Final Report
Sensitive Lakeshore Survey
Whitefish Chain of Lakes
Crow Wing County, Minnesota

March 2012

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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Whitefish Chain of Lakes

Arrowhead Lake (18-0366-00)
Bertha Lake (18-0355-00)
Big Trout Lake (18-0315-00)
Clamshell Lake (18-0356-00)
Cross Lake (18-0312-00)
Daggett Lake (18-0271-00)
Island Lake (18-0269-00)
Little Pine Lake (18-0266-00)
Loon Lake (18-0268-00)
Lower Hay Lake (18-0378-00)
Pig Lake (18-0354-00)
Rush-Hen Lake (18-0311-00)
Whitefish Lake (18-0310-00)

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Executive Summary

This report summarizes the results of plant, animal, and habitat surveys the DNR conducted on the Whitefish Chain of Lakes during the summers of 2010 and 2011 and the ecological model that was developed from the compiled data.

The Whitefish Chain of Lakes contains an abundant and diverse aquatic plant community and physical differences among the lakes influence the types and amounts of plants that occur in each lake. Fifty-five aquatic plant species were identified in the chain including 13 emergent, five floating-leaf, four free-floating, and 33 submerged species. Nine of these species were documented for the first time in the system. In all lakes, submerged plants were frequent within the shore to 15 feet depth zone and in lakes with higher clarity, moderate to sparse plant growth occurred to 25 or 30 feet. Common submerged plants included naiads (*Najas flexilis/guadalupensis*), coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.), northern watermilfoil (*Myriophyllum sibiricum*), and flat-stem pondweed (*Potamogeton zosteriformis*). The non-native submerged plant, curly-leaf pondweed (*Potamogeton crispus*), was present in some of the lakes but was a minor component of the plant community. Emergent and floating-leaf plants occupied 520 acres, or 26% of the shallow water zone. Wild rice and waterlily beds were primarily restricted to protected bays along undeveloped shorelines. Unique plant species included both wetland emergent and submerged plants.

Surveyors identified 99 bird species in the Whitefish Chain of Lakes, including 22 species of greatest conservation need. The species of greatest conservation need included nine forest habitat-dependent, seven wetland habitat-dependent, three aquatic habitat-dependent, and three species that utilize other or multiple habitat types. The common loon was the most commonly recorded species of greatest conservation need, while song sparrows were the most commonly detected species overall. Bird species diversity was highest in the northeast corner of Little Pine Lake and the southern shore of Clamshell Lake.

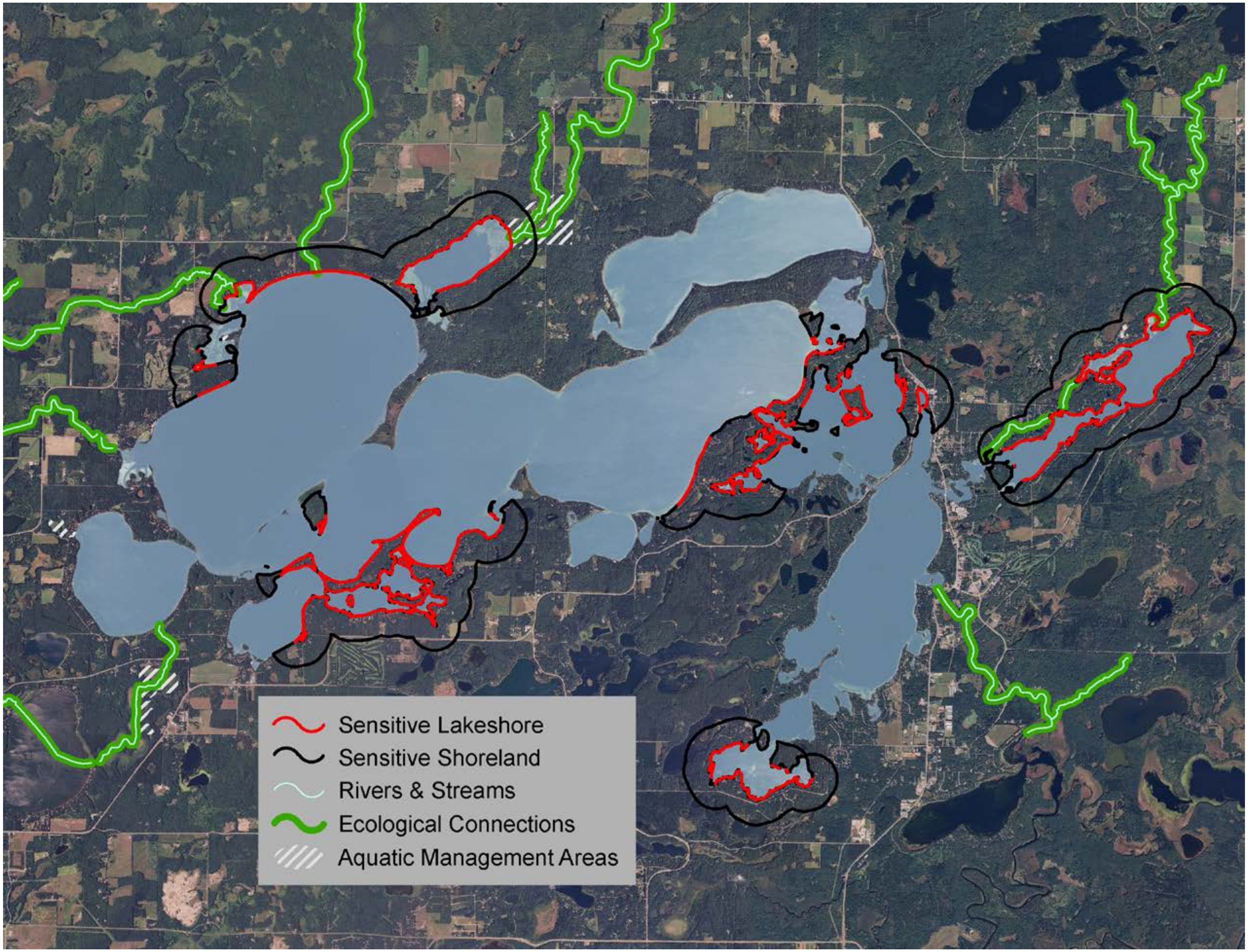
Three near-shore fish species of greatest conservation need, the pugnose shiner, least darter, and longear sunfish, were detected at several locations throughout the Whitefish Chain during the 2010 and 2011 nongame fish surveys. In addition, one offshore-dwelling species of greatest conservation need, the greater redhorse, was also identified. Three proxy species, the blacknose shiner, blackchin shiner, and banded killifish, were noted at many survey sites, particularly on Clamshell Lake, Big Trout Lake, and the southern bay of Cross Lake. Thirty-nine different fish species were documented during the surveys, bringing the total historical observed fish community to 50 species. Eight fish species not previously documented in the Whitefish Chain were identified during the surveys. The newly identified species were the central mudminnow, creek chub, finescale dace, least darter, longnose dace, mottled sculpin, pugnose shiner, and spotfin shiner.

Both green frogs and mink frogs were documented during the Whitefish Chain of Lakes frog surveys. Green frogs were recorded more frequently than mink frogs, and were heard at approximately 14% of the survey sites. Green frogs were primarily found along the east and southern shorelines of the chain. Mink frogs were primarily found in the northwest bays of Whitefish Lake and around Arrowhead Lake. Other anuran species documented in the chain

included gray tree frogs, spring peepers, American toads, northern leopard frogs, western chorus frogs, and wood frogs.

An ecological model based on major conservation principles was used to assess lakeshore sensitivity. The benefit of this approach is that criteria come from the science-based surveys and the value of the lakeshore is objectively assessed. Environmental decision-making is complex and often based on multiple lines of evidence. Integrating the information from these multiple lines of evidence is rarely a simple process. Here, the ecological model used 14 attributes (hydrological conditions and documented plant and animal presence) to identify sensitive areas of shoreland. A sensitivity index was calculated for each shoreland segment by summing the scores of the 14 attributes. Hydric soils have been used in previous sensitive lakeshore analyses, but were not available in Crow Wing County and so were not used in this analysis. Lakeshore segments were then clustered by sensitivity index values using established geospatial algorithms. Sensitive lakeshore areas were buffered and important ecological connections or linkages mapped. The identification of sensitive lakeshore areas by this method is an objective, repeatable and quantitative approach to the combination of multiple lines of evidence through calculation of weight of evidence. The ecological model results are lake-specific, in that the model results are intended to recognize the most probable highly sensitive lakeshores for a specific lake or waterbody.

The ecological model identified 10 primary sensitive lakeshore areas to be considered for potential resource protection districts by Crow Wing County. 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. The rivers and streams connected to the Whitefish 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
Aquatic Management Areas

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.

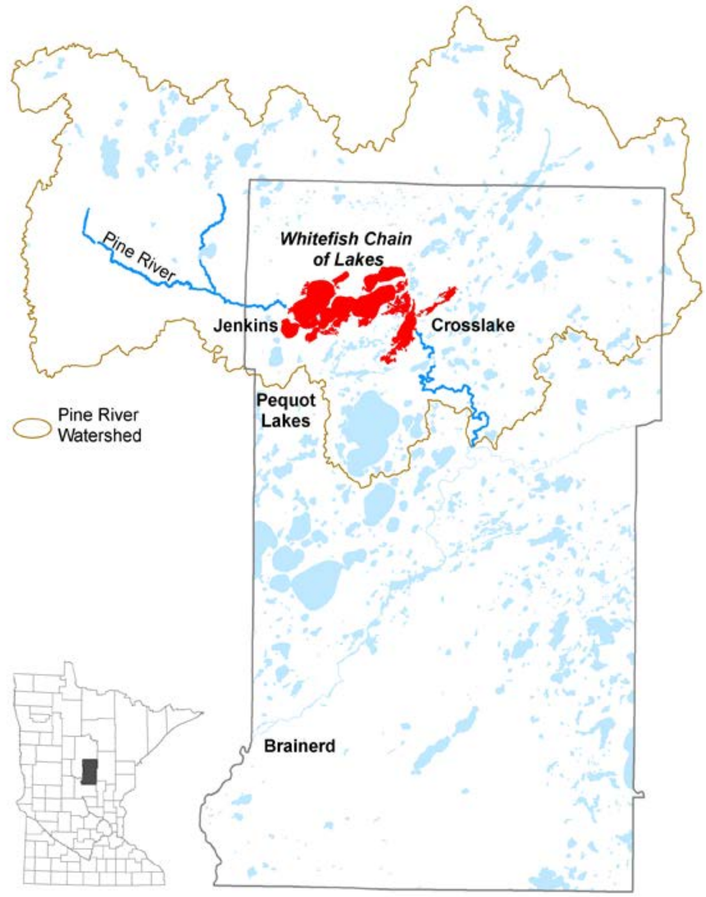
The final component of identifying sensitive lakeshore areas is to deliver advice to local governments and other groups who could use the information to maintain high quality environmental conditions and to protect habitat for species of greatest conservation need.

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 Whitefish Chain of Lakes sensitive lakeshore areas.

Lake Description

The Whitefish Chain of Lakes is located near the cities of Crosslake, Jenkins, and Pequot Lakes, in Crow Wing County, north-central Minnesota (Figure 1). These lakes occur in the southern half of the Pine River Watershed and are connected to the Pine River, which drains the watershed to the south.

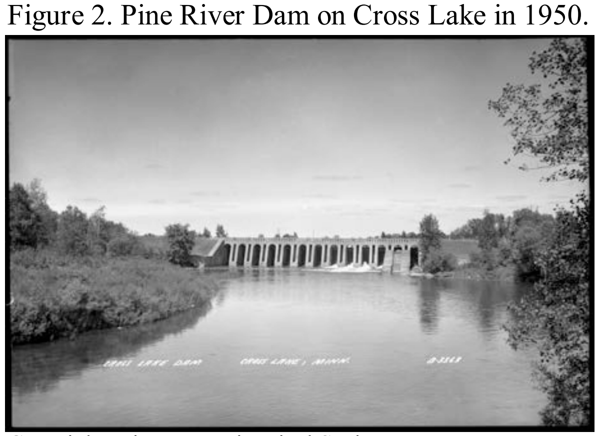
Figure 1. Location of the Whitefish Chain of Lakes in Crow Wing County.



The chain of lakes includes 13 waterbodies[1] and is named for Whitefish Lake, the largest lake in the system. Whitefish Lake is a natural flow-through lake with an inlet from and outlet to the Pine River. Water flows southeast from the west side of Whitefish Lake into a navigable channel that connects to Rush-Hen Lake, and continues southeast as it outlets at Cross Lake (Figure 3).

Many of these lakes were not originally connected but were joined after 1886 when the Pine River Dam (Figure 2) was completed at Cross Lake and raised water levels, making permanent channels between the lakes (Upham 1920) (Figure 4). Some lands that originally occurred as peninsulas adjacent to open water became converted to islands as water levels increased.

Figure 2. Pine River Dam on Cross Lake in 1950.



Although lakes in the Whitefish Chain are connected, differences such as lake size, depth, flow, and shoreland management create differences in nutrient levels and water clarity between the lakes. Lakes range

[1] The total number of waterbodies considered to be part of the Whitefish Chain of Lakes varies. We included the lakes that are directly connected to the main portion of the chain.

in depth and trophic status from shallow and eutrophic, such as Arrowhead Lake, to deep and oligotrophic, such as Big Trout and Island-Loon lakes (Figure 5). Water clarity ranges from nine feet in Little Pine, Daggett, and Arrowhead lakes to 14 feet in Big Trout, Island-Loon, and Lower Hay lakes (Table 1).

The Whitefish Chain of Lakes is popular with recreationalists (Knapp 2005). Approximately 91% of the Whitefish Chain shoreline is privately owned and has about 14 resorts. Six public accesses are available on the chain; they are located on Lower Hay, Whitefish, Clamshell, Big Trout, and Cross lakes (Figure 3). The Minnesota DNR Section of Fisheries primarily manages Whitefish Lake for walleye and northern pike (MN DNR 2005). Big Trout Lake is the only lake in the Brainerd Fisheries area that is managed and stocked for trout.

The Whitefish Chain covers a surface area of over 14,000 acres and has a total shoreline length of 115 miles. Whitefish Lake is the largest of the 13 lakes and the second largest in the Pine River Watershed. It has a surface area of about 7,715 acres and 32 miles of shoreline (Table 1). Loon, Island and Pig lakes are the smallest lakes in the chain, each having a surface area less than 200 acres.

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

Lake Name	Total Surface Area (acres)	Littoral Area[2] (acres)	Percent Littoral Area	Shoreline Length (miles)	DNR Lake Class[3]	Trophic Status[4]	Max depth (feet)	Secchi depth[5] (feet)
Whitefish	7,715	2,713	35	32	22	M	138	11
Cross	1,813	879	48	21	25	M	84	12
Big Trout	1,363	369	27	9	22	O	128	14
Rush-Hen	858	499	58	15	25	M	105	13
Lower Hay	693	215	31	4	27	M	100	14
Little Pine	352	225	64	7	34	E	36	9
Bertha	337	142	42	4	23	M	64	10
Arrowhead	296	296	100	4	39	E	13	9
Daggett	231	130	56	7	34	E	23	9
Clamshell	208	142	68	5	32	M	44	13
Pig	181	75	41	2	23	M	56	13
Island	176	85	48	5	23	O	76	14
Loon	49	36	73				30	
Entire Whitefish Chain	14,272	5,806	41	115	N/A	N/A	N/A	N/A

2 Lake area where water depths are 15 feet or less
3 Source: Schupp 1992.
4 Trophic Status: E = Eutrophic (high nutrients), M = Mesotrophic (moderate nutrients), O = Oligotrophic (low nutrients)
5 Mean mid-summer (June-September) Secchi disc readings (Source: MPCA, 2011)

Figure 3. Features of the Whitefish Chain of Lakes.

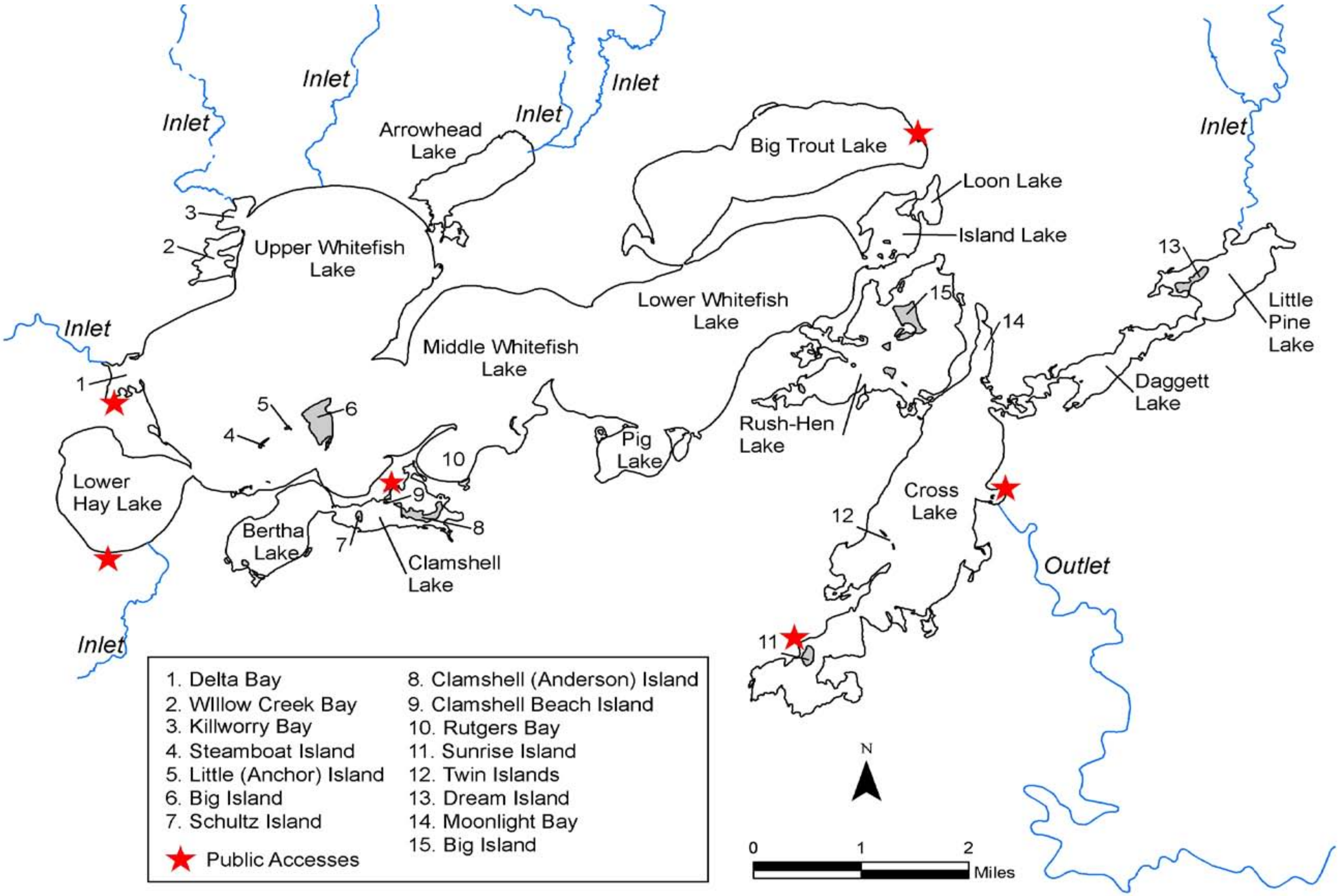


Figure 4. Historical map of the Whitefish Chain of Lakes (as interpreted from 1913 hand-drawn map).

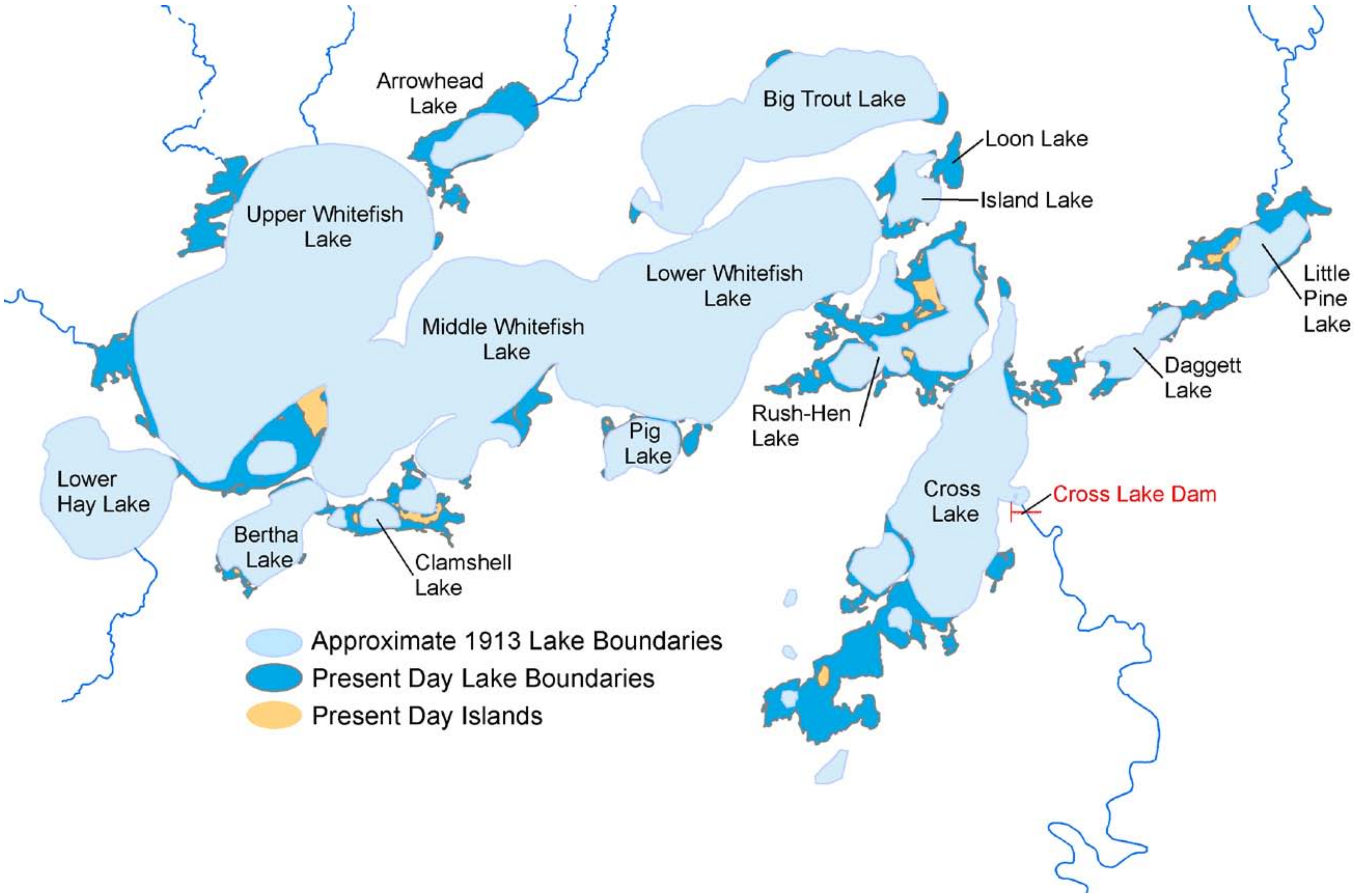
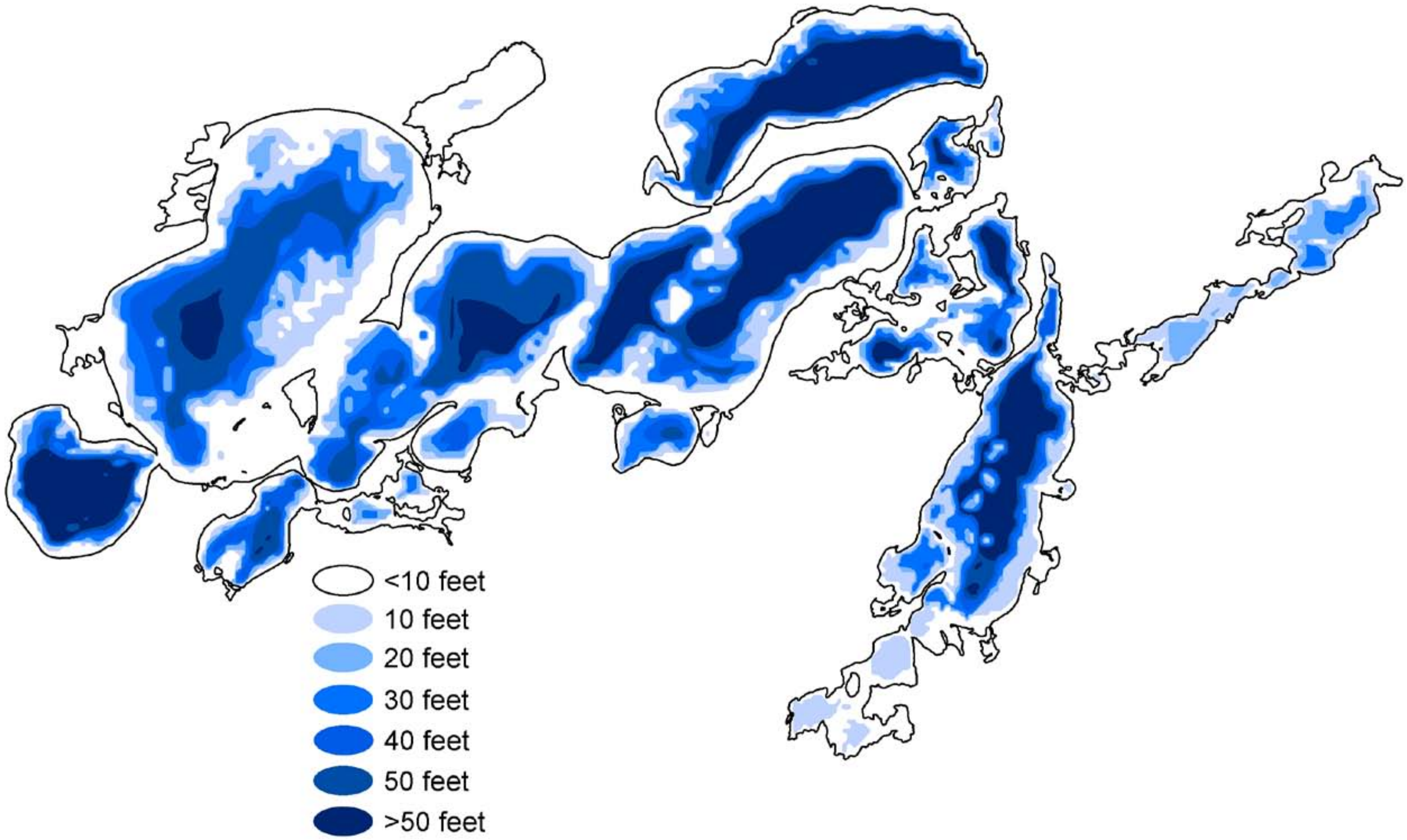


Figure 5. Present day depth contours of the Whitefish Chain of Lakes.



I. Field Surveys and Data Collection

Survey and data collection followed Minnesota's Sensitive Lakeshore Identification Manual protocol (MN DNR 2009). Resource managers gathered information on 14 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, near-shore plant occurrence, aquatic plant richness, presence of emergent and floating-leaf plant beds, unique plant species, near-shore substrate, birds, bird species richness, 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 Whitefish 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.

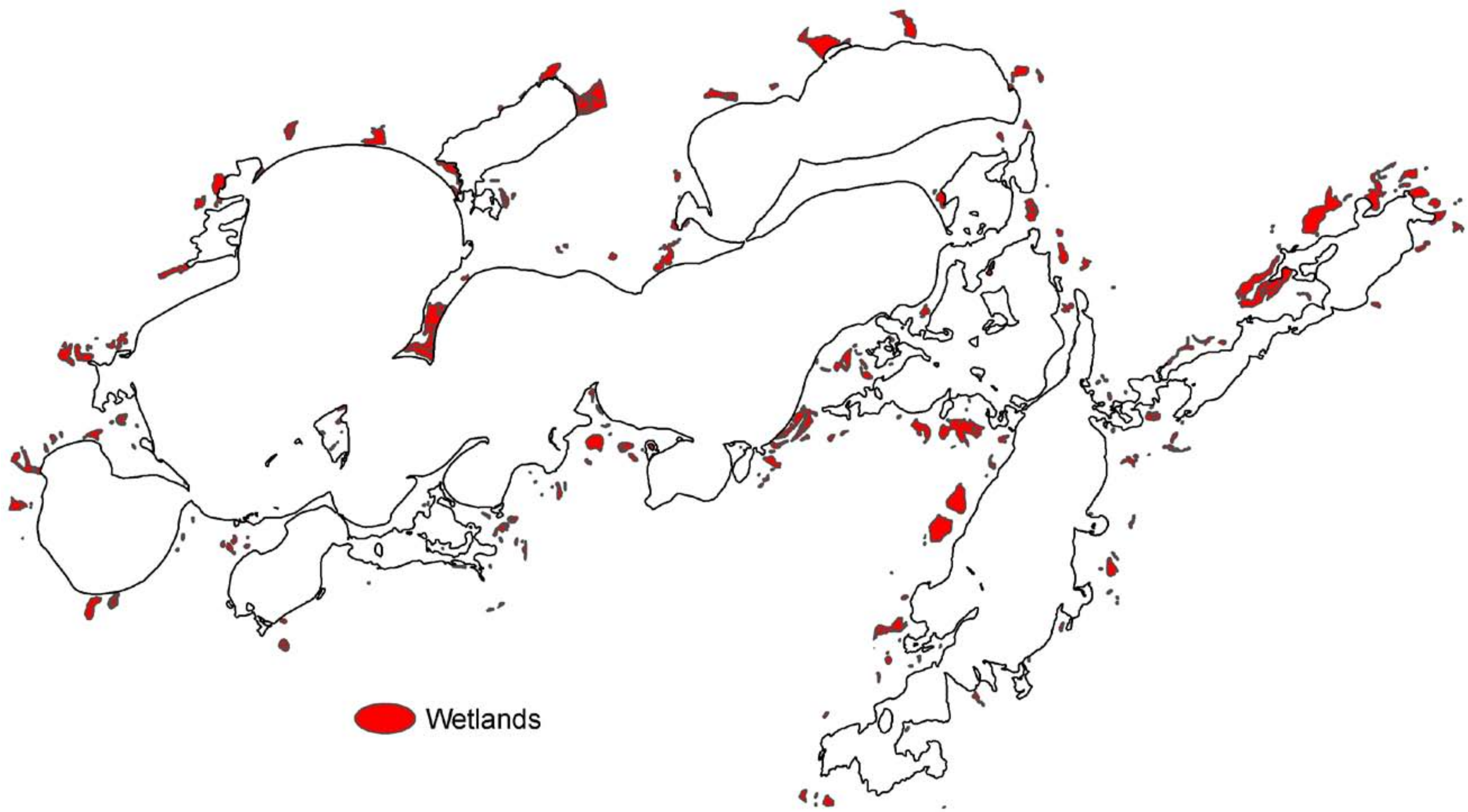
Results

Approximately 624 acres within the shoreland area of the entire Whitefish Chain of Lakes are described as wetlands by NWI (Figure 6). These wetlands comprise 6% of the Whitefish Chain of Lakes shoreland district (10,151 acres). Large wetland complexes do not occur in this system but numerous small (mean area of two acres) wetlands are scattered around the shoreline, adjacent to lakeshores. The largest wetland system occurs along the north and west shores of Little Pine 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 Little Pine Lake

Figure 6. Distribution of wetlands within 1320 feet of the entire Whitefish Chain of Lakes shoreline.



Plant Surveys

Objectives

1. Record aquatic plant species present in each lake
2. Describe distribution of vegetation in the Whitefish 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 the lakes and plants were found to a maximum depth of 30 feet. Most of the plants occurred in the 0 to 15 feet depth zone and within this zone, 92% of the sites were vegetated. In Big Trout, Island, Clamshell, Pig, Lower Hay, and Daggett lakes, water clarity was sufficiently high to allow moderate plant growth beyond the 15 feet depth.

The Whitefish Chain of Lakes contains a rich aquatic plant community with fifty-five aquatic plant species documented including 33 submerged, four free-floating, five floating-leaved, and 13 emergent species. Nine of these species were recorded for the first time in the chain in 2010 and 2011. The number of plant species found in each one square meter sample site ranged from 0 to 13 with a mean of three species per site.

The submerged plant community was dominated by naiads (*Najas flexilis/guadalupensis*), which occurred with a frequency[6] of 43%. Other commonly occurring submerged plants included coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.), northern watermilfoil (*Myriophyllum sibiricum*), and flat-stem pondweed (*Potamogeton zosteriformis*). The non-native submerged plant, curly-leaf pondweed (*Potamogeton crispus*), was present in some of the lakes but was a minor component of the plant community.

Beds of floating-leaf and emergent plants were primarily restricted to shallow bays. They covered about 520 acres, or 26% of the shallow water zone (0 to 5 feet). Arrowhead and Little Pine lakes had the greatest percent of shallow water occupied by emergent and floating-leaf plants while highly developed lakes like Cross Lake and Lower Hay had few emergent or floating-leaf plant beds. The largest waterlily (*Nymphaea odorata* and *Nuphar variegata*) beds occurred in Rush-Hen, Little Pine, and Clamshell lakes. The largest wild rice (*Zizania palustris*) beds were found in Willow Creek Bay, Delta Bay, and Arrowhead Lake.

Five unique, submerged aquatic plants were documented in the Whitefish Chain of Lakes: flat-leaved bladderwort (*Utricularia intermedia*), lesser bladderwort (*Utricularia minor*), humped bladderwort (*Utricularia gibba*), water bulrush (*Schoenoplectus subterminalis*), and creeping

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

spearwort (*Ranunculus flammula*). Three unique wetland emergent plants were documented: wild calla (*Calla palustris*), cottongrass sedge (*Eriophorum* sp.), and bog rosemary (*Andromeda glaucophylla*).

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 cell 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 and were therefore included in this survey.

Figure 7. Bed of muskgrass

Muskgrass (*Chara* sp.; Figure 7) 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. 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.

Figure 8. Coontail

Coontail (*Ceratophyllum demersum*; Figure 8) is the most common submerged flowering plant in Minnesota lakes. It grows entirely submerged 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 then begins 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 9. Southern naiad

Photo: Kerry Dressler ©1996 Univ. of Florida Center for Aquatic Plants

Southern naiad (*Najas guadalupensis*; Figure 9) has not been reported in many Minnesota lakes but it is native to the state. It closely resembles a related submerged species, bushy pondweed (*Najas flexilis*) and it can be difficult to distinguish the two species. Bushy pondweed is an annual plant that grows each year from seed. Southern naiad can grow from seed and overwinter as a perennial plant. Both species grows low in the water column and produce seeds and foliage that provide important duck food and good fish cover.

Figure 10. Northern watermilfoil

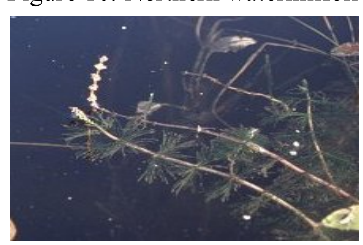


Photo by: Andrew Hipp (UW Madison-Wisc State Herbarium)

Northern watermilfoil (*Myriophyllum sibiricum*; Figure 10) 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 hard 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.

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 includes flat-stem pondweed (*Potamogeton zosteriformis*; Figure 11) and Robbin's pondweed (*P. robbinsii*). 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 12), and variable pondweed (*P. gramineus*). Narrow-leaf pondweeds, such as sago pondweed (*Stuckenia pectinata;* Figure 13), and Fries' pondweed (*Potamogeton friesii*) have very narrow, almost needle-width leaves.

Figure 11. Flat-stem pondweed

Figure 12. White-stem pondweed

Figure 13. A narrow-leaf (Sago) pondweed

Canada waterweed (*Elodea canadensis*; Figure 14) is a perennial submerged species that is widespread throughout Minnesota. It is adapted to a variety of conditions and is tolerant of low light and prefers soft substrates. Canada waterweed can overwinter as an evergreen plant and spreads primarily by fragments.

Figure 14. Canada waterweed

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.

White and yellow waterlilies can be found in lakes in both northern and southern Minnesota. White waterlily (*Nymphaea odorata*; Figure 15) has showy white flowers and round leaves with radiating veins. Yellow waterlily (*Nuphar variegata*; Figure 16) 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 seven feet and white waterlily may occur to depths of 10 feet (Nichols1999b).

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 17). 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.

Watershield (*Brasenia schreberi*) is most often found in soft-water lakes (Borman et al. 2001) in northern Minnesota. It has relatively small, floating oval leaves and small reddish flowers (Figure 18). The leaves are green on top, while the underside of the leaves and stems are reddish-purple. The leaves and stems of watershield have a slippery, gelatinous coating.

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 19). 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.

Narrow-leaved emergent plants include bulrushes and spikerushes. Bulrush (*Schoenoplectus* spp.) is an emergent, perennial plant that occurs in lakes and wetlands throughout

Figure 15. White waterlily

Figure 16. Yellow waterlily

Figure 17. Floating smartweed

Figure 18. Watershield

Figure 19. Floating-leaf pondweed

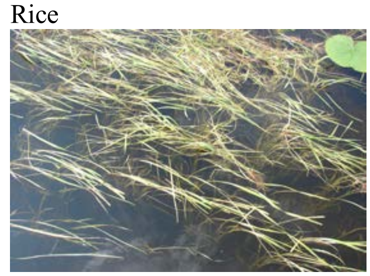
Minnesota (Ownbey and Morley 1991). Bulrush stems are round in cross section and lack showy leaves. Clusters of small flowers form near at the tips of long, narrow stalks. This emergent may occur from shore to water depths of about six feet and its stems may extend several feet above the water surface (Figure 20). Bulrush stands are particularly susceptible to destruction by excess herbivory and direct removal by humans.

Figure 20. Bulrush


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 21). Cattails provide shelter and food for many different kinds of fish and bird species.

Figure 21. Cattails


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 22) 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 22. Floating stage of Wild Rice


Burreeds (*Sparganium* spp.; Figure 23) are perennial, emergent plants with leaves 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 achenes 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 23. Burreed in Whitefish Lake


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 24. Lesser bladderwort

Photo by: Paul Skawinski, UW-Stevens Point Herbarium. © 2009

Bladderworts (*Utricularia* spp.) are a group of submerged plants that produce roots but do not firmly anchor to the lake bottom. Greater bladderwort (*U. vulgaris)* is found in lakes and ponds throughout Minnesota but several other species are much less common. Unique bladderwort species include humped bladderwort (*Utricularia gibba*), lesser bladderwort (*U. minor*; Figure 24), and flat-leaved bladderwort (*U. intermedia*). These small, submerged plants are often confused with algae because of their fine stems and leaves. Bladderworts have specialized air bladders that regulate their position in the water column. They also act as "underwater Venus fly-traps" by catching and digesting small insects in their bladders. Bladderworts produce small but showy flowers that emerge above the water surface. They prefer soft substrates (Nichols 1999b) but also float freely in the water column and may be found in protected areas such as waterlily beds. They are found in protected, shallow lake areas and have been documented at scattered locations throughout northern Minnesota (Ownbey and Morley 1991).

Figure 25. Water bulrush

Photo by: D.W. Taylor. Copyright 1996.

Water bulrush (*Schoenoplectus subterminalis*; Figure 25) is closely related to the emergent bulrush plants but grows primarily as a submerged plant. It is a rooted perennial with fine, grass-like leaves and may form mats near the water surface. In mid to late summer its leaf tips and flower stalk may emerge above the water surface. This species once had a patchy distribution throughout North America but may now be extirpated from Illinois (Flora of North America 1993+) and its conservation status is listed as critically impaired in several other states (NatureServe 2008). It is infrequently found in Wisconsin (Nichols 1999b) and Minnesota (Ownbey and Morley 1991) lakes.

Figure 26. Creeping spearwort

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

Creeping spearwort (*Ranunculus flammula;* Figure 26) 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 Crow Wing 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+).

Wild calla (*Calla palustris*; Figure 27) is an emergent perennial wetland plant that may grow along marshy lakeshores as well as in wooded swamps, marshes and bogs (Nichols 1999b). The plant is recognizable by its heart-shaped leaves and the showy, white petal-like spathe. This is a species of northern latitudes and Minnesota is the southwestern limit of its range (Flora of North America 1993+). Within Minnesota, wild calla primarily occurs in the northeast half of the state (Ownbey and Morley 1991).

Figure 27. Wild calla

Slender cottongrass (*Eriophorum gracile*) is an emergent grass-like plant named for its distinctive white seed heads that resemble tufts of cotton (Figure 28). Plants are colonial and spread from long, creeping rhizomes (Flora of North America 1993+). These plants occur in open and forested wet peatlands of Minnesota. Potential threats to this species include habitat destruction by hydrologic alterations, grazing, motorized vehicle use, peat mining, invasive species and global climate change (Decker et al. 2006).

Figure 28. Cottongrass

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 Whitefish Chain of Lakes were described and measured using several techniques as found in Minnesota's Sensitive Lakeshore Identification Manual (MN DNR, 2009 V2). Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MnTaxa (2011). 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. Little Pine, Daggett, Cross, Rush-Hen and Big Trout lakes were surveyed in 2010 (Simon and Perleberg 2010a-d) and Island-Loon, Lower Hay, Arrowhead, Whitefish, Pig, Bertha, and Clamshell were surveyed in 2011 (Simon and Perleberg 2012a-g).

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 Whitefish Lake, points were spaced 100 meters apart in the main basin and 65 meters apart in the bays. On the other 12 lakes, points were spaced 65 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 to the 25 or 30 feet depth (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 12 to 30 feet), the summary data presented in this report is 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 2008 and 2010 Farm Service Administrative (FSA) true color aerial photographs. Field surveys were conducted September 2010 and July and August 2011 to map plants like bulrush (*Schoenoplectus* spp.), 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 Whitefish 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 Whitefish Chain of Lakes.

Surveyors searched for unique and rare aquatic plant species in 2010 and 2011 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.

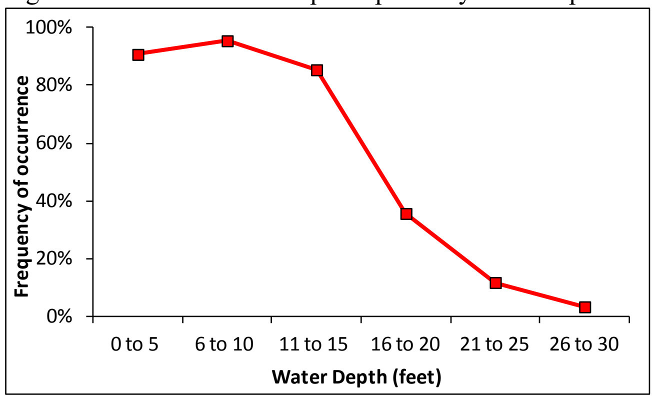
If unique or rare plant species were located, surveyors recorded the site location, the plant species found, associated plant species, approximate water depth and substrate type. When necessary, plant specimens were sent to the authority in the field for identification verification and annotation. Voucher 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 20 feet in most lakes. Maximum depth of plant growth was to 30 feet. However, 95% of the vegetated sites occurred in the 0 to 15 feet depth zone and 92% of the sample sites in that zone contained plants. In depths greater than 15 feet only 20% of sites were vegetated (Figure 29).

Figure 29. Distribution of aquatic plants by water depth



In lakes with moderate clarity (mid-summer Secchi disc reading of 12 feet or less), plant growth was mostly found in depths of 15 feet and less. In most lakes with higher clarity, plant growth extended beyond the 15 feet depth (Table 3). The exception was lower and middle Whitefish basins where, despite adequate light levels, heavy wave action may have limited plant growth beyond the 13 feet depth.

Within the 0 to 20 feet zone, 87% of all sites contained vegetation but frequency ranged from 57% in Daggett Lake to 97% in Clamshell Lake (Table 3).

Aquatic plant species observed

In 2010 and 2011, 55 aquatic plant species were recorded in the Whitefish Chain and the plant community included 33 submerged, four free-floating, five floating-leaf, and 13 emergent species (Table 4). Since 1939, this brings the total number of plant species that have been documented in these lakes to 60 (Table 5), making the Whitefish Chain among the richest in the state. Plant richness was highest in lakes like Little Pine (44 species) and Rush-Hen (41 species), where there was a diversity of submerged, floating-leaved, and emergent plants.

The non-native submerged species, curly-leaf pondweed (*Potamogeton crispus*), which was first documented in the chain in 1961, was located in eight of the 13 lakes during the 2010 and 2011 surveys. It was most frequent in Little Pine and Daggett Lake but was not the dominant species in any lake. Non-native shoreland plants included purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinaceae*), and turf grass (Table 6).

Submerged plants
Submerged plants were abundant along shallow shorelines, in protected bays and around the islands (Figure 30). 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. Naiads were the most frequent submerged plants, occurring around the entire shoreline and in 43% of all sample sites (Table 4). Other commonly occurring submerged species were coontail (39%), muskgrass (31%), northern watermilfoil (27%), and flat-stem pondweed (25%).

Floating-leaf and emergent plants
Floating-leaf and emergent plants were most common in the zero to five feet depth zone. These plant beds covered 520 acres or 26% of the shallow water zone (0 to 5 feet) (Table 7). Arrowhead and Little Pine lakes had the greatest percent of shallow water occupied by emergent and floating-leaf plants, 82% and 63%, respectively. In the shallow waters of Cross Lake, less than 10% of the area contained emergent and floating-leaf plants. No emergent or floating-leaf plant beds were present on Lower Hay. About 150 acres of floating-leaf plant beds were mapped and the largest beds occurred in Rush-Hen, Little Pine and Clamshell lakes (Figure 31). Floating-leaf plants included white waterlily, yellow waterlily, watershield, floating smartweed, and floating-leaf pondweed. Surveyors mapped approximately 370 acres of emergent plants and the most common species was wild rice. The largest wild rice beds were found in Willow Creek Bay, Delta Bay, and Arrowhead Lake (Figure 31). Other emergent plants occurred at scattered locations around the chain and included bulrush, cattails, arrowhead, spikerush, and burreed. Many of these emergent plants occupied the transitional zone between the lake and adjacent wetlands.

Wild rice bed in Willow Creek Bay, Whitefish Lake, 2011.

Waterlilies and burreed in Rush-Hen Lake, 2010

Waterlily bed in Clamshell Lake, 2011.

Unique plants
In addition to the commonly occurring plants in the Whitefish Chain, eight unique aquatic plant species were located (Table 8). Unique plants included five submerged species and three wetland emergent species. These species were found in undisturbed, shallow areas (depth less than five feet) throughout the Whitefish Chain where boat traffic is limited. The lakes with the highest numbers of unique species were Rush-Hen and Little Pine (Figure 32).

Species richness

The number of plant species found in each one square meter sample site ranged from zero to 13 with a mean of three species per site. Sites of high species richness (six or more species per site) occurred at numerous locations in shallow bays, around islands, and along shallow shorelines (Figure 33). Lakes where mean species richness per site exceeded the overall mean value include Rush-Hen, Lower Hay, Island-Loon, Bertha, and Clamshell.

Table 2. Sampling effort by lake

Lake	Survey Dates	Total number of sites sampled	Number of sample sites in each water depth zone (feet)							Max depth sampled
			0-5	6-10	11-15	16-20	Total sites sampled 0 to 20 feet	21-25	26-30	
Little Pine	6/2-3/2010	183	96	31	26	21	174	[7]9	0	20
Daggett	6/14/2010	143	42	36	14	51	143	0	0	20
Cross	6/17,21,22,28; 7/13,20,29/2010	968	214	287	349	71	921	47	0	25
Rush-Hen	7/ 26,29; 8/2,12/2010	557	161	256	31	29	477	38	42	30
Island-Loon	8/ 29,30/2011	152	52	44	17	13	126	16	10	30
Big Trout	7/21,22/2010	433	192	115	39	26	372	31	30	30
Arrowhead[8]	6/14; 8/10/2011	245	119	119	7	n/a	245	n/a	n/a	12
Lower Hay	8/11,18/2011	203	36	88	15	21	160	23	20	30
Whitefish	6/8;7/25,26,28;8/3,4, 10,11,15,18,22/2011	1522	279	708	265	96	1348	72	102	30
Pig	7/26-27/2011	88	20	28	9	16	73	4	11	30
Clamshell	7/27/2011	186	77	70	4	13	164	13	9	30
Bertha	8/15/2011	152	30	68	20	7	125	18	9	30
Entire chain		4832	1318	1850	796	364	4328	271	233	n/a

[7] Sampling in this depth zone was incomplete; partial sampling was conducted and vegetation was determined to be too sparse to continue sampling in this depth zone (i.e. No vegetation was found).

[8] Arrowhead Lake has a maximum depth of 12 feet and was the only lake surveyed to 12 feet

Table 3. Summary data of Point-Intercept Survey for the Whitefish Chain of Lakes 0 to 20 feet, (2010-2011).

(Blue highlight indicates lakes where mid-summer Secchi disc is >12 feet)

	Entire chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead*	Lower Hay	Upper Whitefish	Lower Whitefish	Pig	Clamshell	Bertha
Number of samples (0-20 ft)	4328	174	143	921	477	126	372	245	160	735	613	73	164	125
Frequency of plant occurrence (%)	87	78	57	87	94	91	89	95	93	85	82	95	97	94
Max rooting depth	n/a	15	20	21	30	23	27	11	25	28	25	21	24	21
Depth at which 95% of vegetation occurred	15	11	16	15	14	19	19	10	17	13	13	20	18	15
Number of submerged species	33	24	17	24	27	26	25	19	19	22	20	20	26	20
Number of free-floating species	4	3	3	1	2	2	3	2	1	3	2	0	2	1
Number of floating-leaf species	5	4	4	4	5	5	3	4	0	3	2	3	4	3
Number of emergent species	13	6	5	3	4	6	8	5	2	4	4	5	6	6
Total #of all plant species found	55	37	29	32	38	39	39	30	22	32	28	28	38	30
Mean # of plant species per sample site	2.8	2.9	1.6	2.4	4.2	3.9	2.1	2.9	3.2	2.7	2.4	3.0	4.3	3.9

Table 4. Frequency of aquatic plant species in the Whitefish Chain of Lakes, 2010 and 2011.

SUBMERGED 0 to 20 feet			Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island- Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Bertha	Clamshell
	Common name	**Scientific name** N→	**4328**	**174**	**143**	**921**	**477**	**126**	**373**	**245**	**160**	**1348**	**73**	**125**	**164**
Lg algae + moss	Muskgrass	*Chara* sp.	31	6	6	34	33	19	68	5	33	31	40	17	27
	Stonewort	*Nitella* sp.	<1	2	--	<1	<1	--	1	--	--	--	--	--	--
	Watermoss	*Not identified to genus*	1	7	--	<1	6	6	2	<1	--	<1	--	--	2
Monocots	Needlegrass	*Eleocharis acicularis*	1	--	--	1	1	--	1	--	--	<1	--	P	P
	Canada waterweed	*Elodea canadensis*	18	11	5	9	29	35	10	35	21	18	12	22	37
	Water stargrass	*Heteranthera dubia*	4	5	3	2	8	11	1	<1	6	3	8	6	11
	Bushy pondweed	*Najas flexilis*	43	3	6	2	11	3	6	--	3	3	1	6	13
	Southern naiad	*Najas guadalupensis*		1	2	30	47	50	2	40	47	55	49	72	40
	Large-leaf pondweed	*Potamogeton amplifolius*	2	--	P	1	8	10	2	<1	2	1	1	4	12
	Curly-leaf pondweed (I)	*Potamogeton crispus*	2	24	17	1	<1	--	P	--	--	<1	3	--	--
	Ribbon-leaf pondweed	*Potamogeton epihydrus*	P	--	--	--	--	--	--	P	--	--	--	--	--
	Narrow-leaf pondweed group	*Potamogeton friesii* *Potamogeton pusillus* *Potamogeton strictifolius*	14	10	2	9	18	15	13	1	15	11	22	10	27
	Variable pondweed	*Potamogeton gramineus*	4	P	--	3	4	4	5	--	6	5	7	4	5
	Illinois pondweed	*Potamogeton illinoensis*	5	--	--	4	8	8	8	--	7	4	5	6	13
	White-stem pondweed	*Potamogeton praelongus*	11	11	10	21	15	9	5	2	11	7	14	14	8
	Clasping-leaf pondweed	*Potamogeton richardsonii*	7	--	--	2	10	17	7	4	12	5	5	25	27
	Robbin's pondweed	*Potamogeton robbinsii*	3	3	1	7	4	6	--	--	--	1	10	2	14
	Flat-stem pondweed	*Potamogeton zosteriformis*	25	28	22	20	29	46	12	38	34	21	26	46	41
	Creeping spearwort	*Ranunculus flammula*	<1	--	--	--	--	P	<1	--	--	--	--	--	1
	Water bulrush	*Schoenoplectus subterminalis*	<1	P	--	--	--	2	--	--	--	--	--	--	--
	Sago pondweed	*Stuckenia pectinata*	4	2	3	2	9	10	7	--	6	2	7	12	7
	Wild celery	*Vallisneria americana*	12	2	5	13	32	32	4	1	8	6	11	26	34

Table 4 (continued). Frequency of aquatic plant species in the Whitefish Chain of Lakes, 2010 and 2011.

SUBMERGED 0 to 20 feet			Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island- Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Bertha	Clamshell
	Common name	**Scientific name**	**N→** **4328**	**174**	**143**	**921**	**477**	**126**	**373**	**245**	**160**	**1348**	**73**	**125**	**164**
Dicots	Water marigold	*Bidens beckii*	4	1	1	4	10	10	3	1	12	2	7	7	4
	Coontail	*Ceratophyllum demersum*	39	57	34	26	53	42	16	77	53	40	48	46	24
	Northern watermilfoil	*Myriophyllum sibiricum*	27	28	18	29	49	35	16	4	37	23	26	47	34
	Whorled watermilfoil	*Myriophyllum verticillatum*	P	--	--	--	--	P	--	--	--	--	--	--	--
	White water buttercup	*Ranunculus aquatilis*	3	8	1	2	9	9	8	1	3	1	1	2	2
	Greater bladderwort	*Utricularia vulgaris*	3	14	--	1	8	9	5	4	1	1	--	--	4
	Flat-leaved bladderwort	*Utricularia intermedia*	<1	3	--	--	1	2	<1	<1	--	--	--	--	1
	Lesser bladderwort	*Utricularia minor*	<1	5	--	--	1	2	--	P	--	--	--	--	1
	Humped bladderwort	*Utricularia gibba*	<1	1	--	--	<1	--	--	--	--	--	--	--	1
Free-floating	Star duckweed	*Lemna trisulca*	8	33	12	1	7	--	<1	42	1	7	--	6	12
	Lesser duckweed	*Lemna* sp.	<1	2	1	--	--	P	1	--	--	--	--	--	--
	Greater duckweed	*Spirodela polyhriza*	<1	2	1	--	--	P	1	1	--	1	--	--	1
	Water meal	*Wolffia* sp.	<1	--	--	--	<1	--	--	--	--	<1	--	--	--

P= Present in lake but was not found in any survey sites. (--) = plant was absent in that lake

Table 4 (continued). Frequency of aquatic plant species in the Whitefish Chain of Lakes, 2010 and 2011.

Floating-leaf and Emergent (0 to 5 feet)				**Entire Chain**	**Little Pine**	**Daggett**	**Cross**	**Rush-Hen**	**Island-Loon**	**Big Trout**	**Arrowhead**	**Lower Hay**	**Whitefish**	**Pig**	**Bertha**	**Clamshell**
	Common Name	**Scientific Name**	**N →**	**1318**	**96**	**42**	**214**	**161**	**52**	**192**	**119**	**160**	**279**	**20**	**30**	**77**
Floating-leaf*	Watershield	*Brasenia schreberi*		1	P	--	<1	3	4	--	2	--	--	--	--	--
	White waterlily	*Nymphaea odorata*		10	17	11	1	15	23	3	19	--	--	15	20	22
	Yellow waterlily	*Nuphar variegata*		4	8	P	--	4	17	2	13	--	--	P	P	10
	Floating smartweed	*Persicaria amphibia*		<1	P	--	P	1	P	--	--	--	--	--	P	P
	Floating-leaf pondweed	*Potamogeton natans*		2	--	--	P	1	15	3	2	--	--	P	--	12
Emergent	River bulrush	*Bolboschoenus fluviatilis*		P	--	P	--	--	--	--	--	--	--	--	P	--
	Spikerush	*Eleocharis* sp.		<1	P	--	--	--	--	1	--	--	--	P	--	P
	Horsetail	*Equisetum fluviatile*		P	--	--	--	--	--	P	--	--	--	--	--	--
	Arrowhead	*Sagittaria cuneata*[a]														
	Broad-leaf arrowhead	*Sagittaria latifolia*[b]		1	P	2	--	P	2	1	P	3	3	P	3	3
	Stiff wapato	*Sagittaria rigida*[c]														
	Bulrush	*Schoenoplectus acutus* / *Schoenoplectus tabernaemontani*		<1	P	P	<1	P	P	1	P	--	--	P	--	P
	Three-square bulrush	*Schoenoplectus pungens*		P	P	--	--	--	P	--	--	--	--	--	P	--
	Eastern burreed	*Sparganium americana*[d]		1	1	6	P	1	4	1	1	--	--	P	3	P
	Giant burreed	*Sparganium eurycarpum*[e]														
	Broad-leaf cattail	*Typha latifolia*		<1	--	P	<1	--	P	P	--	--	--	P	--	P
	Narrow-leaf cattail	*Typha* sp.		<1	1	2	--	--	P	P	P	--	--		P	
	Wild rice	*Zizania palustris*		8	15	--	--	P	--	P	34	6	6	--	P	P

*Frequency values for floating-leaf species represent the occurrence of these species only within the sites that were surveyed.
P= Present in lake but was not found in any survey sites. (--) = plant was absent in that lake

Table 5. Historical and current aquatic plants in the Whitefish Chain of Lakes, 1938 to 2011.
Submerged

	Common name	Scientific name	1938	1942	1950	1954	1955	1960	1961	1987	1990	1991	1995	2010-2011
Lg algae + moss	Muskgrass	*Chara* sp.	X	X	X	X	X	X	X		X	X	[a]X	X
	Stonewort	*Nitella* sp.												X
	Watermoss	*Not identified to genus*											[a]X	X
Monocots	Needlegrass	*Eleocharis acicularis*									X		[a,b]X	X
	Canada waterweed	*Elodea canadensis*	X	X	X		X	X	X	X	X	X	[a,b]X	X
	Water stargrass	*Heteranthera dubia*											[b]X	X
	Leaf-less watermilfoil	*Myriophyllum tenellum*											[a]X	
	Bushy pondweed	*Najas flexilis*	X							X	X	X	[a,b]X	X
	Southern naiad	*Najas guadalupensis*												X
	Large-leaf pondweed	*Potamogeton amplifolius*			X			X	X	X	X	X	[a,b]X	X
	Curly-leaf pondweed (I)	*Potamogeton crispus*							X	X	X	X	[a]X	X
	Ribbon-leaf pondweed	*Potamogeton epihydrus*												X
	Variable pondweed	*Potamogeton gramineus*			X			X				X	[a,b]X	X
	Illinois pondweed	*Potamogeton illinoensis*											[b]X	X
	Narrow-leaf pondweed group	*Potamogeton friesii*											[a]X	X
		Potamogeton pusillus											[b]X	X
		Potamogeton strictifolius									X		[b]X	X
		Potamogeton sp.					X				X	X	[a]X	X
	River pondweed	*Potamogeton nodosus*											[a,b]X	X
	White-stem pondweed	*Potamogeton praelongus*	X					X		X	X	X	[a,b]X	X
	Clasping-leaf pondweed	*Potamogeton richardsonii*			X			X		X	X	X	[a,b]X	X
	Robbin's pondweed	*Potamogeton robbinsii*			X			X			X	X	[a]X	X
	Flat-stem pondweed	*Potamogeton zosteriformis*	X	X	X			X		X	X	X	[a,b]X	X
	Creeping spearwort	*Ranunculus flammula*											[b]X	X
	Thread-leaved pondweed	*Stuckenia filiformis*											[b]X	
	Sago pondweed	*Stuckenia pectinata*	X	X	X			X		X	X	X	[a,b]X	X
	Water bulrush	*Schoenoplectus subterminalis*												X
	Wild celery	*Vallisneria americana*	X		X			X		X	X	X	[a,b]X	X
		Total	7	4	9	1	2	10	4	9	13	12	23	25

Table 5 (Continued). Historical and current aquatic plants in the Whitefish Chain of Lakes, 1938 to 2011.
Submerged

	Common name	**Scientific name**	**1938**	**1942**	**1950**	**1954**	**1955**	**1960**	**1961**	**1987**	**1990**	**1991**	**1995**	**2010-2011**
Dicots	Water marigold	*Bidens beckii*			X									X
	Coontail	*Ceratophyllum demersum*	X	X	X	X	X	X		X	X	X	[a,b]X	X
	Northern watermilfoil	*Myriophyllum sibiricum*	X	X	X	X		X	X	X	X	X	[a,b]X	X
	Whorled watermilfoil	*Myriophyllum verticillatum*												X
	White water buttercup	*Ranunculus aquatilis*								X	X		[a,b]X	X
	Greater bladderwort	*Utricularia vulgaris*			X								[a,b]X	X
	Flat-leaved bladderwort	*Utricularia intermedia*											[a]X	X
	Lesser bladderwort	*Utricularia minor*												X
	Humped bladderwort	*Utricularia gibba*												X
		Total	2	2	4	2	1	2	1	3	3	2	5	9

Free-Floating

Common name	**Scientific name**	**1938**	**1942**	**1950**	**1954**	**1955**	**1960**	**1961**	**1987**	**1990**	**1991**	**1995**	**2010-2011**
Star duckweed	*Lemna trisulca*								X	X		[a,b]X	X
Lesser duckweed	*Lemna* sp.								X			[a,b]X	X
Greater duckweed	*Spirodela polyhriza*			X								[b]X	X
Spotted watermeal	*Wolffia borealis*											[b]X	*X
Columbian watermeal	*Wolffia columbiana*											[b]X	
	Total	0	0	1	0	0	0	0	2	1	0	5	4

Table 5 (Continued). Historical and current aquatic plants in the Whitefish Chain of Lakes, 1938 to 2011.

Floating-leaved

Common name	Scientific name	1938	1942	1950	1954	1955	1960	1961	1987	1990	1991	1995	2010-2011
Water shield	*Brasenia schreberi*												X
White waterlily	*Nymphaea odorata*			X			X		X	X	X	[a,b]X	X
Yellow waterlily	*Nuphar variegata*			X			X		X	X	X	[a,b]X	X
Floating-leaf pondweed	*Potamogeton natans*	X	X	X			X	X		X	X	[a,b]X	X
Floating-leaf smartweed	*Persicaria amphibia*										X	[a]X	X
	Total	1	1	3	0	0	3	1	2	3	4	4	5

Emergents

Common name	Scientific name	1938	1942	1950	1954	1955	1960	1961	1987	1990	1991	1995	2010-2011
River bulrush	*Bolboschoenus fluviatilis*												X
Bald spikerush	*Eleocharis erythropoda*											[b]X	
Spikerush	*Eleocharis palustris*									X		[a,b]X	X
Horsetail	*Equisetum fluviatile*									X		[a,b]X	X
Brown-fruited rush	*Juncus peleocarpus*											[b]X	
Giant cane	*Phragmites australis*											[a]X	X
Arrowhead	*Sagittaria cuneata*									X		[a,b]X	X
Broad-leaf arrowhead	*Sagittaria latifolia*									X	X		X
Three-square bulrush	*Schoenoplectus pungens*									X			X
Bulrush	*Schoenoplectus acutus* *Schoenoplectus tabernaemontani*		*X	*X	*X		*X	*X		*X		[a,b]X	*X
Eastern burreed	*Sparganium americanum*									[1]X		[a,b]X	X
Giant burreed	*Sparganium eurycarpum*								X	X			X
Narrow-leaf cattail	*Typha angustifolia*		X	X	*X			*X	*X	X			X
Broad-leaf cattail	*Typha latifolia*			X			X			X	X		X
Wild rice	*Zizania palustris*								X	X		[a,b]X	X
	Total	0	2	3	2	0	2	2	3	11	2	9	13

Table 5 (continued). Historical and current aquatic plants in the Whitefish Chain of Lakes, 1938 to 2011.
*X = Plant was only identified to genus
[a]X = 1995 DNR Fisheries Surveys
[b]X = 1995 Minnesota County Biological Survey, Karen Myhre

[1]X = Sparganium fluctuans was reported in 1990 but not documented with a voucher specimen. We list it here under Eastern burreed (which was documented in 1995 and 2011) but we do not know for certain which species was found during the 1990 survey.

a - *Sagittaria cuneata* was recorded in Rush-Hen, Big Trout, Lower Hay and Whitefish Lakes.
b - *Sagittaria latifolia* was recorded in Big Trout Lake
c - *Sagittaria rigida* was recorded in Arrowhead and Bertha Lakes.
d - *Sparganium americana* was recorded in Island-Loon and Arrowhead Lakes;
e - *Sparganium eurycarpum* was recorded in Daggett, Cross, Big Trout, Island-Loon, Arrowhead, Whitefish, Pig, Bertha, and Clamshell Lakes.

(I) Indicates plant is not native to Minnesota
Nomenclature follows MnTaxa 2011.

Table 6. Wetland plants in the Whitefish Chain of Lakes, 1990, 2010 and 2011.

Description	Common Name	Scientific Name	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Wetland Forbs	Sweet flag	*Acorus americanus*	--	--	--	--	--	--	2	--	2	--	--	--
	Swamp milkweed	*Asclepias incarnata*	--	--	2	1	--	2	--	--	2	--	--	--
	Sedge	*Carex* spp.	1	--	--	[a] 1	--	[a] 2	[a] 1	--	--	--	--	--
	Wild calla	*Calla palustris*	1	1	--	--	--	--	1	--	--	--	--	--
	Cottongrass	*Eriophorum gracile*	1	--	--	--	--	--	--	--	--	--	--	--
	Joe-pye weed	*Eupatorium dubium*	--	--	--	--	--	--	1	--	--	--	--	--
	Upland horsetail	*Equisetum* sp.	--	--	--	--	--	[a] 2	--	--	--	--	--	--
	Bedstraw	*Galium* sp.	--	--	--	--	--	--	[a] 1	--	--	--	--	--
	St. John's wort	*Hypericum* sp.	[a] 1	--	--	--	--	--	--	--	--	--	--	--
	Touch-me-nots	*Impatiens* sp.	--	--	--	--	--	--	[a] 1	--	--	--	--	--
	Blue flag iris	*Iris versicolor*	1,2	1	1,2	1,2	2	--	--	--	--	2	2	1
	Purple loosestrife (I)	*Lythrum salicaria*	--	--	1	2	--	--	--	--	2	--	--	--
	Tufted loosestrife	*Lysimachia thyrsiflora*	1	--	--	--	--	--	--	--	--	--	--	--
	Bushy knotweed	*Polygonum* sp.	--	--	[a] 2	--	[a] 2	--	--	--	--	--	--	--
	Water dock	*Rumex* sp.	[a] 1	--	--	[a] 1	[a] 2	--	--	--	--	--	--	--
	Skullcap	*Scutellaria galericulata*	--	--	--	--	1	--	1	--	--	--	--	--
	Water parsnip	*Sium suave*	1	--	--	--	--	--	--	--	--	--	--	--
Wetland Shrubs	Alder	*Alnus* sp.	[a] 1	--	--	--	--	--	[a] 1	--	--	--	--	--
	Bog birch	*Betula pumila*	1	--	--	--	--	--	--	--	--	--	--	--
Upland Grasses	Reed canary grass (I)	*Phalaris arundinaceae*	1,2	--	1	1	1,2	2	1	--	1,2	1,2	--	--
		Total	11	2	5	6	5	4	9	4	4	2	1	1

Survey:
1 = 2010 and 2011 (Perleberg and Simon, Point-intercept survey)
2 = DNR Fisheries lake files (1990)

[a] = identified only to genus level (I) Indicates plant is not native to Minnesota
Nomenclature follows MnTaxa 2011.

Table 7. Emergent and floating-leaf acres of the Whitefish Chain of Lakes, September 2010 and July and August 2011

Lakes	**Emergent Acres**	**Floating-Leaf Acres**	**Total Acres of emergent and floating-leaf**	**Acres of Shallow Water (0-5 ft)**	**% shallow w/emergents and floating-leaf (0-5 ft)**
Arrowhead	131	--	131	160	82%
Little Pine	66	17	83	131	63%
Island-Loon	<1	22	22	66	33%
Clamshell	<1	29	29	91	32%
Daggett	2	14	16	68	24%
Whitefish	140	13	153	723	21%
Rush-Hen	8	27	35	195	18%
Bertha	<1	7	7	45	16%
Pig	<1	2	2	13	15%
Big Trout	14	5	19	169	11%
Cross	9	14	23	295	8%
Lower Hay	--	--	--	50	0%
Entire Chain	370	150	520	2009	26%

Table 8. Unique plants of the Whitefish Chain of Lakes, 2010 and 2011.
(--) = plant absent in that lake

Life Form	Common name	Number of sites per species											
		Little Pine	Daggett	Cross Lake	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Submerged	Flat-leaved bladderwort	6	--	--	7	3	1	1	--	--	--	2	--
	Lesser bladderwort	9	--	--	4	2	--	--	--	--	--	1	--
	Humped bladderwort	1	--	--	--	--	--	--	--	--	--	1	--
	Water bulrush	1	--	--	--	2	--	--	--	--	--	--	--
	Creeping spearwort	--	--	--	--	1	1	--	--	--	--	1	--
Wetland Emergent	Wild calla	1	3	--	--	--	--	4	--	2	--	--	--
	Cottongrass sedge	1	--	--	--	--	--	--	--	--	--	--	--
	Bog rosemary	--	--	--	--	--	--	1	--	--	--	--	--
Total number of species per lake		6	1	0	2	4	2	3	0	1	0	4	0

Figure 30. Distribution of aquatic plants on the Whitefish Chain of Lakes, 2010 – 2011.

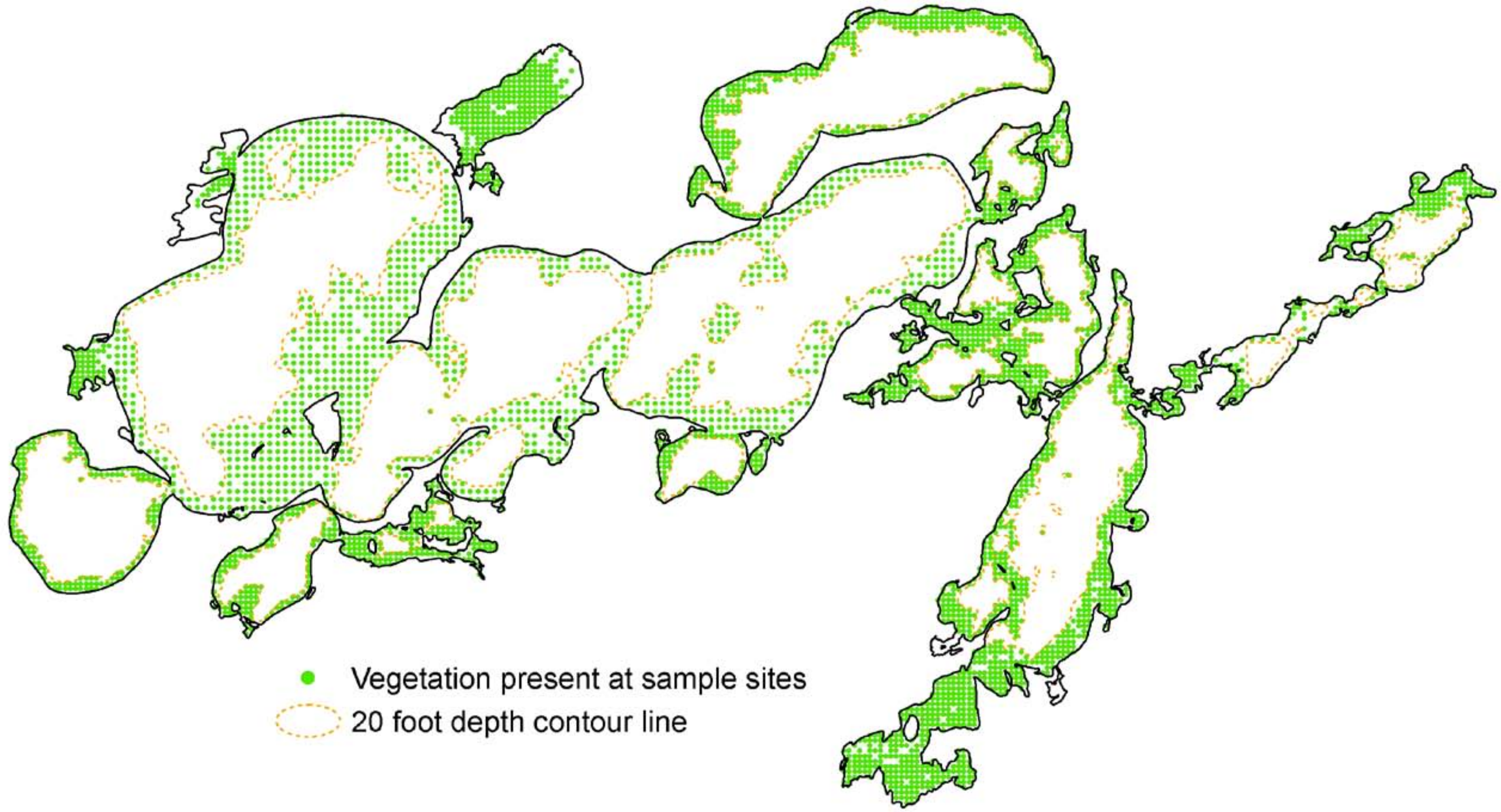


Figure 31. Emergent and floating-leaf plant beds on the Whitefish Chain of Lakes, 2010 - 2011.

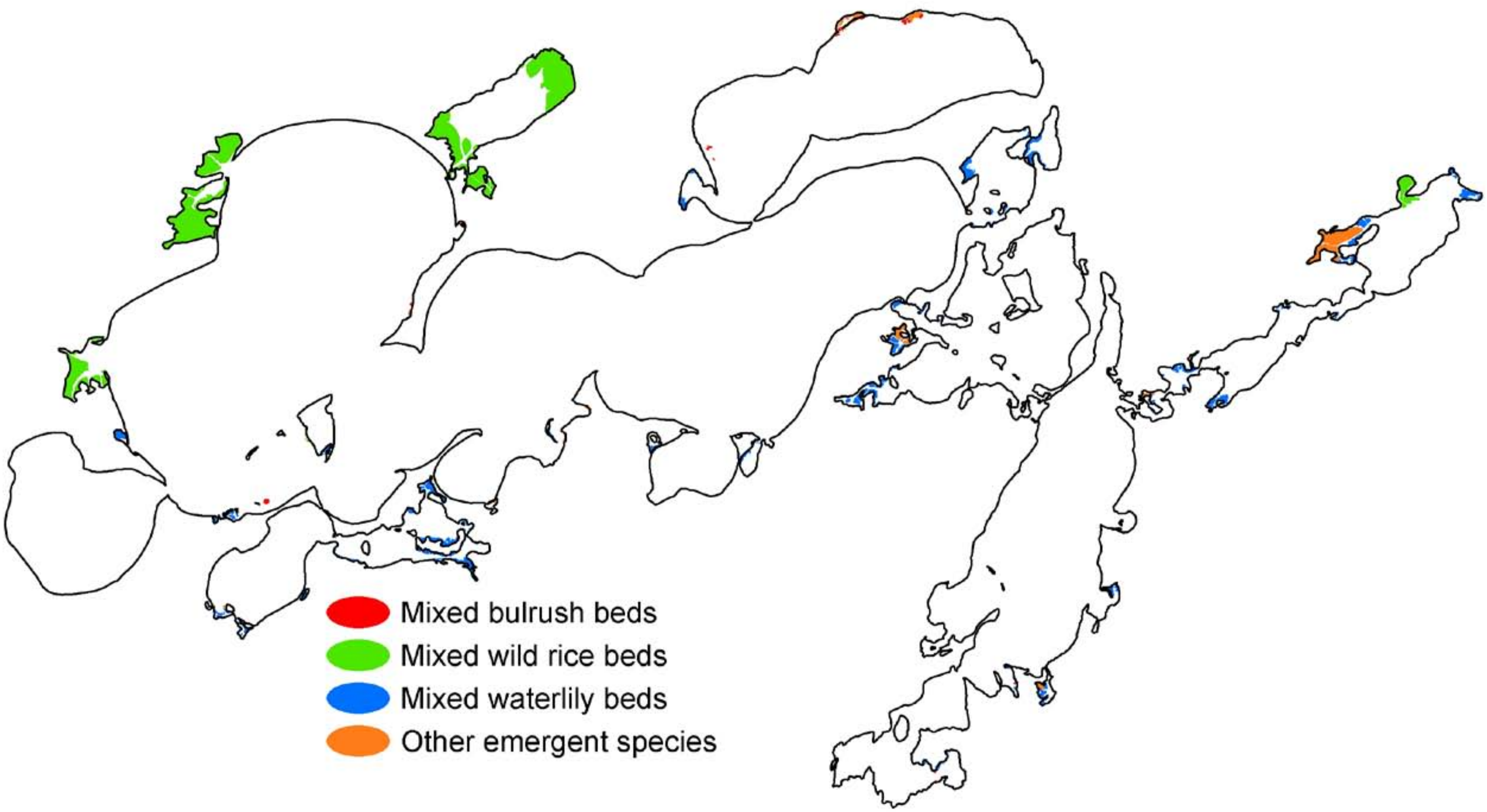


Figure 32. Locations of unique plants on the Whitefish Chain of Lakes, 2010 - 2011.

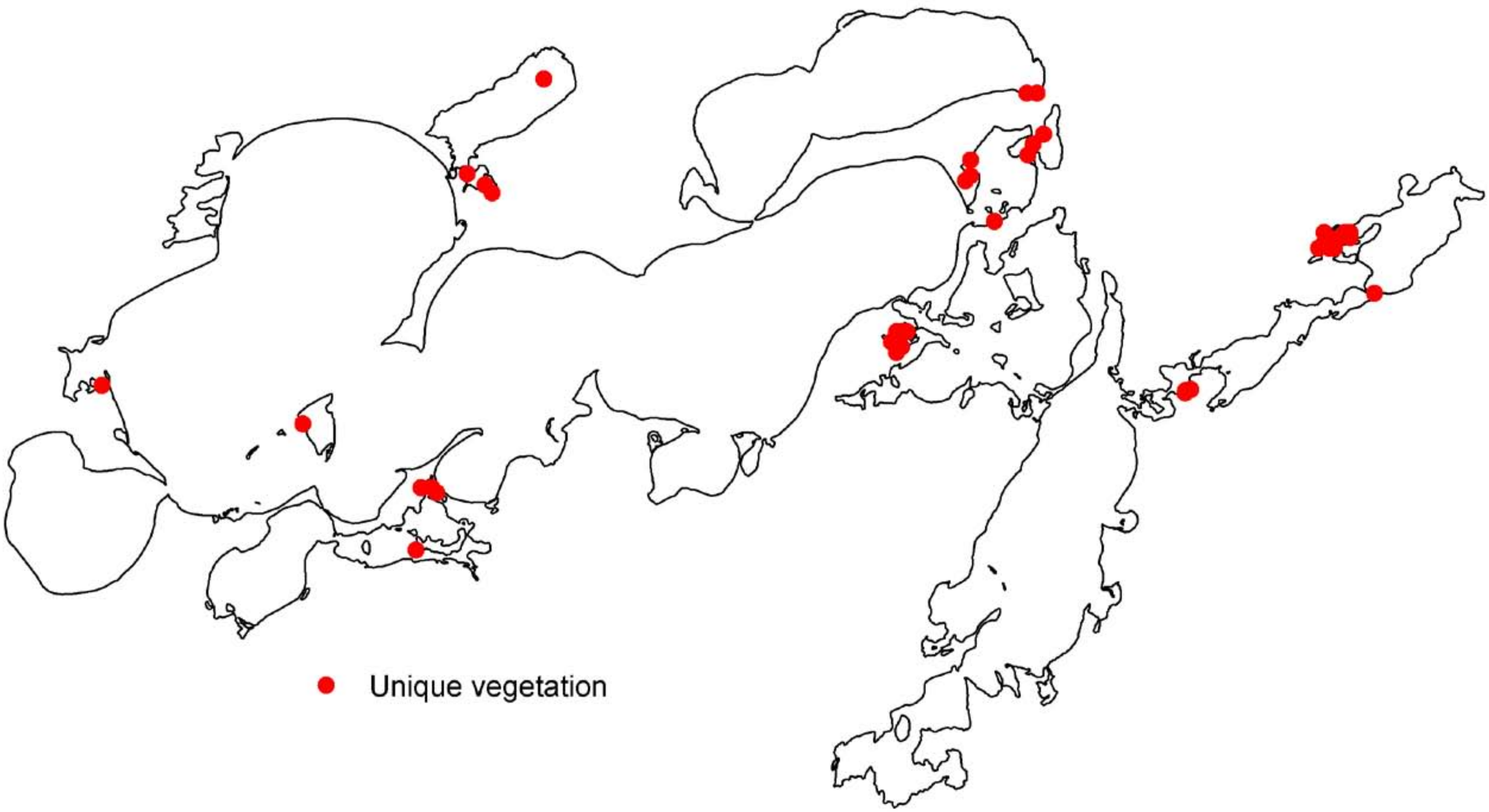
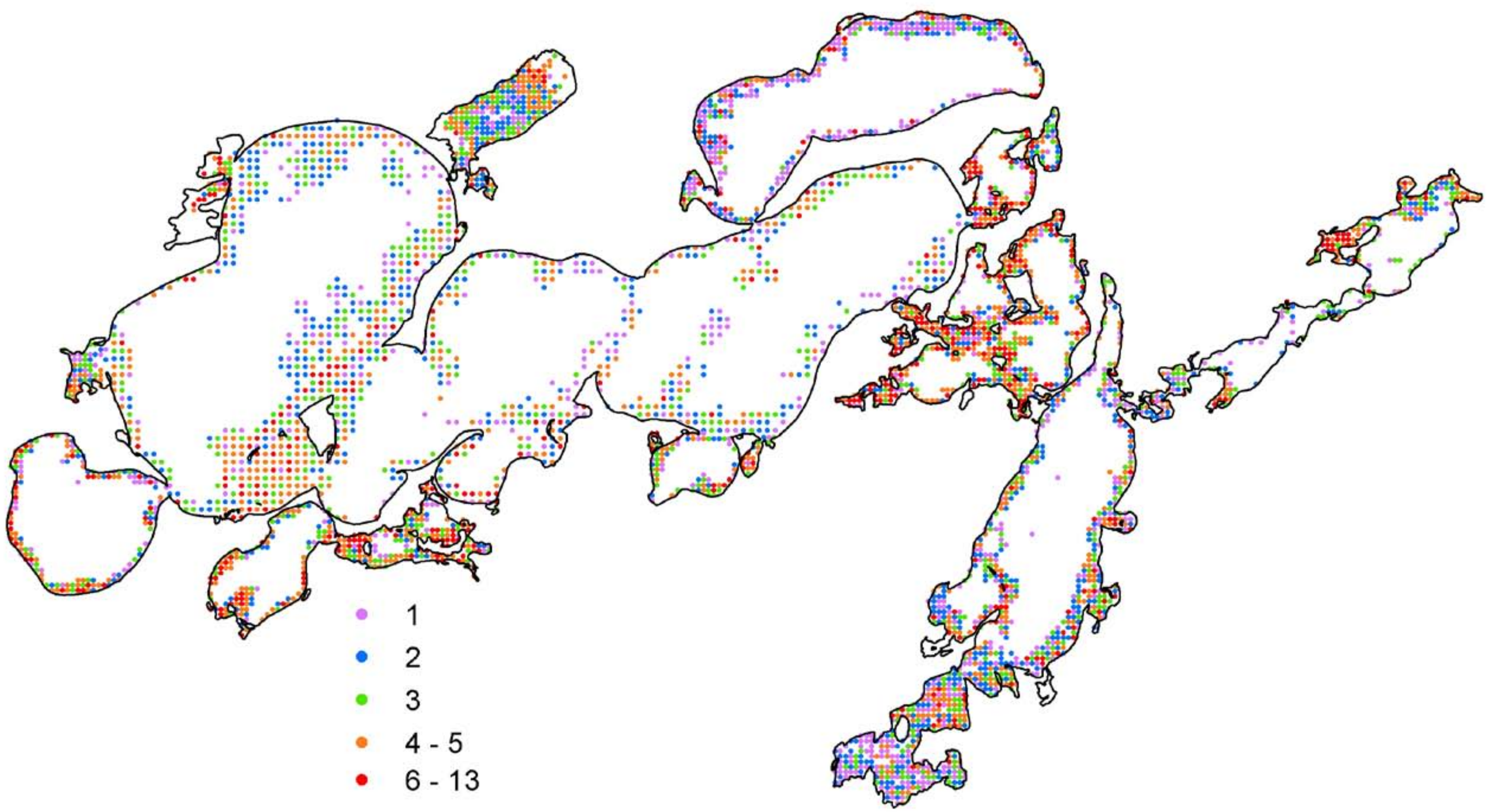


Figure 33. Aquatic plant richness (number of species per sampling station) on the Whitefish Chain of Lakes, 2010 - 2011.



Near-shore Substrates

Objectives

1. Describe and map the near-shore substrates of the Whitefish 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 that range from soft to hard, 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 an island in Whitefish Lake, 2011.

Methods

Near-shore substrate in the Whitefish Chain of Lakes was evaluated at a total of 2,948 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 12 Lakes, and 100 meters apart on the main basins of Whitefish Lake. Surveyors described substrate at 2,504 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 444 of these stations.

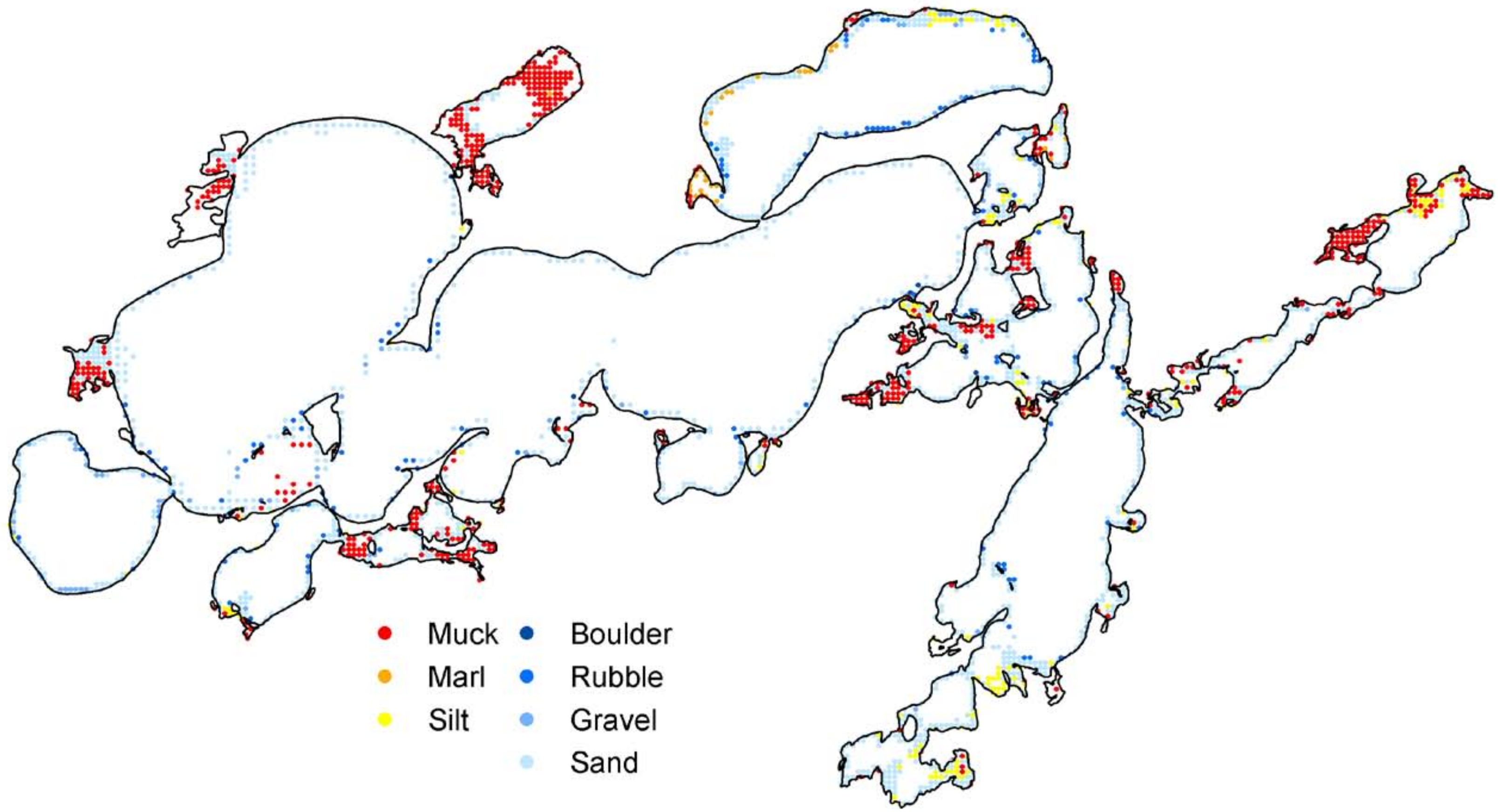
Surveyors evaluated substrate by tapping a pole into the lake bottom; soft substrate could usually be brought to the surface on the pole or sampling rake for evaluation. If this method was not feasible, substrate was evaluated by visual observation of the lake bottom. Standard lake substrate classes 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 Whitefish Chain of Lakes ranged from soft (muck, marl, and silt) to hard (boulder, rubble, gravel, and sand) (Figure 34). Muck substrates were frequent in Arrowhead Lake, the northeast arm of Little Pine Lake, Delta, Killworry and Willow Creek bays of Whitefish Lake, Clamshell Lake, and Rush-Hen Lake. Silt substrates were common in Cross, Little Pine, Big Trout, and Rush-Hen lakes. Sand substrates were frequent in the windswept open areas of Whitefish, Lower Hay, Big Trout, Cross, Little Pine, Daggett, Rush-Hen, Island-Loon, Bertha, and Pig lakes. Overall, sand was the most common substrate type, and occurred at nearly 61% of the sample locations.

Figure 34. Distribution of near-shore substrates in the Whitefish Chain of Lakes, 2010 and 2011.



Bird Surveys

Objectives

1. Record presence of all bird species detected during point count surveys
2. Record presence of marsh birds detected with call-playback surveys
3. Document all non-survey observations of birds
4. Develop distribution maps for species of greatest conservation need

Introduction

Bird Species of Greatest Conservation Need
There are 97 bird species of greatest conservation need (SGCN) in Minnesota. Species of greatest conservation need are documented in Minnesota's State Wildlife Action Plan, Tomorrow's Habitat for the Wild and Rare (2006). Twenty-two of these species were identified on the Whitefish Chain of Lakes.

Figure 35. American bittern

Photo by: Andrea Lambrecht

American bitterns (*Botaurus lentiginosus*; Figure 35) are medium-sized wading birds. They are cryptically colored; the upperparts are dark brown, while the neck and body are streaked with brown. Adults have a black patch on either side of the throat. When disturbed, bitterns "freeze" with their bills pointed upward, or sway side to side like the grasses surrounding them, allowing them to blend into the vegetation. Unlike many other colony-nesting herons, American bitterns nest singly on a platform of grasses and reeds. Habitat includes shallow, densely vegetated shorelines and marshes. Habitat loss has been a major factor in the decline of American bittern populations. Habitat degradation and pesticide contamination have also negatively affected bittern numbers.

Figure 36 Bald eagle

Photo by: Carrol Henderson

Bald eagles (*Haliaeetus leucocephalus*; Figure 36) are an increasingly common sight in Minnesota. Once listed as an endangered species, bald eagle numbers have rebounded due to effective environmental protection laws and conservation efforts. Adult bald eagles are easily identified by the white head and tail, although these colors don't appear until birds are 4 or 5 years old. Prior to that, eagles are generally dark brown with white feathers scattered along the wings, head, tail and back. They are found in forested areas near large, open bodies of water. Although bald eagle numbers are increasing, these birds still face threats from environmental contaminants and destruction of habitat. Bald eagles are listed as a species of Special Concern in Minnesota.

Black-billed cuckoos (*Coccyzus erythropthalmus*; Figure 37) are one of two cuckoo species regularly found in Minnesota. These slender, long-tailed birds summer and breed in Minnesota and the east-central United States before heading south to spend the winter in South America. Black-billed cuckoos have a brown back and white underside, and may be distinguished by a curved black bill and red ring around the eye. The call is a repetitive "cu-cu-cu," often uttered in flight. This bird inhabits deciduous forests and thickets, and is often found near water. The black-billed cuckoo is listed as a species of Regional Concern on the Partners in Flight watchlist.

Figure 37. Black-billed cuckoo

Photo source: U.S. Fish and Wildlife Service

Common loons (*Gavia immer*; Figure 38) are one of Minnesota's most recognizable birds. They are found from northeastern to central Minnesota, and numbers are higher here than in any other state except Alaska. These large diving birds possess red eyes and a large, dark pointed bill that is well-adapted for catching fish. Loons spend most of their time in water, and go ashore only to mate and incubate eggs. Summer plumage is spotted black and white, while in winter the colors are gray above and white below. Loon populations are closely monitored in Minnesota; however, these birds still face threats, particularly in the form of human disturbance and lead poisoning.

Figure 38. Common loon

Photo by: Carrol Henderson

Common nighthawks (*Chordeiles minor*; Figure 39) are most often seen in the air, exhibiting an erratic flight pattern as they forage for insects. They are cryptically colored with brown, gray, and white mottling. A white bar is visible across the wing when the bird is in flight. The breeding ritual includes a dramatic display during which the male dives straight toward the ground before quickly turning upward; air rushing through the wings makes a deep booming sound. Originally found in open rural areas, the nighthawk has adapted to urban settings and often nests on gravel rooftops. Despite their adaptability, nighthawks have declined in some areas. Predation and a decreased insect food base due to the use of pesticides may be factors in this decline.

Figure 39. Common nighthawk

Photo by: Carrol Henderson

Common terns (*Sterna hirundo*; Figure 40) are the most widespread terns in North America. In the breeding season common terns have a solid black cap with gray back and underparts. The gray wings have dark edges. The rump is white, and the legs and bill are orange-red in color. Common terns nest in colonies, often on islands or peninsulas of larger lakes with sandy substrates. Populations of common terns declined in the late 1800s, when their feathers were used to adorn clothing, and again in the 1970s, likely due to poisoning by pesticides. Habitat loss, nest predation, and disturbance by humans may also negatively affect common terns.

Figure 40. Common tern

Photo by: Carrol Henderson

Eastern wood-pewees (*Contopus virens*; Figure 41) are medium-sized, nondescript birds common in Eastern forests. They utilize multiple habitat types, including deciduous forests, mixed woods, and suburban areas. This bird gets its name from its call, a slurred "pee-ah-wee." Eastern wood-pewees are grayish-olive above, with a paler throat and belly and whitish wingbars. They forage throughout the canopy, often flying out from their perch to catch insects before returning to the same perch. Populations of eastern wood-pewees are declining throughout much of their range. One possible cause of the decline is the increase in white-tailed deer. Deer browse and decrease the lower-canopy foraging area available to the eastern wood-pewee.

Figure 41. Eastern wood-pewee

Photo by: J.A. Spendelow

Golden-winged warblers (*Vermivora chrysoptera*; Figure 42) are small, active, insectivorous warblers. They possess a distinctive yellow crown and yellow patch on the wings. A black mask and throat contrast with the gray and white plumage on the back and breast. They often inhabit forest edges, such as those along marshes, bogs, and fields, and are also common in alder shrub swamps. Regional declines of the golden-winged warbler are considerable. Human-caused disturbance and hybridization with increasing numbers of blue-winged warblers are correlated with the declines.

Figure 42. Golden-winged warbler

Photo by: Carrol Henderson, MN DNR

The least bittern (*Ixobrychus exilis*; Figure 43) is the smallest member of the heron family found in North America. Although rarely seen, the least bittern is fairly common within suitable habitat. Least bitterns breed in densely vegetated marshes throughout much of the eastern United States. The crown, back and tail of the least bittern are greenish in color, while the throat, sides and underparts are streaked with brown and white. The small size and narrow body of the least bittern allow it to move easily through dense emergent vegetation. These birds often forage while clinging to reeds and branches with their long curved claws. Secretive marsh birds such as the least bittern are difficult to survey accurately, so population trends are unclear. Destruction of wetlands poses a major threat to this species.

Figure 43. Least bittern

Photo by: Thomas Bentley, www.thomasbentley.com

Least flycatchers (*Empidonax minimus*; Figure 44) are the smallest flycatchers found in Minnesota. Like many other flycatchers, they are olive to gray in color with two white wingbars and whitish underparts. They have a small bill and a prominent white eye ring. The best way to distinguish least flycatchers from other flycatchers is the call, a harsh "che-bek." These birds are often found along water edges in mature, open woods. Least flycatchers are common throughout most of their range where habitat is suitable. However, they are sensitive to human disturbance and require large areas of forest to survive.

Figure 44. Least flycatcher

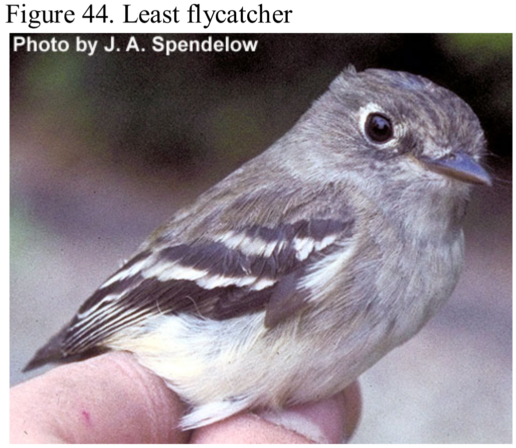


Photo by: J.A. Spendelow

Marsh wrens (*Cistothorus palustris*; Figure 45) are small, stocky wrens. Their color is brown with black and white streaks on the back and black barring on the tail. They have a dark brown or black cap and a white eye line. Marsh wrens are noisy birds, and sing almost continually during the breeding season. They often hold their tails in an upright position, in "classic" wren posture. Marsh wrens inhabit a variety of marshes. Emergent vegetation, such as cattails or bulrush, is one of the most important habitat components. While populations of marsh wrens are increasing in some areas, others are threatened by loss and degradation of wetland habitat.

Figure 45. Marsh wren

Photo by: Dave Herr

Ovenbirds (*Seiurus aurocapillus*; Figure 46) are rarely seen birds of the forest. However, their loud "teacher, teacher, teacher" song is commonly heard during the summer months. They dwell on the ground, and build a covered nest that resembles a Dutch oven. Ovenbirds are olive-brown with a boldly streaked breast. Two black stripes border an orange crown. They have a thin bill and a white eye ring. They breed in mature deciduous and mixed forests, especially those with minimal undergrowth. Ovenbird numbers appear to be stable, but the birds are vulnerable to forest fragmentation and parasitism by brown-headed cowbirds (*Molothrus ater*).

Figure 46. Ovenbird

Photo courtesy of: U.S. Fish and Wildlife Service

Rose-breasted grosbeaks (*Pheucticus ludovicianus*; Figure 47) are summer visitors to Minnesota bird feeders. The males are easily identified by a red triangle on a white breast, with a black head and back and a large bill. Females are more difficult to identify, and resemble a large sparrow with brown and white streaks. Rose-breasted grosbeaks are found in open woodlands near water, edges of marshes, meadows and woodlands, and suburban parks and gardens. The winter range spans from southern Mexico to South America and the Caribbean. Significant regional declines in rose-breasted grosbeak populations have been noted. Protection of large, unfragmented areas of hardwood forest would be beneficial to the rose-breasted grosbeak.

Figure 47. Rose-breasted grosbeak

Photo by: J.A. Spendelow

The red-headed woodpecker (*Melanerpes erythrocephalus*; Figure 48) is the most strikingly colored woodpecker in Minnesota. These medium-sized birds have a deep red head and neck, black back and tail, and white underparts. They are omnivorous, and unlike many woodpeckers, are adept at capturing insects in flight. They utilize primarily oak savanna and grassland habitats, nesting in large old trees and snags. Although red-headed woodpeckers are found throughout the central and eastern states, populations are sparsely distributed. Numbers of red-headed woodpeckers have declined dramatically since the 1960s, due primarily to loss and degradation of habitat through removal of snags, agricultural development, and regeneration of forests.

Figure 48. Red-headed woodpecker

Photo by: Dave Menke

Sedge wrens (*Cistothorus platensis*; Figure 49) are small, brown wrens with buffy underparts and white streaks on the back and crown. They have an indistinct white eye stripe, and often hold their short tails in a cocked, upright position. As their name implies, they prefer marshes and meadows with abundant dense sedges and grasses. The nest is often made of sedges, as well. Sedge wrens are unpredictable in their migration patterns, and may be abundant in an area one year and completely absent the next. Human development of wetlands is the primary reason for the recent notable declines in sedge wren populations.

Figure 49. Sedge wren

Photo by: Berlin Heck

The swamp sparrow's (*Melospiza georgiana*; Figure 50) slow trill is a familiar sound in swampy areas in the summer. Other wetlands, such as bogs and meadows, may also harbor populations of this species. Nests are built on marsh vegetation, often with cattail leaves or grass arching over the top. Swamp sparrows eat mainly seeds and fruits, but may also be adventurous feeders, wading in the water and putting their heads underneath in order to capture aquatic insects. This rusty-colored bird has black streaks on the back and an unstreaked gray breast and neck. A reddish cap is easily visible during the breeding season. Swamp sparrows thrive in suitable habitat; however, destruction of wetlands has put this species at risk.

Figure 50. Swamp sparrow

Photo by: Jim Stasz

The trumpeter swan (*Cygnus buccinator*; Figure 51) is the largest of the North American waterfowl. It inhabits lakes, ponds, and large rivers, feeding on roots and stems of aquatic vegetation. Adult trumpeter swans are all white with a black bill and face. Juveniles are whitish-gray with a mottled bill. Historically, trumpeter swans nested across much of North America. However, excessive hunting in the 19th and early 20th centuries led to large population declines, and by 1880 trumpeter swans had disappeared from Minnesota. Captive breeding programs and habitat protection efforts have been successful, and the Minnesota population now numbers over 2000. However, habitat loss and lead poisoning still pose threats to swan populations. This bird is listed as Threatened in Minnesota.

Figure 51. Trumpeter swan

Photo by: Dave Herr

The veery (*Catharus fuscescens*; Figure 52) is one of the most easily identifiable thrushes. It has faint dark spots on a buffy breast and a reddish brown back and head. The legs are pink and the eyes are dark with an indistinct light eye ring. The veery was named after its most common call, a "vee-er" sound. Riparian areas with dense vegetation and wetlands within large forests are good places to find the veery. They spend much of their time on the ground, foraging for insects underneath the leaf litter. The veery is suffering declines throughout many parts of its range. Destruction of winter habitat and parasitism by brown-headed cowbirds are major reasons cited for the decline.

Figure 52. Veery

Photo by: Deanna Dawson

Virginia rails (*Rallus limicola*; Figure 53) are rarely seen, ground-dwelling marsh birds. They have a rusty-colored breast and belly, brown-streaked back, and black and white barring on the flanks. The bill is reddish and slightly curved. The cheeks are gray and the throat is white. The Virginia rail rarely flies, and spends most of its time walking through dense vegetation in freshwater marshes. Like many of the marsh birds, Virginia rails are best detected through their vocalizations, including grunts and a metallic "tic." Population information is limited, but several reports have indicated declines in some areas. Loss of wetland habitat may negatively affect rail numbers.

Figure 53. Virginia rail

Photo by: David Arbour

The Eastern whip-poor-will (*Caprimulgus vociferus*; Figure 54) is a medium-sized member of the nightjar family (the common nighthawk is also part of this group). Whip-poor-wills are active at night, when they come out to forage for insects. They spend their days sleeping on the forest floor, where their cryptic coloring helps them remain hidden. The feathers are mottled black, brown, and gray, and the throat is black. Whip-poor-wills breed in mixed or deciduous forests with little or no understory, often adjacent to grassy fields or other openings. Long-term population declines have been documented through much of the whip-poor-will's range, though the reasons are not well understood. Threats include habitat loss and fragmentation, predation, and a declining prey base (due to pesticide use).

Figure 54. Whip-poor-will

Photo by: John Cassady, www.audubon.org (Common Birds in Decline)

The wood thrush (*Hylocichla mustelina*; Figure 55) has become a symbol of declining neotropical birds, its population having decreased significantly in recent decades over much of its range. Wood thrushes can be distinguished from other North American thrushes by a rusty head and blackish spots contrasting with white underparts and a dull white eye-ring. The flutelike song of the wood thrush, its hallmark, is a familiar sound in eastern deciduous woodlands in summer, especially at dawn and dusk. Primary habitat features include a shrub layer, shade, and leaf litter, which enhance feeding and nesting. Destruction and fragmentation of forests in both breeding and wintering areas are factors in the species' declining abundance.

Figure 55. Wood thrush

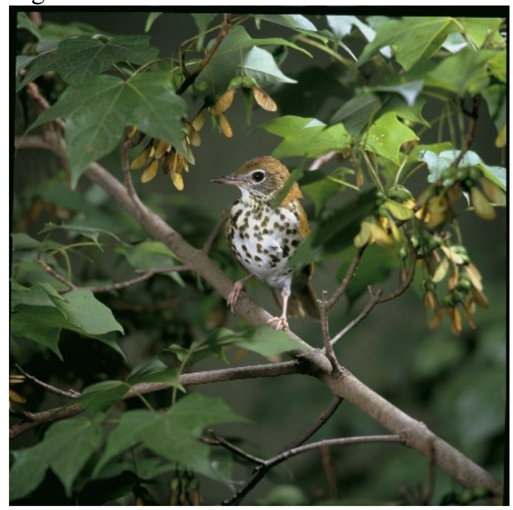


Photo courtesy of: U.S. Fish and Wildlife Service

The yellow-bellied sapsucker's (*Sphyrapicus varius*; Figure 56) name describes it well. This medium-sized woodpecker exhibits a yellow underside, and feeds primarily on sap it harvests from trees. The forehead and crown are red, and the throat is also red in the male. The back and sides are striped with black and white. Deciduous forests and riparian areas along streams characterize the breeding habitat of this species. Yellow-bellied sapsuckers create a food source for many other species when they drill holes for sap, and are therefore considered an important part of the ecosystem. Populations currently appear stable, and care should be taken to ensure they remain that way.

Figure 56. Yellow-bellied sapsucker

Photo by: J.A. Spendelow

Methods

Surveyors used several techniques to collect information on bird species. Point counts were conducted at 474 stations, located 400 meters apart along the lakeshore. Surveyors listened for five minutes per station and recorded all species detected (heard or seen) within that time. Point count surveys were conducted in the early morning hours, when species were most likely to be singing. Call-playback surveys were conducted at survey stations that had appropriate habitat. At each station, surveyors played a tape that included the calls of six marsh birds (least bittern (*Ixobrychus exilis*), yellow rail (*Coturnicops noveboracensis*), sora (*Porzana carolina*), Virginia rail (*Rallus limicola*), American bittern (*Botaurus lentiginosus*), and pied-billed grebe (*Podilymbus podiceps*)) and listened for a response. Call-playback surveys generally took place in the early evening. Both survey techniques were dependent on good listening conditions, and surveys were stopped if inclement conditions prevented the ability to hear bird vocalizations. Casual observations of birds seen or heard on the lake or on the lakeshore were also recorded.

Results

Surveyors identified 22 species of greatest conservation need on the Whitefish Chain of Lakes (Table 9). The common loon was by far the most commonly recorded species of greatest conservation need; this species was documented at 87 survey stations. Over 40% of the stations on Lower Hay Lake included loons, as did over 20% of the stations on Bertha, Big Trout, Pig, and Whitefish Lakes. The yellow-bellied sapsucker was second in abundance, identified at 53 sites. This species was found with the greatest frequency on Arrowhead, Little Pine, and Pig Lakes. Bald eagles were regularly recorded on the Whitefish Chain; this bird was found at 44 stations overall. Ovenbirds were recorded at 30 locations, while the veery was documented at 29. Both of these species were found with the greatest frequency on Arrowhead Lake, and were recorded at six percent of the survey stations overall. Swamp sparrows and rose-breasted grosbeaks were each identified at five percent of the survey locations. Again, Arrowhead Lake had the highest concentration of these two species of greatest conservation need. Swamp sparrows were also fairly common in Little Pine Lake, whereas rose-breasted grosbeaks were regularly recorded in Clamshell Lake. Five species of greatest conservation need were found rarely. The American bittern, red-headed woodpecker, trumpeter swan, and wood thrush were found at only one survey station each. The single red-headed woodpecker sighting was on Cross Lake, while the other three species were recorded on Whitefish Lake. A single Eastern whip-poor-will was heard on Arrowhead Lake by surveyors conducting frog surveys. The remaining species of greatest conservation need identified during the surveys, each found at fewer than five percent of the total survey stations, were the black-billed cuckoo, common nighthawk, common tern, eastern wood-pewee, golden-winged warbler, least bittern, least flycatcher, marsh wren, sedge wren, and Virginia rail. Whitefish Lake had the greatest number of bird species of greatest conservation need recorded; surveyors documented 18 SGCN on this lake. Arrowhead Lake had 14 SGCN, Little Pine Lake had 10, Cross Lake had nine, and Big Trout Lake had eight. Seven species of greatest conservation need were recorded on Bertha, Clamshell, and Lower Hay Lakes. Five species of greatest conservation need were identified on Rush-Hen Lake, four were recorded on Island-Loon Lake, and three SGCN each were documented on Daggett and Pig Lakes.

Surveyors recorded 96 bird species during the point count and call-playback surveys on the Whitefish Chain of Lakes. Three additional species were recorded during frog and fish surveys, for a total of 99 recorded species (Table 9). Whitefish Lake had the greatest species diversity, with 82 bird species identified on the lakeshore. Arrowhead had 61 species, Cross, and Rush-Hen Lakes had 60 recorded species, while Lower Hay Lake had 56 and Little Pine Lake had 55. Surveyors documented 49 bird species on Big Trout Lake, 48 species on Bertha Lake, 47 species on Clamshell Lake, and 44 species on Island-Loon Lake. Thirty-seven bird species were noted on Daggett Lake and 36 were identified on Pig Lake.

Overall, song sparrows were the most frequently recorded species; they were found at 78% of the survey stations. They were also the most commonly recorded species on all individual lakes except Clamshell, Daggett, and Little Pine. The most frequently documented species on Clamshell and Little Pine Lakes was the American robin, whereas the most recorded species on Daggett Lake was the chipping sparrow. The song sparrow was the second most abundant species on Clamshell and Little Pine Lakes, and the fifth most abundant on Daggett Lake.

American robins and red-eyed vireos were the second most commonly recorded species on the Whitefish Chain overall. They were each identified at over 50% of the survey stations. Rounding out the top five most commonly recorded species overall were the red-winged blackbird and the blue jay. These species were each found at over 40% of the survey locations. The top five most frequently documented species by lake were:

Arrowhead: 1) song sparrow, 2) red-winged blackbird, 3) red-eyed vireo, 4) yellow warbler, 5) wood duck

Bertha: 1) song sparrow, 2) chipping sparrow, 3) black-capped chickadee, 4) red-eyed vireo, 5) American goldfinch/eastern phoebe

Big Trout: 1) song sparrow, 2) red-eyed vireo, 3) American robin, 4) blue jay/American crow

Clamshell: 1) American robin, 2) song sparrow, 3) chipping sparrow, 4) red-winged blackbird, 5) baltimore oriole/yellow warbler/warbling vireo

Cross: 1) song sparrow, 2) American robin, 3) red-eyed vireo, 4) blue jay/American crow

Daggett: 1) chipping sparrow, 2) blue jay, 3) red-eyed vireo, 4) eastern phoebe, 5) song sparrow/American robin/American crow

Island-Loon: 1) song sparrow, 2) red-winged blackbird, 3) common grackle, 4) American robin/yellow warbler

Little Pine: 1) American robin, 2) song sparrow, 3) red-eyed vireo, 4) red-winged blackbird/eastern phoebe/white-breasted nuthatch

Lower Hay: 1) song sparrow, 2) American robin, 3) red-eyed vireo, 4) blue jay, 5) chipping sparrow

Pig: 1) song sparrow, 2) black-capped chickadee, 3) blue jay/American crow/house wren

Rush-Hen: 1) song sparrow, 2) American robin, 3) red-eyed vireo, 4) blue jay, 5) black-capped chickadee

Whitefish: 1) song sparrow, 2) red-eyed vireo, 3) red-winged blackbird, 4) American robin, 5) blue jay

Three aquatic habitat-dependent species of greatest conservation need were documented on the Whitefish Chain of Lakes (Figure 57). Common loons were recorded on each of the twelve lakes in the Whitefish Chain, and most lakes had multiple sightings. Loons were seen not only within protected bays and near islands, but also at various locations along the main shoreline. Common terns were found at two locations. One was seen near Big Island in Whitefish Lake, while the other was recorded south of Twin Islands in Cross Lake. A single trumpeter swan was seen in Killworry Bay on the western edge of Whitefish Lake.

The majority of the bird species of greatest conservation need documented on the Whitefish Chain of Lakes were forest-dwelling species (Figure 58). Yellow-bellied sapsuckers were recorded most frequently, and were found on every lake in the chain. Eleven of the twelve lakes had multiple detections of this species of greatest conservation need. Both the veery and the ovenbird were also fairly widely distributed within the Whitefish Chain. The veery was found on eight lakes (Arrowhead, Bertha, Big Trout, Clamshell, Cross, Little Pine, Rush-Hen and Whitefish), while the ovenbird was found on seven of the lakes, including Arrowhead, Big Trout, Clamshell, Cross, Little Pine, Lower Hay, and Whitefish. Rose-breasted grosbeaks were found on all lakes except Big Trout, Daggett, and Island-Loon. This species was particularly abundant in Arrowhead and Clamshell Lakes. Least flycatchers were also a common occurrence in Arrowhead Lake. This forest-dweller was also found at scattered locations in Bertha, Big Trout, Clamshell, and Whitefish Lakes. The eastern wood-pewee was recorded in half of the lakes: Arrowhead, Bertha, Big Trout, Cross, Little Pine, and Whitefish. Several forest inhabiting species of greatest conservation need were recorded rarely. The black-billed cuckoo was identified at two locations on Arrowhead Lake, and a single wood thrush was recorded on Whitefish Lake. An Eastern whip-poor-will, heard during frog surveys, was documented on the northern end of Arrowhead Lake.

Seven wetland-dwelling bird species of greatest conservation need were identified on the Whitefish Chain (Figure 59). The swamp sparrow, although found on only five lakes in the chain, was by far the most widely distributed of these species. The swamp sparrow was a regular inhabitant of the Arrowhead Lake shoreline, and was also documented in Island-Loon, Little Pine, Lower Hay, and Whitefish Lakes. Golden-winged warblers, which utilize both wetland and forest habitat, were sparsely scattered within the Whitefish Chain. Surveyors recorded this species on Arrowhead, Big Trout, Little Pine, Lower Hay, and Whitefish Lakes. Three of the four Virginia rails were found within small, protected bays. This species was recorded on Arrowhead and Whitefish Lakes. The least bittern and marsh wren were each documented at two locations on the western half of Whitefish Lake, and the American bittern was heard at one survey station, also in the western half of the lake.

Three additional species were documented on the Whitefish Chain of Lakes (Figure 60). Two of these, the bald eagle and the common nighthawk, occupy a variety of habitats. Bald eagles were widely distributed along the entire shoreline of the Whitefish Chain. Common nighthawks were recorded on the northern edge of Arrowhead Lake and in Willow Creek Bay on Whitefish Lake. During the point-count surveys, a single adult red-headed woodpecker was identified near the southern tip of Cross Lake (Figure 60). During fish surveys, surveyors also recorded red-headed woodpeckers (including a juvenile) on the northern shoreline of Whitefish Lake and along the northwestern edge of Island-Loon Lake. Critical habitat for this species often consists of grassland and oak savanna, but may also include lakeshore habitat with an oak canopy and open understory.

Table 9. Species list and frequency of occurrence of bird species identified during Whitefish Chain of Lakes surveys, May 2010 – August 2011. * denotes a species of greatest conservation need. "X" indicates a species was documented on the lake, but not during bird surveys. Values represent percent of surveyed sample sites in which a bird species occurred (N=474).

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Waterfowl	Canada Goose	*Branta canadensis*	4	13	8	6	5	10	0	5	6	1	0	5	0
	Trumpeter Swan*	*Cygnus buccinator*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	Wood Duck	*Aix sponsa*	11	17	4	1	12	19	3	62	12	9	14	14	0
	Gadwall	*Anas streptera*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	Mallard	*Anas platyrhynchos*	12	0	8	15	14	14	11	14	12	13	29	14	6
	Blue-winged Teal	*Anas discors*	<1	0	0	0	0	5	0	0	0	0	0	0	0
	Ring-necked Duck	*Aythya collaris*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	Common Goldeneye	*Bucephala clangula*	3	0	12	2	2	5	0	0	0	5	0	5	6
	Hooded Merganser	*Lophodytes cucullatus*	1	0	4	0	0	0	0	0	6	2	0	0	0
	Common Merganser	*Mergus merganser*	3	0	0	3	3	0	3	0	0	5	0	0	0
Loons	Common Loon*	*Gavia immer*	18	4	12	16	15	10	26	10	41	22	29	18	24
Herons/ bitterns	American Bittern*	*Botaurus lentiginosus*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	Least Bittern*	*Ixobrychus exilis*	<1	0	0	0	0	0	0	0	0	2	0	0	0
	Great Blue Heron	*Ardea herodias*	13	17	0	14	20	5	14	5	6	14	29	14	12
	Green Heron	*Butorides virescens*	7	17	0	8	8	14	6	5	18	4	14	5	0
Vultures	Turkey Vulture	*Cathartes aura*	<1	0	0	1	0	0	0	0	0	0	0	0	0
Hawks/ eagles	Osprey	*Pandion haliaetus*	2	0	0	2	2	0	0	0	24	2	0	0	0
	Bald Eagle*	*Haliaeetus leucocephalus*	9	9	4	7	8	10	6	10	6	14	0	5	18
Falcons	Merlin	*Falco columbarius*	2	4	0	6	5	0	0	0	12	0	0	0	0
Rails/ coots	Virginia Rail*	*Rallus limicola*	1	0	0	0	0	0	0	5	0	2	0	0	0
	Sora	*Porzana carolina*	2	9	0	0	0	0	0	14	0	2	0	0	0
Plovers	Killdeer	*Charadrius vociferus*	<1	0	0	1	0	0	0	0	0	1	0	0	0
Sandpipers	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	X	0	0	0
	Spotted Sandpiper	*Actitis macularia*	<1	0	4	0	2	0	0	0	0	0	0	0	0

Table 9, continued.

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Gulls/terns	Bonaparte's Gull	*Chroicocephalus philadelphia*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	Ring-billed Gull	*Larus delawarensis*	7	0	8	9	8	5	3	10	24	6	0	5	12
	Caspian Tern	*Sterna caspia*	1	0	0	0	0	0	3	0	6	1	0	5	0
	Common Tern*	*Sterna hirundo*	<1	0	0	1	0	0	0	0	0	1	0	0	0
Pigeons	Mourning Dove	*Zenaida macroura*	4	0	0	8	5	0	0	10	0	5	0	0	12
Cuckoos	Black-billed Cuckoo*	*Coccyzus erythropthalmus*	<1	0	0	0	0	0	0	10	0	0	0	0	0
Owls	Great-horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	X	0	0
Goatsuckers	Common Nighthawk*	*Chordeiles minor*	1	0	0	0	0	0	0	10	0	1	0	0	0
	Eastern Whip-poor-will*	*Caprimulgus vociferus*	0	0	0	0	0	0	0	X	0	0	0	0	0
Swifts	Chimney Swift	*Chaetura pelagica*	1	0	0	0	5	0	0	0	0	0	0	0	0
Hummingbirds	Ruby-throated Hummingbird	*Archilochus colubris*	2	4	4	0	2	0	3	0	0	2	14	0	6
Kingfishers	Belted Kingfisher	*Ceryle alcyon*	7	13	4	9	3	19	0	19	12	6	0	0	18
Woodpeckers	Red-headed Woodpecker*	*Melanerpes erythrocephalus*	<1	0	0	1	0	0	0	0	0	0	0	0	0
	Red-bellied Woodpecker	*Melanerpes carolinus*	11	26	20	9	14	29	6	0	35	5	14	5	12
	Yellow-bellied Sapsucker*	*Sphyrapicus varius*	11	30	20	3	5	5	9	38	24	7	43	18	18
	Downy Woodpecker	*Picoides pubescens*	5	13	0	0	0	14	0	19	12	7	0	9	6
	Hairy Woodpecker	*Picoides villosus*	7	0	12	9	8	10	0	0	29	6	14	0	6
	Northern Flicker	*Colaptes auratus*	14	35	4	2	21	14	11	43	29	13	0	18	6
	Pileated Woodpecker	*Dryocopus pileatus*	6	13	16	6	5	14	6	5	0	6	14	0	0
Flycatchers	Eastern Wood-Pewee*	*Contopus virens*	2	4	0	1	0	0	6	5	0	2	0	0	6
	Least Flycatcher*	*Empidonax minimus*	3	0	0	0	0	0	6	19	0	3	0	5	6
	Eastern Phoebe	*Sayornis phoebe*	30	53	48	28	24	19	40	10	41	27	43	23	47

Table 9, continued.

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Flycatchers	Great Crested Flycatcher	*Myiarchus crinitus*	17	4	8	11	20	24	37	24	18	17	0	23	12
	Eastern Kingbird	*Tyrannus tyrannus*	15	35	8	5	26	0	3	24	24	12	14	36	18
Vireos	Yellow-throated Vireo	*Vireo flavifrons*	2	9	0	0	3	0	0	10	0	1	0	0	6
	Warbling Vireo	*Vireo gilvus*	19	35	8	18	15	10	9	33	12	18	14	45	18
	Red-eyed Vireo	*Vireo olivaceus*	51	61	53	45	44	29	57	67	71	54	43	41	53
Jays/ crows	Blue Jay	*Cyanocitta cristata*	43	48	56	39	42	10	49	48	65	45	71	23	35
	American Crow	*Corvus brachyrhynchos*	37	35	44	39	27	38	49	52	47	37	71	0	29
	Common Raven	*Corvus corax*	1	4	0	0	2	0	0	0	0	2	0	0	0
Swallows	Purple Martin	*Progne subis*	1	0	0	3	0	0	0	0	6	0	0	0	6
	Tree Swallow	*Tachycineta bicolor*	23	39	20	23	32	0	20	24	47	20	43	14	24
	Bank Swallow	*Riparia riparia*	2	0	0	2	5	0	9	0	0	1	0	0	0
	Cliff Swallow	*Petrochelidon pyrrhonota*	1	0	0	3	3	0	0	0	0	0	0	0	0
	Barn Swallow	*Hirundo rustica*	14	17	16	20	20	24	17	5	12	5	14	5	24
Chickadees	Black-capped Chickadee	*Poecile atricapilla*	33	48	24	29	41	29	20	14	47	32	86	27	59
Nuthatches	Red-breasted Nuthatch	*Sitta canadensis*	8	13	0	0	3	19	9	10	18	8	29	18	18
	White-breasted Nuthatch	*Sitta carolinensis*	17	52	36	10	27	10	3	10	12	13	0	9	35
Creepers	Brown Creeper	*Certhia americana*	1	0	0	0	2	0	0	0	0	3	0	0	0
Wrens	House Wren	*Troglodytes aedon*	22	17	36	14	23	14	29	5	29	20	71	41	29
	Sedge Wren*	*Cistothorus platensis*	1	4	0	0	0	0	0	10	0	0	0	0	0
	Marsh Wren*	*Cistothorus palustris*	<1	0	0	0	0	0	0	0	0	2	0	0	0
Thrushes	Eastern Bluebird	*Sialia sialis*	1	0	16	1	0	0	0	0	0	0	0	0	0
	Veery*	*Catharus fuscescens*	6	9	0	1	2	0	3	57	0	7	0	9	6
	Hermit Thrush	*Catharus guttatus*	1	0	0	0	0	0	0	5	0	2	0	0	0
	Wood Thrush*	*Hylocichla mustelina*	<1	0	0	0	0	0	0	0	0	1	0	0	0
	American Robin	*Turdus migratorius*	51	83	44	53	48	43	51	10	71	48	57	73	41

Table 9, continued.

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Mockingbirds	Gray Catbird	*Dumetella carolinensis*	6	0	0	2	3	5	3	33	18	5	14	9	6
Starlings	European Starling	*Sturnus vulgaris*	1	0	0	0	2	0	0	0	6	1	0	0	0
Waxwings	Cedar Waxwing	*Bombycilla cedrorum*	13	17	0	8	21	24	9	10	29	6	14	36	18
Warblers	Ovenbird*	*Seiurus aurocapilla*	6	9	0	1	0	0	6	33	24	9	0	9	0
	Golden-winged Warbler*	*Vermivora chrysoptera*	1	9	0	0	0	0	3	5	6	1	0	0	0
	Black-and-white Warbler	*Mniotilta varia*	8	17	0	3	3	10	14	29	0	10	0	9	0
	Nashville Warbler	*Oreothlypis ruficapilla*	1	4	0	1	0	0	0	5	0	2	0	0	0
	Common Yellowthroat	*Geothlypis trichas*	15	30	4	7	5	0	23	48	35	21	14	5	0
	American Redstart	*Setophaga ruticilla*	9	17	0	2	2	0	0	43	12	14	0	32	6
	Yellow Warbler	*Setophaga petechia*	27	30	0	9	23	43	17	67	35	37	14	45	24
	Chestnut-sided Warbler	*Setophaga pensylvanica*	8	13	0	5	0	0	0	38	35	5	0	18	29
	Pine Warbler	*Setophaga pinus*	13	9	0	1	21	19	17	0	29	6	43	18	18
	Yellow-rumped Warbler	*Setophaga coronata*	3	4	0	0	2	5	9	5	12	4	14	0	6
Sparrows	Chipping Sparrow	*Spizella passerina*	31	30	60	24	27	29	29	19	53	22	29	55	76
	Song Sparrow	*Melospiza melodia*	78	78	44	67	80	81	89	86	10	85	86	68	82
	Swamp Sparrow*	*Melospiza georgiana*	5	17	0	0	0	5	0	38	6	8	0	0	0
Cardinals/ tanagers	Scarlet Tanager	*Piranga olivacea*	1	0	0	0	0	0	3	5	6	1	0	0	6
	Northern Cardinal	*Cardinalis cardinalis*	2	0	0	0	3	5	0	14	0	2	0	5	0
	Rose-breasted Grosbeak*	*Pheucticus ludovicianus*	5	9	0	1	2	0	0	33	12	4	14	18	6
	Indigo Bunting	*Passerina cyanea*	<1	4	0	0	0	0	0	0	0	0	0	0	0
Blackbirds	Red-winged Blackbird	*Agelaius phoeniceus*	44	52	24	37	29	76	40	81	35	50	57	50	35
	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	<1	0	0	0	0	0	0	0	6	0	0	0	0
	Common Grackle	*Quiscalus quiscula*	28	43	4	36	36	62	17	43	41	22	29	0	6
	Brown-headed Cowbird	*Molothrus ater*	7	13	0	9	2	5	3	5	6	5	0	41	0
	Baltimore Oriole	*Icterus galbula*	27	39	12	30	26	33	20	57	47	16	43	45	35

Table 9, continued.

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Finches	Purple Finch	*Carpodacus purpureus*	<1	0	0	0	0	0	0	0	0	0	0	5	0
	Pine Siskin	*Spinus pinus*	<1	0	0	0	0	0	0	0	6	0	0	0	0
	American Goldfinch	*Spinus tristis*	20	17	12	11	24	14	11	38	29	17	29	41	47

Figure 57. Distribution of aquatic habitat-dependent bird species of greatest conservation need documented on the Whitefish Chain of Lakes during point-count surveys, May – June, 2010 – 2011.

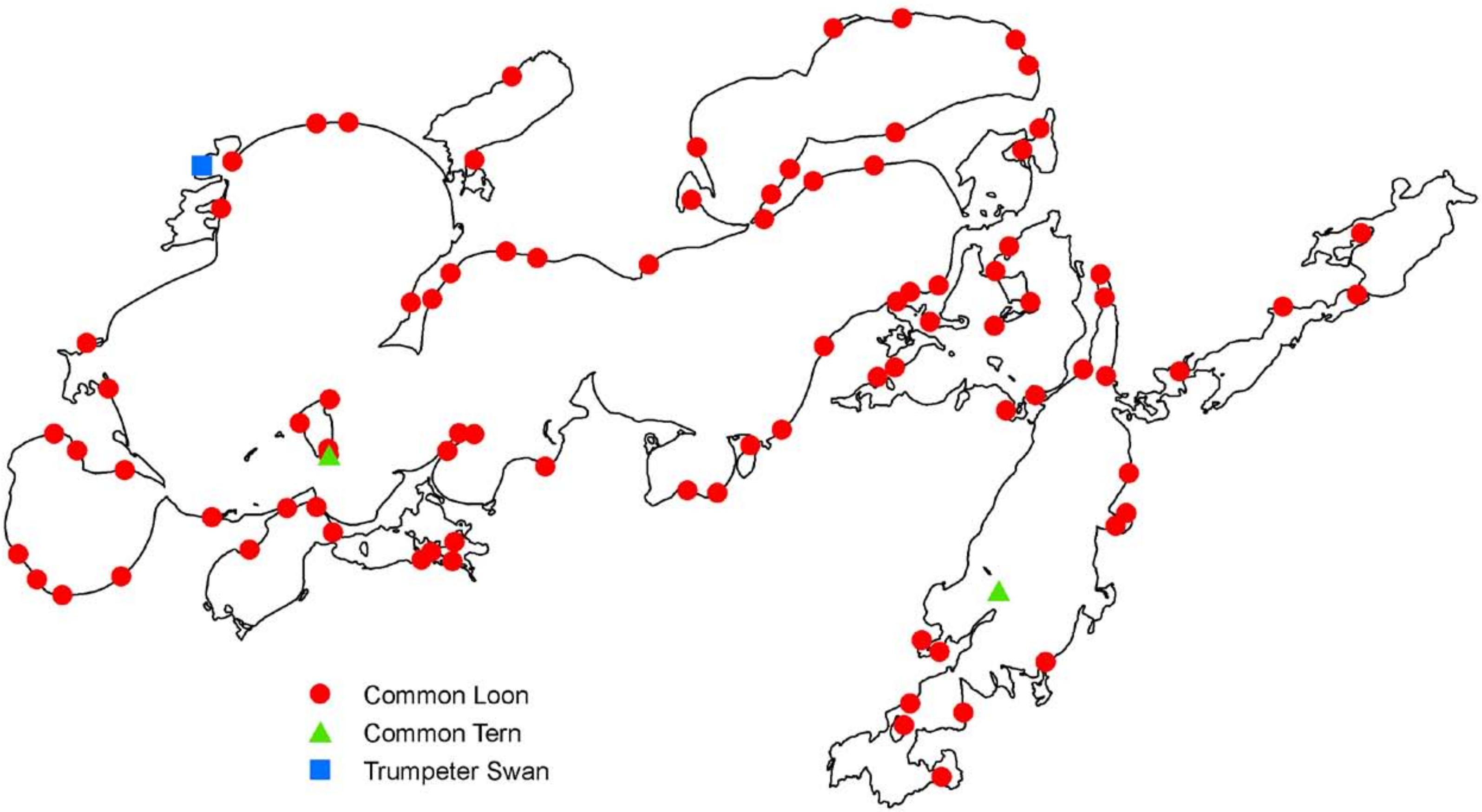


Figure 58. Distribution of forest habitat-dependent bird species of greatest conservation need documented on the Whitefish Chain of Lakes during point-count surveys, May – June, 2010 – 2011.

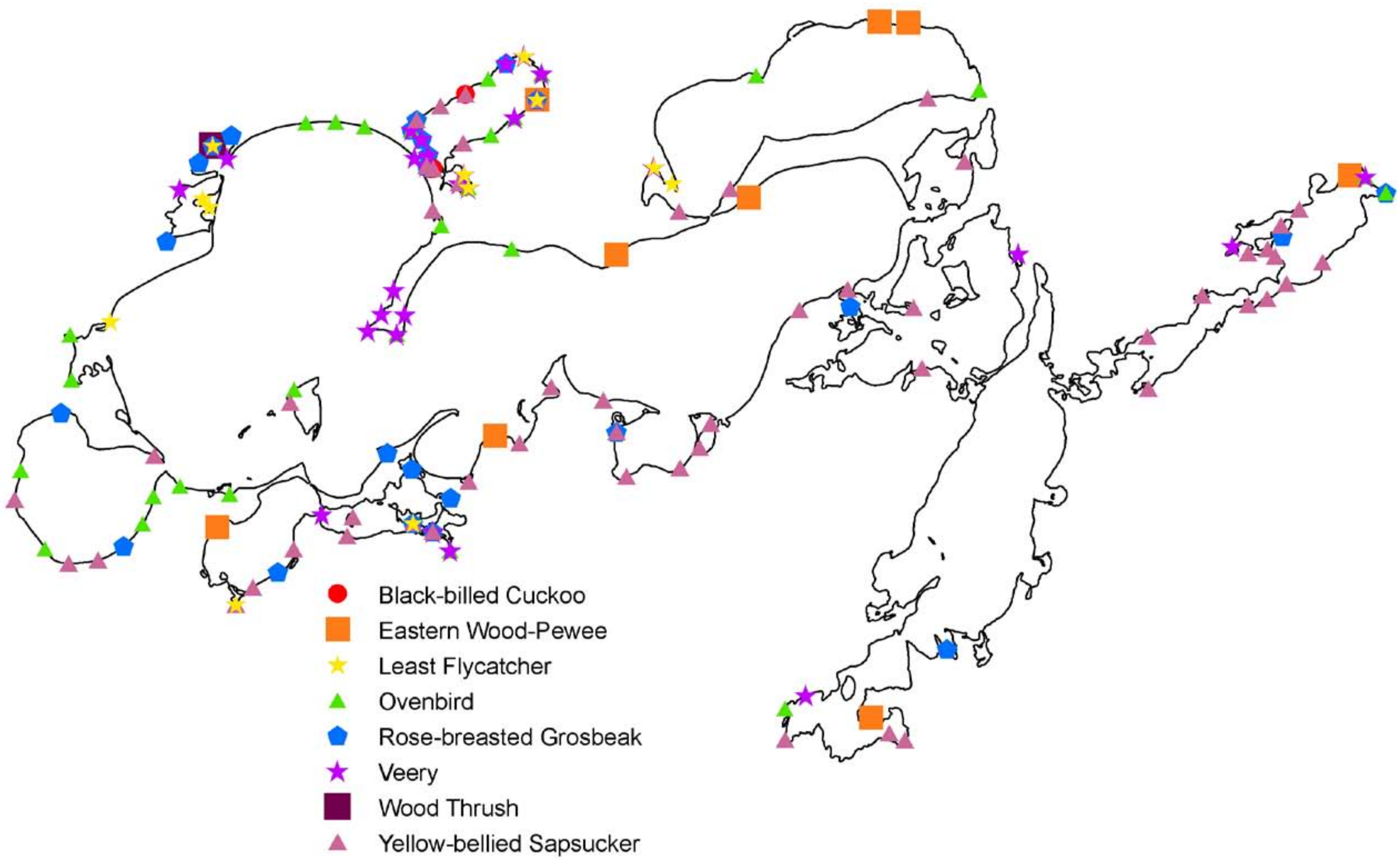


Figure 59. Distribution of wetland habitat-dependent bird species of greatest conservation need documented on the Whitefish Chain of Lakes during point-count surveys, May – June, 2010 – 2011.

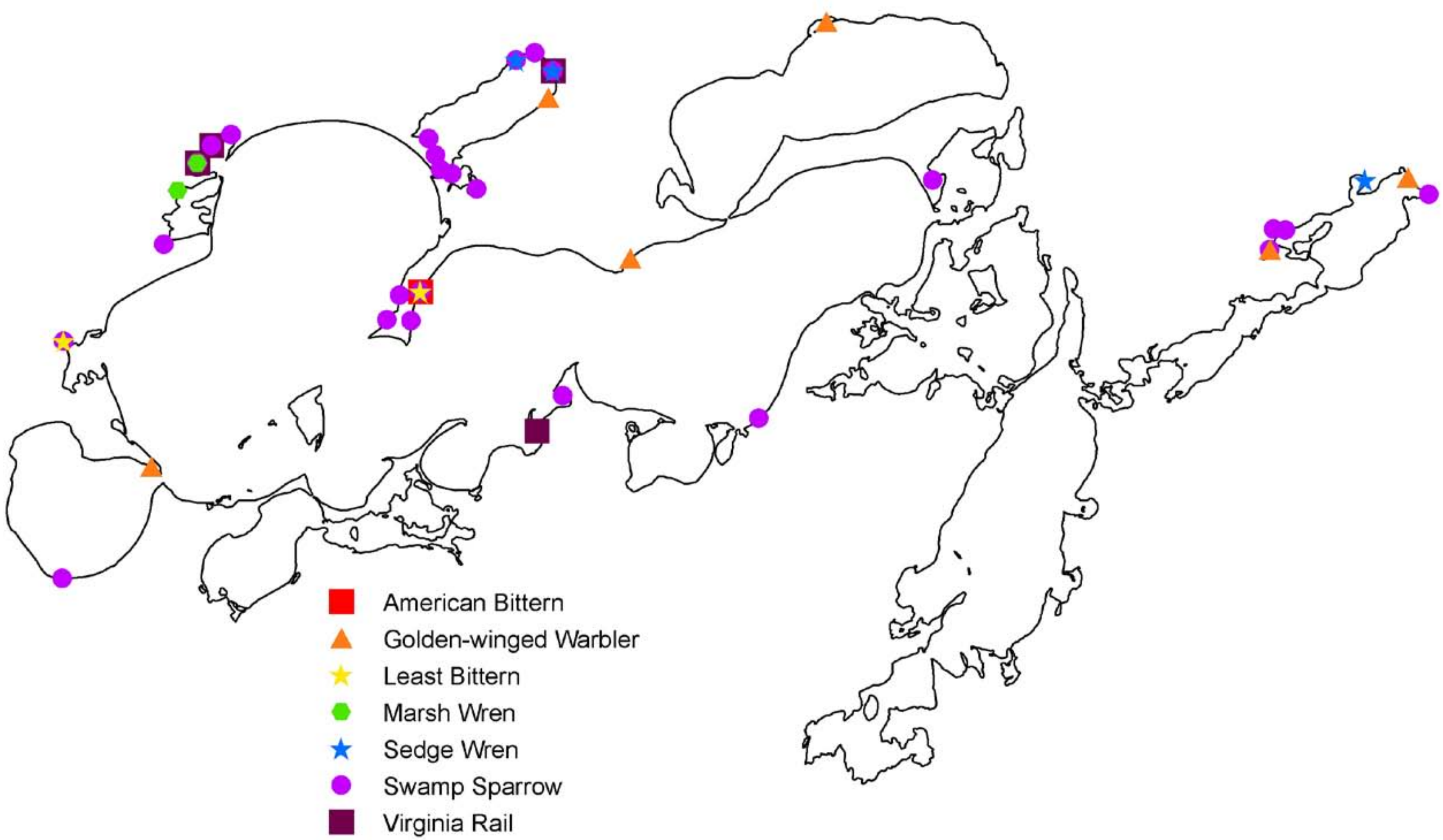
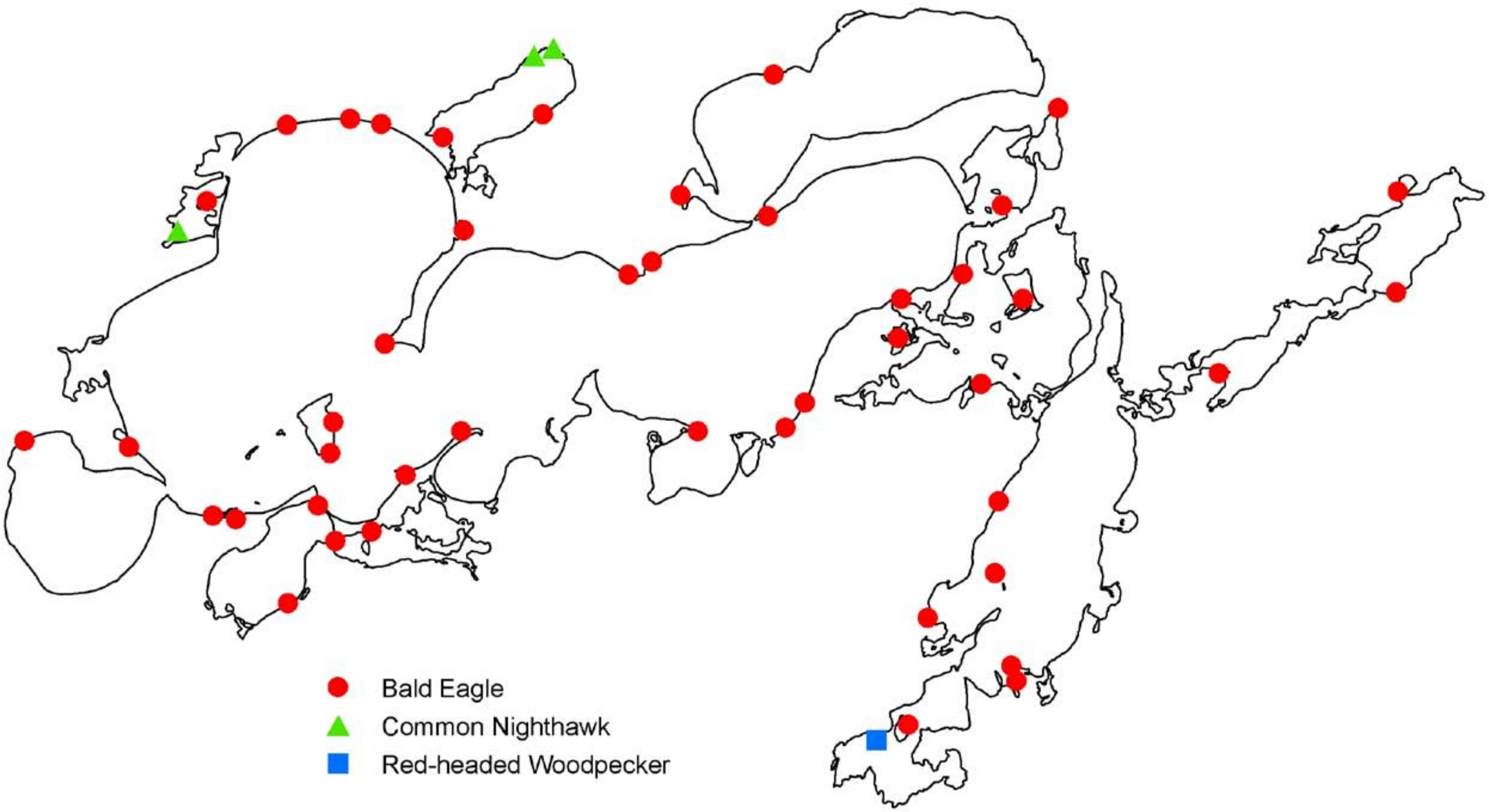


Figure 60. Distribution of bird species of conservation need that occupy a variety of or habitats other than those listed above documented on the Whitefish Chain of Lakes during point-count surveys, May – June, 2010 – 2011.



Bird Species Richness

Objective

1. Calculate and map bird richness around the shoreline of the Whitefish Chain of Lakes

Introduction

Bird species richness is affected by a number of factors, including habitat diversity and area, habitat composition, fragmentation, competition, and presence of exotic species. Species richness is generally highest in non-fragmented habitats with a variety of vegetation types. Anthropogenic disturbance, in particular, may negatively affect bird species richness in a variety of ways. Human presence in an area may result in the loss or destruction of critical habitat. Elimination of vegetation and use of pesticides may reduce the food base for a number of bird species. Human activity in an area may also disturb breeding or nesting birds. Maintaining large areas of natural habitat will be beneficial to maintaining diversity of bird species.

Methods

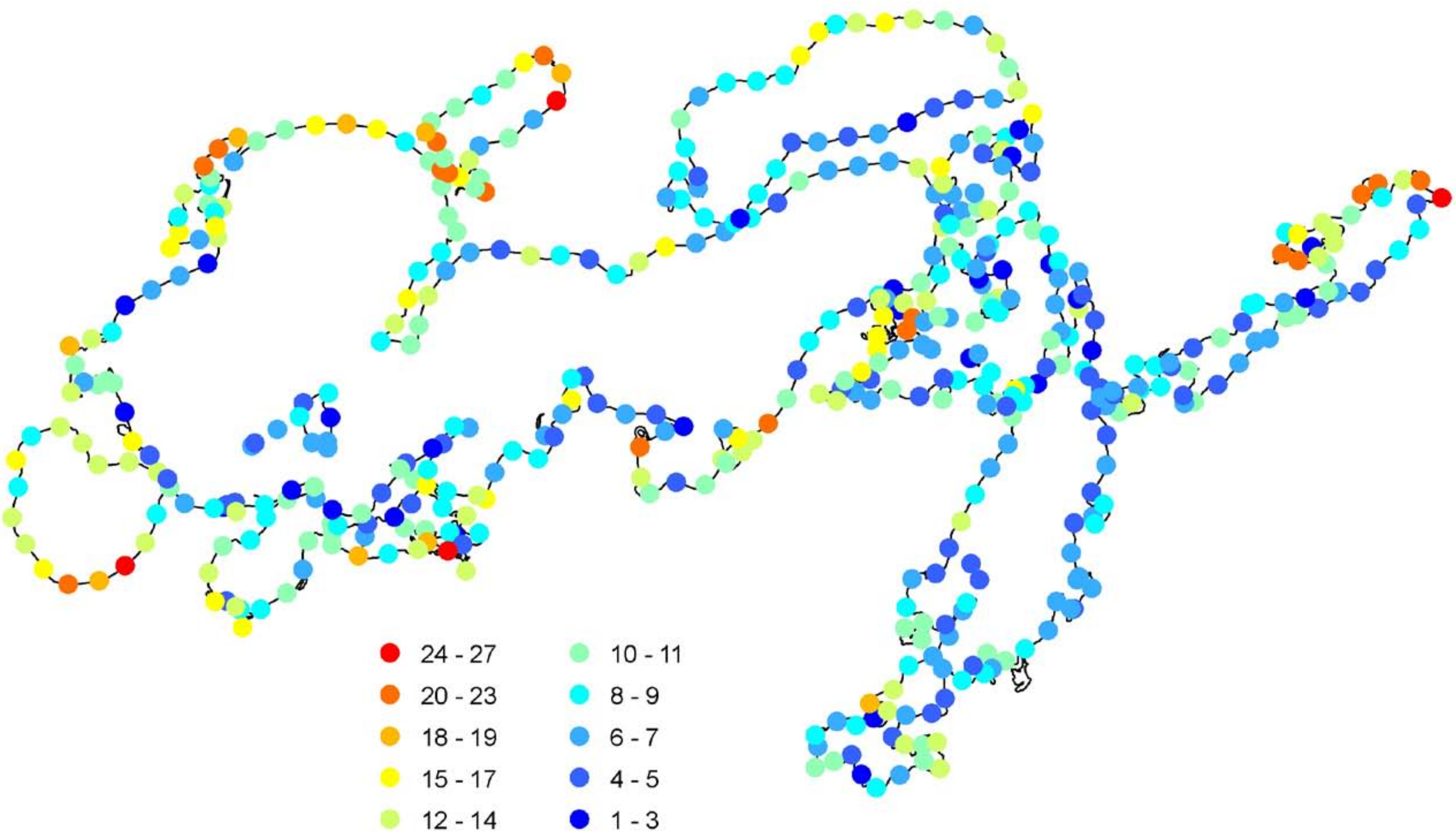
Bird species were documented during the point count and call-playback sampling surveys. At each survey station, surveyors identified and recorded the number of species found.

Results

Overall bird species richness (the number of bird species recorded at a single survey point) on the Whitefish Chain of Lakes ranged from one to 27 species at each site surveyed (Figure 61). Over 40% (N = 195) of the survey stations had ten or more species documented. Surveyors recorded fewer than five species at just over 10% of the stations. The two sites with the maximum number of species were located within Little Pine Lake (northeast corner) and along the southern shore of Clamshell Lake. Average bird species richness per survey point varied by lake. Arrowhead Lake and Lower Hay Lake had the greatest average bird species richness, with an average of over 14 species per survey station.

The maximum number of species of greatest conservation need recorded at a single survey station was seven. Surveyors recorded six species of greatest conservation need at one additional site and five species of greatest conservation need at four sites. Three of these high SGCN diversity sites were located in the northeast corner of Arrowhead Lake, and two were located within Killworry Bay on Whitefish Lake. The final site was within Clamshell Lake. Over half (N = 253) of the survey stations did not have species of greatest conservation need observed.

Figure 61. Bird species richness (number of species per sample site) on the Whitefish Chain of Lakes, May – June, 2010 – 2011.



Loon Nesting Areas

Objectives

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

Introduction

Daggett Lake loon and chicks, 2010.

The Volunteer LoonWatcher survey began in 1979 as a way for the DNR to obtain information on loon nesting areas 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.

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.

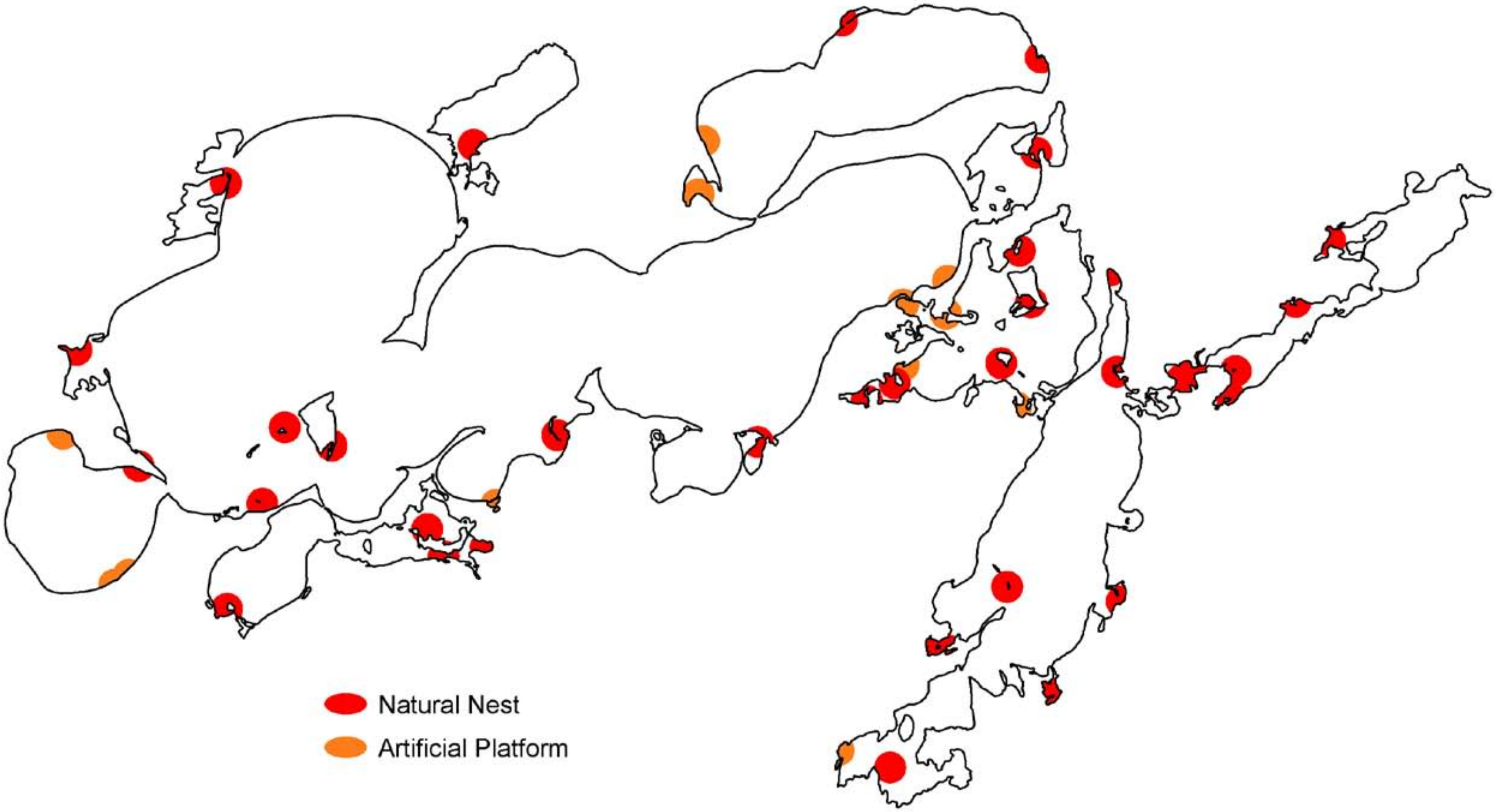
Methods

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

Since 1987, approximately 47 loon nesting areas have been identified on the Whitefish Chain of Lakes (Figure 62). Eleven of these nesting areas occur (or have occurred) on Whitefish Lake, nine were located on both Cross and Rush-Hen lakes and five nesting areas were recorded on Daggett Lake. Four loon nesting areas have been mapped on Big Trout Lake and three each have been documented on Lower Hay and Clamshell lakes. Arrowhead, Island-Loon, Little Pine, and Bertha lakes each have one documented loon nesting area. The majority of the documented nests (nearly three-fourths) are natural; 12 of the 47 areas have utilized an artificial nesting platform. Many of the nesting areas, including those on Whitefish Lake and Cross Lake, were located within protected bays, including Willow Creek/Killworry Bays, Delta Bay, and Moonlight Bay. Multiple nests were located near islands, and several were scattered along the main shoreline. Eighteen nesting areas were identified as active during 2011.

Figure 62. Location of natural loon nests and manmade loon platforms recorded on the Whitefish Chain of Lakes between 1987 and 2011.



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 competition, pollution, water quality 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 green frog (*Rana clamitans*) and mink frog (*Rana septentrionalis*). 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 63. Green frog

Photo by: Jeff LeClere, www.herpnet.net

<u>Green frogs</u> (Figure 63) 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.

Figure 64. Mink frog

Photo by: Jeff LeClere, www.herpnet.net

<u>Mink frogs</u> (Figure 64) are typically green in color with darker green or brown mottling. They emit a musky 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.

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. Surveyors listened for up to five minutes for all frog and toad calls at each station. An estimate of abundance and a calling index were recorded for both green and mink frogs. For other species, only a calling index was recorded. If survey conditions such as rain or wind noticeably affected listening ability, the survey was terminated. Frog surveys were conducted at 468 stations on the Whitefish Chain during the summer of 2010. An additional ten stations were not surveyed because of inaccessibility due to the presence of wild rice beds. As a supplement to the aquatic frog surveys, researchers conducting bird surveys on the Whitefish Chain during 2010 and 2011 noted frog and toad presence at survey stations.

Results

Target species

Both green frogs and mink frogs were documented during the Whitefish Chain of Lakes frog surveys (Figure 65). Green frogs were the most commonly documented frog species on the Whitefish Chain. Surveyors recorded this species at 68 survey stations (Figure 65), found most frequently along the shorelines of lakes in the east and south regions of the chain; Bertha, Clamshell, Big Trout, Island-Loon, Rush-Hen, Cross, Daggett, and Little Pine. Although not as widespread, green frogs were also documented at one station on Lower Hay Lake and three stations along the shoreline of Whitefish Lake. Abundance estimates of green frogs ranged from one frog (at 16 stations) to more than 20 frogs (at one station). The highest densities of green frogs were found in a small bay on the east side of Cross Lake (Figure 66). Index values for green frogs ranged from one (individual frogs could be counted; silence between calls) to three (full chorus of frogs; calls constant, continuous, and overlapping).

Mink frogs were documented at 36 stations on the Whitefish Chain (Figure 67), occurring in northern regions of the chain on the following lakes; Arrowhead, Whitefish, Big Trout, Island-Loon, Rush-Hen, Cross, Daggett, and Little Pine. On Whitefish Lake, mink frogs were limited to the vegetated bays at the northwest end of the lake and also occurred at a single point on the south shore just east of Pig Lake. Mink frogs were also limited on Rush-Hen Lake, associated with the western shoreline, while a single mink frog was found at one station at the north end of Cross Lake. The highest densities of mink frogs were found in the northwest bays of Whitefish Lake and the northeast end of Arrowhead Lake (Figure 67). Abundance estimates ranged from one frog (at 10 stations) to more than 10 frogs (at two stations); no mink frog choruses were recorded.

Other species

In addition to green and mink frogs, surveyors recorded gray treefrogs (*Hyla versicolor*), spring peepers (*Pseudacris crucifer*), American toads (*Bufo americanus*), northern leopard frogs (*Rana pipiens*), western chorus frogs (*Pseudacris triseriata*) and wood frogs (*Rana sylvatica*) along the shorelines of the Whitefish Chain. Gray treefrogs were documented at 21 survey stations.

Although they were distributed widely, they were particularly abundant along sections of shoreline at Arrowhead Lake, Lower Hay Lake, and Big Island on Whitefish Lake. Spring peepers were recorded at four stations, all associated with Arrowhead Lake, Whitefish Lake, and Big Island on Whitefish Lake. Surveyors also documented American toads, northern leopard frogs, western chorus frogs, and wood frogs at various locations during bird surveys.

Figure 65. Distribution of green and mink frogs documented during surveys on the Whitefish Chain of Lakes, 2010.

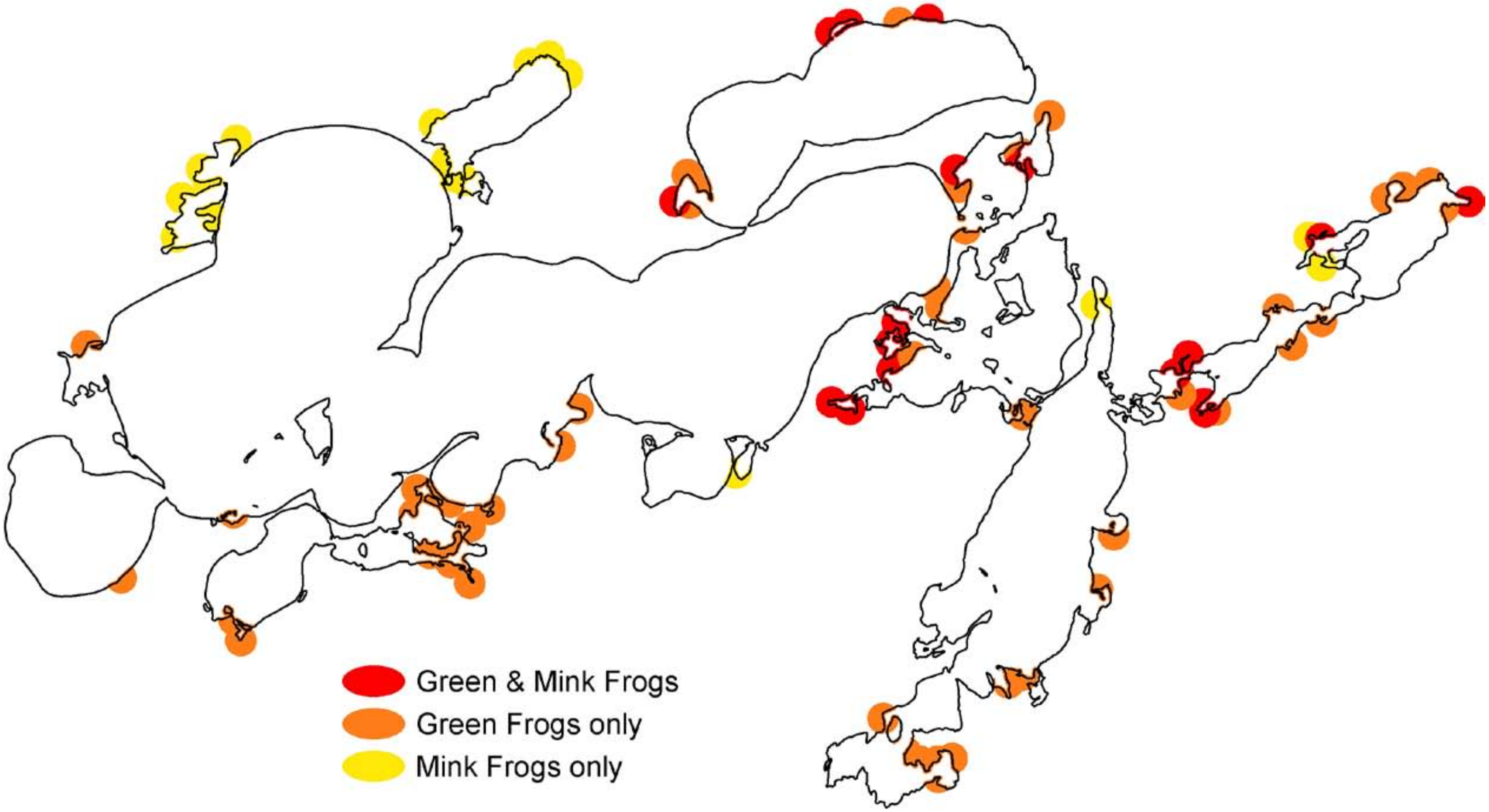


Figure 66. Abundance estimates of green frogs on the Whitefish Chain of Lakes, 2010.

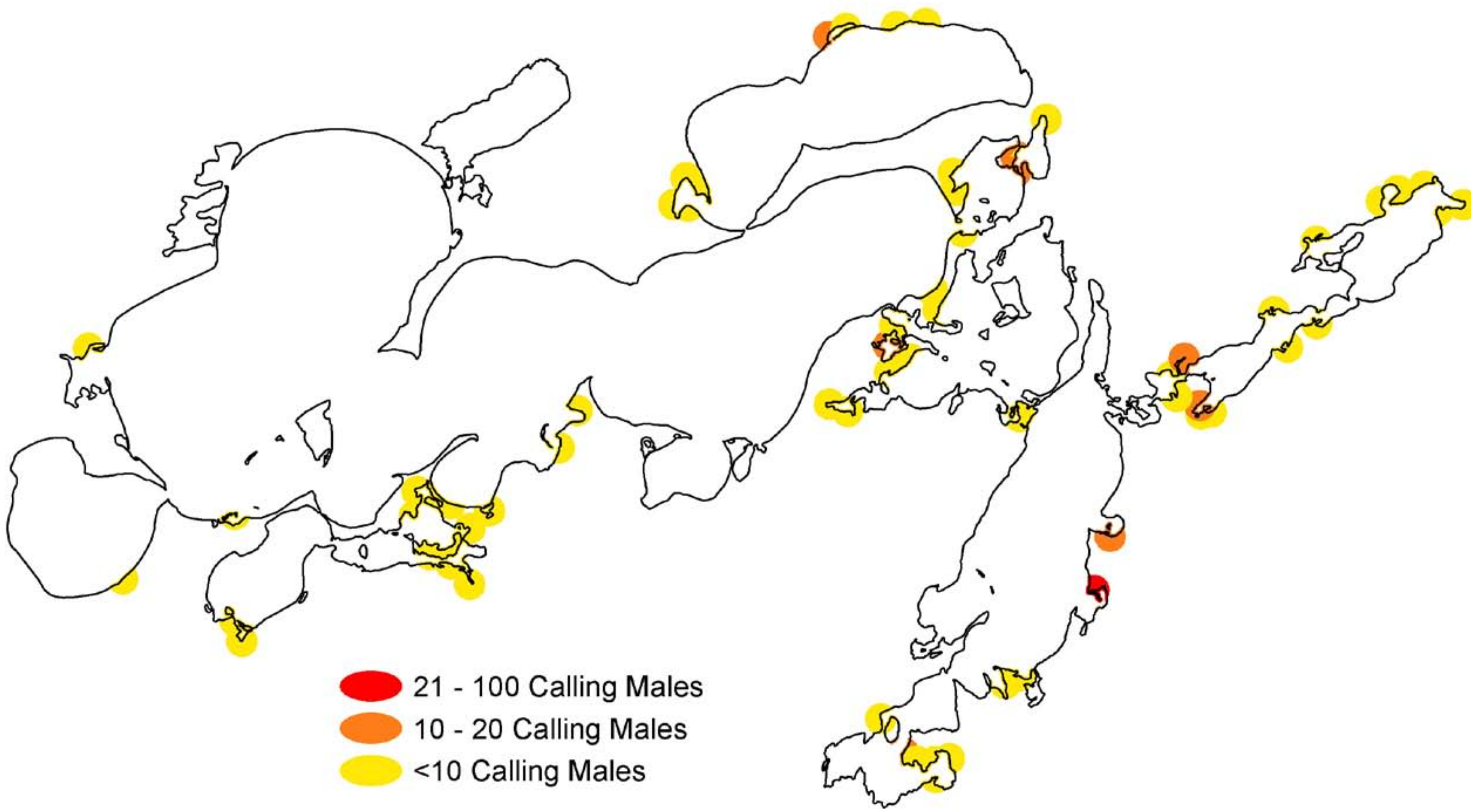
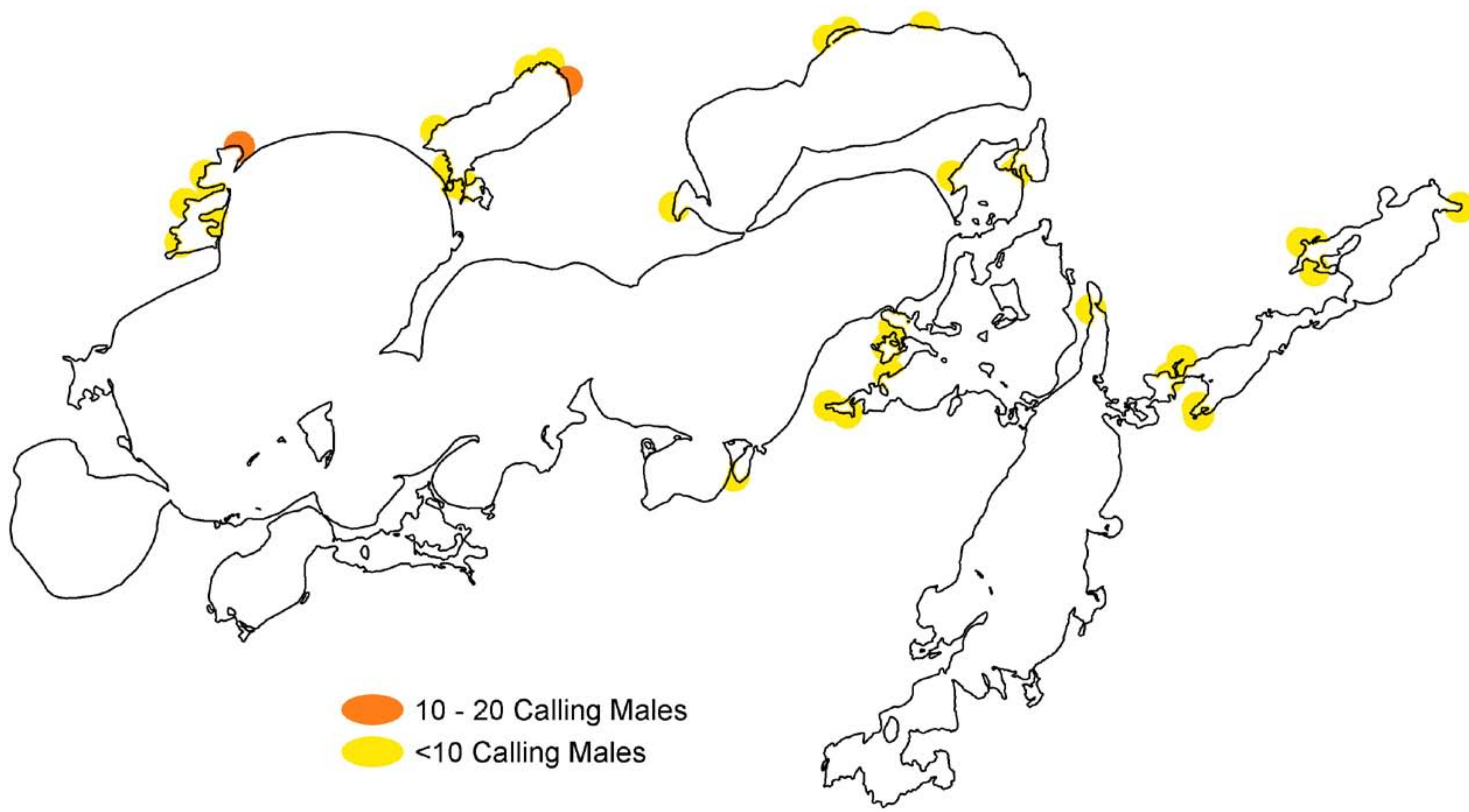


Figure 67. Abundance estimates of mink frogs on the Whitefish Chain of Lakes, 2010.



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
Within the state of Minnesota, there are 47 fish species of greatest conservation need (SGCN). Of these 47 species, three are near-shore species found within Crow Wing 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 68) are small (38 – 56 mm), slender, silverish-yellow minnows. They possess a distinctively upturned mouth that gives them a "pugnose" appearance. They are secretive minnows, and are often found in schools of 15 to 35 individuals. Pugnose shiners inhabit clear lakes and low-gradient streams and are intolerant of turbidity. Vegetation, particularly pondweed, coontail, and bulrush, is an important habitat component.

Figure 68. Pugnose shiner

Photo by: Konrad Schmidt

Least darters (*Etheostoma microperca*; Figure 69) 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 are a preferred habitat feature. Removal of vegetation, riparian area modification, and poor water quality all pose threats to the least darter.

Figure 69. Least darter

Photo by: Konrad Schmidt

Longear sunfish (*Lepomis megalotis*; Figure 70) 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 70. 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 SGCNs.

Blackchin shiners (*Notropis heterodon*; Figure 71) 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 71. Blackchin shiner

Photo by: Konrad Schmidt

Blacknose shiners (*Notropis heterolepis*; Figure 72) 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 72. Blacknose shiner

Photo by: Konrad Schmidt

Banded killifish (*Fundulus diaphanus*; Figure 73) 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 73. 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 birds and 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 accessible. All species captured using the different sampling methods were identified and counted. Target fish species included near-shore species of greatest conservation need (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 (%) of a sampling area that contained submerged aquatic vegetation.

Results

Fish surveys were conducted at 459 survey stations. An additional 19 stations were not surveyed due to inaccessibility influenced by the presence of wild rice beds or dense aquatic vegetation. Three near-shore fish species of greatest conservation need and all three proxy species were detected during these surveys. The pugnose shiner was found at a single location on Rush-Hen Lake (Figure 75). Least darters were documented at five stations; three on Big Trout and two on Cross. Longear sunfish were more widely distributed, present at 28 survey stations including 13 on Cross, nine on Rush-Hen, three on Daggett, two on Whitefish, and one on Bertha.

Banded killifish were the most frequently documented proxy species, occurring on all lakes throughout the chain with the exception of Arrowhead Lake (Figure 76). Surveyors found this species at 71 survey stations. Less frequently occurring, blackchin shiners were found at 22 locations; seven on Cross, three on Whitefish, three on Big Trout, three on Clamshell, two on Island-Loon, and one each on Bertha, Daggett, Little Pine, and Rush-Hen. Also less widespread, blacknose shiners were documented at 21 survey sites; five on Cross, three on Clamshell, three on Island-Loon, three on Lower Hay, two on Rush-Hen, two on Big Trout, one on Bertha, one on Daggett, and one on Whitefish.

Aquatic plant biovolume was greater than 80% at sites that contained pugnose shiners and least darters. Substrate type was generally soft and small in diameter, consisting of muck, silt, or sand. Sites supporting longear sunfish had variable biovolume, ranging from zero to 95% biovolume. On Cross Lake, longear sunfish were most frequently found in the rocky shoreline structure, and included longear/sunfish hybrids. Proxy species were found mainly on muck, silt, or sand substrates. Aquatic plant biovolume was virtually identical between sites that contained proxy species and sites that did not.

Arrowhead Lake sampling sites generally had the highest biovolume, averaging over 70%. Clamshell averaged nearly 62% biovolume followed by Rush-Hen at 44%, Little Pine at 43%, Daggett at 40%, Island-Loon at 26%, Cross at 25%, Whitefish at 22%, Bertha at 19%, Big Trout at 19%, Lower Hay at 17%, and Pig at 8%.

Overall, thirty-nine fish species were identified across the entire chain (Table 10). Bluegills and largemouth bass occurred most frequently; surveyors found these species at 57% of stations sampled. Also widespread were bluntnose minnows found at 45% of sites surveyed, followed by yellow perch at 43% and johnny darters at 42% of locations surveyed. Species classified as "singletons" (only a single specimen captured during the entire survey period) include spotfin shiner, pugnose shiner, finescale dace, creek chub, and greater redhorse.

Several fish species previously undocumented in the Whitefish Chain were identified. Eight new species were found, bringing the total historical observed fish community on this chain of lakes to 50 species. The newly documented species include central mudminnow, creek chub, finescale dace, least darter, longnose dace, mottled sculpin, pugnose shiner, and spotfin shiner.

One additional fish species of greatest conservation need, the greater redhorse (*Moxostoma valenciennesi*; Figure 74) was documented. One greater redhorse was captured in a seine-haul on Whitefish Lake. Although greater redhorse are not a near-shore species, they are sensitive to chemical pollutants and turbidity, and inhabit clear water rivers and lakes.

Other species documented during past surveys on the Whitefish Chain of Lakes not captured during this survey include walleye, shorthead redhorse, silver redhorse, golden redhorse, lake whitefish, tullibee (cisco), emerald shiner, bigmouth shiner, fathead minnow, northern redbelly dace, and trout-perch.

Figure 74. Greater redhorse

Table 10. Species list and frequency of occurrence of fish species identified during Whitefish Chain of Lakes surveys, July 2010 – August 2011. * denotes a species of greatest conservation need. Values represent percent of survey stations in which a fish species occurred (N=459)

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Bowfins	Bowfin	*Amia calva*	2	12	0	2	3	5	0	0	0	0	0	0	0
Minnows	Spotfin shiner	*Cyprinella spiloptera*	<1	0	0	0	0	0	0	0	0	<1	0	0	0
	Common shiner	*Notropis cornutus*	2	0	0	0	0	0	9	0	0	7	0	0	0
	Hornyhead chub	*Nocomis biguttatus*	<1	0	0	3	0	0	0	0	0	<1	0	0	0
	Golden shiner	*Notemigonus crysoleucas*	8	6	0	3	6	5	6	71	6	2	0	29	0
	Pugnose shiner*	*Notropis anogenus*	<1	0	0	0	2	0	0	0	0	0	0	0	0
	Blackchin shiner	*Notropis heterodon*	5	6	4	8	2	10	9	0	0	2	0	14	6
	Blacknose shiner	*Notropis heterolepis*	5	0	4	6	3	14	6	0	19	<1	0	14	6
	Spottail shiner	*Notropis hudsonius*	10	0	0	1	0	0	26	14	31	20	0	0	17
	Mimic shiner	*Notropis volucellus*	12	0	4	5	3	0	34	14	13	23	0	5	6
	Finescale dace	*Phoxinus neogaeus*	<1	0	0	0	0	0	0	0	0	<1	0	0	0
	Bluntnose minnow	*Pimephales notatus*	45	18	48	51	36	67	71	10	44	44	43	38	56
	Longnose Dace	*Semotilus atromaculatus*	13	12	4	2	2	10	24	0	31	28	43	0	17
	Creek Chub	*Semotilus atromaculatus*	<1	0	0	0	0	0	0	0	0	<1	0	0	0
Suckers	White sucker	*Catostomus commersonii*	6	0	0	0	2	0	9	10	25	14	0	0	0
	Greater redhorse*	*Moxostoma valenciennesi*	<1	0	0	0	0	0	0	0	0	<1	0	0	0
Bullheads & Catfishes	Black bullhead	*Ameiurus melas*	<1	0	0	0	0	0	0	0	0	<1	0	5	0
	Yellow bullhead	*Ameiurus natalis*	5	6	0	9	6	14	0	0	0	4	14	5	6
	Brown bullhead	*Ameiurus nebulosus*	<1	0	0	0	2	0	0	0	0	<1	0	0	0
	Tadpole madtom	*Noturus gyrinus*	1	0	0	1	0	0	0	0	0	2	0	0	6
Pikes	Northern pike	*Esox lucius*	2	0	0	2	2	0	0	10	0	3	0	5	0
Mudminnows	Central mudminnow	*Umbra limi*	9	18	7	3	17	14	20	24	0	2	0	14	11
Burbot	Burbot	*Lota lota*	1	0	0	2	0	0	0	0	0	<1	0	0	0

Table 10, continued.

Description	Common Name	Scientific Name	Entire Chain	Little Pine	Daggett	Cross	Rush-Hen	Island-Loon	Big Trout	Arrowhead	Lower Hay	Whitefish	Pig	Clamshell	Bertha
Killifishes & Topminnows	Banded killifish	*Fundulus diaphanus*	15	6	7	21	12	10	34	0	13	11	14	38	17
Sticklebacks	Brook stickleback	*Culaea inconstans*	<1	0	0	0	2	0	0	0	0	2	0	0	0
Sculpin	Mottled sculpin	*Cottus bairdii*	2	0	0	0	0	0	17	0	0	3	0	0	0
Sunfishes	Rock bass	*Ambloplites rupestris*	13	6	26	25	8	19	14	0	0	12	14	0	0
	Green sunfish	*Lepomis cyanellus*	22	41	67	37	12	38	26	0	6	6	43	14	33
	Pumpkinseed	*Lepomis gibbosus*	16	6	19	23	24	19	9	10	0	13	14	10	11
	Bluegill	*Lepomis macrochirus*	57	35	63	66	80	43	63	14	6	45	43	71	33
	Longear sunfish*	*Lepomis megalotis*	5	0	11	15	14	0	0	0	0	2	0	0	6
	Smallmouth bass	*Micropterus dolomieu*	15	0	0	13	20	24	31	0	6	22	14	0	0
	Largemouth bass	*Micropterus salmoides*	57	41	48	62	53	71	57	81	69	50	71	67	56
	Black crappie	*Pomoxis nigromaculatus*	4	0	0	0	2	0	0	57	0	3	0	5	0
Perches	Iowa darter	*Etheostoma exile*	13	0	11	20	12	19	29	5	1	5	0	33	17
	Least darter*	*Etheostoma microperca*	1	0	0	2	0	0	9	0	0	0	0	0	0
	Johnny darter	*Etheostoma nigrum*	42	12	19	41	17	33	83	5	94	53	43	29	67
	Yellow perch	*Perca flavescens*	43	18	37	29	47	48	34	57	63	50	29	48	50
	Logperch	*Percina caprodes*	38	18	22	47	11	14	37	0	88	62	57	0	44

Figure 75. Distribution of near-shore fish species of greatest conservation need documented during surveys on the Whitefish Chain of Lakes, July 2010 – August 2011.

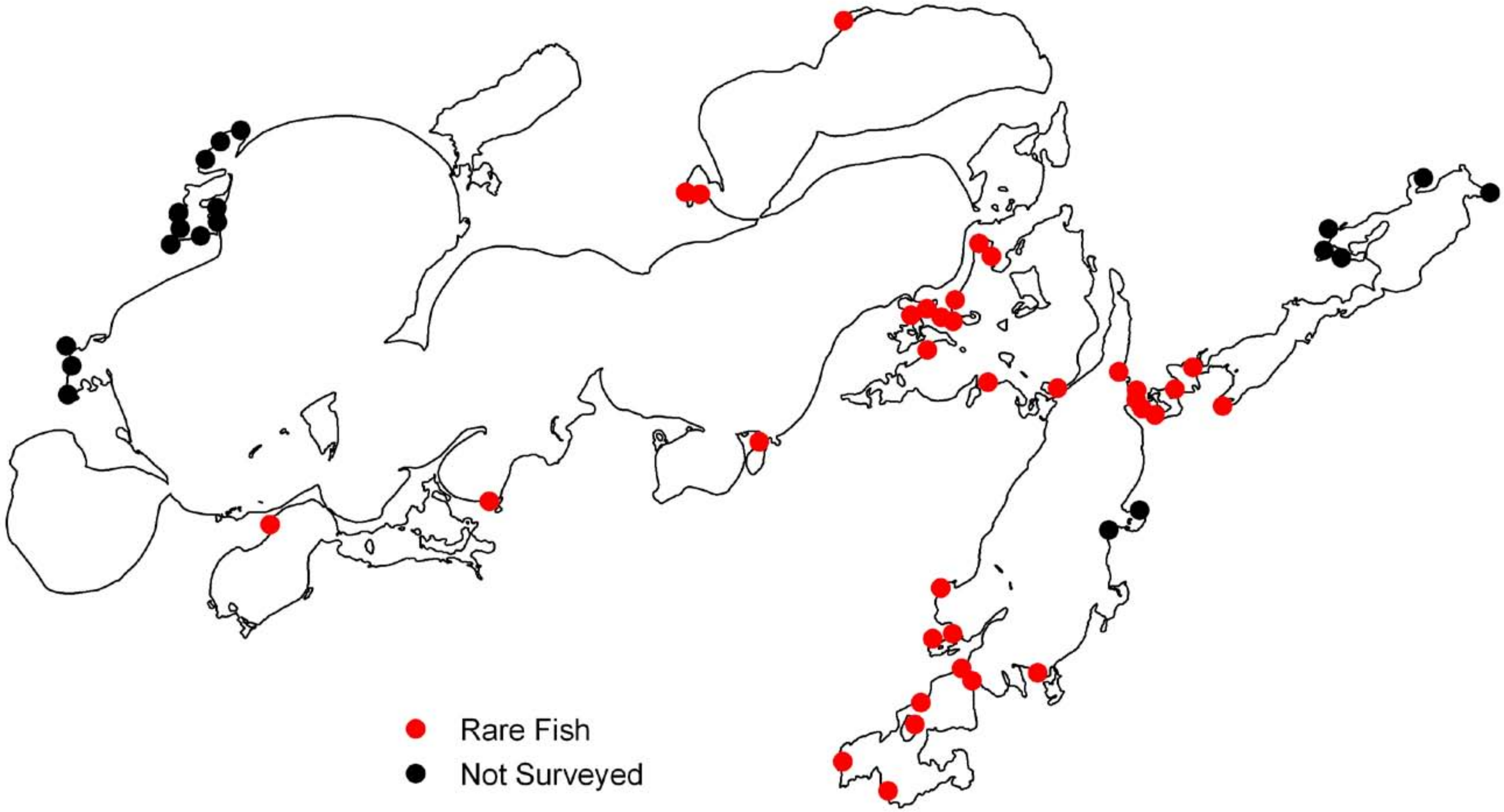
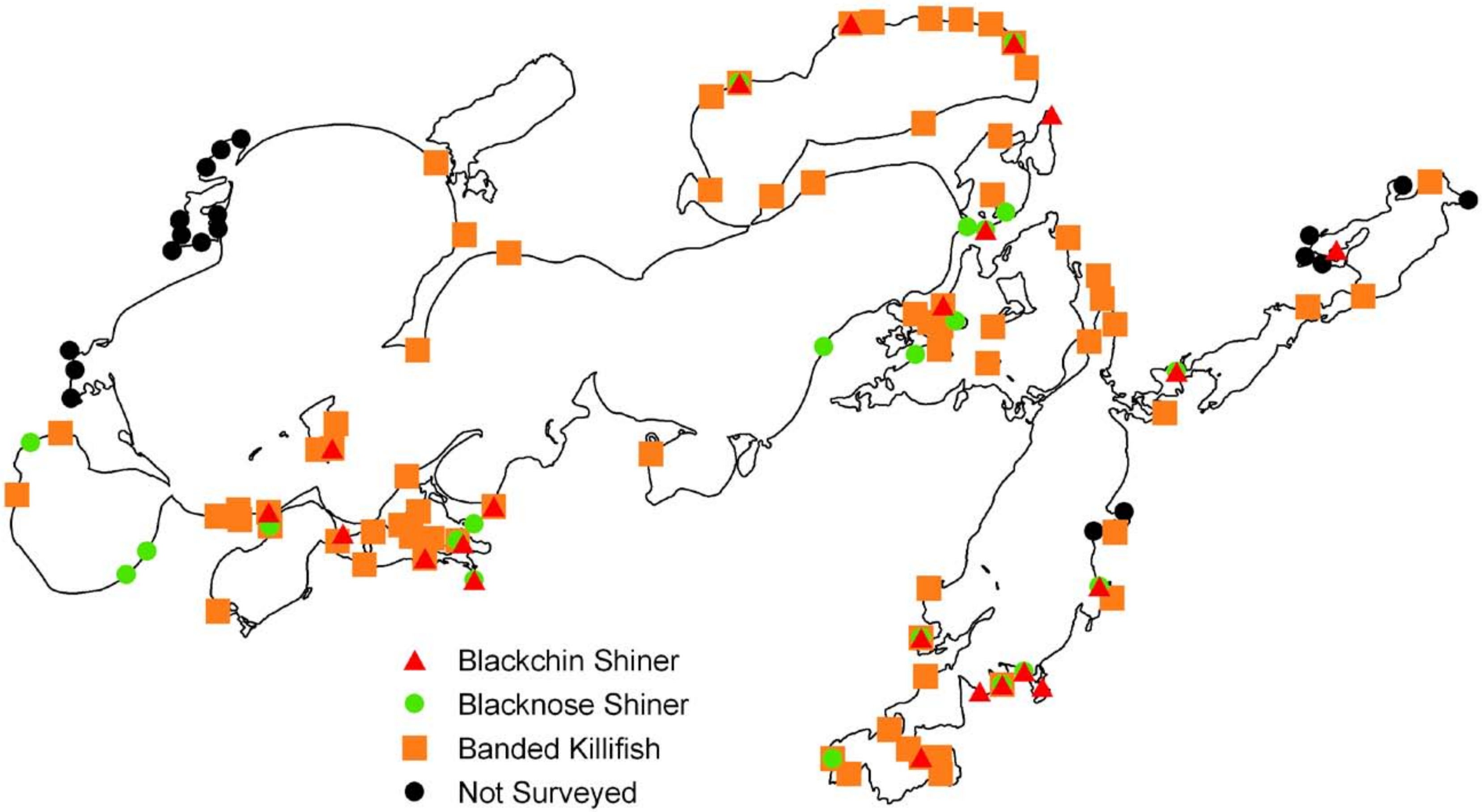


Figure 76. Distribution of fish proxy species documented during surveys on the Whitefish Chain of Lakes, July 2010 – August 2011.



Aquatic Vertebrate Richness

Objectives

1. Calculate and map aquatic vertebrate richness around the shoreline of the Whitefish 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 trapnetting, 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.

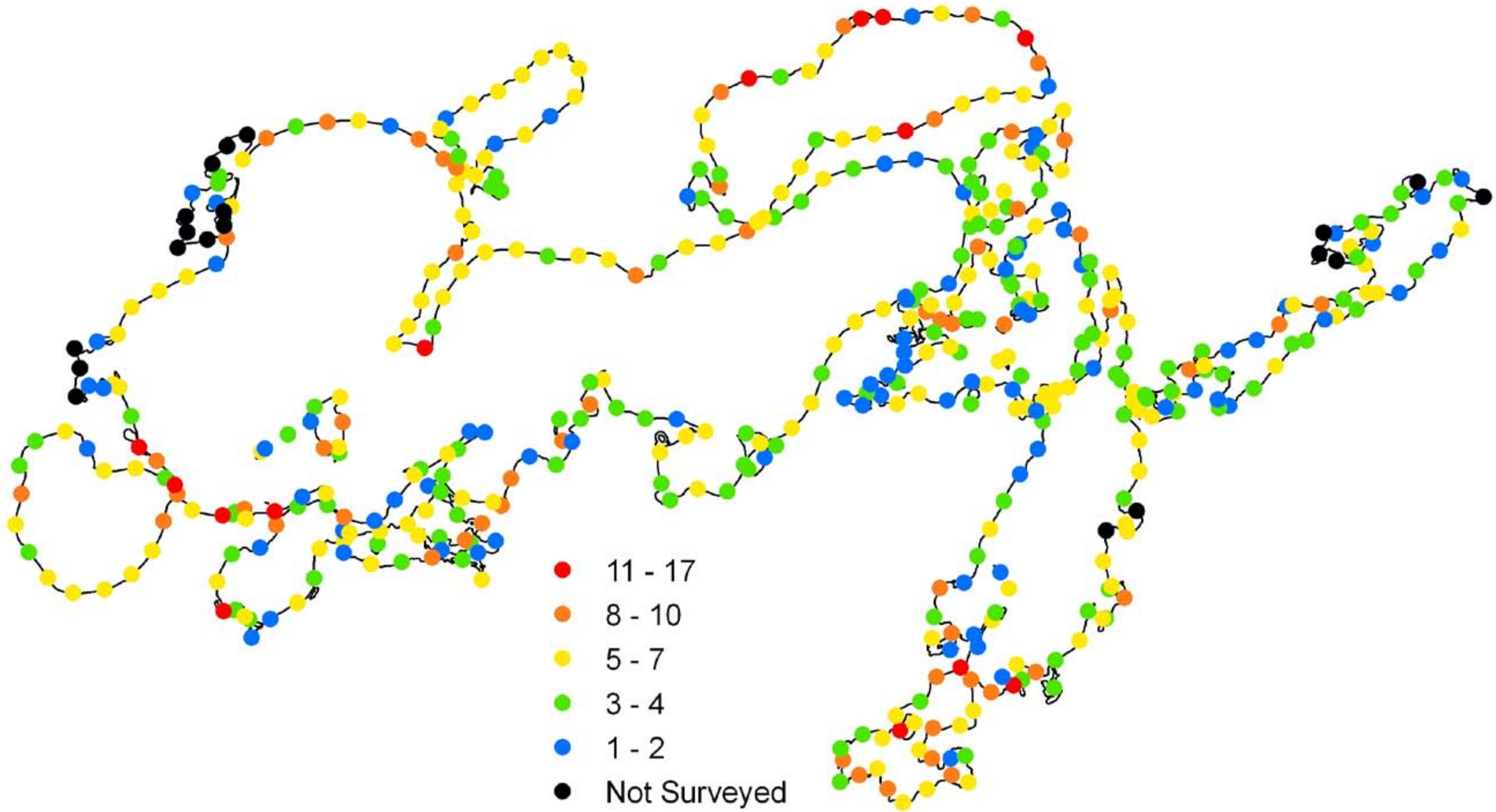
Results

Individual survey stations contained between one and 17 aquatic vertebrate species (Figure 77). Big Trout Lake had the maximum number of species at a single site (N=17), along with two sites at 14 species each. Whitefish Lake also had one site with 14 species, followed by Big Trout with 13 species at a single site. Throughout the entire chain, survey effort yielded 10 or more species at 25 (5%) sites sampled, while 30 sites (7%) yielded only a single aquatic vertebrate species. Overall, Whitefish Lake revealed the greatest lake-wide diversity with 36 aquatic vertebrate species, followed by Cross Lake and Rush-Hen with 27 species found on each.

The majority of the documented vertebrate species were fish, although mink frogs and green frogs were also documented. Hybrid sunfish were observed during the surveys, but were not included in the analysis. All of the aquatic vertebrate species identified during the surveys were native. Several invertebrate species were also documented at sample sites, including native crayfish, mussels, insect larvae, and bryozoans.

Low species richness values calculated for some sites may not necessarily reflect actual vertebrate diversity. Survey stations with abundant aquatic vegetation limited the ability to conduct seine hauls, and electrofishing at these sites was conducted from a boat and may not have been as effective as standard shoreline electrofishing techniques. Therefore, actual species richness for some locations may well be higher than survey results indicate.

Figure 77. Aquatic vertebrate species richness (number of species per survey station) documented during fish surveys on the Whitefish Chain of Lakes, July 2010 – August 2011.



Other Rare Features

Objectives

1. Map rare features occurring within the extended state-defined shoreland area of the Whitefish 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 Federally 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.

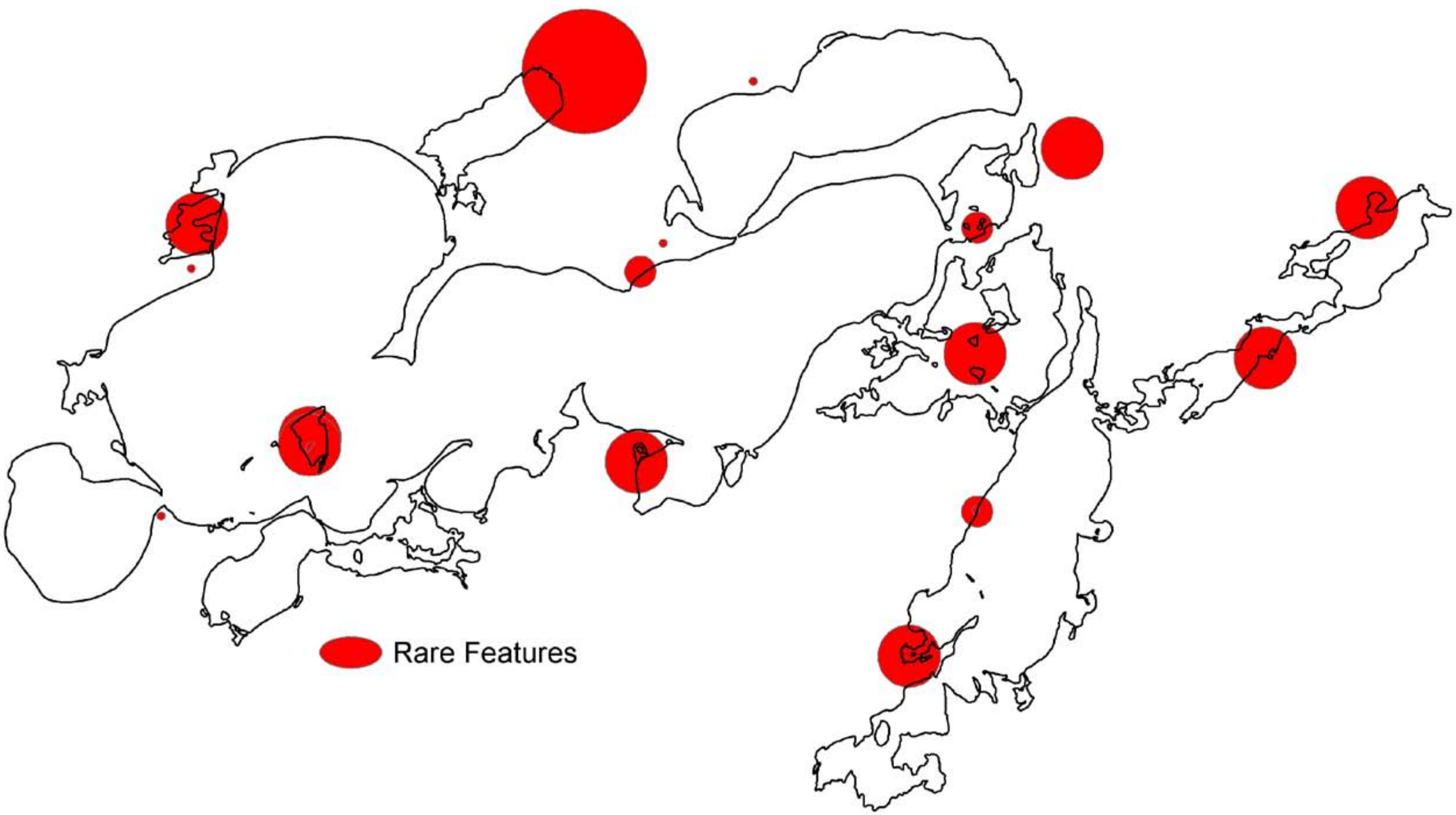
Methods

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

Seven rare features have been documented within 1320 feet of the Whitefish Chain of Lakes shoreline (Figure 78). The rare features include the nesting areas of a bird species of special concern, as well as locations of two special concern fish species, and three fern species of special concern and endangered status. The publication of exact descriptive and locational information is prohibited in order to help protect these rare species.

Figure 78. Natural Heritage Database rare features (Federal or State-listed endangered, threatened, or special concern species) located within 1320 feet of the Whitefish 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.

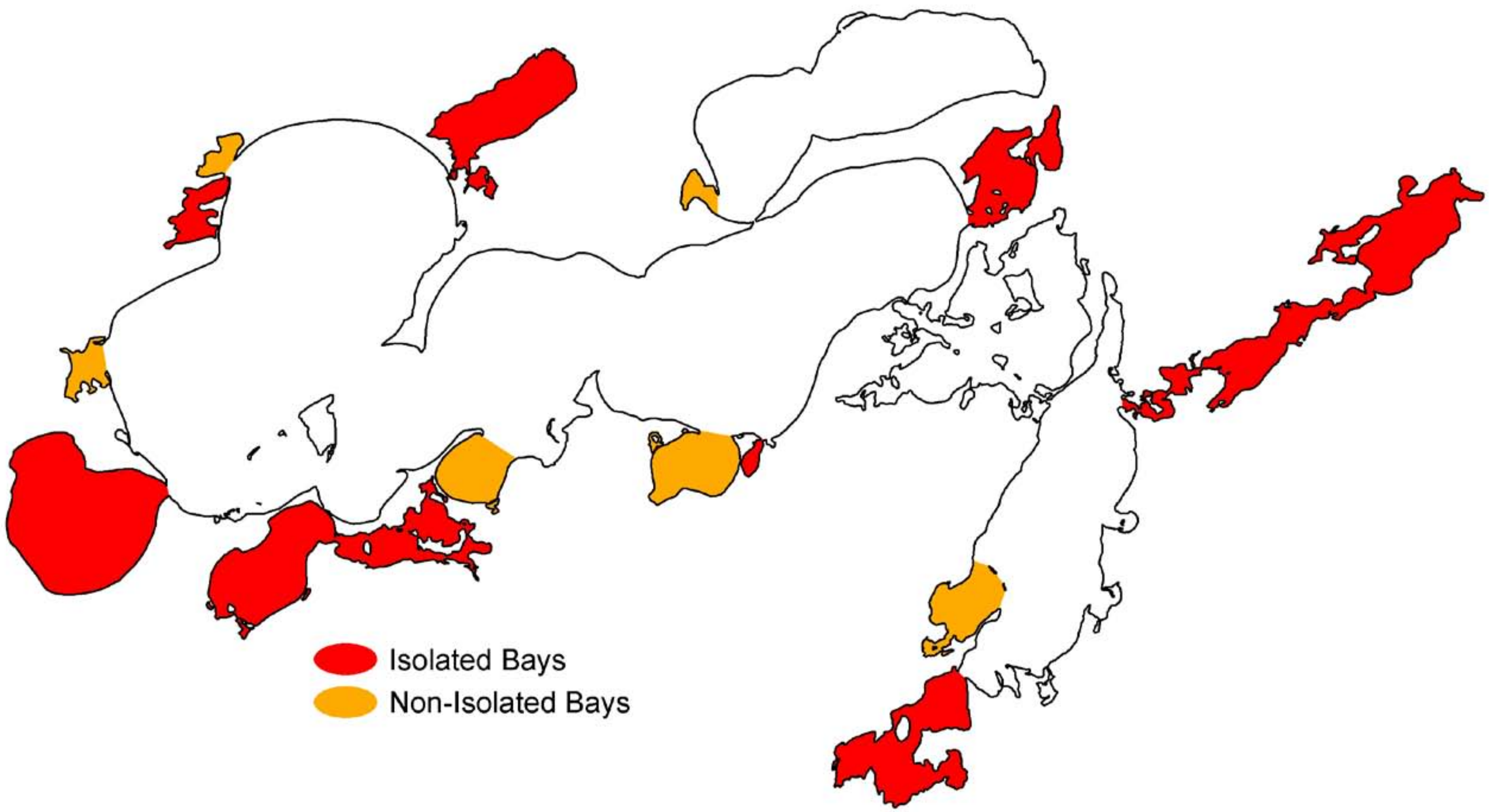
Methods

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, 10 isolated bays and 6 non-isolated bays were identified on the Whitefish Chain of Lakes (Figure 79). Bays were delineated by looking at the chain as a whole. Arrowhead, Island-Loon, Lower Hay, Bertha, Clamshell, Little Pine, and Daggett lakes were considered isolated from the main basin of Whitefish Lake. On Whitefish Lake, Willow Creek Bay, and the southeast bay by Pig Lake were considered Isolated. Two isolated bays were located on Cross Lake; one was the channel that connects Cross Lake to Daggett Lake, and the other was the southern bay. Non-isolated bays included three bays on Whitefish Lake: Killworry Bay, Delta Bay, Rutgers Bay; Pig Lake, the southwest bay on Big Trout Lake and the west bay on Cross Lake.

Figure 79. Location of isolated and non-isolated bays on the Whitefish 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 14 variables. These scores were based on each variable's presence or abundance in relation to the analysis window (Table 11). 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 80). 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 81). 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 82).

Table 11. 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
Birds	3	Presence of 3 or more species of greatest conservation need (SGCN) within analysis window
	2	Presence of 2 SGCN
	1	Presence of 1 SGCN
	0	No SGCN present
Bird Richness	3	Total number of bird species within analysis window > 25
	2	Total number of bird species 11 – 25
	1	Total number of bird species 1 – 10
	0	No bird species observed
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

Table 11, continued.

Variable	Score	Criteria
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
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 80. Total score layer created by summing scores of all 14 variables. Highest total scores represent most sensitive areas of shoreline.

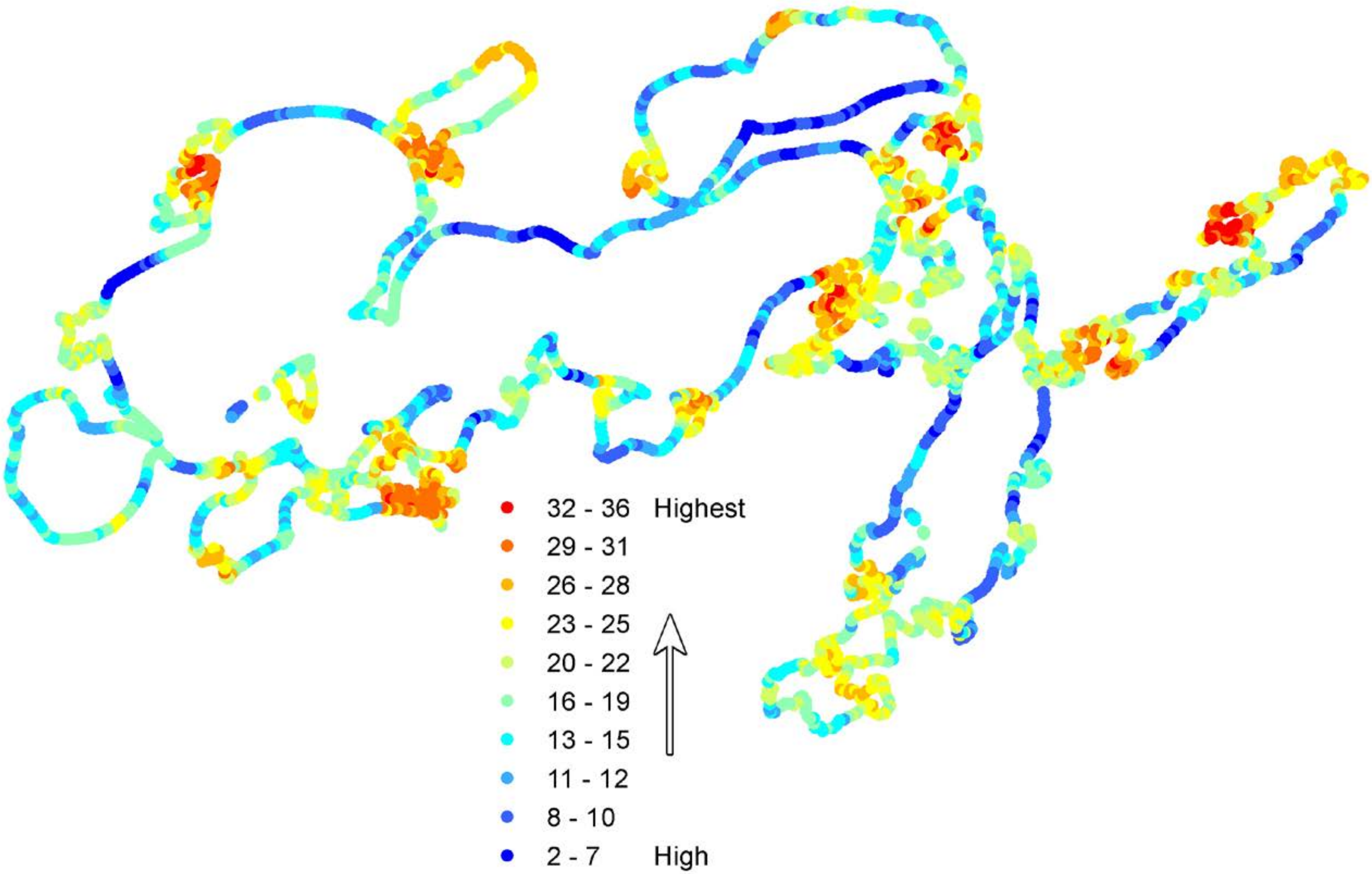


Figure 81. GIS-identified clusters of points with similar total scores. Red areas are those with high scores (i.e., areas of highly sensitive shoreland).

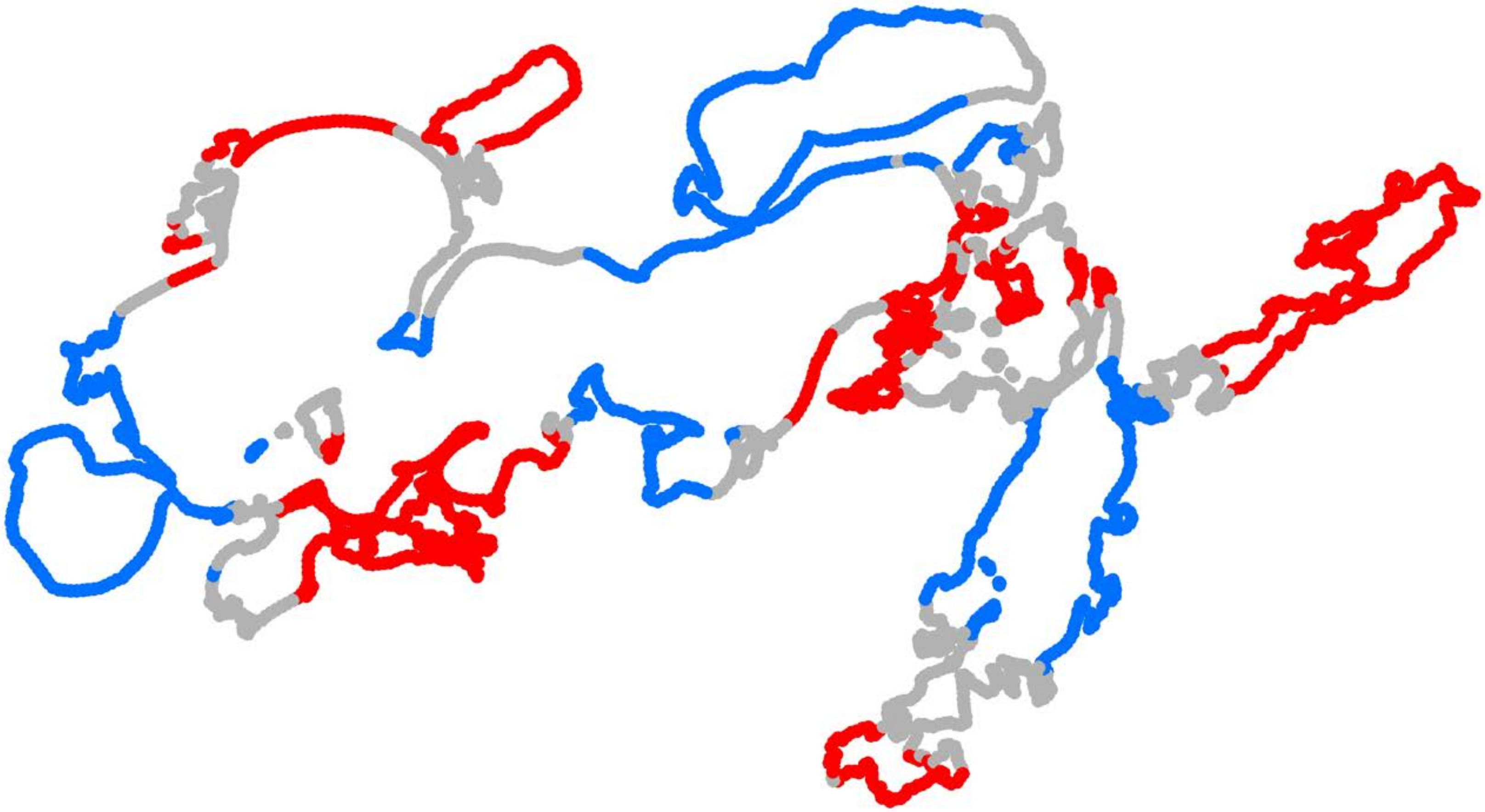
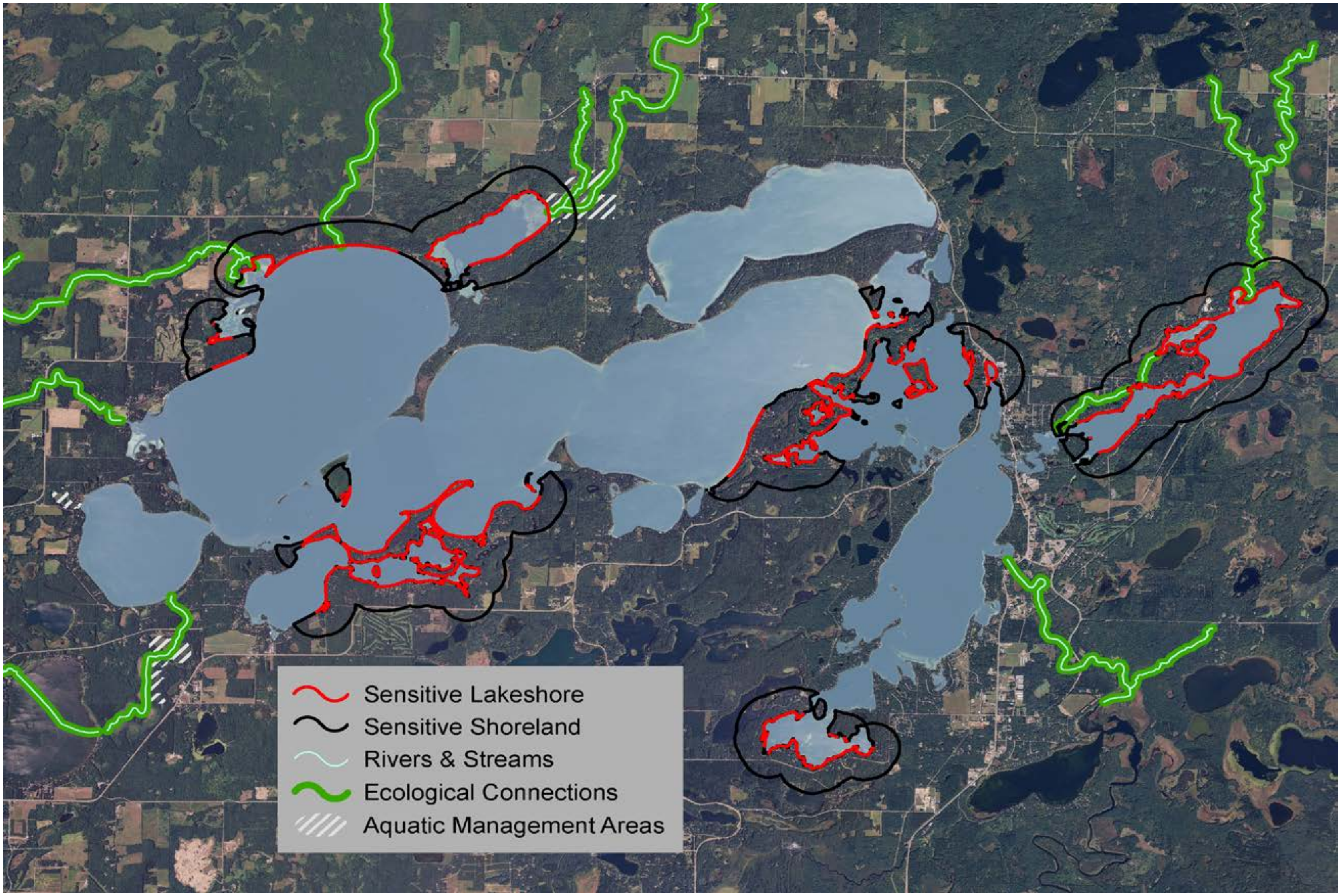


Figure 82. The Whitefish Chain of Lakes sensitive lakeshore areas identified by the ecological model, and ecological connections.



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 Pine River outlet were identified as important ecological connections. The Pine River (Whitefish Lake) and Daggett Brook (Little Pine Lake) are major inlets that contribute flow between all 13 lakes. Five minor inlets, including Hay Creek (Hay Lake), Willow Creek Bay (Whitefish Lake), Spring Brook (Whitefish Lake), Spring Brook (Arrowhead Lake), and Thompson Creek (Arrowhead Lake) provide important habitat connectivity for fish and other wildlife to and from the Whitefish Chain. The Pine River flows out of the chain at the Cross Lake Dam, where it then flows south and eventually into the Mississippi River. Aquatic management areas of Hay Creek and Thompson Creek are good habitat for fish, birds, and amphibians.

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 Whitefish 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.

Big Island on Whitefish Lake contains high quality stands of red oak-basswood forest that provide habitat for several rare plant species. The south end of the island was identified as sensitive shoreland but the entire island is ecologically significant.

Emergent and floating-leaf plant beds that occur outside of the sensitive shoreland districts are areas of ecological significance. Isolated stands of bulrush occur in Big Trout Lake. 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.

There are two aquatic Management Areas on Big and Little Islands in Whitefish Lake and Big Island in Rush-Hen Lake that are of ecological significance. These areas are owned by the Minnesota Department of Natural Resources, Section of Fisheries.

Sensitive Lakeshore

Several stretches of shoreline along the Whitefish 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 Whitefish 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 Whitefish Chain of Lakes, and the value of the lakes themselves.

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Addendum. The hotspot analysis with a fixed Euclidean distance search radius of 2000 feet, which is the distance used for other sensitive lakeshore analyses. The original Whitefish Chain of Lakes analysis was done using an analysis distance of 2000 meters (Figures 81 and 82).

Figure 81[Alternative]. GIS-identified clusters of points with similar total scores. Red areas are those with high scores (i.e., areas of highly sensitive shoreland). Hotspot analysis with a fixed Euclidean distance search radius of 2000 feet.

Figure 82 [Alternative]. The Whitefish Chain of Lakes sensitive lakeshore areas identified by the ecological model, and ecological connections. Hotspot analysis with a fixed Euclidean distance search radius of 2000 feet.