Final Report
Sensitive Lakeshore Survey
Bass Lake
Itasca County, Minnesota

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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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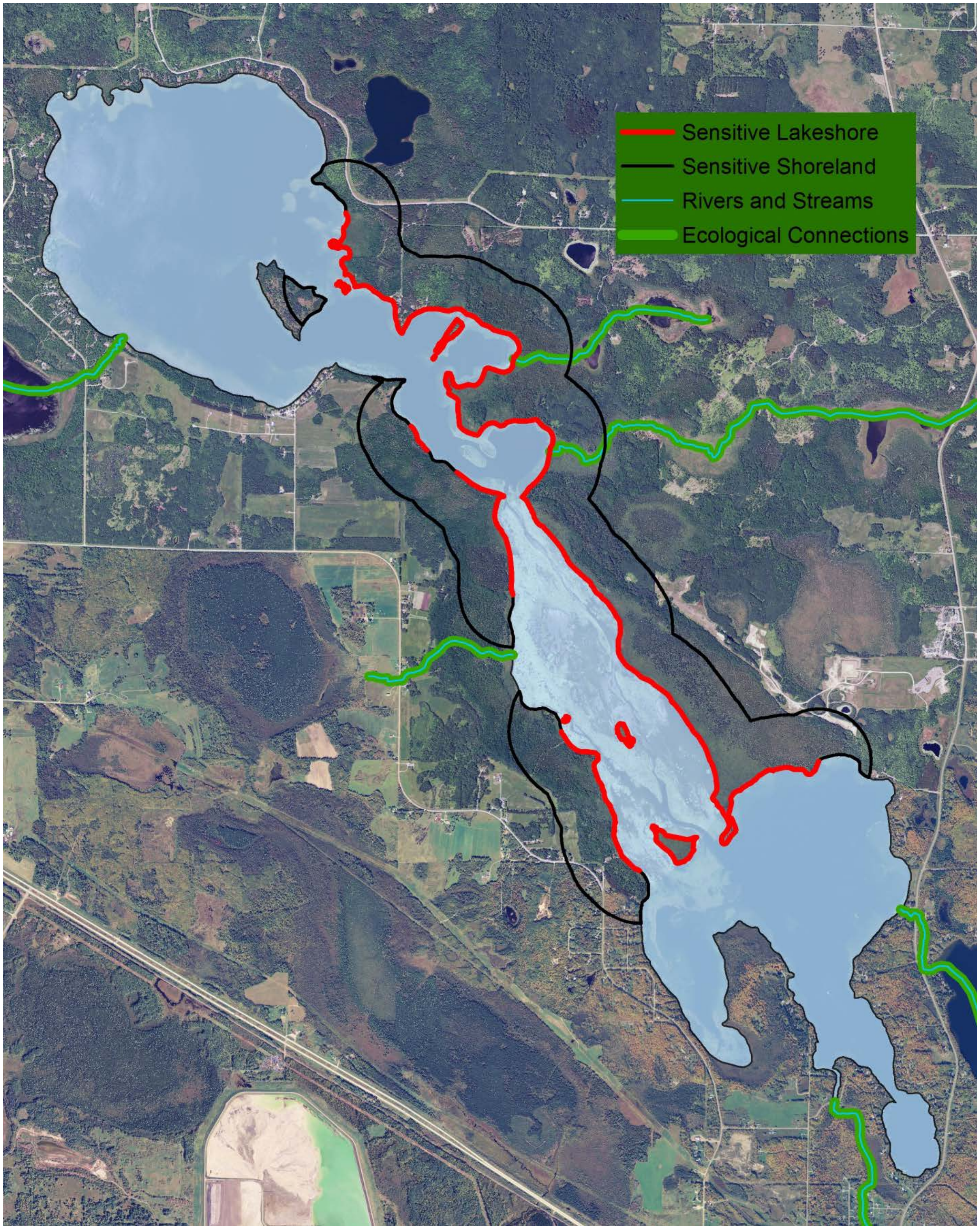
Executive Summary

Thirteen biological and physical attributes of the Bass Lake lakeshore area were assessed using the Minnesota Department of Natural Resources’ sensitive lakeshore identification protocol. These attributes were scored and analyzed, and the results were incorporated into maps that delineate sensitive shoreline and sensitive shoreland. Approximately 9.5 miles, or 40% of the shoreline of Bass Lake was identified as sensitive.

Forty-four native aquatic plant taxa were documented in Bass Lake, including 25 submerged, three free-floating, six floating-leaved and 10 emergent taxa. Submerged aquatic plants occurred around the entire perimeter of Bass Lake and plants were found to a depth of 20 feet. Common submerged plants included muskgrass, coontail, flat-stem pondweed, Canada waterweed and northern watermilfoil. Approximately 1,005 acres of the lake were occupied by emergent or floating-leaved plant beds, including wild rice, bulrush, white waterlily, yellow waterlily and floating-leaf pondweed. Five unique plant species were also recorded in Bass Lake.

Four loon nesting areas were identified on Bass Lake in 2012. All documented nests were natural nests, and no active artificial nest platforms were recorded. Both mink and green frogs were recorded during the Bass Lake frog surveys, and frogs were heard along essentially the entire shoreline of Bass Lake. Surveyors documented one fish species of greatest conservation need, the longear sunfish, at Bass Lake. In addition, all three proxy species (blackchin shiner, blacknose shiner, banded killifish) were found at various survey stations within the lake. In total, surveyors identified 21 fish species in Bass Lake in 2012.

The ecological model identified the channel and nearby areas to be considered for potential resource protection districts by Itasca County. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. The rivers and streams connected to Bass Lake 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 and Streams
Ecological Connections

Introduction

Minnesota's lakes are one of its most valuable resources. The 12,000 lakes in the state provide various industrial, commercial, and recreational opportunities, as well as provide water supplies for various communities and represent sites of important cultural significance. 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.

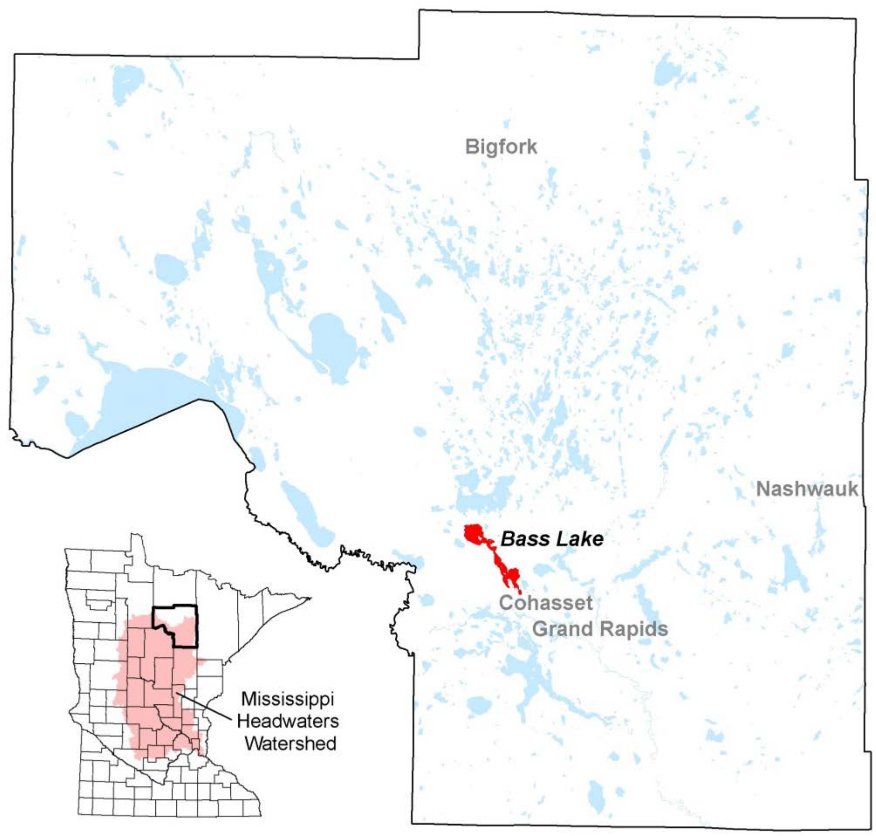
The final component of identifying sensitive lakeshore areas is to deliver advice to local governments and other groups who could use the information to maintain high quality environmental conditions and to protect habitat for species of greatest conservation need.

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 Bass Lake sensitive lakeshore areas.

Lake Description

Bass Lake (DOW 31-0576-00) is located within the Mississippi River Headwaters Watershed, northwest of the city of Cohasset, in Itasca County, Minnesota (Figure 1).

Figure 1. Location of Bass Lake in Itasca County, Minnesota.



Bass Lake is comprised of two distinct basins connected by a wide channel (Figure 2). The lake has multiple inlets, including Bass Brook, which enters the lake from the north and exits it from the south. Several islands occur within the lake, three of which are protected as state Aquatic Management Areas.

Bass Lake lies just outside the Chippewa National Forest, and much of the land surrounding the lake is forested. Residential homes and resorts are scattered along the basin shorelines, while the shoreline along the channel remains relatively undeveloped. Two public accesses are located on the north basin, and one is located on the south basin of Bass Lake.

Bass Lake has a surface area of 2,715 acres, and is the 10th largest lake in Itasca County. It has a maximum depth of 76 feet, but approximately half of the lake is 15 feet or less in depth (Figure 3). The maximum depth of the channel is 10 feet. In 2012, the average Secchi depth (which measures water transparency) for Bass Lake was 18 feet (MPCA 2013). Based on this and other measurements, Bass Lake is described as mesotrophic, or moderately nutrient-enriched.

Figure 2. Features of Bass Lake.

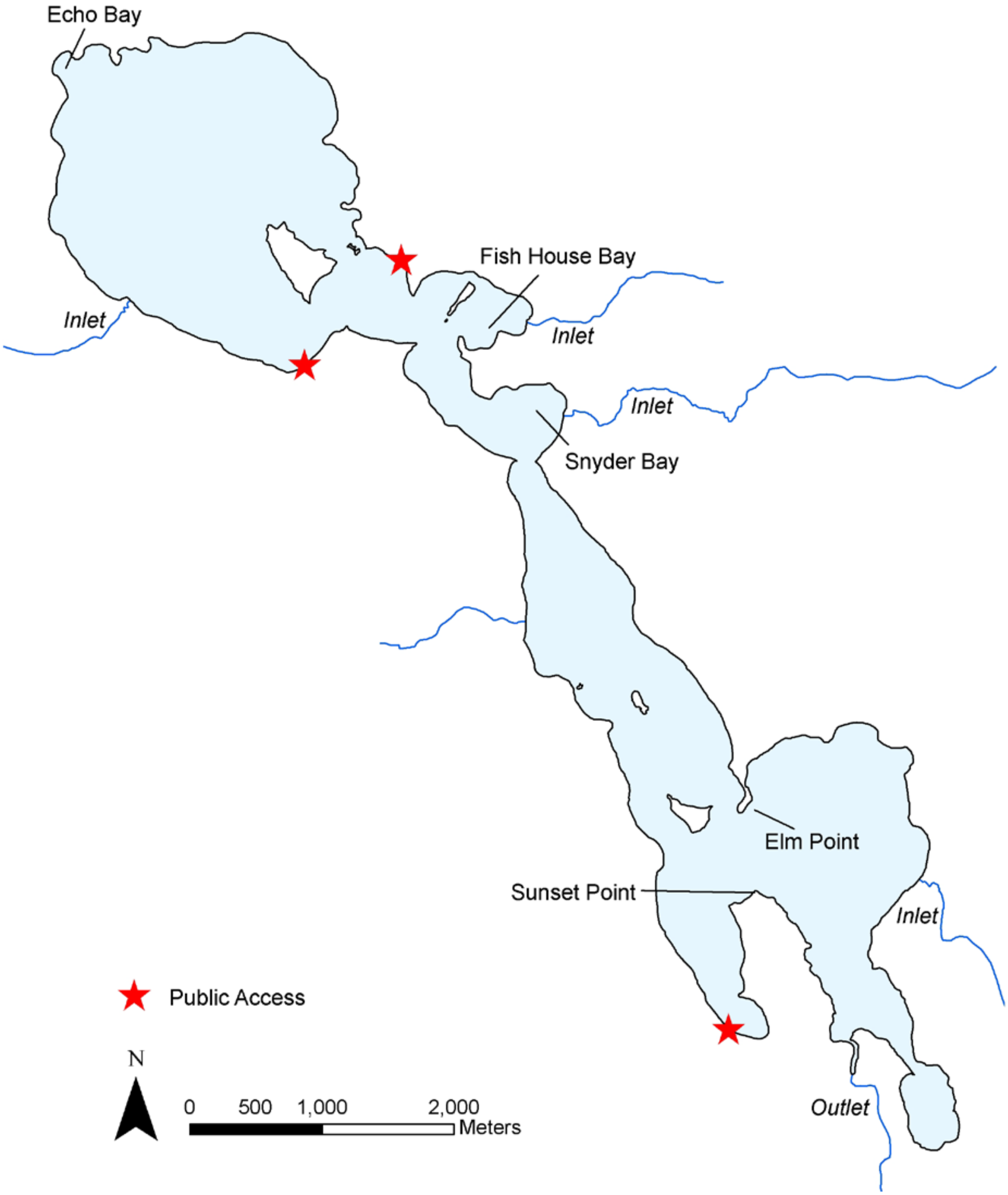
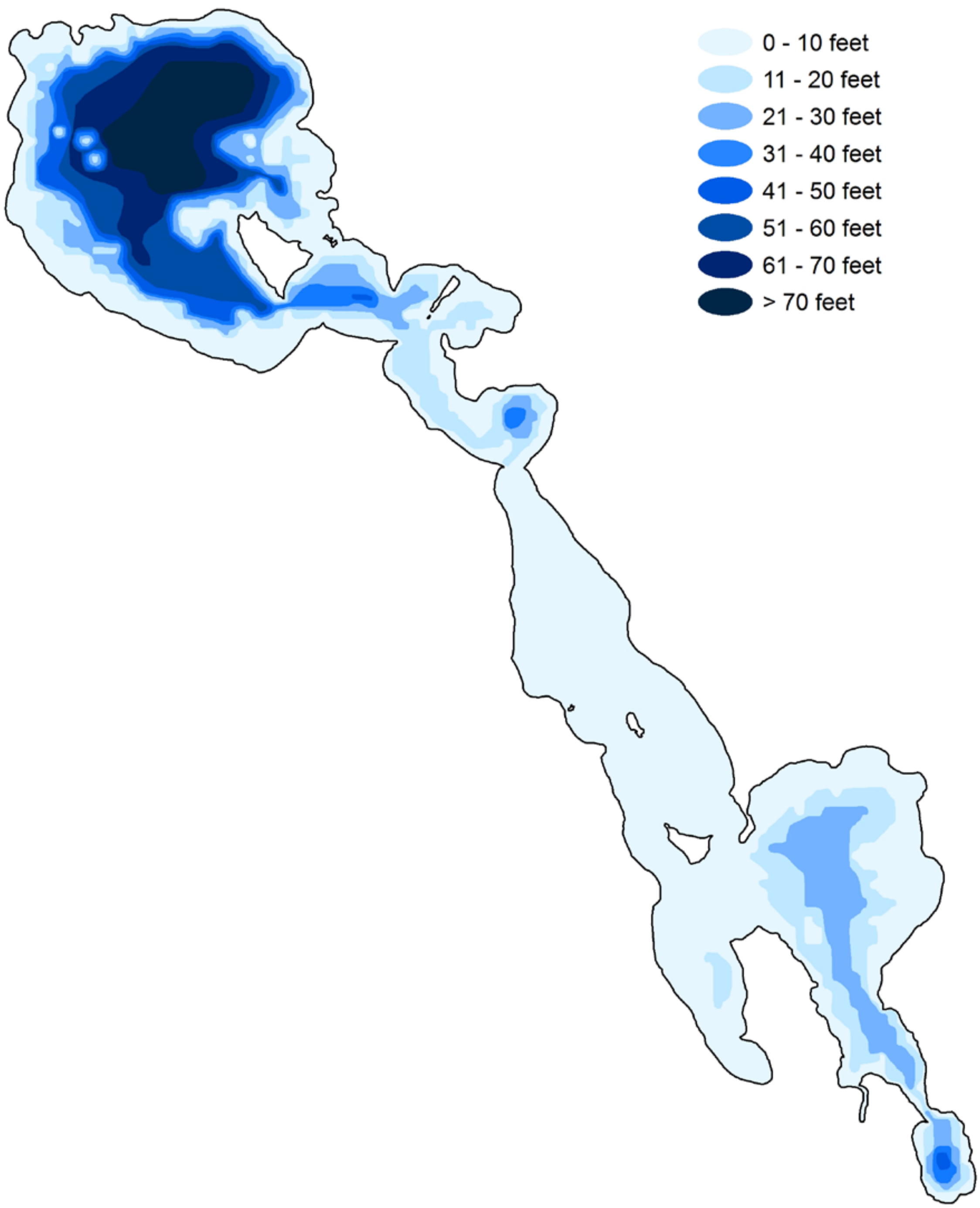


Figure 3. Present-day depth contours of Bass Lake.



I. Field Surveys and Data Collection

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

Pugnose shiner photo courtesy of Konrad Schmidt

Wetlands

Objectives

1. Map wetlands within the extended state-defined shoreland area (within 1320 feet of shoreline) of Bass Lake

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.

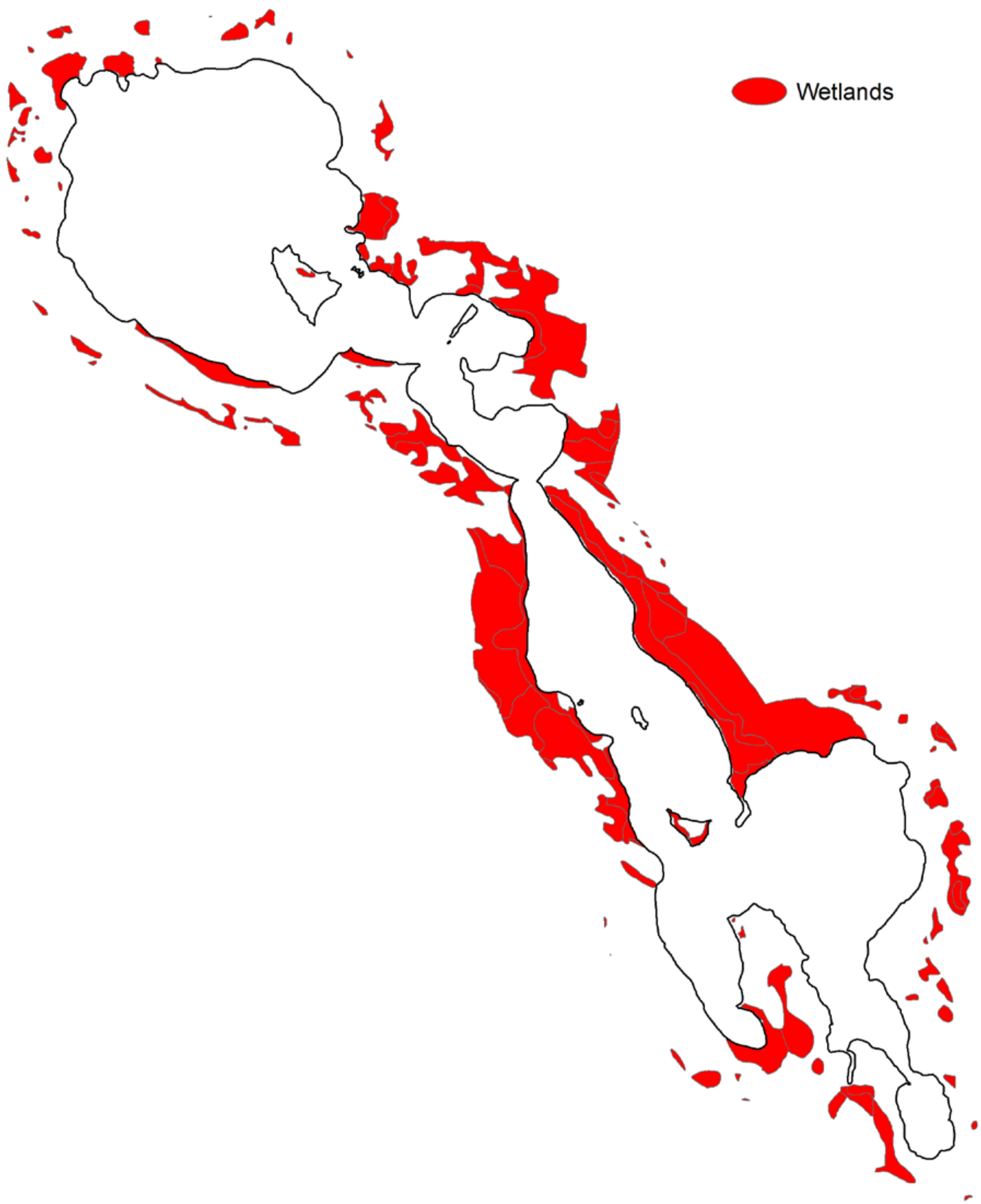
Results

Approximately 977 acres within the shoreland area of Bass Lake are described as wetlands by NWI (Figure 4). These wetlands comprise over 30% of the Bass Lake shoreland district. The majority of the wetlands are located along the channel between the north and south basins of Bass Lake. The largest wetlands, including several greater than 50 acres in size, are also located here. Smaller, scattered wetlands occur along the shorelines of both basins.

The majority of the wetlands were forested wetlands (Cowardin et al. 1979, MN DNR 2003), with deciduous and evergreen trees. Other wetland types included emergent or marsh systems, characterized by herbaceous vegetation including cattails (*Typha* spp.), giant cane (*Phragmites australis* and sedges *(Carex* spp.) and scrub-shrub or shrubland systems with alder (*Alnus* sp.), willow (*Salix* spp.) and bog birch (*Betula pumila*). The water regime varied among wetlands, and included saturated, permanently flooded, semipermanently flooded and seasonally flooded soils.

Wetland along channel in Bass Lake.

Figure 4. Distribution of wetlands within 1320 feet of the Bass Lake shoreline.



Hydric Soils

Objectives

1. Map hydric soils within the extended state-defined shoreland area (within 1320 feet of shoreline) of Bass Lake

Introduction

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

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

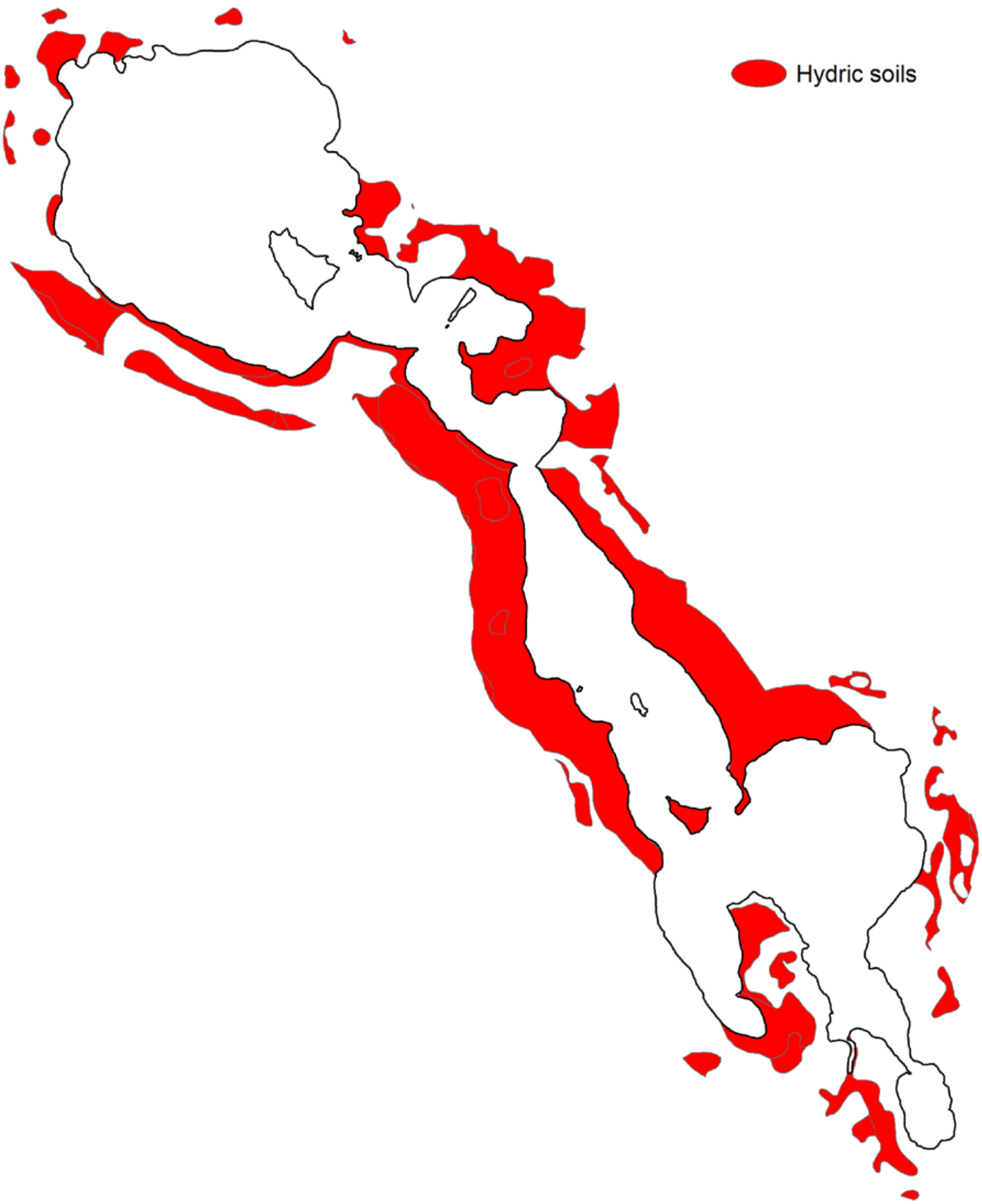
Methods

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

Results

Hydric soils are distributed along much of the shoreline of Bass Lake (Figure 5). Like the wetlands, the largest complexes are located near the channel between the lake basins. Smaller areas of hydric soils are found within the shoreland areas surrounding the basins. Nearly 1400 acres of hydric soils are located within the shoreland of Bass Lake. Soil types include muck, mucky peat, loamy sand, and clayey deposits. Most soils have high organic matter content and are very poorly drained.

Figure 5. Distribution of hydric soils within 1320 feet of Bass Lake.



Plant Surveys

Objectives

1. Record presence and abundance of all aquatic plant taxa
2. Describe distribution of vegetation in Bass Lake
    a. Estimate maximum depth of plant colonization
    b. Estimate plant occurrence in bays versus main lake
    c. 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 taxa richness

Summary

Forty-four native aquatic plant taxa have been documented in Bass Lake, including 25 submerged, three free-floating, six floating-leaved and 10 emergent taxa.

Submerged aquatic plants occurred around the entire perimeter of Bass Lake and plants were found to a depth of 20 feet. Plant occurrence was greatest in depths from 0 to 15 feet, where 84% of the sites were vegetated. Common submerged plants included muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), flat-stem pondweed (*Potamogeton zosteriformis*), Canada waterweed (*Elodea canadensis*) and northern watermilfoil (*Myriophyllum sibiricum*).

Emergent and floating-leaf plants were restricted to shallow water, and within the 0 to 8 feet depth zone, 1,005 acres (37% of the lake) were occupied by emergent or floating-leaved plant beds. About 419 acres of wild rice (*Zizania palustris*) or mixed beds of wild rice and other plants were mapped. Approximately 383 acres of bulrush (*Schoenoplectus* sp.) beds were delineated. Floating-leaf plants covered about 196 acres and included white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*) and floating-leaf pondweed (*Potamogeton natans*).

Unique plants documented in Bass Lake were flat-leaved bladderwort (*Utricularia intermedia*), lesser bladderwort (*Utricularia minor*), hornwort (*Ceratophyllum echinatum*), small burreed (*Sparganium natans*), and wild calla (*Calla palustris*).

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, 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 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.

Muskgrass (*Chara* sp.; Figure 6) is a large algae that is common in many hard water Minnesota lakes. This plant resembles higher plants but does not form flowers or true leaves, stems and 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.

Figure 6. Bed of muskgrass

Submerged rooted plants

Submerged plants have leaves that grow below the water surface, although 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 leaf shapes that include broad ovals, long and grass-like, or finely dissected.

Coontail (*Ceratophyllum demersum*; Figure 7) 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 before beginning new growth early in spring. Because it is only loosely rooted to the lake bottom it may drift between depth zones (Borman et al. 2001). Coontail provides important cover for young fish, including bluegills, perch, largemouth bass and northern pike. It also supports aquatic insects beneficial to both fish and waterfowl.


Figure 7. Coontail

<u>Pondweeds</u> (*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 is 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. <u>Ribbon-leaf pondweeds</u> are plants with long, narrow, grass-like leaves, including flat-stem pondweed (*Potamogeton zosteriformis*; Figure 8). <u>Broad-leaf pondweeds</u> are often referred to as "cabbage" by anglers and include large-leaf pondweed (*P. amplifolius*; Figure 9), Illinois pondweed (*P. illinoensis*), white-stem pondweed (*P. praelongus*), variable pondweed (*Potamogeton gramineus*) and clasping-leaf pondweed (*P. richardsonii*). <u>Narrow-leaf pondweeds</u>, such as Sago pondweed (*Stuckenia pectinata;* Figure 10) have very narrow, almost needle-width leaves.


Figure 8. Flat-stem pondweed.


Figure 9. Large-leaf pondweed


Figure 10. Sago pondweed

<u>Canada waterweed</u> (*Elodea canadensis*; Figure 11) is a perennial submerged species that is widespread throughout Minnesota. It is adapted to a variety of conditions and is tolerant of low light. It prefers soft substrates for growth. Canada waterweed can overwinter as an evergreen plant and spreads primarily by fragments.


Figure 11. Canada waterweed

Northern watermilfoil (*Myriophyllum sibiricum*; Figure 12) 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. It is sometimes confused with the non-native, Eurasian watermilfoil.

Figure 12. Northern watermilfoil

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

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 13) has showy white flowers and round leaves with radiating veins. Yellow waterlily (*Nuphar variegata*; Figure 14) has smaller yellow flowers and oblong leaves with parallel veins. These species often co-occur in mixed beds but yellow waterlily is generally restricted to depths less than seven feet, whereas white waterlily may occur to depths of ten feet (Nichols1999b).

Figure 13. White waterlily

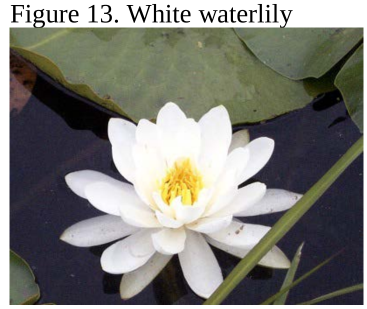
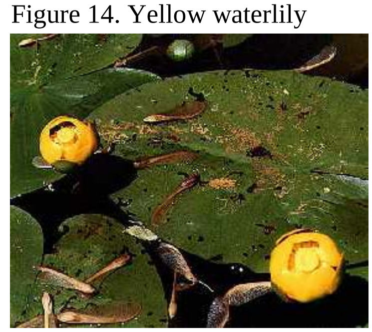


Figure 14. Yellow waterlily



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

Figure 15. Floating smartweed

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

Emergent aquatic plants have stems and/or leaves that extend well above the water surface. Most emergent plants are flowering plants, though their flowers may be reduced in size. Emergent plants include perennial plants as well as annual plants. Emergent plants can be grouped by leaf width as narrow-leaved, grass-leaved and broad-leaved plants.

Figure 16. Floating-leaf pondweed

Bulrushes (*Schoenoplectus* spp.) (Figure 17) are emergent, narrow-leaved, perennial plants that occur in lakes and wetlands throughout Minnesota (Ownbey and Morley 1991). Bulrush stems are round in cross section and lack showy leaves. Clusters of small flowers form near 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. Bulrush stands are particularly susceptible to destruction by excess herbivory and direct removal by humans.

Figure 17. Bulrush

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

Figure 18. Floating stage of wild rice

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.
- Plants 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 19. Bladderwort flowers

Bladderworts (*Utricularia* spp.) are a group of submerged plants with finely divided leaves. They 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 flat-leaved bladderwort (*U. intermedia*) and lesser bladderwort (*U. minor*). 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 the bladders. Bladderworts produce small but showy flowers (Figure 19) 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 20. Hornwort

Photo by: Paul Skawinski (UW Stevens Point Herbarium)

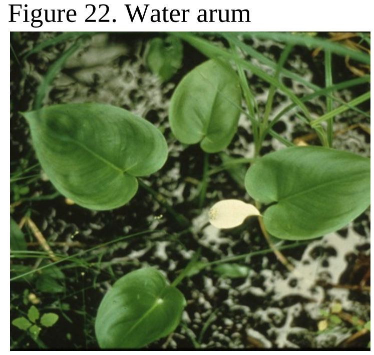
Hornwort (*Ceratophyllum echinatum*) is a submerged plant that resembles the more commonly occurring coontail. Hornwort leaves are forked three times whereas coontail is forked only twice (Nichols 1999b). It forms distinctive spiny seeds (Figure 20). Hornwort occurs in soft-water (low alkalinity) lakes of northern Minnesota. It is found on softer substrates and can grow in water depths up to three meters.

Figure 21. Small burreed.

Photo by: John Sulman, UW Stevens Point

There are several species of burreed (*Sparganium* spp.) in Minnesota and the genus includes emergent and floating-leaf plants. Burreeds are named for their bur-like cluster of fruits. Small burreed (*Sparganium natans*) is the smallest burreed in the state and occurs in small pools and protected bays of lakes in northeastern Minnesota. This plant forms floating, grass-like leaves that may be up to 0.6 meters in length. On mudflats, small burreed may grow as an emergent plant. Flowers are formed in early summer and fruits (Figure 21) are formed in middle to late summer.

Figure 22. Water arum



Water arum (*Calla palustris*; Figure 22) 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 2007). Within Minnesota, water arum primarily occurs in the northeastern half of the state (Ownbey and Morley 1991).

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 the 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 Bass Lake were described and measured using several techniques as found in Minnesota's Sensitive Lakeshore Identification Manual. Plant nomenclature follows MNTaxa 2012.

Grid point-intercept survey

The submerged plant community of Bass Lake was surveyed in July and August, 2012 (Simon and Perleberg 2012) using a grid point-intercept survey (Madsen 1999). A GIS computer program was used to establish aquatic plant survey points 65 meters apart throughout the littoral (i.e., vegetated) zone of the lake. In the field, surveyors navigated to each site with a handheld Global Positioning (GPS) unit. Sampling was focused within the shore to 20 feet depth zone where surveyors could reach sites by boat or wading. Areas of the lake where shallow water and dense vegetation prevented boat navigation (such as the shoreward edges of the channel) were not physically sampled. Surveyors sampled a subset (n = 40) of sites in the 21-25 feet depth zone but did not locate any vegetation in these deeper sites. A total of 1,349 sites were sampled within the shore to 20 feet depth interval. At each sample site, water depth was measured, vegetation within a one-meter squared area was sampled using a double-headed garden rake and all aquatic plant species present within the sample plot were identified. Frequency of occurrence was calculated using the survey sites between shore and 20 feet depth as the percent of sampled sites where vegetation was detected. Any additional species found outside the sample plots were recorded as present in the lake.

Emergent and floating-leaf bed delineation

Mapping focused on emergent and floating-leaf plant beds that were at least 0.01 acres, or about 400 square feet, in size (generally larger than the surface area covered by a pontoon boat). Draft maps of floating-leaf and emergent plant beds were created prior to field surveys using 2010 Farm Service Administrative (FSA) true color aerial photographs. Field surveys were conducted in September 2012 to map plants like bulrush, which are difficult to identify from aerial photos, and to verify photo-interpretation delineations 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 Bass Lake 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 Bass Lake.

Surveyors searched for unique and rare plant species in 2012 during the lakewide point-intercept survey and while mapping emergent and floating-leaf plant beds. Surveyors used professional experience to include search sites most likely to contain rare and unique plants and included factors such as shoreline development, substrate type, water depth, and native plant community type in their site selection.

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 unique or rare species and were submitted to The Herbarium of the University of Minnesota, Bell Museum of Natural History, St. Paul, MN.

Results

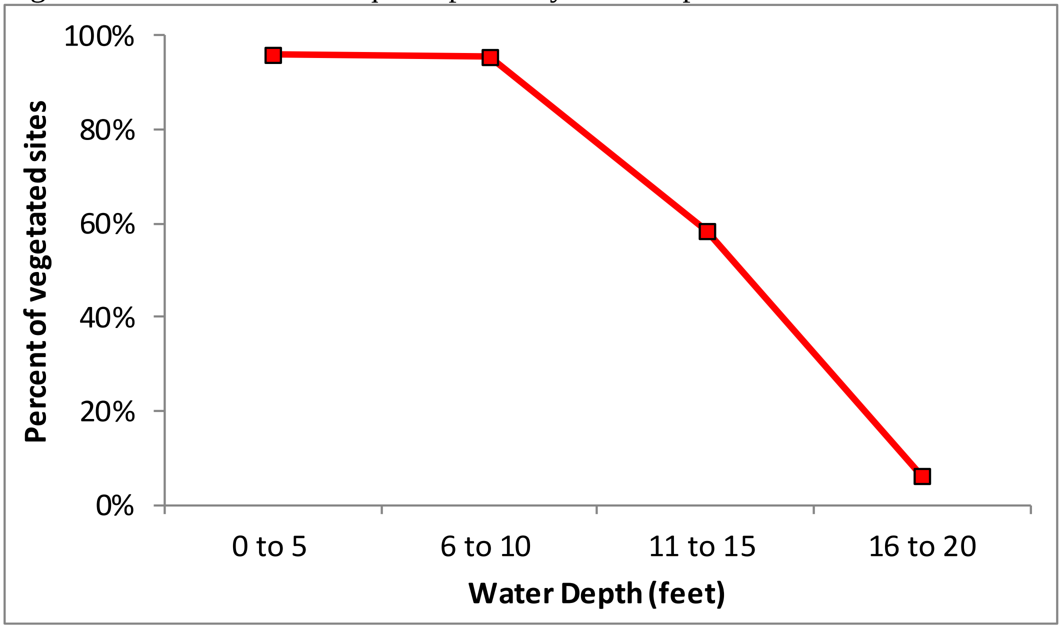
Distribution of plants by water depth

Aquatic plants were found from shore to a depth of 20 feet. Within that zone, 77% of the sites contained vegetation. The greatest occurrence of plants was in the depth zone from 0 to 10 feet, where 87% of the sample sites contained plants. Plant occurrence declined with increasing water depth and in water depths of 16 to 20 feet, plant frequency was 6% (Figure 23).

Aquatic plant species observed

A total of 44 native aquatic plant taxa have been recorded in Bass Lake, including 25 submerged, three free-floating (Table 1), six floating-leaf and 10 emergent taxa (Table 2). Several species that can be difficult to distinguish in the field were grouped together for analysis.

Figure 23. Distribution of aquatic plants by water depth.



Submerged plants

Submerged plants were the most common type of plants present in Bass Lake and occurred throughout the vegetated zone (Figure 24). The submerged plant community included leafy plants that are anchored to the lake bottom by roots as well as large algae that may resemble leafy plants but are weakly anchored to the lake bottom. Muskgrass was the most common species and occurred in 37% of all sample sites (Table 1). Muskgrass was widespread around the shoreline and dominated the 0 to 5 feet depth zone. Other submerged species that were frequent in Bass Lake were coontail (16%), flat-stem pondweed (16%), Canada waterweed (14%) and northern watermilfoil (14%).

Figure 24. Aquatic plant distribution in Bass Lake, 2012.

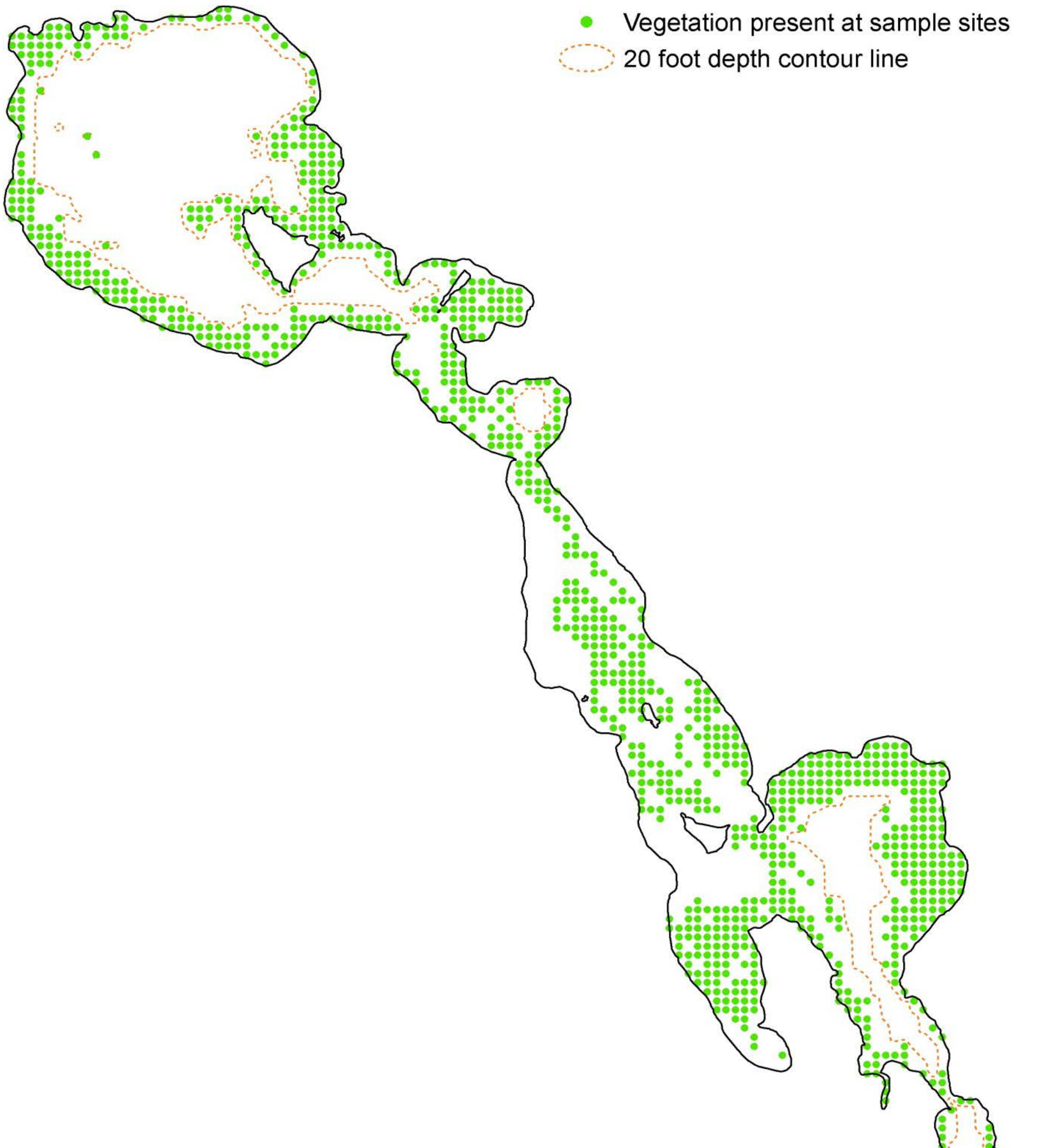


Table 1. Submerged and free-floating aquatic plants recorded in Bass Lake, 2012.

Description			Common name	Scientific name	Frequency[a]
Non-flowering	Large algae		Muskgrass	*Chara* sp.	37
			Stonewort	*Nitella* sp.	3
	Aquatic moss		Watermoss	*Not identified to genus*	1
Flowering plants	Small, entire-leaved plants		Bushy pondweed	*Najas flexilis*	[b]9
			Southern naiad	*Najas guadalupensis*	
			Canada waterweed	*Elodea canadensis*	14
	Pondweeds	Ribbon-leaf	Flat-stem pondweed	*Potamogeton zosteriformis*	16
		Fine-leaf	Fries' pondweed	*Potamogeton friesii*	3
			Sago pondweed	*Stuckenia pectinata*	1
		Broad-leaf	Illinois pondweed	*Potamogeton illinoensis*	5
			Large-leaf pondweed	*Potamogeton amplifolius*	4
			Clasping-leaf pondweed	*Potamogeton richardsonii*	3
			Variable pondweed	*Potamogeton gramineus*	2
			White-stem pondweed	*Potamogeton praelongus*	1
	Other ribbon-leaf plants		Wild celery	*Vallisneria americana*	8
			Water stargrass	*Heteranthera dubia*	2
	Divided-leaf plants		Coontail	*Ceratophyllum demersum*	16
			Hornwort	*Ceratophyllum echinatum*	<1
			Northern watermilfoil	*Myriophyllum sibiricum*	14
			Whorled watermilfoil	*Myriophyllum verticillatum*	<1
			Water marigold	*Bidens beckii*	2
			White water buttercup	*Ranunculus aquatilis*	3
			Greater bladderwort	*Utricularia vulgaris*	9
			Flat-leaved bladderwort	*Utricularia intermedia*	2
			Lesser bladderwort	*Utricularia minor*	<1
Free-floating			Star duckweed	*Lemna trisulca*	9
			Lesser duckweed	*Lemna* sp.	1
			Greater duckweed	*Spirodela polyhriza*	2

[a]Frequency values are provided for taxa that were observed within point-intercept survey sample stations. They represent the percent of the sample stations within the shore to 20 feet depth zone (N = 1,349) that contained a plant taxon.

[b]Species in this genus were grouped together for analysis because field identification to the species level was difficult.

Floating-leaf and emergent plants

Floating-leaf and emergent plants occurred in water depths of 8 feet and less. About 196 acres of floating-leaf plant beds were mapped and the largest beds occurred in the protected channel area that connects the north and south basins (Figure 27). The most common floating-leaf plant species were white waterlily, yellow waterlily, and floating-leaf pondweed. Because surveyors avoided motoring into floating-leaf plant beds, the frequency values obtained for these taxa (Table 2) were lower than the actual lakewide occurrence. Frequency values for floating-leaf taxa represent the occurrence of these taxa only within the sites that were surveyed. Waterlily beds (Figure 25) often contained scattered bulrush plants (Figure 26) as well as submerged plants and were usually associated with muck sediments.

Surveyors delineated approximately 809 acres of emergent plants and the most common taxa were bulrush and wild rice. About 419 acres of wild rice and mixed wild rice were mapped and about 383 acres of bulrush and mixed bulrush were mapped.

Other emergent plants occurred at scattered locations around the lake and included spikerush, burreed, giant cane, arrowhead, and cattails. Many of these emergent plants occupied the transitional zone between the lake and adjacent wetlands. Numerous additional native emergents occurred in these adjacent wetlands but this survey did not include an exhaustive wetland species inventory.

Figure 25. Waterlily and wild rice bed in Bass Lake, 2012.

Figure 26. Bulrush and waterlily bed in Bass Lake, 2012.

Table 2. Floating-leaf and emergent aquatic plants recorded in Bass Lake, 2012.

Description		Common Name	Scientific Name	Frequency[a]
Floating-leaf		White waterlily	*Nymphaea odorata*	16
		Yellow waterlily	*Nuphar variegata*	13
		Floating-leaf pondweed	*Potamogeton natans*	11
		Small burreed	*Sparganium natans*	<1
		Watershield	*Brasenia schreberi*	<1
		Floating-leaf smartweed	*Persicaria amphibia*	[c]X
Emergent	Narrow-leaf	Bulrush	*Schoenoplectus* sp.	[b]34
		Spikerush	*Eleocharis palustris*	4
		Horsetail	*Equisetum fluviatilis*	1
	Grass-leaf	Wild rice	*Zizania palustris*	19
		Giant cane	*Phragmites australis*	1
		Narrow-leaved cattail	*Typha angustifolia*	[d]<1
		Giant burreed	*Sparganium eurycarpum*	[b]<1
		Narrow-leaf burreed	*Sparganium emersum*	[c]X
		River bulrush	*Bolboschoenus fluviatile*	[c]X
	Broad-leaf	Broad-leaved arrowhead	*Sagittaria latifolia*	[b]1
Wetland Emergent		Wild calla	*Calla palustris*	[c]X
		Sedge	*Carex* sp.	<1
		Purple loosestrife(I)	*Lythrum salicaria*	<1

[a]Frequency values are provided for taxa that were observed within point-intercept survey sample stations. They represent the percent of the sample stations within the shore to 8 feet depth zone (N = 914) that contained a plant taxon.

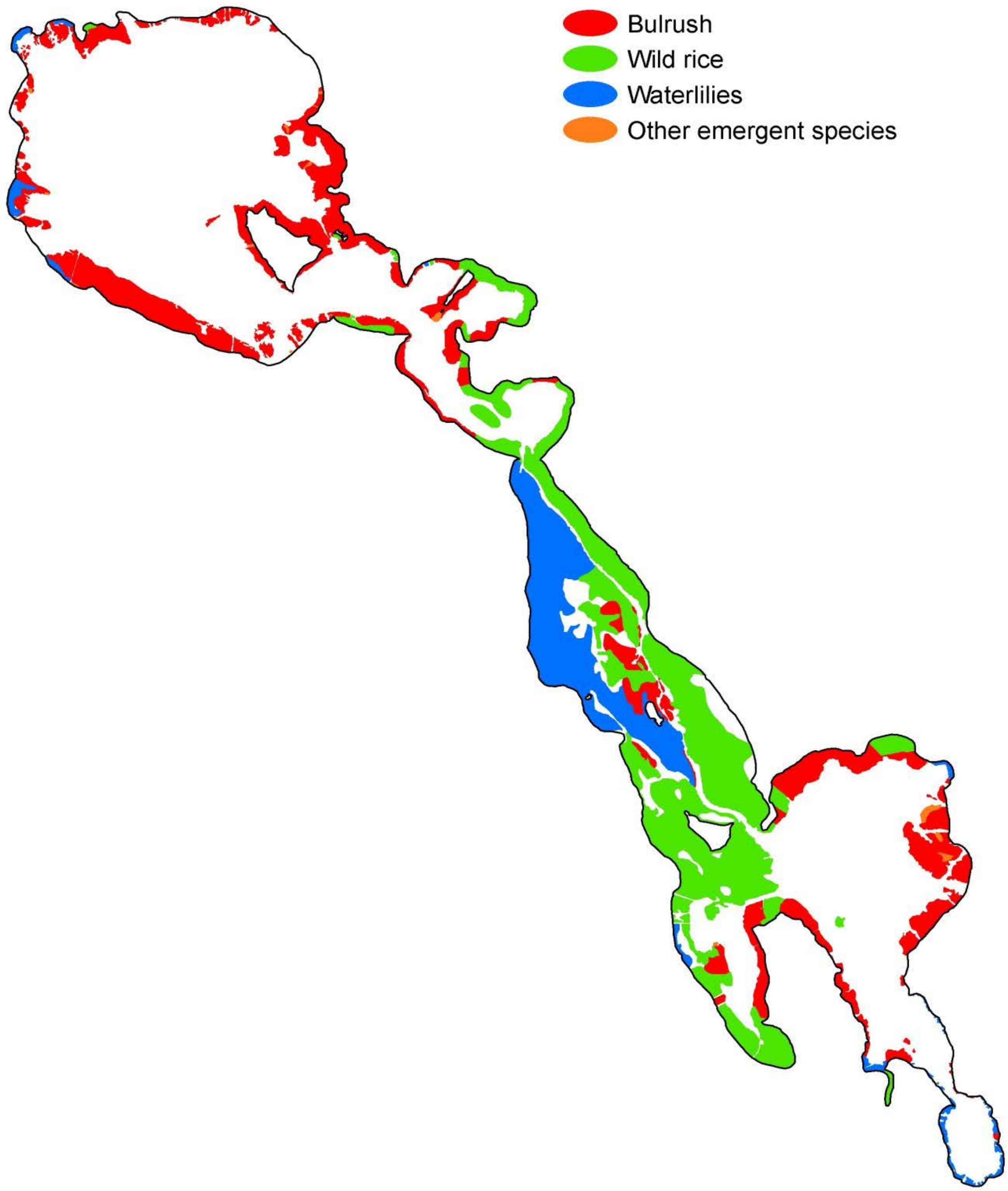
[b]Species in this genus were grouped together for analysis because field identification to the species level was difficult. Hard-stem bulrush (*Schoenoplectus acutus*) and soft-stem (*Schoenoplectus tabernaemontani*) bulrush may have been present in the lake but were not distinguished to the species level.

[c]X = located during the 2012 point-intercept survey but only found outside of sample points.

[d]X = In 2012, surveyors positively identified narrow-leaf cattail. Broad-leaf cattail may have also been present, but was not identified to the species level.

I = introduced to Minnesota

Figure 27. Distribution of floating-leaf and emergent plant beds in Bass Lake, 2012.



Unique plants

In addition to the commonly occurring plants in Bass Lake, five unique plant species were located: flat-leaved bladderwort (*Utricularia intermedia*), minor bladderwort (*Utricularia minor*), hornwort (*Ceratophyllum echinatum*), small burreed (*Sparganium natans*) and wild calla (*Calla palustris*) (Figure 28.). These species are not widespread in Minnesota but their presence is indicative of relatively undisturbed native plant beds in and adjacent to Bass Lake.

Species richness

The number of plant taxa found in each one square meter sample site ranged from 0 to 11 (Figure 29). Sites with the greatest number of species were generally located in protected bays; these sample sites had a mean of 2.4 plant taxa per site. Sites of high species richness (six or more taxa per site) often occurred in depths less than 10 feet and included sites where emergent, floating-leaf and submerged plants co-occurred.

Figure 28. Unique aquatic plants in Bass Lake, 2012.

Figure 29. Aquatic plant richness (number of taxa per sampling station), 2012.

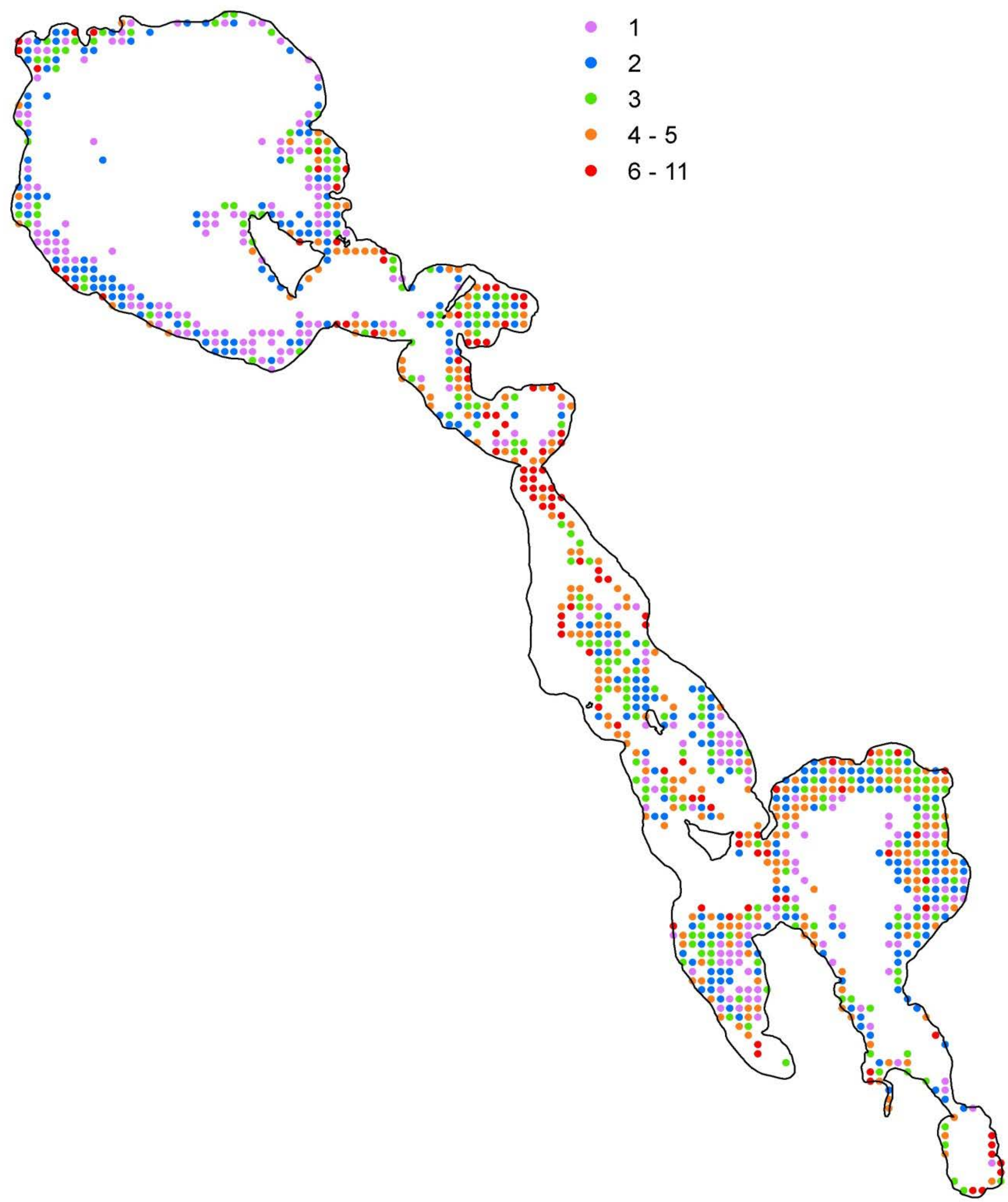


Table 3. Historical and current aquatic plants in Bass Lake, 1946 to 2012.

Submerged plants

<table>
<tr><th>Common Name</th><th>Scientific Name</th><th>1946</th><th>1998</th><th>2000</th><th>2012</th></tr>
<tr><td>Muskgrass</td><td>Chara sp.</td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Stonewort</td><td>Nitella sp.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Watermoss</td><td>Not identified to genus</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Canada waterweed</td><td>Elodea canadensis</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Water stargrass</td><td>Heteranthera dubia</td><td></td><td></td><td>X</td><td>X</td></tr>
<tr><td>Bushy pondweed</td><td>Najas flexilis</td><td>X</td><td>X</td><td>X</td><td>[a]X</td></tr>
<tr><td>Southern naiad</td><td>Najas guadalupensis</td><td></td><td></td><td></td><td>[a]X</td></tr>
<tr><td>Large-leaf pondweed</td><td>Potamogeton amplifolius</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Variable pondweed</td><td>Potamogeton gramineus</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Illinois pondweed</td><td>Potamogeton illinoensis</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Fries pondweed</td><td>Potamogeton friesii</td><td></td><td>X</td><td>X</td><td rowspan="4">[b]X</td></tr>
<tr><td>Leafy pondweed</td><td>Potamogeton foliosus</td><td></td><td></td><td>X</td></tr>
<tr><td>Straight-leaved pondweed</td><td>Potamogeton strictifolius</td><td></td><td></td><td>X</td></tr>
<tr><td>Not identified to species</td><td>Potamogeton sp.</td><td></td><td>X</td><td></td></tr>
<tr><td>River pondweed</td><td>Potamogeton nodosus</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>White-stem pondweed</td><td>Potamogeton praelongus</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Clasping leaf pondweed</td><td>Potamogeton richardsonii</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Flat-stem pondweed</td><td>Potamogeton zosteriformis</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>White water buttercup</td><td>Ranunculus aquatilis</td><td></td><td></td><td>X</td><td>X</td></tr>
<tr><td>Yellow water crowfoot</td><td>Ranunculus flabellaris</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>Sago pondweed</td><td>Stuckenia pectinata</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Wild celery</td><td>Vallisneria americana</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Water marigold</td><td>Bidens beckii</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Coontail</td><td>Ceratophyllum demersum</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Hornwort</td><td>Ceratophyllum echinatum</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Northern watermilfoil</td><td>Myriophyllum sibiricum</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Whorled watermilfoil</td><td>Myriophyllum verticillatum</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Flat-leaved bladderwort</td><td>Utricularia intermedia</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Lesser bladderwort</td><td>Utricularia minor</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Greater bladderwort</td><td>Utricularia vulgaris</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td colspan="2">Total</td><td>10</td><td>18</td><td>19</td><td>25</td></tr>
</table>

[a] Bushy pondweed (*Najas flexilis*) and southern naiad (*Najas guadalupensis*) were both present in the lake but were grouped together for analysis because field identification to the species level was difficult.

[b] At least one species of narrow-leaf pondweed was identified in the lake in 2012: Fries' pondweed (*Potamogeton friesii*). Additional narrow-leaf pondweed species (*Potamogeton* spp.) may have also been present.

Table 3, continued. Historical and current aquatic plants in Bass Lake, 1946 to 2012

Free-floating plants

Common Name	Scientific Name	1946	1998	2000	2012
Star duckweed	*Lemna trisulca*		X		X
Lesser duckweed	*Lemna* spp.		X		X
Greater duckweed	*Spirodela polyrhiza*		X	X	X
	Total	0	3	1	3

Floating-leaved plants

Common Name	Scientific Name	1946	1998	2000	2012
Watershield	*Brasenia schreberi*				X
White waterlily	*Nymphaea odorata*	X	X	X	X
Yellow waterlily	*Nuphar variegata*	X	X	X	X
Floating-leaf smartweed	*Persicaria amphibia*		X	X	X
Floating leaf pondweed	*Potamogeton natans*	X	X	X	X
Floating-leaf burreed	*Sparganium natans*				X
	Total	3	4	4	6

Emergent plants

Common Name	Scientific Name	1946	1998	2000	2012
River bulrush	*Bolboschoenus fluviatile*				X
Spikerush	*Eleocharis palustris*		[G]X	X	X
Horsetail	*Equisetum fluviatilis*		X		X
Brown-fruited rush	*Juncus pelocarpus*			X	
Giant cane	*Phragmites australis*	X	X	X	X
Broad-leaf arrowhead	*Sagittaria latifolia*	[G]X	[G]X	X	[G]X
Bulrush	*Schoenoplectus* sp.	[H]X	[H]X	[H]X	[H]X
Narrow-leaf burreed	*Sparganium emersum*				X
Giant burreed	*Sparganium eurycarpum*		[G]X		X
Narrow-leaved cattail	*Typha* sp.				X
Broad-leaved cattail	*Typha latifolia*	X			
Wild rice	*Zizania palustris*	X	X	X	X
	Total	5	7	6	10

Wetland emergent plants

Common Name	Scientific Name	1946	1998	2000	2012
Sedge	*Carex* sp.				X
Wild calla	*Calla palustris*				X
Purple loosestrife	*Lythrum salicaria*				X
	Total	0	0	0	3

[G]Some plants were only identified to the genus level in this lake. It is possible that additional species of the genus were present in the lake, but only one species was positively identified.
[H]"Species of bulrush" (*Schoenoplectus* sp.) was used to record bulrush plants that were hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*S. tabernaemontani*) or the hybrid.
P=Present in lake but did not occur in any sample sites

1946 (August 14-29) Bureau of Fisheries Research, Minnesota Department of Conservation
1998 (July 13) Division of Fisheries survey
2000 (July 27) Karen Myhre, Minnesota Biological survey, MNDNR Division of Ecological and Water Resources
2012 (July and August) Simon, Perleberg, Johnson, Walker-O'Beirne, MNDNR Point-Intercept survey, Division of Ecological and Water Resources

Near-shore Substrates

Objectives

1. Describe and map the near-shore substrates of Bass Lake

Introduction

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

Sand shoreline along Bass Lake, 2012.

Methods

Near-shore substrate in Bass Lake was evaluated at a total of 1031 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 in Bass Lake, and surveyors described substrate at 938 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 93 of these stations.

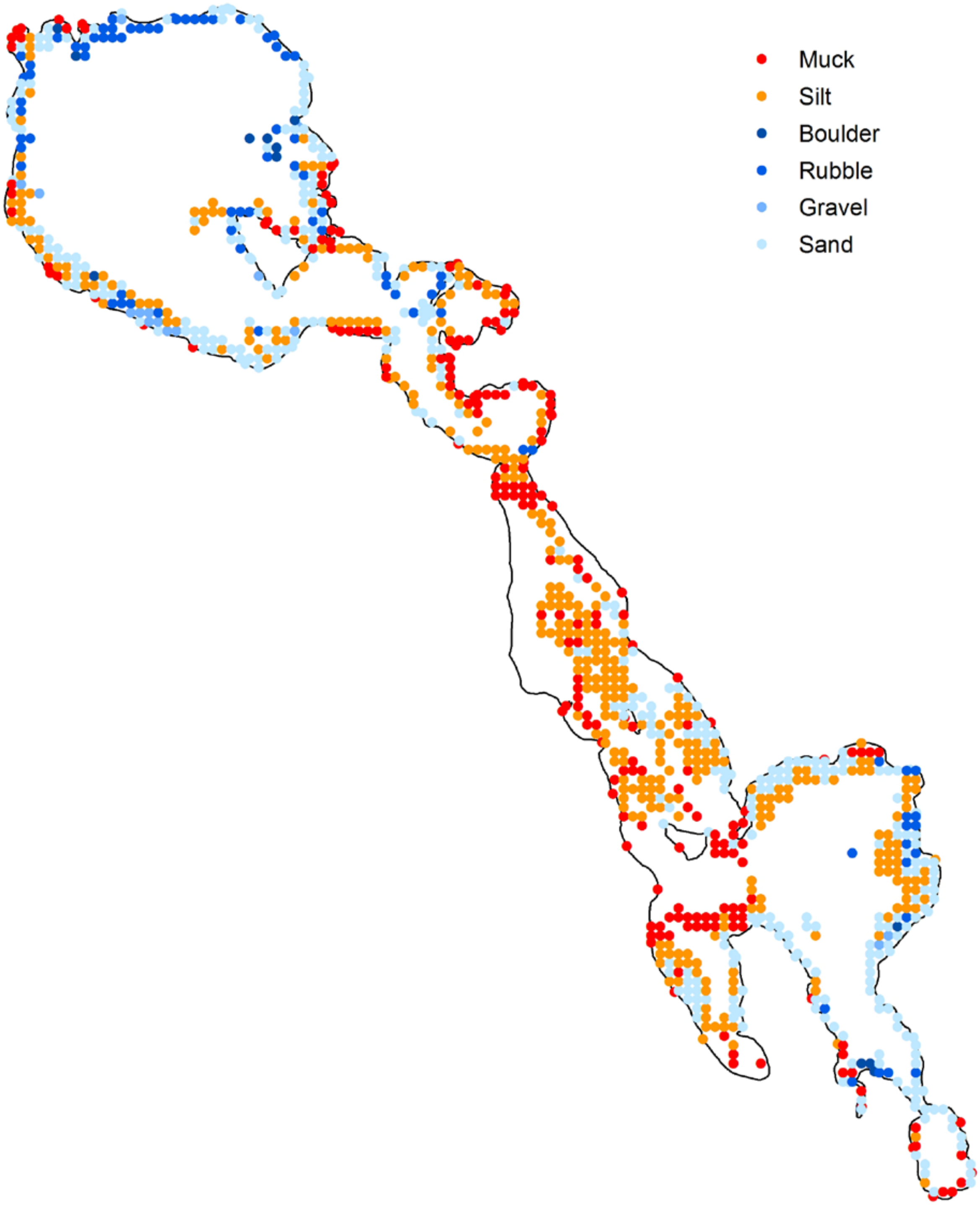
Surveyors evaluated substrate by tapping a pole into the lake bottom; soft substrate could usually be brought to the surface on the pole or sampling rake for evaluation. If this method was not feasible, substrate was evaluated by visual observation of the lake bottom. Standard lake substrate classes 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 in Bass Lake ranged from soft (muck and silt) to hard (boulder, rubble, gravel, and sand) (Figure 30). Soft substrates were most common within the channel, although areas of muck and silt were also scattered along the basins shorelines. Sand substrates were found frequently in the south basin, while the north basin had pockets of rubble and gravel in addition to sand. Overall, sand and silt were the most common substrate types; each occurred at nearly 35% of the sample locations.

Figure 30. Distribution of near-shore substrates in Bass Lake, 2012.



Loon Nesting Areas

Objectives

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

Introduction

Loon pair with chick

Photo by: Paul Bolstad

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

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

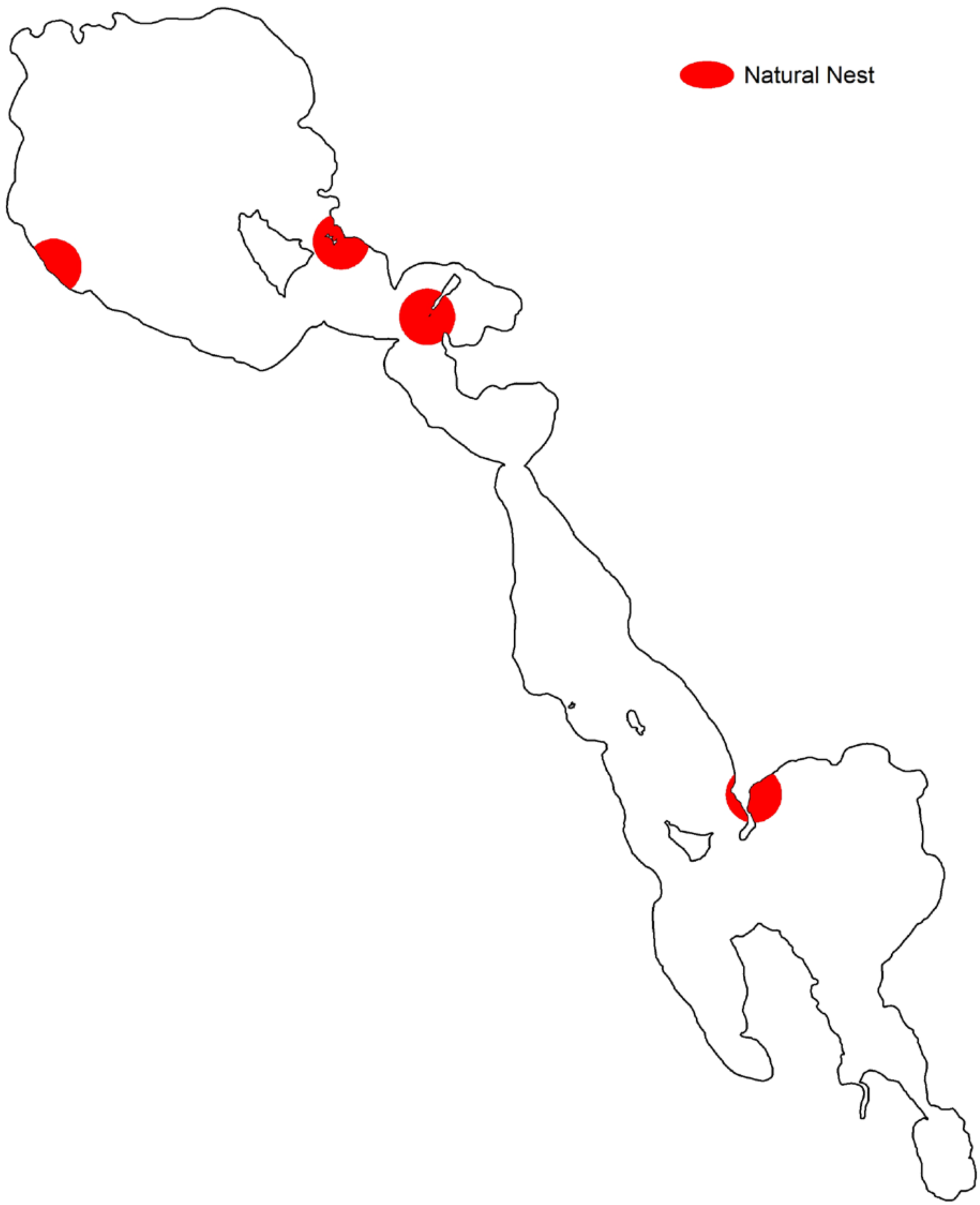
Methods

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

Results

Four loon nesting areas were identified on Bass Lake in 2012. Two of the nests were located in the north basin, one was found near the island in Fish House Bay, and one nest was recorded near Elm Point (Figure 31). All documented nests were natural nests, and no active artificial nest platforms were recorded.

Figure 31. Location of natural loon nests recorded in Bass Lake, 2012.



Aquatic Frog Surveys

Objectives

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

Introduction

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

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

Figure 32. Mink frog

Photo by: Jeff LeClere, www.herpnet.net

Mink frogs (Figure 32) are typically green in color with darker green or brown mottling. They emit an odor similar to that of a mink when handled. They inhabit quiet waters near the edges of wooded lakes, ponds, and streams, and are considered the most aquatic of the frogs found in Minnesota. Populations of mink frogs have potentially been declining recently, and the numbers of observed deformities have been increasing.

Figure 33. Green frog

Photo by: Jeff LeClere, www.herpnet.net

Green frogs (Figure 33) are medium-sized, greenish or brownish frogs with small dark spots. The belly is often brighter in color than the back. A large tympanum (eardrum) helps identify the green frog. They can be found in a variety of habitats surrounding lakes, streams, marshes, and swamps, but are strongly associated with the shallow water of lakeshores. Although green frog populations are generally stable, regional declines and local extinctions have been noted.

Methods

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

Results

Target species

Mink frogs were documented at 45 survey stations during the Bass Lake frog surveys (Figure 34). Mink frogs were heard consistently along the channel of Bass Lake, as well as in Fish House Bay. They were also heard at scattered locations in the north and south basins. At survey stations where mink frogs were present, abundance estimates ranged from one to over 20 frogs (Figure 35). The greatest numbers of mink frogs were heard at survey stations in the channel. Green frogs were recorded at 51 of 97 survey stations on Bass Lake. As with the mink frogs, abundance estimates for green frogs ranged between one and over 20 frogs at a survey station (Figure 36). Green frogs were documented along much of the Bass Lake shoreline. The stations with the greatest numbers of green frogs were primarily within Fish House Bay, and included survey stations on the island.

Other species

In addition to green and mink frogs, surveyors also documented gray treefrogs (*Hyla versicolor*) and American toads (*Bufo americanus*) on Bass Lake. Gray treefrogs were heard at over 40% (N = 40) of the 97 stations surveyed. Index values for gray treefrogs ranged from one (individual frog calls could be distinguished; no overlap) to three (individual calls could no longer be distinguished; full chorus). American toads were recorded at five survey stations on the western shoreline of Bass Lake. Index values for American toads at these stations equaled two (individual calls could be distinguished, but some overlap of calls).

Figure 34. Distribution of mink and green frogs heard during the Bass Lake frog surveys, June 2012.

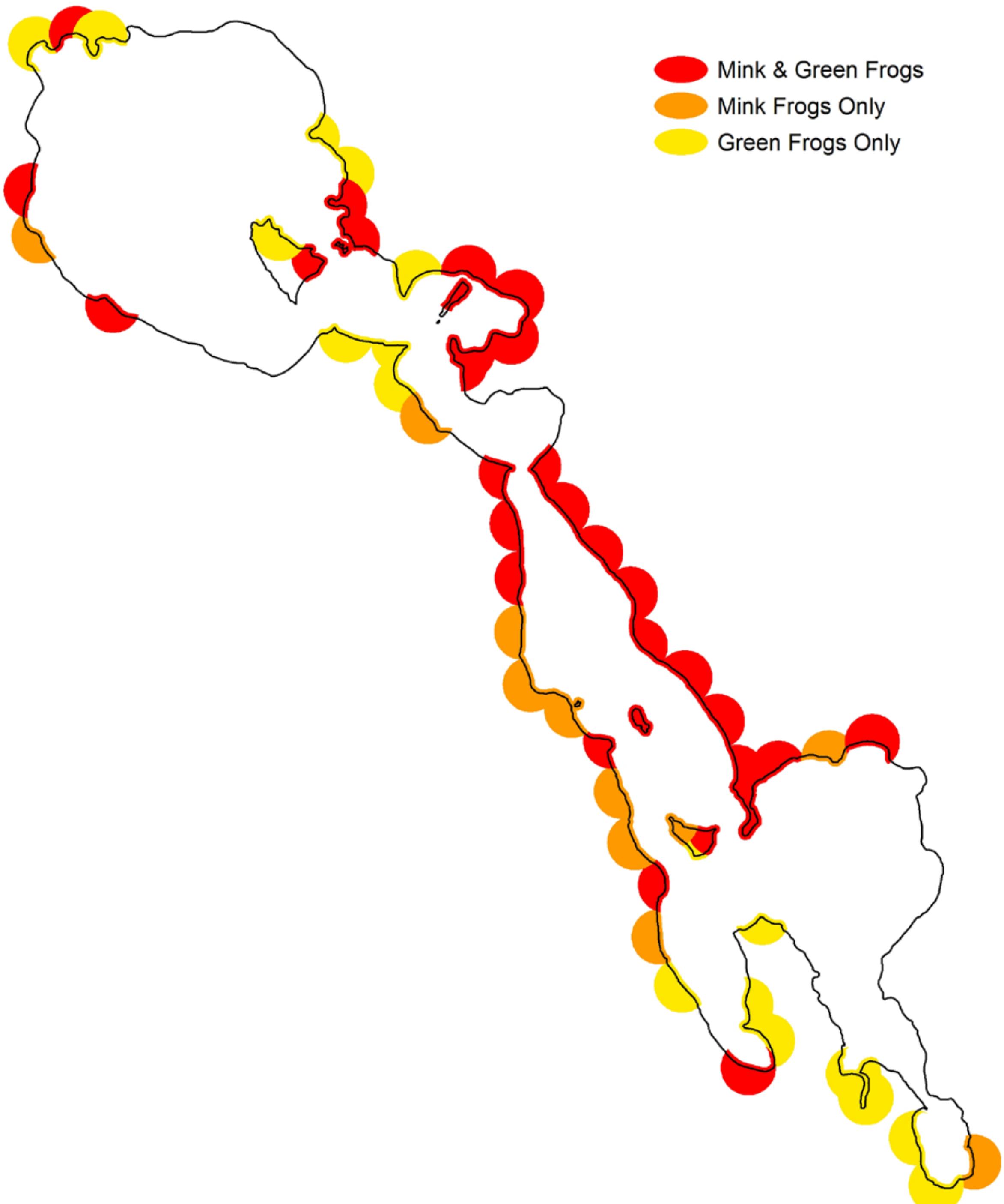


Figure 35. Abundance of mink frogs heard during the Bass Lake frog surveys, June 2012.

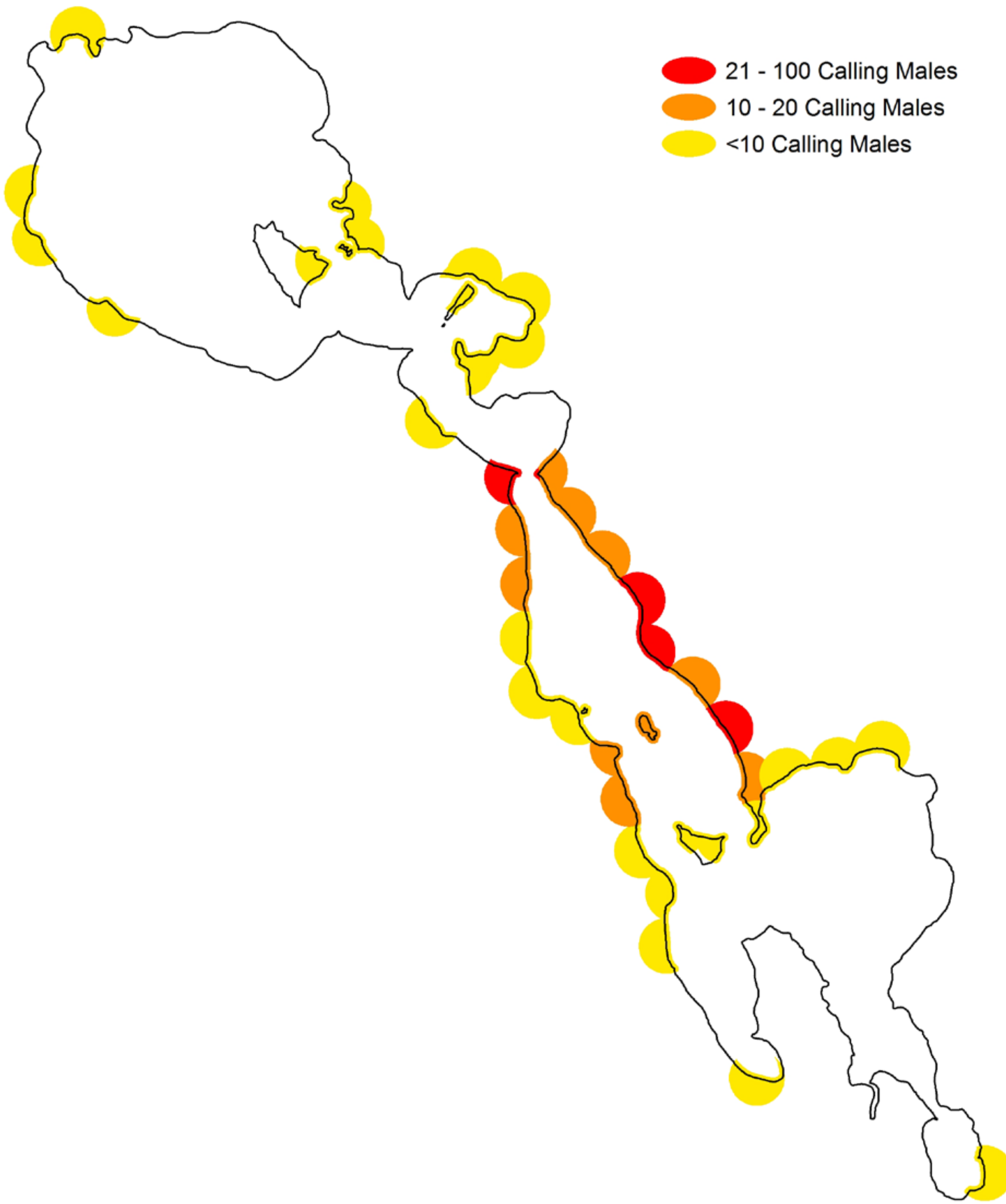
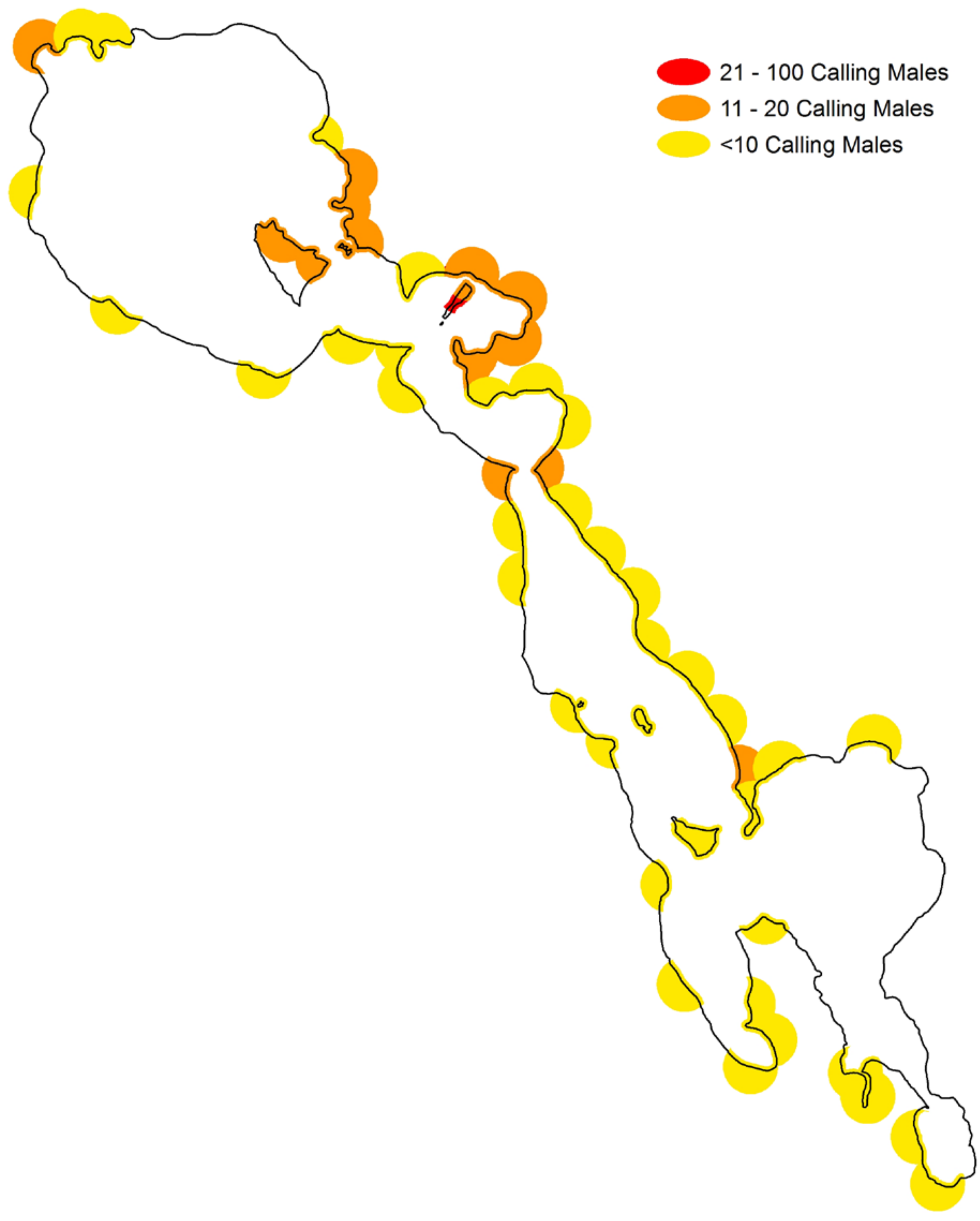


Figure 36. Abundance of green frogs heard during the Bass Lake frog surveys, June 2012.



Nongame Fish Surveys

Objectives

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

Introduction

Fish Species of Greatest Conservation Need
There are 47 fish species of greatest conservation need (SGCN) within the state of Minnesota MN DNR 2006). Of these 47 species, three are near-shore species found within Itasca County. The pugnose shiner and least darter are listed as species of Special Concern in the State of Minnesota. The longear sunfish exhibits a spotty distribution, and is listed as threatened in Wisconsin.

Pugnose shiners (*Notropis anogenus*; Figure 37) are small (38 – 56 mm), slender, silverish-yellow minnows. They possess large eyes and a distinctively upturned mouth that gives them a "pugnose" appearance. They are secretive minnows, and are found often in schools of 15 to 35 individuals. Pugnose minnows inhabit clear lakes and low-gradient streams and are extremely intolerant of turbidity. Vegetation, particularly pondweed, coontail, and bulrush, is an important habitat component.

Figure 37. Pugnose shiner

Photo by: Konrad Schmidt

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

Figure 38. Least darter

Photo by: Konrad Schmidt

Longear sunfish (*Lepomis megalotis*; Figure 39) 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 39. Longear sunfish

Photo by: Konrad Schmidt

Proxy species

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

Blackchin shiners (*Notropis heterodon*; Figure 40) 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 40. Blackchin shiner

Photo by: Konrad Schmidt

Blacknose shiners (*Notropis heterolepis*; Figure 41) 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 41. Blacknose shiner

Photo by: Konrad Schmidt

Banded killifish (*Fundulus diaphanus*; Figure 42) 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 42. Banded killifish

Photo by: Konrad Schmidt

Methods

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

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

Results

One fish species of greatest conservation need, the longear sunfish, was documented at Bass Lake (Figure 43). Longear sunfish were found at four survey stations, all in the north basin. The number of longear sunfish recorded at these stations ranged from one to 11. All three proxy fish species were also documented in Bass Lake (Figure 44). Blackchin shiners were identified at 10 survey stations, and were found within both the north and south basins as well as the channel. Surveyors counted 16 individual blackchin shiners. Banded killifish were documented at two stations (one individual at each), and a single blacknose shiner was found at one survey station. Substrate type at sites where species of greatest conservation need and proxy species were present was either sand or muck. Aquatic vegetation biovolume was similar between sites that contained SGCN and proxy species and sites that did not.

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

In total, surveyors identified 21 fish species in Bass Lake in 2012 (Table 4). Largemouth bass, recorded at 35 (of 93) survey stations, were the most frequently documented species. Yellow perch, found at 26 survey stations, were the most abundant fish recorded. Bluegills and central mudminnows were found at 20 or more stations. Black crapppie, burbot, mottled sculpin, and spottail shiner were detected at fewer than five stations each.

Figure 43. Distribution of rare fish species documented during the Bass Lake fish surveys, 2012.

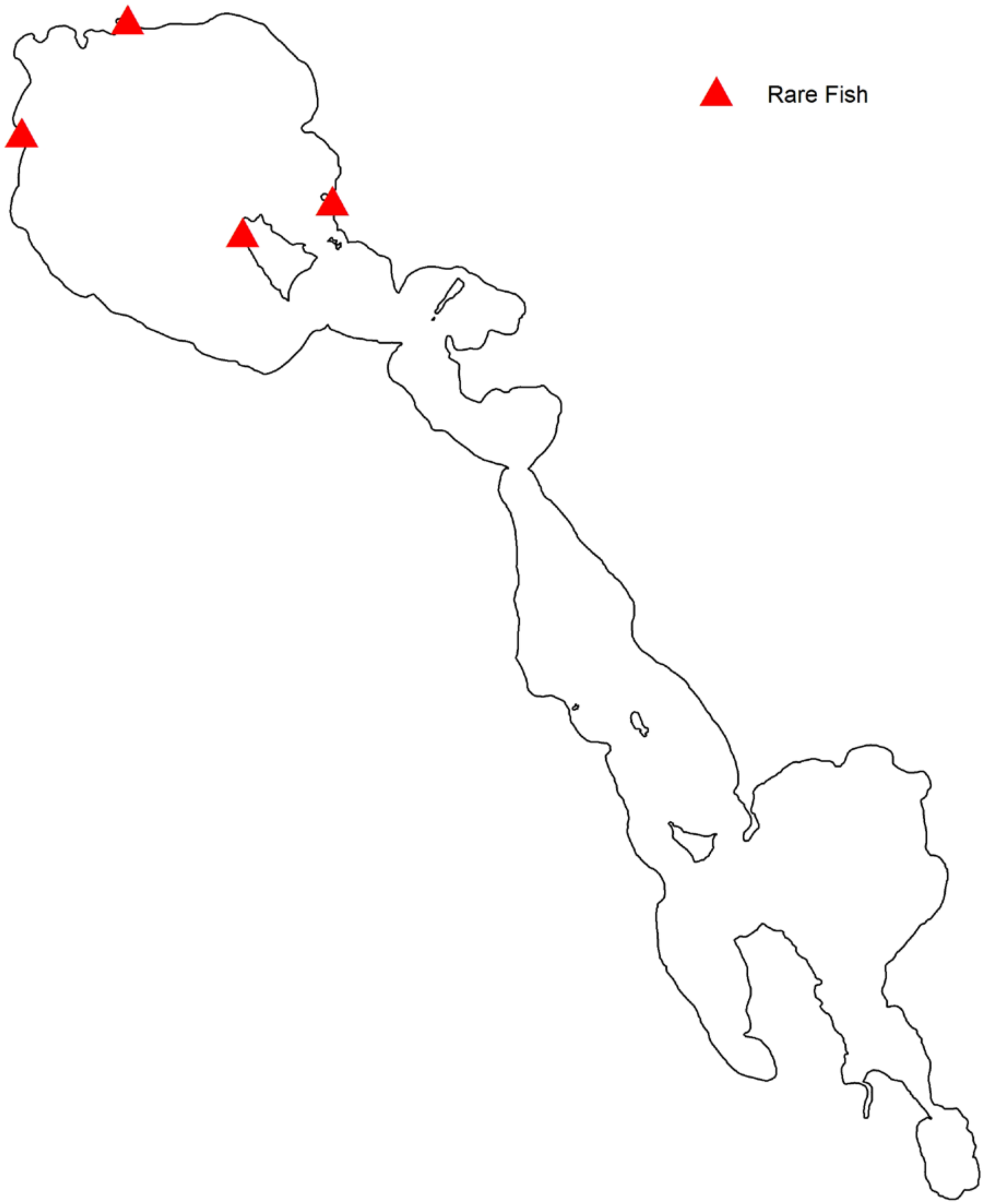


Figure 44. Distribution of fish proxy species documented during the Bass Lake fish surveys, 2012.

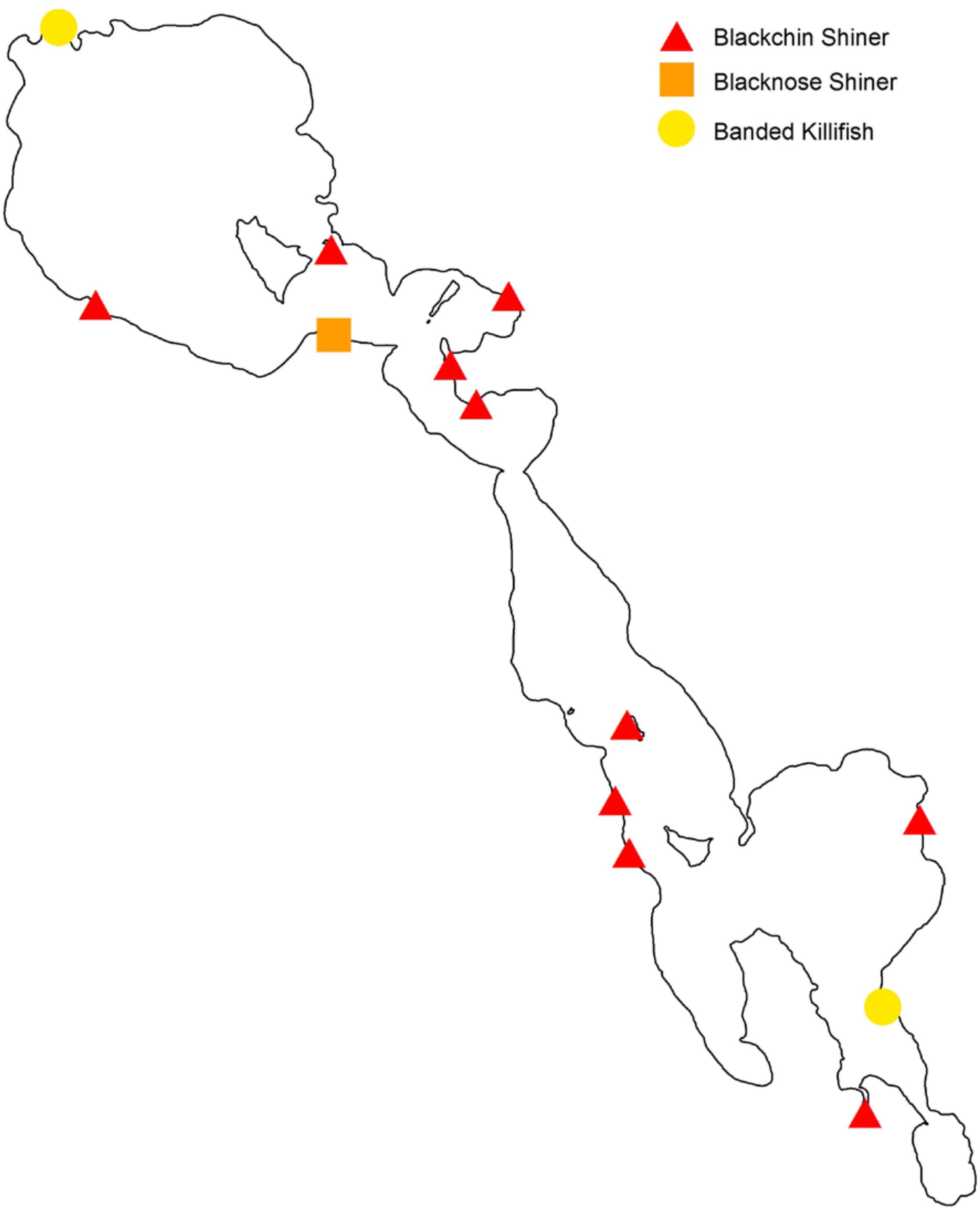


Table 4. Abundance and frequency of occurrence of fish species identified during Bass Lake fish surveys, 2012. * denotes species of greatest conservation need.

Description	**Common Name**	**Scientific Name**	**#[a]**	**%[b]**
Minnows/carps	Golden shiner	*Notemigonus crysoleucas*	12	10
	Blackchin shiner	*Notropis heterodon*	16	11
	Blacknose shiner	*Notropis heterolepis*	1	1
	Spottail shiner	*Notropis hudsonius*	2	2
	Bluntnose minnow	*Pimephales notatus*	59	9
North American freshwater	Yellow bullhead	*Ameiurus natalis*	9	1
	Tadpole madtom	*Noturus gyrinus*	7	6
Mudminnows	Central mudminnow	*Umbra limi*	38	22
Burbots	Burbot	*Lota lota*	1	1
Killifishes	Banded killifish	*Fundulus diaphanus*	2	2
Sculpins	Mottled sculpin	*Cottus bairdi*	6	3
Sunfishes	Rock bass	*Ambloplites rupestris*	27	16
	Pumpkinseed	*Lepomis gibbosus*	55	13
	Bluegill	*Lepomis macrochirus*	72	25
	Longear sunfish*	*Lepomis megalotis*	17	4
	Smallmouth bass	*Micropterus dolomieu*	10	5
	Largemouth bass	*Macropterus salmoides*	66	38
	Black crappie	*Pomoxis nigromaculatus*	1	1
Perches	Iowa darter	*Etheostoma exile*	9	9
	Johnny darter	*Etheostoma nigrum*	10	5
	Yellow perch	*Perca flavescens*	208	28

[a]# - Total number of individuals found.

[b]% - Percent of surveyed sample sites in which a species occurred (N = 93).

Aquatic Vertebrate Richness

Objective

1. Calculate and map aquatic vertebrate richness around the shoreline of Bass Lake

Introduction

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

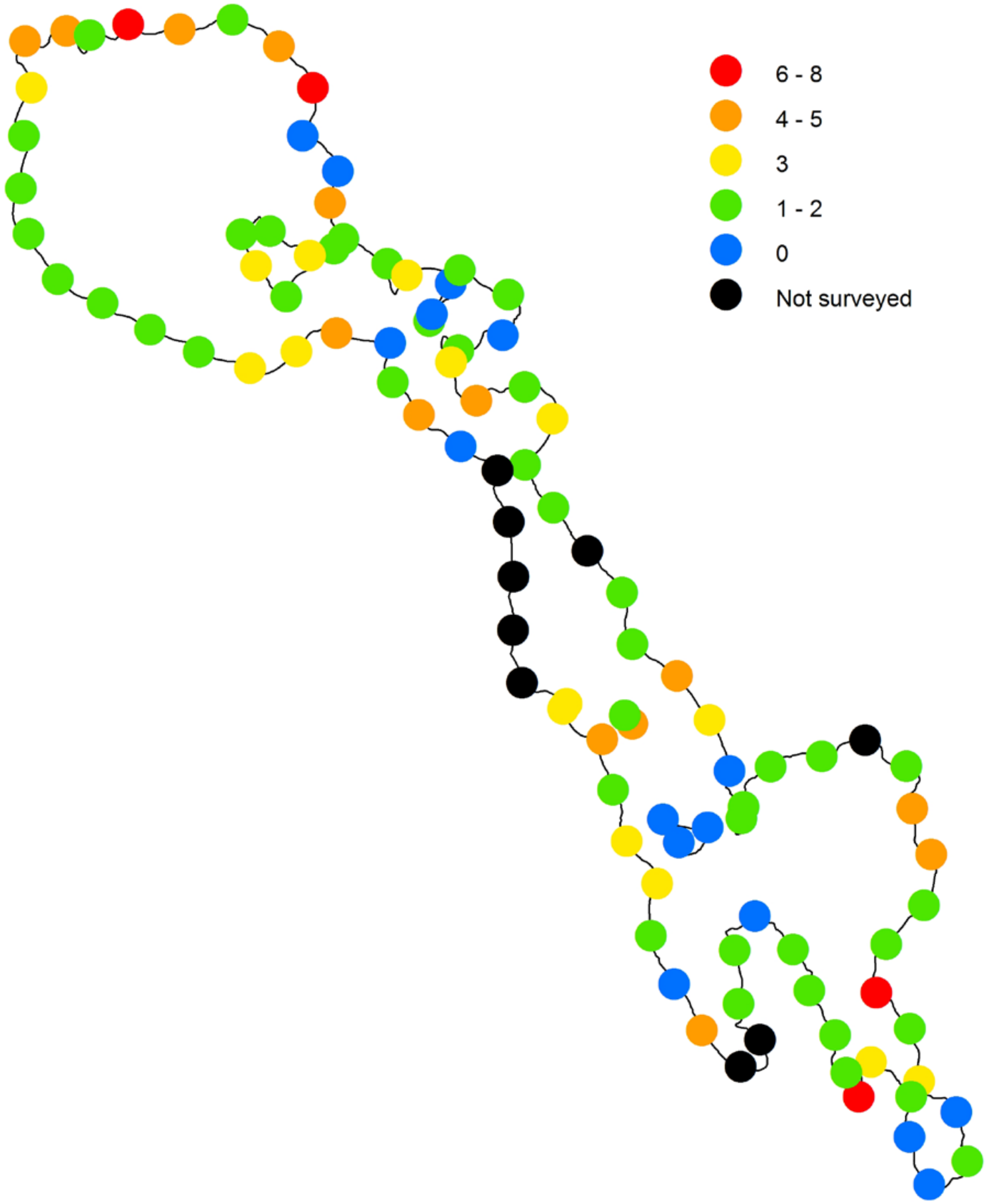
Methods

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

Results

The number of species per Bass Lake sample site ranged from zero to eight (Figure 45). High diversity sites were scattered along the shoreline of lake, and included locations in both basins as well as the channel. Several stations in the channel and the south basin were not surveyed due to inaccessibility. Ten of the 93 surveyed sample sites had five or more species documented, and 16 of the surveyed stations had zero species documented. At a number of the zero-fish sites, seining was not conducted because of excessive vegetation or soft substrate; these sites may have had fish present but surveyors were not able to document them.

Figure 45. Aquatic vertebrate species richness (number of species per sample site) in Bass Lake, 2012.



Other Rare Features

Objectives

1. Map rare features occurring within the extended state-defined shoreland area of Bass Lake

Introduction

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

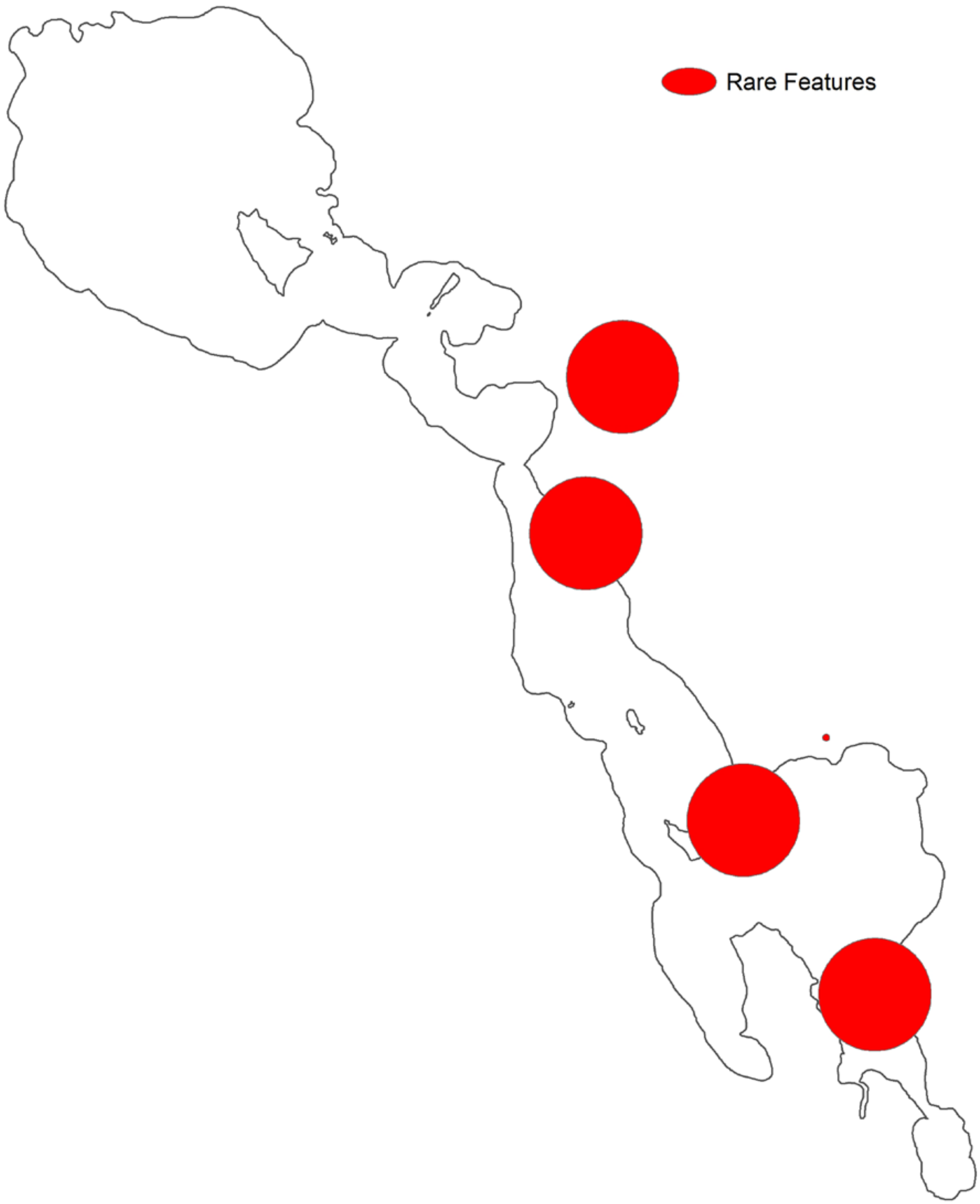
Methods

Researchers obtained locations of rare features from the Rare Features Database. Only “listed” animal and plant species (Federal or State endangered, threatened, special concern, or SGCN) 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

Five occurrences of rare features have been documented within 1320 feet of the Bass Lake shoreline (Figure 46). The rare features include a bird species of greatest conservation need, as well as a plant species of special concern. The publication of exact descriptive and locational information is prohibited in order to help protect these rare species.

Figure 46. Natural Heritage Database rare features (Federal or State-listed endangered, threatened, special concern, or SGCN species) located within 1320 feet of the Bass Lake shoreline.



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.

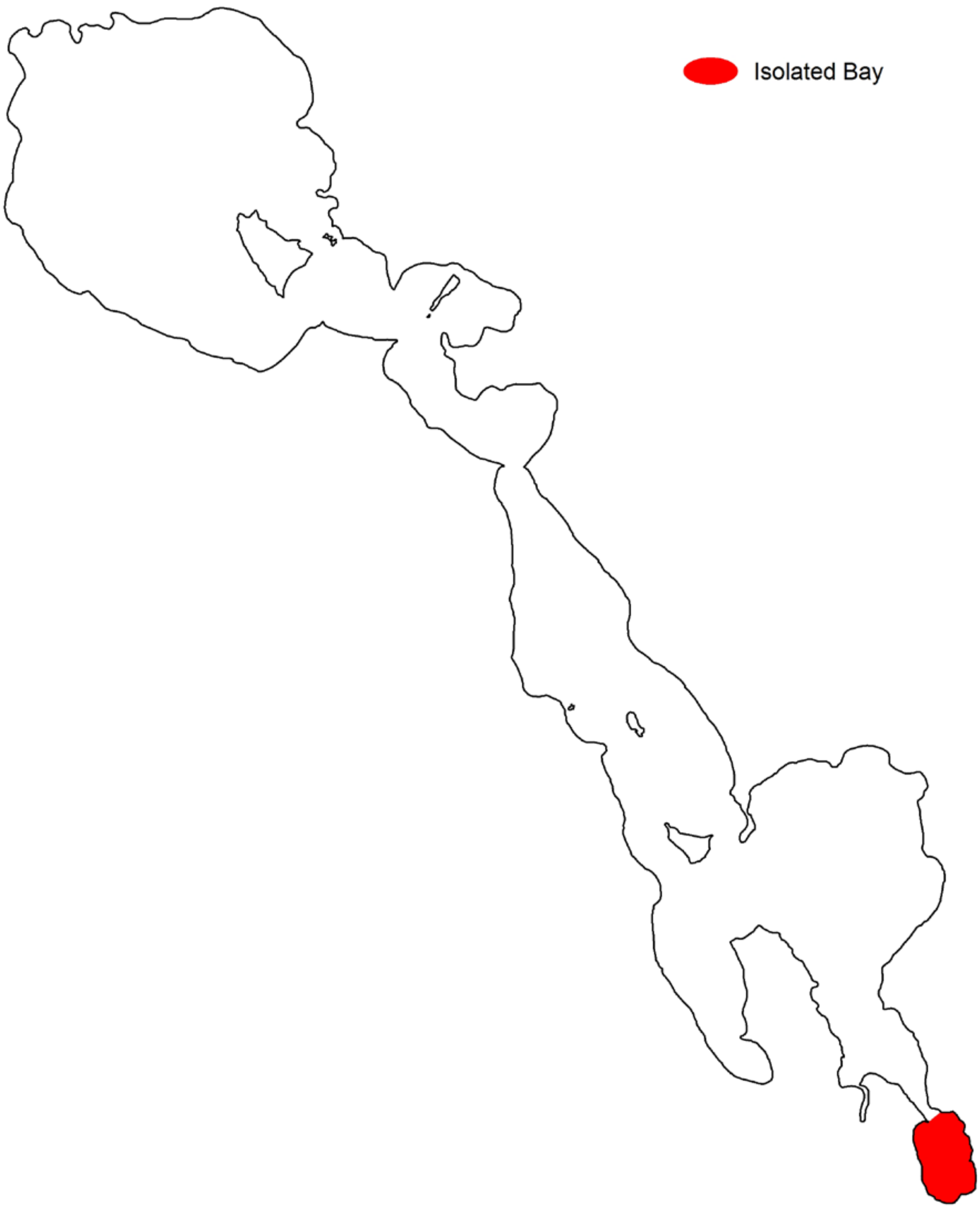
Methods

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

One isolated bay was identified on Bass Lake (Figure 47). This bay is located at the southern tip of the south basin. Although several other areas are identified as bays on earlier maps (e.g., Figure 2) and in the text, they do not function as bays in the biological sense, and were not included here.

Figure 47. Location of bays on Bass Lake.



II. Ecological Model Development

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

In order to develop a continuous sensitivity score along the shoreline, the ecological model used a moving analysis window that included both shoreland and near-shore areas. Resource managers developed a system to score each of the 13 variables. These scores were based on each variable's presence or abundance in relation to the analysis window (Table 5). 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 48). 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 49). 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 50).

Table 5. Criteria for assigning scores to analysis windows for each variable.

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

Table 5, continued.

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

Figure 48. Total score layer created by summing scores of all 13 variables. Highest total scores represent most sensitive areas of shoreline.

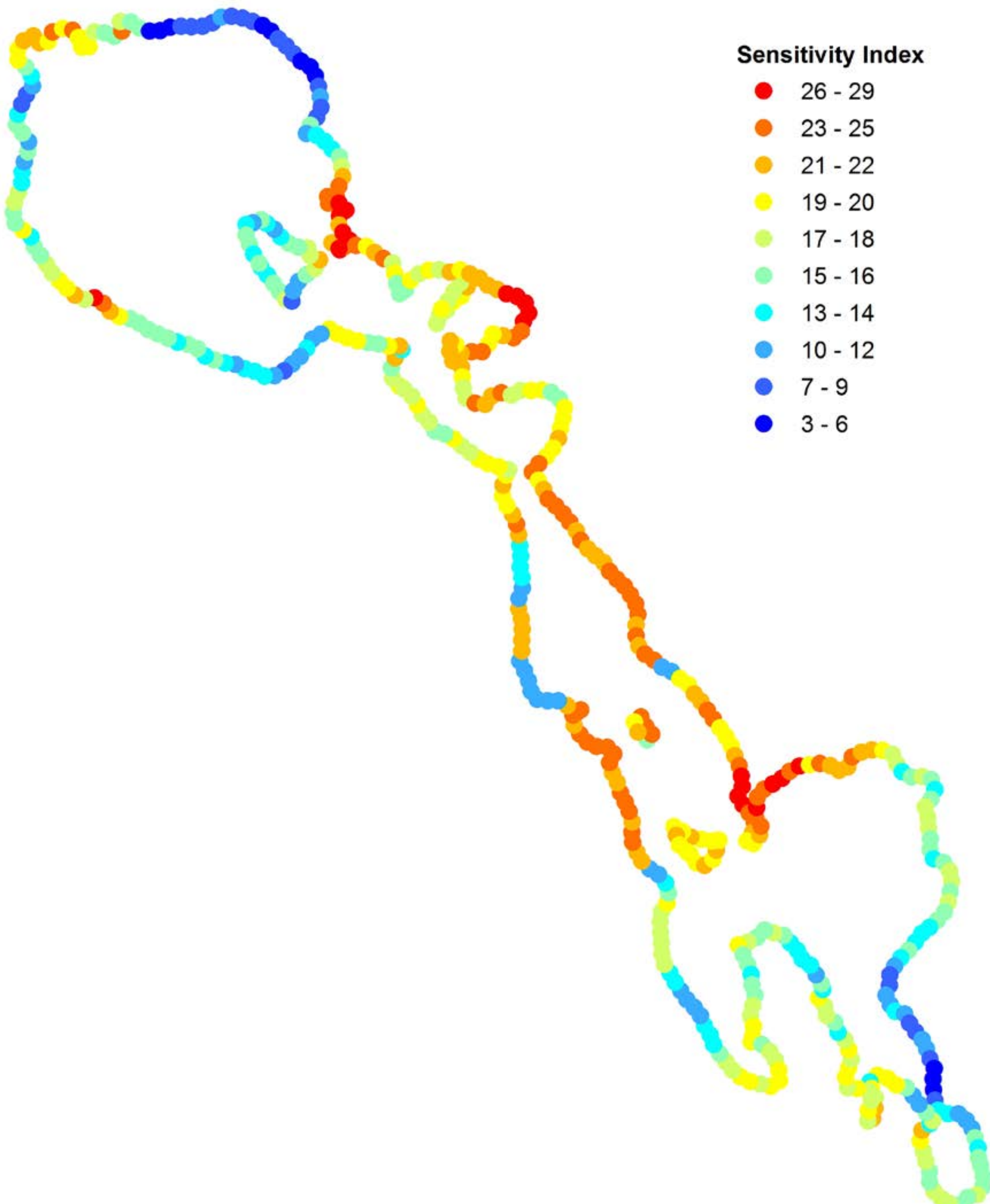


Figure 49. GIS-identified clusters of points with similar total scores. Red areas are those with high scores (i.e., areas of highly sensitive shoreland).

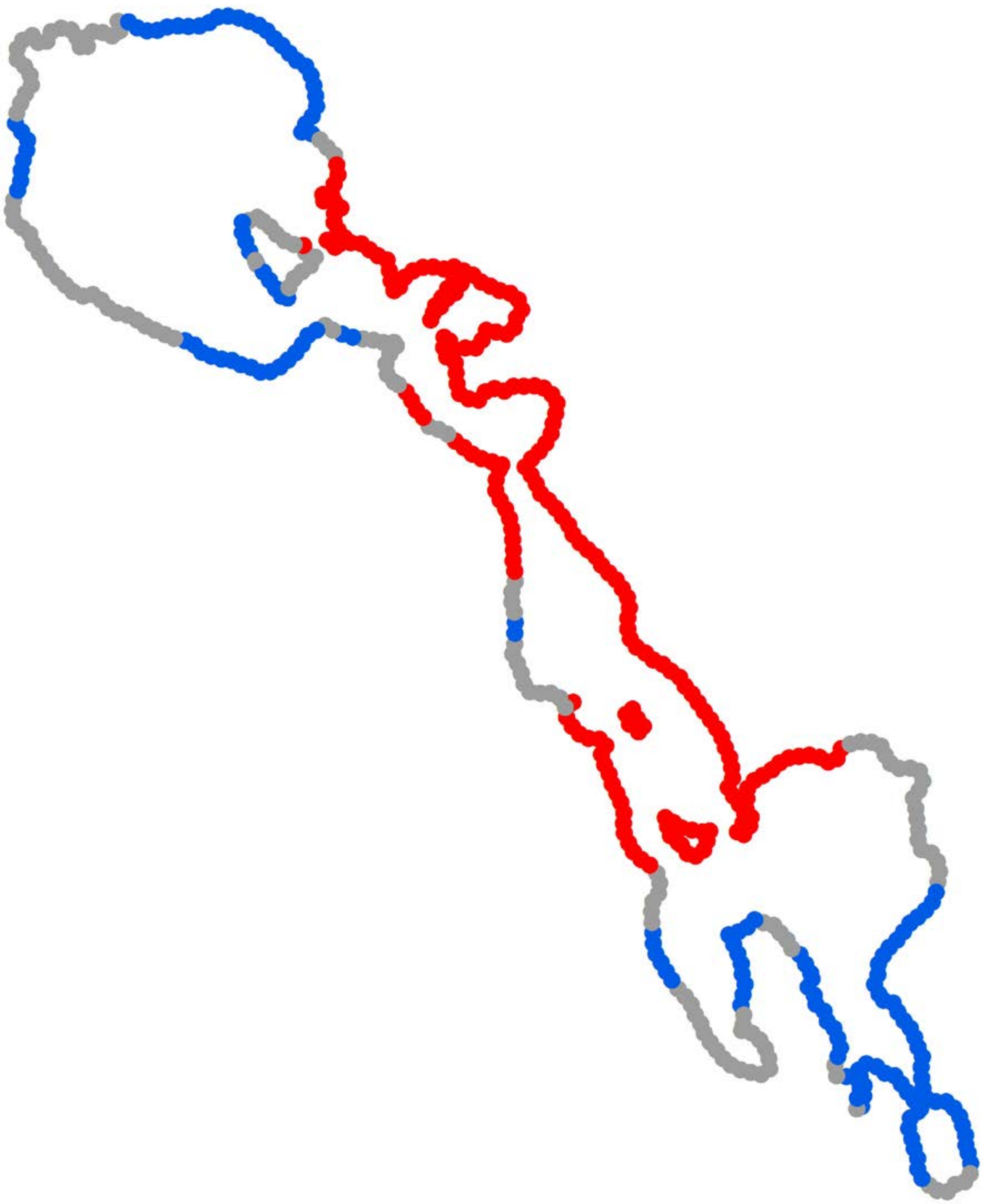
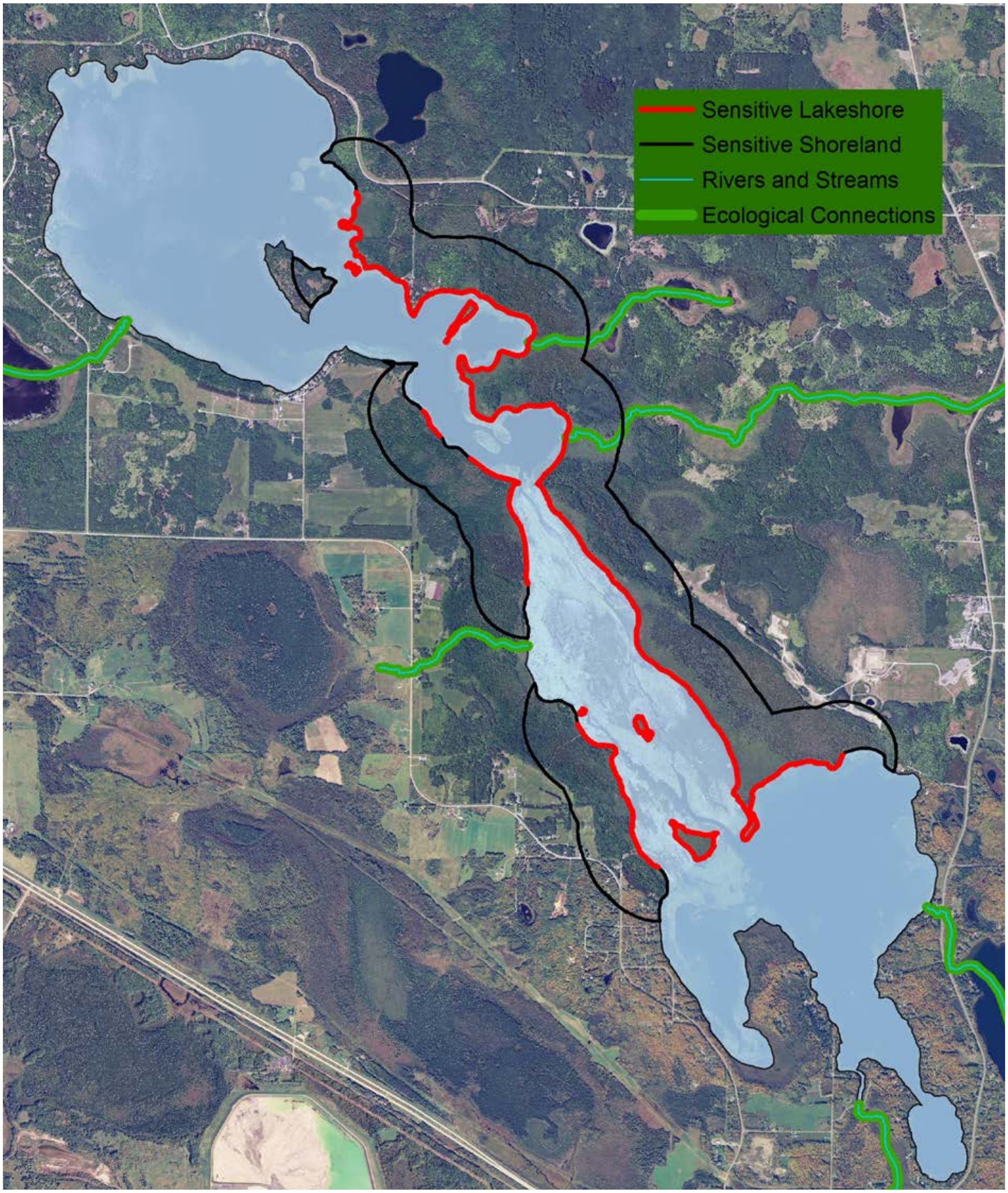


Figure 50. The Bass Lake sensitive lakeshore areas identified by the ecological model, and ecological connections.



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. Bass Brook flows into the north basin of Bass Lake from Stevens Lake, flows through Bass Lake, and then outflows from the south basin before eventually emptying into the Mississippi River. Pohl Creek flows through several small lakes before entering Bass Lake in Snyder Bay and a small unnamed stream connects Mallard Lake to Bass Lake's Fish House Bay. A stream enters Bass Lake from Little Bass Lake in the southern basin, and a small stream in the channel connects Bass Lake to a nearby wetland.

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 Bass Lake that contain important plant communities but these sites are not necessarily associated with priority shoreland features. Identifying these sites is important, although exact delineation of their boundaries can be difficult if they occur in the water and/or if they are patchy in distribution.

Emergent and floating-leaf plant beds that occur outside of the sensitive shoreland districts are areas of ecological significance. Further destruction of bulrush plants would be particularly detrimental because attempts to restore these types of plants have had limited success.

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

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

Sensitive Lakeshore

The channel and nearby areas of Bass Lake, as well as small stretches of shoreline in the north and south basins (Figure 48) 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 Bass Lake 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 Bass Lake, and the value of the lake itself.

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