

Conservation Assessment
for
Hudson Bay Sedge (Carex heleonastes L.f.)

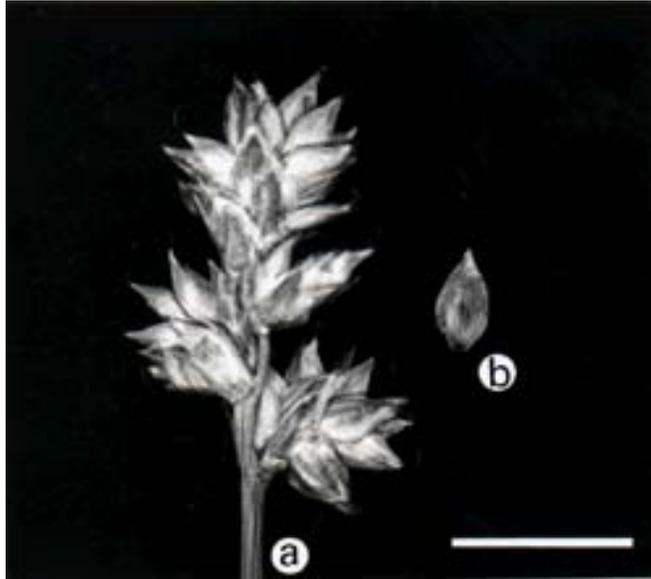


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USDA Forest Service, Eastern Region
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Hiawatha National Forest



This document is undergoing peer review, comments welcome

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

Carex heleonastes L.f. (Hudson Bay sedge) is designated as a Regional Forester Sensitive Species on the Hiawatha National Forest in the Eastern Region of the U.S. Forest Service. This species is not known to occur on any other National Forest in the United States. The purpose of this document is to provide the background information necessary to prepare a Conservation Strategy which will include management actions to conserve the species.

Carex heleonastes is circumpolar; occurring in Eurasia and North America (Böcher 1952, Hultén 1968). Populations in North America are scattered from Alaska south to British Columbia and east to Labrador (Böcher 1952, NatureServe Explorer 2001). One disjunct population occurs in the Upper Peninsula of Michigan (Reznicek & Henson 1982). The Michigan population is the only population in the contiguous United States and over 370 miles (600 km) from the nearest known population in the Hudson Bay lowlands (Reznicek & Henson 1982).

C. heleonastes is generally rare throughout North America (Böcher 1952). In Michigan *C. heleonastes* is listed as "endangered" (Michigan Natural Features Inventory [MNFI] 2002); while in Alaska (the only other state with known populations), it is listed as "imperiled" (S2) (NatureServe Explorer 2001). *C. heleonastes* is also ranked as "imperiled" (S2) in four of the ten Canadian provinces that it occurs. In North America, this species tends to occur in open, calcareous wetlands such as fens (Scoggan 1978, Gleason & Cronquist 1991). Other habitats listed by sources include: bogs, muskegs, lake shores, swamps, wet sandy roadsides, and seeps. The scattered and disjunct distribution of *C. heleonastes* throughout northern North America may be the result of glaciation history and habitat requirements of the species (Given & Soper 1981).

Flowering culms of *C. heleonastes* are erect, grow taller than leaves (measuring between 10 and 40 cm tall), and are scabrous below the inflorescence (Gleason & Cronquist 1991, Toivonen 2002). The inflorescence consists of head-like clusters of two to six sessile spikes that are gynaeandrous (Gleason & Cronquist 1991, Toivonen 2002). The pistils have two stigmas, and the achenes are lenticular. Perigynia are not winged, have short beaks, are glabrous, and are filled by the achenes. Pistillate scales are tinged with brown, and bracts are scale-like (Gleason & Cronquist 1991, Toivonen 2002).

Like most *Carex* species, *C. heleonastes* is probably self-compatible and wind-pollinated (Catling *et al.* 1990). It reproduces asexually by rhizomatous growth in addition to sexually with seeds (Mackenzie 1940, Gleason & Cronquist 1991). Seeds of *Carex* species tend to be dormant at the time of dispersal (Schütz 2000). Once dormancy has been broken, a combination of conditions including fluctuating temperatures, light exposure, and warm temperatures may initiate germination in the spring (Schütz 2000). Seeds that do not germinate in a given year in many *Carex* species are added to a persistent seed bank (Schütz 2000). *C. heleonastes* develops a combination of short and long rhizomes (Bernard 1990). Research suggests that *Carex* genets (genetically distinct individuals) are long-lived (Bernard 1990).

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Herbarium and Heritage Data: We appreciate the sharing of occurrence information for this species from Heritage personnel both in the United States and Canada, along with the helpful assistance of Herbarium personnel. See Contacts section at end of report for a complete list.

Editorial Committee

- We thank Jan Schultz, of the Hiawatha National Forest, for her suggestions and patience through numerous revisions.
- Also appreciated was the editorial assistance of the following contract employees working with the Hiawatha National Forest: Beverly Braden, contract botanist.

Literature Search

- We thank Laura Hutchinson of the North Central Research Library for performing initial species inquiries and sending us relevant research articles.
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NOMENCLATURE AND TAXONOMY

The *Carex* genus contains about 2000 species (Reznicek 1990). Basic characteristics of the genus include narrow grass-like leaves that are three-ranked, triangular stems, and closed sheaths (Gleason & Cronquist 1991). Flowers do not have perianths and occur on spikes* that are bisexual or unisexual (Gleason & Cronquist 1991). Bisexual spikes are either *androgynous* in which staminate flowers are above pistillate flowers or *gynaecandrous* in which pistillate flowers are above staminate flowers. Each flower is subtended by a scale; and pistillate flowers are within a sac-like scale called the perigynium. Other characteristics often used in distinguishing species include the shape of the achene, the number of stigmas, and the number of spikes.

Table 1. Current taxonomic placement and nomenclature of *C. heleonastes* (Toivonen 2002).

Family:	Cyperaceae
Genus:	<i>Carex</i>
Section:	<i>Glareosae</i> G. Don
Scientific name:	<i>Carex heleonastes</i> L.f.
Common name:	Hudson Bay sedge
USDA Symbol:	CAHE4
Synonymy:	<i>Carex neurochlaena</i> Holm

Often in technical field manuals, *Carex* is broken into smaller taxonomical categories called "sections." Relatively recent literature lists the section of *C. heleonastes* as *Heleonastes* Kunth emend. Mack. (Toivonen 1981, Gleason & Cronquist 1991), or *Canescentes* (Fries) Christ (Reznicek and Henson 1982). The apparently correct name of this section is *Glareosae* (Reznicek 1990, Toivonen 2002, Table 1). Two subspecies of *C. heleonastes* have been recognized until recently: *C. heleonastes* L.f. ssp. *heleonastes* and *C. heleonastes* L.f. ssp. *neurochlaena* (Holm) Böcher (Kartesz 1994, PLANTS 2001). The treatment of *Cyperaceae* in the Flora of North America Volume 23 does not distinguish these two subspecies (Toivonen 2002). This document likewise does not distinguish these subspecies.

DESCRIPTION OF SPECIES

Carex heleonastes has flowering culms that reach 10 to 40 cm tall (usually taller than leaves), grow erect in small tufts, and are scabrous immediately below the inflorescences (Mackenzie 1940, Welsh 1974, Gleason & Cronquist 1991, Toivonen 2002). Inflorescences consist of head-like clusters of sessile spikes (2-6) that are gynaecandrous. Pistillate flowers have pistils with two stigmas and pistillate scales have a reddish-brown tinge. Bracts are scale-like. Perigynia are not winged, are glabrous, have short beaks (<0.5 mm), and are filled by achenes (Mackenzie 1940, Welsh 1974, Gleason & Cronquist 1991, Toivonen 2002). Refer to Table 2 for more details regarding technical characteristics of *C. heleonastes*.

* Technically the spikes are spikelets, as they are part of a compound inflorescence. Literature, however, generally uses the term "spike" when describing inflorescence of *Carex*.

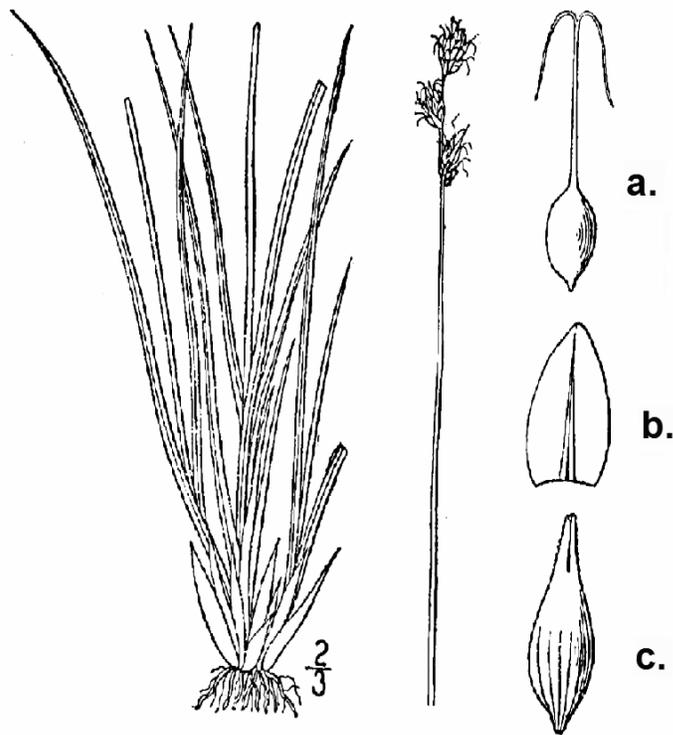


Fig. 1. Drawing of *C. heleonastes*. (a: pistil, b. pistillate scale, c. perigynium). From: Britton, N.L., and A. Brown. 1913. *Illustrated flora of the northern states and Canada*. Vol. 1: 484.



Fig. 2. *Carex heleonastes*: a. inflorescence, b. perigynium. Photo used with permission of A.A. Reznicek.

Table 2. Technical characteristics of *Carex heleonastes* L.f. (Hudson Bay sedge).
References for descriptions: Mackenzie 1940, Polunin 1959, Hultén 1968, Welsh 1974,
Moss 1983, Gleason & Cronquist 1991, Douglas & Ceska 2001, Toivonen 2002.

- General: Perennial, culms in small tufts, in addition to having slender rhizomes. $2n=56$ (Moss, 1983)
- Flowering culms: 10-40 cm tall, usually taller than leaves, triangular, scabrous angles especially on upper stem, slender, erect, and base has a brown tint.
- Leaves: 4-8, originating from the lower fourth of flowering culms, 5-15 cm long, 1-2 mm broad, flat or channeled, scabrous closest to the tip, light green, bluish-green, to grayish-green.
- Inflorescences: 7-30 mm long, 5-10 mm wide, erect, 2-6 spikes (Fig. 1 & Fig. 2). **Spikes** are sessile, 4-10 mm long, 4-7 mm wide, overlapping, clustered in a head (the lower spikes may be 3-12 mm apart), gynaeandrous, few staminate flowers per spike. **Pistillate scales:** Slightly shorter than perigynia, elliptic to ovate, acute to obtuse, with a scarios margin, tinted brown (varying from yellowish, pale to reddish) with hyaline or pale-colored margins, sometimes the midrib is green (Fig. 1b). **Perigynia:** 5-10 per spike; 2-3.5 mm long; 1-1.5 mm broad; planoconvex (one side flat, the other convex); many nerves on each side; lance, elliptic, ovate, or obovate; wingless, although with sharp margins; glabrous; greenish-white below; straw-colored to brownish above or throughout; white-dotted (may be faint) (Fig. 1c). **Perigynia beak:** Short (0.3 - 0.5 mm long), reddish brown, serrulate or smooth. **Stigmas:** Two. **Achenes:** 1.5 mm long by 1 mm broad, filling perigynia, lenticular (convex shaped on both sides), sessile, apiculate, jointed with the deciduous style (Fig. 1f). **Bracts:** Scale-like, lower-most 3-6 mm long
-

LIFE HISTORY

Reproduction

Limited information is available on the life history of *C. heleonastes*. Life history traits of other sedges may be relevant in understanding this species. *C. heleonastes* reproduces sexually with seeds and asexually by a combination of short and long rhizomes (Mackenzie 1940, Gleason & Cronquist 1991).

Sexual Reproduction

Carex heleonastes is monoecious with both pistillate and staminate flowers occurring on each spike. Like most *Carex* species, one would expect that it is self-compatible and wind-pollinated (Catling *et al.* 1990). Mature spikes may be found between June and August (MNFI 1985; Alberta Natural Heritage Information Centre 2002, Appendix 2; Reznicek & Henson 1982). Research suggests that *Carex* species, like other plants that

have rhizomatous (clonal) growth, rarely are able to establish new seedlings (Schütz 2000).

Schütz (2000) and Schütz and Rave (1999) researched seed germination of European *Carex* species. Although these species are from a different continent, the biology of European species is probably similar to North American species. Schütz (2000) found that *Carex* species have primary dormancy, in which ripe seeds are dormant until the dormancy mechanism is broken. To be released from dormancy, the seeds of many *Carex* species must go through cold stratification. In a study of 32 temperate *Carex* species, Schütz & Rave (1999) determined that 70-80% of species had increased germination rates after a period of cold stratification. This dormancy cycle prevents seeds from germinating in the summer when competition with other plants would make their establishment difficult (Schütz 2000).

The seeds of many *Carex* species are believed to go through annual dormancy cycles (Schütz 2000). Each year cold winter temperatures may release the seeds from dormancy (Schütz 2000). Schütz (2000) indicates that in the spring, germination is initiated when a combination of specific conditions occurs including relatively high temperatures, daily fluctuations in temperatures, and light exposure. If seeds do not germinate in the spring, the seeds may become secondarily dormant as the temperature rises (Schütz 2000).

Schütz (2000) also indicates that most *Carex* species have persistent seed banks. Results from many studies have shown that viable *Carex* seeds tend to occur in deep soil layers, suggesting that the seeds can persist for decades in the soil (McGraw *et al.* 1991, Hendry *et al.* 1995, Schütz 2000). Studies indicate that *Carex* species from a wide range of habitats, including fens, have persistent seed banks (Schütz 2000).

Research has shown that in some *Carex* species of the arctic or alpine regions, primary induction of flowering shoots (development of floral primordia) begins in the fall and overwinters, while secondary induction (culm elongation and inflorescence development) tends to occur in the spring and summer (Bernard 1990, Heide 1997). Additional flowering shoots may begin developing in the spring and summer, although at a slower rate than the first shoots of the spring. Flowering shoots die after fruit dispersal, which is often within a year of development (Bernard 1990, Heide 1997). In areas with short growing seasons, flowering shoots may take multiple years to develop, depending on the conditions (Alexeev 1988).

Many species of *Carex* hybridize with one another. Hybrids of *C. heleonastes* and *C. canescens* (*C. canescens* L. x *heleonastes* L. f.) have been found in Scandinavia and British Columbia (Toivonen 1981). These hybrids have physical characteristics that are intermediate of the parent species. The hybrids are apparently sterile as pollen of the hybrids was abortive and no perigynia examined were ripe (Toivonen 1981).

Asexual Reproduction

The development of *Carex* genets (genetically distinct individuals) can be divided into five stages (Alexeev 1988). After germinating from the seed, the genet is a seedling for

the first year. For the following two to three years, the genet is a juvenile. During the third stage, it is a mature virgin that reproduces vegetatively by rhizomatous growth and non-flowering shoots. Generative individuals, during the fourth stage, have flowering shoots, in addition to vegetative growth. An aging genet is the final stage that consists of non-flowering shoots and senescent shoots and roots. Some researchers suggest that different parts of a genet may be in different developmental stages (Bernard 1990). Depending on conditions, some species take seven to eight years to reach the generative stage in which flowering occurs (Alexeev 1988). A genet could theoretically live hundreds or thousands of years. Studies have indicated that genets of certain species live at least 10 to 50 years (Bernard 1990). Using DNA tests to distinguish culms of distinct genets, Steinger *et al.* (1996) determined that one genet of *C. curvula* has more than 7000 culms. Given the average annual rate of growth of the genet, they expect that the plant is over 2000 years old.

In a literature review, Bernard (1990) describes what is known regarding the vegetative reproduction of *Carex* species. The morphology of the rhizomes that a *Carex* species has determines its growth form (Bernard 1990). Some species produced long rhizomes creating a matted growth form. Other species have only short rhizomes; consequently each genet of these species consists of a single tiller clump. *C. heleonastes* has the third type of growth form, in which plants produce a combination of long and short rhizomes (Gleason & Cronquist 1991). This growth form consists of tufts or tiller clumps that are matted together (Bernard 1990).

Ecology

Conditions in the fall may contribute to the number of flowering stems of *Carex* species during the following spring. Growing arctic-alpine species of *Carex* in growth chambers, Heide (1997) determined that a combination of temperature and photoperiod (daylight length) conditions during a primary induction period affect the percent of plants that flower and the number of culms per plant that flower during a secondary induction period. Such research suggests that a combination of the photoperiod and temperatures in the fall influence the numbers of flowering culms in the spring.

Fungi (including arbuscular mycorrhizal, ectomycorrhizal, and dark septate fungi) have been found in association with the roots of certain *Carex* species (Miller *et al.* 1999). The fungi may have a mutualistic relationship with these *Carex* species, as such an association has been found in other plant groups. This relationship, however, is probably not obligate since fungi have been found seasonally or only in some populations of a given species (Miller *et al.* 1999). In a study of 23 *Carex* species in Illinois, 16 had arbuscular mycorrhizal fungi present in the roots (Miller *et al.* 1999). From that study, Miller *et al.* found that *Carex* species occurring in alkaline conditions were more often associated with mycorrhizal fungi than those occurring in acidic conditions. Species of wet habitats were less likely to have a mycorrhizal association (Miller *et al.* 1999). Symbiotic fungi associations have not been studied in *C. heleonastes*.

HABITAT

Range-wide

Most sources indicate that *C. heleonastes* occurs in open areas that are wet or damp (Appendix 1). Some sources and site descriptions (see Appendix 2) indicate that *C. heleonastes* occurs in "bogs" or "fens." Bogs and fens produce a peat layer due to slow decomposition rates of plant material (Crum 1992). Fens usually have an influx of mineral-rich water draining from calcareous rock that makes the water alkaline, and they are usually dominated by sedges. Bogs have mineral-poor water that is acidic, and they are usually covered by a layer of *Sphagnum* moss (Crum 1992). Böcher (1952) looked at specimens of *C. heleonastes* from throughout the world and reviewed literature of the time concerning the species. He concluded that the species occurs in mesotrophic conditions based on literature from Norway. Mesotrophic plants are suited for soil with intermediate mineral content and neutral acidity (Crum 1992).

The use of the word "fen" and "bog" in habitat descriptions of *C. heleonastes* suggest that the species may tolerate a variety of pH conditions. However, the definitions for these words given by Crum (1992) may not have been used strictly by authors or site surveyors. For example, the terms "calcareous" or "alkaline" are used to describe bogs in a few descriptions (MNFI 1985, British Columbia Conservation Data Centre 2002, Appendix 2) which seems incompatible with Crum's definition of a bog as acidic. The occurrence of the term "bog" in some descriptions may be the result of the superficial similarities of fens and bogs. For example, some species of *Sphagnum* are common in fens (Crum 1992), and may influence a surveyor to describe a calcareous peatland as a bog.

One might expect that in North America, *C. heleonastes* tends to occur in calcareous wetlands or fens, more often than bogs. Like 60% of arctic-alpine species found in the Lake Superior Basin (Given and Soper 1981), the population in Michigan occurs in a calcareous peatland (MNFI 1985). An association of *C. heleonastes* with calcareous substrates is mentioned in three published habitat descriptions including Gleason and Cronquist (1991) covering eastern North America, Scoggan (1978) covering Canada, and Moss (1983) covering Alberta. More detailed habitat descriptions and consistent use of terminology is needed to improve the classification of the habitat. Other habitats listed in descriptions include lake shores, swamps, wet sandy roadside, and seeps. Appendix 1 contains habitat descriptions from technical plant manuals.

National Forests

Hiawatha National Forest, Michigan

The single population of *C. heleonastes* in Michigan occurs in a patterned fen. A patterned fen is "a minerotrophic shrub-herb peatland characterized by sedge peat ridges (strings) and hollows (flarks) oriented across the slope and perpendicular to the flow of groundwater" (MNFI 2003). *Carex heleonastes* is "[r]are but widespread in open, fen-like, sedge-dominated swales" (Reznicek & Henson 1982). The open swales that *C. heleonastes* is found occur within "a sparse, wet, woodland of stunted *Picea mariana* with scattered *Larix laricina* and *Thuja occidentalis*" (Reznicek & Henson 1982).

Dominant species within the openings include *Scirpus hudsonianus*, *Carex limosa*, *C. diandra*, *Smilacina trifolia*, and *Rubus pubescens* (Reznicek & Henson 1982). Other species associated with *C. heleonastes* include: *Saxifraga pennsylvanica*, *Cypridedium reginae*, *Cypridedium calceolus*, *Eriophorum viridicarinatum*, *Lonicera* spp. *Ledum groenlandicum* (MNFI 1985).

The patterned fen has calcareous soil that has a pH of 7.0 to 8.0 (MNFI 1985). The soils are of Carbondale muck and Rifle peat (MNFI 1985). The rock below the soil consists of dolomite, limestone, and other marine sedimentary rocks (Ludwig 1994). The elevation varies from 785 ft. to 838 ft (Ludwig 1994). The soils are rich in magnesium and have shallow peat deposits (3-4 ft. deep). The average annual snowfall in the area is 80-120 inches and the average annual rainfall is 32-34 inches (Ludwig 1994).

DISTRIBUTION AND ABUNDANCE

Range-wide Distribution

C. heleonastes is a circumpolar species that occurs in primarily northern areas of Eurasia and North America (Böcher 1952). In Asia the species occurs in parts of the former U.S.S.R. including Caucasus, Ciscaucasia, West Siberia, and East Siberia (Krechetovich 1935). In Europe *C. heleonastes* occurs in northern European countries including Finland, Germany, Norway, Poland, Russia, Iceland, and Sweden. The species also occurs in mountainous areas in the Alps (Austria, France, Italy, and Switzerland), isolated areas of the eastern Carpathians (Romania), and western Bulgaria (Tutin *et al.* (eds.) 1980). In North America the species occurs in widely disjunct populations from Alaska, the Yukon, and British Columbia in the west to Labrador in the east (NatureServe Explorer 2001). A distantly disjunct population occurs in the Upper Peninsula of Michigan. Table 3 displays the ten Canadian provinces and two U.S. states in which the species occurs.

In an examination of the "*Carex heleonastes -amblyorhyncha* complex," Böcher (1952, p. 25) indicates that *C. heleonastes* is "surprisingly rare" in North America, compared to Eurasia. Abundance information, from the two U.S. states and ten Canadian provinces in which the species occurs (Table 3), supports Böcher's statement. The information suggests that *C. heleonastes* is not common in any part of Canada or the United States.

Böcher (1952) states that the primary range of *C. heleonastes* is "markedly subarctic-continental." He also notes that the main range of *C. heleonastes* was covered by large ice sheets during the last glaciation. The species may have survived the glaciation in northern Russia and West Siberia and expanded its range to its present locations (Böcher 1952). Other isolated occurrences in Europe may be relict populations that survived the glacier.

Table 3. Abundance of *C. heleonastes* in each Canadian province and U.S. state in which it occurs.

Location	Abundance
Alaska	"Widely disjunct sites in much of mainland Alaska and Yukon..." (Welsh 1974). No occurrences are documented on the two National Forests in Alaska (Rob Lipkin pers. comm. 2002). Five element occurrences are listed by the Alaska Natural Heritage Program (2002, Appendix 2).
Michigan	Michigan has one known occurrence. "The Schoolcraft County station ... represents the first record for Michigan and for the contiguous United States. [<i>C. heleonastes</i>] is confined at that site to a small area, and has not been found in apparently similar habitat nearby" (MNFI 1985).
Alberta	"A rare Alberta species" (Kershaw <i>et al.</i> (eds.) 2001). Sixteen occurrences are listed by the Alberta Natural Heritage Information Centre (Appendix 2).
British Columbia	"Rare in BC east of the Coast-Cascade Mountains" (Douglas & Ceska 2001). Nine occurrences are list by the British Columbia Conservation Data Centre (Appendix 2).
Labrador	One Labrador site is indicated on the map showing the range of <i>C. heleonastes</i> in Porsild & Cody (1980).
Manitoba	No specimen is at the University of Manitoba (WIN) herbarium in Manitoba. The curator, Dr. Bruce Ford, once saw a potential specimen which was not left at the herbarium (Jason Greenall, pers. comm. 2002). Three records of collections are mentioned by Scoggan (1957) in <u>Flora of Manitoba</u> (Appendix 2).
Northwest Territories	"In our area known from a single collection in Nahanni National Park." (Porsild & Cody 1980).
Nunavut	No Nunavut sites are indicated on the map showing the range of <i>C. heleonates</i> (Porsild & Cody 1980).
Ontario	About 12 known occurrences are located exclusively in the Hudson Bay lowlands (Michael Oldham pers. comm. 2002). Possibly 5 additional sites were located by Michael Oldham in 2000 and 2001.
Quebec	"Rare in ... Quebec..." (Argus & White 1982). Four Quebec sites are indicated on the map showing the range of <i>C. heleonastes</i> (Porsild & Cody 1980; Blondeau 1987, Appendix 2).
Saskatchewan	"Small number of sites unevenly distributed" (Saskatchewan CDC 2002). The Saskatchewan CDC lists 13 occurrences (Saskatchewan CDC 2002).
Yukon Territory	"Known in the Mayo area of the Yukon Territory and considered rare by Douglas <i>et al.</i> (1981)" (Cody 1996).

Böcher (1952) did not hypothesize on reasons for the sporadic distribution of the species in North America. Boreal or prairie zones are in the southern and central parts of Alberta, Saskatchewan, Manitoba, Ontario, and Quebec; while Michigan is primarily in a deciduous forest zone (Given and Soper 1981). If *C. heleonastes* is a subarctic species (as was suggested by Böcher), populations in these regions are south of the species' primary range; such populations may be restricted to areas with an arctic-alpine element.

Given and Soper (1981) in a review of literature discuss possible explanations for the existence of species typically found in arctic or alpine conditions that are located in disjunct locations such as the Lake Superior Basin. They indicate that the most probable explanation is that the populations are relics of a previously wider distribution of the species that followed the recession of the last glaciation. Given and Soper (1981) cite numerous studies that have found fossil records of pollen from tundra-type plants in the contiguous United States. In particular, they cite a study by Miller and Bennighoff (1969) that describes a plant deposit in northern Michigan from 13,300 to 12,500 years before the present (BP) that contained pollen from tundra flora. Given and Soper indicate that arctic-alpine conditions tend to persist in habitats such as cliffs, lake shores, and river gorges. Such conditions are known in parts of the Gulf of St. Lawrence, Manitoba, Alberta, Saskatchewan, and near the shores of the Great Lakes (Given & Soper 1981).

The sporadic distribution of *C. heleonastes* in North America may relate to its habitat requirements. Like other arctic-alpine flora, *C. heleonastes* tends to occur in calcareous soils (Scoggan 1978, Gleason & Cronquist 1991). Argus and White (1982) indicate that it occurs, more specifically, in fens. Calcareous fens are "probably one of the rarest [wetland plant communities] in North America" (Eggers & Reed 1986). More details in habitat descriptions, consistent terminology, and research on the habitat requirements of *C. heleonastes* are needed to clarify if the species is limited by specific habitat requirements.

State and National Forest Distribution

Michigan: The only population in the Eastern Region of the U.S. Forest Service occurs on the Hiawatha National Forest. The population was discovered in 1981 by Don Henson and is the only population that is documented in the lower 48 States (Reznicek & Henson 1982).

Since 1831, botanists have recognized an arctic-alpine element in the Lake Superior Basin (Given & Soper, 1981). Given and Soper (1981) identified 48 species that have primarily an arctic-alpine range that occur in the Lake Superior Basin. *C. heleonastes* is an addition to their list as the population in Michigan was not discovered until after their publication (Reznicek & Henson 1982). Most species listed by Given and Soper are in rocky habitats along the lake shore, while the Michigan population of *C. heleonastes* is about 10 miles from Lake Superior and in a wetland. Most of the species listed also occur on the north shore of Lake Superior, while the one known population of *C. heleonastes* in the Lake Superior Basin is near the south shore. Like 60% of the species that Given and Soper identified, the population of *C. heleonastes* in the Lake Superior Basin grows in calcareous soil (MNFI, 1985).

RANGE WIDE STATUS

Range wide status can be assessed by a ranking system developed by The Nature Conservancy, NatureServe, and the Natural Heritage Network (NatureServe Explorer 2001). This ranking system uses information on species that are tracked by The Nature Conservancy and Natural Heritage Programs throughout the world. The global ranking (G-rank) gives the status of a species throughout its range. Each country that the species occurs has a national ranking (N-rank) that indicates the species vulnerability within that country. If the species occurs within the boundaries of provinces, states, or other divisions within a country, the species is given a subnational ranking (S-rank) for that area (NatureServe Explorer 2001).

The number or letter following G, N, or S is the ranking of the current vulnerability of the species within the given geographical boundary. Numeral ratings range from 1 to 5. The more vulnerable a species is to extirpation within the given geographical boundary, the lower the numeral rating (NatureServe Explorer 2001). If a letter or punctuation follows the G, N, or S, the current status has not been determined; the letter indicates what is known about the species (Nature Serve Explorer 2001).

Table 4. Subnational rank (S) of *C. heleonastes* in the U.S. states and Canadian provinces that it occurs as listed by NatureServe (2001). (S1 = critically imperiled, S2= imperiled, S2S3= imperiled to vulnerable, SR= reported, S?= unranked).

U. S. State	Subnational Rank	Canadian Province	Subnational Rank
Alaska	S2	Alberta	S2
Michigan	S1	British Columbia	S2S3
		Labrador	SR
		Manitoba	S2
		Northwest Territories	SR
		Nunavut	SR
		Ontario	S2
		Quebec	S?
		Saskatchewan	S2
		Yukon Territory	SR

C. heleonastes has a global rank of "G4" indicating that it is "apparently secure" throughout most of its range (Nature Serve Explorer 2001). The national rank in the United States is "N2" (02 Oct. 2000) indicating that it is "imperiled" in this country. The status of *C. heleonastes* is "critically imperiled" in Michigan (S1) with only one known population and "imperiled" (S2) in Alaska (Table 4, NatureServe Explorer 2001). *C. heleonastes* is also listed as "endangered" by the State of Michigan (MNFI 2002). In Canada, the National Heritage Status of *C. heleonastes* is unranked (N? [08 Aug. 1993]). *C. heleonastes* is "reported" (SR) or "unranked" (S?) in 5 of the 10 Canadian provinces that it occurs (Labrador, Northwest Territories, Nunavut, Quebec, and Yukon). *C. heleonastes* is ranked between "imperiled" and "vulnerable" in British Columbia, while it is ranked as "imperiled" (S2) in Alberta, Manitoba, Saskatchewan, and Ontario (Table 4).

Ranking by States and the U.S. Forest Service

The Eastern Region (Region 9) of the U.S. Forest Service has listed *C. heleonastes* as a Regional Forester Sensitive Species (RFSS) on the Hiawatha National Forest in Michigan (USDA Forest Service 2000).

POPULATION BIOLOGY AND VIABILITY

The population biology and viability of *C. heleonastes* have not been studied. However, other species within the same genus or with a similar growth form may share some common characteristics. In other *Carex* species, the numbers of flowering culms per genet may fluctuate from one year to the next depending on conditions during the fall such as temperatures and photoperiod (Heide 1997). *Carex* species that grow rhizomatously tend to reproduce sexually infrequently (Eriksson 1989) and be long-lived (Bernard 1990). The combination of a matted and tuft growth form present in *C. heleonastes*, may allow the species to exploit open space quickly and grow rapidly (Bernard 1990). Possibly the habitat requirements of the species (i.e. dependency on arctic-alpine conditions and possibly calcareous soil) prevents it from expanding its range beyond the current location in Michigan.

Given the scattered distribution of *C. heleonastes* in North America, one might expect that populations have been isolated from one another for many generations. Isolated populations tend to lose a different assortment of alleles over time through genetic drift (the random fluctuation of allele frequencies within a population) (Futuyma 1986). If the populations are not large enough to replenish the loss of alleles by mutations and there is no gene flow (via seeds or pollen) from other populations, genetic variation of the populations would be expected to decrease (Futuyma 1986). Populations widely distributed may also adapt to different conditions. Such adaptations may favor certain alleles in one population that are not favored in others, making the populations more genetically distinct (Futuyma 1986). Low genetic variability may make a species less capable of adapting to changes in the environment (Primack 1993, pp. 253-276).

Studies of other boreal or arctic sedges indicate that a few other *Carex* species with disjunct populations have low genetic variation. *C. rariflora* and *C. paupercula* are circumboreal sedges that, like *C. heleonastes*, have disjunct populations scattered across North America (Vellend & Waterway 1999). Studies of allozyme frequencies of these two species reveal that the species have low genetic variability within populations and populations are quite genetically differentiated (Vellend & Waterway 1999). Seven other arctic sedges that have been studied have relatively high genetic variation (cited by Vellend & Waterway 1999). These seven species, however, are common and dominant in their habitats.

The habitat descriptions (Appendix 2) give few clues to the general population structure of *C. heleonastes*. The population in Michigan, two populations in Alberta (Element Occurrence 1 and 2), and one population in British Columbia are described as growing at a relatively low density (Appendix 2). Possibly the species often has a low density, at least in areas south of its primary range in the subarctic, but other descriptions have not included such information.

The population of *C. heleonastes* on the Hiawatha National Forest is not only at the edge of its range, but also may be distantly disjunct from other populations. The viability of the population is dependent on the arctic-alpine conditions that have been associated with the Lake Superior Basin. Such conditions may include calcareous soils, cooler summer temperatures, longer spring conditions, and high snow fall amounts related to lake-effect snow (Given & Soper 1981).

The population of *C. heleonastes* on the Hiawatha National Forest is described as "rare but widespread" (Reznicek & Henson 1982). The species apparently is confined to a single fen area (MNFI 1985). This population most likely has very little or no immigration of seed or pollen material from other populations for quite some time as the closest known population is over 370 miles away. Although the population is not noticeably small (Reznicek pers. comm. 2002), such an isolated population is likely to have low genetic variability and be genetically distinct from other populations.

POTENTIAL THREATS

C. heleonastes is rare in North America to a degree that protecting and monitoring populations is appropriate in at least five of the ten Canadian provinces that it occurs and both of the U.S. states in which it occurs. A Natural Heritage ranking of "imperiled" in the U.S. (N2) implies that the species is in imminent danger of extirpation in this country. However, the urgency implied by the species' ranking in the U.S. is weakened by the fact that the species is circumpolar and has a global ranking of "apparently secure" (G4). In addition, the species has probably been rare in North America since arctic-like conditions retreated after the last glaciation. One would expect that a naturally rare species may be more adapted to the rare condition, than species that become rare suddenly by human influences. Moreover, no evidence suggests that known populations are declining. Such factors suggest that current populations are not in immediate peril.

Present or Threatened Risks to Habitat

Climate change may be a significant threat to populations of *C. heleonastes*. Scientists throughout the world have predicted that a worldwide warming trend (global warming) is beginning to occur and will continue to increase during the coming century (Primack, 1993, pp. 157-161; Levitus *et al.* 2001). Global warming is an expected effect of the increase in carbon dioxide and other "greenhouse gases" in the atmosphere from human activities (Primack, 1993, pp 157-161; Levitus *et al.* 2001). Given that *C. heleonastes* is a subarctic species (Böcher 1952), populations at the southern margin of the species' range in Canada and the U.S. may be negatively affected by an increase in annual temperatures. The population in the Upper Peninsula of Michigan may be very vulnerable to extirpation if annual temperatures increase. This population is distantly disjunct from other populations and may persist due to the cooling effect of being within ten miles of Lake Superior. A slightly warmer climate could make the habitat unsuitable.

The population on the Hiawatha National Forest in Michigan is located close to an old railroad grade that has been turned into a snowmobile trail. Emissions from snowmobiles crossing the wetland could affect the population. Snowmobiles have been cited by the

EPA as releasing almost 100 times the pollution as an average car (EPA 2001). The U.S. Geological Survey undertook a chemical analysis of the snowpack and snow runoff along snowmobile trails relative to off-road snowpack in Yellowstone National Park (Ingersoll, 1998). The results indicate that elevated levels of chemicals emitted by snowmobiles are found in the snowpack along trails. Ammonium and sulfates are "reliable indicators of snowmobile emissions in nearby snowpacks" (Ingersoll, 1998). Concentrations of hydrocarbons especially toluene, benzene, and xylenes are also elevated in the snowpack within trails as well as the snowmelt runoff along snowmobile trails. The amount of chemicals in the snow correlates with the amount of snowmobile traffic (Ingersoll, 1998). The level of the threat that the snowmobile trail in Michigan poses is unknown since the amount of snowmobile traffic has not been determined.

In addition, the railroad grade passing through the fen in Michigan does not have culverts and a disruption in water drainage has been visible by "pooling" on one side of the grade (Ludwig 1994). The *C. heleonastes* population could be affected by the disruption in waterflow in the wetland caused by the railroad grade. On the other hand, a restoration of the natural hydrology could also affect the population negatively.

Disease or Predation

Smuts and leaf-galls are two potential parasites of *C. heleonastes*. Smuts (a type of fungal infection) are known to infect *Carex* species. Smuts in the *Anthracoidea* genus are known to infect species related to *C. heleonastes* (Toivonen 1981). A species of nematode, *Anguina caricis*, has been documented to make galls on leaves of *C. heleonastes* and other *Carex* species in Russia (Solov'eva & Krall'1982). Galls on *C. heleonastes* in North America have not been documented.

Carex leaves are an important food source for both wild and domestic animals, especially in the arctic (Bernard 1990). *Carex* plants that are grazed upon, can regrow new leaves since the meristems of the shoots are usually not damaged (Kotanen & Jefferies 1989). Although herbivory is usually not beneficial to plants, its negative effects may be mild (Barbour *et al.* 1987). Herbivory may shorten the life of individual shoots (Bernard 1990). Plants, including a few arctic sedges, have compensatory growth, in which defoliation may trigger the plant to grow new tissue at a faster rate (Barbour *et al.* 1987, Kotanen & Jefferies 1989). One site description in British Columbia indicates that grazing cattle were in the vicinity of a *C. heleonastes* population (Appendix 2). No information is available on how or if herbivory affects populations of *C. heleonastes*.

Other Natural or Human Factors

Potentially the lack of knowledge regarding *C. heleonastes* populations could prevent needed management of populations if the species begins to decline. Information regarding populations of *C. heleonastes* in North America may be limited due to its habitat and graminoid form. The wetland habitat in which *C. heleonastes* typically occurs, tends to be less accessible by vehicles than terrestrial habitats and may lead to fewer populations being located or monitored. *Carex* species may be overlooked by many people as they are quite inconspicuous and difficult to distinguish. Being inconspicuous and occurring in inaccessible locations, however, may protect the

populations to some degree. Such a species is not threatened by being picked or collected by the general public for its attractiveness. The species' habitat is not often disturbed by humans since such remote wetlands are not usually suitable for development or other human uses. On the other hand, if populations were declining, documentation of the decline could be unnoticed for many years.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

The only known occurrence of *C. heleonastes* in Michigan is within the Hiawatha National Forest. In that forest it is within an area that is a candidate Research Natural Area (RNA). The species is protected by its classification as a Regional Forester Sensitive Species on the National Forest and it is also recognized as "endangered" by the State of Michigan.

Populations in Alaska and Canada are somewhat protected by the remoteness of their locations. Some of the occurrences listed in Appendix 2 are in parks and wilderness areas. One population in Alaska is in the Arctic National Wildlife Refuge (Alaska Natural Heritage Program 2002). In Alberta populations are in Goose Mountain Ecological Reserve, Jasper National Park, Brazeau Tufa Natural Area, and Willmore Wilderness Park (Alberta National Heritage Information Centre 2002). In British Columbia a population is in Tweedsmuir Park (British Columbia CDC 2002). In Ontario some populations are in Polar Bear Provincial Park (Ontario National Heritage Information Centre 2002). In the Northwest Territory, the one known population is in Nahanni National Park (Porsild & Cody 1980).

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

Böcher (1952) clarified the taxonomy of *C. heleonastes* in addition to theorizing on the habitat and distribution of the species. Other publications discuss newly discovered populations and physical characteristics of the species (Blondeau 1987, Reznicek & Henson 1982)

C. heleonastes is a target species during rare plant surveys on the Hiawatha National Forest prior to management activities. However, no new populations have been located from these surveys. Michael Oldham of the Natural Heritage Information Centre in Ottawa Ontario has surveyed for *C. heleonastes* in recent years and located potentially five previously unknown populations (Mike Oldham pers. comm. 2001). He intends to search more potential habitat in Ontario in the future.

Survey Protocol

Surveying likely habitats for *C. heleonastes* could reveal undiscovered populations. Undiscovered populations may exist given that the species is inconspicuous, difficult to identify, and it occurs in somewhat remote locations. Although the patterned fen in which the Michigan population occurs is quite unique to the area, other populations could exist in the Lake Superior Basin. Michael Oldham (pers. comm. 2002), of Ontario's

Natural Heritage Information Centre, indicates that potential habitat occurs in the Hudson Bay lowlands of Ontario and along the north shore of Lake Superior.

Surveys for *C. heleonastes* should be performed by botanists that are experienced in identifying and locating sedges. Likely habitat should be identified and be searched. On the Hiawatha National Forest, fens near Lake Superior, in particular near the known population, may be the most likely locations of other populations. Surveys should be performed when fruit are most likely to be ripe (mid June through early August). Any populations that are located should be thoroughly described including details such as associated species, numbers of flowering and fruiting culms, the area the population covers, and the pH of the soil at the location.

Research Priorities

Like many *Carex* species, very little is known about the biology of *C. heleonastes*. The *Carex* genus has, until relatively recently, been an under-studied genus (Catling *et al.* 1990). Research on the life history, ecology, habitat, and population genetics of *C. heleonastes* would be interesting and useful for managing populations.

1. Monitoring known populations is an important first step in understanding the life history of *C. heleonastes*. Simple descriptions of the size and structure of populations annually could indicate if populations are increasing in size or decreasing. If monitoring could incorporate environmental conditions, one might be able to relate changes in population sizes to changes in the environment. One might, for example, be able to determine if fall weather influences the number of flowering culms the following spring, as has been determined for other species (Heide 1997). One might also be able to determine if new seedlings establish regularly.
2. In Michigan, the amount of snowmobile traffic traveling through the fen that *C. heleonastes* occurs should be determined. If the traffic is not heavy, snowmobiling may not be a significant threat. However, if traffic is relatively heavy, the snowmobile trail could be an immediate threat to the population of *C. heleonastes*. Sulfates are one of the most notable chemicals found in snowpack along snowmobile trails in Yellowstone National Park (Ingersoll, 1998) and are also one of the chemicals associated with acid rain (Primack 1993, pp. 152). Given that the fen in Michigan has naturally high pH levels, plants including *C. heleonastes* and other rare species may be sensitive to a decrease in pH levels. Especially if snowmobile traffic is heavy, a study of the snowmobile by-products that enter the fen should be carried out. Such a study could indicate if the pollution will affect the chemistry of the fen. If the snowmobile traffic is affecting the fen, the snowmobile trail should be re-routed or steps should be taken to decrease the numbers of snowmobiles using this particular trail.
3. Habitat descriptions of *C. heleonastes* do not clearly indicate the habitat requirements of this species. The species may be limited to calcareous conditions (see "Habitat" section). Research of herbarium records could improve the details

of the habitat descriptions presented in this document. A list of associated species in each habitat might suggest if the conditions are in fact acidic or alkaline. Certain locations that *C. heleonastes* is known to occur may have documented information concerning the soil type and habitat. Visiting sites of *C. heleonastes* and describing the habitat in detail would also improve the understanding of the species. Another method to understand the species' habitat requirements would be to perform a greenhouse experiment in which seeds or rhizomes are grown in different soils (or with other variables) to determine what conditions limit the species' growth and what conditions promote the species' growth.

4. A population genetics study of *C. heleonastes* would be very interesting and informative. One could sample a portion of plants throughout North America to determine the population genetics of the species. As was described in the section "Population Biology and Viability," one might expect that populations of *C. heleonastes* are genetically distinct and isolated populations would have low genetic variation. Such a study might suggest how long populations have been isolated from one another by the genetic variances between the populations. Such a study would not only increase information about this species, but it would also contribute to the general pool of knowledge concerning population genetics.

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APPENDIX

Appendix 1. Habitat descriptions of *C. heleonastes* throughout the species' range. Note that these descriptions are from technical field guilds from specific areas that may include general range-wide descriptions.

Range-wide	"Mesotrophic bog plants" (Böcher 1952). "Wet open places and mossy bogs" (Polunin 1959).
Asia	Russia: "Peat bogs" (Krechetovich 1935).
Europe	"Damp places" (Tutin <i>et al.</i> (ed.) 1980).
North America	"Wet open places" (Mackenzie 1940). "Mires, damp meadows lowlands, 0-1500 m" (Toivonen 2002).
Canada	"Wet open places and shores (often calcareous)" (Scoggan 1978).
Alberta	"Bogs and marshes, often calcareous" (Moss 1983). "Wet, calcareous sites such as fens and marshes" (Kershaw <i>et al.</i> (eds) 2001). Of the 16 occurrences listed in the Alberta Natural Heritage Information Centre (2002, Appendix 2), 6 were described as occurring in bogs, 5 occur in fens, 1 occurs in a wetland within a forest (<i>Picea engelmannii</i>) and 1 was in a <i>Salix</i> meadow. The average elevation of the 16 occurrences was 953 meters.
British Columbia	"Bogs and fens in the montane zone" (Douglas & Ceska 2001). Of the nine populations listed by the British Columbia Conservation Data Centre (2002, Appendix 2), four were described as occurring in fens or calcareous bogs, one was in a bog, one in a meadow, one in a wet pebbly beach, and two had no habitat descriptions. Associated Species (listed in at least one site): <i>Betula glandulosa</i> , <i>Carex limosa</i> , <i>Carex paupercula</i> , <i>Carex</i> spp., <i>Eriophorum chamissonis</i> , <i>Salix pedicellaris</i> , and <i>Sphagnum</i> species.
Northwest Territories	"Northern peat bog species" (Porsild & Cody 1980).
Ontario	"Fens" (Argus & White 1982).
Saskatchewan	"Wet open bogs, fens and shores" (Saskatchewan Conservation Data Centre [CDC] 2002).
Yukon	"Peat bogs" (Cody 1996).
United States	

Appendix 1. Habitat descriptions of *C. heleonastes* throughout the species' range. Note that these descriptions are from technical field guilds from specific areas that may include general range-wide descriptions.

<u>Alaska</u>	"Peat bogs, swamps." (Hultén 1968). "Muskegs, bogs, and seeps" (Welsh 1974). Of the five populations recorded by the Alaska Natural Heritage Program (2002, Appendix 2), two were found in black spruce muskegs, one was at the edge of a marly pond, one was on a wet sandy roadside, and one had no habitat description.
<u>Eastern U.S.</u>	"Wet open places, especially in calcareous regions" (Gleason & Cronquist 1991).
<u>Michigan</u>	A single population found in 1981 occurs in a patterned fen on the Hiawatha Nation Forest (See habitat description below, Reznicek & Henson 1981).

Appendix 2.

Element Occurrences of *Carex heleonastes*

This appendix lists element occurrences of *Carex heleonastes* L.f. in the two U.S. states that it occurs (Michigan and Alaska) and in Canadian provinces that had occurrence information available on the species (Alberta, British Columbia, Manitoba, and Ontario). Descriptions are in alphabetical order by U.S. state and then Canadian province.

Alaska

Location: Arctic National Wildlife Refuge, Alaska
Dates observed: August 1954
Habitat: "Small undrained marly pond, at pond margins, with *Kobresia simpliuscula*."
Source of information: Alaska Natural Heritage Program 2002.

Location: Seward Peninsula, Alaska
Dates observed: July 1993
Habitat: "wet sandy roadside . . . near airstrip".
"wet sandy roadside"
Source of information: Alaska Natural Heritage Program 2002.

Location: Alaska
Year(s) observed: in Hultén, 1941-1950
Source of information: Alaska Natural Heritage Program 2002.

Location: Alaska
Dates observed: August 1949

Habitat: "Morainic till, in burned muskeg; in pools in burned black spruce; and in DRYAS moss slough."
Source of information: Alaska Natural Heritage Program 2002.

Location: Alaska
Dates observed: July 1968
Habitat: "Black spruce muskeg."
Source of information: Alaska Natural Heritage Program 2002.

Michigan

Location: Schoolcraft County, Michigan
Dates observed: June 1981, 1982
Habitat: "An alkaline *Picea-Thuja-Larix* muskeg with many openings; a sphagnum groundcover. Soil: Carbondale muck and Rifle peat, pH. 7-8 Limited to a small area; not found in the surrounding bogs."
Source of information: Michigan Natural Features Inventory 2002.

Alberta, Canada

Location: Alberta
Dates observed: July 1953; July 1963
Elevation (m): 846
Flower maturity: "Mature spikelets."
Population size: 1953: "very widespread over many acres of open part of marsh."
Habitat: "In shallow water in marsh. Among other sedges and grasses in open bog."
Source of information: Alberta Natural Heritage Information Centre 2002 (Occurrence number 1).

Location: Alberta
Dates observed: June 1983
Elevation (m): 1295
Flower maturity: "Very immature spikelets."
Population size: "Scarce."
Habitat: "Patterned fen."
Source of information: Alberta Natural Heritage Information Centre 2002 (Occurrence number 2).

Location: Alberta
Dates observed: August 1961
Elevation (m): 1340
Flower maturity: (Moss notes that the plant is immature and therefore some doubt about ID. [but likely ok-PJC])

Habitat: "Open bog."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 3).

Location: Alberta
Dates observed: August 1974
Elevation (m): 945
Flower maturity: Post-mature spikelets.
Habitat: "Fen."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 4).

Location: Alberta
Dates observed: August 1958
Elevation (m): 1018
Flower maturity: Mature spikelets
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 5).

Location: Alberta
Dates observed: July 1983
Elevation (m): 290
Flower maturity: Mature spikelets
Habitat: "Black spruce-labrador tea-Sphagnum bog."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 6).

Location: Alberta
Dates observed: June 1982
Elevation (m): 610
Flower maturity: Spikelets
Habitat: "Fen."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 7).

Location: Alberta
Dates observed: June 1982
Elevation (m): 693
Habitat: "Buckbean-sedge association."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 8).

Location: Alberta
Dates observed: June 1981
Elevation (m): 1100
Flower maturity: Spikelets

Habitat: "Birch-bog, laurel-sedge fen."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 9).

Location: Alberta
Dates observed: July 1966
Elevation (m): 762
Flower maturity: Spikelets
Habitat: "bog."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 10).

Location: Alberta
Dates observed: July 1966
Elevation (m): 1040
Habitat: "In open bog."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 11).

Location: Alberta
Dates observed: July 1963
Elevation (m): 700
Flower maturity: spikelets
Habitat: "Wet open muskeg."
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 12).

Location: Alberta
Dates observed: June 1981
Elevation (m): 632
Habitat: "Swamp birch-sedge bog"
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 13).

Location: Alberta
Dates observed: August 1976
Elevation (m): 1605
Habitat: "*Picea engelmannii*/*Salix* forest; valley wetland (Sali com?)"
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 14).

Location: Alberta
Dates observed: August 1985
Elevation (m): 1740
Habitat: "Willow meadow along creek."

Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 15).

Location: Alberta
Dates observed: July 2000
Elevation (m): 630
Habitat: "Open rich treed fen along seepage course."
Associated Species: *Picea mariana/Larix laricina/Ledum groenlandicum/
Sphagnum spp.*
Source of information: Alberta Natural Heritage Information Centre 2002
(Occurrence number 16).

British Columbia, CANADA

Location: British Columbia
Dates observed: July 1980
Biogeoclimatic Zone: Sub-boreal spruce, very dry and cold (SBSSxc -WCU).
Associated Species: *Salix pedicellaris, Carex*
Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia
Dates observed: July 1979
Biogeoclimatic Zones: Sub-boreal pine-spruce, very dry and cold (SBPSxc-WCU)
Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia
Dates observed: June 1960
Biogeoclimatic Zones: Boreal white and black spruce, dry and cool (BWBSdk2-
HYH).
Habitat: "In calcareous bog."
Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia
Dates observed: July 1989
Biogeoclimatic Zones: Engelmann Spruce, wet and cool (ESSFwc3 ESSFwk 1 -
QUH).
Habitat: "Fen with *Betula glandulosa* and *Carex*."
Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia
Dates observed: July 1941
Habitat: "Wet shingly beach."
Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia
Dates observed: June 1961

Biogeoclimatic Zones: Upper TSUGA zone; ICHwk1-SHH (Interior Cedar-hemlock, wet and cool); ICHmw3-SHH, (Interior Cedar-hemlock, moist and warm);

Habitat: "Fen."

Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia

Dates observed: August 1972

Biogeoclimatic Zones: Interior Douglas-fir, dry and cool (NTU-IDF dk1)

Habitat: "Meadow."

Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia

Dates observed: July 1983

Biogeoclimatic Zones: Engelmann Spruce-Subalpine Fir, very dry and very cold (ESSFxv-WCU).

Habitat: "Fen; *Carex limosa*, *C. paupercula*."

Source of information: British Columbia Conservation Data Centre 2002.

Location: British Columbia

Dates observed: August 2000

Elevation: 1360 m

Habitat: "In small opening in *Eriophorum chamissonis*-Sphagnum bog with *Potentilla palustris*, *Carex rostrata*, *Equisetum hymenale*, surrounded by *Betula glandulosa*, *Salix pedicellaris*, & *Sphagnum*."

Population size: "130 [plants], all fruiting over 100 x 40 m & 5 pls ca. 80 m E in opening; cattle present but congregated on large *Phalaris arundinacea*-*Carex utriculata* opening."

Source of information: British Columbia Conservation Data Centre 2002.

Manitoba, CANADA

Location: Norway House, Manitoba

Dates observed: 1839

Source of information: Scoggan 1957

Location: York Factory, Manitoba

Dates observed: 1902

Source of information: Scoggan 1957

Location: MacBride Lake, Manitoba

Dates observed: 1956

Source of information: Scoggan 1957

Ontario, CANADA

Location: Kenora District, Ontario
Dates observed: August 1958
Habitat: "Bois de Melege humide."
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1958
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1953
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1973
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1973
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1977
Habitat: "Graminoid fen."
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: July 1978
Habitat: "Fen like edge of lake."
Source of information: Ontario Natural Heritage Information Centre 2002

Location: Kenora District, Ontario
Dates observed: August 1953
Source of information: Ontario Natural Heritage Information Centre 2002

Quebec, CANADA

Location: Vicinity of Schefferville or Lac Knob, Quebec
Habitat: Small populations in the fens
Source: Blondeau & Cayouette 1987; Waterway pers. comm. 2002

Location: Vicinity of Kuujjuak (Fort Chimo), Quebec
Dates observed: July 1982

Associated Species: *Eriophorum angustifolium* and *Scirpus hudsonianus*
Source: Blondeau & Cayouette 1987

Location: Golfe de Richmond, Quebec
Dates observed: July 1982
Habitat: Rich fen
Associated Species: *Carex limosa*, *Menyanthes trifoliata*, *C. chordorrhiza*,
Scorpidium scorpioides, *Salix pedicellaris*, *Myrica gale*
Source: Blondeau & Cayouette 1987

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