

Species Conservation Assessment
For

***Juncus stygius* var. *americanus* Buchenau**
(Moor rush, bog rush)

USDA Forest Service, Eastern Region
Hiawatha National Forest
October 2004



This Conservation Assessment was prepared to compile the published and unpublished information on *Juncus stygius* var. *americanus* Buchenau. This report provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It is an administrative study only and does not represent a management decision by the U.S. Forest Service. Although the best scientific information available was used and subject experts were consulted in preparation of this document and its review, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if the reader has any information that will assist in conserving this species, 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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Outside Reviewers

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National Forest Reviewers

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Herbarium and Heritage Data

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Editorial Committee

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Executive Summary

Juncus stygius var. *americanus* is designated as an R9 Sensitive Species on the Hiawatha National Forest in Michigan's Upper Peninsula, Eastern Region of the Forest Service. It is listed S1S2 in Michigan (Threatened) and S1 in Wisconsin (Endangered), very rare to extremely rare and vulnerable to extirpation, with a G5 global ranking (secure globally, though may be quite rare in parts of its range). Moor rush is listed as special concern in Minnesota where it shows a strong preference for patterned peatlands in the northeastern section of the state (Coffin & Pfanmuller 1988). The purpose of this document is to provide the background information necessary to prepare a Conservation Approach that will ultimately include management actions to conserve this species.

Commonly known as moor rush or bog rush, this species has an interrupted circumboreal distribution, with the main part of its range centered in Canada. In the United States it is scattered throughout south central Alaska, the Midwest, and New England. *Juncus stygius* var. *americanus* is characteristic of cold, wet, weakly acidic habitats, especially those where fluctuating water tables create vegetative gaps. It tends to grow singly or in small clumps with 1-4 striped reddish brown flowers in 1-3 heads. This perennial plant flowers in late summer (fertile July to August). *Juncus stygius* var. *americanus* has very specific hydrology requirements; therefore, the principal threats are large-scale disturbances to its peatland habitat and surrounding watersheds. These threats include mineral exploration, peat mining, pollution of watershed waters, alterations of hydrologic regime, and acid rain.

Introduction/objectives

The National Forest Management Act and USDA Forest Service policy require that National Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has established populations and a distribution of reproductive individuals sufficient to ensure the continued existence of the species throughout its range within a given planning area. In addition to those species listed as Endangered or Threatened under the Endangered Species Act, or Species of Concern by the U.S. Fish and Wildlife Service, the Forest Service lists species that are sensitive within each region – Regional Forester Sensitive Species (RFSS). A designation of “sensitive” affords some additional regulatory protection.

Juncus stygius var. *americanus* Buchenau is a Regional Forester Sensitive Species (RFSS) in the Eastern Region of the National Forests. It is listed as a RFSS (Regional Forest Sensitive Species) on the Hiawatha National Forest in Michigan, the Chequamegon-Nicolet National Forest in Wisconsin, and the Superior National Forest in Minnesota.

The objectives of this document are to:

1. Provide an overview of current scientific knowledge for this species.
2. Provide a summary of the distribution and status of this species, both rangewide and within the Eastern Region of the National Forests.

3. Provide the available background information needed to prepare a subsequent Conservation Approach.

Nomenclature and Taxonomy: (NatureServe 2003, USDA NRCS Plants 2003)

Class: Liliopsida (monocots)

Order: Juncales

Family: Juncaceae (rush family)

Scientific name: *Juncus stygius* var. *americanus* L.

Synonym: *Juncus stygius* ssp. *americanus* (Buchenau) Hultén

Common names: moor rush, bog rush

USDA NRCS Plant Code: JUSTA

Taxonomy Note:

While *Juncus stygius* var. *stygius* was originally described from Europe, the subspecies *americanus* is from North America and Asia. The American plant differs from the Eurasian plant in having larger, more distinctly mucronate capsules (Hultén 1968).

Species Description

While this rush is unique, it is easy to miss because of its small size, its often singular occurrence, and its tendency to intermingle with *Rhynchospora alba* (Glaser 1992b). *Juncus stygius* var. *americanus* has a short, terminal, compact inflorescence of only 1 to 3 heads with each head having only 1 to 4 flowers. The margins of the tepals are a chaffy white, giving the whole inflorescence a conspicuous whitish cast (Crispin *et al.* 1985). Stems of this rush grow singly or in small clumps and have a few flat, narrow leaves, that are nearly all basal (often with 1 leaf above the middle of the stem) without hard cross-partitions (Voss 1972, Chadde 1998). Seeds within the ovoid capsules are the largest among *Juncus* species and have pale appendages or tails at both ends of the seed body (Crispin *et al.* 1985).

Material for this section comes from Brooks & Clemants 2000, Chadde 1998, Chadde 1999, Engelmann 1868, and Gleason & Cronquist 1991.

Species Technical Characteristics:

Stems: Grow singly or in small loosely cespitose clumps, erect, round in section.

Height: 1-4 dm

Roots: Rhizomes short, slender, sparingly branched.

Leaf arrangement and type: Leaves filiform, rounded in section or somewhat flattened, 1-3 leaves near base with one leaf above middle of stem, 3-15 cm long and 0.5-2 mm wide; auricles short (1-2 cm) and rounded if present.

Inflorescence: 1-3 obovate heads (5-10 mm wide), each with 1-4 flowers, peduncles erect to 1 cm long; primarily bracts nearly equal or slightly surpassing flower heads.

Flowers: Tepals lance-shaped (4-5 mm long), striped and straw-colored to red-brown with white chaffy margins; stamens 6, nearly as long as the tepals; Short and recurved stigmas, filaments 5-8 times longer (2.5 – 3.5 mm) than the anthers (0.4 – 0.5 mm), and much longer than the pistil (1 – 1.2 mm).

Fruits: Ovate capsules, greenish-brown, pseudo-3-locular, 5.5 – 9.0 mm long, longer than the tepals, tipped with a distinct point.

Seeds: Pale yellow, fusiform, body 0.8 – 1.1 mm, tails 1.0 – 1.4 mm long, seed coat loose and easily removed, scarcely striated.

Habitat and Ecology:

Juncus stygius var. *americanus* is characteristic of landforms that are subject to a fluctuating water table. In Minnesota, in particular, the favored habitat is patterned fens; here the water tracks (zones where runoff is channeled across the peat surface) contain a distinctive network of peat ridges (strings) and pools (flarks) that are arranged perpendicular to the slope (Glaser 1992a). Moor rush seems to show a fugitive strategy by exploiting areas where the water level has recently changed to create a break in the vegetative mat (Glaser 1992b). Chadde (1999) cites openings in black spruce and tamarack swamps, as well as floating organic mats, low areas in patterned fens, and edges of ponds as habitat for *J. stygius* var. *americanus*. Throughout its range it occupies wet, mossy habitats (Crispin *et al.* 1985) and poor fen seeps that arise at the margin of raised bogs (Glaser pers. comm. 2004). The Wisconsin DNR (1993) lists bogs, marshes, shallow pools, and open, boggy, possibly calcareous meadows as habitat. Paul Glaser (pers. comm. 2004) stated that this species has a wide range of ecological tolerance with respect to surface-water chemistry, although it never grows on ombrotrophic raised bogs. In Minnesota, (Glaser pers. comm. 2004) states that moor rush is a faithful fen indicator species requiring surface waters with a pH above 4.2 and Ca concentration greater than 2 mg/l. Glaser *et al.* (in press) has also collected this species in extremely rich fens (“spring-fed channels”) in Minnesota and the Hudson Bay Lowlands.

Michigan

Two of the Michigan’s sites occur on the Hiawatha National Forest. *Juncus stygius* var. *americanus* was found in Delta County in a northern fen, near a semi-open cedar-spruce-tamarack forest. Associates in the *Sphagnum* ground cover included *Carex gynandra* and *Scirpus cespitosus* (MNFI 2003). Occurring in a flark, associates in the Mackinac County peatland complex included *Rhynchospora alba*, *Carex limosa*, *C. livida*, *C.*

lasiocarpa, *Utricularia intermedia*, *Cladium mariscoides*, *Sphagnum teres*, *Scirpus cespitosus*, and *Menyanthes trifoliata* (MNFI 2003). The quaking mat at the Mackinac Co. site is located in a bog lake surrounded by a *Chamaedaphne calyculata* shrub zone, a moat, and a sugar maple forest (MNFI 2003). Moor rush has also been found at another Mackinac County site on the Lake Superior State Forest on a *Sphagnum*-sedge floating mat with *Utricularia cornuta*, *Pogonia ophioglossoides*, *Rhynchospora fusca*, *R. alba*, and *Lycopodium inundatum* (Crispin *et al.* 1985).

In Luce County, local populations of moor rush occurring in a patterned fen are associated with *Lycopodium inundatum*, *Rhynchospora alba*, *Carex elixis*, *C. leptalea*, *Xyris montana*, *Aster nemoralis*, *Pogonia ophioglossoides*, *Lobelia kalmii*, *Andromedia polifolia*, and *Solidago uliginosa* (University of Michigan herbarium 2003). According to Chadde (1999), other Michigan associates include *Chamaedaphne calyculata*, *Carex oligosperma*, *C. dioica*, and *Drosera rotundifolia*, as well as various *Sphagnum* mosses.

There are also two historical occurrences, one from Isle Royale (1901) and another from Presque Isle in Marquette County (1889) (Voss 1972). Presque Isle is a city park that has had extensive use by the inhabitants of Marquette and at times has been heavily browsed by deer. Isle Royale might harbor additional populations if wetland areas were extensively surveyed for this species in July and August.

Wisconsin

In Wisconsin, the open, waterlogged, alkaline meadow in Florence County where *Juncus stygius* var. *americanus* is found is unusual for its abundance of tussocks of *Scirpus hudsonianus* and the extreme wetness of the *Sphagnum*-sedge mat, mostly under one to several inches of water. It is associated with the typical bog sedges such as *Drosera* spp., *Sarracenia purpurea*, *Arethusa bulbosa*, *Calopogon tuberosus*, *Carex livida*, *Lycopodium inundatum*, *Rhynchospora capillacea*, *Triglochin maritimum*, and *Xyris* sp. (Solheim and Judziewicz 1984).

Minnesota

In Minnesota, *J. stygius* var. *americanus* shows a strong preference for patterned peatlands, specifically flark formations and shallow pools that form in minerotrophic water tracks (Coffin and Pfanmuller 1988). However, its habitat can vary from the margins of deep pools (North Black River), to mud-bottomed pools (Red Lake), and low clumps of *Sphagnum* (Mud Lake, Sand Lake) (Glaser 1992b). These sites are all wet, sunny, weakly acidic habitats that are usually dominated by sedges (Coffin and Pfanmuller 1988). *Juncus stygius* var. *americanus* has very specific hydrology and pH requirements. It often exploits areas where fluctuating water tables create breaks in the vegetation. The bog pools, and patterned fens where the moor rush grows tend to be weakly acidic or alkaline. Throughout its range, *J. stygius* var. *americanus* is a minerotrophic indicator, and in Minnesota this species has only been found in transitional rich fens (pH 5.2-5.4; Ca concentration 2.4-13 mg l⁻¹) (Glaser 1992b).

In the Agassiz lowlands, a poorly drained lake plain and paludified peatland, *J. stygius* var. *americanus* is associated with many other rare species of northern, boreal

distribution. These include *Achillea siberica*, *Arethusa bulbosa*, *Cladium mariscoides*, *Cypripedium arietinum*, *Drosera anglica*, *D. linearis*, *Nymphaea tetragona*, *Ranunculus lapponicus*, and *Xyris montana* (Albert 1995). Other Minnesota associates include *Carex livida* var. *radicaulis*, *Rhynchospora alba*, *Drosera intermedia*, *Pogonia ophioglossoides* (Wheeler and Glaser 1979), *Carex lasiocarpa* var. *americana*, *Carex limosa*, *Menyanthes trifoliata*, *Campylium stellatum*, *Scorpidium scorpioides*, *Triglochin maritime*, *Utricularia intermedia*, and *Sphagnum subsecundum* (Glaser *et al.* 1981).

Maine and New England

In New England, *J. stygius* var. *americanus* prefers calcareous sites (Crow 1982). In Maine, *Juncus stygius* var. *americanus* has been documented from 10 locations (New England towns) in Aroostock, Penobscot, and Somerset counties. Hellquist found *J. stygius* var. *americanus* to be common, occurring with *Rhynchospora alba* in a large open part of Crystal Bog west of a *Thuja* stand in August of 1979. In New Hampshire, *Juncus stygius* var. *americanus* occurs on firmer flarks in a circumneutral to calcareous fen with pH ranging from 6.3 to 8.4 (University of Michigan herbarium 2003). In New York all occurrences are over 20 years old, so it is not known whether this species continues to occur at these sites.

Canada

In the boreal belt of Canada, *Juncus stygius* var. *americanus* also occurs in poor fens, particularly in seeps draining from the edges of raised bogs (Glaser 1992b). In British Columbia the habitat is pond margins and peat bogs in both lowland and montane zones (Douglas *et al.* 2001). On the poor-fen lawn of *Sphagnum* where it occurs in Saskatchewan, *J. stygius* var. *americanus* is associated with *Carex michauxiana*, *Rhynchospora alba*, *Arethusa bulbosa*, *Drosera rotundifolia*, *D. angelica*, *Sarracenia purpurea*, and *Vaccinium oxycoccus* (University of Michigan herbarium 2003).

Old World – *Juncus stygius* var. *stygius*

In Russia (Karelia), *J. stygius* var. *stygius* is found in the *Sphagneta* + *Cariceta* site type: wet mesotrophic herb flarks corresponding to herb-rich flark fen and herb rich sedge fen in the Finnish classification, the *Herbeto-sphagneta* site type: mesotrophic carpets corresponding to herb rich sedge fen, often with sparse tree cover, and the *Cariceta* site type: meso-eutrophic flarks corresponding to herb-rich sedge fen and herb rich flark fen (Antipin *et al.* 1997).

Distribution and Abundance:

Europe – *Juncus stygius* var. *stygius*

Juncus stygius has a wide, circumboreal range. *Juncus stygius* var. *stygius* occurs in northern Europe and is historically known from Norway, Sweden, Finland, and the Baltic Province (Buchenau 1890). It has also been reported from the Karelian Republic, Russia, in the northern and central parts of the Lishkmokh mire (Antipin *et al.* 1997). *Juncus stygius* var. *stygius* was thought to have been lost from Germany in the 1970s, but it was

rediscovered in September 1996 when a small population of about 15 fruiting plants was found on a ground moraine near Bavaria, Germany (Wagner and Wagner 2000).

North America

The North American species *Juncus stygius* var. *americanus* is remarkably disjunct and local, uncommon even within the main part of its range in Canada (Coffin and Pfanmuller 1988). Glaser *et al.* (in press) did a comprehensive survey of patterned peatlands across a 24,000 km² study area of the Hudson Bay Lowlands in the lower Albany River drainage. Only a few new stations of this species were located although nearly the entire landscape was covered. Glaser (pers. comm. 2004) stressed that he has found this *Juncus* to be quite rare across most of its range in North America.

In the main portion of its range, *J. stygius* var. *americanus* is found from south-central Alaska and the Yukon south to British Columbia, Alberta, northern and central Saskatchewan, Manitoba, and the southern boundary of the Northwest Territories, east to Ontario, Quebec, Labrador, Newfoundland, New Brunswick, and Nova Scotia (Brooks & Clements 2000). It is rare in the Yukon, central and northern Northwest Territories, Nunavut, Manitoba, Quebec, and New Brunswick (Brooks & Clements, NatureServe 2003).

Juncus stygius var. *americanus* occurs somewhat more frequently in south central Alaska (6 dots shown on map, Hultén 1968). Recently Glaser (1995) collected *J. stygius* (WR9511, 9512) on a sloping patterned fen in SE Alaska. Glaser (pers. comm. 2004) stated that in this small peatland it was quite common, but he did not find it on other peatlands nearby. Only about two dozen stations are known for the entire northern continental United States, half of these occur in the patterned peatlands of Minnesota (Solheim and Judziewicz 1984, MN NRP 2003). At the southernmost limit of its distribution, *J. stygius* var. *americanus* has been found in Minnesota, Michigan, and Wisconsin (Chadde 1998). It is considered rare in Maine, New York and throughout New England (Crispin *et al.* 1985), and has also been reported from Wyoming (NatureServe 2003).

Michigan

Juncus stygius var. *americanus* has been reported from Keweenaw (historic) Marquette (historic), Luce, Mackinac, and Delta counties in Michigan (Chadde 1999). Slavik and Janke (1987) reported a collection from Isle Royale, Keweenaw County in 1901. It was first collected from “peat bogs in a *Larix* swamp” on Presque Isle (south shore of Lake Superior near Marquette) in 1889 (Beal and Wheeler 1892); it has not been reported from the area since that time (Chadde 2000).

Recent occurrences in Michigan are documented from several sources. One fertile plant was found in Delta County in 1985 at Eighteen Mile Bog on the Hiawatha National Forest, but was not found in June 1996 (MNFI 2003). The first occurrence in Mackinac County found in 1973 was on the Lake Superior State Forest near Ryerse Lake, and observed again in 1984 (MNFI 2003). The most recent Mackinac County occurrence was

in 1991, in an extensive peatland complex at Pointe aux Chenes on the Hiawatha National Forest (MNFI 2003). The Mackinac and Delta County sites are the only stations in the Upper Peninsula that have been recently confirmed extant (Crispin *et al.* 1985). The University of Michigan has herbarium specimens from Luce and Mackinac counties from the 1970's and 1980's. One Luce County element occurrence was from 1979 near Connor Lake in the Lake Superior Forest (University of Michigan Herbarium 2003).

Minnesota

The first record in Minnesota was in 1886 by the Arthur, Bailey, Holway expedition at a location near Vermillion Lake (St. Louis County). The next specimen was discovered nearby at Devil's Island in Long Lake (St. Louis County) in 1952. This species is indeed rare, restricted to a very unusual and fragile wetland type (Wheeler and Glaser 1979). Several new records (5 locations total) resulted from a statewide inventory of ecologically significant peatlands in 1978 (Glaser 1992b). Moor rush usually occurs as a few isolated individuals, although a larger number of tufts were found at Sand Lake in Lake County (Glaser 1992b). Coffin and Pfanmuller (1988) show seven occurrences from five northeastern counties. Over a decade later, Minnesota Natural Heritage Database (2003) listed twelve populations: two populations from Beltrami County, one from Carlton County, five from Koochiching County, and four from Lake County. In addition, there are three historical populations reported for St. Louis County: near Vermillion Lake (1886), and Devil's Island at Long Lake (1913 and 1952) (Coffin and Pfanmuller 1988).

Wisconsin

Juncus stygius var. *americanus* has been reported in Wisconsin from Florence and Vilas counties (WI DNR 1993, S. Janke pers. comm. 2004). A population of several thousand individuals was discovered in Florence County in 1982 just northeast of Grandma Lake (Solheim & Judziewicz 1984). Another population was discovered in Vilas County in 1997 at Black Tern Bog a State Natural Area within the Northern Highland State Forest (S. Janke pers. comm. 2004, S. Spickerman pers. comm. 2004). Like the Minnesota occurrences, these Wisconsin stations are at the southern limit for this taxon.

Maine

In Maine, *Juncus stygius* var. *americanus* has been documented from 10 locations (New England towns) in Aroostock, Penobscot, and Somerset counties. The rarity of *J. stygius* var. *americanus* in Maine can be attributed to its being at the southern limit of its range (Maine Dept. of Cons. 2002). Three historical records are known: two from Fort Kent, last reported in 1908, and one from Crystal Bog, in the town of Crystal, discovered in 1907, but not seen more recently according to Tyler and Gawler (1980). Hellquist (1981), however, found *J. stygius* var. *americanus* to be common in a large open part of Crystal Bog west of a *Thuja* stand in August of 1979. It occurred with *Rhynchospora alba*, with which it is easily confused, this led Hellquist to speculate that *J. stygius* var. *americanus* may have been overlooked in other bogs and could have yet more undiscovered occurrences.

Other eastern states

Only one site is known from New Hampshire, Coos County (University of Michigan 2003). A specimen was collected by Sperduto and Nichols in 1998 and verified by A.A. Reznicek at the University of Michigan Herbarium. It is from Coos County, New Hampshire 2003). Three occurrences are known from New York all located in the northwestern section of the state. The present status of these 20 year old records is not known (New York Natural Heritage Program 2001).

Canada

Even though the main part of its range is in Canada, the distribution of *Juncus stygius* var. *americanus* is rare even there. Encountered at three locations in central Saskatchewan (Nikik Lake, Dore Lake, and Nipekamew River), it is considered rare in that province (Johnson 1989). It is also considered rare in New Brunswick, where it is known from only a few localities in the southeast of the province (Hinds 1986). Moor rush has been found in Manitoba in a string fen near Weskusko (Hinds 1986). Glaser *et al.* (in press) did a comprehensive survey of patterned peatlands across a 24,000 km² study area of the Hudson Bay Lowlands in the lower Albany River drainage. Only a few new stations of this species were located although nearly the entire landscape was covered (Glaser pers. comm. 2004). The greatest concentration of this species is found in northern oceanic areas such as south central Alaska and British Columbia on the west coast, followed by Labrador and Newfoundland Island on the east coast, then northern Ontario just south of Hudson Bay (Brooks & Clemants 2000).

Life History

J. stygius var. *americanus* is a perennial plant. It might be reasonable to conclude vegetative reproduction is likely of less importance than sexual reproduction for this species since Gleason and Cronquist (1991) specified this species as having thin rhizomes, and Brooks and Clements (2000) note that rhizomes are short, and sparingly branched. Its growth habit suggests that vegetative reproduction is not its primary means of reproduction since this species is often found growing as a single individual.

Most *Juncus* taxa, retain very few incompletely developed ovules in a ripe seed-containing capsule (Catling & Spicer 1987); therefore moor rush might be expected to show good seed production. Normally *J. stygius* var. *americanus* has a compact inflorescence of just 1 to 3 heads of only 1 to 4 flowers each. It is not uncommon to find this species with just one head of 1 to 4 flowers (Voss 1972), so only a few seeds are produced per plant. Herbarium specimens collected in July and August were fertile (Crispin *et al.* 1985). The seeds are the largest of any *Juncus* species (Glaser 1992b), which would be a disadvantage for wind dispersal since the seeds would not be carried as far by wind currents as finer seeds. However larger seeds mean more endosperm to help establish a new plant. It appears that the wings on the seeds help the seeds become lodged in mud or other debris (Brooklyn Botanical Garden 2003).

In general, *Juncus* are wind pollinated. This is indicated by a reduced perianth, stigmatic surfaces with numerous, hair-like structures for collecting air-borne pollen and the

absence of nectaries (Judd *et al.* 1999). The perianth of *Juncus stygius* var. *americanus* has a distinctly white chaffy margin. Its whitish appearance lead Tony Reznicek (pers. comm. 2003), University of Michigan, to speculate that this *Juncus* might attract insect pollinators.

Rangewide Protected Status (NatureServe, 2003)

Currently, the official status for *Juncus stygius* var. *americanus* with respect to federal, state, and private agencies is:

- U.S Fish and Wildlife Service:** not listed (none)
- Global Heritage Status Rank:** G5 (16 May 1995)
- U.S National Heritage Status Rank:** N?
- Canada Heritage Status Rank:** N?

With a global rank of G5 and a U.S National rank of N?, The Nature Conservancy lists these rankings as:

- N?:** Not enough information to determine
- G5:** Common, widespread and abundant globally (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.

U.S. Forest Service: Region 9 Sensitive on the Hiawatha National Forest (MI), the Chequamegon-Nicolet National Forest (WI), and the Superior National Forest (MN).

The Regional Forester has identified *Juncus stygius* var. *americanus* as a species for which viability is a concern since it is regionally rare in Minnesota, Wisconsin and Michigan. There are only two locations known on both the Hiawatha National Forest in Michigan and the Superior National Forest in Minnesota (SVE Risk Evaluations). It is state endangered in Wisconsin and at the edge of its range on the Chequamegon-Nicolet National Forest (SVE Risk Evaluation).

U.S. State Heritage Ranks / State legal status

Alaska	SR		New Hampshire	S?	¹
Maine	S2	Special concern	New York	S?	Endangered
Michigan	S1S2	Threatened	Wisconsin	S1	Endangered
Minnesota	S3	Special concern	Wyoming	SR	²

1. New Hampshire list (2000) does not show any confirmed specimens, but there is a specimen at the University of Michigan collected by A. Reznicek
 2. Not in FNA Vol 22 for Wyoming or recognized by the Wyoming Natural Diversity Database (B. Heidel pers. comm. 2004)

Canadian Provincial Heritage Ranks

Alberta	S2	Nova Scotia	S2
British Columbia	S2S3	Nunavut	SR
Labrador (Nfld)	SR	Ontario	S4
Manitoba	S1?	Quebec	SR
New Brunswick	S1	Saskatchewan	SR
Newfoundland Island (Nfld)	SR	Yukon Territory	SR
Northwest Territories	SR		

Definition of State and Provincial Ranks:

S1 = Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.

S2 = Very rare; typically between 6 and 20 known occurrences; may be susceptible to extirpation.

S3 = Rare to uncommon; typically 21-50 known occurrences; S3 species are not yet susceptible to becoming extirpated in the state, but may be if additional populations are put at risk.

S4 = Common, apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.

S5 = Very common; demonstrably secure under present conditions.

SR = Reported from the state, but without persuasive documentation that would provide a basis for either accepting or rejecting the species.

S? = Not enough information available to assess at this time

Population Biology

Gleason and Cronquist (1991) described moor rush as having thin rhizomes, and Brooks and Clements (2000) note that rhizomes are short, and sparingly branched. This characteristic and its typical singular occurrence would lead one to conclude that vegetative reproduction is likely of less importance than sexual reproduction for this species.

In general, *Juncus* seeds germinate relatively easily (Young and Young 1986). *J. stygius* var. *americanus* has only a few flowers which means it does not produce the quantities of seed that many other *Juncus* produce. Also it has a larger seed (Brooks and Clements 2000) which means it would not carry as far by wind as the smaller seeds of other *Juncus* species. Logically because of these two traits, one would expect that its reproduction rates might be reduced compared to other *Juncus*.

Seeds of *Juncus* are light and are easily carried by water. *Juncus stygius* var. *americanus* has quite long tails on both ends. The tails help the seeds subsequently become lodged in the mud or other debris (Brooklyn Botanical Garden 2003).

Population Viability

Juncus stygius var. *americanus* has very specific hydrology and pH requirements (5.2 – 7.0, but often as narrow as 5.2 to 5.4) (Glaser *et al.* 1990). Throughout its range moor rush is a minerotrophic indicator. The distribution of *Juncus stygius* var. *americanus* is very disjunct and local despite a wide geographic range, presumably due to its specific habitat needs. In many states it has been given a protected status. It is of Special Concern in Minnesota, Threatened in Michigan, Endangered in Wisconsin, and is considered Rare in New York and throughout New England. Its numbers are particularly low in the northern United States, which is at its southern limit of distribution. In Canada, *J. stygius* var. *americanus* is rare in the Yukon, Northwest Territories, Manitoba, Quebec, and Nova Scotia, and New Brunswick (Brooks & Clements 2000, NatureServe 2003). Even in areas where it is a bit more common, it is quite specific in habitat. Glaser recently (1995) found it in Alaska. At one Alaskan peatland it was locally common, but not to be found in nearby peatlands (Glaser pers. comm. 2004).

It should be kept in mind that patterned fens are dynamic ecosystems that in geological terms can change quite suddenly, sometimes favorably other times less favorably. At the Lost River peatland there are 2 peat mounds, one that is spring fed, whereas the other is a raised bog. In 1981, Glaser *et al.* discovered that circumneutral groundwater had risen to within one meter of the peat surface of the peat mound that was still a raised bog. A slight change in the hydraulic gradient could potentially cause groundwater to discharge at the surface and convert this bog into a spring fen (Glaser pers. comm. 2004).

Potential Threats

Juncus stygius var. *americanus* is vulnerable because of the specificity of its hydrology and pH requirements. In addition, it is at its southern limit in distribution in the northern United States. Michigan Natural Features Inventory assigned moor rush a 10 rating (highest) for Conservation Ranking; moor rush would not be expected to grow in human altered wetlands (Glaser *et al.* 1990, MNFI 2001). The cold, wet, alkaline conditions required by *J. stygius* var. *americanus* may be best maintained by protecting watershed quality and peatland habitat and avoiding major disturbances, especially hydrologic ones, in areas where *J. stygius* var. *americanus* has been found (Crispin *et al.* 1985).

When reviewing rare plants in Minnesota, *Juncus stygius* var. *americanus* was one among a group of plants received a high rating for need of protection since populations are often just a few individuals and the habitat is primarily patterned fens (Aaseng and Djupstrom 1992). Being confined to patterned peatland habitats, the most serious potential threat in Minnesota is acid rain (Coffin and Pfanmuller 1988). The Red Lake peatland is the largest northern peatland in the United States; therefore, the effects of acid rain would be somewhat buffered in this large landscape (Glaser *et al.* 1981). However, even minimal pollution of the alkaline groundwater has the potential to drastically change plant communities in the Red Lake Peatland (Glaser *et al.* 1981).

Large-scale peat mining for energy production, and mineral exploration were significant threats before peatland protection legislation was passed protecting Red Lake Peatland and three other ecologically significant peatlands. While currently protected, a downturn in the local economy could create increased pressure for peat mining primarily for horticultural use (Aaseng and Djupstrom 1992). In Canada, peatland mining is still a large business and could influence this species outcome (S. Spickerman pers. comm. 2004).

Global warming could be a threat for this species as it is already present in only low numbers and at the southern edge of its United States range. Scientists throughout the world have predicted that a worldwide warming trend will continue to increase in the coming century (Primack 1993; Levitus *et al.* 2001). As the climate continues to warm, it is predicted that the distributions of northern-hemisphere plant species may “migrate” further to the north than their current range. *Juncus stygius* var. *americanus* is near the southern edge of its range in northern Minnesota, Wisconsin, Michigan’s Upper Peninsula and Maine. If the climate in the northern United States warms, this species could become at risk, especially in the United States. Because of the rapidity of warming, plants may not be able to migrate swiftly enough, they may not find suitable habitat along the way north and competition for remaining suitable habitat may become more intense. Monitoring of known sites would help assess long-term viability.

Management and Conservation Issues

In Minnesota, a task force known as the Peatlands Protection Area Review Committee (PARC) was initially formed by the MN DNR’s Mineral Division to assess preservation and peatland development interests. This task force brought together experts from ecology, hydrology, geology, wildlife, botany, and forestry. By 1984, 18 peatlands were identified as candidates for protection. Two types of management areas were defined for each of the peatlands: a core area and a watershed protection area. The primary areas of conflict were mineral exploration and mining, timber harvesting, peat mining, the use of motorized vehicles (especially snowmobiles) and school trust-fund compensation (Aaseng and Djupstrom 1992).

Steve Spickerman (Chequamegon-Nicolet National Forest) suggested (pers. comm. 2004) that not cutting aspen in the immediate vicinity of habitat for *J. stygius* var. *americanus* might eliminate hydrologic disturbance due to beaver inundation. This might be the only way that the Forest Service as a land management agency might influence the outcome of this species.

The paludified peatlands (developed by swamping downslope from a rise) in the Agassiz lowlands where *J. stygius* var. *americanus* has been found in Minnesota have historically been dredged in unsuccessful attempts to farm parts of the peatlands (Heinselman 1963 *cf.* Albert 1995). Adjacent paper birch forests and conifer forests have also been heavily harvested for pulp. Fortunately, the maintenance of the protected peatlands and the quality of their watersheds has since become a priority (Aaseng and Djupstrom 1992).

Glacial Lake Agassiz peatland and Lost Lake peatland were identified as critical landscapes for biodiversity by the Minnesota Heritage Program (Albert 1995).

Although *J. stygius* var. *americanus* may be able to tolerate minimal disturbance as suggested by its presence at the edge of water tracks and margins of ponds, and its presence on a game trail that crosses the Alborn fen in Minnesota (Glaser 1992b), moor rush is generally vulnerable to significant disturbances altering hydrology or pH beyond the range required by the species. The habitat of *Juncus stygius* var. *americanus* in the Canadian peatlands appears to be stable due since this area is within its main range and is isolated from most human interference (Johnson 1981). However, if peatland mining increases than populations could be put at risk.

Summary of Existing Habitat Protection

As of 1991, Minnesota passed legislation to protect the four best examples of peatlands with a core area and a buffer of watershed protection. The largest acreage was set aside at Red Lake Peatlands where *Juncus stygius* var. *americanus* is found (Aaseng and Djupstrom 1992). The designation of The Glacial Lake Agassiz peatlands (Red Lake and Lost River) as critical landscapes for biodiversity by the Minnesota Heritage Program (Albert 1994) should also help ensure protection of these peatlands from outright exploitation.

The inaccessibility of preferred sites for moor rush offers a fair amount of protection to this species. In Minnesota, it is confined to patterned peatlands (12 element occurrences). After the work by Glaser *et al.* (1981, 1990) interest in protecting these peatlands from mining and peat harvest increased and legislation was passed to protect these areas. Only in Minnesota are increasing numbers of element occurrences being located. There is one element occurrence on the Superior National Forest, and two additional element occurrences within the Superior National Forest proclamation boundary (J. Greenlee pers. comm. 2004).

Two of Michigan's sites occur on the Hiawatha Federal Forest (MNFI 2003). The current status of the Luce County sites first observed in 1970 is unknown and is not documented in MNFI database. The Isle Royale and Marquette County sites are historical entries (late 1800s early 1900s). The Wisconsin site at Grandma Lake in Florence County was first located in 1982 and had several thousand individuals; the site has been visited since then repeatedly. This site is on the Chequamegon-Nicolet National Forest and is monitored on nearly a yearly basis; the site is still extant and contains several thousand plants (S. Spickerman pers. comm. 2004). There is another site in Vilas County at Black Tern Bog (a State Natural Area) that was discovered in 1997, and is considered secure (S. Janke pers. comm. 2004). However, it must be remembered that it is not only the lowland habitat of this species that needs protection, but also adjacent upland areas (S. Spickerman pers. comm. 2004).

Research and Monitoring

The Minnesota DNR authorized an extensive study that enabled Biologists to gather baseline data on hydrology, soils, water chemistry, flora, and fauna of the Red Lake Peatland in Minnesota. The understanding and appreciation that resulted as a consequence of gathering this baseline data have greatly contributed to the subsequent effort to preserve the patterned peatland habitat. Additional sites are becoming known, and more scientists are becoming familiar with the habitat of this species as a result of the work done by Glaser (1992) in the Red Lake Peatland. *J. stygius* var. *americanus* is frequently overlooked in identification because of its isolated growth and small stature. However, as more specimens are available in herbariums, field botanists can more easily recognize the plant's characteristic growth and the recurved styles which aid in identification (Glaser 1992b).

Continued monitoring is needed on a more rigorous schedule to further research on specific habitat requirements and to gather any observable life history information. Why do a few sites have up to a 1000 individuals whereas most sites have only a few or an isolated individual?

Summary

Juncus stygius has been known taxonomically as two varieties across its circumpolar range. In northern Europe it is known as var. *stygius*, while in North America it is known as var. *americanus*. *Juncus stygius* var. *americanus* is quite specific in terms of habitat favoring patterned fens with a pH of 5.2 to 7.0. *Rhynchospora alba* is a frequent associate and often *Juncus stygius* grows singly amongst *R. alba* so *Juncus stygius* var. *americanus* is difficult to spot since both species have whitish flowering heads. Other common fen associates include *Triglochin maritima* (common arrow-grass) and *Xyris montana* (yellow-eyed grass). *Juncus stygius* var. *americanus* has been studied most extensively in the Red Lake Peatland in northern Minnesota (Glaser *et al.* 1981, 1990). In Minnesota, moor rush is confined to patterned fens at the margins of water tracks or in small pools called flarks.

Less than 24 sites are known from the northern contiguous United States and over half of these are from patterned fens in Northern Minnesota. Protection of these patterned fens, as well as other suitable habitat, is critical for the survival of this species across the southern limit of its range. Half of the Michigan element occurrences are over 20 years old; this is true for New York and Wisconsin also. This indicates a need for more field surveys to determine whether these populations are still extant. In Canada, although its presence is more frequent than the United States, it is still local and rare across its range. The G5 rating appears somewhat suspect; it may have been assigned that rating based upon var. *stygius* in Europe. *Juncus stygius* var. *americanus* would appear to be truly rare. Glaser (pers. comm. 2004) in his review of this Conservation Assessment stated that “*Juncus stygius* var. *americanus* is one of the rarer vascular plant species in Minnesota and adjacent states. It also seems to be rare and sporadic in occurrence across the boreal belt of Canada”.

References

- Aaseng, N. E. and R. I. Djupstrom. 1992. Peatland protection in the patterned peatlands of Minnesota. (Wright, Coffin and Aasenf, ed.) University of Minnesota. pp. 301-315.
- Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification (Fourth revision: July 1994). Upper Great Lakes Biodiversity Committee. pp. 236-237.
- Anderson, J. P. 1974. Anderson's Flora of Alaska and adjacent parts of Canada. Brigham Young University Press: Provo, Utah. p. 613.
- Antipin, V., Heikkila, R., Lindhilm, T., and Tokarev, P. 1997. Vegetation of Lishkmokh mire in Vodlozersky National Park, eastern Karelian republic, Russia. Suo 48: 93-114.
- Beal, W. J., and C. F. Wheeler. 1892. Michigan Flora. State Agricultural College, East Lansing. p. 142.
- Brooks, R.E., and S.E. Clemants. 2000. Juncaceae *in* Flora of North America. Vol. 22. New York. Oxford University Press. p. 211-267.
- Buchenau, Franz. 1890. Monographia Juncacearum. Verlag von Wilhelm Engelmann. Leipzig. p. 393.
- Catling, P. M. & K. W. Spicer. 1987. The perennial *Juncus* of section *Poiophylli* in the Canadian prairie provinces. Canadian Journal of Botany 65: 750-760.
- Chadde, S. W. 1998. A Great Lakes Wetland Flora. Pocketflora Press. Calumet, Michigan. p. 444.
- Chadde, S. W. 1999. A Forester's Field Guide to the Endangered and Threatened Plants of Michigan's Upper Peninsula. Mead Corporation, Champion International, and Shelter Bay Forests. Pocketflora Press. Calumet, Michigan. pp. 143-144.
- Chadde, S. W. 2000. Natural Features Survey, Lake Superior Shoreline, Marquette County, Michigan. Pocketflora Press. Calumet, Michigan. p. 18.
- Coffin and Pfanmuller (eds.). 1988. Minnesota's Endangered Flora and Fauna. University of Minnesota Press. Minneapolis, MN. p. 191.
- Crispin, S. R., L. A. Wilsman, K. A. Chapman, S. J. Ouwinga. 1985. An overview of endangered and threatened species in Hiawatha National Forest, Michigan.

- Michigan Natural Features Inventory and Michigan Department of Natural Resources Wildlife Division. Hiawatha National Forest. Escanaba, MI.
- Crow, G. E. and C. B. Hellquist. 1961. Aquatic and Wetland Plants of Northeastern North America. Volume 2 Angiosperms: Monocotyledons. The University of Wisconsin Press p.100.
- Crow, G. E. 1982. New England's rare, threatened, and endangered plants. U.S. Department of the Interior, U.S. Fish and Wildlife Service. Washington D.C. p. 75.
- Douglas, George W., D. Meidinger, and J. Pojar. 2001. Illustrated Flora of British Columbia. Ministry of Environment, Lands and Parks. British Columbia Ministry of Forests. p. 242-243.
- Engelmann, G. 1868. North American species of genus *Juncus*. The transactions of the Academy of Science of St. Louis. Volume II. George Knapp and Co., St. Louis. pp. 424-449.
- Glaser, P.H., D.I. Siegel, A.S. Reeve, J.A. Janssens, and D.R. Janecky. (in press). Tectonic drivers for vegetation patterning and landscape evolution in the Albany River region of the Hudson Bay Lowlands. *Journal of Ecology*.
- Glaser, P. H., G. A. Wheeler, E. Gorham, and H. E. Wright. 1981. The patterned mires of the Red Lake Peatland, northern Minnesota: vegetation, water chemistry and landforms. *Journal of Ecology* 69: 575-599.
- Glaser, P. H., J. A., Janssens and D. I. Siegel. 1990. The response of vegetation to chemical and hydrological gradients in the Lost River Peatland, northern Minnesota. *Journal of Ecology* 78: 575-599.
- Glaser, P. H. 1992a. Peat Landforms *in* The Patterned Peatlands of Minnesota (H.E. Wright, B.A. Coffin, and N.E. Aaseng, eds.) University of Minnesota Press, Minnesota, USA. p. 3-13.
- Glaser, P. H. 1992b. Rare Vascular Plants *in* The Patterned Peatlands of Minnesota (H.E. Wright, B.A. Coffin, and N.E. Aaseng, eds.) University of Minnesota Press, Minnesota, USA. p. 61.
- Glaser, P.H. 1995. The impact of forestry roads on sloping peatlands, Wrangell Island, Alaska. Report to the U.S. Forest Service, Alaska Region, Juneau, Alaska.
- Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden. Bronx, New York. p. 663.

- Hellquist, C. B. 1981. The rediscovery of *Juncus stygius* in Maine. *Rhodora* 83: 321-322.
- Hinds, H. 1986. The Flora of New Brunswick. Primrose Press: University of New Brunswick. Fredericton, New Brunswick. p. 132.
- Hultén, E. 1958. The Amphi-Atlantic Plants and their Phytogeographic Connections. Kungl. Svenska Vetenskapsakademiens Handlinar Band 7, Nr. 1. Pp. 1-140 with maps.
- Hultén, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press: Stanford, California. p. 294.
- Johnson, J.D. 1989. Additions to the vascular flora of Manitoba. *Canadian Field Naturalist* 103: 291-293.
- Judd, W.S., C.S. Campbell, E.A. Kellogg, and P.F. Stevens. 1999. *Plant Systematics: A Phylogenetic Approach*. Sinauer Associates, Inc., Sunderland, Massachusetts.
- Kristiansen, J. N. 1977. *Juncus stygius* found in Alta, Finnmark County [northern Norway]. *Blyttia* 35: 167-171.
- Kuznetsov, O. L. 1998. Records of the vascular plant species, new for the flora of Kenozerskii National Park (Arkhangelsk Oblast). *Botanicheskii Zhurnal* 83: 128-131.
- Lakela, O. 1965. A Flora of Northeastern Minnesota. University of Minnesota Press. Minneapolis, Minnesota. p. 114, 443.
- Levitus, S. and J.I. Antonov, J. Wang, T.L. Delworth, K.W. Dixon, A.J. Broccoli. 2001. Anthropological warming of the Earth's climate system; *Science*. Vol. 292, pp. 267-270.
- Magee, D.W. and H. E. Ahles. 1999. Flora of the Northeast—A manual of the vascular flora of New England and adjacent New York. University of Massachusetts Press. Amherst, Massachusetts. p. 325.
- Primack, R.B. 1993. *Essentials of Conservation Biology*. Sinauer Associates, Inc. Sunderland, Massachusetts. p. 157-161.
- Scoggan, H. J. 1978. The Flora of Canada. Part 2. Pteridophyta, Gymnospermae, Monocotyledonae. National Museum of Natural Sciences, Ottawa, Ontario, Publications in Botany Number 7.

- Slavik, A. D. and R. A. Janke. 1987. The Vascular Flora of Isle Royale National Park. *The Michigan Botanist* 26: 91-93, 110.
- Solheim, S. L., and E. J. Judziewicz. 1984. Four noteworthy Wisconsin plants. *Phytologia* 54: 490-492.
- Tyler, H. R., Jr., and S. G. Gawler. 1980. The botanical aspect of Maine's Critical Areas Program. *Rhodora* 82: 207-225.
- University of Michigan herbarium specimens for *Juncus stygius*. Viewed on December 16, 2003 by Beverly Braden.
- Voss, E.G. 1972. Michigan Flora. Part 1. Cranbrook Institute of Science and University of Michigan Herbarium.
- Wagner, A., and I. Wagner. *Juncus stygius*- a recent record for Bavaria and Germany. *Berichte der Bayerischen Botanischen Gesellschaft zur Erforschung der Heimischen Flora*. p. 177-180
- Welsh, S. L. 1974. Anderson's Flora of Alaska and Adjacent Parts of Canada. Brigham Young University Press. Provo, Utah. pp. 613-614.
- Wheeler, G. A., and P. H. Glaser. 1979. Notable vascular plants of the Red Lake Peatland, northern Minnesota. *The Michigan Botanist* 18: 137-142.
- Wisconsin DNR. 1993. Guide to Wisconsin's Endangered and Threatened Plants. Bureau of Endangered Resources, Wisconsin Department of Natural Resources.
- Young, J. A., and C. G. Young. 1986. Collecting, Processing and Germinating Seeds of Wildland Plants. Timber Press. Portland, Oregon. p. 166.

Electronic Databases

- W-1. Brooklyn Botanical Garden
http://www.bbg.org/gar2/topics/botany/parts_fruit.html
- W-2. Maine Department of Conservation (MDOC), Natural Areas Division. 2002.
<http://www.state.me.us/doc/NRIMC/MNAP/factsheets/snameindex.htm>
- W-3. Michigan National Features Inventory (MNFI 2003)
<http://web4.msue.msu.edu/mnfi/>
- W-4. Minnesota – Bell Herbarium. 2003.
<http://wildflowers.umn.edu/common/search.asp>
- W-5. NatureServe Explorer: An online encyclopedia of life. 2003. Version 1.6. Arlington, Virginia, USA. <http://natureserve.org/explorer>

W-6. New Hampshire Natural Heritage Inventory. 2000. Rare Plant Species in New Hampshire.

W-7. New York Natural Heritage Program. 2001. Rare Plant Status List.
Available at: www.dec.state.ny.us/website/dfwmr/heritage/rpsl.pdf

W-8. USDA NRCS Plants Profile. 2003
http://www.plants.usda.gov/plants/cgi_bin/plant_profile.cgi

W-9. Wisconsin State Herbarium, 2003
<http://www.botany.wisc.edu>

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