation in fecundity, may be significant where there are few individuals, perhaps fewer than 50, in a population (Pollard 1966, Keiding 1975). More research is required to determine the importance of demographic stochasticity to population sustainability. Demographic stochasticity is typically not considered as great a threat to population viability as are systematic factors such as continuing habitat loss or elements of environmental stochasticity (Menges 2000).

Natural catastrophes and environmental stochasticities can also extirpate populations. A landslide or avalanche that buries an occurrence is an example of such a natural catastrophe. Environmental stochasticity lies in random, unpredictable changes in weather patterns or in the biotic members of the community (Frankel et al. 1995). Environmental stochasticity also includes elements of global climate change, which if associated with drier and warmer conditions, may adversely affect this species on a rangewide level. Species at the southern edge of their range may be particularly vulnerable to warmer conditions (Lesica and McCune 2004). Warming associated with global climate change could affect mountain habitats and cause tree lines to rise by roughly 350 feet for every degree Fahrenheit of warming. Mountain ecosystems could thus shift upslope, reducing habitat for many sub-alpine and tundra species (U.S. Environmental Protection Agency 1997a). In the last one hundred years, the average temperature in Fort Collins, Colorado, has increased 4.1 °F, and precipitation has decreased by up to 20 percent in many parts of the state. Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model, by 2100 temperatures in Colorado could increase by 3 to 4 °F in spring and fall, with a range of 1 to 8 °F, and 5 to 6 °F in summer and winter, with a range of 2 to 12 °F (U.S. Environmental Protection Agency 1997a). Similar changes have been predicted for Wyoming (U.S. Environmental Protection Agency 1998a), Montana (U.S. Environmental Protection Agency 1997b), and Utah (U.S. Environmental Protection Agency 1998b). One difference between Utah and the other three states is that, within the last century, a trend of slightly increasing precipitation has been noted in the Uinta Mountains (U.S. Environmental Protection Agency 1998b). This can be speculated as somewhat mitigating the negative impacts of warmer temperatures on *Eriophorum scheuchzeri* habitat.

Atmospheric deposition of nitrogen oxides and ammonium are increasing throughout the world. Detrimental impacts from atmospheric pollution on sedge meadows in the Arctic are well documented (Forbes 2004). The western United States has been less affected than the East, but there are hotspots of elevated wet nitrogen (acid rain) deposition in southern California and along the Colorado Front Range when compared with the rest of the West (Barron 2001). Wet nitrogen deposition occurring in the high mountain areas of the Colorado Front Range is high enough to cause chemical and ecological change (Baron et al. 2000, Baron 2001, Rueth and Baron 2002). Some areas in the Colorado Rocky Mountains, such as the Maroon Bells-Snowmass Wilderness in the White River and Grand Mesa-Uncompahgre-Gunnison national forests, are at risk from deposition from emissions originating in southern California and Mexico as well as from the coal-fired power generation plants in Colorado and adjacent states (Hudnell et al. 1998). Air quality is also a concern in the Wind River Range in Wyoming where field developments associated with resource extraction are contributing to a high level of air pollution (Ozenberger personal communication 2002). Experiments have indicated that nitrogen additions in alpine tundra influence the species composition of the community (Bowman et al. 1993, Theodose and Bowman 1997). In dry meadows, grasses particularly increased in abundance at the expense of forb species in response to additional nitrogen. Vegetation composition in nutrient-rich sites may be less affected by an increase in nitrogen than in nutrient-poor sites (Theodose and Bowman 1997). The consequence of a long-term increase in nitrogen deposition on *Eriophorum scheuchzeri* is unknown. Growth chamber and field experiments indicated that in general, *E. scheuchzeri* responded positively to nitrogen fertilization and tissue nitrogen levels increased, but that the response was influenced by plant density (McGraw and Chapin 1989). Nitrogen fertilization to *E. vaginatum* was reported to lead to a decrease in xeromorphic characteristics (Müller-Stoll 1947 in Wein 1973). If *E. scheuchzeri* responds similarly, increased nitrogen deposition may increase its vulnerability to drier and hotter conditions caused by global climate change.

In summary, the threats to *Eriophorum scheuchzeri*, including those concerned with global climate change, are likely largely dependent upon the extent and intensity of the activity and the rarity of the species. Currently, all threats appear to be at tolerable levels for the occurrences of this taxon in Region 2. However, the emphasis is on currently. Even if the intensity of a threat remains the same, an increase in its area of impact will have negative consequences. Impacts from recreational pressures are becoming increasingly apparent. For example, thousands of people are estimated to walk in the alpine tundra regions in Colorado each weekend during the spring, summer, and autumn (Morrow 2002). On one trail alone, 250 people were counted on one weekend day, and hiking trails have become 12 to 15 feet wide in some areas as people walk at the sides of established trails that have become slippery (Morrow 2002). In addition, Morrow (2002) reported that some people were so averse to following designated trails that markers were destroyed. Occasional herbivory and disturbance by herbivores, ranging from geese to large ungulates, appears to be unlikely to substantially impact known *E. scheuchzeri* occurrences (see also Community ecology section). However, herbivory at levels where the aboveground material is significantly reduced, especially if it reoccurs on an annual basis, may be more detrimental (see also Community ecology section). Hydrological changes resulting in less available water and/or removal of the peat substrate either by erosion or extraction are also potentially critical threats. Although *E. scheuchzeri* habitat is typical of many alpine tundra systems that are relatively fragile and unable to recover rapidly from destructive forces, a positive factor is that the water-saturated nature of the habitat potentially facilitates a more immediate recovery than would occur in very dry areas. The potential colonization by invasive and competitive plant species is likely to be exacerbated by both anthropogenic disturbances and warming temperatures and also must not be underestimated. Combinational impacts from interactions between the extent and duration of malentities need further study.

Conservation Status of *Eriophorum scheuchzeri* in Region 2

Six of the seven known *Eriophorum scheuchzeri* occurrences in Wyoming and Colorado are on land managed by USFS Region 2. The other one is on land managed by USFS Region 4. The status of the occurrences in Region 2 is not well known because the taxon is not monitored or given any special management consideration. For this reason, the adequacy of the current management practices in maintaining long-term populations cannot be effectively evaluated.

At the present time, two, possibly three, occurrences within Region 2 appear to be relatively secure because of the land management unit designation as Wilderness Area (Colorado occurrence 2, Wyoming occurrence 1, and possibly Colorado occurrence 3, which may be within the Maroon Bells Snowmass Wilderness Area, in **Table 1**). Although exceptions occur, in general the Wilderness Act prohibits commercial activities, motorized access, roads, bicycles, structures, and facilities within wilderness areas (Wilderness Act of 1964; see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section). Livestock grazing is permitted where it was customary prior to 1964 (Wilderness Act of 1964). However, the occurrence area in the Holy Cross Wilderness (Colorado occurrence 2 in **Table 1**) has not been grazed by domestic livestock for at least 30 years and remains closed to grazing (Nelson personal communication 2005).

Eriophorum scheuchzeri occurrences on National Forest System lands in Region 2 appear to occur in areas that are primarily managed for recreation. Location information for Wyoming occurrence 2 (**Table 1**) indicates that the occurrence may overlap Management Areas 2B and 3A, both of which are primarily managed for recreation (USDA Shoshone National Forest 1994). In Management Area 2B, emphasis is for rural and roaded natural recreation opportunities, and motorized and non-motorized recreation activities, such as driving for pleasure, viewing scenery, picnicking, fishing, snowmobiling, and cross-country skiing, are possible (USDA Shoshone National Forest 1994). Conventional use of highway-type vehicles is provided for in the design and construction of facilities (USDA Shoshone National Forest 1994). In Management Area 3A emphasis is for semi-primitive, non-motorized recreation in both roaded and unroaded areas. Recreation opportunities such as hiking, horseback riding, hunting, and cross-country skiing are available. Seasonal or permanent restrictions on human use may be applied to provide seclusion for wildlife. Investments in compatible resource uses (e.g., livestock grazing and mineral exploration and development) occur, but roads are closed to public use. Commercial and non-commercial tree harvest also occurs (USDA Shoshone National Forest 1994). Similarly, Colorado occurrence 1 (**Table 1**) is likely in an area designated for management under 2B guidelines (USDA Pike-San Isabel National Forests and Cimarron-Comanche National Grasslands 1984). Humans frequently choose areas near water to camp for aesthetic and practical reasons. This leads to habitat degradation at the edges of bodies of water. To minimize such impacts "camping is prohibited within (100) one hundred feet of any trail, lake, or stream that is indicated with a solid blue line on USGS topographic maps" in the Fitzpatrick Wilderness (Aus 1998). In addition, camping by groups with pack or saddle animals is prohibited at the base of Dinwoody Glacier and along the Glacier Trail between the confluence of Dinwoody and Knoll Lake creeks in the Fitzpatrick Wilderness, which is near Wyoming occurrence 1 (**Table 1**).

On National Forest System lands in Region 2, measures are taken to "maintain long-term ground cover, soil structure, water budgets, and flow patterns of wetlands to sustain their ecological function, per 404 regulations" (USDA Forest Service 2001; see Existing regulatory mechanisms, management plans, and conservation strategies section). Under Section 404 regulations of the Clean Water Act, the directives specified are that wetland impacts may be permitted "if mitigation measures are applied to replace wetland values in-kind" (USDA Forest Service 2001). However, on USFS Region 2 lands, the guideline is to specifically "avoid any loss of rare wetlands such as fens and springs" because "these wetlands cannot be replaced in-kind" (USDA Forest Service 2001). The known occurrences of *Eriophorum scheuchzeri* on Region 2 National Forest System lands appear to be largely protected by this guideline.

Management of <u>Eriophorum scheuchzeri</u> in Region 2

Implications and potential conservation elements

Eriophorum scheuchzeri is a relatively widespread but infrequently encountered taxon. The observed morphological variation between *E. scheuchzeri* occurrences in Region 2 may be due to inherent variability within the species, differential gene expression within the species at different locales, the development of ecotypes at different locations, different taxonomic species being represented at different locations, and/or hybridization (e.g., Novoselova 1994a, Ball and Wujek 2002, Hufford and Mazer 2003, Cayouette 2004; see also Systematics and synonymy section). Isolation of populations, especially on disjunct mountain top islands, may well have led to a unique combination of genes in some occurrences that have been lost in other populations. The most extreme extension of this is that of speciation. Speciation in isolated populations is well documented (Grant 1981) although not specifically in *Eriophorum*. It is likely that the most geographically separate populations of any taxon will have the greatest genetic divergence and that a significant loss of genetic diversity may result if populations at the edge of the range, or in obviously disjunct localities, are lost (Lesica and Allendorf 1995). In addition, Lesica and Allendorf (1995) suggested that peripheral populations are potentially important sites of future speciation events, and under some circumstances, conservation of peripheral populations may be beneficial to the protection of the evolutionary process. More study of the genetic differences among the occurrences in Region 2, and with those elsewhere, may clarify the conservation value of these peripheral occurrences.

Eriophorum scheuchzeri grows in fragile alpine tundra habitat, which due to a short growing season and harsh environmental conditions is slow to recover from disturbance made by hiking trails and vehicle tracks (Willard 1979). It is likely that some practices, such as mining and certain recreational activities, have impacted populations in the past, but there is little information on which to base predictions as to its response to specific disturbance types or levels. The importance of maintaining a suitable hydrological regime is paramount to the longevity of all populations. Therefore, minimizing hydrologic changes that result in drier conditions and maintaining the water-saturated peat substrates are likely to be primary management goals when attempting to retain its habitat. *Eriophorum scheuchzeri* populations appear to have two strategies in sustaining populations. Population maintenance apparently relies primarily on relatively long-lived mature individuals while the seed bank appears to provide population survival insurance, for example after a catastrophe to the habitat. In both cases, management practices that increase either the frequency or intensity of natural perturbations, or that provide additional stresses to the system may significantly negatively impact population viability.

The commercial availability of *Eriophorum* species raises an important issue for restoration. There may be a high degree of differentiation into local races (Grant 1981, Linhart and Grant 1996). Introduction of a non-local *Eriophorum* species into an area where plants are already established may be detrimental (Hufford and Mazer 2003). The impact of introducing *Eriophorum* species to an area with no apparent current population is also unclear. Observations on a related species indicated that the genetic composition of seeds in the seed bank was different from that of an extant population (see Reproductive biology and autecology section). This raises questions as to the age of the seeds in the seed bank, triggers involved in their germination, and frequency of natural seed germination events.

There may be more *Eriophorum scheuchzeri* occurrences in Colorado, including on lands managed by USFS Region 2, than is currently recognized because some occurrences that have been reported as being of *E. altaicum* var. *neogaeum* may actually be of *E. scheuchzeri* (Ladyman 2004; see Systematics and synonymy section). Although some Region 2 plant specimens initially identified as *E. altaicum* var. *neogaeum* have been re-evaluated and identified as *E. chamissonis*, there are other specimens that are not as readily classified as such (Ladyman 2004). While these specimens may represent another unique taxon or possibly hybrids involving *E. scheuchzeri*, it is possible that they may be *E. scheuchzeri* (see Systematics and synonymy section). It is also possible that they might be what the Russian specialist Novoselova (1994a) calls *E. altaicum* (Cayouette personal communication 2006; see Systematics and synonymy section). Careful examination of existing herbarium material and additional collections from appropriate sites would likely resolve this issue. A supporting molecular study would also be very valuable (Cayouette personal communication 2006).

Tools and practices

Documented inventory and monitoring activities are needed for *Eriophorum scheuchzeri* and other

Eriophorum species with solitary spikelets in Colorado and Wyoming. Representative specimens need to be collected from each site. Careful identification of these specimens and their deposition at herbaria accessible to the public are essential. Much of the available occurrence information is derived from herbarium specimens or relatively casual observations by botanists and does not provide quantitative information on abundance or spatial extent of the populations. In addition, there is little information on population structure and persistence of either individuals or existing populations. Occurrences need to be studied in the field prior to designing specific management plans.

Species inventory

Relatively little information has been collected on *Eriophorum scheuchzeri* distribution. An important consideration in inventorying this particular species is that it might be confused with other species, particularly when access to individuals is made difficult by wet bog conditions. For example, when observing stands from a distance, *E. scheuchzeri* might be confused with the non-rhizomatous *E. callitrix*, a species that is not currently reported to grow in Colorado but does occur in Wyoming. During field surveys, it is also important to remember that *E. scheuchzeri* grows in close association with other species of *Eriophorum*, such as *E. angustifolium*; this may make estimates of abundance more difficult. The current field survey forms for endangered, threatened, or sensitive plant species used by the Wyoming Natural Diversity Database and the Colorado Natural Heritage Program both request observations that are appropriate for inventory purposes (see **References** section for internet addresses). The number of *E. scheuchzeri* stems, the area they occupy, and the occupied proportion of apparent potential habitat is important information for occurrence comparison. However, the number of stems may not reflect the number of genetically unique individuals or even independent plants because *E. scheuchzeri* exhibits substantial vegetative propagation. The number of shoots may also not reflect the belowground population size since the number of shoots may vary due to environmental conditions in any given year. The easiest way to describe populations over a large area may be to count patches, make note of their size, and estimate or count the numbers of individual stems within the patches, recognizing that a patch may be genetically homogeneous or may contain more than one *Eriophorum* species. Because the number of stems may be difficult to count or even estimate in large occurrences, a semi-quantitative estimate of cover, such as 10 to 20 percent or greater than 90 percent, over a defined area might be a practical compromise. Numeric estimates of abundance are more useful for future trend analyses than are subjective descriptions such as “few,” “many,” “abundant,” etc.

Collecting information on the reproductive status of surveyed plants, specifically recording whether the plants are in flower or fruiting, is valuable in assessing the vigor and reproductive potential of a population. Observations on habitat type and condition are important elements of a population inventory, especially because they provide a context when comparing the occurrence with either other occurrences or the same occurrence in future years. A sketch of the site indicating the plants’ locations is also helpful for future reference. Location coordinates of each occurrence, and sometimes sub-occurrence, are customarily acquired using global positioning system (GPS) technology. Delineating the perimeter of the areas containing plants using GPS and transferring the data onto topographic maps may be a practical way to record the *E. scheuchzeri* occurrence at some sites.

Habitat inventory

The information on habitat currently supplied with descriptions of *Eriophorum scheuchzeri* occurrences in Region 2 is generally not in sufficient detail to make an accurate inventory of suitable habitat in the absence of plants. There have been no studies to relate the abundance or vigor of populations to specific habitat conditions or even to the level of coarse measures such as elevation. There is presently such an insufficient understanding of all the features that comprise “potential” habitat that it is not possible to make a rigorous inventory of areas that will actually be occupied within an area that is currently colonized. The patchy and sparse distribution pattern of *E. scheuchzeri* suggests that certain specific, and as yet largely unknown, microclimate and edaphic conditions are needed to support plants (Webber 1978; see Community ecology section). Available habitat descriptions suggest that, within the restrictions of geology and the eco-climate zones in which it exists, this species may be found in any wetland habitat. It would likely be prudent to consider essentially any area in Region 2 with permanently water-saturated conditions in alpine tundra and sub-alpine regions above 2,700 m (9,000 ft.) as potential habitat.

Population monitoring

No long-term monitoring or demographic studies that targeted *Eriophorum scheuchzeri* have been reported. In-depth demographic studies of *E.*

scheuchzeri populations would entail some level of destructive sampling and are unlikely to be appropriate for the small, isolated occurrences in Colorado and Wyoming. Monitoring, on the other hand, would be very valuable, and a study of the population dynamics may be very useful in developing appropriate management practices.

The monitoring protocol needs to be chosen according to the size of the occurrence and the distribution of plants within the occurrence. Rather than counting stems, a semi-quantitative estimate of cover, as described for making inventory, could be used to describe abundance and distribution (Lavoie et al. 2005). Additional information on using an estimate of cover to monitor occurrences, which may help in preparing monitoring protocols for *Eriophorum scheuchzeri*, can be found in Lavoie et al. (2005), who studied the dynamics of an *E. vaginatum* population in a Quebec peatland. However, when considering this method, it needs to be remembered that *E. vaginatum* is tussock-forming in contrast to *E. scheuchzeri*, which is not.

Elzinga et al. (1998, 2001) and Goldsmith (1991) have discussed using rectangular or square quadrat frames along transect lines to effectively monitor the "clumped-gradient nature" of populations. Any monitoring scheme will need to address the patchy and potentially dynamic nature of *Eriophorum scheuchzeri* occurrences. Problems associated with spatial auto-correlation can result from the use of permanent plots to monitor a dynamic population. If the size of the plot is too small or if the establishment of new plots is not part of the original scheme, then when plants die within the plot and no replacement occurs, it is impossible to know the significance of the change without studying a very large number of similar plots.

The sampling intensity (number of plots or quadrat frames) required for adequate statistical confidence in results from measurements of the density, distribution, and number of stems for a species such as *Eriophorum scheuchzeri* can be exceedingly high. A large number of plots would not only be labor intensive but could be potentially destructive to habitat since the rates of trampling would likely be very high. A more feasible alternative may be to use changes in frequency to measure population trends (Elzinga et al. 1998, 2001, Fertig 2000b). In this method, the percentage of all plots that are occupied by the species within the sample area is recorded. If a plot is occupied by one or more plants (stems), it is assigned a 1; if it is unoccupied, it is assigned a 0. The primary disadvantage of frequency measurements is that the results are strongly influenced by plot size. Frequency scores will be high and shifts in distribution or changes in abundance will be difficult to detect if the plots are too large. Conversely, if the plots are too small, frequency values will be very low and declines in population size will likely go undetected. Choosing a sample size that ensures a baseline frequency of 30 to 70 percent can diminish these problems (Elzinga et al. 1998). An adequate number of plots must be sampled for statistical relevance, and Grieg-Smith (1983) recommended 100 frequency plots per macroplot as a minimum amount. For a perennial species, 51 to 156 plots may be sufficient to detect a 10 percent change in frequency over short time intervals (Elzinga et al. 1998).

One advantage of this method is that frequency measurements are relatively easy, the key decision being the presence or absence of the taxon, and minimal training is required (Elzinga et al. 1998). An additional advantage is that frequency measurements are relatively stable over the growing season, so timing is not typically a critical factor each year. However, timing may still be a consideration for *Eriophorum scheuchzeri*, especially where it grows with other *Eriophorum* species, since flowering heads may affect how the surveyor perceives the presence and abundance of the taxon.

There is one significant caveat to using a frequency monitoring method; both the spatial distribution and the density of a population affect measured frequency (Grieg-Smith 1983). Observing an increase in the proportion of quadrats in which a taxon is observed does not necessarily mean that the plants are increasing in density since the population may actually be becoming more sparsely distributed but shifting to cover more area. This behavior may be in response to shifting resources or other environmental parameters. Therefore, changes are often difficult to interpret biologically. Because frequency results are subject to multiple interpretations, they need to be considered for management purposes in conjunction with other details that are recorded, such as habitat conditions and observations on density with respect to spatial distribution. For example, populations can be mapped initially and then remapped periodically to detect gross changes. In addition, more detailed notes on abundance, density, habitat, and associated species taken at specified intervals would clarify the status of the population and facilitate interpretation of frequency data.

The appropriate frequency for conducting monitoring studies can be evaluated after sites have been visited annually for several years. If relatively little change is occurring, monitoring the occurrences at longer intervals may be the most time and cost effective schedule but potentially at the cost of some loss of biological and ecological information.

Habitat monitoring

The relative lack of information on habitat requirements and on the likelihood that an area will be colonized makes it premature to consider that monitoring of potential habitat in the complete absence of plants would be useful. Habitat monitoring where the taxon is growing is usually an integral part of population monitoring protocols.

Descriptions of habitat during population monitoring activities are needed in order to evaluate how environmental conditions might influence abundance over the long term. Conditions several years prior to the onset of a decrease or increase in population size may be more important than conditions existing during the year the change is observed. Since *Eriophorum scheuchzeri* is an obligate wetland species, maintenance of wetland conditions is crucial to its habitat. Therefore, monitoring the availability of water is an important element of habitat monitoring. For example, the water table may be monitored by inserting well pipes, slotted along their entire length and covered with a geotextile screen, in holes that have been drilled at equal intervals along a transect line positioned appropriately across the wetland (Lavoie et al. 2005). Current land use designation and evidence of land use activities (e.g., mining, grazing, recreational use) are important to include with the monitoring data. Observations on the impacts on *E. scheuchzeri* individuals at the extreme edges of the wetlands as compared to those in the wettest areas would also be valuable.

Population or habitat management approaches

There have been no systematic monitoring programs for populations in protected areas, and therefore the consequences of protection cannot be evaluated. Management practices that have been generally implemented within some National Forests, and that may be beneficial to *Eriophorum scheuchzeri* habitat, include restricting recreational vehicle traffic in wetland areas and routing hikers to designated trails. The consequences of such practices on *E. scheuchzeri* occurrences have not been documented.

Designating a taxon as a USFS sensitive species is a useful conservation tool for at least two reasons. Sensitive species designation requires that the taxon be reviewed during management planning. It also raises awareness of the species to botanists and ecologists outside the USFS and may stimulate interest in reporting occurrences and including the taxon in research projects. Such activities are likely to help clarify the rarity and vulnerabilities of the taxon.

Information Needs

More information on the abundance and distribution of *Eriophorum scheuchzeri* is required. The rarity of *E. scheuchzeri* in the central and southern Rocky Mountains is influenced by its relatively rare habitat, but the taxon also seems rare even within ostensibly suitable habitat.

A thorough examination of *Eriophorum* specimens with solitary-spikelets collected from Colorado, Wyoming, and Utah by a taxonomist who is expert in the genus would be very valuable. In addition, the apparent complexity of the taxonomy suggests that *E. scheuchzeri* is a good candidate for genetic analyses at the molecular level (Raymond 1954, 1957, Novoselova 1993, 1994a, Aitken et al. 1999, Ball and Wujek 2002, Cayouette 2004). Molecular studies may clarify the genetic distinctions between *E. altaicum* var. *neogaeum* (in Colorado), *E. chamissonis*, and *E. scheuchzeri* and lead to new interpretations of the morphological variation within the taxa. Clarification of the identity of the taxon currently called *E. altaicum* var. *neogaeum* in Colorado may result in additional *E. scheuchzeri* occurrences on land managed by Region 2 (Ladyman 2004; see Systematics and synonymy section).

Monitoring known *Eriophorum scheuchzeri* sites is essential in order to understand the implications of existing and new management practices. Monitoring the hydrological regime at existing sites will also help elucidate the regime required for population persistence. Inventory taken to collect baseline data before management practices change and periodic monitoring conducted after the new policy is initiated would provide a means of objectively evaluating the impacts. Therefore, inventory and periodic monitoring of existing sites appear to be important needs.

The factors that limit *Eriophorum scheuchzeri* population size and abundance and that contribute to the variable occurrence sizes are not known. Habitat requirements need to be more rigorously defined. It is unclear as to what exactly constitutes potential habitat. Knowledge of habitat requirements would also help to assess the species' tolerance to, and speed of recovery from, disturbance. The spatial dynamics of populations within suitable habitat are also unknown. Because of the peat building processes associated with its environment, it is assumed that populations are persistent but, the reasons for *E. scheuchzeri*'s patchy distribution need to be more defined. The relative importance of different stages of its life cycle is not known. Therefore, how different management practices might impact critical stages of its life cycle cannot be evaluated. Management practices may also consider that this taxon could be an important arthropod host species and that this aspect of Palustrine System ecology might be important in maintaining a functional community.

In summary, information needs for *Eriophorum scheuchzeri* are as follows:

- ❖ A careful taxonomic examination, by an expert in the genus, of the solitary-headed *Eriophorum* taxa in the Rocky Mountains of Colorado, Wyoming, and Utah needs to carried out. Existing herbarium material and recently collected material from the field needs to be included in the study. A molecular taxonomic study in conjunction with a morphological examination would be particularly valuable.

- ❖ Further inventory of solitary-headed *Eriophorum* taxa, ensuring that accurate identifications are carried out, would clarify the rarity and distribution of *E. scheuchzeri*.

- ❖ Yearly variation and the long-term trends at *Eriophorum scheuchzeri* occurrences, which can be determined by monitoring occurrences on annually, need to be determined.

- ❖ The impact of human activities on populations of *Eriophorum scheuchzeri* needs to be determined in order to facilitate proactive steps towards conservation or threat mitigation.

- ❖ Factors that limit population size and abundance and that contribute to the variable occurrence sizes need to be determined.

- ❖ Specific habitat requirements and the hydrologic regime required for maintenance of sustainable populations need to be more rigorously defined.

DEFINITIONS

Achene – Dry, usually single-seeded fruit. "Seed" in common terminology.

Acuminate – Tapering to the apex but with the sides pinched in before reaching the tip (Harrington and Durrell 1986).

Aneuploidy – A cell or organism whose nuclei possess a chromosome number that is greater, by a small number, than the normal chromosome for that species (Allaby 1992). Instead of having an exact multiple of the haploid number of chromosomes, one or more chromosomes are represented more times than the rest (Allaby 1992).

Authorship – The author's name is typically given after the scientific name. If a name is changed during a treatment revision, both the original author (in parentheses) and the revising author are named. See Greuter et al. (1994) and Greuter et al. (2006) for more details on authorship conventions.

Binomial, trinomial – "Binomial" is derived from the binary nomenclature system in which the name of a species consists of two parts, a generic name (genus) and a specific epithet that, in Latin, modifies the generic name. Together the two parts are the species name. Trinomial is applied when a subspecies or variety is included.

Bog – A peatland that only derives water and nutrients from the atmosphere. Bogs are highly acid and nutrient-poor and dominated by sphagnum mosses and ericaceous shrubs. Bogs occur on peat elevated above the water table. Compare to "fen".

Borrow site – "An area that could be excavated to provide material, such as gravel or sand, to be used as fill elsewhere." (The Mackenzie Gas Project. Industry Definitions. Available online at: http://www.mackenziegasproject.com/).

Cryptogam – A plant that reproduces by spores or gametes rather than seeds (Allaby 1992). For example, algae, cyanobacteria, bryophyta (mosses and liverworts), pteridophyta (ferns, clubmosses and horsetails)

Culm – Stem of a grass, sedge, or rush.

Cuneate – Wedge-shaped (Harrington and Durrell 1986).

Dilution – A "reduction in fitness of hybrids relative to parents caused by expression of only one half of locally adapted alleles. The heterozygous hybrids are underdominant relative to the performance of each parental population in its home environment. Also known as the 'ecological' or 'environmental' mechanism of outbreeding depression" (Hufford and Mazer 2003).

Fen – A peatland that receives significant inputs of water and dissolved solids from a mineral source such as runoff from mineral soil or ground water discharge. A fen is considered geogenous and its vegetation minerotrophic. Compare to "bog". Poor fens are nutrient poor and slightly acidic wetlands, which most often occur in the conifer-hardwood forest zone, though they sometimes occur in the deciduous forest-woodland zone. Poor fens are often mistaken for bogs, but unlike bogs, which are highly acidic and nutrient-poor, poor fens only have mildly acidic surface water and a higher concentration of nutrients than bogs. Poor fens occur on deep peat, which is more than 3 feet deep, and receive little nutrient input from the surrounding uplands.

Globose – Spherical; having the shape of a sphere or ball; nearly orbicular in shape; globular.

Helophyte – A plant, typical of marshy or lake-edge environments, in which the perennating organ lies in soil or mud below the water level but the aerial shoots protrude above the water (Allaby 1992).

Herbaria and their acronyms mentioned in this assessment – Acronyms are according to Holmgren and Holmgren (1998).

ALA	University of Alaska, Fairbanks, AK, USA.
COLO	University of Colorado Herbarium, Boulder, CO, USA.
CS	Colorado State University Herbarium, Fort Collins, CO, USA.
UTC	Garrett Herbarium at the University of Utah, Salt Lake City, UT, USA.
GH	Gray Herbarium at Harvard University, Cambridge, MA, USA.
HSC	Humboldt State University Vascular Plant Herbarium, CA, USA.

UT	Intermountain Herbarium at Utah State University, Logan, UT, USA.
NY	New York Botanical Garden Herbarium, Bronx, NY, USA.
ORE	University of Oregon, Eugene, OR, USA.
OSC	Oregon State University, Corvallis, OR, USA.
RM	Rocky Mountain Herbarium, University of Wyoming, Laramie, WY, USA.
US	United States National Herbarium, Smithsonian Institution, Washington DC, USA.
WILLU	Willamette University, Salem, OR, USA.
WTU	Burke Museum and Herbarium, Univ. of Washington, Seattle, WA, USA.
UBC	University of British Columbia herbarium, Vancouver, Canada.

Hermaphrodite – In the context of the plant kingdom: A plant flower having both the stamens and pistil within the same flower (Guralnik 1982).

Holotype – The single specimen designated as the type of a species by the original author at the time the species name and description was published (New York Botanical Garden 2003).

Hyaline – Translucent or transparent (after Allaby 1992).

Hydrophytes – A plant that is adapted morphologically and/or physiologically to grow in water or very wet environments; the perennating bud lies at the bottom of fairly open water (Allaby 1992). Compare helophyte.

K-selected species – Concept from the logistic population growth model, whereby growth rates as regulated by internal and external factors until they come into equilibrium with environmental resources. K-selected species are long-lived species that produce relatively few progeny and seldom reach the carrying capacity of their environment.

Lanceolate – Shaped like a lance that is broader at the base and tapering towards the apex (Harrington and Durrell 1986).

Lectotytpe – A specimen chosen by a later researcher to serve as if it were the holotype. It is chosen from among the specimens available to the original publishing author (the isotypes, syntypes and/or paratypes) of a scientific name when the holotype was either lost or destroyed, or when no holotype was designated (New York Botanical Garden 2003).

Marshes – These are wetlands dominated by graminoids on mineral soils, for example around the edges of a lake or on an undrained flood plain of a river (after Allaby 1992). Marshes are distinct from bogs, which have peaty soils, but colloquially the term is often used interchangeably with bog and mash (Allaby 1992).

Mire – "A general term for a wetland area and its associated vegetation, applied most often to peaty areas" (Allaby 1992). The term "mire" appears to be most frequently used in European literature.

Mire development – For a good illustration of the different mire development processes and explanations of concave and convex phases see Botch and Masing (1983).

Nothosubspecies – A hybrid subspecies (Greuter et al. 1994).

Ombrotrophic – Raised or blanket bogs that receive all water and nutrients from direct precipitation. Neither ground water nor runoff from surrounding land reaches the surface of the bog. Rain and snow provide the water source, and nutrients are derived from whatever blows in--dust, leaves, bird droppings and feathers, spider webs, animal fur, etc. Water chemistry tends to be acidic, and nutrients for plant growth are in short supply (Charman 2002).

Ovate – Egg-shaped in outline and attached at the wide end (Harrington and Durrell 1986). Sub-ovate indicates the object is "almost ovate".

Palustrine – One of the five major systems in the Classification of Wetlands and Deepwater Habitats (Cowardin et al. 1979). The Palustrine System includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand (Cowardin et al. 1979). It also includes wetland lacking such vegetation, but with all of the following four characteristics; (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of the basin less than 2 m at low water, and (4) salinity due to ocean-derived salts less than 0.5 parts per thousand (Cowardin et al. 1979).

Peatland – This is a generic term for any wetland that accumulates partially decayed plant material.

pH – The reciprocal of the hydrogen ion concentration expressed in moles per liter; a value on a scale 0-14 that gives a measure of acidity or alkalinity of a medium (Allaby 1992). Acidic media have pH values of less than 7; alkaline media have pH values of more than 7.

Ranks – NatureServe and the Heritage Programs Ranking system (Internet site: http://www.natureserve.org/explorer/granks.htm).

G5 designation indicates that the species is "Secure – Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals".

G4 designation indicates that the species is "Apparently Secure – Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals."

S1 designation indicates that the species is "Critically Imperiled – Critically imperiled in the nation or subnation [state or province] because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation. Typically 5 or fewer occurrences or very few remaining individuals (<1,000)."

S2 designation indicates that the species is "Imperiled – Imperiled in the nation or subnation [state or province] because of rarity or because of some factor(s) making it very vulnerable to extirpation from the nation or subnation. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000)."

S3 designation indicates that the species is "Vulnerable – Vulnerable in the nation or subnation [state or province] either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals."

The "?" after a rank indicates that the numeric rank is questionable, or "inexact" and is subject to modification when more information on the taxon is gathered.

Rhizome – A trailing stem growing partly or completely beneath the ground surface and usually rooting at the nodes (Harrington and Durrell 1986).

Stolon – A trailing aboveground stem that roots at the nodes (Harrington and Durrell 1986).

Stress-tolerator – The plant strategy theory developed by Grime et al. (1988) postulates two main determinants of plant distribution in most habitats. The first determinant is stress, which constrains growth and productivity, and the second is disturbance, which destroys biomass. If both these factors are absent and the conditions become optimal for plant growth, then the composition of a plant community is determined by competition between species. As a consequence, it is possible to classify plant species into functional types based on their responses to gradients of productivity and disturbance. The extremes on the gradients of productivity and disturbance are occupied by competitors, under conditions of high productivity and low disturbance, stress-tolerators, which are plants that can withstand continuously low productivity imposed by light, moisture or nutrient stress, and ruderals that exploiting severely disturbed, productive habitats. To represent these functional types, Grime et al. (1988) have developed a triangular model in which the functional types are represented by the corners of a triangular ordination with intermediate types in-between (Department for Environment, Food, and Rural Affairs 1999).

Stress-tolerant competitor – A species having characteristics between those of a stress tolerator and competitor (Grime et al. 1988). See definition of Stress-tolerator.

Subobtuse – Somewhat rounded or blunt at the apex.

Swamp – A seasonally flooded bottomland with more woody plants than a marsh and better drainage than a bog (South Bay Salt Pond Restoration Project Undated).

Synonym – In taxonomy, a plant name that differs from the official name; usually an older name that does not conform to the rules governing priority in the application of names (Allaby 1992).

Tiller – Typically used for grasses to describe a lateral shoot arising at ground level.

Type – As type is used to describe a specimen: A type specimen is a specimen selected to serve as a reference point when a plant species is first named (New York Botanical Garden 2003)

Wetlands – Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al. 1979). In the classification system of Cowardin et al. (1979), wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Xeromorphic – Applied to organisms that show morphological adaptations that enable them to withstand drought (Allaby 1992).

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APPENDIX A

Key to *Eriophorum* taxa (including *Eriophorum chamissonis* and atypical *E. russeolum* ssp. *russeolum*) from Cayouette (2004). See Cayouette (2004) for further details.

1. Spikelets with dark to pale orange-brown bristles.

2. Medial fertile scales 0.7–1.3 mm wide, acuminate, 0.1–0.3 mm wide at 0.2 mm below the apex; achenes narrowly obovoid, glabrous; hypogynous bristles 30-50, 15–20 mm long ________________________ *Eriophorum* x*medium* ssp. *medium*

2. Medial fertile scales 1.2–2.2 mm wide, acute, rarely obtuse or acuminate, 0.2–0.5(–0.9) mm wide at 0.2 mm below the apex; achenes obovoid or ellipsoid, glabrous or scabrous; hypogynous bristles 50–80, 25–40 mm long.

3. Anthers 1.5–3.1 mm long; medial scales with conspicuous hyaline margins and apex, the widest area near the middle or above; spikelets typically obovoid, with dark to pale orange-brown bristles ______________ *Eriophorum russeolum* ssp. *russeolum*

3. Anthers 0.7–1.6(–1.9) mm long; medial scales often with reduced hyaline margins and apex, the widest area not above the middle; spikelets various, spherical, obovoid, or hemispherical, with pale beige-brown to darker bristles.

4. Spikelets spherical, with pale beige-brown bristles; first proximal scale 12–23(–30) mm long; stem below the inflorescence 1.0–2.2 mm wide; medial scales covered with small reddish-brown longitudinal spots in hyaline areas; achene beak rarely curved; western North America _____ *Eriophorum chamissonis*

4. Spikelets obovoid or hemispherical, with pale to dark orange-brown bristles; first proximal scale 8–11 mm long; stem below the inflorescence 0.6–1.2 mm wide; medial scales usually without reddish-brown longitudinal spots; achene beak frequently curved; amphi-Atlantic ____________ atypical *Eriophorum russeolum* and/or intermediates between *E. xmedium* and *E. russeolum*

1. Spikelets with white to whitish bristles.

5. Medial scales (0.8–)1.0–2.4 mm wide, acute, 0.25–0.6 mm wide at 0.2 mm below the apex, widest mostly at the middle or above, with well developed hyaline margins; anthers (1.3–)1.5–3.1 mm long; achenes ellipsoid or obovoid, scabrous or glabrous, beak base 0.1–0.2 mm wide ____ *Eriophorum russeolum* ssp. *leiocarpum*

5. Medial scales 0.3–1.5(–1.7) mm wide, acuminate to narrowly acuminate, 0.05–0.3(–0.4) mm wide at 0.2 mm below the apex, widest below the middle or close to the base, with frequently reduced hyaline margins; anthers 0.35–1.6 mm long; achenes narrowly obovoid, always glabrous, beak base 0.05–0.1 mm wide.

6. Anthers 0.9–1.6 mm long; hypogynous bristles (10–)22–32 mm long; stigmatic branches 1.0–2.2 mm long __________________ *Eriophorum* x*medium* ssp. *album*

6. Anthers 0.35–1.0 mm long; hypogynous bristles 10–25 mm long; stigmatic branches 0.5–1.3(–1.5) mm long ____________________ *Eriophorum scheuchzeri* s.l.

7. Spikelets hemispherical; proximal fertile scales dark, with dark margins or reduced hyaline margins sharply differentiated from the darker parts; medial scales narrowly acuminate (usually 0.1 mm wide at 0.2 mm below the apex), 0.3–0.7(–0.9) mm wide near the middle; mature achenes beige brown to olive-brown, slightly lustrous ________________*Eriophorum scheuchzeri* ssp. *scheuchzeri*

7. Spikelets spherical; proximal fertile scales bicolored, with lower and medial parts dark but gradually passing to various tones of gray and conspicuous marginal and apical hyaline areas; medial scales acuminate (usually 0.2 mm wide at 0.2 mm below the apex), (0.5–)0.7–1.4(–1.6) mm wide near the middle; mature achenes orange-brown to dark reddish-brown, mostly dull ________________________ *Eriophorum scheuchzeri* ssp. *arcticum*