An Evaluation of the Ecological Significance of the Headwaters Site

Northern Superior Uplands Ecological Land Classification System Section;
Laurentian Uplands Subsection
Lake and St. Louis Counties, Minnesota

Prepared by:
Department of Natural Resources
Minnesota County Biological Survey
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SUMMARY

DATE: January 2007 **AUTHORS:** Chel Anderson and Ethan Perry

NAME OF SITE: Headwaters **COUNTY:** St. Louis and Lake

STATEWIDE BIODIVERSITY RANK: Outstanding

ECS REGION: Northern Superior Uplands Section; Laurentian Uplands Subsection (Figure 1)

DNR QUAD CODES (USGS QUADS): H22d, H23c (Babbitt SE, Greenwood Lake West)
H23b (Slate Lake West)

LEGAL DESCRIPTION: T58N R12W Sec 1-4, 9-16, 21
T59N R12W Sec 1, 11-15, 22-28, 33-36
T58N R11W Sec 3-10, 16-18
T59N R11W Sec 4-12, 14-23, 27-34

APPROXIMATE ACREAGE: 38,713

OWNERSHIP: U.S. Forest Service, State of Minnesota, St. Louis and Lake counties, private inholdings (Figure 2; Table 7)

ECOLOGICAL SIGNIFICANCE

Overview

The Headwaters Site straddles the continental divide, with water from the Site flowing both east through the Great Lakes to the Atlantic Ocean and north to the Arctic Ocean. Paradoxically, the divide runs through a peatland. Although the peatland appears flat, water flows out of it from all sides, forming the ultimate source of rivers that eventually reach two different oceans. The Site is the headwaters of four rivers: Stony River, Dunka River, South Branch Partridge River, and the St. Louis River, which is the second largest tributary to Lake Superior (Figure 3 page 83).

The Headwaters Site encompasses vast peatlands on its eastern side, unfragmented upland forests in the west, and broad transition zones between them. Within the Site are two distinct areas, referred to in the document as the “Extensive Peatlands” and the “Big Lake Area,” which are linked hydrologically as part of the Upper St. Louis River watershed. The Extensive Peatlands area is a mosaic of open and forested wetland communities and includes forested upland islands and peninsulas. The Big Lake Area, in the southwestern quarter of the Site, includes Big Lake and surrounding unfragmented upland forest interspersed with small wetlands.

The Headwaters Site is unique in northeastern Minnesota in several ways. The size and complexity of the peatlands in the Extensive Peatlands are unmatched in the Northern Superior Uplands Ecological Land Classification System (ECS) Section. The Sand Lake Peatland Scientific and Natural Area (SNA), established by the Wetlands Conservation Act of 1991, protects one of the

15 most significant peatlands in the state, and it is by far the largest SNA in the Section (MN DNR 1984).

The Nature Conservancy's (TNC) Superior Mixed Forest (SMF) Ecoregion Plan identifies the Sand Lake/Seven Beavers (SL7B) conservation area, including the entire Headwaters Site, as one of 51 conservation areas in the Ecoregion[1] that best represent the ecosystems and species of the Ecoregion, and serve as a blueprint for conservation action (The Nature Conservancy and Nature Conservancy Canada 2002). According to the SMF Ecoregion Plan, these conservation areas are the best opportunities for conserving the full diversity of terrestrial and aquatic ecosystems and globally rare or declining species.[2] The SMF Ecoregion Plan identifies these areas as critical places for conserving biodiversity (SMF Plan - Section 7.5) and outlines the threats to conservation and conservation targets for these areas (SMF Plan - Appendix F), recognizing that more detailed site planning is needed to address how to implement conservation efforts (Section 7.5).

The Minnesota Pollution Control Agency has ranked the Upper St. Louis River watershed in the second highest category in the Lake Superior Basin for watershed integrity (Minnesota Pollution Control Agency 2003). The Headwaters Site is among the highest quality areas within the watershed. The upland forest surrounding Big Lake is among the largest, if not the largest, unfragmented, predominantly upland forest in the North Shore Highlands, Toimi Uplands, and Laurentian Uplands (NTL) ECS Subsections. The upland forest area covers 7,920 acres (including 788-acre Big Lake). This high-quality, fire-dependent forest has not been logged in recent decades, except for two stands totaling 140 acres, along the northern edge of the Site.

Covering an area roughly 11 to 12 miles (from northeast to southwest) by 7 to 8 miles (from northwest to southeast), the Headwaters Site is a mosaic of high-quality native plant communities that have functioned under relatively undisturbed conditions since the nineteenth and early twentieth century, when parts of the Site were logged and then burned by wildfires. A corridor containing a railroad grade and power line crosses this vast area, representing the only major permanent conversion of the natural landscape. Minnesota County Biological Survey (MCBS) sites bordering about two-thirds of the Site's boundary have been assigned High or Moderate statewide Biodiversity Significance (Figure 4, page 85). The lack of roads, absence of recent large-scale logging, and large size of the Site allow for natural functioning of ecological processes. These processes include disturbances such as wind, fire, and flooding, as well as plant species competition, nutrient cycling, and hydrology. Natural landscape patterns, such as patch size of the various plant communities, have not been altered, in comparison with most other parts of northeastern Minnesota (White and Host 2003). Minimal recent human disturbance also results in a landscape with very few populations of exotic or invasive species.

The predominant upland forest native plant community in the Big Lake Area is Aspen - Birch Forest [FDn43b], with inclusions of Upland White Cedar Forest [FDn43c] and White Pine - Red

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[1] The SMF Ecoregion is located near Lake Superior and includes portions of Michigan, Wisconsin, Minnesota, Manitoba and Ontario.

[2] The Sand Lake Seven Beavers terrestrial conservation area intersects with the Sand Lake Complex/St. Louis River headwaters and the Upper Cloquet River aquatic conservation areas, identified in the Great Lakes Ecoregion Plan (The Nature Conservancy 2000).

Pine Forest [FDn43a] (Figure 5, page 87)[3]. Isolated wetlands within the Big Lake Area's upland forest support a variety of native plant communities, including Northern Poor Conifer Swamp [APn81], Northern Rich Spruce Swamp (Basin) [FPn62], White Cedar Swamp (FPn63a), Northern Alder Swamp [FPn73a], and Black Ash - Conifer Swamp [WFn64a]. (See Native Plant Communities below for descriptions, and Relevés, Appendix 2, page 61.)

The Extensive Peatlands are composed of a complex of native plant communities, including Northern Cedar Swamp [FPn63]; Northern Rich Spruce Swamp (Basin) [FPn62]; Northern Alder Swamp [FPn73]; Northern Rich Tamarack Swamp (Water Track) [FPn81]; Northern Rich Fen (Water Track) [OPn91]; Northern Rich Fen (Basin) [OPn92]; Northern Shrub Shore Fen [OPn81]; Northern Spruce Bog [APn80]; Northern Poor Conifer Swamp [APn81]; Northern Open Bog [APn90]; and Northern Poor Fen [APn91]. The many upland islands in this portion of the Site provide additional native plant community diversity, supporting community types in the Northern Dry-Mesic Mixed Woodland [FDn33] and White Pine-Red Pine Forest [FDn43] classes (Figure 5). (See Native Plant Communities below for descriptions and Relevés, Appendix 2.)
The Headwaters Site supports healthy known populations of eight state-listed plant species, all of which are listed as Special Concern (SPC) in Minnesota: coastal sedge *(Carex exilis)*, Michaux's sedge *(Carex michauxiana)*, English sundew *(Drosera anglica)*, bog rush *(Juncus stygius)*, small green wood orchid *(Platanthera clavellata)*, Lapland buttercup *(Ranunculus lapponicus)*, sooty-colored beak rush *(Rhynchospora fusca)*, pedicelled woolgrass *(Scirpus cyperinus/S. pedicellatus)*, and Torrey's mannagrass *(Puccinellia pallida)* (see Table 3, page 26, and Element Occurrence Records, Appendix 1, page 49). The unfragmented complex of high-quality native plant communities within and across the Site's landforms provide excellent habitat for a wide variety of animal species distinctive of the landscape, including moose, gray wolf, sandhill cranes, American bitterns, boreal and great gray owls, and numerous amphibians, butterflies, and small mammals.

In 2005 and 2006 the Minnesota County Biological Survey of the MN DNR conducted rare plant and native plant community fieldwork, mapped the native plant communities and completed this Ecological Evaluation of the Headwaters Site. Based on the natural features and conditions revealed through this recent work and that of others since the 1980s, MCBS recommends the primary management objective for the Headwaters Site be to protect, enhance, or restore ecological processes and native plant community composition and structure. In accordance with this objective, the site or portions of the site may be identified by landowners or land management agencies for conservation activities such as special vegetation management, including ecologically based silviculture and forest development activities,[4] or for designation as a park (city, county, state, or private), research natural area, non-motorized recreation area, scientific and natural area, or other reserve. This Ecological Evaluation has been written to characterize the ecological significance of the MCBS Site as a whole and to serve as a guide for conservation action by the various landowners.

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[3] The native plant community names and codes used in this document generally refer to the plant community classification presented and described in MN DNR (2003).

[4] Examples of ecologically based silviculture are described in the strategic direction document of the North Shore Highlands, Toimi Uplands, and Laurentian Uplands Subsection Forest Resource Management Plan, which includes management direction, strategies, and goals for vegetation management of state forestlands administered by the Department of Natural Resources, divisions of Forestry, Fish and Wildlife, and Trails and Waterways within the North Shore Highlands, Toimi Uplands, and Laurentian Uplands subsections (MN DNR 2004b).

Geologic Context and Features

The Headwaters Site is within the Laurentian Uplands Subsection of the Northern Superior Uplands Section of the Ecological Classification System (see Figure 1, page 81). ECS Sections are divided into Subsections, which are further divided into Land Type Associations (LTAs).[5] The bedrock of the Site is of Precambrian age (1.6 billion to 600 million years old); Duluth Complex igneous rocks related to the Mid-continent Rift System underlie the Site (Green 1982). The surficial geology (Figure 6, page 89) expressed at the Site is the result of activity of the Rainy and Superior lobes of the Late Wisconsin Glaciation, which ended 10,000 to 12,000 years ago (Ojakangas and Matsch 1982).

Landforms left by these glacial lobes are described by Hobbs and Goebel (1982) and the University of Minnesota-Duluth (1997). The uplands in the western and northern parts of the Site, including the Big Lake Area, are part of end and ground moraines associated with the eastern end of the Big-Bird Lake Moraine LTA and the southern edge of the Isabella Moraine LTA. Rainy Lobe deposits constitute most of these features, but Superior Lobe deposits occur in the far northern part of the Site. The Rainy Lobe till plain, characterized by low topographical relief and many wetlands, is located west and north of Big Lake. Two areas of glacial drift with somewhat more topographic relief are present to the east and northeast of Big Lake (Rainy Lobe) and in the Isabella Moraine LTA (Superior Lobe). Within the Greenwood Lake Till Plain LTA, Rainy Lobe ground moraine fringes the Site's southern boundary and two fingers of Rainy Lobe outwash project into the Site's east-central boundary. Eskers run throughout the Site, generally from southwest to northeast (parallel to flow of the Rainy Lobe), including along the eastern shore of Big Lake. Elevations in the Site range from about 1,630 feet, where the Dunka River leaves the Site, to about 1,760 feet at the top of the esker deposits at the south end of Big Lake.

Outside of the Big Lake Area, the Site's soils are principally peat (Holocene) of the Seven Beavers Peatland LTA. Peat formation likely began at the Headwaters Site 5,000 to 6,000 years ago. Peat depth ranges from 15 to 53+ inches. Within the Extensive Peatlands, movement of water, which is typically imperceptible on the ground, sculpts raised bogs, water tracks, and swamps. Drumlin and esker islands of loamy till, one to fifty-five acres in size, break the peatland's flat to very gently sloping relief.

The U. S. Forest Service has mapped approximately 42% (16,800 acres) of the land within the Headwaters Site to Ecological Land Types (ELT) 1, 2, 5, 6, 7, 9, 13, and 14 and Land Type Phases (LTP) 4, 7, 10A, 10B, 13B, 13C, 16A, 24, 30A, 30B, 30C, 31A, 32, 44A, 44B, 44C, and 47, for which the agency has comprehensive descriptions of landform associations, soil properties, and suitability analyses for a variety of land management and development activities (B. Luelling, pers. comm. 2005). The glacial drift is more than 40 inches and less than 100 feet thick. Typically, mineral soils on ground moraines, end moraines, and till plains are sandy loams over gravelly sandy loam, often with a hardpan below these layers. In areas of outwash, which are less common in the Site, soils are fine sand over sand and gravel. On steep to gently sloping terrain, mineral soils are typically derived from till associated with ridges with convex, concave, or nearly linear slopes. Upland mineral soils are typically of moderate fertility, dry and warm during the growing season, and with a rapid rate of infiltration and permeability. Exceptions are lower concave side slopes transitioning to wetlands, and drainages, where soils are cooler, typically with mesic to wet-mesic conditions.

[5] See MN DNR (2003) or Minnesota DNR website (http://www.dnr.state.mn.us/ecs/212L/index.html) for a description of the Ecological Land Classification System and units (sections and subsections) in Minnesota,

Hydrologic Context and Features

As mentioned above, the Headwaters Site straddles the continental divide, with water from the Site flowing both east through the Great Lakes to the Atlantic Ocean and north to the Arctic Ocean. Paradoxically, the divide runs through a peatland. Although the peatland appears flat, water flows out of it from all sides, forming the ultimate source of rivers that eventually reach two different oceans. The Site is the headwaters of four rivers: Stony River, Dunka River, South Branch Partridge River, and the St. Louis River (Figure 3, page 83). The largest river leaving the Site is the North River, which flows south into Seven Beavers Lake, the source of the St. Louis River. Water from Big Lake flows west into the Partridge River system, which later joins the St. Louis River on its way to Lake Superior. These two sixth-level sub-watersheds constitute the headwaters of the St. Louis River watershed; the St. Louis River is the second largest tributary to Lake Superior. Water from the northwestern part of the peatland flows out the Dunka River to Birch Lake and eventually to the Rainy River and the Arctic Ocean. The northeastern-most part of the Site is also part of the Rainy River drainage, by way of Nip Creek and Sand River to the Stony River, and Birch Lake.

Upper St. Louis River Watershed

The Minnesota Pollution Control Agency has conducted a ranked assessment of the integrity of minor watersheds in Minnesota's portion of the Lake Superior Basin (Minnesota Pollution Control Agency 2003). Ranking was based on condition parameters, including stressors or disturbances within the watershed; and on vulnerability parameters, including values at risk that can be affected by management activities. Overall, the Upper St. Louis River watershed ranked in the second highest of five categories of condition among the minor watersheds in Minnesota's portion of the Lake Superior basin. Although no similar ranking of the Rainy River basin watersheds has been done, the quality of the native plant communities and undeveloped character of the Upper Rainy River minor watersheds within the Headwaters Site suggests a similar condition.

Streams

Within the Headwaters Site, the generally flat landscape and high percentage of lakes and wetlands combine to create an area with relatively few streams. Streams in the area are generally unconfined, sinuous, and have low gradients. Annual low flows typically occur during the winter, from December through March. Annual peak flows can occur anytime between March and November, but most often are associated with snowmelt in early April (Fedora 2005).

Stream flow response to precipitation is highly influenced by water table elevations in the surrounding wetlands. When water tables are high, precipitation moves quickly through the undecomposed surface layers of peat to become streamflow. When water tables are low, rainfall first raises the water table, and little water becomes available for streamflow until the water table is recharged. Generally, low flows in the Site's streams are likely to be lower than in surrounding watersheds except in those streams that intercept regional groundwater tables. The pH of streams in the Site reflects the differing degrees of groundwater influence.

The North River is the major stream of the Headwaters Site. Along with its tributary, Ridgepole Creek, it drains the majority of the Extensive Peatlands into Seven Beavers Lake, following a mostly sinuous, low-gradient channel. For most of its length the width is only a few yards, widening to 30 yards at the mouth (Fedora 2005). The substrate is predominantly silt, with a sand

component in places. At low water, mudflats along the shore are extremely soft. Devil crayfish *(Cambarus diogenes)* burrows were observed in these mudflats; this native species appears to be declining in number in parts of its range as a result of insecticide use and a decrease in suitable habitat (Michigan Department of Natural Resources). Inlets along the North River, where channels sometimes drain water into the river, have mud flats with spikerushes *(Eleocharis* spp.), narrow-panicled rush (Juncus brevicaudatus), mare's tail *(Hippuris vulgaris)*, arrowheads (Sagit*taria* spp.), scheuchzeria *(Scheuchzeria palustris)*, buckbean *(Menyanthes trifoliata)*, and even a few spatulate-leaved sundew *(Drosera intermedia)*. The vegetated bank is about 16 inches above normal water level. The floodplain is dominated by extensive open rich fens, primarily Northern Rich Fen [OPn92], sometimes with *Sphagnum* moss and sometimes without. These fens contain a very large population of Michaux's sedge *(Carex michauxiana)*, listed as Special Concern in Minnesota. There are a few small patches of Northern Shrub Shore Fen [OPn81] within the rich fens; these areas have greater cover of sweet gale *(Myrica gale)* and leatherleaf *(Chamaedaphne calyculata)*. A few places along the river also tend toward Sedge Meadow [WMn82b], which has less fen wiregrass sedge *(Carex lasiocarpa)* and more beaked sedge *(Carex utriculata)* and lake sedge *(Carex lacustris)* compared to rich fen communities. (See Native Plant Communities below for more detailed descriptions of these communities.)

The dominant plants growing in the river channel are yellow pond lily *(Nuphar variegata)*, small yellow waterlily *(Nuphar microphylla)*, white waterlily *(Nymphaea odorata)*, and floating bur reed *(Sparganium fluctuans)*. These species never cover extensive areas. There are scattered patches of Torrey's mannagrass *(Puccinellia pallida)*, listed as Special Concern in Minnesota, along the water's edge.

The lower stretch of the North River flows without obstruction, but above Ridgepole Creek the gradient is almost entirely controlled by small beaver dams, which have been built to the top of the channel (Fedora 2005). According to Fedora (2005), historical aerial photos revealed that the pattern of stream meanders remains remarkably unchanged since 1934, despite historical logging and road construction activities. Although no trees currently grow near the banks of the lower North River, there are some dead tree stumps, suggesting that water levels have fluctuated significantly in the past. A 1934 aerial photo shows a higher water level than subsequent photos, which show a stable level that matches current conditions.

Nip Creek is part of the Rainy River watershed. This state-designated trout stream flows northward along the Site's northern boundary from its headwaters in a wetland-and-upland-island complex in the east-central portion of the Site.

Two unnamed creeks, tributaries of the Dunka River (in the Rainy River watershed), flow to the northwest from the Site. One of these originates from a large bog and fen complex and the other originates from the highly heterogeneous mosaic of wetlands and uplands in the northeast corner of the Site. Both have narrow, sinuous, low-gradient channels, with width generally less than 26 feet. Active and abandoned beaver dams and flooding are common. Ponds are also common. Along much of the southern extent of these tributaries there are bands of open, low-shrub and graminoid-dominated vegetation adjacent to the channels. Where observed by MCBS ecologists, the substrate along these tributaries is predominantly silt.

Lakes

Lakes of the Headwaters Site are rich in dissolved minerals, with circumneutral pH as evidenced by water chemistry sampling and abundant presence of aquatic species typical of circumneutral waters, such as wild rice and water lilies. Origin of lake water is unknown, but the most likely sources are groundwater springs and streams where present. These waters have significant influence on adjacent native plant communities, depending on how excess water leaves the lake (see discussion below in Peatlands Hydrology).

Big Lake lies within the upland forest landscape of the western part of the Site. At 788 acres, its maximum depth is 30 feet and it has very little emergent or floating vegetation or wetland fringe compared to nearby large lakes. Almost the entire shoreline is thickly forested. Unlike Seven Beavers Lake, it has no significant tributaries, but it is the source of the South Branch Partridge River. Minnesota Department of Natural Resources (MN DNR) Fisheries mid-summer measurements of the lake between 1979 and 1993 documented a pH range of 7.34–7.8 (J. Geis, pers. comm. 2005). The only shoreline development is a single private cabin set well above the southern shore and accessed by all-terrain vehicle (ATV) or snowmobile, and a boat landing where several boats are stored at the southern tip, which is accessed by an ATV trail across the railroad tracks.

Peatland Lakes

Swamp Lake is a small lake ringed by a 30–100 foot band of Low Shrub Poor Fen [APn91a] vegetation. The fen consists of a mat of *Sphagnum* moss, floating near the water's edge but firm near the surrounding forested peatland. Mounds of *Sphagnum* are covered with the low shrub, leatherleaf. Other species common in the fen include Labrador tea *(Ledum groenlandicum),* small cranberry *(Vaccinium oxycoccos),* scheuchzeria, marsh St. John's wort *(Triadenum fraseri),* pitcher plant *(Sarracenia purpurea),* marsh cinquefoil *(Potentilla palustris),* bog wiregrass, and poor sedge *(Carex paupercula).* There has been recent ATV traffic on federal land along the northwestern shore, which has left deep tracks in the fen vegetation. A single boat was observed, on St. Louis County land, on the southern shore where a trail leads to a county-lease cabin 755 feet away on the closest upland outside the Headwaters Site.

The Extensive Peatlands complex includes eleven lakes, three 10 acres or less in size and the rest ranging from 30 to 160 acres. All the lakes support some floating-leaved aquatic vegetation. Lake-filling—the gradual process of vegetation growing over lakes—has likely already occurred in the Headwaters peatlands, eliminating and effectively masking the past presence of other lakes. Current evidence of this process is found in Bonga, Continental, Ridgepole, and Fools lakes, and to a lesser extent in three unnamed lakes northwest of Lobo Lake, where floating peat mats occur along all or parts of lake edges. Except in the case of Ridgepole Lake, where an open fen mat 30–130 feet wide rings the entire lake, the mats are discontinuous. All of the lakeshore mats support open fen communities [OPn81, APn91], but the shore along Bonga Lake also supports some bands of Cattail - Sedge Marsh [MRn83a].

The absence of a floating peat margin on Culkin Lake, Lobo Lake, and a small-unnamed lake north of Bonga Lake is evidence of strong groundwater discharge to these lakes.

Peatlands Hydrology

Peatlands in the Headwaters Site are nutrient poor, reflecting the amount, source, and movement

of water in the flat to very gently sloping landscape. The peatlands have three sources of water: precipitation, groundwater, and runoff. Bogs, the poorest peatland communities, receive water only from precipitation. Surface water in bogs flows away from or around areas where domes of peat have developed (usually downslope from flow obstructions or over minor drainage divides), limiting pH to less than 4.2. While the water table is often at or near the surface in these areas, significant drawdowns are common. In fens, influence by groundwater or runoff raises surface water pH above 4.2. Underlying substrates and adjacent uplands influence the presence and abundance of mineral-rich groundwater, with direct effects on water chemistry and native plant communities.

In the Extensive Peatlands portion of the Site, run-off from uplands and raised-peat landforms drains down-slope and coalesces into water tracks, which terminate in tributary streams to the North River at the down-slope margin of the peatland. The pH increases to 5.5 or higher in the water tracks, depending on the amount and chemistry of surface run-off and groundwater inputs. The water table is near the surface and stable, with little seasonal variability; both conditions directly affect plant composition of wetland communities in the Extensive Peatlands. Figure 3 (page 83) illustrates the general direction of surface water movement in the peatland complex.

The Site's medium to coarse, loamy upland soils permit rapid infiltration of water from rainfall and snowmelt, which then flows laterally into adjacent peatlands or downward into the groundwater aquifer. Water moving to the peatlands from upland landforms, including islands, accumulates minerals and creates distinctive environmental gradients that are reflected in the vegetation. There are wide gradients of white cedar *(Thuja occidentalis)* ([Northern Cedar Swamp (Northeastern)][FPn63a]) or speckled alder *(Alnus incana)* ([Alder – (Maple – Loosestrife) Swamp] [FPn73a]) where water is moving downslope in the large peatlands. Narrower gradients are present on the upstream side of the peatlands or of islands within it, where there is very little water movement.

The Site's peatland lakes also have significant influence on adjacent vegetation, depending on the water chemistry of the lake and how excess water leaves the lake. In lakes with stream outlets, abrupt environmental gradients often exist between the lake, whose water is rich in minerals and near neutral in pH, and adjacent acid peatland plant communities. On the margins of these lakes this narrow gradient is often occupied by sweet gale. In lakes without stream outlets, excess water tends to move downstream from the lake over a broad area. This mineral-rich water fans out through the peat along some part of the lake edge, supporting rich peatland forest in areas near the lake. With increasing distance from the lake, the mineral content of the water is diluted, the ecological gradient diminishes, and the vegetation becomes dominated by acid peatland communities. The Lobo and Continental lakes areas have good examples of water fans and of abrupt gradients between bogs and swamps (Figure 3, page 83 and Figure 5, page 87).

Historic Vegetation

According to Marschner's map of past vegetation of Minnesota (Marschner, date unknown), vegetation prior to European settlement around Big Lake was dominated by Aspen-Birch (trending to Conifers) with interspersed Conifer Bogs and Swamps. Current vegetation is similar. The northwestern part of the Headwaters Site on the Superior Lobe glacial drift was Jack Pine Barrens and Openings according to Marschner, but Public Land Survey (PLS) line notes

(1873–1894) indicate a dense forest with jack pine *(Pinus banksiana)* as a component. Aspen (Populus tremuloides and P. grandidentata) and birch *(Betula papyrifera)* currently dominate this area. Pines south of Big Lake, as indicated by PLS bearing trees, are no longer present, but north of Big Lake they are still present, along with white cedars. The PLS line notes for the entire area around Big Lake include tamarack *(Larix laricina)* as a component, but this species no longer appears to be present in the uplands.

In the Extensive Peatlands, both Marschner and the PLS line notes describe the presettlement vegetation as principally wetlands of spruce and tamarack with islands of upland forest, and adjacent uplands in the north with mixed white and red pine forests on the Rainy and Superior Lobe drift. A dense understory of beaked hazelnut and balsam fir in the uplands, and alder and cedar in wetlands are also mentioned in the PLS general descriptions. With the possible exception of the loss of tamarack from the upland communities, little about the vegetation has changed in this portion of the Site.

Natural Disturbance History and Forest Development

In the past, fire was the dominant natural disturbance in the forests of the Headwaters Site and fire-scarred stumps are abundant in pine-dominated upland islands in the Extensive Peatlands. In the transitional zone between the uplands around Big Lake and the peatlands to the east, there has been some recent wind damage to mixed stands of aspen, balsam fir *(Abies balsamea),* and black spruce *(Picea mariana).* The damage was not evident on 1997 MN DNR color-infra-red photography of the area, but occurred before 2003 Farm Service Agency photography, possibly part of the wide-ranging blowdown of July 4, 1999. Conditions in these 20–25 patches of blowdown—which are mostly less than one to two acres, with the largest about five acres—provide sites for establishment of long-lived conifers from nearby pine and spruce seed sources. Even within the blowdown areas there are still some standing trees.

Other natural disturbances to forest ecosystems are caused by insects and parasites, such as spruce budworm *(Choristoneura fumiferana),* larch sawfly (*Pristiphora erichsonii),* eastern larch beetle *(Dendroctonus simplex),* and dwarf mistletoe *(Arceuthobium pusillum).* Spruce budworm, a moth larva that favors balsam fir, has not had any recent impact on the Headwaters Site. Larch sawfly larvae can defoliate tamaracks. In Minnesota old tamaracks are rare because of huge sawfly outbreaks in the first half of the 1900s (MN DNR Division of Forestry 1997). Since the 1970s, when two species of European wasps that parasitize sawflies were introduced, outbreaks have been small (Seybold et al. 2002, Barzen 2002). Larch beetles, which can kill tamaracks by boring into their phloem, continue to affect tamaracks in Minnesota, but mortality was not observed in the Headwaters Site. Dwarf mistletoe is a parasitic plant that favors black spruce and can cause tree mortality over large areas, but in the Headwaters Site infestations are small. When a canopy of nearly pure black spruce is opened, other tree species, particularly tamarack, often regenerate, along with black spruce stunted by the parasite.

An analysis of Public Land Survey records completed by the MN DNR reports an average rotation of catastrophic fire in Northern Mesic Mixed Forest [FDn43] in northern Minnesota, the predominate forest class of the Headwaters Site, of about 220 years (MN DNR 2003). This forest class includes both white pine *(Pinus strobus)* – red pine *(Pinus resinosa)* forests and aspen – birch forests. The rotation of severe surface fires was about 260 years, resulting in an

estimated combined rotation for catastrophic and surface fires of 115 years (J. Almendinger, pers. com. 2006). In a report to the Minnesota Forest Resources Council, Frelich (1999) used information from several studies to estimate a rotation of stand-replacing fire of 150–300 years for white pine–red pine forest and 100–200 years for birch-aspen-spruce-balsam fir forest. White pine–red pine forests had additional surface fires every 40 years on average. Both analyses reported rotations of stand-leveling windthrow of over 1,000 years. Partial windthrow was of course much more frequent.

Native plant communities in the Acid Peatlands and Forested Rich Peatlands Systems dominate the extensive forested peatlands of the Headwaters Site, including Northern Spruce Bogs [APn80], Northern Poor Conifer Swamps [APn81], Northern Rich Spruce Swamps (Basin) [FPn62], and Northern Rich Tamarack Swamp (Water Track) [FPn81]. Bogs and poor swamps have much longer rotations of catastrophic fire than the upland forests (greater than 1,000 years for [APn80] and about 570 years for [APn81]) and shorter surface fire rotations (120 and 90 years, respectively) (MN DNR 2003). The effects of fire on these peatlands are described as ranging from black spruce mortality and maintenance of nearly continuous leatherleaf cover to conversion to open bog, depending on fire intensity (MN DNR 2003). Fire frequency in rich spruce swamps [FPn62] is similar to that in the upland forests (about 220 years), probably because the swamps are often embedded within upland landscapes that determine the overall fire rotation for the area. This may be true in the area around Big Lake, but the rich spruce stands to the east within the extensive peatland probably burned less frequently. Stand-leveling windthrow is uncommon in all three forested peatland types: 700 years for [APn80], 500 years for [APn81], and greater than 1,000 years for [FPn62].

In Carlson's study (2001) of a wildfire in the Border Lakes Subsection, intermixed wet forests and upland forests both burned, but a larger proportion of the wetlands were left unburned. The amount of tree canopy cover left after the fire was variable across the landscape, even within the uplands. In the aspen-birch cover type, very little forest was untouched by fire: roughly 60–70% of the area lost more than 75% of its canopy, and roughly 20–30% of the area lost 6–50%. More than half the white pine – red pine type lost 25–75% of its canopy, while the rest was burned either more severely or less severely. The patch sizes of the severity classes were also variable, averaging about 2.5 acres. This study is only one example of fire effects on forest patterns. Differences in Land Type Associations within the subsection would likely result in different fire behavior. However, these patterns provide a picture of what the upland forest in the Headwaters Site might have looked like after a natural disturbance. Natural disturbance patterns in the Headwaters landscape may also account, in part, for the presence of the transitional communities described below (see Forested Peatland/Upland Transition Complex [FPT_CX], page 24).

In the open peatland communities, environmental conditions, including cycles of inundation and drawdown, are very consistent. Under natural conditions succession is gradual and related to vegetation changes in response to changing water chemistry and quantity rather than catastrophic disturbance. Some natural disturbance occurs at a small scale, for example moose wallows and narrow (less than 20 inches wide) linear tracks of peat disturbance created by moose travel.

Native Plant Communities (see Figure 5, page 87)

The earliest plant community research in the Headwaters Site, conducted between 1978 and

1981, focused on the peatlands as part of the MN DNR's Peat Program (Wright et al. 1992). Field surveys of both upland and wetland native plant communities were conducted by MCBS plant ecologists during the summer of 2005 and a map of plant communities was prepared for the Site in 2006. The various plant communities in the Headwaters Site are principally communities represented in the Fire-Dependent Forest, Forested Rich Peatland, and Acid Peatland systems. Open Rich Peatland System communities cover less area. (More description of systems and the MN DNR's native plant community classification and additional information on community ecology can be found in MN DNR [2003] and on the MN DNR website [http://www.dnr.state.mn.us/npc/index.html].)

The Headwaters Site's native plant communities are typically high quality due to their size (relative to the size at which they occur naturally), condition, and landscape context. They also reflect the range of environmental gradients, ecological conditions, and repeatable patterns of the LTAs. Most of the native plant communities are functioning under relatively undisturbed conditions and provide habitat for rare species. The statewide conservation ranking of the communities in the Site ranges from S2 to S5, and several of those ranked as S3, S4, or S5 appear to be rare or unique in the Laurentian Uplands Subsection (MN DNR 2004a; see also Native Plant Community Ranking and Assessment below for definitions of S-Ranks).

Extensive Peatlands Native Plant Communities
The native plant communities of the Acid and Open Peatland systems that form the extensive patterned peatlands in the northern and eastern part of the Site are unique in the Northern Superior Uplands Section and among the highest quality in the state, with fine examples of many of the characteristic peatland landforms, including forested raised bogs, which in Minnesota are at the southern edge of their continental range (MN DNR 1984). The Acid and Open Peatland communities of the Extensive Peatlands area are interspersed with communities of the Forested Rich Peatland and Wet Meadow/Carr systems, as well as islands of upland mesic mixed forest from the Fire-Dependent Forest/Woodland System.

Big Lake Area Native Plant Communities
In the Big Lake Area, upland fire-dependent communities are dominant, with interspersed peatlands. The communities in this area occur in patches larger on average than those in most of the Laurentian Uplands Subsection. The uplands and peatlands in this area are linked by many examples of distinct transitional vegetation that do not cleanly fit the plant communities in the MN DNR's native plant community classification. A detailed description of these communities is presented below in Forested Peatland/Upland Transition Complex [FPT_CX], on page 24.

Native Plant Community Ranking and Assessment
Minnesota's native plant communities have been evaluated and assigned ranks based on the Natural Heritage Conservation Status Rank (S-Rank) system developed by NatureServe (2002). The resulting community S-Rank is a value (S1 to S5) assigned to a native plant community type (or subtype) that best characterizes the relative rarity or endangerment of high-quality examples of the community statewide. These ranks are defined in the table below and appear with the community descriptions in the text.

Table 1. Statewide Natural Heritage Conservation Ranks (S-Ranks) for Native Plant Community (NPC)Types (MN DNR 2004a)

NPC Type S-Rank	Definition
S1	Critically imperiled.
S2	Imperiled.
S3	Rare or uncommon.
S4	Widespread, abundant, and apparently secure, but with cause for long-term concern.
S5	Demonstrably widespread, abundant, and secure.

Native Plant Community Descriptions

In the community classification described in the MN DNR's Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province (MN DNR 2003), vegetation types are arranged hierarchically within Systems. Plant community classes (such as [FDn43]) are divided into types (such as [FDn43a], [FDn43b], and [FDn43c]), and types are often divided into subtypes (such as [FDn43b1] and [FDn43b2]). Descriptions for each of the native plant community and community complex map units used in Figure 5 are found in this section under a brief description of the associated System. See the Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province (MN DNR 2003) for further information concerning the System level of the classification.

Fire-Dependent Forest/Woodland System

Fire-Dependent Forest/Woodland communities are dominated by species adapted to survive repeated fires and regenerate successfully after fires. Evergreens are prevalent, most visibly pines and other conifers. These communities are strongly influenced by fires that periodically remove the litter, duff, and organic material, and that can have significant effect on nutrient cycling and availability. In the Laurentian Mixed Forest Province, fire-dependent communities occur on well-drained or thin soils over bedrock. The random behavior of wildfires causes nutrient availability in these communities to be episodic and unpredictable. Prior to fire suppression, because the rotation period for surface fires was equal to or longer than that for stand-regenerating fires, Northern Fire-Dependent [FDn] communities in this system tended to become multi-aged as they matured, with fairly constant recruitment of shade-tolerant species.

Northern Mesic Mixed Forest Class [FDn43] 5689 Acres

In the Headwaters the canopies of mesic forests are most often mixed, but range from solely coniferous to solely deciduous. White, red, and jack pine, aspen, paper birch, white cedar, white spruce *(Picea glauca),* black spruce, and balsam fir are all important canopy species. Within the Site this community occurs in landscape settings ranging from small isolated islands within the Extensive Peatlands (often remnant eskers), to large patches on morainal landforms, particularly in the upland-dominated Big Lake Area. The shrub layer is dominated by deciduous species and variable in cover. Beaked hazelnut *(Corylus cornuta),* bush honeysuckle *(Diervilla Lonicera),* and mountain maple *(Acer spicatum)* are common shrubs. In the patchy to continuous cover of ground-layer plants, Canada mayflower *(Maianthemum canadense),* bunchberry *(Cornus canadensis),* wild sarsaparilla *(Aralia nudicaulis),* bluebead lily *(Clintonia borealis),* and large-leaved aster *(Aster macrophyllus)* are common. Mosses and lichens are common on exposed rock, tree boles, and coarse woody debris.

White Pine – Red Pine Forest [FDn43a] S2/ 1128 Acres
Pine forests occur as inclusions within the Headwaters Site's widespread [FDn43b1] forests (described below) and are prevalent on islands within the Extensive Peatlands, including eskers. Some stands have nearly pure canopies of red pine or jack pine, while others are dominated by white pine or a mix of species. Many pines are in the 14–18 inch diameter-at-breast-height (dbh) range, and old charred snags are common on some islands. Some stands have an open understory; others have thick stands of young balsam fir, or a dense understory of tall shrubs (e.g., mountain maple and beaked hazelnut). Ground-layer vegetation is similar to that in [FDn43b1], but is often sparser and sometimes includes species of drier environments, such as bush juniper *(Juniperus communis),* snowberry *(Symphoricarpos albus),* and pipsissewa *(Chimaphila umbellata).*

Old-growth white pine and red pine stands in T59N R12W, SW¼ Section 13 have been designated as old-growth by the state, or evaluated for old-growth qualities by the U.S. Forest Service. The adjacent forest in Section 14 is of similar composition, and although some cutting is evident on 1948 aerial photos, it retains some old-growth qualities. In the two sections, old pine forest totals about 112 acres. Additionally, one high-quality twenty-five acre stand in the U.S. Forest Service candidate Research Natural Area (T58N R12W, S½ Section 12) is dominated by white pines averaging 14–16 inches dbh (one pine near this stand measured 37 inches dbh), mixed with 10–12 inch dbh black spruce (of the same height as the pines) and a few white cedars. U.S. Forest Service inventory data estimate the stand origin year as 1896, but selective cutting is apparent on 1948 aerial photos. Natural origin mesic pine communities dominated by white, red, or jack pine also occur on peatland islands in T59N R12 Sections 13 and 24 and T59N R11W, Sections 7, 8, 9, 10, 18, and 19 (some designated old growth).

In the Big Lake Area ecologists have visited two small pine stands. One 3-acre stand is predominantly red pine averaging 16 inches dbh mixed with birch, aspen, and balsam fir (T59N R12W, SW¼ SW¼ Section 35). The other, observed by Puchalski (1995) in T59N R12W, SE¼ Section 28 and NE¼ Section 33, is dominated by large white pines, some over 30 inches. Puchalski noted significant white pine seedling regeneration in the area. In addition, a jack pine dominated stand was observed in T59N R12W SE¼ Section 28 during a 2005 helicopter overflight.

Aspen – Birch Forest Balsam Fir Subtype [FDn43b1] S4/ 2031 Acres
The predominant upland forests at the Site are mixed hardwood and conifer forests [FDn43b1] with a variable conifer component, mostly spruces and balsam fir, with conifer abundance typically increasing near peatland communities. In the Big Lake Area black spruce is more abundant than white spruce. According to 1998 MN DNR timber appraisal reports for T59N R12W Section 36, black spruce makes up 75–80% of all spruce trees. These forests are generally even-aged with trees averaging 12 inches dbh and with some (especially aspen) up to 18 inches dbh. There have been some recent blowdowns up to 5 acres in size near the upland-peatland transition east of Big Lake. In the northwestern part of the Site jack pine is a minor component of this forest community. Red maple *(Acer rubrum)* is also a significant component.

The understory of [FDn43b1] is typical of the community type [FDn43b], and includes beaked hazelnut, mountain maple, fly honeysuckle *(Lonicera canadensis),* dwarf raspberry *(Rubus*

pubescens), large-leaved aster, bluebead lily, bunchberry, Canada mayflower, wild sarsaparilla, starflower *(Trientalis borealis),* rose twisted stalk *(Streptopus lanceolatus),* woodland horsetail *(Equisetum sylvaticum),* sweet-scented bedstraw *(Galium triflorum),* lady fern *(Athyrium filix-femina),* spinulose shield fern *(Dryopteris carthusiana),* common oak fern *(Gymnocarpium dryopteris),* shining firmoss *(Huperzia lucidula),* round-branched groundpine *(Lycopodium dendroideum),* pointed woodrush *(Luzula acuminata),* mountain rice grass *(Oryzopsis asperifolia),* false melic grass *(Schizachne purpurascens),* long-stalked sedge *(Carex pedunculata),* and drooping wood sedge *(Carex arctata).*

Some small areas in low spots have wetter soil than the dominant forest. These areas often hold temporary puddles, or seasonal pools, but the vegetation only occasionally includes wetland indicators, such as black ash *(Fraxinus nigra).* The tree canopy is often open.

Upland White Cedar Forest [FDn43c] S3/ 816 Acres

Upland White Cedar Forests have been documented at several places in the Site. The MN DNR has a 31-acre designated old-growth upland cedar stand in T59N R11W, SW¼ NW¼ Section 20. In his survey for the U.S. Forest Service, Puchalski (1995) observed upland cedar forest in T58N R12W, NW¼ SE¼ Section 10, and T59N R12W, N½ SE¼ Section 27, and noted sugar maple *(Acer saccharum)* as a canopy component. [Note: Puchalski also mentioned an area of young sugar maple forest in T59N R12W, NW¼ NW¼ Section 36. These maple trees are not readily differentiated from the surrounding forest on color infrared aerial photos, but they indicate the possibility of a small patch of mesic hardwood forest, such as [MHn35 (S3) or MHn45b (S2).] A large block of upland white cedar occurs in the central area of the Site north of the railroad tracks, associated with a large area of uplands of low relief within the Extensive Peatland. During an overflight in 2005, significant areas of white cedar were observed in T59N R12W Sections 27, 33, and 34. There is also upland cedar along the northeastern shore of Big Lake, where patches of Canada yew *(Taxus canadensis)* were observed in 2005. White cedar was also often observed as a canopy species component of other [FDn43] forest types within the Site, such as [FDn43a and FDn43b1]. In general, the understory of upland cedar forest is sparse, but includes the species listed above for [FDn43b1] and often also has mesic species like naked miterwort *(Mitella nuda)* and goldthread *(Coptis trifolia).*

Wet Forest System

Wet Forest communities in the Headwaters Site occur along riparian corridors or in shallow basins where there is a steady supply of groundwater, but which does not inundate the mineral soil for long periods of the growing season. Variations in microtopography and groundwater supply are essential to sustaining these communities.

Lowland White Cedar Forest [WFn53a] S3/ 53 Acres

Occurring in only a few small patches in the area north of Big Lake, wet cedar forests are similar to black ash-conifer swamps [WFn64a], but with greater canopy cover of white cedars and often with greater moss ground cover. The community grows on shallow peat or mineral muck. Ecologists visited only two patches (at the northeast end of Big Lake) during MCBS surveying. The others were classified by aerial photography interpretation, so they may actually be northern cedar swamps [FPn63a], which also has a cedar-dominated canopy. Classification was based on the presence of black ash in the canopy or proximity to rich wetland types. In addition

to the species of [WFn64a], wet cedar forests often contain twinflower, creeping snowberry *(Gaultheria hispidula),* and long-stalked sedge.

Northern Wet Ash Swamp Class [WFn55] 20 Acres
A handful of examples of Northern Wet Ash Swamps have been mapped in the Headwaters Site based on aerial photography interpretation. Ecologists visited none of them during MCBS surveying. This community is richer and drier than Black Ash - Conifer Swamp [WFn64a]. It occurs adjacent to beaver-influenced wetlands (and Big Lake) where groundwater is richer in nutrients than in most of the Site.

Black Ash – Conifer Swamp [WFn64a] S4/ 77 Acres
Although not a common community type in the Site, there are small isolated depressions of Black Ash – Conifer Swamp within upland regions. Strongly influenced by groundwater, the community is the richest in nutrients of all the forested wetland types in the Site. Black ash is the dominant tree species (sometimes with cedar or tamarack) and there is often a dense shrub layer of mountain maple, speckled alder, swamp red currant *(Ribes triste),* and swamp gooseberry *(Ribes hirtellum),* among others. The forb layer is very diverse, including dwarf raspberry, naked miterwort, alpine enchanter's nightshade *(Circaea alpina),* goldthread, woodland horsetail, three-leaved false Solomon's seal *(Smilacina trifolia),* lady fern, spinulose shield fern, sensitive fern *(Onoclea sensibilis),* common oak fern, rough bedstraw *(Galium asprellum),* sweet-scented bedstraw, northern bugleweed *(Lycopus uniflorus),* mad dog skullcap *(Scutellaria lateriflora),* willow-herbs *(Epilobium* spp.), marsh marigold *(Caltha palustris),* spotted Joe pye weed *(Eupatorium maculatum),* flat-topped aster *(Aster umbellatus),* red-stemmed aster *(Aster puniceus),* tall Northern bog orchid *(Platanthera hyperborea),* and swamp thistle *(Cirsium muticum).* Common graminoids include fowl manna grass *(Glyceria striata),* Canada blue-joint *(Calamagrostis canadensis),* drooping woodreed *(Cinna latifolia),* graceful sedge *(Carex gracillima),* bladder sedge *(Carex intumescens),* bristle-stalked sedge (*Carex leptalea),* soft-leaved sedge *(Carex disperma),* and brownish sedge *(Carex brunnescens).*

Forested Rich Peatland System

Forested Rich Peatland communities within the Headwaters Site occur on deep (>15 inches) peat. They derive the majority of their water from mineral-rich groundwater and have surface-water pH of 5.5 to 7.5. In these rich peatlands, stagnant groundwater tables are typically below the peat surface, especially during the summer. During periods of high water-table levels, pools often form at the surface in hollows that are common among the hummocks around trees bases.

Rich Spruce Swamp (Basin) [FPn62a] S3/ 4234 Acres
Rich Spruce Swamp is a common peatland type in the Site. The community occurs as a component of the Extensive Peatlands in the east and in isolated depressions within the Big Lake Area uplands. The largest expanses are in the southern part of the Site, on either side of the North River corridor. This area was clearcut in the 1940s, so is now nearly pure, even-aged black spruce about 60–70 years old and averaging about 6 inches dbh. Tamarack was probably a larger component in the past. There are open patches of dwarf mistletoe *(Arceuthobium pusillum)* damage, but these are not extensive. In general, the tree canopy is very dense, the shrub layer sparse, and there is a continuous mat of *Sphagnum* and other mosses. Common shrubs are speckled alder, Labrador tea, leatherleaf, willows, and bog laurel *(Kalmia polifolia).* Ground-

layer species include creeping snowberry, small cranberry, three-leaved false Solomon's seal, twinflower, woodland horsetail, bunchberry, bluebead lily, starflower, dwarf raspberry, bristly clubmoss, three-seeded bog sedge *(Carex trisperma)*, and occasional northern comandra *(Geocaulon lividum).*

One species of Special Concern was observed in this community type, Lapland buttercup.

Northern Cedar Swamp Northeast [FPn63a] S4/ 1802 Acres
Cedar swamps are common as patches within the uplands around Big Lake and near the edges of the Extensive Peatlands farther east. The largest examples are near the railroad track along the western edge of the Headwaters Site and at the northeast end of Big Lake. This community is richer than other peatland types, such as Rich Spruce Swamp [FPn62], but poorer than Black Ash - Conifer Swamps [WFn64]. It develops on shallow to deep peat.

Balsam fir and black spruce often join white cedar in the tree canopy. Pools are common, and a continuous carpet of mosses, especially *Sphagnum* mosses, covers most of the rest of the ground. The shrub layer is variable, often including speckled alder, red-osier dogwood *(Cornus sericea)*, dwarf alder *(Rhamnus alnifolia)*, Labrador tea, fly honeysuckle, and swamp fly honeysuckle *(Lonicera oblongifolia).* The ground-layer vegetation includes dwarf raspberry, twinflower *(Linnaea borealis)*, creeping snowberry, goldthread, naked miterwort, starflower, bunchberry, bluebead lily, wild sarsaparilla, red-stemmed aster, northern bugleweed, three-leaved false Solomon's seal, woodland horsetail, crested fern *(Dryopteris cristata)*, spinulose shield fern, cinnamon fern *(Osmunda cinnamomea)*, long beech fern *(Phegopteris connectilis)*, common oak fern, lesser rattlesnake plantain *(Goodyera repens)*, bristly clubmoss *(Lycopodium annotinum)*, shining firmoss, small northern bog orchid *(Platanthera obtusata)*, and heart-leaved twayblade *(Listera cordata).* Graminoids include bluejoint, bladder sedge, soft-leaved sedge, bristle-stalked sedge, three-seeded bog sedge, and graceful sedge.

Lapland buttercup *(Ranunculus lapponicus)*, a species listed as Special Concern, was observed in the Site's rich spruce swamp, but it is actually more typical of cedar swamps and likely occurs in them.

Alder Swamp [FPn73a] S5/ 106 Acres
Alder Swamp is not extensive in the Site, but patches are interspersed with other peatland types. Some alder swamps are not peatlands and do not have a layer of *Sphagnum* moss, but these are rare in the area. Only one tiny example was observed in the Site, at the northern tip of Big Lake. Most alder swamps grow on peat with hummocks of *Sphagnum*. Although there are often stunted balsam fir, white cedar, and black spruce in the community type, they constitute <25% canopy cover, while shrubs are the dominant vegetation, including speckled alder, willows *(Salix* spp.), red-osier dogwood, Labrador tea, bog birch *(Betula pumila)*, red raspberry *(Rubus idaeus)*, and various gooseberries and currants *(Ribes* spp.). Ground-layer vegetation includes dwarf raspberry, goldthread, spotted touch-me-not *(Impatiens capensis)*, northern bugleweed, tufted loosestrife *(Lysimachia thyrsiflora)*, three-leaved false Solomon's seal, wild calla *(Calla palustris)*, northern blue flag *(Iris versicolor)*, red-stemmed aster, flat-topped aster, bog goldenrod *(Solidago uliginosa)*, spotted Joe pye weed, tall northern bog orchid, crested fern, spinulose shield fern, Canada mayflower, and bunchberry. Graminoids include bluejoint,

fowl manna grass, soft-leaved sedge, bristle-stalked sedge, three-seeded bog sedge, silvery sedge *(Carex canescens),* and sometimes lake sedge.

Northern Rich Tamarack Swamp Class (Water Track) [FPn81] 363 Acres
Northern Rich Tamarack Swamp is a part of the Extensive Peatlands complex in landscape settings of deep peat, influenced by lateral flow of groundwater in water tracks originating from two of the peatlands lakes. Surface pH is >5.5. Feather and *Sphagnum* mosses typically have greater than 50% cover, and hummocks and water-filled hollows are common. Cover of forbs, grasses and sedges is sparse but diverse, including marsh cinquefoil, pitcher plant, three-leaved false Solomon's seal, soft-leaved sedge, bristle-stalked sedge and poor sedge. The cover of shrubs varies, relying on hummocks that rise above the water table for suitable habitat. Dominant low shrubs are ericaceous species such as Labrador tea, small cranberry, leatherleaf, and bog rosemary *(Andromeda glaucophylla).* Dominant tall shrubs are usually bog birch and willows. In the Headwaters, tamarack, along with scattered black spruce and white cedar, comprise the patchy canopy.

Rich Tamarack – (Alder) Swamp [FPn82a] S5/ 2430 Acres
Rich Tamarack – (Alder) Swamp occurs as part of the Extensive Peatlands complex and embedded within fire-dependent communities in the Big Lake area. Feather and *Sphagnum* mosses typically have > 50% cover, and hummocks and water-filled hollows are common. Mixed with the tamarack are white cedar, black spruce, and balsam fir trees, forming an interrupted canopy. The shrub layer is often very dense and diverse, including speckled alder, willows, bog birch, Labrador tea, red-osier dogwood, swamp fly honeysuckle, winterberry *(Ilex verticillata),* dwarf alder, gooseberries and currants, and red raspberry. Cover of forbs, grasses and sedges is variable. Ground-layer species include small cranberry, bog rosemary *(Andromeda glaucophylla),* dwarf raspberry, goldthread, bunchberry, bluebead lily, woodland horsetail, field horsetail *(Equisetum arvense),* three-leaved false Solomon's seal, red-stemmed aster, northern blue flag, buckbean, cinnamon fern, and crested fern.

Open Rich Peatland System

Open Rich Peatland communities within the Headwaters Site occur on deep (>15 inches) peat. They derive the majority of their water from mineral-rich groundwater and have surface-water pH of 5.5 to 7.5. Shore fens along the margins of ponds and lakes are influenced also by pond or lake water, and shore fens in laggs are influenced also by run-off from adjacent uplands. In all of these locations, inundation is also often a regular occurrence. Open rich fen water tracks are highly influenced by groundwater, which creates surface flow poor in nutrients, but rich enough in minerals to maintain a pH >5.5. The water supply and level is typically stable near the peat surface, with little seasonal variability (Boelter and Verry 1977; MN DNR 2003).

Northern Shrub Shore Fen Class [OPn81] 12 Acres
Shrub shore fen communities within the Site are typically of small extent and narrow, occurring on floating mats of peat at the margins of peatland lakes, ponds, and streams, or in laggs at the edges of peatlands. Moss cover is usually high and dominated by *Sphagnum*. Cover of ericaceous shrubs is usually high. Cover of grasses is variable and that of forbs and trees is sparse. These communities are influenced by circumneutral water from an adjacent water body, or by runoff from adjacent uplands, which maintains a pH of >5.5. Plants in these communities are adapted to low nutrients and periodic flooding.

Bog Birch – Alder Shore Fen [OPn81a] S5/ 114 Acres
Bog Birch – Alder Shore Fen [OPn81a] occurs in the Headwaters Site in lagg zones at the edges of peatlands, including along the edges of islands within the peatlands. The shrubs bog birch and speckled alder are typically dense, mosses are patchy, and forbs and grasses have little presence. This community also occurs along low-gradient streams, especially tributaries to the North River. These occurrences are mapped as part of the Shrub Shore Fen/Low Gradient Stream Complex [SFS_CX] described below.

Leatherleaf – Sweet Gale Shore Fen [OPn81b] S-5
Leatherleaf – Sweet Gale Shore Fen [OPn81b] occurs along low-gradient streams, especially tributaries to the North River. These occurrences are mapped as part of the Shrub Shore Fen/ Low Gradient Stream Complex [SFS_CX] described below. Leatherleaf – Sweet Gale Shore Fen also occurs on floating mats too narrow to map along the edges of lakes and ponds. In this community, mosses, especially *Sphagnum*, carpet the surface, and shrubs such as sweet gale and leatherleaf are common. Tamarack and black spruce are sparse, and stunted when present. Grasses and forbs are not prominent, but beaked sedge, lake sedge, fen wiregrass sedge, blue-joint, and tussock sedge were commonly observed.

Shrub Rich Fen (Water Track) [OPn91a] S5/ 65 Acres
Shrub Rich Fens at the Site have up to 75% cover of bog birch over a continuous, saturated *Sphagnum* carpet. Occasional low hummocks commonly support fen wiregrass sedge and three-leaved false Solomon's seal, and less often leatherleaf, Labrador tea, stunted tamarack, and black spruce. Small patches of buckbean are common. The community is present over large areas of the featureless water tracks in the northern half of the site.

Graminoid Rich Fen (Water Track) [OPn91b] S4/ 104 Acres
Graminoid Rich Fen (Water Track) is part of the open peatland mosaic. In the Headwaters Site it is characterized by wet lawns of fine-leaved sedges such as fen wiregrass sedge, lead-colored sedge *(Carex livida)*, lantern sedge *(Carex limosa)*, coastal sedge *(Carex exilis)*(listed as Special Concern in Minnesota), and tufted bulrush (Scirpus cespitosus), with occasional subtle hollows dominated by brown mosses and peat-bottomed pools. These pools, oriented perpendicular to groundwater flow, harbor characteristic aquatic species such as lesser bladderwort *(Utricularia minor)*, seaside arrow grass *(Triglochin maritima)*, and lead-colored sedge. Shrubs such as bog rosemary, leatherleaf, small cranberry, bog birch, and sweet gale are often perched on drier hummocks that sometimes punctuate the graminoid lawns, but have <25% cover. Scattered tamaracks and white cedar less than 20 inches tall also grow on these mounds. Forbs commonly observed in this community include pitcher plant, round-leaved sundew *(Drosera rotundifolia)*, northern white violet *(Viola macloskeyi)*, water horsetail *(Equisetum fluviatile)*, rose pogonia *(Pogonia ophioglossoides)*, and bog goldenrod.

Graminoid Rich Fen (Basin) [OPn92a] S4/ 34 Acres
Communities in this class are open rich fens that appear to be transitional between Northern Rich Fen (Water Track) and Northern Wet Meadow/Carr communities. Both types in the class, Graminoid Rich Fen [OPn92a] and Graminoid – Sphagnum Rich Fen [OPn92b] are present in the Site and often intermingle with each other. They are found primarily along the North River, where they grow in floodplain soil saturated by a moderately fluctuating water table associated

with the river. In Graminoid Rich Fen (Basin) communities the cover of *Sphagnum* is typically < 25%. Common graminoids include fen wiregrass sedge, beaked sedge, bluejoint, rattlesnake grass *(Glyceria canadensis)*, cottongrasses *(Eriophorum* spp.), white beak rush *(Rhynchospora alba)*, three-way sedge *(Dulichium arundinaceum)*, and winter bentgrass *(Agrostis scabra)*. Michaux's sedge, a species of Special Concern, is also common along the North River and is actually a dominant species in some areas. Another species of Special Concern, pedicelled woolgrass, is also documented from the river shore. Other species in the community include water horsetail, pitcher plant, round-leaved sundew, marsh cinquefoil, bog aster *(Aster borealis)*, marsh St. John's wort, northern bugleweed, marsh bellflower *(Campanula aparinoides)*, tufted loosestrife, willow herbs, northern marsh fern *(Thelypteris palustris)*, and northern blue flag. Scattered, stunted tamaracks are common.

Graminoid – Sphagnum Rich Fen (Basin) [OPn92b] S4/ 47 Acres
Communities in this class are open rich fens that appear to be transitional between Northern Rich Fen (Watertrack) and Northern Wet Meadow/Carr communities. Both types in the class, Graminoid Rich Fen [OPn92a] and Graminoid – Sphagnum Rich Fen [OPn92b] are present in the Site and often intermingle with each other. They are found primarily along the North River, where they grow in floodplain soil saturated by a moderately fluctuating water table associated with the river. The cover of *Sphagnum* in Graminoid – Sphagnum Rich Fen (Basin) communities is > 50%. These fens have modest amounts of sweet gale, bog willow *(Salix pedicellaris)*, and leatherleaf. Common graminoids include fen wiregrass sedge, beaked sedge, bluejoint, rattlesnake grass *(Glyceria canadensis)*, cottongrasses *(Eriophorum* spp.), white beak rush *(Rhynchospora alba)*, three-way sedge *(Dulichium arundinaceum)*, and winter bentgrass *(Agrostis scabra)*. Other species in the community include small cranberry, bog rosemary, water horsetail, pitcher plant, round-leaved sundew, marsh cinquefoil, bog goldenrod, bog aster *(Aster borealis)*, marsh St. John's wort, northern bugleweed, marsh bellflower *(Campanula aparinoides)*, tufted loosestrife, northern marsh fern *(Thelypteris palustris)*, and northern blue flag. Scattered, stunted tamaracks are common.

Acid Peatland System

Raised acid peatlands such as open bogs [APn90] and semi-treed bogs [APn80] occupy large areas of the Headwaters Site's extensive peatland area. They occur on deep (>15 inches) peat and are dependent on precipitation because the *Sphagnum* substrate elevates the community above the flood level of runoff from surrounding uplands and groundwater cannot move through the dense accumulation of peat. As a consequence, water flows away from or around the peat surface, limiting additions of nutrients and minerals. *Sphagnum*-induced chemical changes in the stagnant surface water lowers pH values of these acidic peatlands communities to <4.2. The water table is usually near the surface, but large drawdowns of the water table are common. Poor conifer swamp communities [APn81] are typically transitional between bogs and fens, rich swamps, or uplands. Their surface pH lies between 4.2 and 5.5 as they receive some minerotrophic ground or surface water. These communities experience some water-table fluctuations, but not as severe as the raised bogs. Bogs and poor conifer swamps in the Site are usually dominated by black spruce, which has suffered some mortality from dwarf mistletoe, but not extensive damage. Poor fens [APn91] have developed on the fringes of some of the raised bogs, in characteristic water tracks with a higher, but still acidic pH of up to 5.5. In some instances, these water tracks gradually transition into rich fens.

Black Spruce Bog [APn80a] S5/ 2108 Acres
Portions of the Headwaters site mapped as Black Spruce Bog include areas where the [APn80a1] and [APn80a2] subtypes are intermingled and not readily mapped as separate entities, and areas where the canopy cover does not clearly indicate one or the other of the subtypes. The structure and composition of the areas mapped as [APn80a] are similar to those of the subtypes described below.

Black Spruce Bog (Treed Subtype) [APn80a1] S5/ 1307 Acres
The Treed Subtype of Black Spruce Bog is prominent in the patterned peatlands of the Headwaters Site, particularly north of the railroad tracks in T59N R11W Sections 15 and 22. Here, the community is present on linear crests where it is readily discernible in aerial photos and from the ground as a radiating linear pattern of black spruce following the subtly sloping concave sides. On upper portions of the bog crests, shading cover of black spruce provides habitat for shade-tolerant species such as velvet-leaved blueberry *(Vaccinium myrtilloides),* Indian pipe *(Monotropa uniflora),* and heart-leaved twayblade. Other occurrences of [APn80a1] lacking the pattern of linear treed crests are present throughout the large peatland complex. High, well-developed hummocks of *Sphagnum* and mats of *Pleurozium* moss are typical in these communities, supporting Labrador tea, leatherleaf, creeping snowberry, small cranberry, three-seeded bog sedge, and few-fruited sedge *(Carex pauciflora).*

Black Spruce Bog (Semi-Treed Subtype) [APn80a2] S5/ 740 Acres
The Semi-Treed Subtype of Black Spruce Bog occurs in patterned peatlands at the bases of bog crests and near the tops of drains, where the water table is high enough to limit tree cover to scattered, stunted black spruce. More tamarack, few-fruited sedge, pitcher plant, and tussock cottongrass *(Eriophorum vaginatum)* are present in this community than in [APn80a1], in response to sparser tree cover of black spruce and higher light conditions. High, well-developed hummocks of *Sphagnum* and mats of *Pleurozium* moss are typical in these communities, supporting Labrador tea, leatherleaf, creeping snowberry, small cranberry, and three-seeded bog sedge.

Northern Poor Conifer Swamp Class [APn81]/ 1294 Acres
Poor Conifer Swamps occur throughout the Headwaters site. Moss cover is continuous and dominated by *Sphagnum* species. Low hummocks and hollows are common. Forbs are sparse, and graminoid cover is < 25%, with fine-leaved species being the most important. Ericaceous species dominate the low shrub layer, and the tall shrub layer typically includes minerotrophic indicators such as bog birch, speckled alder, and willows. The patchy canopy is dominated by stunted black spruce or tamarack. Species diversity is relatively low, but includes minerotrophic indicators.

Poor Black Spruce Swamp [APn81a] S4/ 471 Acres
Poor Black Spruce Swamp occurs in the Headwaters Site in small patches (relative to the other peatland communities), typically in transitional settings between bogs and richer peatland community types or uplands. Cover of stunted black spruce is greater than 50% and occasionally the community has a tall, closed-canopy structure. The ericaceous shrubs Labrador tea and leatherleaf dominate the low shrub layer, which also includes cranberries *(Vaccinium macrocarpon* or *V. oxycoccos),* velvet-leaved blueberry, bog rosemary, creeping snowberry, and bog

laurel. Tall shrubs like speckled alder, willow, and bog birch are occasional. Low hummocks and shallow hollows support a moderate sedge cover including three-fruited bog sedge and creeping sedge, and a sparse forb cover including three-leaved false Solomon's seal, pitcher plant, buckbean, marsh cinquefoil, Pyrola species, round-leaved sundew, and tall white bog orchid *(Platanthera dilatata).*

Poor Tamarack – Black Spruce Swamp (APn81b) S4/ 1641 Acres
Poor Tamarack – Black Spruce Swamp occurs in the Headwaters Site in small patches (relative to the other peatland communities), typically in transitional settings similar to those of poor black spruce swamp, although slightly wetter. Tree cover ranges from 25% to 50% and consists of stunted black spruce with occasional tamarack or vise versa. The ericaceous shrubs Labrador tea and leatherleaf dominate the low shrub layer, which also includes cranberries, velvet-leaved blueberry, bog rosemary, creeping snowberry, and bog laurel. Tall shrubs such as speckled alder, willow, and bog birch are occasional. Low hummocks and shallow hollows support a moderate sedge cover including three-fruited bog sedge and creeping sedge, and a sparse forb cover including three-leaved false Solomon's seal, pitcher plant, buckbean, marsh cinquefoil, Pyrola species, round-leaved sundew, and tall white bog orchid.

Poor Tamarack – Black Spruce Swamp (Black Spruce Subtype) [APn81b1] S4/ 193 Acres
In this subtype, black spruce dominates the canopy with the occasional tamarack. Round-leaved sundew, few-fruited sedge, and buckbean are more often associated with this subtype than with [APn81b2].

Poor Tamarack – Black Spruce Swamp (Tamarack Subtype) [APn81b2] S4/ 159 Acres
Dominated by tamarack and typically with black spruce, this subtype has a slightly more open canopy than APn81b1. Lowbush blueberry *(Vaccinium angustifolium)* is found in the understory, and leatherleaf and bog rosemary are more abundant than in APn81b1.

Northern Open Bog Class [APn90] 239 Acres
Northern Open Bog is present in the Headwaters Site on the sides of raised bog crests, at the upper ends of water tracks, and in the interiors of basins isolated or peripheral to the large patterned peatland. The peat surface is elevated and isolated from groundwater, with a pH of <4.2. Saturation and fast growth of *Sphagnum* severely limit black spruce and tamarack growth. Microtopography is often pronounced, with deep hollows, low *Sphagnum* carpets, and well-developed hummocks.

Low Shrub Bog [APn90a] S5/ 475 Acres
Deep hollows and high hummocks are common in Low Shrub Bogs. Hummocks are dry enough to support a moderate to dense cover of Labrador tea, leatherleaf, bog rosemary, creeping snowberry, and bog laurel, as well as scattered stunted black spruce and tamarack. Forbs such as pitcher plant and round-leaved sundew are typically restricted to small openings among the shrubs and have sparse cover.

Graminoid Bog (Typic Subtype) [APn90b1] S4/ 85 Acres
The Typic Subtype of Graminoid Bog is associated with the large, crested, raised bogs in the patterned peatlands, forming incipient water tracks of wet *Sphagnum* carpets with low hummocks. Bog wiregrass sedge *(Carex oligosperma),* few-fruited sedge, tussock cottongrass, tall

cottongrass *(Eriophorum polystachion),* and lake sedge dominate the hollows and mats, ornamented with pitcher plants and scheuchzeria. Ericaceous shrubs dominate the hummocks, with scattered pitcher plants and round-leaved sundew.

Northern Poor Fen Class [APn91] 139 Acres
Northern Poor Fens are a common aspect of the large patterned peatland portion of the Site and have pH ranging from 4.2 to 5.5.The largest occurrences of the community types in this class are associated with the lower sides of crested raised bogs where they develop as recognizable drains and water tracks that gradually transition into rich fens. Smaller occurrences are associated with floating peat mats on the margins of several of the Site's lakes and ponds.

Low Shrub Poor Fen [APn91a] S5/ 1484 Acres
Low Shrub Poor Fens occur either on floating mats or as part of the peatlands complex. They are characterized by *Sphagnum* hummocks with a relatively homogeneous and dominant cover of leatherleaf and bog birch. Hollows are rare, as are forbs and grasses. This community also develops on the distinct peat ridges, or "strings", adjacent to the "flarks" [APn91c2] described below. Together, strings and flarks create the distinctive pattern characteristic of the "ribbed fens" found in some portions of water tracks.

Graminoid Poor Fen (Basin) [APn91b] S3/ 80 Acres
Graminoid Poor Fen (Basin) occurs on floating mats at the edges of some peatland lakes and ponds and at the edges of the large peatlands complex. Bog wiregrass, few-fruited sedge, and tussock cottongrass dominate the *Sphagnum* carpet, with white beak rush, scheuchzeria, and lantern sedge common in wet hollows.

Graminoid Poor Fen (Featureless Watertrack Subtype) [APn91c1] S4/ 664 Acres
The Featureless Watertrack Subtype of Graminoid Poor Fen is characterized by leatherleaf, bog birch, bog willow, and stunted black spruce and tamarack present on scattered low hummocks. Fen wiregrass sedge and coastal sedge dominate the flora, which also includes creeping sedge, bristle-stalked sedge, lantern sedge, and slender sedge *(Carex echinata).* Forbs such as pitcher plant and buckbean are frequent, along with lesser amounts of small green wood orchid, a species listed as Special Concern. Additional species such as lead-colored sedge, white beak rush, Scheuchzeria, and bog rush are found in shallow wet hollows.

Graminoid Poor Fen (Flark Subtype) [APn91c2] S4/ 279 Acres
The Flark Subtype of Graminoid Poor Fen is a fen dominated by the graminoid species present in [APn91c1], but has well-differentiated peat-bottom pools lying perpendicular to the flow of groundwater and framed by drier moss hummocks that form strings of rich or poor shrub fen. The pools are habitat for aquatic species, such as horned bladderwort *(Utricularia cornuta),* not found in [APn91c1], as well as spatulate-leaved sundew, lead-colored sedge, white beak rush, scheuchzeria, and bog rush.

Wet Meadow/Carr System
Wet Meadow/Carr communities are shrub- or graminoid-dominated wetlands annually subject to inundation flowing spring thaw and heavy rains and to periodic drawdowns during the summer. Broad-leaved graminoids are common, but shrubs often dominate drier sites. Although

peak water levels are high enough and persist long enough to prevent trees (and often shrubs) from becoming established, there may be little to no standing water during much of the growing season. Surface water, derived from run-off, stream flow, or ground water, is circumneutral, with pH 6.0–8.0, and has high mineral and nutrient content. These communities are associated with wetland basins, stream and drainage ways, drained beaver ponds, and shallow bays, or are present as semi-floating mats on sheltered lakeshores.

Northern Wet Meadow/Carr Class [WMn82] 113 Acres
Communities in the Wet Meadow/Carr class occur as small wetland patches dominated by dense graminoids such as bluejoint, lake sedge, and tussock sedge *(Carex stricta)*; tall shrubs such as willows, speckled alder, and red-osier dogwood; or a combination of these.

Willow – Dogwood Shrub Swamp [WMn82a] S4/ 56 Acres
Willow – Dogwood Shrub Swamps are circumneutral (pH 6.0–8.0) open wetland communities. They occur in small patches within the large peatlands complex, near the margin of the peatlands and in shallow drains. Water levels vary over the growing season, with both inundation and drawdown common. Moss cover and species composition varies both within and among communities. Dominant vascular plant cover varies from tall shrubs such as speckled alder, red-osier dogwood, willows, bog birch, and meadowsweet *(Spiraea alba)*, to a variety of graminoids, including lake sedge, beaked sedge, bluejoint, tussock sedge, fowl manna grass, soft-leaved sedge, bristle-stalked sedge, and three-seeded bog sedge. Forbs are a significant component of the community's flora, including bog goldenrod, dwarf raspberry, three-leaved false Solomon's seal, red-stemmed aster, flat-topped aster, northern blue flag, violets, willow herb species, and crested fern. Frequent inundation limits tree cover to scattered black spruce and balsam fir.

Sedge Meadow [WMn82b] S5/ 54 Acres
Beaked sedge, lake sedge, bluejoint, and tussock sedge typically dominate or share dominance in this community, which occurs in the wetland complex along the North River, as small patches near the margin of the patterned peatlands, and as small strips of sedge meadow at the northeast end of Big Lake. Water levels vary over the growing season, with both inundation and drawdown common. pH ranges from 6.0–8.0. Willows, speckled alder, meadowsweet, and red-osier dogwood are sometimes present but typically have <25% combined cover. Forbs such as marsh bellflower, marsh skullcap *(Scutellaria galericulata)*, willow herb species, great water dock *(Rumex orbiculatus)*, and marsh cinquefoil grow among the dense sedge and grass cover.

Marsh System

Tall forbs, grasses, and sedges dominate Marsh communities in wetlands with standing water. Where marshes are adjacent to streams, slow-moving water is present during most of the growing season. Marsh communities may be rooted in mineral soil or floating mats. Stability of water level is dependent on whether inputs include groundwater as a source. If drawdown occurs, it coincides with drought cycles, and is not seasonal. Nutrient levels are usually high, and pH of water is typically circumneutral to basic, but dependent on properties of the substrates in the surrounding landscape.

Northern Mixed Cattail Marsh (Northern) [MRn83] S4/ 3 Acres
Mixed Cattail Marshes are emergent marsh communities typically dominated by cattails *(Typha*

spp.) but with a significant component of graminoids including sedges, woolgrass, and bluejoint. Shrubs are uncommon. In addition to cattails, marsh cinquefoil, tufted loosestrife, and linear-leaved willow-herb *(Epilobium leptophyllum)* are common forbs. Cover of floating-leaved and submergent aquatic plants is sparse. The scattered, small occurrences of this community are on floating mats along some peatland lakes and rooted in mineral soil in a few shallow wetland basins.

Native Plant Community Complex Descriptions

Alder Swamp/Forested Peatland Complex [AFP_CX] 868 Acres
This complex encompasses areas of Northern Rich Alder Swamp [FPn73] intermixed with various Forested Peatland classes, including Northern Rich Spruce Swamp [FPn62], Northern Cedar Swamp [FPn63], and Northern Rich Tamarack Swamp [FPn82]. It also occurs where Northern Rich Alder Swamp and Northern Wet Cedar Forest [WFn53] are intermixed. In areas mapped as [AFP_CX], individual native plant communities are difficult to assign for two reasons: 1) the communities are too small or convoluted to map accurately; and 2) the boundaries between communities are gradual, ecotonal, or vague. Tree cover is variable, typically about 25%, with small, scattered patches sometimes approaching 75% cover. Common tree species are black spruce, white cedar, tamarack, and balsam fir, with lesser amounts of paper birch, quaking aspen, and balsam poplar. Open areas have a shrub canopy of nearly pure alder with scattered individual trees and small clumps.

Shrub Shore Fen/Low Gradient Stream Complex [SFS_CX] 60 Acres
This complex includes long, linear occurrences of Bog Birch – Alder Shore Fen [OPn81a] and Leatherleaf – Sweet Gale Shore Fen [OPn81b] communities (described above) and their associated streams, where the streams are too narrow to map and/or where open water appears to be intermittent.

Beaver Wetland Complex [BW_CX] 513 Acres
This mapping complex is used to represent small to medium-sized wetlands whose character has been altered or is influenced by beaver-created impoundments, usually along watershed drainages. These are generally unforested wetlands, although trees and shrubs may have been common prior to beaver impoundment. Standing dead trees (snags) and shrubs and downed wood are common in many of these wetlands. Patches of open water occur directly behind the dam (often mapped separately as open water). Cattails, lake sedge, and other tussock-forming sedges are often dominant in the wettest zones near the dam. Slightly drier zones often support speckled alder, ericaceous shrubs, or bluejoint. Remnants of the wetland communities present before flooding by beaver dams are sometimes found at higher elevations in the watershed. Wetland community types that are frequently inundated by beavers include alder swamp, wet meadow, poor and rich fen, wet cedar forest, tamarack swamp, and black spruce swamp.

Forested Peatland/Upland Transition Complex [FPT_CX] 1530 Acres
This mapping unit identifies areas where a similar tree canopy occurs on adjacent forested peatlands and upland forests, making mapping by aerial photo difficult. The edges between these uplands and peatlands often support distinct transitional communities that do not clearly fit the plant communities described in the MN DNR's Field Guide to the Native Plant Communities of Minnesota (MN DNR 2003). This complex of upland, peatland, and transitional zones occurs

where there are minor variations in elevation, either in a matrix of swamp with low islands of upland/semi-upland forest, or where large uplands are adjacent to large peatlands. The soils of the transition zones are moderately- to well-drained sandy loam with or without a clay hardpan and no evidence of gleying. Soils are typically cobbly or shallow to bedrock, with ground cover a mix of *Sphagnum*, *Pleurozium*, and other mosses. Various upland and peatland community classes can occur together in this complex, depending on the location, including Northern Rich Spruce Swamp [FPn62], Northern Cedar Swamp [FPn63], Northern Wet Cedar Forest [WFn53], Northern Mesic Mixed Forest [FDn43], and Northern Poor Dry-Mesic Mixed Woodland [FDn32].

In the Headwaters Site the peatlands and transition zones of this complex are dominated by black spruce, while the uplands have mixed black spruce, balsam fir, aspen, birch, and white pine. Tree cover is typically dense (>75%), but occasional openings are created by budworm mortality to balsam firs or mistletoe mortality to spruces. The two dominant community classes that grade into each other are Northern Rich Spruce Swamp [FPn62] and Northern Mesic Mixed Forest [FDn43]. In the transition zones between them, shrubs and herbaceous vegetation combine species typical of both peatlands and uplands, including those listed in Table 2. The transitional communities are associated with Ecological Land Types 13 and 2 (mapped by the U.S. Forest Service) and perhaps others.

Table 2. Examples of Species from Transition Zones

Peatland Species
Labrador tea, swamp fly honeysuckle, three-leaved false Solomon's seal, purple-leaved willow-herb *(Epilobium coloratum)*, goldthread, soft-leaved sedge, three-fruited bog sedge
Upland Species
prickly wild rose *(Rosa acicularis)*, mountain ashes *(Sorbus* spp.), beaked hazelnut, red-berried elder *(Sambucus racemosa)*, mountain maple, velvet-leaved blueberry, rose twisted stalk, cow wheat *(Melampyrum lineare)*, twinflower, starflower, wild sarsaparilla, Canada mayflower, bunchberry, common wood sorrel *(Oxalis acetosella)*, lady fern, spinulose shield fern, bristly clubmoss, round-branched ground pine, pointed woodrush, mountain rice grass , false melic grass *(Schizachne purpurascens)*, drooping wood sedge

Young Forest Complex [YF_CX] 983 Acres
Regenerating (<30 years old) upland and wetland forest communities within the Headwaters site. These areas are typically the result of timber harvest, but in some instances are forests regenerating after windthrow or spruce budworm mortality.

Rare Plants

The Headwaters Site's rare plant species data are stored in the MN DNR Natural Heritage Information System. Table 3 (below) lists the Site's rare plant occurrences recorded to date. The first data on rare plant populations were collected from the peatland complex in the 1980s during assessments conducted for the MN DNR's Minerals Division Task Force on Peatlands of Special Interest (MN DNR 1984). Puchalski (1995) conducted a search for rare plants around Big Lake in preparation for a proposed U.S. Forest Service timber harvest (which never occurred). He covered 5,000 acres with varying intensity and found no plant species listed by the State of Minnesota as Endangered, Threatened, or Special Concern. He found one occurrence of matricary grapefern *(Botrychium matricariifolium)*, which is tracked by the state but not listed, on MN DNR land (T59N R12W NWNW36). Judith Jones, working for The Nature Conservancy, also collected rare species data (Jones 1999).

MCBS plant ecologists and botanists have surveyed many parts of the Site, including significant survey work in 2005. Yet the Site has been far from thoroughly searched and native plant communities whose type and quality are similar to those supporting rare populations need additional survey.

Table 3. Rare plant occurrences in the Headwater's Site recorded to date.

Scientific Name	Common Name	Status	Location	Notes
Arethusa bulbosa	dragon's mouth	Tracked (not listed)	Peatlands	One very large population; numerous other individuals and small populations
Botrychium matricari-ifolium	Matricary grape-fern	Tracked (not listed)	T59NR12W NWNW36	Single plant found in 1995
Carex exilis	Coastal sedge	Special Concern	Patterned peatland	Large populations
Carex michauxiana	Michaux's sedge	Special Concern	Lower North River; and many other populations	One extremely large population; numerous viable populations
Drosera anglica	English sundew	Special Concern	Patterned peatland	Numerous populations
Juncus stygius var. *americanus*	Bog rush	Special Concern	Patterned peatland, and peatland pond edges	Numerous populations
Platanthera clavellata	Small green wood orchid	Special Concern	Peatlands	Scattered
Ranunculus lapponicus	Lapland buttercup	Special Concern	T58N R11W SWNW6	Scattered within 25 m2
Rhynchospora fusca	Sooty-colored beak-rush	Special Concern	Patterned peatland	Several populations of varying size
Scirpus cyperinus/ S. pedicellatus	Pedicelled wool-grass	Tracked (not listed)	Along North River	Scattered patches
Puccinellia pallida	Torrey's mannagrass	Special Concern	Along North River	Scattered patches

Animals

Information regarding the presence of and use of habitats in the Headwaters Site by individual animal species is more limited than that available for plants. No comprehensive animal surveys, except for birds, have been conducted to date in the Site. However, beginning in the late 1970s, considerable study of patterned peatlands in Minnesota was conducted as part of the Minnesota Peat Program and included animal species and their habitat use of these ecosystems. Applicable information from that work is referenced here to give a more complete picture of these facets of the Site and their significance.

Federally listed species

The U.S. Fish and Wildlife Service currently lists the gray wolf *(Canis lupus)*, Canada lynx *(Lynx canadensis)*, and bald eagle *(Haliaeetus leucocephalus)*, which have been documented in north-eastern Minnesota, as "Threatened." Bald eagles (which are also listed by the State of Minnesota as a species of Special Concern) have a documented nesting site on the western side of Big Lake. Gray wolf sign was observed in the Site by MCBS ecologists in 2005. Lying within the Superior National Forest, the Site is considered by the U.S. Fish and Wildlife Service to provide habitat for the Canada lynx.

Birds

MCBS conducted a breeding bird survey in the Sand Lake Peatland on June 3–5, 2003. Except where otherwise noted, the birds in Table 4 were observed during that survey. No other focused bird survey work has been done, although observations from the Site by knowledgeable MN DNR staff have been included in the table. None are listed as Endangered, Threatened, or Special Concern. Other bird species are also likely to breed in the Site.

Table 4. Breeding Birds Observed in or near the Headwaters Site

Habitat	Common Name	Scientific Name	Remarks
Water	Canada Goose	*Branta canadensis*	
Water	Mallard	*Anas platyrhynchos*	
Water	Black Duck	*Anas rubripes*	Observed Sept. 2005 in North River; may have been migrants
Water	Ring-necked Duck	*Aythya collaris*	
Water	Common Loon	*Gavia immer*	
Conifer	Spruce Grouse	*Canachites canadensis*	Observed in 1987 (S. Wilson, pers. comm.)
Conifer	Great Gray Owl	*Strix nebulosa*	
Conifer	Black-backed Woodpecker	*Picoides arcticus*	
Conifer	Olive-sided Flycatcher	*Contopus cooperi*	
Conifer	Yellow-bellied Flycatcher	*Empidonax flaviventris*	
Conifer	Blue-headed Vireo	*Vireo solitarius*	
Conifer	Gray Jay	*Perisoreus canadensis*	
Conifer	Boreal Chickadee	*Parus hudsonicus*	Observed by MCBS near Site and probably occurs within it
Conifer	Golden-crowned Kinglet	*Regulus satrapa*	Observed by MCBS near Site and probably occurs within it
Conifer	Swainson's Thrush	*Catharus ustulatus*	
Conifer	Northern Parula	*Parula americana*	
Conifer	Magnolia Warbler	*Dendroica magnolia*	
Conifer	Yellow-rumped Warbler	*Dendroica coronata*	
Conifer	Pine Warbler	*Dendroica pinus*	Observed by MCBS near Site; uncommon in this part of state
Conifer	Palm Warbler	*Dendroica palmarum*	
Conifer	Connecticut Warbler	*Oporornis agilis*	

Table 4. Breeding Birds Observed in or near the Headwaters Site continued

Habitat	Common Name	Scientific Name	Remarks
Conifer	Lincoln's Sparrow	*Melospiza lincolnii*	
Conifer	Dark-eyed Junco	*Junco hyemalis*	
Conifer	White-winged Crossbill	*Loxia leucoptera*	
Conifer/Upl. Forest	Boreal Owl	*Aegolius funereus*	S. Wilson, pers. comm.
Forest	Broad-winged Hawk	*Buteo platypterus*	Observed by MCBS near Site and probably occurs within it
Forest	Ruby-throated Hummingbird	*Archilochus colubris*	Observed by MCBS near Site and probably occurs within it
Forest	Pileated Woodpecker	*Drycocopus pileatus*	Observed by MCBS near Site and probably occurs within it
Forest	Yellow-bellied Sapsucker	*Sphyrapicus varius*	
Forest	Hairy Woodpecker	*Picoides villosus*	Observed by MCBS near Site and probably occurs within it
Forest	Eastern Wood-pewee	*Contopus virens*	Observed by MCBS near Site and probably occurs within it
Forest	Least Flycatcher	*Empidonax minimus*	
Forest	Red-eyed Vireo	*Vireo olivaceus*	
Forest	Red-breasted Nuthatch	*Sitta canadensis*	Observed by MCBS near Site and probably occurs within it
Forest	Brown Creeper	*Certhia americana*	
Forest	Winter Wren	*Troglodytes troglodytes*	
Forest	Hermit Thrush	*Catharus guttatus*	
Forest	Veery	*Catharus fuscescens*	Observed by MCBS near Site and probably occurs within it
Forest	Canada Warbler	*Wilsonia canadensis*	Observed by MCBS near Site and probably occurs within it
Forest	Chestnut-sided Warbler	*Dendroica pensylvanica*	
Forest	Black-throated Green Warbler	*Dendroica virens*	
Forest	Blackburnian Warbler	*Dendroica fusca*	Observed by MCBS near Site and probably occurs within it
Forest	American Redstart	*Setophaga ruticilla*	Observed by MCBS near Site and probably occurs within it
Forest	Black-and-white Warbler	*Mniotilta varia*	
Forest	Ovenbird	*Seiurus aurocapilla*	
Forest	Mourning Warbler	*Oporornis philadelphicus*	
Forest	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	
Forest	Baltimore Oriole	*Icterus galbula*	
Forest	Purple Finch	*Carpodacus purpureus*	
Forest/Shrub	Nashville Warbler	*Vermivora ruficapilla*	

Table 4. Breeding Birds Observed in or near the Headwaters Site continued

Habitat	Common Name	Scientific Name	Remarks
Forest/Edge	Ruffed Grouse	*Bonasa umbellus*	Observed by MCBS near Site and probably occurs within it
Forest/Edge	Northern Flicker	*Colaptes auraptus*	Observed by MCBS near Site and probably occurs within it
Forest/Edge	White-throated Sparrow	*Zonotrichia albicollis*	
Swamp/Shrub	Northern Waterthush	*Seiurus noveboracensis*	
Shrub	Alder Flycatcher	*Empidonax alnorum*	
Shrub	Common Yellowthroat	*Geothlypis trichas*	
Shrub/Edge	Yellow Warbler	*Dendroica petechia*	
Shrub/Edge	Wilson's Warbler	*Wilsonia pusilla*	South of main breeding range
Shrub/Open Wetland	Eastern Kingbird	*Tyrannus tyrannus*	
Open Wetland	Northern Harrier	*Circus cyaneus*	
Open Wetland	American Bittern	*Botaurus lentiginosus*	Observed 2005
Open Wetland	Sandhill Crane	*Grus canadensis*	
Open Wetland	Wilson's Snipe	*Gallinago delicata*	
Open Wetland	Sedge Wren	*Cistothorus platensis*	
Open Wetland	Savannah Sparrow	*Passerculus sandwichensis*	
Open Wetland	Le Conte's Sparrow	*Ammodramus leconteii*	
Open Wetland	Swamp Sparrow	*Melospiza georgiana*	
Open Wetland	Red-winged Blackbird	*Agelaius phoeniceus*	
Open Wetland	Brewer's Blackbird	*Euphagus cyanocephalus*	Colony observed near Ridgepole Lake 1988 (S. Wilson, pers. comm.)
Edge	American Kestrel	*Falco sparverius*	
Edge	Tree Swallow	*Tachycineta bicolor*	
Edge	Eastern Bluebird	*Sialia sialis*	Observed in 1988 (S. Wilson, pers. comm.)
Edge	Cedar Waxwing	*Bombycilla cedrorum*	
Edge	Song Sparrow	*Melospiza melodia*	
General	Downy Woodpecker	*Picoides pubescens*	
General	Blue Jay	*Cyanocitta cristata*	
General	American Crow	*Corvus brachyrhynchos*	
General	Common Raven	*Corvus corax*	
General	Black-capped Chickadee	*Poecile atricapillus*	
General	American Robin	*Turdus migratorius*	
General	Chipping Sparrow	*Spizella passerina*	

Although not state or federally listed, the boreal owl is an uncommon species in Minnesota. Its breeding range is restricted to the far northeastern counties and it has been observed in the Head-

waters Site. Boreal owls forage in lowland conifers and nest in abandoned holes excavated by pileated woodpeckers in mature aspen trees. The Headwaters Site has both uplands with mature aspen and adjacent lowland conifer forests and likely provides some of the best habitat in the state for this species.

A breeding pair of adult sandhill cranes (also tracked, but not state or federally listed) and one sub-adult plumaged bird were observed in July 2002, and breeding season pairs were observed during fieldwork in both 2003 and 2005. This species rarely breeds in northeastern Minnesota.

Mammals

Among the earliest written documentation of mammals from the Headwaters Site is from the 1891 Public Land Survey General Description for T59N R11W, in which the surveyor wrote, "Great numbers of Caribou (American Reindeer) live in these swamps on the mosses that grow in great abundance. If these animals are to be preserved, a fork of 10 sq. miles should be fenced and guarded as they are fast disappearing before the Winchester rifles of the hunters." Although the caribou did not survive landscape changes and hunting pressures in the Headwaters region, a wide variety of mammals still inhabit the landscape, and have been observed or are likely to occur in the Site. No site-specific mammal surveys have been conducted in the Headwaters Site. However, MCBS ecologists noted evidence and observations of wolf, moose, red squirrel, white-tailed deer, beaver, and black bear in 2005. Survey work and observation in habitats in Minnesota of similar type and quality also provide some indication of the species likely to be present and the habitats they are likely to use. Mammals potentially found in the Headwaters Site are listed in Table 5.

Table 5. Mammals Potentially Found in the Headwaters Site (Wright et al. 1992, G. Nordquist, pers. comm. 2006).

Common Name	Scientific Name
Arctic Shrew	*Sorex arcticus*
Masked Shrew	*Sorex cinereus*
Pygmy Shrew	*Sorex hoyi*
Water Shrew	*Sorex palustris*
Northern Short-tailed Shrew	*Blarina brevicauda*
Star-nosed Mole	*Condylura cristata*
Little Brown Myotis	*Myotis lucifugus*
Northern Myotis	*Myotis septentrionalis*
Eastern Red Bat	*Lasiurus borealis*
Hoary Bat	*Lasiurus cinereus*
Silver-haired Bat	*Lasionycteris noctivagans*
Big Brown Bat	*Eptisicus fuscus*
Snowshoe Hare	*Lepus americanus*
Least Chipmunk	*Tamias minimus*
Eastern Chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*

Table 5. Mammals Potentially Found in the Headwaters Site continued

Common Name	Scientific Name
Franklin's Ground Squirrel	*Spermophilus franklinii*
Red Squirrel	*Tamiasciurus hudsonicus*
Northern Flying Squirrel	*Glaucomys sabrinus*
American Beaver	*Castor canadensis*
White-footed Mouse	*Peromyscus leucopus*
Woodland Deer Mouse	*Peromyscus maniculatus gracilis*
Southern Red-backed Vole	*Clethrionomys gapperi*
Meadow Vole	*Microtus pennsylvanicus*
Southern Bog Lemming	*Synamptomys cooperi*
Meadow Jumping Mouse	*Zapus hudsonius*
Woodland Jumping Mouse	*Napaeozapus insignis*
Common Porcupine	*Erethizon dorsatum*
Red Fox	*Vulpes vulpes*
Coyote	*Canis latrans*
Gray Wolf	*Canis lupus*
Black Bear	*Ursus americanus*
Common Raccoon	*Procyon lotor*
American Marten	*Martes americana*
Fisher	*Martes pennanti*
Ermine	*Mustela erminea*
Mink	*Mustela vison*
Northern River Otter	*Lontra canadensis*
Striped Skunk	*Mephitis mephitis*
Lynx	*Lynx canadensis*
Bobcat	*Lynx rufus*
White-tailed Deer	*Odocoileus virginianus*
Moose	*Alces alces*

Reptiles and Amphibians

No herpetofaunal surveys have been conducted specific to the Headwaters Site. However, survey work in wetland and forest habitats of similar type and quality in northern Minnesota provides some indication of the species likely to be present and the habitats they are likely to use. Research suggests amphibians are extremely important in the ecological dynamics of both aquatic and terrestrial environments (Burton and Likens 1975; Stockwell 1985; Wright et al. 1992; DeMaynadier and Hunter 1995). Evidence of amphibian biomass and number of individuals suggests there is probably more biomass of amphibians in Minnesota's large patterned peatlands than all other vertebrates combined (Wright et al. 1992). While research has also shown a similar significance in some forest habitats, the fire-dependent communities typical of the Headwaters have not specifically been studied. The Headwaters Site, with its wide variety of wetland types,

both within the uplands and the peatland complex, provides a stable base of unfragmented breeding and over-wintering habitat that can support robust amphibian and reptile populations, which are limited in their ability to disperse in response to unfavorable annual or cyclic environmental conditions such as drought.

While there is relatively low herpetofaunal species richness in large peatlands, especially in nutrient-poor bogs, amphibians and reptiles are nevertheless an abundant and conspicuous faunal component whose individual presence and abundance is influenced by a complex combination of physical, biotic, and historical factors (Wright et al. 1992). Seasonal ponds and semi-permanent wetlands in upland forests provide important breeding habitat for a variety of woodland amphibians. Wood frogs *(Rana sylvatica),* spring peepers *(Hyla c. crucifer),* gray treefrogs *(Hyla versicolor),* and blue-spotted salamanders *(Ambystoma laterale)* are likely to occur in the Site, utilizing temporary wetlands and surrounding upland forest habitat. Eastern red-backed salamanders *(Plethodon c. cinereus)* may occur in forests with sufficient duff layers and coarse woody debris, where eggs are laid. Eastern newts *(Notophthalmus v. viridescens),* northern leopard frogs *(Rana pipiens),* green frogs *(Rana clamitans melanota),* and mink frogs *(Rana septentrionalis)* likely occupy permanent water bodies and creeks. Other species likely using the Site's habitats include American toads *(Bufo a. americanus),* boreal chorus frogs *(Pseudacris maculata),* snapping turtles *(Chelydra s. serpentine),* painted turtles *(Chrysemys picta belli),* common gartersnakes *(Thamnophis s. sirtalis),* and red-bellied snakes *(Storeria o. occipitomaculata).* The most limited herpetofaunal habitat in the Headwaters Site may be turtle nesting sites (C. Hall, pers. comm. 2006).

Fish

Significant fisheries in the Headwaters Site are limited to Big Lake. Surveys there have recorded burbot, northern pike, rock bass, walleye, white sucker, and yellow perch. Fisheries data for the upper North River include three species: white sucker *(Catostomus commersoni),* walleye *(Stizostedion vitreum),* and shorthead redhorse *(Moxostoma macrolepidotum).* According to a hydrological report by Fedora (2005), aquatic organisms in the North River likely include species in the families Cyprinidae (minnow), Gasterosteidae (stickleback), Percidae (perch), and Umbridae (mudminnow). A fisheries survey of nearby Cougar Lake turned up only fathead minnows *(Pimephales promelas)* and brook sticklebacks *(Culaea inconstans).*

Invertebrates

Although there are some nearby records, no invertebrate surveys have been conducted specific to the Headwaters Site. However, limited invertebrate survey work in wetland and upland habitats of similar type and quality in northeastern Minnesota provides some indication of the species likely to be present.

Butterflies

In the Headwaters area, as elsewhere in Minnesota, more is known about butterflies than other invertebrate fauna. There are several distinctive butterflies of the northeastern part of Minnesota that either have been documented from the area or could occur in the Site's habitats. Three of these species are listed in Minnesota as Special Concern. Mancinus alpine *(Erebia mancinus,* formerly *E. disa mancinus*), which is listed as Special Concern, has been documented from the area and is associated with shady, black spruce-dominated habitats. Other peatland butterflies

documented from the area during 2005 include the bog fritillary *(Boloria eunomia),* Freija fritillary *(Boloria freija),* Jutta arctic *(Oeneis jutta),* arctic fritillary *(Boloria chariclea),* and Frigga fritillary *(Boloria frigga)* (R. Dana, pers. comm. 2006).

The red-disked alpine *(Erebia discoidalis)* occurs in the area. Although not a true peatland insect, it seems to occur in damp meadow areas on the margins. The arctic fritillary *(Boloria chariclea)* is often associated with habitats near peatlands (R. Dana, pers. comm. 2006).

Macoun's arctic *(Oeneis macounii),* about which little is known with respect to abundance, has been encountered in jack pine woodlands in the general area. Minnesota may be the only state in the contiguous United States where this species occurs. Its habitat preferences are uncertain, but it has most often been encountered in upland jack pine woodland or jack pine forest with openings. Nabokov's blue *(Lycaeides idas nabokovi),* listed as Special Concern, is also a possibility in openings in upland settings of jack pine and in black spruce forest if its host plant, dwarf bilberry *(Vaccinium cespitosum),* is present (R. Dana, pers. comm. 2006).

Another more remote possibility is the extremely elusive grizzled skipper *(Pyrgus centaureae freija),* a species listed as Special Concern. Within its main range, its habitat is described as "forest edges and openings as well as mixed scrub/heath tundra … in the taiga zone, adjacent to or in boggy areas, or in scrubby willow thickets on the tundra." The species is also known to occur well into the boreal forest of Canada; for instance, it is known from a number of locations in southern Manitoba (Klassen et al. 1989, Layberry et al. 1998). It is known in Minnesota only from the McNair Site, 13 miles south of the Headwaters Site (R. Dana, pers. comm. 2006). Table 6 below summarizes the localized and common butterflies from the Headwaters and surrounding area.

Table 6. Butterflies of Headwaters and Surrounding Area (R. Dana, pers. comm. 2006)

Peatland associates:	
Grizzled skipper *Pyrgus centaureae freija* (remote possibility) SPC	Bog fritillary *Boloria eunomia*
Frigga fritillary *Boloria frigga*	Freija fritillary *Boloria freija*
Arctic fritillary *Boloria chariclea*	Taiga alpine *Erebia mancinus*
Red-disked alpine *Erebia discoidalis* SPC	Macoun's arctic *Oeneis macounii*
Jutta arctic *Oeneis jutta*	Dorcas copper *Lycaena dorcas*
Cranberry copper *Lycaena epixanthe*	
Northern species, somewhat localized:	
Pine elfin *Callophrys niphon*	Hoary elfin *Callophrys polia*
Tawny crescent *Phyciodes batesii*	Western tailed blue *Everes amyntula*
Satyr anglewing *Polygonia faunus*	Harris's checkerspot *Chlosyne harrisii*
Harvester *Feniseca tarquinius*	
Northern species, common:	
Mustard white *Pieris oleracea*	Canadian tiger swallowtail *Papilio canadensis*
Brown elfin *Callophrys augustinus*	Pink-edged sulphur *Colias interior*
Atlantis fritillary *Speyeria atlantis*	Spring azure *Celastrina ladon**
Compton's tortoiseshell *Nymphalis vau-album*	Green comma *Polygonia faunus*

Table 6. Butterflies of Headwaters and Surrounding Area continued

Common roadside skipper *Amblyscirtes vialis*	Pepper-and-salt skipper *Amblyscirtes hegon*
Widespread species, common:	
Dreamy dusky wing *Erynnis icelus*	Tawny-edged skipper *Polites themistocles*
Hobomok skipper *Poanes hobomok*	Dun skipper *Euphyes vestris*
Clouded sulphur *Colias philodice*	Acadian hairstreak *Satyrium acadicum*
Eastern tailed blue *Everes comyntas*	Summer azure *Celastrina neglecta**
Aphrodite fritillary *Speyeria aphrodite*	Great spangled fritillary *Speyeria cybele*
Silver-bordered fritillary *Boloria selene*	Meadow fritillary *Boloria bellona*
Silvery checkerspot *Chlosyne nycteis*	Northern crescent *Phyciodes cocyta* (=*selenis*)
Comma *Polygonia comma*	Gray comma *Polygonia progne*
Mourning cloak *Nymphalis antiopa*	Milbert's tortoiseshell *Nymphalis milberti*
Virginia lady *Vanessa virginiensis*	White admiral *Limenitis arthemis arthemis*
Viceroy *Limenitis archippus*	Northern pearly-eye *Enodia anthedon*
Little wood-satyr *Megisto cymela*	Common wood-nymph *Cercyonis pegala*

*Follows Layberry et al., who recognize two species of this genus in our area. Others recognize three species.

Other invertebrates

Quite a few moth species that are more wide-ranging father north, are restricted to peatland habitats at the southern limits of their ranges, such as those at the Headwaters Site, but little is known about them in Minnesota. Some species of leafhoppers are also likely to fit this pattern, and perhaps species of many other invertebrate groups such as beetles, caddisflies, flies, and wasps (R. Dana, pers. comm. 2006).

HUMAN DISTURBANCE AND USE

The primary human use of the general Headwaters area has been for timber harvest, starting in the early 1900s. This early cutting was probably high-grading for white pine and other high-value trees. The Skibo Sawmill was located on the north side of the St. Louis River, downstream from Seven Beavers Lake. A tug company operated on Seven Beavers Lake to move logs, and a couple of rafting booms are still lying in mud on the lower North River. Log transport on the St. Louis River to the Skibo Sawmill likely involved the use of a splash dam at the outlet of Seven Beavers Lake (Fedora 2005). This may have increased water levels in the lake and its tributaries, as is evident for the North River in a 1934 aerial photo. Old dead stumps along the treeless bank of the North River may be a result of this fluctuation.

Historical aerial photos demonstrate extensive cutting of peatland (and some upland) forests in the North River area in the 1930s and 1940s. Most of the rich spruce swamps in the area were clearcut, but bogs and poor conifer swamps were not cut. In the extensive upland forests around Big Lake, 1948 aerial photos show a network of narrow forest roads through a predominately deciduous forest about 20–30 years old. The tree canopy usually obscures the roads, but they are clear whenever they cross small peatlands. Because such extensive clearcutting was unlikely in this remote area at such an early date, this forest probably regenerated after a fire around 1920. The roads visible in the 1948 photos probably date from pre-fire high-grading. Harvesting continues today at a much smaller scale, particularly in the northwest corner of the Site. There has

also been a recent timber sale on islands within the peatland near Ridgepole Lake. Winter roads associated with this and the earlier swamp forest harvests are still evident in narrow tracks in the open peatlands and narrow, linear canopy openings in the forests.

Despite the history of extensive logging activities and the sensitivity of stream channels to changes in hydrologic processes and sediment inputs, Fedora (2005) found no evidence of changes to stream channels in the upper St. Louis River watershed. Stream banks have been stable over decades, and no changes in stream channel erosion, deposition, or channel migration were observed. In fact, the Headwaters Site as a whole has recovered remarkably from past logging, and ecological processes continue to function at a large scale.

MCBS survey work in 2005 found large upland and lowland areas in the Headwaters Site to be free of non-native species, including earthworms. Typically, non-native species within the Site were associated with roads and upland trails, and with forest stands that have been managed since the 1960s. No comprehensive earthworm surveys were conducted, but the forest in much of the Site is probably worm-free due to the lack of human traffic, recent disturbance, and likely introduction sites. In mesic hardwood forests, European earthworms can change soil profiles and negatively impact some understory ferns and other herbaceous species (Hale 2004, Hale and Host 2005). Although preliminary results do not show similar effects on vegetation in fire-dependent forests, the full impact is unknown, and the ecological change could be significant (Hale and Host 2005). The only likely places for the introduction of earthworms in the Site are at Big Lake and the cabin near Swamp Lake (via discarded bait) or the area along the Dunka River Road in the northwest (via transport and deposition by vehicle tire treads). MCBS field surveys in these areas found no obvious signs of earthworm presence, but surveys did not specifically target earthworms.

Timber harvest at the Site has resulted in changes in the age-class distribution of the forests. The predominance of forests in the range of 60–80 years old, which is a result of past logging and probably also the huge early-century fires that often started in logging slash, mirrors the skew in age class in northeastern Minnesota as a whole and the under-representation of older multi-aged conifers (MFRC 2003). In at least some parts of the Headwaters Site there appear to be fewer of the older residual patches than would be expected in forests that burned naturally (such as the pattern of residuals documented in naturally burned forests by Carlson [2001]). Nevertheless, the Site may represent the best opportunity in the Section to restore the multi-aged conifer stage in patch sizes approximating natural patterns.

Human activities may also have directly and indirectly changed tree species composition in some forests in the Headwaters Site. According to one study of northeastern Minnesota, white pine and tamarack each currently make up 0.5% of the trees in aspen-birch-spruce-balsam fir forests, compared to 8% and 7% in presettlement times (White 2001). The same study showed an increase in aspen from 7.5 % to 26.5%, closely matching the present composition in the Headwaters Site. Although some of the mixed aspen-birch-spruce-balsam fir forest [FDn43b] in the Site has a significant conifer component (predominantly balsam fir and black spruce), this forest type has fewer of some long-lived conifers than it did historically. Many Public Land Survey bearing trees south of Big Lake, for example, were white pines, but few pines grow in that area today. Pines still grow in parts of the upland forest to the north of Big Lake, possibly as a result of less intensive high-grade logging.

Roads and Trails

There are no all-season roads in the Headwaters Site, but there are trails and logging roads (including old logging roads in the peatlands) that have persisted for decades. Along many of these roads in the peatlands, road construction removed the porous peat layer that raises the surface above the water table (or the layer was compacted, even in winter, by heavy use), and the layer of *Sphagnum* moss has been replaced by sedge-dominated vegetation. Compacted peat can also block the flow of water through a peatland, but Fedora (2005) found no evidence of altered hydrology as a result of winter roads. He stressed, however, that further investigation would be required for a thorough evaluation. Some old peatland logging roads have become overgrown (often with alder) and are no longer passable, including some that are visible on current aerial photos. Even trails still used by snowmobiles do not generally receive heavy use at present. Most roads and trails were designed only for winter use because of the extensive wetlands, but there are some upland ATV trails south of Big Lake. Additionally, there has been some non-winter ATV use of the winter roads, causing localized damage.

Railroads

Railroad grades present at the Headwaters Site may be disrupting water flow through the peatlands. Fedora (2005) makes particular note of the railroad crossing on the North River. The two culverts present at the crossing are evidently insufficient during high water flow, causing build-up on the upstream side and a scour pool on the downstream side. In addition, a tributary stream was diverted to this crossing, adding more water volume. The increased flooding has altered wetlands covering about 18.8 acres upstream. This same railroad grade has also blocked water flowing toward Cougar Lake, flooding part of the rich fen to the south.

Recreation

Recreational use of the area is relatively low, due to difficult access. A little-used hiking trail follows an esker southwest from Big Lake toward Stone Lake. There is a boat landing at the southern tip of Big Lake, where several boats are stored; the landing is accessed by an ATV trail across the railroad tracks. ATV trails also lead to another spot on the eastern shore of Big Lake and to a private cabin. The U.S. Forest Service maintains a campsite on the western shore. A county cabin leaseholder keeps a single boat at Swamp Lake. A rotten boat by the edge of Lobo Lake indicates some past use. Dispersed recreation such as camping, and ATV use of minimum maintenance roads, logging roads, and trails is common, particularly during the fall hunting season.

LAND OWNERSHIP PATTERN

The U.S. Forest Service and the MN DNR manage most of the Headwaters Site (see Table 7 below and Figure 2, page 81). The DNR manages the majority of the extensive peatland, while the Forest Service manages the majority of the uplands around Big Lake and in the northwestern corner of the Site. About half the state-owned peatland is within the Sand Lake Peatlands SNA, and most of the federal peatlands are within the Big Lake – Seven Beavers candidate Research Natural Area, which extends west to the shore of Big Lake. There are scattered parcels of St. Louis County and Lake County land, and The Nature Conservancy owns several parcels in the southeastern part of the Site. Some land along railroad tracks is owned by mining or railroad companies, and there are a few private non-industrial parcels, particularly around Big Lake.

Table 7. Ownership in the Headwaters Site

Ownership	Acres	Percent	Combined Percent
U.S. Forest Service (non-cRNA)	14,248	38	53
U.S. Forest Service (cRNA)	5,469	15	
Minnesota State Forest	9,855	26	37
Minnesota Scientific and Natural Area	4,103	11	
St. Louis County	1,145	3	3
Lake County	393	1	1
The Nature Conservancy	824	2	2
Other Private Land	1,409	4	4
TOTAL UPLAND	37,446	100	100
Lakes	1,267		
TOTAL AREA	38,713		

THREATS

The primary threats to the ecological and biological integrity of the Headwaters Site are: 1) fragmentation, decreased patch size, and edge effects associated with roads, timber harvesting, and recreational developments such as campgrounds or dispersed sites, boat landings, and some types of trails; 2) silvicultural methods that do not mimic the spatial and temporal scale and intensity of natural disturbances relevant to the native plant community being managed; 3) introduction and establishment of exotic species as a result of all the above mentioned activities and via all non-winter uses of roads, logging access routes, winter roads, trails, and water access; and 4) fire suppression in fire-dependent native plant communities.

MANAGEMENT RECOMMENDATIONS

Overview

The Headwaters Site is a large, natural area with features of widely recognized statewide ecological and biological significance. These include:

- one of the 15 most significant peatlands in the state (MN DNR 1984, Wright et al. 1992);
- the largest SNA in the Northern Superior Uplands Section;
- one of the largest, unfragmented, predominantly upland forest patches in the Laurentian Uplands, Toimi Uplands, and North Shore Highlands subsections;
- an ecologically functional mosaic of high quality native plant and animal communities;
- a concentration of excellent occurrences of rare species populations;
- support of species with large home ranges;
- six state-designated old-growth stands;
- remote, undeveloped lakes.

The Site's Outstanding Statewide Biodiversity Significance rank and recommendation by MCBS as an area for ecologically based management reflect these features, and its importance from a statewide and regional perspective. The Headwaters Site's natural features merit protection and management intended to sustain the Site's biological and ecological features and value. This is particularly crucial in the face of increasing pressures on public and private lands in northeastern Minnesota ranging from increasing demand for wood products and recreational access to the subdivision, sale, and development of large blocks of commercial forest and other private lands.

The Headwaters Site is part of the Sand Lake/Seven Beavers Project Area that has been identified as a priority conservation area by The Nature Conservancy (The Nature Conservancy 2000; The Nature Conservancy and Nature Conservancy Canada 2002). In part, recognition of this unique and high-quality landscape prompted the formation of the Sand Lake/Seven Beavers (SL7B) collaborative, which provides a forum for informed, coordinated land management among the large landowners of a four-township area (Figure 1, page 79). The collaborative was formally organized in December 2002 via a Memorandum of Understanding (MOU) agreement, signed by Lake County Land Department, MN DNR, TNC, and U.S. Forest Service Superior National Forest. The MOU states that the agreement "provides the framework for cooperation and coordination between the parties within the Sand Lake/Seven Beavers Area, in order to serve the public interest in the conservation and management of this Area." The St Louis County Land Department was not a signatory, but also participates in the collaborative.

To date, the collaborative has supported a watershed assessment and a forested communities assessment for the area. It also formed a data management group to compile biodiversity and forest management related survey, inventory, and project-planning data. The collaborative has also agreed to develop mutually agreed upon landscape objectives for units/zones within the SL7B area.

Management options appropriate to the exceptional qualities and opportunities present in the Site include: 1) protection using RNA and SNA designation of additional public lands; and 2) similar protection strategies on private and county lands, or acquisition if necessary. Wherever these protection strategies are not pursued, MCBS recommends that any other management use a selected set of approaches in a manner designed and coordinated by the landowners to meet carefully crafted ecological goals at the landscape, LTA, and native plant community scale.

The two sections below contain more detailed recommendations for protection and management. Table 8 summarizes these recommendations.

Table 8. Summary of MCBS Recommendations for the Headwaters Site

Actions
• Protect Ecologically Important Lowland Conifers as designated Old-Growth, if appropriate, or as Scientific and Natural Area (DNR)
• Establish Big Lake – Seven Beavers Research Natural Area (U.S. Forest Service)
• Maintain large patch sizes of mature upland and peatland forests, particularly the forest around Big Lake
• Allow natural processes to predominate
Research Needs
• Investigate natural disturbance ecology of Site (landforms, native plant communities, applicable natural disturbances) to inform management
Management Considerations
• Maintain biodiversity significance factors that contribute to MCBS rank of Outstanding, including hydrological and ecological connections between uplands and peatlands, large patch sizes, minimal fragmentation, intact ecological function at multiple scales, and support of regional scale organisms
• Be consistent with the Minnesota Forest Resources Council Landscape Committee vision, Superior National Forest Plan, and MN DNR NTL Subsection Forest Resource Management Plan

Table 8. Summary of MCBS Recommendations for the Headwaters Site continued

Management Considerations continued
• Use techniques to mimic full range of natural disturbances, particularly fire
• Use ecologically compatible management practices previously applied and evaluated outside the Site
• Effect an increase in multi-aged forest growth stages
• Effect an increase in long-lived conifers
• Avoid abrupt forest edges
• Minimize all roads and trails; no new permanent roads; restore duplicate roads and trails to native vegetation
• Prevent exotic species encroachment (including earthworms) via roads and road-building, harvest equipment, and recreational activities

Protection Recommendations

A study of potential natural areas to represent ecosystems in the Superior National Forest (SNF) resulted in the identification of three areas within the Headwaters Site: Dunka, Sand Lake Peatlands SNA Addition, and Big Lake – Seven Beavers (Vora 1997). As part of the SNF Plan revision there was further evaluation of the SNF for potential Research Natural Areas. The Big Lake – Seven Beavers potential Research Natural Area (approximately 6,750 acres), including both peatlands and upland forests, was identified as a priority (Wagner et al. 2000). Most of this area (5,469 acres) was included in the final SNF Plan in 2004 as a Candidate Research Natural Area (Figure 2, page 83). The Headwaters Site also includes the Sand lake Peatlands SNA, and six state-designated old-growth stands.

Peatlands

Roughly two-thirds of the Headwaters Site's peatlands are owned by the MN DNR and one-third by the U.S. Forest Service. About half of the Site's peatlands, including the majority of the patterned peatlands, is currently protected in the Sand Lake Peatland SNA.

The NTL Subsection Forest Resource Management Plan identifies almost all of the remaining peatlands on state land in the Site as Ecologically Important Lowland Conifers (EILC), including the lands identified by the MN DNR in its 1984 report (MN DNR 1984) as the Sand Lake Peatland Watershed Protection Area (WPA) (Figure 7, page 91). The delineation of the WPA was intended to highlight the importance of peatlands bordering the SNA to the protected features in the SNA, alerting managers to the need to consider the higher hydrologic sensitivity of these lands in management decisions. The WPA was limited to peatlands, and did not address the hydrologic connections between uplands and peatlands in the SNA (N. Aaseng, pers. comm. 2006). The EILC designation provides temporary protection until a State of Minnesota old-growth policy is developed for lowland conifers. MCBS recommends that lands designated as EILC in the Extensive Peatlands area of the Headwaters Site be permanently protected, either by SNA designation or as old-growth (if appropriate). This peatland area is unique in the Northern Superior Uplands Section, warranting its protection as a whole. In addition, the EILC lands in the Extensive Peatlands are ecologically linked to the Sand Lake Peatland SNA so activity on the EILC lands has the potential to impact protected lands in the SNA.

Most of the peatlands owned by the U.S. Forest Service, including most of the North River peatland, is within the Big Lake – Seven Beavers Candidate Research Natural Area (cRNA). The Forest Service should establish this area as an RNA. The RNA, together with the SNA, a long-

term protection commitment by the MN DNR for the EILC, and the parcels owned by The Nature Conservancy, would protect most of the Extensive Peatlands, stretching from Seven Beavers Lake to Bonga Lake. The RNA would also protect some adjacent uplands ecologically linked to the peatlands, as well as a portion of the shoreline of Big Lake.

Uplands

Existing protected areas, combined with the peatland protections recommended above, cover roughly half the Headwaters Site. The largest area not covered is the fire-dependent upland forest intermixed with small peatlands around Big Lake. At roughly 7,000 acres, this forest is one of the largest unfragmented upland forests in the Laurentian Uplands, Toimi Uplands, and North Shore Highlands subsections. This mature forest has some significant development of structural and compositional diversity, such as older patches and older individual trees. In addition, an unfragmented mosaic of forested upland and lowland communities projects from this large patch into the patterned peatland complex in the north-central part of the Site. During the Superior National Forest Plan revision of 2004, the U.S. Forest Service identified the federally owned portion of the upland forest in the Big Lake Area as one of the few large, mature/old upland patches greater than 1,000 acres on the SNF. Implementation of the SNF Plan goals for large, mature/old upland patches on the landscape should maintain this area as a large mature upland patch during the term of the Plan (D. Ryan, pers. comm. 2006).

The lack of disturbance in these areas since forest stand initiation, dating from the late 1800s through the 1930s, has allowed the development of mature to old forest communities in which natural disturbance patterns have been operating at multiple scales over a large area. With a high proportion of long-lived conifers and a high degree of compositional and structural diversity, these upland communities are an integral part of landscape connectivity within the Site, functioning as transitional connections between the peatland LTA and the two adjacent morainal LTAs.

In light of intensifying land use of all kinds and its impacts (such as parcelization, fragmentation, and spread of exotic species) as well as the potential impacts of climate change on forests and their biota in northeastern Minnesota, there is a clear need for some fire-dependent upland forest landscapes in the Laurentian Uplands, Toimi Uplands, and North Shore Highlands subsections to be kept in reference condition. In these Subsections most of the upland forest communities that have received permanent protection are mesic hardwood forests or small patches of old-growth conifer forest. The large area of high-quality fire-dependent forest in the Big Lake Area of the Headwaters Site is a prime candidate to be managed through coordinated protection. MCBS recommends that lands lying within the natural boundaries of the large mature/old upland patch in the Big Lake Area and projecting into the peatland complex, be given high priority for protection; it is recommended that the patch be maintained and the native plant communities throughout allowed to continue to grow and develop in their current and older growth stages.

Uplands throughout the Site are ecologically linked to the peatlands, including through transitional communities immediately adjacent to the peatlands. In particular, MCBS recommends no harvest in the upland-peatland transition forests where black spruce is a significant component of the canopy, subcanopy, or understory.

Management Considerations

MCBS recommends that any forest management in the Headwaters resemble the natural disturbance regimes and natural stand development processes relevant to this heterogeneous landscape and its native plant communities. It is recommended that any harvest undertaken in the Headwaters Site be: 1) informed by site-specific understanding of natural disturbance ecology and native plant community ecology; 2) guided by and consistent with recent landscape planning efforts; 3) meet carefully crafted ecological goals and objectives at the landscape, LTA, and native plant community scales; and 4) include only those silvicultural approaches that have been tried in similar conditions outside the Site and proved to be successful in achieving the desired ecological goals and objectives.

Research Needs

Silviculture that does not mimic the spatial and temporal scale and intensity of natural disturbances relevant to the native plant communities being managed threatens the Site's ecological integrity. An understanding of the natural disturbance ecology of the Site is necessary to inform any management intended to mimic natural disturbance regimes and sustain ecological function and biological features.

Further investigation into the natural disturbance ecology of the Site is recommended to inform patch planning and design (including the size, native plant community composition, and age class of patches in the landscape mosaic) and goals for structural and compositional variation within patches. For instance, patterns in the conifer swamp native plant communities in the Extensive Peatlands reflect patch size and within-patch variation (or lack thereof) resulting from past management, and not necessarily from natural disturbance regimes. In upland patches, past management ranging from selective harvest to fire suppression may have altered patch landscape patterns and patterns within patches.

Ecologically compatible forest management practices have not been widely used in the landscape of northeastern Minnesota, nor have outcomes been monitored and evaluated. The statewide and regional ecological and biological importance of the Headwater Site make it valuable as a reference area for studies involving evaluation of ecologically compatible management practices. In such studies, any experimentation with specific management practices should be done on adjacent lands or similar native plant communities elsewhere, with outcomes evaluated against conditions at the Headwaters Site. Only if proven successful in ecological management on other sites should such practices be used in the Headwaters Site.

Landscape Guidance

The Northeast Regional Landscape Committee of the Minnesota Forest Resources Council in 2003 reported on the desired future condition of forests in the region (MFRC 2003). Elements of the Council's report that are especially applicable to the Headwaters Site are summarized in table 9.

According to the Superior National Forest Plan of 2004, the Headwaters Site is part of Management Areas 10.2 – Longer Rotation Emphasis, 8.6 – Riparian Emphasis, and 6.1 – Semi-primitive Motorized Recreation, in addition to the candidate RNA (Management Area 8.2a) mentioned above.

Table 9. Summary of Minnesota Forest Resources Council Report on Desired Forest Condition

• Forests should approximate/move toward the range of variability (the spectrum of conditions possible in ecosystem composition, structure, and function considering both temporal and spatial factors) for plant communities naturally living and reproducing in northeastern Minnesota.
• Forests should have spatial patterns (size and location of openings) that are consistent with the ecology of northeastern Minnesota.

Based on the features and quality described in this ecological evaluation, the Headwaters Site is ranked by MCBS as having Outstanding Statewide Biodiversity Significance. The MN DNR's North Shore, Toimi Uplands, and Laurentian Uplands Subsection Forest Management Plan (General Direction Statement-1E) directs management of MCBS Sites of Statewide Biodiversity Significance "to sustain or minimize the loss to the biodiversity significance factors that contribute to the ranking" (MN DNR 2004b). Strategies presented in the plan that are relevant to management of biodiversity at the Headwaters Site are listed in Table 10.

Table 10. Summary of Strategies for Management of MCBS Sites of Statewide Biodiversity Significance in North Shore, Toimi Uplands, and Laurentian Uplands Subsection Forest Management Plan.

• Consider the broader context and significance of the MCBS site as a whole when assigning management objectives and selecting stands for treatment.
• Determine location and composition of stand conversions based on native plant community (NPC) class.
• Have forest mangers determine the NPC Class for stands planned for site preparation and tree planting
• Plan forest development activities using the Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province.
• Allow some stands to succeed naturally to long-lived conifer communities.
• Strive to emulate the within-stand composition, structure, and function of older vegetative growth stages (VGSs) when managing some stands.
• Apply variable density techniques during harvest or reforestation.
• Apply variable retention techniques during harvest.
• Designate some stands as ERF (extended rotation forests) to provide old forest conditions.
• Maintain or increase within-stand species, age, and structural composition that is moving toward the mix and proportion of species found in the native plant community appropriate to that site.
• Whenever possible and practical, manage stand cover type conversions with less intensive site preparation or plantations with less intensive timber stand improvement.
• Increase the use of prescribed fire as a silvicultural technique in managing fire-dependent NPCs.
• Locate roads to minimize fragmentation of MCBS site.
• Emulate natural disturbance conditions in large patch management.
• Apply special management recommendations for known rare features.
• Defer management of some stands for further assessment (e.g., Ecologically Important Lowland Conifers and nominated natural areas).

Patch Recommendations
MCBS recommends the large patch sizes and minimal habitat fragmentation of the Site be maintained, which will require active coordination of management activities across ownerships. MCBS recommends patch planning and implementation in any part of the Site be consistent with the above landscape planning direction and with investigation specific to the Site.

Restoration Recommendations
To move the forest age-class distribution toward the range of natural variation, the mature and pole-mature growth stages, if managed, require an approach that allows them to move into the old multi-aged growth stage (see MFRC 2003). This will happen naturally as forests age if rotations are lengthened and seed sources for older growth stage species are present. However, in places where seed trees from older stage species are absent, active restoration via management and forest development activities may speed up this process. If natural gaps do not exist, planting or seeding these species may require some timber harvest to open up the canopy. Given the existing overall ecological and biological integrity of the communities, MCBS recommends that all planting be accomplished without the use of intensive mechanical site preparation or herbicides. MCBS also recommends the use of prescribed fire for site preparation to, for instance, establish pines to restore or sustain heterogeneity, or to maintain mid-successional communities such as mesic pine forests.

Native Plant Community/Stand Composition and Structure Recommendations
In general, MCBS recommends natural processes be allowed to predominate in the Headwaters Site. It is recommended that any harvest in the Headwaters Site resemble the natural disturbance regimes and natural stand development processes relevant to this heterogeneous landscape and its native plant communities. For example, in upland communities within the Extensive Peatlands and the greater Big Lake Area patch, MCBS recommends that harvest prescriptions result in much greater cover of post-harvest residual trees than traditional clearcuts with residuals.

MCBS recommends that the intent of forest management be stand continuation not stand initiation. The Voluntary Site-level Forest Management Guidelines (MFRC 2005) suggest 5% canopy cover of residuals, but wildfires usually leave much more than this (Carlson 2001), as does windthrow. Retention at harvest, informed by an understanding of the applicable natural disturbance regimes and in conjunction with complimentary rotations, is recommended to achieve specific structural and, by association, compositional goals. For example, rare native plant communities such as mesic pine [FDn43a] and upland cedar [FDn43c] communities should be reserved, and their dominant species (red pine, white pine, and white cedar) retained in mixed forests to sustain elements of older growth stages and provide a local seed source for natural regeneration. Variable retention harvest and variable density thinning prescriptions (Franklin et al. 1997) in aspen-dominated stands should promote retention and establishment of long-lived conifers (white pine, white spruce, white cedar, and tamarack) to move the forest toward more natural species composition ratios (see Human Disturbance and Use above).

If cutting occurs, edges between treated and untreated areas should not be ‘hard’. Hard edges are abrupt, with little or no transition between closed-canopy forest and harvest openings, and increase subsequent windthrow and change the environment (in terms of light, moisture, etc.) in the adjacent forest. Instead, the tree canopy in treated areas should be gradually reduced with increasing distance from the closed-canopy forest.

In areas where dwarf mistletoe is identified as a concern, it is recommended that any effort to reduce the severity and extent of mistletoe infection recognize that dwarf mistletoe is an integral part of the ecosystem and complete eradication is not the objective. The following is recommended regarding treatment decisions:

- Dwarf mistletoe develops and spreads slowly; therefore there is time to implement management actions to slow or halt the spread of mistletoe infection. Mistletoe spreads more slowly in even-aged than uneven-aged forests, and more slowly in mixed forests comprised of host and non-host species.
- Conduct on-site evaluation of the severity and incidence of the mistletoe infection using a broadly accepted approach such as the Hawksworth six-class rating system. (Severity is defined as the average rating of all infected trees. Incidence is the proportion of susceptible trees infected within the stand).
- In areas where timber production is the priority, slowing or halting the spread of dwarf mistletoe infection into these stands should be the objective, as opposed to complete eradication within the infected stand.
- If it is determined that management of dwarf mistletoe in a stand at the Headwaters Site is imperative, use minimum host-free buffer distances recognized in the literature (50–65 feet). Incorporate natural barriers—such as lakes, rivers, and forests types other than black spruce (which serve as host-free buffers)—and other barriers such as existing roads, railroad and power line ROWs, and so on, into the management area design.
- Pruning (using specified methodology) combined with monitoring may be an acceptable approach for managing mistletoe infection in environmentally sensitive areas (e.g., adjacent to lakes, in riparian areas, in areas of hydrologic concern, or in areas with operability concerns).
- Prescribed burning should be seriously considered when treating areas rated with heavy mistletoe infection adjacent to or within the Headwaters Site.

Slash

MCBS recommends that slash from logging activities be evenly distributed over harvested areas of the patch, and the amount of large coarse woody debris (CWD) be maintained or increased. Decaying CWD contributes significantly to nutrient cycling in the forest ecosystem, helps in maintaining productivity, and provides habitat for species that form the base of the food web, including lichens, mosses, insects, amphibians, small mammals, and microorganisms.

Roads and Trails

Roads, both temporary and permanent, are among the few incontrovertible threats to the Site's integrity. Roads create additional forest edges that alter the environment of the forest, often disrupt water flow in wetlands, can be a barrier to the movements of some small vertebrate and invertebrate species, and facilitate the invasion of exotic plant and animal species (Trombulak and Frissell 2000). Exotic species are one of the greatest threats to native species, and to human-disturbed ecosystems worldwide (Reid and Miller 1989). Road building and use facilitate invasion by exotic species by providing a seedbed and regularly introducing seeds or other propagules (via fill materials, mulch, and equipment, and via users and their vehicles) into a conducive environment for establishment and growth (Westbrook 1998). MCBS survey work in 2005 found large upland and lowland areas in the Headwaters Site to be free of non-native species. Other portions not visited, but with similar absence of recent disturbance can be reasonably assumed to also be free of exotic species. Typically, non-native species within the Site were associated with roads and upland trails, and with forest stands that have been managed since 1960s.

Much of the forest in the Headwaters Site is probably free of exotic earthworm species. A major vector for earthworm establishment is road building, especially because of the fill brought in from off-site. In forest types, earthworms have been found to change soil profiles and negatively impact some understory fern and wildflower species (Hale 2004, Hale and Host 2005). Currently, there are no known control methods; once established, earthworms cannot be removed.

MCBS recommends roads, both temporary and permanent, be kept to an absolute minimum through careful planning and coordination among landowners. Given the extent of existing roads and trails and increasing off-highway vehicle use on these trails, we recommend no construction of new permanent roads or access for any purpose; that duplicate roads be eliminated through restoration of corridors to native vegetation; and closure of temporary roads or access be immediate and effective both when a management project has been completed and between work periods if multiple years of activity are necessary. Although trails normally cause less damage than roads, both motorized and non-motorized wheeled vehicles can act as vectors, carrying and dispersing earthworm eggs, exotic insect larvae, and propagules of exotic plant species on their tires along trails.

The peatlands complex and wetland areas within uplands are inappropriate for non-winter trails. It is possible that snowmobile trails may cross wetlands without extensive negative impacts. However, repeated, abnormally deep freezing on heavily used and compacted trails can alter vegetative composition. Given the extent of existing winter roads and trails and increasing off-highway vehicle use on these trails, MCBS recommends no new winter access roads be established in the Extensive Peatlands, that winter road access be limited to a few existing winter roads, and duplicate winter access be eliminated and corridors be restored to native vegetation where necessary.

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