Final Report
Sensitive Lakeshore Survey
Sand Chain of Lakes
Itasca County, Minnesota

October 2013

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ECOLOGICAL AND WATER RESOURCES

A Product of the Intra-Lake Zoning to Protect Sensitive Lakeshores Project

Application of Minnesota's Sensitive Lakeshore Identification Manual: *A Conservation Strategy for Minnesota's Lakeshores*

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Sand Chain of Lakes
Sand Lake (31-0826-00)
Little Sand Lake (31-0853-00)
Portage Lake (31-0824-00)
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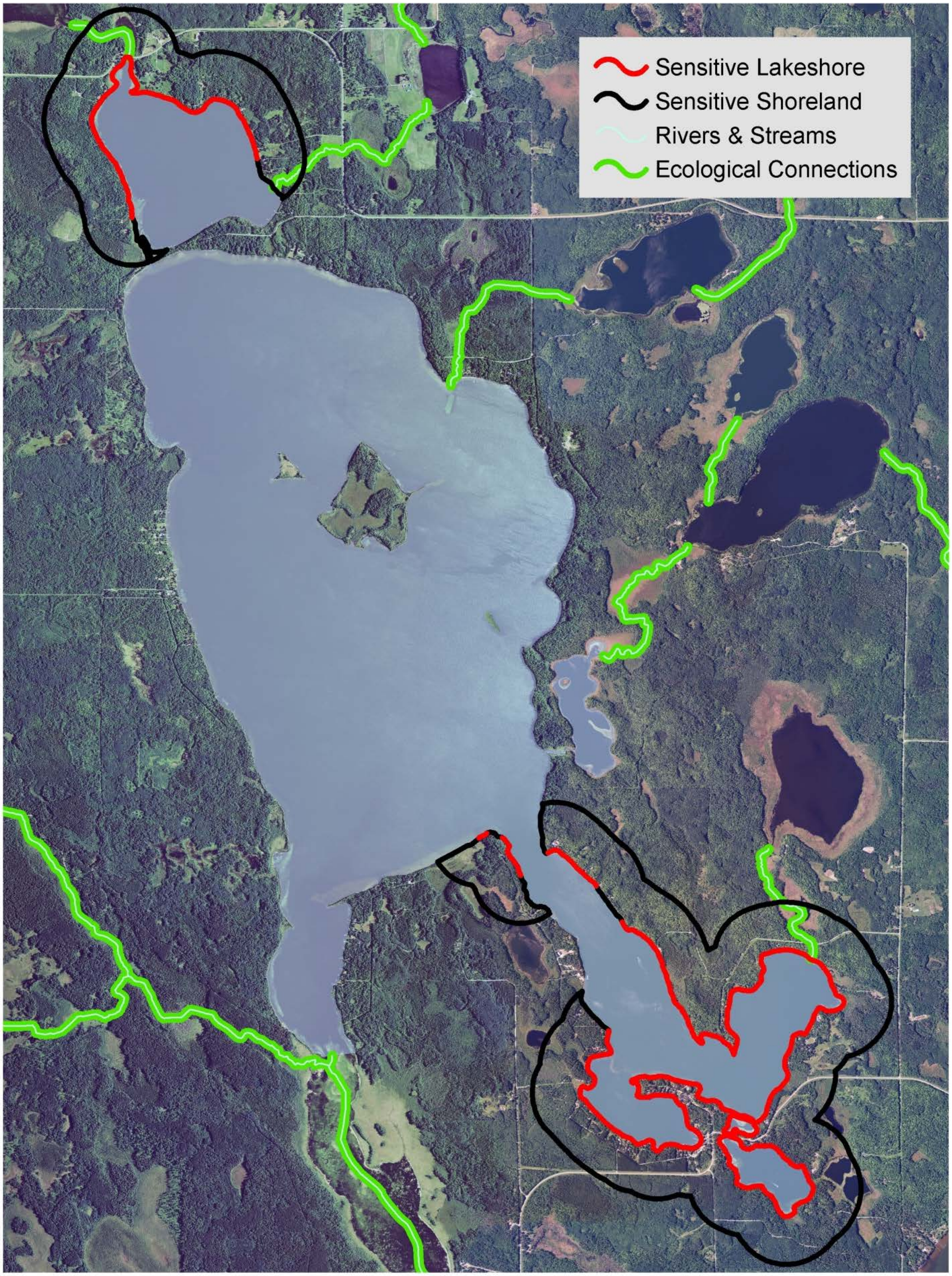
Executive Summary

Aquatic plants occurred around the entire perimeter of the Sand Chain of Lakes. Surveyors recorded 44 native aquatic plant species in the Sand Chain. The plant community included 26 submerged, four free-floating, five floating-leaf, and nine emergent species. Since 1957, this brings the total number of plant species that have been documented in these lakes to 46, making the Sand Chain among the richest in the state. Maximum depth of plant growth was to 20 feet in Sand Lake. Floating-leaf and emergent plant beds covered 388 acres. Bird's Eye and Portage lakes had the greatest percent of shallow water occupied by emergent and floating-leaf plants. In addition, two unique submerged aquatic plant species were located within the Sand Chain of Lakes.

Three proxy fish species (blackchin shiner, blacknose shiner, and banded killifish) were documented in the Sand Chain of Lakes in 2012. In total, surveyors identified 29 fish species in the Sand Chain of Lakes. Green frogs were not documented during the frog surveys, but mink frogs were recorded at various locations along the lake shorelines. Four loon nesting areas were identified on the Sand Chain of Lakes in 2012.

The ecological model identified two primary sensitive lakeshore areas to be considered for potential resource protection districts by Itasca County. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. The rivers and streams connected to the Sand Chain of Lakes are also an important part of the ecosystem. They provide valuable connectivity between the lakes and nearby habitat. The county may use this objective, science-based information in making decisions about districting and reclassification of lakeshore areas. The most probable highly sensitive lakeshore areas and the recommended resource protection districts are:



Sensitive Lakeshore
Sensitive Shoreland
Rivers & Streams
Ecological Connections

Introduction

Minnesota's lakes are one of its most valuable resources. The 12,000 lakes in the state provide various industrial, commercial, and recreational opportunities. They are also home to numerous fish, wildlife, and plant species.

Among the many actions that will help protect lakes and the natural resource benefits they provide, protection of important shoreland areas is one of the most important. Shorelands are critically important because of their proximity to the lake (the outcomes from poor land management practices are delivered directly to the adjacent lake) and the diversity of habitats they provide. In particular, naturally vegetated shorelines provide critical feeding, nesting, resting and breeding habitat for many species. Common loons avoid clear beaches and instead nest in sheltered areas of shallow water where nests are protected from wind and wave action. Mink frogs and green frogs are shoreline-dependent species that prefer quiet bays and protected areas with a high abundance of aquatic plants. Fish such as the least darter, longear sunfish, and pugnose shiner are strongly associated with large, near-shore stands of aquatic plants.

Without effective protection, increasing development pressure along lakeshores may negatively impact lakes as well as their shoreline-dependent species – and Minnesota's lakeshores are being developed at a rapid rate. With this in mind, the Minnesota Department of Natural Resources developed a protocol for identifying "sensitive" areas of lakeshore. Sensitive lakeshores represent geographical areas comprised of shorelands, shorelines and the near-shore areas, defined by natural and biological features that provide unique or critical ecological habitat. Sensitive lakeshores also include:

1. Vulnerable shoreland due to soil conditions (i.e., high proportion of hydric soils);
2. Areas vulnerable to development (e.g., wetlands, shallow bays, extensive littoral zones, etc.);
3. Nutrient susceptible areas;
4. Areas with high species richness;
5. Significant fish and wildlife habitat;
6. Critical habitat for species of greatest conservation need; and
7. Areas that provide habitat connectivity

Species of greatest conservation need are animals whose populations are rare, declining or vulnerable to decline (MN DNR 2006). They are also species whose populations are below levels desirable to ensure their long-term health and stability. Multiple species of greatest conservation need depend on lakeshore areas.

The sensitive shorelands protocol consists of three components. The first component involves field surveys to evaluate the distribution of high priority plant and animal species. Aquatic plant surveys are conducted in both submerged habitats and near-shore areas, and assess the lake-wide vegetation communities as well as describe unique plant areas. Target animal species include species of greatest conservation need as well as proxy species that represent animals with similar life history characteristics. This first component also involves the compilation of existing data such as soil type, wetland abundance, and size and shape of natural areas.

The second component involves the development of an ecological model that objectively and consistently ranks lakeshore areas for sensitive area designation. The model is based on the results of the field surveys and analysis of the additional variables. Lakeshore areas used by focal species, areas of high biodiversity, and critical and vulnerable habitats are important elements in the ecological model used to identify sensitive lakeshore areas. Because the model is based on scientific data, it provides objective, repeatable results and can be used as the basis for regulatory action.

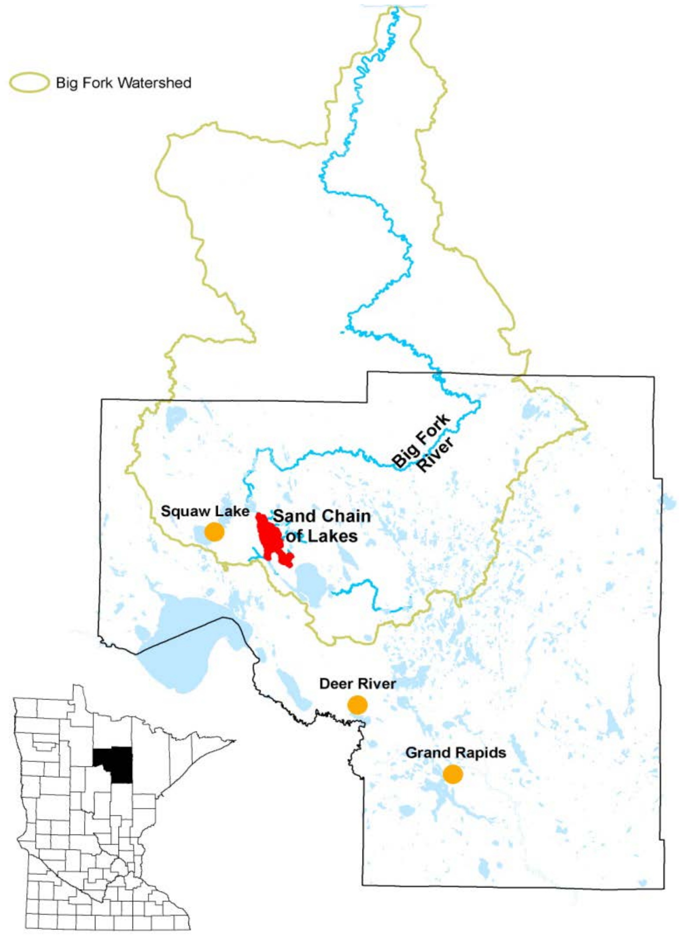
The final component of identifying sensitive lakeshore areas is to deliver advice to local governments and other groups who could use the information to maintain high quality environmental conditions and to protect habitat for species of greatest conservation need.

This report summarizes the results of the field surveys and data analysis and describes the development of the ecological model. It also presents the ecological model delineation of the Sand Chain of Lakes sensitive lakeshore areas.

Lake Description

The Sand Chain of Lakes is located near the cities of Squaw Lake and Deer River, in Itasca County, northern Minnesota (Figure 1). The Sand Chain of Lakes is comprised of four lakes: Sand Lake, Little Sand Lake, Portage Lake, and Bird's Eye Lake. These lakes occur in the southern half of the Big Fork Watershed and are connected to the Big Fork River, which drains the watershed to the north.

Figure 1. Location of the Sand Chain of Lakes in Itasca County, Minnesota.



The chain of lakes is named for Sand Lake, the largest lake in the system. Sand Lake is a natural flow-through lake with an inlet from the Bowstring River and an outlet to the Big Fork River. Water flows northwest from the southwest side of Sand Lake into a navigable channel that outflows to Little Sand Lake (Figure 2).

Although the lakes in the Sand Chain are connected, differences in lake size, depth, flow, and shoreland management create differences in nutrient levels and water clarity among the lakes. All four lakes are mesotrophic but maximum depth ranges from 70 feet in Sand Lake to only 20 feet in Little Sand Lake (Figure 3). Water clarity ranges from six feet in Little Sand Lake to 11 feet in Portage Lake (Table 1).

One public access is available on the "straights" of Sand Lake (Figure 2). The Minnesota DNR Section of Fisheries manages Sand Lake primarily for walleye (Weitzel 2012).

The Sand Chain of Lakes covers a surface area of over 4,700 acres and has a total shoreline length of 30 miles. Sand Lake is the largest of the four lakes and the third largest in the Big Fork Watershed. It has a surface area of about 4,225 acres and 23 miles of shoreline (Table 1). Bird's Eye and Portage lakes are the smallest in the chain, and each has a surface area less than 100 acres.

Table 1. Descriptive characteristics of the Sand Chain of Lakes.

Lake Name	Total surface area (acres)	Littoral area[1] (acres)	Percent littoral area	Shoreline length (miles)	DNR lake class[2]	Trophic status[3]	Max depth (feet)	Secchi depth[4] (feet)
Sand	4,225	1,897	45	23.0	22	M	70	6.5
Little Sand	353	231	64	3.6	29	M	20	6.0
Portage	64	36	52	1.5	28	M	60	11.0
Bird's Eye	80	45	55	2.0	28	M	50	10.0
Entire Sand Chain	4,722	2,209	47	30.1	N/A	N/A	N/A	N/A

[1] Lake area where water depths are 15 feet or less
[2] Source: Schupp 1992
[3] Trophic Status: E = Eutrophic (high nutrients), M = Mesotrophic (moderate nutrients), O = Oligotrophic (low nutrients)
[4] Mean mid-summer (June-September) Secchi disc readings (Source: MPCA, 2012)

Figure 2. Features of the Sand Chain of Lakes.

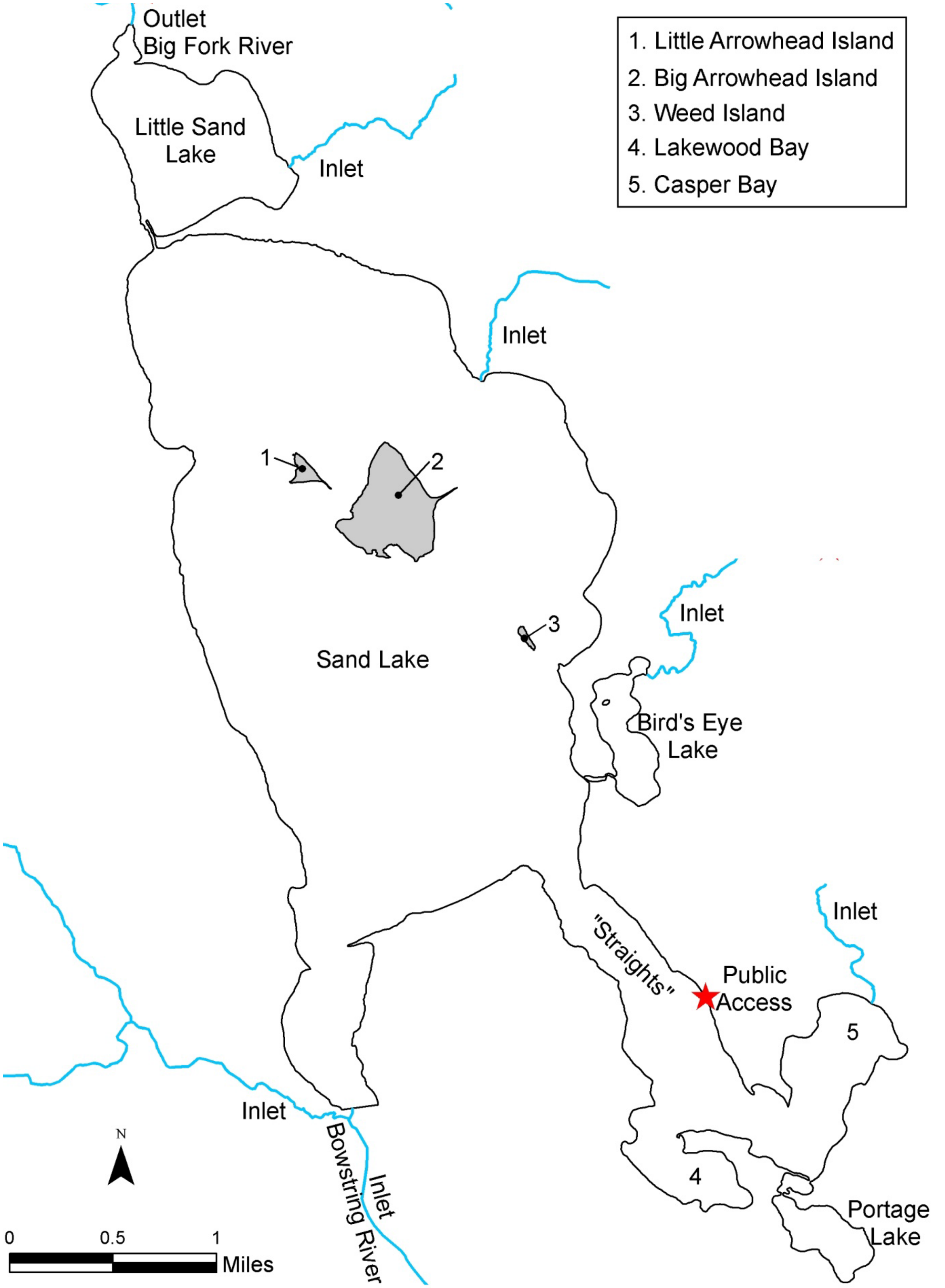
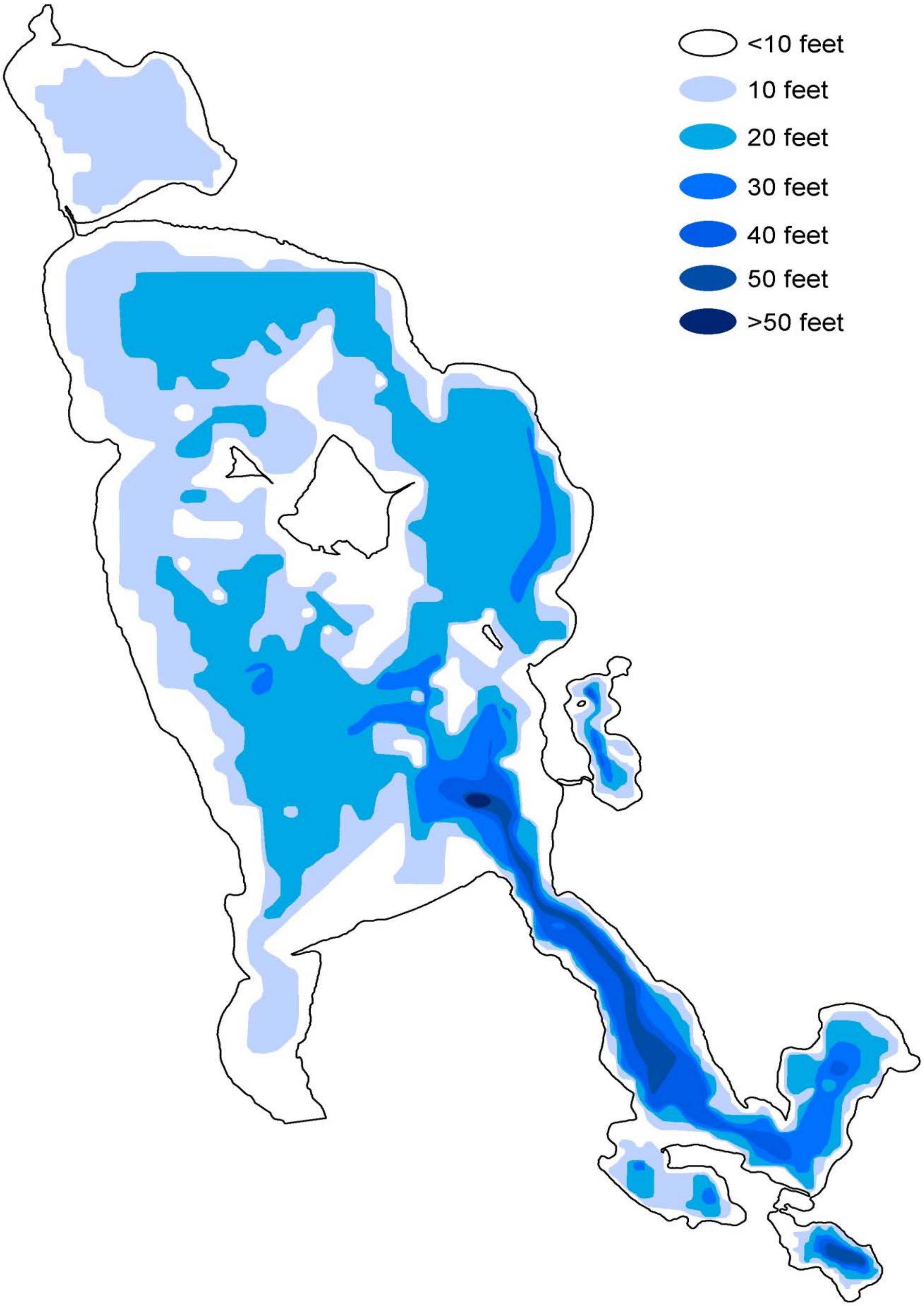


Figure 3. Present-day depth contours of the Sand Chain of Lakes.



I. Field Surveys and Data Collection

Survey and data collection followed Minnesota's Sensitive Lakeshore Identification Manual protocol (MN DNR 2012). Resource managers gathered information on 13 different variables in order to develop the sensitive shorelands model. Sources of data included current and historical field surveys, informational databases, aerial photographs, and published literature. The variables used in this project were: wetlands, hydric soils, near-shore plant occurrence, aquatic plant richness, presence of emergent and floating-leaf plant beds, unique plant species, near-shore substrate, loon nesting areas, frogs, fish, aquatic vertebrate species richness, rare features, and size and shape of natural areas.

Pugnose shiner photo courtesy of Konrad Schmidt

Wetlands

Objectives

1. Map wetlands within the extended state-defined shoreland area (within 1320 feet of shoreline) of the Sand Chain of Lakes

Introduction

Wetlands are important habitat types that provide a variety of services to the environment, to plants and animals, and to humans. Wetland vegetation filters pollutants and fertilizers, making the water cleaner. The roots and stems of wetland plants trap sediments and silt, preventing them from entering other water bodies such as lakes. They protect shorelines against erosion by buffering the wave action and by holding soil in place. Wetlands can store water during heavy rainfalls, effectively implementing flood control. This water may be released at other times during the year to recharge the groundwater. Wetlands also provide valuable habitat for many wildlife species. Birds use wetlands for feeding, breeding, and nesting areas as well as migratory stopover areas. Fish may utilize wetlands for spawning or for shelter. Numerous plants will grow only in the specific conditions provided by wetlands. Finally, wetlands provide a variety of recreational opportunities, including fishing, hunting, boating, photography, and bird watching.

Although the definitions of wetlands vary considerably, in general, wetlands are lands in which the soil is covered with water all year or at least during the growing season. This prolonged presence of water is the major factor in determining the nature of soil development and the plants and animals that inhabit the area. The more technical definition includes three criteria:

1. Hydrology – the substrate is saturated with water or covered by shallow water at some time during the growing season of each year
2. Hydrophytes – at least periodically, the land supports predominantly hydrophytes (plants adapted to life in flooded or saturated soils)
3. Hydric soils – the substrate is predominantly undrained hydric soil (flooded or saturated soils) (adapted from Cowardin et al. 1979)

Methods

Wetland data were obtained from the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service (USFWS). The NWI project was conducted between 1991 and 1994 using aerial photography from 1979 – 1988. Wetland polygons obtained from the NWI were mapped in a Geographic Information System (GIS) computer program. Only wetlands occurring within the extended state-defined shoreland area (i.e., within 1320 feet of the shoreline) were considered in this project. Wetlands classified as lacustrine or occurring lakeward of the ordinary high water mark were excluded from this analysis.

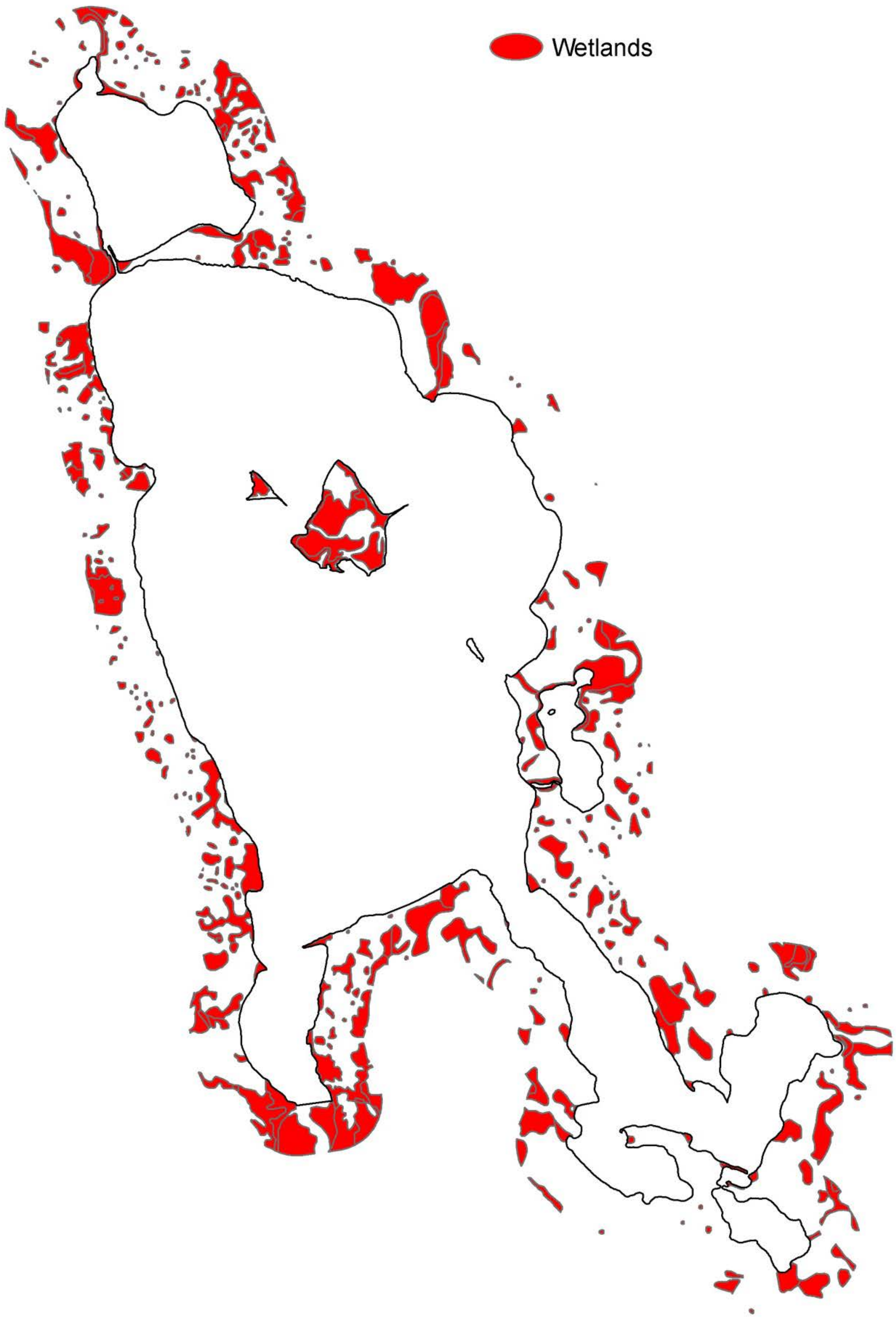
Results

Approximately 943 acres within the shoreland area of the entire Sand Chain of Lakes are described as wetlands by NWI (Figure 4). These wetlands comprise 25% of the Sand Chain of Lakes shoreland district (3,786 acres). Large wetland complexes do not occur in this system but numerous small (average size = four acres) wetlands are scattered around the shoreline, adjacent to lakeshores. The largest wetland system (about 32 acres) occurs along the northeast bay of Bird's Eye Lake.

The dominant wetland types included marsh systems (MN DNR 2003) characterized by herbaceous, emergent wetland vegetation and wetland shrubland systems (MN DNR 2003) dominated by deciduous or evergreen shrubs. The water regime varied among wetlands, and included saturated, seasonally flooded, and intermittently exposed soils.

Wetland in Sand Lake

Figure 4. Distribution of wetlands within 1320 feet of the Sand Chain of Lakes shoreline.



Hydric Soils

Objectives

1. Map hydric soils within the extended state-defined shoreland area (within 1320 feet of shoreline) of the Sand Chain of Lakes

Introduction

Hydric soils are defined as those soils formed under conditions of saturation, flooding, or ponding. The saturation of these soils combined with microbial activity causes oxygen depletion; hydric soils are characterized by anaerobic conditions during the growing season. These conditions often result in the accumulation of a thick layer of organic matter, and the reduction of iron or other elements.

Hydric soils are one of the "diagnostic environmental characteristics" that define a wetland (along with hydrology and vegetation). Identification of hydric soils may indicate the presence of wetlands, and provide managers with valuable information on where to focus conservation efforts.

Methods

The National Cooperative Soil Survey, a joint effort of the USDA Natural Resources Conservation Service (NRCS) with other Federal agencies, State agencies, County agencies, and local participants, provided soil survey data. Polygons delineating hydric soils were mapped in a GIS computer program. Only hydric soils within 1320 feet of the shoreline were considered in this project.

Results

Hydric soils are present along nearly all of the shoreline of the Sand Chain of Lakes (Figure 5). Approximately 675 total acres of hydric soils are located within the shoreland (area within 1320 feet of the shoreline). Soil types include muck, mucky peat, sandy loam, silt loam, and loamy sand. The organic matter content of these soils ranges from low to very high, and most of the soils are very poorly drained.

Figure 5. Distribution of hydric soils within 1320 feet of the Sand Chain of Lakes.

Plant Surveys

Objectives

1. Record aquatic plant species present in each lake
2. Describe distribution of vegetation in the Sand Chain of Lakes
    a. Estimate maximum depth of plant colonization
    b. Estimate and map the near-shore occurrence of vegetation
3. Delineate and describe floating-leaf and emergent plant beds
4. Map distribution and describe habitat of unique plant species
5. Calculate and map aquatic plant species richness

Summary

Aquatic plants occurred around the entire perimeter of each lake in the Sand Chain of Lakes and were found to a maximum depth of 20 feet. Within the 0 to 20 feet depth zone, 47% of sites contained plants but plant occurrence was highest (87%) in the 0 to 10 feet depth zone.

The Sand Chain of Lakes contains a rich aquatic plant community with forty-four aquatic plant species documented including 26 submerged, four free-floating, five floating-leaved, and nine emergent species. Eight of these species were recorded for the first time in the chain in 2012. The number of plant species found in each one square meter sample site ranged from 0 to 10 with a mean of 1.4 species per site. Shallow sites (those less than 6 feet deep) contained the highest diversity of plants.

The submerged plant community was dominated by coontail (*Ceratophyllum demersum*), which occurred with a frequency[5] of 16%. Other commonly occurring submerged plants included narrow-leaf pondweeds (*Potamogeton* spp.), northern watermilfoil (*Myriophyllum sibiricum*), flat-stem pondweed (*Potamogeton zosteriformis*), muskgrass (*Chara* sp.), and wild celery (*Vallisneria americana*).

Beds of floating-leaf and emergent plants were primarily restricted to shallow bays. They covered about 388 acres, or 49% of the shallow water zone (0 to 6 feet). Bird's Eye and Portage lakes had more shallow water occupied by emergent and floating-leaf plants than the more highly developed lakes like Sand and Little Sand. The largest waterlily (*Nymphaea odorata* and *Nuphar variegata*) beds occurred in Portage Lake. The largest bulrush (*Schoenoplectus* sp.) beds were found in Sand Lake. Nearly the entire shoreline of Bird's Eye Lake was ringed by wild rice (*Zizania palustris*) beds.

Two unique, submerged aquatic plants were documented in the Sand Chain of Lakes: mare's tail (*Hippuris vulgaris*) and creeping spearwort (*Ranunculus flammula*).

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[5] Frequency of occurrence was calculated for sample sites in the 0-20 feet depth zone.

Introduction

The types and amounts of aquatic vegetation that occur within a lake are influenced by a variety of factors including water clarity, water chemistry, water depth, shoreline slope, substrate, and wave activity. Deep or wind-swept areas may lack in aquatic plant growth, whereas sheltered shallow areas may support an abundant and diverse native aquatic plant community that in turn, provides critical fish and wildlife habitat and other lake benefits. The annual abundance, distribution and composition of aquatic plant communities may change due to environmental factors, predation, the specific phenology of each plant species, introductions of non-native plant or animal species, and human activities in and around the lake.

Non-native aquatic plant species, such as curly-leaf pondweed (*Potamogeton crispus*), may impact lakes, particularly if they form dense surface mats that shade out native plants. However, the mere presence of an invasive species in a lake may have little or no impact on the native plant community and the presence of a healthy native plant community may help limit the growth of non-natives.

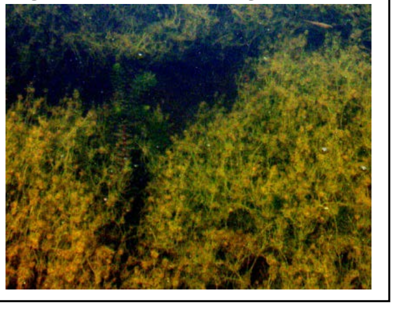
Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. Motorboat activity in vegetated areas can be particularly harmful for species such as bulrush, wild rice and waterlilies. Shoreline and watershed development can also indirectly influence aquatic plant growth if it results in changes to the overall water quality and clarity. Limiting these types of activities can help protect native aquatic plant species.

Submerged plants
Submerged plants have leaves that grow below the water surface, but some species also have the ability to form floating and/or emergent leaves, particularly in shallow, sheltered sites. Submerged plants may be firmly attached to the lake bottom by roots or rhizomes, or they may drift freely with the water current. This group includes non-flowering plants such as large algae, mosses, and fern-like plants, and flowering plants that may produce flowers above or below the water surface. Submerged plants may form low-growing mats or may grow several feet in the water column with leaves that may be broad ovals, long and grass-like, or finely dissected.

Submerged macroalgae
Algae are primitive forms of plants that do not form true roots, flowers or vascular tissue. They range in size from single cells to giant seaweed. Freshwater algae that live in Minnesota lakes include tiny, free-floating planktonic algae, filamentous algae, and macroalgae. Macroalgae often resemble rooted plants and provide similar habitat and water quality benefits.

Muskgrass (*Chara* sp.; Figure 6) is a large algae that is common in many hard water Minnesota lakes. This plant resembles higher plants but does not form flowers or true leaves, stems or roots. Muskgrass grows entirely submerged, is often found at the deep edge of the plant zone (Arber 1920), and may form thick "carpets" on the lake bottom. These beds provide important habitat for fish spawning and nesting.

Figure 6. Bed of muskgrass



Muskgrass has a brittle texture and a characteristic "musky" odor. It is adapted to a variety of substrates and is often the first species to colonize open areas of lake bottom where it can act as a sediment stabilizer.

Submerged flowering plants

Most of Minnesota's submerged plants do form flowers but they are often small, inconspicuous submerged flowers or non-showy flowers that emerge above the water surface. While submerged plants can reproduce by seed, they typically reproduce clonally.

Coontail (*Ceratophyllum demersum*; Figure 7) is the most common submerged flowering plant in Minnesota lakes. It grows entirely under the water and is adapted to a broad range of lake conditions, including turbid water. Coontail is a perennial and can over-winter as a green plant under the ice and before beginning new growth early in spring. Because it is only loosely rooted to the lake bottom it may drift between depth zones (Borman et al. 2001). Coontail provides important cover for young fish, including bluegills, perch, largemouth bass and northern pike. It also supports aquatic insects beneficial to both fish and waterfowl.

Figure 7. Coontail

Northern watermilfoil (*Myriophyllum sibiricum*; Figure 8) is a native, submerged plant. It is a rooted perennial with finely dissected leaves. Particularly in depths less than 10 feet, this plant may reach the water surface. It spreads primarily by stem fragments and over-winters by hardy rootstalks and winter buds. Northern watermilfoil is not tolerant to turbidity and grows best in clear water lakes. For information on how to distinguish the native northern watermilfoil from the non-native Eurasian watermilfoil, click here: identification.

Figure 8. Northern watermilfoil

Photo by: Andrew Hipp (UW Madison-Wisc State Herbarium)

Pondweeds (*Potamogeton* spp. and *Stuckenia* spp.) are one of the largest groups of submerged plants in Minnesota lakes. These plants are rooted perennials and their rhizomes may form mats on the lake bottom that help consolidate soil (Arber 1920). Pondweeds have opposite, entire leaves and form "cigar-shaped" flowers that emerge above the water surface. Many pondweed species overwinter as hardy rhizomes while other species produce tubers, specialized winter buds, or remain "evergreen" under the ice. Seeds and tubers of pondweeds are an important source of waterfowl food (Fassett 1957). The foliage of pondweeds provides food for a variety of marsh birds, shore birds and wildlife and provides shelter, shade and spawning sites for a range of fish species (Borman et al. 2001). Pondweeds inhabit a wide range of aquatic sites and species vary in their water chemistry and substrate preferences and tolerance to turbidity. There are over 20 species of pondweeds in Minnesota and they vary in leaf shapes and sizes. Depending on water clarity and depth, these plants may reach the water surface and may produce flowers that extend above the water. Some pondweeds may also form floating leaves.

Pondweeds can be grouped by their leaf shape and size. Ribbon-leaf pondweeds are plants with long, narrow, grass-like leaves. This group included flat-stem pondweed (*Potamogeton* *zosteriformis*; Figure 9). Broad-leaf pondweeds are often referred to as "cabbage" by anglers and include large-leaf pondweed (*Potamogeton amplifolius*), Illinois pondweed (*P. illinoensis*), clasping-leaf pondweed (*P. richardsonii*), white-stem pondweed (*P. praelongus*; Figure 10), and variable pondweed (*P. gramineus*). Narrow-leaf pondweeds, such as sago pondweed (*Stuckenia pectinata;* Figure 11), Fries' pondweed (*Potamogeton friesii*), and small pondweed (*P. pusillus*) have very narrow, almost needle-width leaves.

Figure 9. Flat-stem pondweed

Figure 10. White-stem pondweed

Figure 11. Sago pondweed

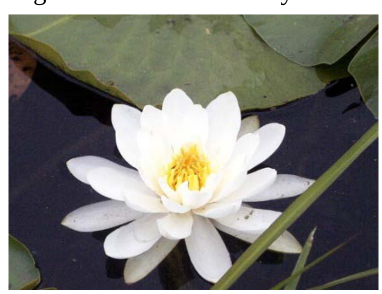
Wild celery (*Vallisneria americana*; Figure 12) is a rooted, perennial submerged plant that resembles ribbon-leaved pondweeds. Unlike the pondweeds that have branches of leaves, wild celery leaves all arise from the base of the plant. Beds of wild celery provide food and shelter for fish and all parts of the plant are consumed by waterfowl, shorebirds and muskrats (Borman et al. 2001). Wild celery is a particularly important food source for canvasback ducks (Varro 2003).

Figure 12. Wild celery

Floating-leaf and emergent plants

Floating-leaf and emergent aquatic plants are anchored in the lake bottom and their root systems often form extensive networks that help consolidate and stabilize bottom substrate. Beds of floating-leaf and emergent plants help buffer the shoreline from wave action, offer shelter for insects and young fish, and provide shade for fish and frogs. These beds also provide food, cover and nesting material for waterfowl, marsh birds and muskrat. Floating-leaf and emergent plants are most often found in shallow water to depths of about six feet and may extend lake-ward onto mudflats and into adjacent wetlands.

Figure 13. White waterlily



White and yellow waterlilies can be found in lakes in both northern and southern Minnesota. White waterlily (*Nymphaea odorata*; Figure 13) has showy white flowers and round leaves with radiating veins. Yellow waterlily (*Nuphar variegata*; Figure 14) has smaller yellow flowers and oblong leaves with parallel veins. These species often co-occur in mixed beds but yellow waterlily is generally restricted to depths less than

Figure 14. Yellow waterlily

seven feet and white waterlily may occur to depths of 10 feet (Nichols1999b).

Figure 15. Floating smartweed

Floating smartweed (*Persicaria amphibia*) has floating leaves that are alternate and smooth with a rounded tip. Floating smartweed has a pink flower that is arranged in an oval cluster (Figure 15). It is usually found in quiet back waters of lakes and ponds. Floating smartweed is a perennial plant that reproduces by seeds and overwintering rhizomes (Borman et al. 2001). Floating smartweed is common throughout Minnesota and is a good source of food for deer, muskrat, and waterfowl.

Figure 16. Floating-leaf pondweed

Floating-leaf pondweed (*Potamogeton natans*) occurs throughout Minnesota and is most often found in depths less than five feet (Nichols 1999b). The floating leaves of this plant are smaller than waterlily leaves and have a heart-shaped base (Figure 16). Fruits of this plant provide an important food source for waterfowl.

Emergent aquatic plants have stems and/or leaves that extend well above the water surface. Most emergent plants are flowering plants, though their flowers may be reduced in size. Emergent plants include perennial plants as well as annual plants.

Figure 17. Bulrush

Narrow-leaved emergent plants include bulrushes and spikerushes. Bulrush (*Schoenoplectus* spp.) is an emergent, perennial plant that occurs in lakes and wetlands throughout Minnesota (Ownbey and Morley 1991). Bulrush stems are round in cross section and lack showy leaves. Clusters of small flowers form near at the tips of long, narrow stalks. This emergent may occur from shore to water depths of about six feet and its stems may extend several feet above the water surface (Figure 17). Bulrush stands are particularly susceptible to destruction by excess herbivory and direct removal by humans.

Figure 18. Floating stage of wild rice

Wild rice (*Zizania palustris*) prefers soft substrates (Lee 1986, Nichols 1999b) and generally requires moving water for growth (MN DNR 2008). Wild rice is an annual plant that germinates each year from seed that fell to the lake bottom in the previous fall. The plant begins growth underwater and then forms a floating-leaf stage (Figure 18) before becoming fully emergent. Wild rice is susceptible to disturbance because it is weakly rooted to the lake bottom. In addition to its ecological value as habitat and food for wildlife, wild rice has important cultural and economic values in Minnesota (MN DNR 2008). This valuable plant is increasingly threatened by factors such as lakeshore development and increased water recreational use (MN DNR 2008).

Figure 19. Burreed

Burreeds (*Sparganium* spp.; Figure 19) are perennial plants that resemble cattails but are shorter in height with triangular leaves. Burreed grows in shallow water (less than four feet) along shorelines and in wetlands throughout Minnesota. Some burreed species form only floating leaves, some are only emergent or some can form both types of leaves. The plants produce fruits with nut-like fruits that are eaten by ducks, common snipe and rails; the stems and leaves are a preferred food of muskrats and deer (Newmaster et al. 1997).

Figure 20. Cattails

Cattails (*Typha* spp.) are emergent plants that are found in lakes and marshes throughout Minnesota. They are perennial plants that emerge from a spreading rhizome and they have long and narrow leaves (Figure 20). Cattails provide shelter and food for many different kinds of fish and bird species.

Unique aquatic plants

Unique aquatic plant species are of high conservation importance. These species may include:

- Plant species that are not listed as rare but are uncommon in the state or locally. These may include species that are proposed for rare listing.
- Plant species with high coefficient of conservatism values (C values). These values range from 0 to 10 and represent the "estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be a pre-settlement condition" (Nichols 1999a, Bourdaghs et al. 2006). Plant species with assigned C values of 9 and 10 were included as unique species.

Figure 21. Mare's tail

Mare's tail (*Hippuris vulgaris*) is a submerged plant with whorls of leaves that resemble a horse's tail (Figure 21). This plant occurs primarily in northern Minnesota lakes but is relatively uncommon. In the Sand Chain of Lakes, it was found in only one site. It is often associated with cold-water streams or springs (Voss 1985) and its presence in a waterbody may be indicative of relatively good water quality. This submerged plant may form emergent leaves and stems in shallow water.

Figure 22. Creeping spearwort

Photo: Emmet J. Judziewicz, U W – Stevens Point & Madison, WI State Herbarium

Creeping spearwort (*Ranunculus flammula;* Figure 22) is a member of the buttercup family and if stranded on mudflats, it may form characteristic yellow buttercup flowers. The submerged linear leaves emerge in small clusters from arched runners or stolons. This plant grows on hard substrates like sand and gravel (Borman et al. 2001). In Itasca County lakes it often grows as a submerged plant but may grow as a short emergent on mudflats. Creeping spearwort is mostly found in lakes in the northern half of Minnesota (Flora of North America 1993+).

Species richness
Species richness is defined as the number of species present in a community and is often used as a simple measure of biodiversity (Magurran 2004). In aquatic plant communities, species richness is influenced by many complex factors (Pip 1987) including water chemistry, transparency, habitat area and habitat diversity (Vestergaard and Sand-Jensen 2000, Rolon et al. 2008). In Minnesota, water chemistry strongly influences which plant species can potentially occur in a lake (Moyle 1945), and thus, indirectly influences lakewide species richness. The trophic status of a lake further influences plant species richness and eutrophic and hypereutrophic habitats have been associated with reduced species richness (Pip 1987). Within a region of Minnesota, lakewide aquatic plant species richness can be used as a general indicator of the lake clarity and overall health of the lake plant community. Loss of aquatic plant species has been associated with anthropogenic eutrophication (Stuckey 1971, Nicholson 1981, Niemeier and Hubert 1986) and shoreland development (Meredith 1983).

Within a lake, plant species richness generally declines with increasing water depth, as fewer species are tolerant of lower light levels available at deeper depths. Substrate, wind fetch, and other physical site characteristics also influence plant species richness within lakes.

Methods

The aquatic plant communities of the Sand Chain of Lakes were described and measured using several techniques as found in Minnesota's Sensitive Lakeshore Identification Manual (MN DNR, 2012 V3). Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MnTaxa (2012). Several species that can be difficult to distinguish in the field were grouped together for analysis.

Grid point-intercept survey
A grid point-intercept survey method (Madsen 1999) was used to describe the lakewide distribution and diversity of aquatic plants. Sand, Little Sand, Portage and Bird's Eye lakes were surveyed in 2012 (Simon and Perleberg 2012).

A Geographic Information System (GIS) computer program was used to establish aquatic plant survey points across the entire basin of each lake. In order to effectively sample commonly occurring species, an effort was made to sample a minimum of 125 sites within the 0 to 20 feet depth zone on most lakes. On Sand Lake, points were spaced 125 meters apart in the main basin and 65 meters apart in the "straights." On Little Sand Lake, points were spaced 65 meters apart, and on Bird's Eye and Portage lakes points were spaced 40 meters apart. In the field, surveyors sampled all sites where water depth was 20 feet and less. In deeper water, subsampling was used to determine if sampling should be conducted out to 25 feet (Table 2).

Surveyors navigated to each site using a handheld Global Positioning System (GPS) unit. At each sample site, water depth was measured and all vegetation within a one-meter squared area was sampled using a double-headed weighted garden rake. All aquatic plant species present within the sample plot were recorded and frequency of occurrence was calculated as the percent of sites within the vegetated zone that contained plants. Because the maximum vegetated depth zone varied among individual lakes (from 17 to 20 feet), the summary data presented in this report are based on sample sites within the shore to 20 feet. Any additional species found outside the sample plots were recorded as present in the lake and those data were not included in frequency calculations.

Emergent and floating-leaf bed delineation

Mapping focused on plant beds that were at least 0.01 acres, or about 400 square feet, in size (generally larger than the surface area covered by a pontoon boat). Draft maps of floating-leaf and emergent plant beds were created prior to field surveys using 2010 Farm Service Administrative (FSA) true color aerial photographs. Field surveys were conducted September 2011 and August 2012 to map plants like bulrush, which are difficult to identify from aerial photos, and to verify photo-interpretation of other plant beds. Surveyors mapped emergent and floating-leaf plant beds in the field by motoring or wading around the perimeter of each bed and recording a track with a handheld GPS unit. Field data were uploaded to a computer and a GIS software program was used to estimate acreage. Plant beds were classified by the dominant species or species-group.

Searches for unique and rare species

Prior to fieldwork, surveyors obtained known locations of state and federally listed rare plants within one mile of the Sand Chain of Lakes from the Rare Features Database of the MN DNR Natural Heritage Information System. Surveyors also queried the University of Minnesota Herbarium Vascular Plant Collection database and DNR Fisheries Lake Files to determine if certain plant species had previously been documented in or near the Sand Chain of Lakes.

Surveyors searched for unique and rare aquatic plant species in 2012 during the lakewide point-intercept surveys. Surveyors did not conduct shoreline surveys for upland plants but recorded some of the more common emergent plants they observed.

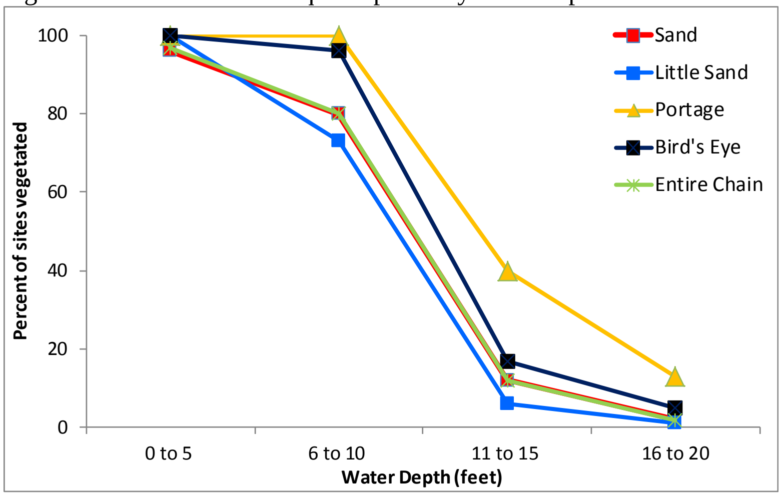
If unique or rare plant species were located, surveyors recorded the site location, the plant species found, associated plant species, approximate water depth and substrate type. When necessary, plant specimens were sent to the authority in the field for identification verification and annotation. Voucher specimens were made to document new locations of rare species, county records and some other species and were submitted to The Herbarium of the University of Minnesota, Bell Museum of Natural History, St. Paul, MN.

Results

Distribution of plants by water depth

Aquatic plants occurred around the entire perimeter of the lakes and grew to a depth of at least 17 feet in each lake. Maximum depth of plant growth was to 20 feet in Sand Lake. Within the 0 to 20 feet depth zone, 47% of all sites contained plants; within individual lakes, plant frequency ranged from 32% in Little Sand Lake to 72% in Portage Lake (Table 3). Within the entire chain, 93% of the vegetated sites occurred in the 0 to 10 feet depth zone and 87% of the sample sites in that zone contained plants. In all lakes, plant frequency declined with increasing water depth and in depths greater than 15 feet only 2% of sites were vegetated (Figure 23).

Figure 23. Distribution of aquatic plants by water depth



Aquatic plant species observed

In 2012, 44 native aquatic plant species were recorded in the Sand Chain. The plant community included 26 submerged, four free-floating, five floating-leaf, and nine emergent species (Table 4). Since 1957, this brings the total number of plant species that have been documented in these lakes to 46 (Table 5), making the Sand Chain among the richest in the state. Plant richness was highest in Sand (41 species) and Portage (32 species) lakes, where there was a diversity of submerged, floating-leaved, and emergent plants.

Non-native aquatic plants have not been documented in these lakes but non-native shoreland plants included purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinaceae*) (Table 4).

Submerged plants

Submerged plants were the most common type of plants present in the lakes and occurred throughout the vegetated zone (Figure 24). The submerged plant community included leafy plants that are anchored to the lake bottom by roots as well as large algae that may resemble leafy plants but are weakly anchored to the lake bottom. Coontail was the most frequent submerged plant, occurring around the entire shoreline of Bird's Eye, Little Sand and Portage lakes and in 16% of all sample sites (Table 4). Other submerged species occurring frequently in the chain were narrow-leaved pondweeds (15% of all sample sites), northern watermilfoil (12%), flat-stem pondweed (12%), muskgrass (9%), and wild celery (9%). Within individual lakes, the relative dominance of these species varied; for example, muskgrass was found in 33% of the Portage Lake sites but occurred in less than 10% of sites in other lakes.

Floating-leaf and emergent plants
Floating-leaf and emergent plants were most common in the 0 to 6 feet depth zone. These plant beds covered 388 acres or 49% of this shallow water zone (Table 6). Bird's Eye and Portage lakes had the greatest percent of shallow water occupied by emergent and floating-leaf plants (88% and 62%, respectively).

About 15 acres of floating-leaf plant beds were mapped and the largest bed occurred in Portage Lake (Figure 25). Floating-leaf plants included white waterlily, yellow waterlily, floating smartweed, and floating-leaf pondweed.

Surveyors mapped approximately 373 acres of emergent plants and the most common species was bulrush. The largest bulrush beds occurred in Sand Lake where nearly the entire perimeter of the lake and Big Arrowhead Island were ringed with bulrush or mixed bulrush stands (Figure 25). Wild rice beds occurred around nearly the entire shoreline of Bird's Eye Lake, the west shore of Little Sand Lake and along several shorelines of the other lakes. Other emergent plants occurred at scattered locations around the chain and included cattails, arrowhead, spikerush, giant cane, river bulrush, and burreed. Many of these emergent plants occupied the transitional zone between the lake and adjacent wetlands.

Bulrush bed in Sand Lake, 2011.

White and yellow waterlilies in Portage Lake, 2012.

Wild rice bed in Bird's Eye Lake, 2012.

Unique plants
In addition to the commonly occurring plants in the Sand Chain, two unique submerged aquatic plant species were located, mare's tail (*Hippuris vulgaris*) and creeping spearwort (*Ranunculus flammula*). These plants were detected in only a few sites (Table 7). Mare's tail was found in Sand Lake and creeping spearwort was found in Little Sand and Portage lakes (Figure 26). These species were found in shallow areas (depth less than five feet) of these lakes where boat traffic is limited.

Species richness at individual sample sites
The number of plant species found in each one square meter sample site ranged from 0 to 10 with a mean of 1.4 species per site. Sites where the highest taxa richness was observed (six or more species per site) often occurred in depths less than 10 feet and included sites where emergent, floating-leaf and submerged plants co-occurred (Figure 27). Portage Lake was the only lake where mean species richness per site exceeded the overall mean value of the entire chain.

Table 2. Sampling effort by lake, 2012.

Lake	Total number of sites sampled	Number of sample sites in each water depth zone					Max depth sampled (ft)
		0-5 ft	6-10 ft	11-15 ft	16-20 ft	21-25 ft	
Sand	792	178	277	146	191	5	*26
Little Sand	327	42	77	81	127	0	20
Portage	100	41	9	15	16	19	25
Bird's Eye	109	15	25	25	44	1	*21
Entire chain	1334	276	388	267	378	25	n/a

*not all sites at this depth were sampled

Table 3. Point-intercept survey summary data for the Sand Chain of Lakes, 2012.

	Entire chain	**Sand**	**Little Sand**	**Portage**	**Bird's Eye**
Number of samples (0-20 ft)	1309	792	327	81	108
Frequency of plant occurrence (%)	47	52	32	72	42
Max rooting depth (ft)	20	20	17	17	19
Depth at which 95% of vegetation occurred (ft)	10	10	11	14	14
Number of submerged species	26	24	20	18	17
Number of free-floating species	4	3	1	3	1
Number of floating-leaf species	5	5	3	3	4
Number of emergent species	9	9	5	8	4
Total # of all plant species found	44	41	29	32	26
Mean # of plant species per sample site	1.4	1.4	1.1	2.2	1.3

Table 4. Frequency of aquatic plant species in the Sand Chain of Lakes, 2012.

Submerged and free-floating taxa within 0 to 20 feet depth zone *Surveyors could not always distinguish *Najas flexilis* from *Najas guadalupensis* and they were grouped together for analysis.				Entire Chain	Sand	Little Sand	Portage	Bird's Eye
				Frequency (% occurrence)				
		Common name	**Scientific Name**	1309	792	327	81	109
Algae/ moss		Muskgrass	*Chara* sp.	9	9	5	33	4
Algae/ moss		Stonewort	*Nitella* sp.	3	5	1	--	--
Algae/ moss		Watermoss	*Not identified to genus*	1	2	--	5	--
Monocots		Needlegrass	*Eleocharis acicularis*	<1	1	--	--	--
Monocots		Canada waterweed	*Elodea canadensis*	2	1	3	9	1
Monocots		Water stargrass	*Heteranthera dubia*	<1	<1	--	--	1
Monocots		Mare's tail	*Hippuris vulgaris*	<1	<1	--	--	--
Monocots		Bushy pondweed	*Najas flexilis**	6	6	8	7	4
Monocots		Southern naiad	*Najas guadalupensis**					
Monocots	Narrow-leaf pondweed group	Fries' pondweed	*Potamogeton friesii*	15	15	17	2	16
Monocots	Narrow-leaf pondweed group	Small pondweed	*Potamogeton pusillus*					
Monocots	Narrow-leaf pondweed group	Sago pondweed	*Stuckenia pectinata*	2	2	2	4	2
Monocots	Broad-leaf pondweed group	Large-leaf pondweed	*Potamogeton amplifolius*	1	2	P	5	1
Monocots	Broad-leaf pondweed group	Variable pondweed	*Potamogeton gramineus*	3	5	2	--	--
Monocots	Broad-leaf pondweed group	Illinois pondweed	*Potamogeton illinoensis*	<1	<1	--	P	1
Monocots	Broad-leaf pondweed group	White-stem pondweed	*Potamogeton praelongus*	1	1	1	--	--
Monocots	Broad-leaf pondweed group	Clasping-leaf pondweed	*Potamogeton richardsonii*	6	8	3	P	4
Monocots		Flat-stem pondweed	*Potamogeton zosteriformis*	12	14	8	27	3
Monocots		Creeping spearwort	*Ranunculus flammula*	<1	--	<1	1	--
Monocots		Arrowhead - Submerged	*Sagittaria* spp.	1	--	--	--	--
Monocots		Wild celery	*Vallisneria americana*	9	12	6	2	6
Dicots		Water marigold	*Bidens beckii*	1	1	1	--	--
Dicots		Coontail	*Ceratophyllum demersum*	16	13	14	44	23
Dicots		Northern watermilfoil	*Myriophyllum sibiricum*	12	11	16	20	2
Dicots		White water buttercup	*Ranunculus aquatilis*	5	6	6	4	1
Dicots		Greater bladderwort	*Utricularia vulgaris*	1	1	<1	2	6
			Total number of submerged taxa	26	24	20	18	17
Free-floating		Star duckweed	*Lemna trisulca*	3	3	2	1	6
Free-floating		Lesser duckweed	*Lemna* sp.	<1	<1	--	--	--
Free-floating		Greater duckweed	*Spirodela polyhriza*	<1	<1	--	2	--
Free-floating		Water meal	*Wolffia* sp.	<1	--	--	1	--
			Total number of free-floating taxa	4	3	1	3	1

Table 4 (continued). Frequency of aquatic plant species in the Sand Chain of Lakes, 2012.

Floating-leaf and emergent taxa within 0 to 6 feet depth zone			Entire Chain	Sand	Little Sand	Portage	Bird's Eye
			Frequency (% occurrence)				
	Common name	**Scientific Name**	373	237	68	45	23
Emergent	River bulrush	*Bolboschoenus fluviatilis*	<1	<1	--	--	--
	Spikerush	*Eleocharis palustris*	4	5	6	P	--
	Horsetail	*Equisetum fluviatile*	P	P	--	P	--
	Arrowhead	*Sagittaria* sp.	<1	2	1	4	P
	Bulrush	*Schoenoplectus* sp.[G]	23	27	19	20	P
	Giant burreed	*Sparganium eurycarpum*	[G]1	[G]1	--	[G]P	--
	Narrow-leaved cattail	*Typha angustifolia*	2	2	P	4	--
	Broad-leaved cattail	*Typha latifolia*	<1	<1	--	P	P
	Wild rice	*Zizania palustris*	20	11	21	20	100
		Total number of emergent taxa	9	9	5	8	4
Floating-leaf	White waterlily	*Nymphaea odorata*	6	5	7	9	13
	Yellow waterlily	*Nuphar variegata*	15	10	19	29	30
	Floating-leaf pondweed	*Potamogeton natans*	5	3	7	7	13
	Floating-leaf smartweed	*Persicaria amphibia*	P	P	--	--	--
	Arum-leaved arrowhead	*Sagittaria cuneata*	<1	P	--	--	<1
		Total number of floating-leaf taxa	5	5	3	3	4
		Total number of all taxa	44	41	29	32	26

[G]Some plants were only identified to the genus level in this lake. It is possible that additional species of the genus were present in the lake, but only one species was positively identified.
P= Present in lake but not found in any survey sites
(--) = plant was absent in that lake

Table 5. Historical and current aquatic plants in the Sand Chain of Lakes, 1957 to 2012.

Submerged

Common name	**Scientific name**	**1957**	**1975**	**1984**	**2001**	**2002**	**2012**
Muskgrass	*Chara* sp.	X					X
Stonewort	*Nitella* sp.						X
Watermoss	*Not identified to genus*	X					X
Needlegrass	*Eleocharis acicularis*						X
Canada waterweed	*Elodea canadensis*	X	X	X		X	X
Water stargrass	*Heteranthera dubia*						X
Mare's tail	*Hippuris vulgaris*	X					X
Bushy pondweed	*Najas flexilis*	X		X	X	X	X
Southern naiad	*Najas guadalupensis*						X
Large-leaf pondweed	*Potamogeton amplifolius*			X	X		X
Variable pondweed	*Potamogeton gramineus*			X	X		X
Illinois pondweed	*Potamogeton illinoensis*				X		X
	Potamogeton friesii				X	X	X
Narrow-leaf pondweed group	*Potamogeton pusillus*			[G]X	X		X
	Potamogeton strictifolius		X				
White-stem pondweed	*Potamogeton praelongus*	X	X	X	X	X	X
Clasping-leaf pondweed	*Potamogeton richardsonii*	X	X		X	X	X
Flat-stem pondweed	*Potamogeton zosteriformis*	X	X	X	X	X	X
Arrowhead – submerged	*Sagittaria* sp.						[G]X
Filiform pondweed	*Stuckenia filiformis*				X		
Sago pondweed	*Stuckenia pectinata*	X			X		X
Wild celery	*Vallisneria americana*	X	X		X	X	X
Water marigold	*Bidens beckii*				X		X
Coontail	*Ceratophyllum demersum*	X	X	X	X	X	X
Northern watermilfoil	*Myriophyllum sibiricum*	X	X	X	X	X	X
White water buttercup	*Ranunculus aquatilis*				X	X	X
Creeping spearwort	*Ranunculus flammula*						X
Greater bladderwort	*Utricularia vulgaris*	X	X		X	X	X
	Total	13	9	9	17	11	26

Free-floating

Common name	**Scientific name**	**1957**	**1975**	**1984**	**2001**	**2002**	**2012**
Star duckweed	*Lemna trisulca*		X		X	X	X
Lesser duckweed	*Lemna* sp.	X	X				X
Greater duckweed	*Spirodela polyhriza*					X	X
Watermeal	*Wolffia* sp.						X
	Total	1	2	0	1	2	4

Floating-leaved

Common name	Scientific name	1957	1975	1984	2001	2002	2012
White waterlily	*Nymphaea odorata*	X	X	X	X	X	X
Yellow waterlily	*Nuphar variegata*	X	X	X	X	X	X
Floating-leaf pondweed	*Potamogeton natans*	X	X	X		X	X
Floating-leaf smartweed	*Persicaria amphibia*				X		X
Arrowhead	*Sagittaria cuneata*						X
	Total	3	3	3	3	3	5

Emergents

Common name	Scientific name	1957	1975	1984	2001	2002	2012
River bulrush	*Bolboschoenus fluviatilis*				X	X	X
Spikerush	*Eleocharis palustris*		X	X	X	X	X
Horsetail	*Equisetum fluviatile*	X	X				X
Broad-leaf arrowhead	*Sagittaria latifolia*	[G]X	X				[G]X
Stiff wapato	*Sagittaria rigida*				X		
Bulrush	*Schoenoplectus acutus* *Schoenoplectus tabernaemontani*	[A]X	[A]X	[A]X	[A]X	[A]X	[A]X
Giant burreed	*Sparganium eurycarpum*	X			X	X	[G]X
Narrow-leaved cattail	*Typha angustifolia*	[G]X					X
Broad-leaved cattail	*Typha latifolia*		X	X			X
Wild rice	*Zizania palustris*	X	X	X	X	X	X
	Total	6	6	4	6	5	9

Wetland emergents

Common name	Scientific name	1957	1975	1984	2001	2002	2012
Sweet flag	*Acorus calamus*	X					
Sedge	*Carex* sp.		X				X
Purple loosestrife (I)	*Lythrum salicaria*						X
Reed canary grass (I)	*Phalaris arundinaceae*						X
Giant cane	*Phragmites australis*	X	X	X		X	X
	Total	2	2	1	0	1	4

(I) = Introduced to Minnesota
[A]"Bulrush species"(*Schoenoplectus* sp.) was used to record bulrush plants that were hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*S. tabernaemontani*) or the hybrid.
[G]Some plants were only identified to the genus level in this lake. It is possible that additional species of the genus were present in the lake, but only one species was positively identified.

1957: Arthur Peterson, Robert Bredemus, Minnesota Department of Conservation, Bureau of Research and Planning
1975: Marc Olson, Lloyd Steen, MNDNR Division of Game and Fish.
1984: MNDNR Division of Game and Fish
2001: Karen Myhre, Minnesota Biological Survey of Sand Lake, MNDNR Division of Ecological and Water Resources
2002: Karen Myhre, Minnesota Biological Survey of Little Sand Lake, MNDNR Division of Ecological and Water Resources
2012: Simon, Perleberg, Johnson, Walker-O'Beirne, Point-Intercept survey, MNDNR Division of Ecological and Water Resources

Table 6. Emergent and floating-leaf acreage in the Sand Chain of Lakes, September 2011 and August 2012.

Lake	**Emergent acres**	**Floating-leaf acres**	**Total emergent/floating leaf acres**	**Acres of shallow water (0-6 ft)**	**% shallow (0 – 6 ft) sites w/emergents and floating-leaf**
Sand	302	11	313	657	48
Little Sand	40	1	41	83	49
Portage	10	3	13	21	62
Bird's Eye	21	0	21	24	88
Entire Chain	373	15	388	785	49

Table 7. Unique plants of the Sand Chain of Lakes, 2012.

Life Form	**Common name**	**Number of sites per species**			
		Sand	Little Sand	Portage	Bird's Eye
Submerged	Marestail	1	--	--	--
	Creeping spearwort	--	1	1	--
Total number of species per lake		1	1	1	0

(--) = plant absent in that lake

Figure 24. Distribution of submerged aquatic plants on the Sand Chain of Lakes, 2012.

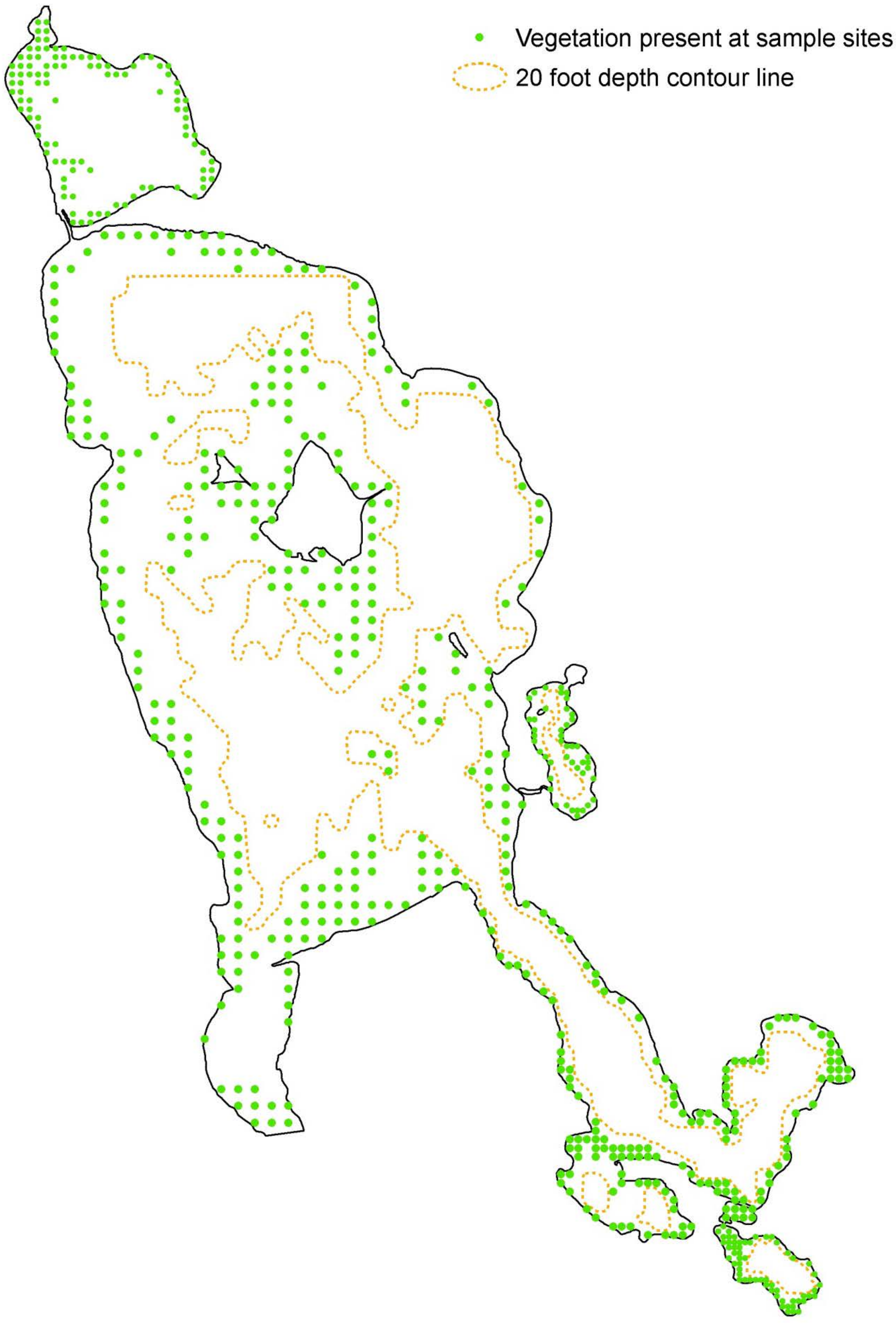


Figure 25. Emergent and floating-leaf plant beds on the Sand Chain of Lakes, 2012.

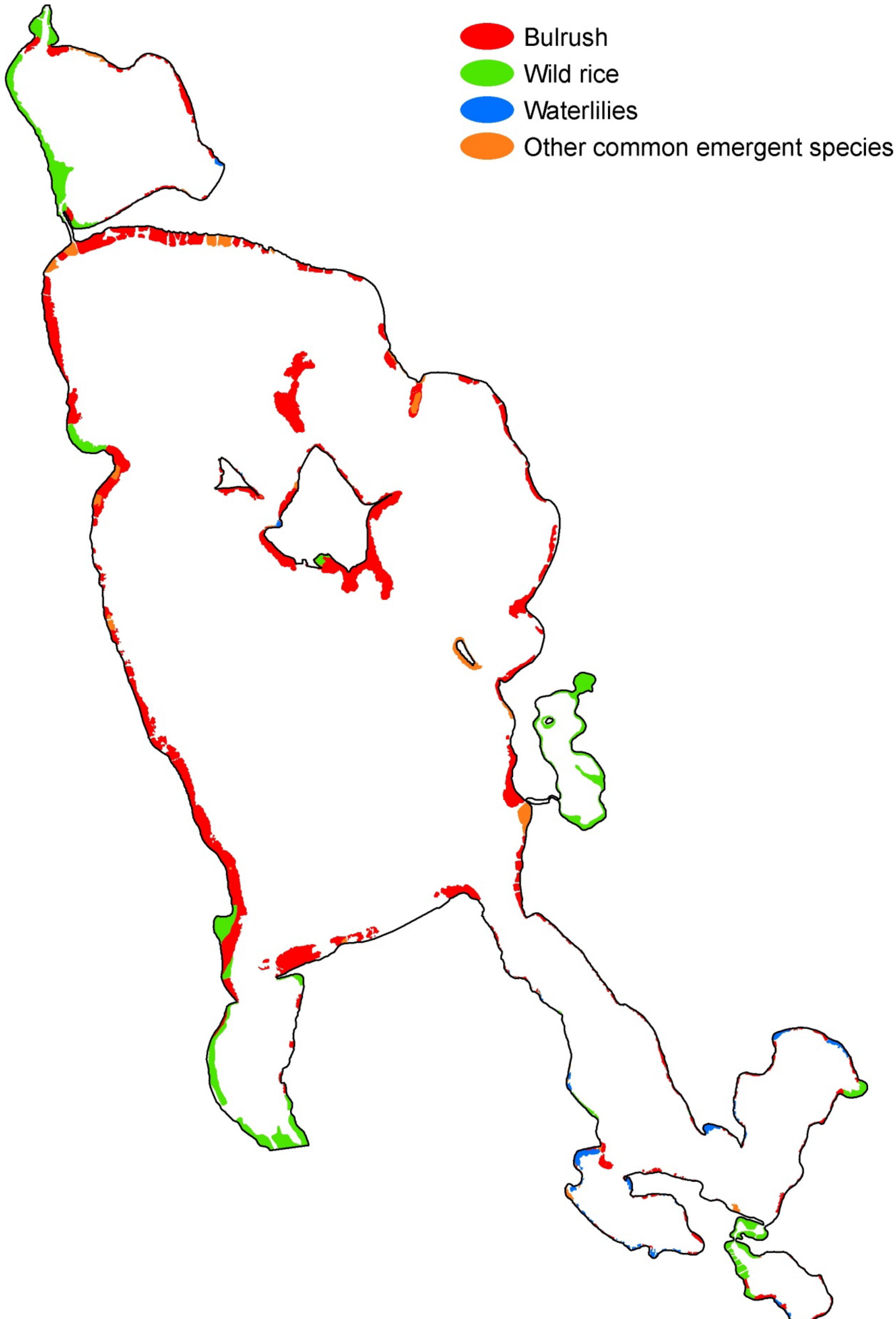


Figure 26. Locations of unique plants on the Sand Chain of Lakes, 2012.

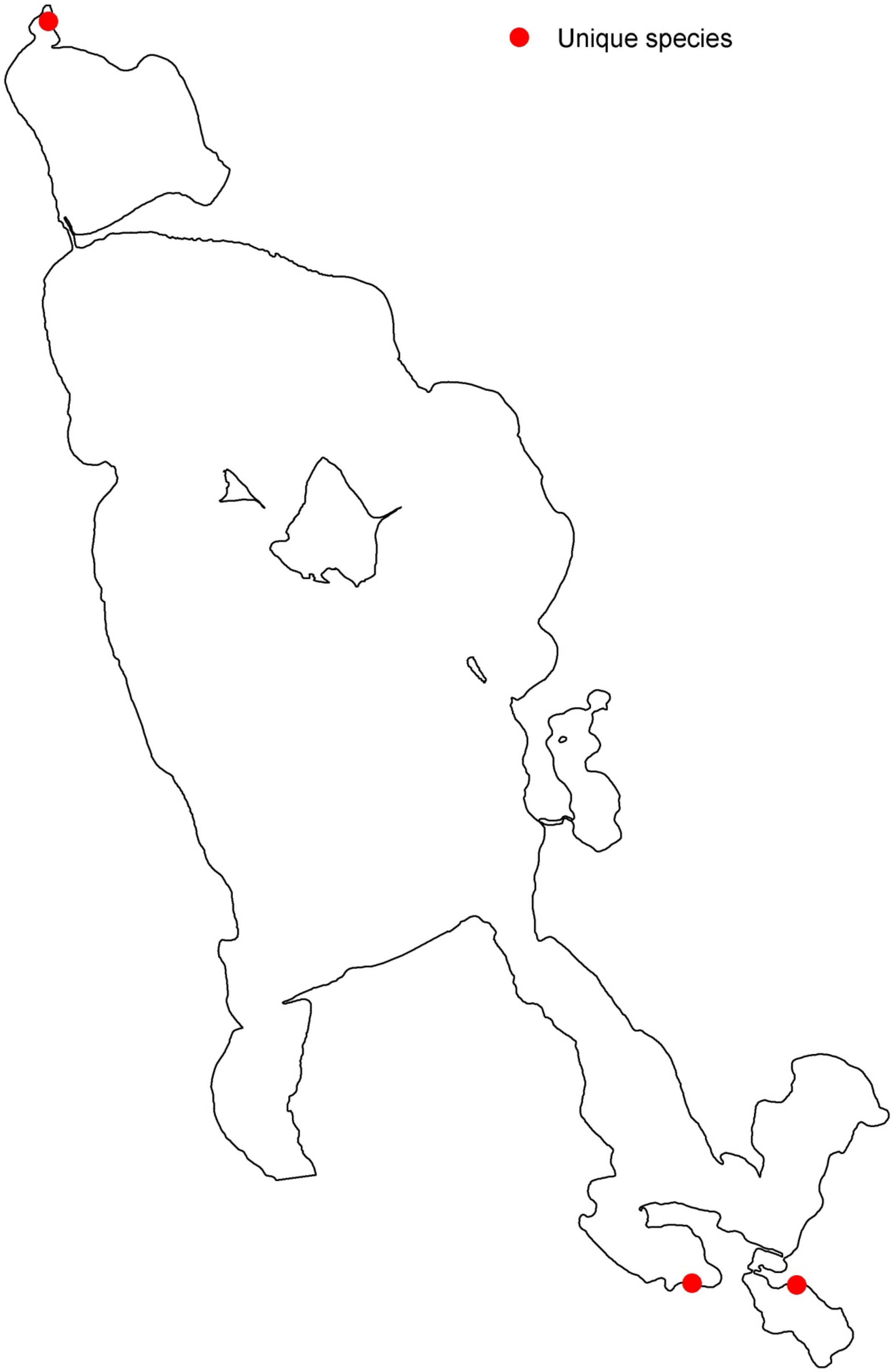
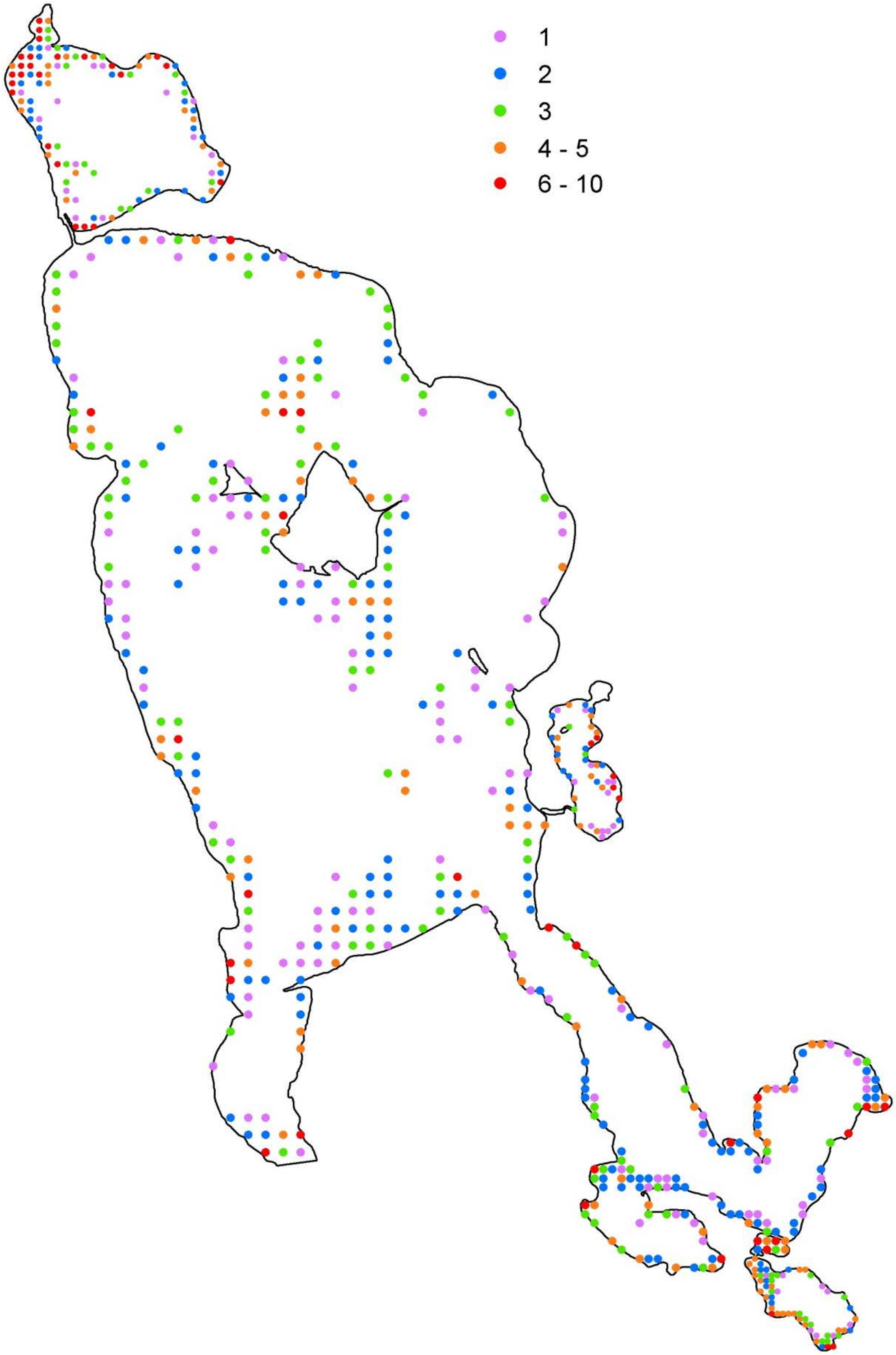


Figure 27. Aquatic plant richness (number of species per sampling station) on the Sand Chain of Lakes, 2012.



Near-shore Substrates

Objectives

1. Describe and map the near-shore substrates of the Sand Chain of Lakes

Introduction

Substrate type can have an effect on species make-up and richness. Some fish, such as the pugnose shiner, least darter, and longear sunfish, prefer small diameter substrates, such as silt, muck, and sand. Other species, such as walleye, prefer hard bottom substrates with a larger diameter, such as gravel and rubble. A diverse substrate will also allow plants with different habitat requirements to exist within a system. For example, bulrush may occur on sand, gravel or marl whereas yellow waterlily prefers soft substrates (Nichols 1999b).

Natural sand shoreline along the west shore of Bird's Eye Lake, 2012.

Methods

Near-shore substrate in the Sand Chain of Lakes was evaluated at a total of 744 sampling stations set up in the grid point-intercept aquatic plant survey and near-shore fish surveys. Plant point-intercept sample stations were spaced 65 meters apart on Little Sand Lake and on the southeast arm of Sand Lake, 40 meters apart on Bird's Eye and Portage lakes, and 125 meters apart on the main basin of Sand Lake. Surveyors described substrate at 629 of these sites that were located between the shore and the seven foot water depth. To increase sample coverage at near-shore sites not covered by the grid sampling, substrate was also evaluated at near-shore fish sample stations. Fish sample stations were located every 400 meters around the perimeter of the lakeshore and substrate was evaluated at 115 of these stations.

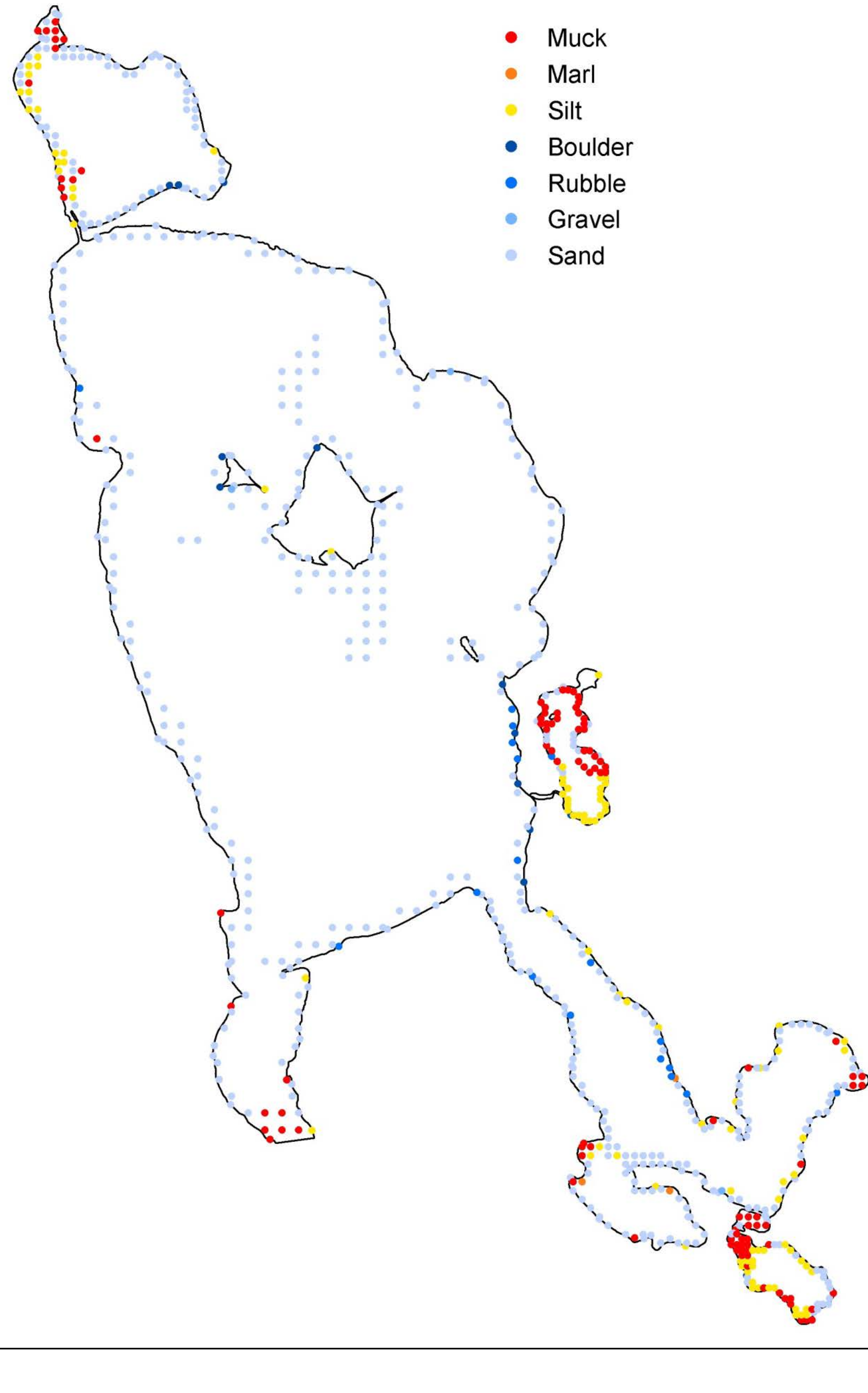
Surveyors evaluated substrate by tapping a pole into the lake bottom; soft substrate could usually be brought to the surface on the pole or sampling rake for evaluation. If this method was not feasible, substrate was evaluated by visual observation of the lake bottom. Standard lake substrate classes were based on the DNR Lake Survey Manual (MN DNR 1993):

Substrate Group	**Type**	**Description**
Hard Bottom	Boulder	Diameter over 10 inches
	Rubble	Diameter 3 to 10 inches
	Gravel	Diameter 1/8 to 3 inches
	Sand	Diameter less than 1/8 inch
Soft Bottom	Silt	Fine material with little grittiness
	Marl	Calcareous material
	Muck	Decomposed organic material

Results

Substrate types documented on the Sand Chain of Lakes ranged from soft (muck, marl, and silt) to hard (boulder, rubble, gravel, and sand) (Figure 28). Muck substrates were frequent in Bird's Eye Lake, the north bay of Little Sand Lake, and the channel that connects Sand to Portage Lake. Silt substrates were common in Bird's Eye and Portage lakes. Sand substrates were frequent in the windswept open areas of Sand Lake. Overall, sand was the most common substrate type, and occurred at nearly 68% of the sample locations.

Figure 28. Distribution of near-shore substrates in the Sand Chain of Lakes, 2012.



Loon Nesting Areas

Objectives

1. Map current and historical loon nesting areas
2. Identify loon nests as natural or manmade

Introduction

The Volunteer LoonWatcher survey began in 1979 as a way for the DNR to obtain information on loon numbers and nesting success on a variety of lakes in Minnesota. Each year volunteer loon watchers observe the loons on a selected lake and fill out a report, noting information such as number of loons, number of nests, and number of chicks. Locations of loon nests, if known, are also documented in the report.

Loon pair with chick

Photo by: Paul Bolstad

Common loons may be easily disturbed by human presence, and tend to avoid nesting where development has occurred. They prefer protected areas such as bays and islands, especially those areas with quiet shallow water and patchy emergent vegetation that provides cover. Identification of these loon nesting sites will help managers prevent degradation and destruction of these sensitive areas.

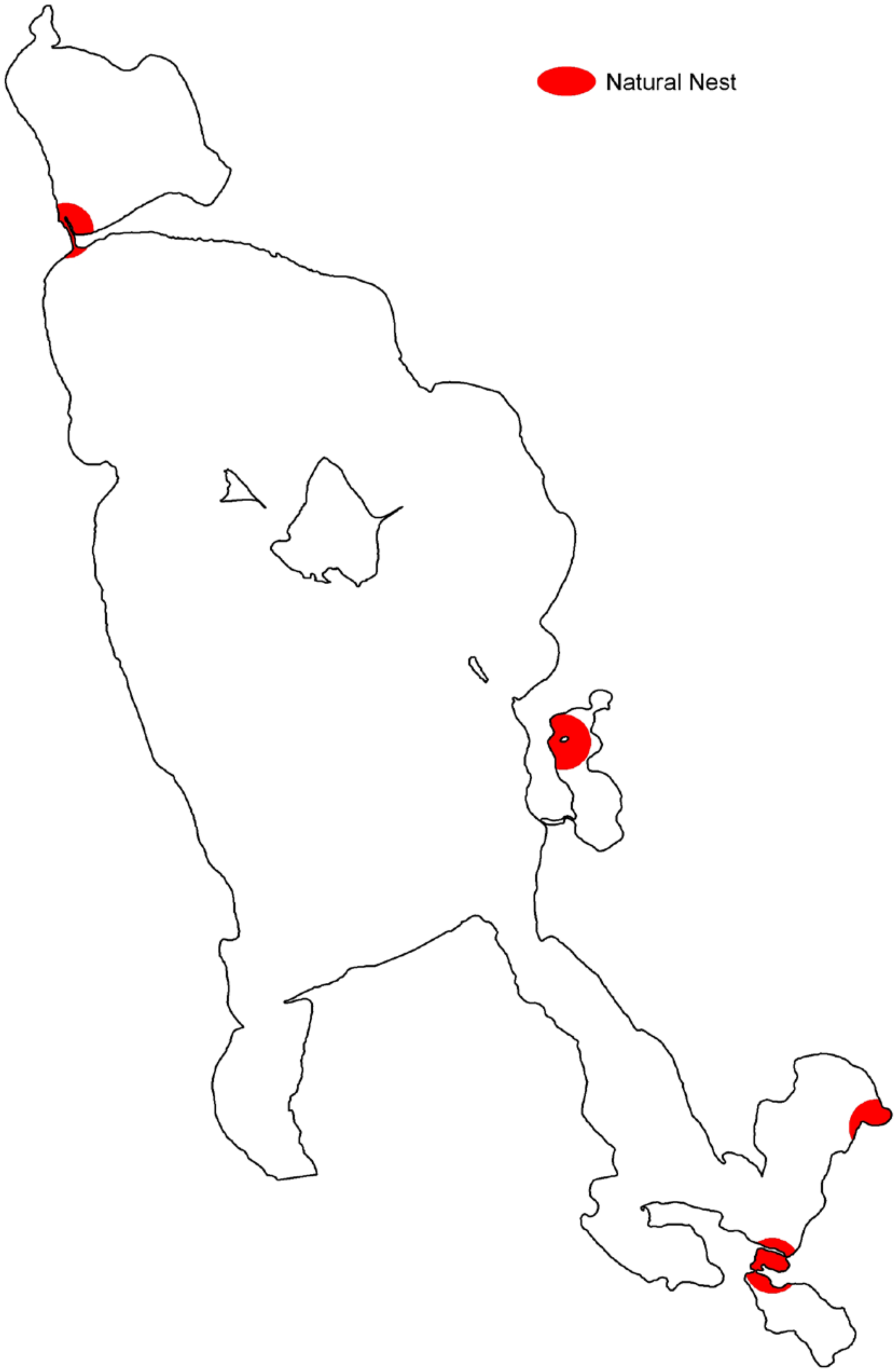
Methods

Using information from LoonWatcher reports and bird, fish, and vegetation survey crews, researchers mapped loon nesting locations in GIS. Mapped nests were buffered by 200 meters to account for locational uncertainty. Nests were identified as either natural or manmade (artificial platforms). All former and current natural nesting locations and artificial platforms used by loons were included in the maps and analysis; artificial platforms not utilized by loons were not included.

Results

Four loon nesting areas were identified on the Sand Chain of Lakes in 2012. One nest was located in Little Sand Lake, near the channel to Sand Lake, two nests were located in the southeastern corner of Sand Lake, and one nest was documented on an island in Bird's Eye Lake (Figure 29). All documented nests were natural nests, and no active artificial nest platforms were recorded.

Figure 29. Location of natural loon nests recorded on the Sand Chain of Lakes, 2012.



Aquatic Frog Surveys

Objectives

1. Record index of abundance for all frogs and toads
2. Estimate actual abundance of green and mink frogs
3. Develop distribution maps for green and mink frogs

Introduction

Amphibians are ideal indicator species of lakeshore habitats. Although population declines may be caused by a number of factors, including predation, competition, and introduction of exotic species, amphibians are particularly prone to local extinctions resulting from human-caused alteration and fragmentation of their habitat. Removal of vegetation and woody debris, retaining wall construction, and other common landscaping practices all have been found to negatively affect amphibian populations.

Target species for the frog surveys were mink frog (*Rana septentrionalis*) and green frog (*Rana clamitans*). These frogs, which are strongly associated with larger lakes, are easily surveyed during their breeding season, which extends from May until August. During this time they establish and defend distinct territories, and inhabit vegetated areas along the lakeshore.

Figure 30. Mink frog

Photo by: Jeff LeClere, www.herpnet.net

Mink frogs (Figure 30) are typically green in color with darker green or brown mottling. They emit an odor similar to that of a mink when handled. They inhabit quiet waters near the edges of wooded lakes, ponds, and streams, and are considered the most aquatic of the frogs found in Minnesota. Populations of mink frogs have potentially been declining recently, and the numbers of observed deformities have been increasing.

Figure 31. Green frog

Photo by: Jeff LeClere, www.herpnet.net

Green frogs (Figure 31) are medium-sized, greenish or brownish frogs with small dark spots. The belly is often brighter in color than the back. A large tympanum (eardrum) helps identify the green frog. They can be found in a variety of habitats surrounding lakes, streams, marshes, and swamps, but are strongly associated with the shallow water of lakeshores. Although green frog populations are generally stable, regional declines and local extinctions have been noted.

Methods

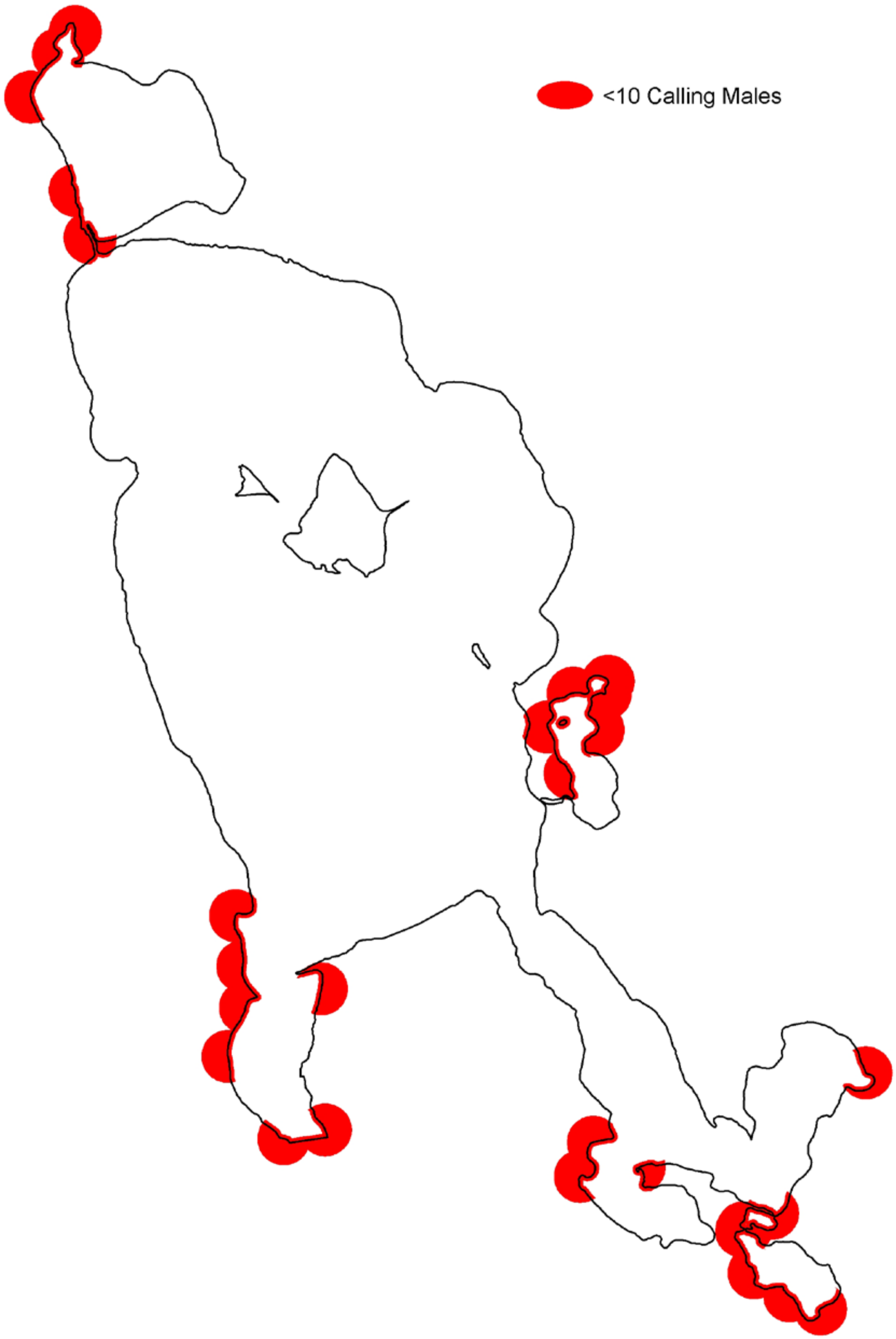
The aquatic frog survey methodology followed the Minnesota Frog and Toad Calling Survey (MFTCS) protocol (see Minnesota's Sensitive Lakeshore Identification Manual for additional information on how this protocol was adjusted for water routes). Frog survey points were located around the entire lake, spaced 400 meters apart. Surveys were conducted between sunset and 1:00 AM. At each station surveyors listened for up to five minutes for all frog and toad calls. An estimate of abundance and a calling index were recorded for both green and mink frogs. For other species, only calling index was recorded. If survey conditions such as rain or wind noticeably affected listening ability, the survey was terminated.

Results

Target species
Mink frogs were documented at 30 survey stations during the Sand Chain of Lakes frog surveys (Figure 32). Mink frogs were heard primarily along the shorelines of the smaller lakes in the chain (Little Sand, Portage, and Bird's Eye); on Sand Lake, mink frog locations were confined to the southern bays. At survey stations where mink frogs were present, abundance estimates ranged from one to two frogs. Green frogs were not recorded on the Sand Chain of Lakes during frog surveys, but they were documented on the lake during fish surveys in mid-July.

Other species
Gray treefrogs (*Hyla versicolor*) were heard at scattered locations around Sand Lake, as well as at survey stations on Bird's Eye and Portage lakes. Index values for gray treefrogs ranged from one (individual frog calls could be distinguished; no overlap) to two (individual calls can be distinguished, but some overlap of calls).

Figure 32. Distribution of mink frogs heard during Sand Chain of Lakes frog surveys, July 2012.



Nongame Fish Surveys

Objectives

1. Record presence and abundance of near-shore fish species of greatest conservation need
2. Record presence and abundance of proxy species
3. Develop distribution maps for species of greatest conservation need and proxy species
4. Identify habitat (substrate and aquatic vegetation biovolume) associated with presence of species of greatest conservation need and proxy species
5. Identify near-shore fish assemblages

Introduction

Fish Species of Greatest Conservation Need
There are 47 fish species of greatest conservation need (SGCN) within the state of Minnesota. Of these 47 species, three are near-shore species found within Itasca County. The pugnose shiner and least darter are listed as species of Special Concern in the state of Minnesota. The longear sunfish exhibits a spotty distribution, and is listed as threatened in Wisconsin.

Pugnose shiners (*Notropis anogenus*; Figure 33) are small (38 – 56 mm), slender, silverish-yellow minnows. They possess large eyes and a distinctively upturned mouth that gives them a "pugnose" appearance. They are secretive minnows, and are found often in schools of 15 to 35 individuals. Pugnose minnows inhabit clear lakes and low-gradient streams and are extremely intolerant of turbidity. Vegetation, particularly pondweed, coontail, and bulrush, is an important habitat component.

Figure 33. Pugnose shiner

Photo by: Konrad Schmidt

Least darters (*Etheostoma microperca*; Figure 34) are Minnesota's smallest fish, averaging only 25 – 38 mm in length. They are olive-brown in color with scattered dark brown spots and markings and four dark bars radiating from the eye. Males possess an extremely long pectoral fin. Least darters are found in clear, shallow areas of low-gradient streams or lakes. Extensive beds of muskgrass (*Chara* spp.) are a preferred habitat feature. Removal of vegetation, riparian area modification, and poor water quality all pose threats to the least darter.

Figure 34. Least darter

Photo by: Konrad Schmidt

Longear sunfish (*Lepomis megalotis*; Figure 35) are a deep-bodied fish reaching a length of 71 – 94 mm. These colorful fish have a belly that is orange-red, and the sides are speckled with turquoise. Adults have an elongated opercular "ear flap" that is trimmed in white. Like the other species of greatest conservation need, the longear sunfish prefers clear, shallow, vegetated areas and is intolerant of turbidity.

Figure 35. Longear sunfish

Photo by: Konrad Schmidt

Proxy species

Proxy species have similar life history characteristics and occupy habitat similar to species of greatest conservation need; they represent indicator species for those SGCN.

Blackchin shiners (*Notropis heterodon*; Figure 36) are small (50 – 75 mm) fish with a bronze-colored back and silver sides and belly. A dark lateral band extends through the chin. Like the species of greatest conservation need, the blackchin shiner inhabits clear water with abundant submerged aquatic vegetation; it also prefers a clean sand or gravel substrate. This species cannot tolerate turbidity or loss of aquatic vegetation.

Figure 36. Blackchin shiner

Photo by: Konrad Schmidt

Blacknose shiners (*Notropis heterolepis*; Figure 37) are similar in size and coloration to blackchin shiners. However, the dark lateral line does not extend through the lips or chin. Scales on the back are outlined in a dark color, giving them a crosshatch appearance. Blacknose shiners are sensitive to turbidity and pollution, and their range has contracted since the beginning of the century. Habitat includes clean, well-oxygenated lakes and streams with plentiful vegetation and low turbidity and pollution.

Figure 37. Blacknose shiner

Photo by: Konrad Schmidt

Banded killifish (*Fundulus diaphanus*; Figure 38) are slender fish with slightly flattened heads. The mouth, which opens dorsally, is an adaptation for surface feeding. Dark vertical bars are present along the sides. Size ranges from about 50 – 100 mm. Calm, clear, shallow water with abundant aquatic vegetation and a sandy or gravely substrate is preferred by the killifish.

Figure 38. Banded killifish

Photo by: Konrad Schmidt

Methods

Fish surveys were conducted using Minnesota's Sensitive Lakeshore Survey Protocol. Fish survey stations were located 400 meters apart, and were the same stations used for surveying aquatic frogs. At each station, fish were sampled using two different methods: shoreline seining and electrofishing. At several locations, excessive vegetation, depth, or soft substrate prevented surveyors from using seines. However, electrofishing samples were still collected, from a boat if necessary. Several sample stations were excluded because they overlapped another station or were in close proximity to a loon nest. All species captured using the different sampling methods were identified and counted. Target fish species included near-shore species of greatest conservation concern (pugnose shiner, least darter, and longear sunfish) and proxy species (blackchin shiner, blacknose shiner, and banded killifish). These species are associated with large, near-shore stands of aquatic grasses and macrophytes. They are intolerant to disturbance, and have been extirpated from lakes where extensive watershed and lakeshore development has occurred.

In addition to the fish data, habitat data were collected at each sampling station. Substrate data were recorded using standard near-shore classes. Aquatic vegetation biovolume was also estimated at each station; this represented the volume (percent) of a sampling area that contained submerged aquatic vegetation.

Results

All three proxy fish species were documented in the Sand Chain of Lakes (Figure 39). Blacknose shiners were identified in the greatest numbers; surveyors counted over 2500 individuals. Blacknose shiners were found within all lakes in the Sand Chain, and were scattered around the shoreline at 29 different survey stations. Blackchin shiners were recorded at six survey stations in Sand Lake; 30 individuals were documented. Surveyors found one banded killifish at a survey station in the southern end of Sand Lake. Banded killifish were the most frequently documented proxy species. No fish species of greatest conservation need were identified in the Sand Chain of Lakes. Substrate type at sites where species of greatest conservation need and proxy species were present was primarily sand, but other small-diameter substrates such as silt and muck were also recorded. Aquatic vegetation biovolume was similar between sites that contained proxy species and sites that did not.

The presence of these sensitive fish species may indicate minimal disturbance in several areas of the lake. However, because populations of these species are vulnerable across their ranges, continued monitoring and maintenance of these shoreline habitats is necessary to ensure continued existence of these populations. Limiting macrophyte removal, pesticide and herbicide use, and modification of the riparian zone will help maintain good water quality and a healthy aquatic plant community.

In total, surveyors identified 29 fish species in the Sand Chain of Lakes in 2012 (Table 8). Bluntnose minnows and yellow perch, each recorded at 30 or more (of 122) survey stations, were the most frequently documented species. Blacknose shiners, found at 29 survey sites, rounded out the list of the top three most commonly recorded species, and topped the list of most abundant fish. Several species, including banded killifish, fathead minnow, northern redbelly dace, shorthead redhorse, trout-pike, walleye, and yellow bullhead were detected at only one station each.

Figure 39. Distribution of fish proxy species documented during Sand Chain of Lakes fish surveys, 2012.

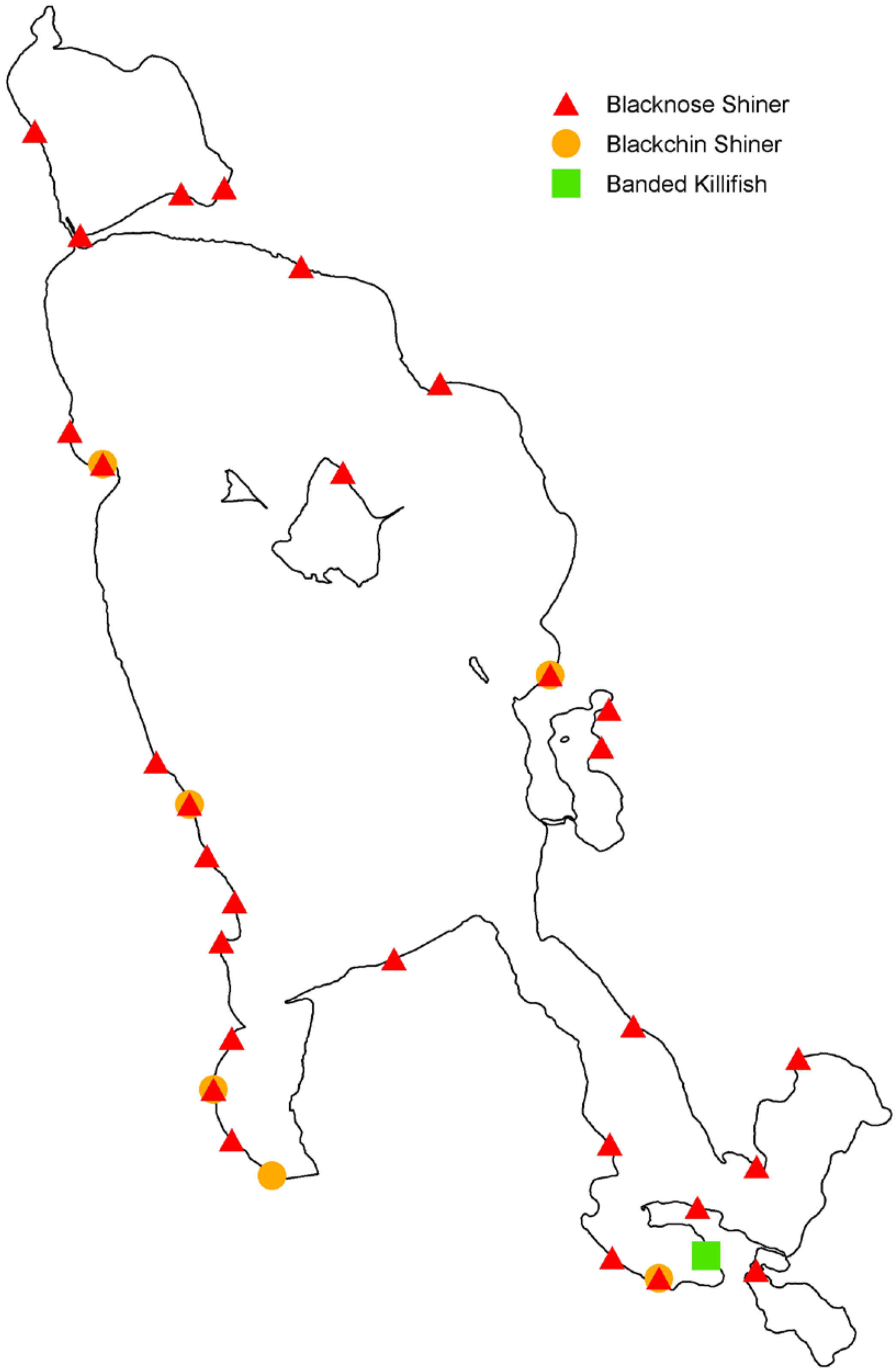


Table 8. Frequency of occurrence of fish species identified during Sand Chain of Lakes fish surveys, 2012. Values represent percent of survey stations in which a fish species occurred (N=122)

Description	**Common Name**	**Scientific Name**	**Sand Chain**	**Sand**	**Little Sand**	**Bird's Eye**	**Portage**
Bowfins	Bowfin	*Amia calva*	2	2	0	0	0
Minnows/carps	Golden shiner	*Notemigonus crysoleucas*	4	2	1	1	0
	Blackchin shiner	*Notropis heterodon*	5	5	0	0	0
	Blacknose shiner	*Notropis heterolepis*	24	18	3	2	1
	Spottail shiner	*Notropis hudsonius*	2	2	0	0	0
	Mimic shiner	*Notropis volucellus*	13	12	1	0	0
	Northern redbelly dace	*Phoxinus eos*	1	1	0	0	0
	Bluntnose minnow	*Pimephales notatus*	25	23	2	0	0
	Fathead minnow	*Pimephales promelas*	1	1	0	0	0
	Longnose dace	*Rhinichthys cataractae*	13	13	0	0	0
Suckers	Shorthead redhorse	*Moxostoma macrolepidotum*	1	1	0	0	0
North American freshwater catfishes	Yellow bullhead	*Ameiurus natalis*	1	0	0	0	1
	Tadpole madtom	*Noturus gyrinus*	4	3	0	0	1
Pikes	Northern pike	*Esox lucius*	5	5	0	0	0
Mudminnows	Central mudminnow	*Umbra limi*	11	6	2	2	2
Trout perches	Trout-perch	*Percopsis omiscomaycus*	1	1	0	0	0
Burbots	Burbot	*Lota lota*	2	2	0	0	0
Killifishes	Banded killifish	*Fundulus diaphanus*	1	1	0	0	0
Sculpins	Mottled sculpin	*Cottus bairdi*	10	10	0	0	0
Sunfishes	Rock bass	*Ambloplites rupestris*	13	13	0	0	0
	Pumpkinseed	*Lepomis gibbosus*	4	2	0	1	1
	Bluegill	*Lepomis macrochirus*	13	7	1	4	2
	Largemouth bass	*Macropterus salmoides*	2	2	0	0	0

	Black crappie	*Pomoxis nigromaculatus*	7	5	0	2	0
Perches	Iowa darter	*Etheostoma exile*	4	3	1	0	0
	Johnny darter	*Etheostoma nigrum*	7	6	1	0	0
	Yellow perch	*Perca flavescens*	25	21	2	1	1
	Logperch	*Percina caprodes*	2	2	0	0	0
	Walleye	*Sander vitreus*	1	0	1	0	0

Aquatic Vertebrate Richness

Objective

1. Calculate and map aquatic vertebrate richness around the shoreline of the Sand Chain of Lakes

Introduction

A variety of factors may influence aquatic vertebrate richness, including habitat diversity, water chemistry, flow regime, competition, and predation. High aquatic vertebrate richness indicates a healthy lakeshore community with diverse habitat, good water quality, varied flow regimes, and a sustainable level of competition and predation. A diverse aquatic vertebrate community will also help support diversity at higher trophic levels.

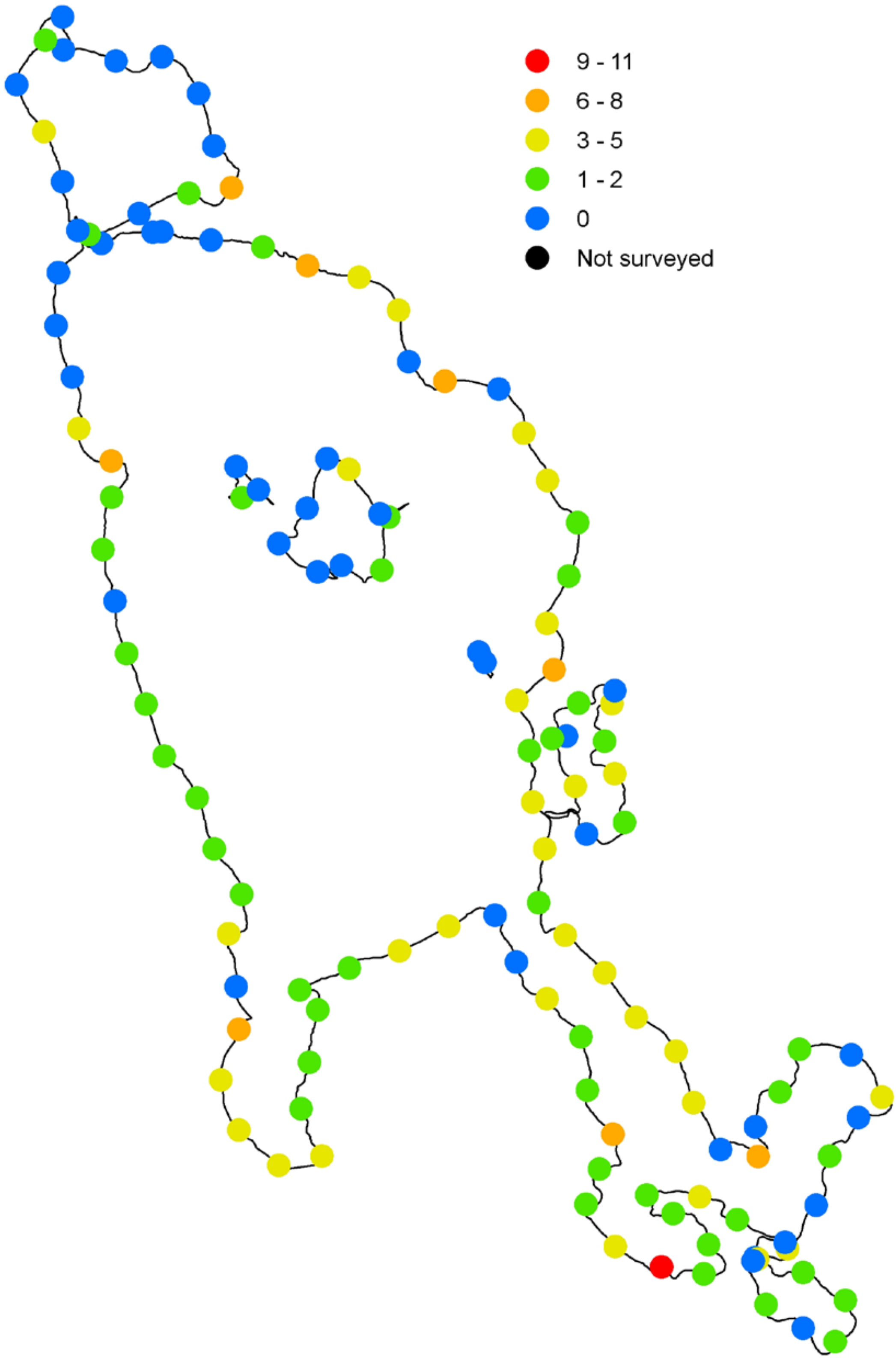
Methods

Aquatic vertebrate species were documented during the nongame fish sampling surveys. All aquatic vertebrates, including fish, frogs, and turtles, captured during seining and electrofishing surveys were identified to the species level. Young-of-year animals that could not be identified to the species level and hybrids were not used in the analysis.

Results

The number of species per Sand Chain of Lakes sample site ranged from zero to 11 (Figure 40). The site with the highest recorded aquatic vertebrate diversity (11 species documented) was located within Lakewood Bay. Sixteen of the 122 sample sites had five or more species documented, and 37 of the stations had zero species documented. At a number of the zero-fish sites, seining was not conducted because of excessive vegetation or soft substrate; these sites may have had fish present but surveyors were not able to document them.

Figure 40. Aquatic vertebrate species richness (number of species per sample site) in the Sand Chain of Lakes, 2012.



Other Rare Features

Objectives

1. Map rare features occurring within the extended state-defined shoreland area of the Sand Chain of Lakes

Introduction

The Minnesota Natural Heritage Information System provides information on Minnesota's rare animals, plants, native plant communities, and other features. The Rare Features Database includes information from both historical records and current field surveys. All Federal and State-listed endangered and threatened species and state species of special concern are tracked by the Natural Heritage program. The program also gathers information on animal aggregations, geologic features, and rare plants with no legal status.

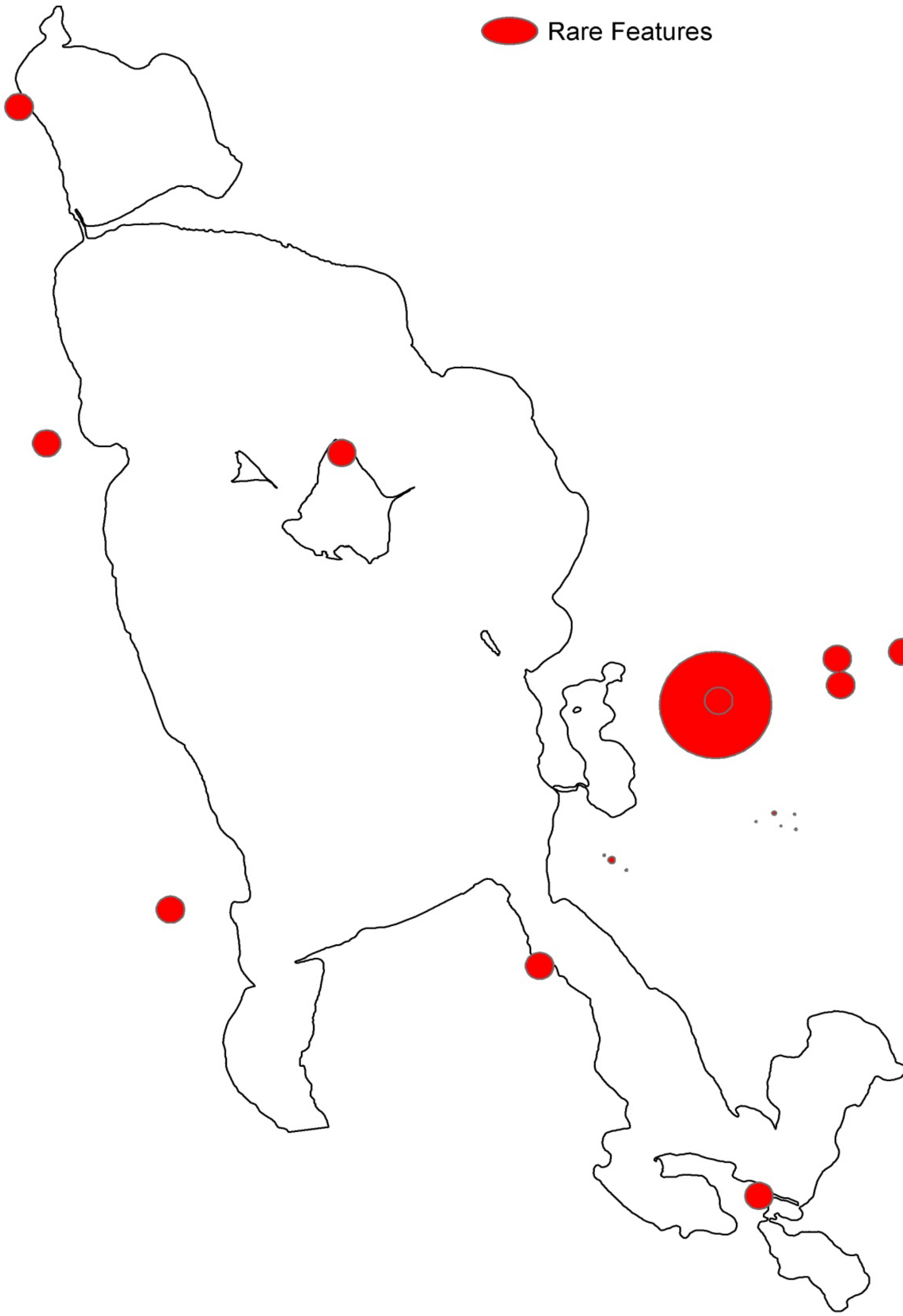
Methods

Researchers obtained locations of rare features from the Rare Features Database. Only “listed” animal and plant species (Federal or State endangered, threatened, or special concern) were considered in this project; non-listed unique plant species were included in the “Unique Plant Species” section of this report. Rare features within 1320 feet of the shoreline were mapped using GIS. Varying buffer sizes around rare feature locations represent locational uncertainty, and do not indicate the size of the area occupied by a rare feature.

Results

Eight occurrences of rare features have been documented within 1320 feet of the Sand Chain of Lakes shoreline (Figure 41). The rare features include the nesting areas of a bird species of special concern, as well as locations of one special concern orchid and one fern species of special concern. The publication of exact descriptive and locational information is prohibited in order to help protect these rare species.

Figure 41. Natural Heritage Database rare features (Federal or State-listed endangered, threatened, or special concern species) located within 1320 feet of the Sand Chain of Lakes shorelines.



Bay Delineation

Objectives

1. Determine whether areas of the lakes are in isolated bays, non-isolated bays, or not within bays

Introduction

Bays are defined as bodies of water partially enclosed by land. They often offer some degree of protection from the wind and waves to those species living within them. These protected areas provide habitat for a number of aquatic plant species, and bays are frequently characterized by abundant vegetation. These areas of calm water and plentiful vegetation, in turn, provide habitat for a number of fish and wildlife species. Protecting these areas will be beneficial to a variety of plant and animal species.

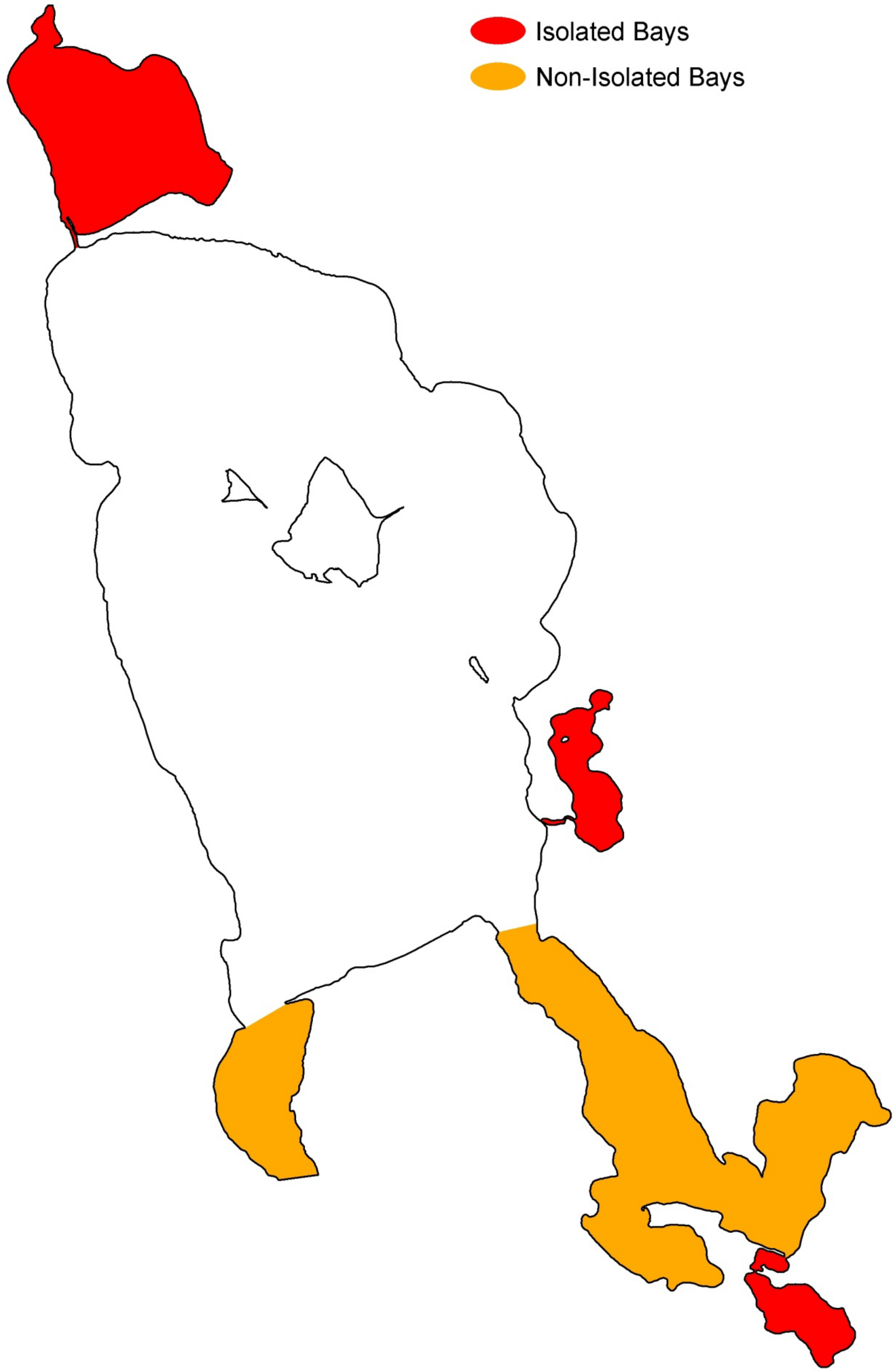
Methods

Bays were delineated using lake maps and aerial photos. Obvious bays (e.g., significant indentations of shoreline, bodies of water set off from main body or enclosed by land) were mapped based on inspection of lake maps. Additional bays were identified using aerial photos. Underwater shoals or reefs that offset a body of water from the main body were visible only in these photographs. Non-isolated bays were open to the main water body by a wide mouth. Isolated bays had a narrower connection to the main water body, or were offshoots of non-isolated bays.

Results

Overall, three isolated bays and four non-isolated bays were identified on the Sand Chain of Lakes (Figure 42). Bays were delineated by looking at the chain as a whole. Although lakes in themselves, Portage, Little Sand and Bird's Eye lakes were function as bays for the chain of lakes, and were identified as isolated bays. Non-isolated bays included four bays on Sand Lake: Southwest Bay, the "Straights," Lakewood Bay and Casper Bay.

Figure 42. Location of isolated and non-isolated bays on the Sand Chain of Lakes.



II. Ecological Model Development

The second component of the sensitive lakeshore area protocol involved the development of an ecological model. The model scored lakeshore areas based on calculations of sensitivity. The model incorporated results of the field surveys and analysis of additional data, so included information on plant and animal communities as well as hydrological conditions.

In order to develop a continuous sensitivity score along the shoreline, the ecological model used a moving analysis window that included both shoreland and near-shore areas. Resource managers developed a system to score each of the 13 variables. These scores were based on each variable's presence or abundance in relation to the analysis window (Table 9). Each analysis window was assigned a score, which was equal to the highest score present within a window. On occasion, point data were buffered by a set distance and converted to polygons to account for locational uncertainty before inclusion in the model.

Scores for each of the layers were summed (Figure 43). This map represents an index of sensitivity; those points with higher total scores are highly sensitive, whereas points with lower total scores have lower sensitivity.

Once the total score index was developed for the shoreline, clusters of points along the shoreline with similar values were identified using GIS (Figure 44). The clusters with high values (i.e., areas of highly sensitive shoreline) were buffered by ¼ mile. These buffered areas were defined as most likely highly sensitive lakeshore areas. These areas will be forwarded to the local government for potential designation as resource protection areas (Figure 45).

Table 9. Criteria for assigning scores to analysis windows for each variable.

Variable	Score	Criteria
Wetlands	3	> 25% of analysis window is in wetlands
	2	12.5 – 25% is in wetlands
	1	< 12.5% is in wetlands
	0	No wetlands present
Near-shore Plant Occurrence	3	Frequency of occurrence is > 75% (> 75% of points within analysis window contained vegetation)
	2	Frequency of occurrence is 25 – 75%
	1	Frequency of occurrence < 25%
	0	No vegetation present
Aquatic Plant Richness	3	Total number of plant species per analysis window > 10
	2	Total number of plant species 5 – 10
	1	Total number of plant species 1 – 4
	0	No vegetation present
Presence of Emergent and Floating-leaf Plant Beds	3	Emergent and/or floating-leaf plant stands occupy > 25% of the aquatic portion of the analysis window
	2	Stands occupy 5 – 25%
	1	Stands present but occupy less than 5%
	0	No emergent or floating-leaf plant beds present
Unique and Rare Plant Species	3	Presence of 2 or more unique or rare plant species within analysis window
	2	Presence of 1 unique plant species
	0	No unique plant species present
Near-shore Substrate	3	Frequency of occurrence is > 50% soft substrate (> 50% of points within analysis window consist of soft substrate)
	2	Frequency of occurrence is 25 – 50% soft substrate
	1	Frequency of occurrence < 25% soft substrate
	0	No soft substrate present
Loon Nesting Areas	3	Presence of natural loon nest within analysis window
	2	Presence of artificial loon nest (nesting platform)
	0	No loon nesting observed
Frogs	3	Presence of both mink frogs and green frogs within analysis window
	2	Presence of mink frogs or green frogs
	0	Neither mink frogs nor green frogs present
Fish	3	Presence of one or more SGCN within analysis window
	2	Presence of one or more proxy species
	0	Neither SGCN nor proxies observed

Table 9, continued.

Variable	Score	Criteria
Aquatic Vertebrate Richness	3	Total number of aquatic vertebrate species within analysis window > 10
	2	Total number of aquatic vertebrate species 5 – 10
	1	Total number of aquatic vertebrate species 1 – 4
	0	No aquatic vertebrate species observed
Rare Features	3	Presence of multiple Natural Heritage features within analysis window
	2	Presence of one Natural Heritage feature
	0	No Natural Heritage feature present
Bays	3	Isolated bay within analysis window
	2	Non-isolated bay
	0	Not a distinctive bay

Figure 43. Total score layer created by summing scores of all 13 variables. Highest total scores represent most sensitive areas of shoreline.

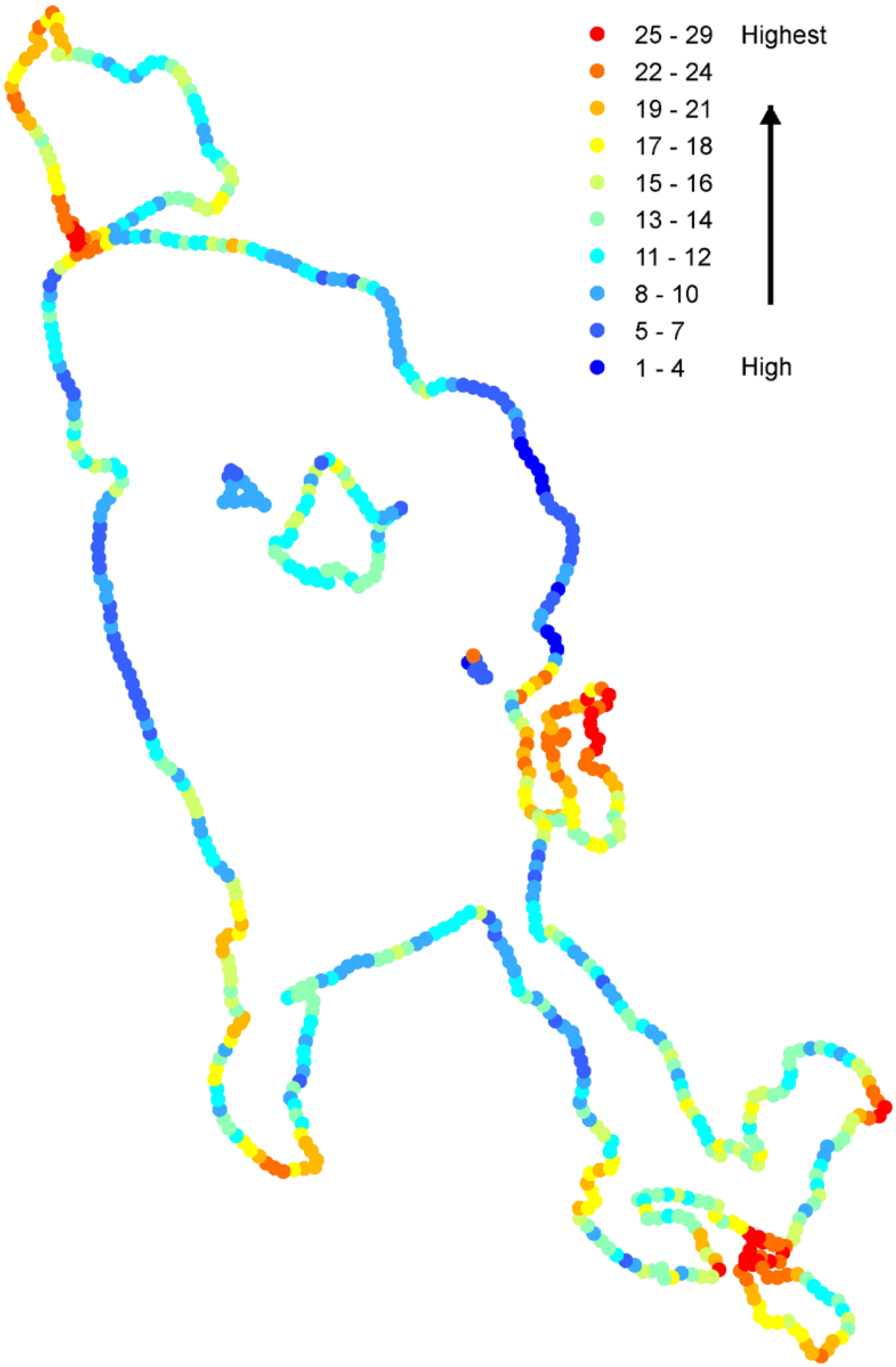


Figure 44. GIS-identified clusters of points with similar total scores. Red areas are those with high scores (i.e., areas of highly sensitive shoreland).

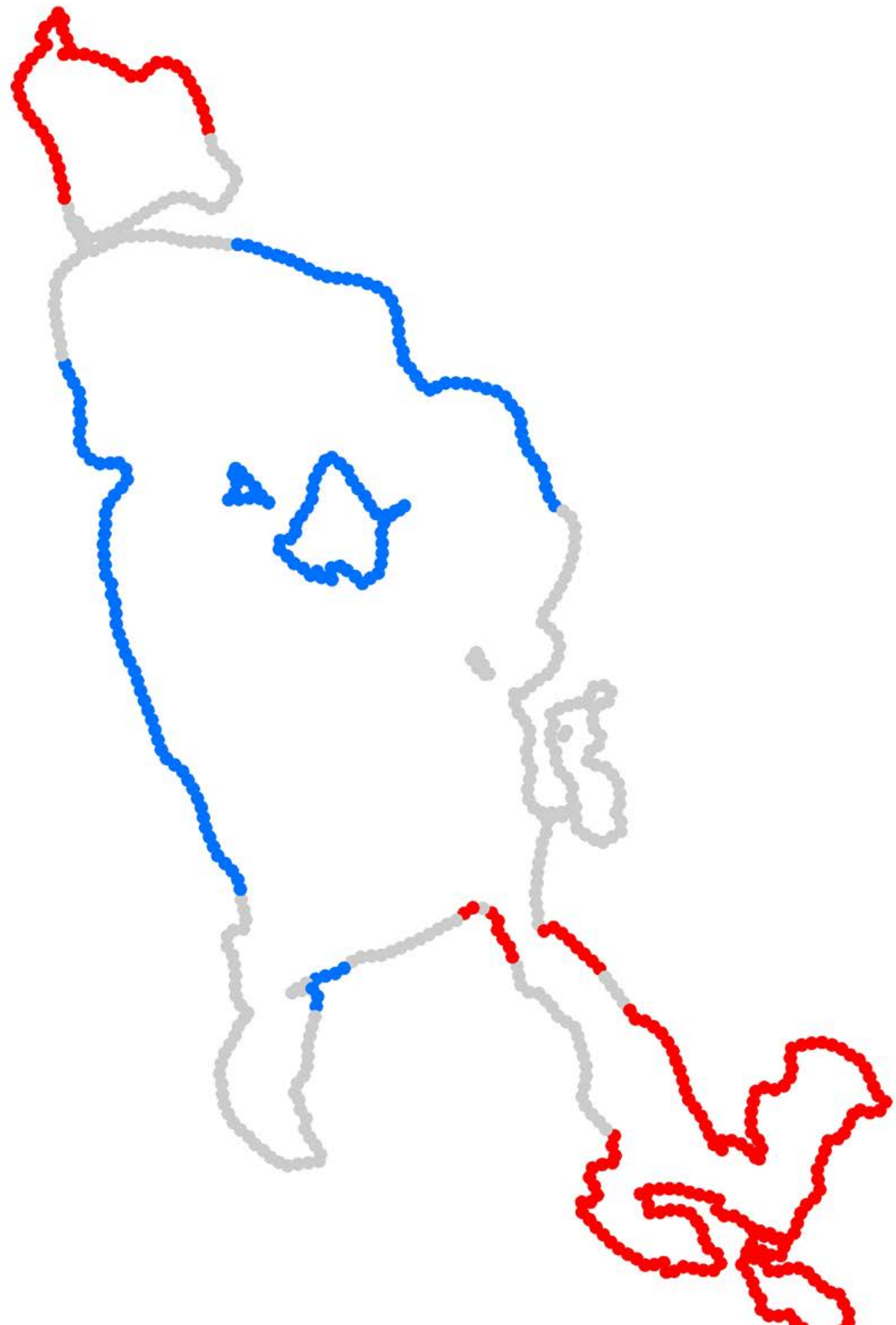
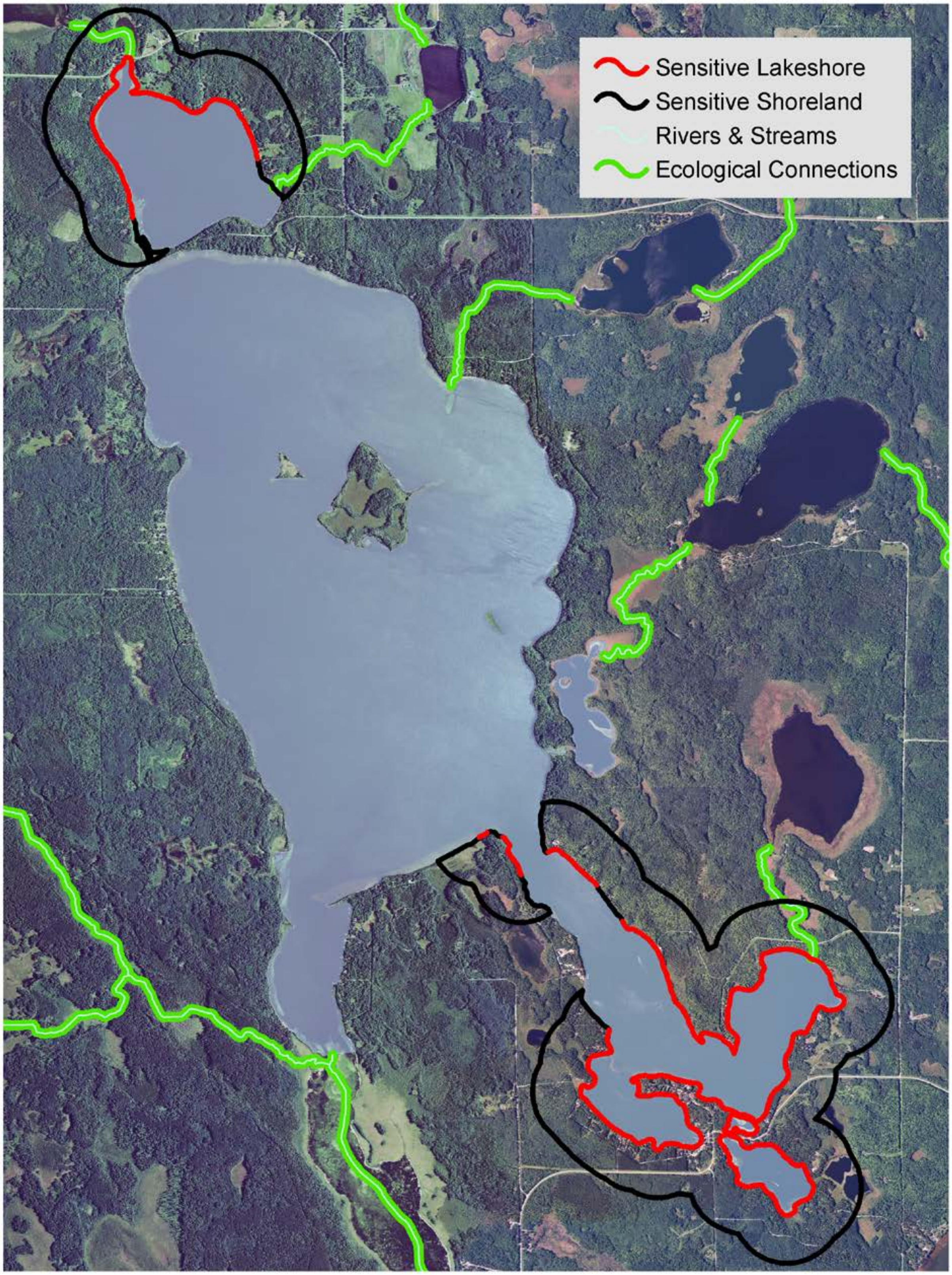


Figure 45. The Sand Chain of Lakes sensitive lakeshore areas identified by the ecological model, and ecological connections.



Habitat Connectivity

In addition to the sensitive shorelands identified through the GIS model, surveyors considered adjacent river shorelines that provide habitat connectivity to and from the lake shorelands. Aquatic habitat connectivity allows for the movement of aquatic organisms within a watershed, and the benefits are numerous. Organisms can move between existing habitats, colonize new areas, or recolonize former habitat in the wake of local extinctions. Connectivity allows organisms to move between multiple waterbodies and access various food sources. It allows animals with different vegetation requirements during different life stages to access those habitats. It allows movement of animals from various populations, increasing diversity. Several rivers and streams were identified as important ecological connections. Multiple inlets and the Big Fork River outlet were identified as important ecological connections. The Big Fork River is the major inlet that contributes flow between all four lakes. Five minor inlets, including Dinner Creek (Sand Lake) and four other unnamed inlets provide important habitat connectivity for fish and other wildlife to and from the Sand Chain. The Big Fork River flows out of the chain at the north end of Little Sand Lake, where it then flows north to the Rainy River which forms the Minnesota/Canada border.

Depending on the existing shoreland classification of these rivers and streams, the County may use the ecological connection recommendation to consider reclassifying to a more protective river class.

Other Areas of Ecological Significance

There are additional aquatic areas of ecological significance in the Sand Chain of Lakes that contain important plant communities but these sites are not necessarily associated with priority shoreland features. Identifying these sites is important, although exact delineation of their boundaries can be difficult if they occur in the water and/or if they are patchy in distribution.

Emergent and floating-leaf plant beds that occur outside of the sensitive shoreland districts are areas of ecological significance. Isolated off-shore bulrush stands occur in Sand Lake near Big Arrowhead Island. Further destruction of bulrush plants would be particularly detrimental because attempts to restore these types of plants have had limited success.

Native submerged plant beds are also considered sites of ecological significance, regardless of whether or not they are associated with priority shorelines. Not only do these beds provide critical habitat for fish and wildlife, but they may also help mitigate the potentially harmful impacts if invasive plants occur in the lake.

One of the primary threats to these sites is the direct destruction of plant beds through aquatic plant management and recreational boating activities. Planning efforts, such as the development of a Lake Vegetation Management Plan, can be used to set specific management practices within these types of sites.

Sensitive Lakeshore

Several stretches of shoreline along the Sand Chain of Lakes were identified as sensitive by the ecological model. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. Critical habitat, such as wetland habitat, was also present in the highest quantities near these areas. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. Although the shoreline itself is important, development and land alteration nearby has a significant negative effect on many species. Fragmented habitats often contain high numbers of invasive, non-native plants and animals that may outcompete native species. The larger a natural area is, the more likely it is to support populations of native plants and animals. Large natural areas that support a diversity of species and habitats help comprise a healthy ecosystem. The rivers and streams connected to the Sand Chain of Lakes are also an important part of the ecosystem. They provide valuable connectivity between the lakes and nearby habitat. Protection of these important corridors will help minimize fragmentation, and will help maintain the health of the lake ecosystem. Protection of both the shoreline itself and the habitat surrounding the shoreline will be the most effective way to preserve the plant and animal communities in and around the Sand Chain of Lakes, and the value of the lakes themselves.

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