Aquatic Plant Management Plan

Mudhen Lake Rehabilitation District

Burnett County, WI
May 12, 2012

Sponsored By
Mudhen Lake Rehabilitation District

Aquatic Plant Advisory Committee Members:

- Dan and Diane Heintz
- Scott and Cyndi Stennes
- Jeff Fagerstrom
- Kandace Unger
- Julie Schmidt
- Mike Hoefs
- Mike Huber
- Steve Hoffman
- Ted and Wilhelmina Fischer
- Larry Peine

Advisory Committee

Dave Ferris	Burnett County Conservationist
Pamela Toshner	WI DNR Lakes & Rivers Management
Kathy Bartilson	Water Quality Biologist/Statewide Aquatic Plant Management Coordinator WI DNR

Prepared By

Burnett County Land & Water Conservation Department	Plan Writing and Facilitation Brad Morris, AIS Coordinator

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Introduction

The Aquatic Plant Management Plan for Mudhen Lake is sponsored by the Mudhen Rehabilitation District. The planning phase of the project is funded, in part, by the Burnett County Land and Water Conservation Department and the Mudhen Lake Rehabilitation District.

Knowing that Eurasian water milfoil (*Myriophyllum spicatum*) is found in several lakes in Burnett and Washburn County, concerned members of the Mudhen Lake Rehabilitation District authorized an extensive assessment of Mudhen Lake aquatic macrophytes using the Wisconsin Department of Natural Resources statewide guidelines for conducting systematic point intercept macrophyte sampling. This Aquatic Plant Management Plan for Mudhen Lake presents a strategy for managing aquatic plants by protecting native plant populations and preventing the establishment of invasive species. The plan includes data about the plant community, watershed, and water quality, as well as other non plant species. Based on this data and public input, goals and strategies for the sound management of aquatic plants in Mudhen Lake are presented. This plan will guide the Mudhen Lake Rehabilitation District, Burnett County, and the Wisconsin Department of Natural Resources in aquatic plant management for Mudhen Lake over the next five years (from 2012 through 2017).

Public Input for Plan Development

On June 28th, 2010, members of the Mudhen Lake Rehabilitation District met to discuss the process of creating an Aquatic Plant Management (APM) Plan. At this meeting, a tentative Aquatic Plant Advisory Committee was established. Furthermore, the recommendation of additional committee members was discussed with the assumption that additional members would be added in the near future. During this meeting a date was established (August 13, 2011) to hold a kick-off meeting. An announcement was sent to each lake home resident informing them about the meeting, including time and location. Additionally, at the first meeting, those present reviewed aquatic plant management planning requirements and discussed initial concerns.

On August 13, 2011, a Public meeting was held to discuss the concerns of Mudhen Lake and to establish those concerns as the primary focus of writing the Aquatic Plant Management Plan for the lake. Prior to the meeting date, a Public Notice was advertised for three weeks in the Spooner Advocate. A total of 36 people were present for the meeting. Minutes of the meeting were recorded. A summary of the concerns are listed below:

- Protect, prevent and control the spread of aquatic invasive species such as Zebra mussels and Eurasian water milfoil
- Control and prevent nutrient run-off/shore land preservation/restoration
- Issues concerning Carp populations

- Encouraging the growth of native plants
- Mass education on various subjects related to protecting and preserving this natural resource, including wildlife and fish species enhancement
- Boat landing inspections
- Issues concerning the amount of Eurasian water milfoil in Burnett County

A brief meeting was held immediately after the Kick-off meeting to establish a committee. The Mudhen Lake Rehabilitation District board announced the availability of the draft Aquatic Plant Management Plan for review by April 6, 2012. Copies will be available at the following locations: Burnett County Government Center Land and Water Conservation Department Room 21, online at the Burnett County Website, and from Mudhen Lake Aquatic Plant Management committee members. Comments and suggestions can be mailed or emailed to the address/addresses below.

Schedule for Plan Completion May 5, 2012

Final draft for DNR and public review by May 12, 2012

Comments accepted on the plan through April 27, 2012

Send comments via mail or email to:

Brad Morris
Burnett County Land and Water Conservation Department
7410 County Road K, #109
Siren, WI 54872
bmorris@burnettcounty.org

Board meeting to review comments TBD

Lake Information

Mudhen Lake (WBIC 2649500) is a 569 acre lake located in Burnett County. It has a maximum depth of 66 FEET. Features include a public boat landing. Fish in the lake include Panfish, Largemouth Bass, Northern Pike. Water clarity is moderate, with an average Secchi visibility of 11.5 feet, creating a littoral zone of 17 feet, which classifies this lake as a Mesotrophic lake.

Table 1: Lake Information

	Mudhen Lake
Size (acres)	569
Mean depth (feet)	14
Maximum depth (feet)	66
Littoral zone depth (feet)	18

A Map of Mudhen Lake can be found on the following page in Figure 1.

Historic Descriptions[2]

1992- Mud Hen Lake is a 563 acre, hard water, drainage lake located at the headwaters of the North Fork Wood River. The lake community formed a lake district around this lake in 1977. A feasibility study was conducted and the results published in 1981. Mud Hen Lake was documented as a mesotrophic body with good water quality and relatively few trophic problems at present. Management alternatives suggested for this lake concentrated on water quality protection measures but also mentioned aeration, macrophyte harvesting and water level stabilization. This lake should be ranked high for funding implementation measures that follow through on the management recommendations set down in the 1981 report. The lake district should be encouraged to continue the pursuit of a long range management plan to direct and prioritize their future lake management efforts.
1966- Source: 1966, Surface Water Resources of Burnett County Mud Hen Lake, T38N, R17W, Sections 15, 16, 17, 21 Surface Acres = 572.7, Maximum Depth = 65 feet, M.P.A. 85 ppm, Secchi Disk 11 feet A hard water, seepage lake which is the headwaters of the North Fork Wood River. Its outlet flow is approximately 3.3 cubic feet per second. The fish population is composed of northern pike, largemouth bass, bluegill, perch, black crappie, pumpkinseed, bullhead, white sucker, bowfin and common shiner. The lakeshore is mostly upland hardwoods except for an area of tag alder, tamarack and spruce swamp in the northeast end and near the outlet. This swampy area provides habitat for nesting mallards, blue-winged teal, wood ducks and loons. Large numbers of migrant puddle ducks, diving ducks, coots and geese use the lake at times. The littoral zone has an abundant growth of bulrushes, spike rush, pickerelweed, pondweed species, water lilies and water shield. The east end of the lake has a large stand of bulrushes which extends almost one-third the length of the lake. There are five resorts, 44 cottages and dwellings and one church camp around the lake. Lindberg Park, a town park, at the southeast end of the lake, provides access and picnicking facilities. The park is the only public frontage and amounts to 0.02 miles.[2]

Water Quality

Water quality is frequently reported by the trophic state or nutrient level of the lake. Nutrient-rich lakes are classified as eutrophic. These lakes tend to have abundant aquatic plant growth and low water clarity due to algae blooms. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms. Oligotrophic lakes are nutrient-poor with little growth of plants and algae.

Secchi depth readings are one way to assess the trophic state of a lake. The Secchi depth is the depth at which the black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. Secchi depth readings, phosphorus concentrations, and chlorophyll measurements can each be used to calculate a Trophic State Index (TSI) for lakes. TSI values range from 0 – 110. Lakes with TSI values greater than 50 are considered eutrophic. Those with values in the 40 to 50 range are mesotrophic. Lakes with TSI values below 40 are considered oligotrophic.

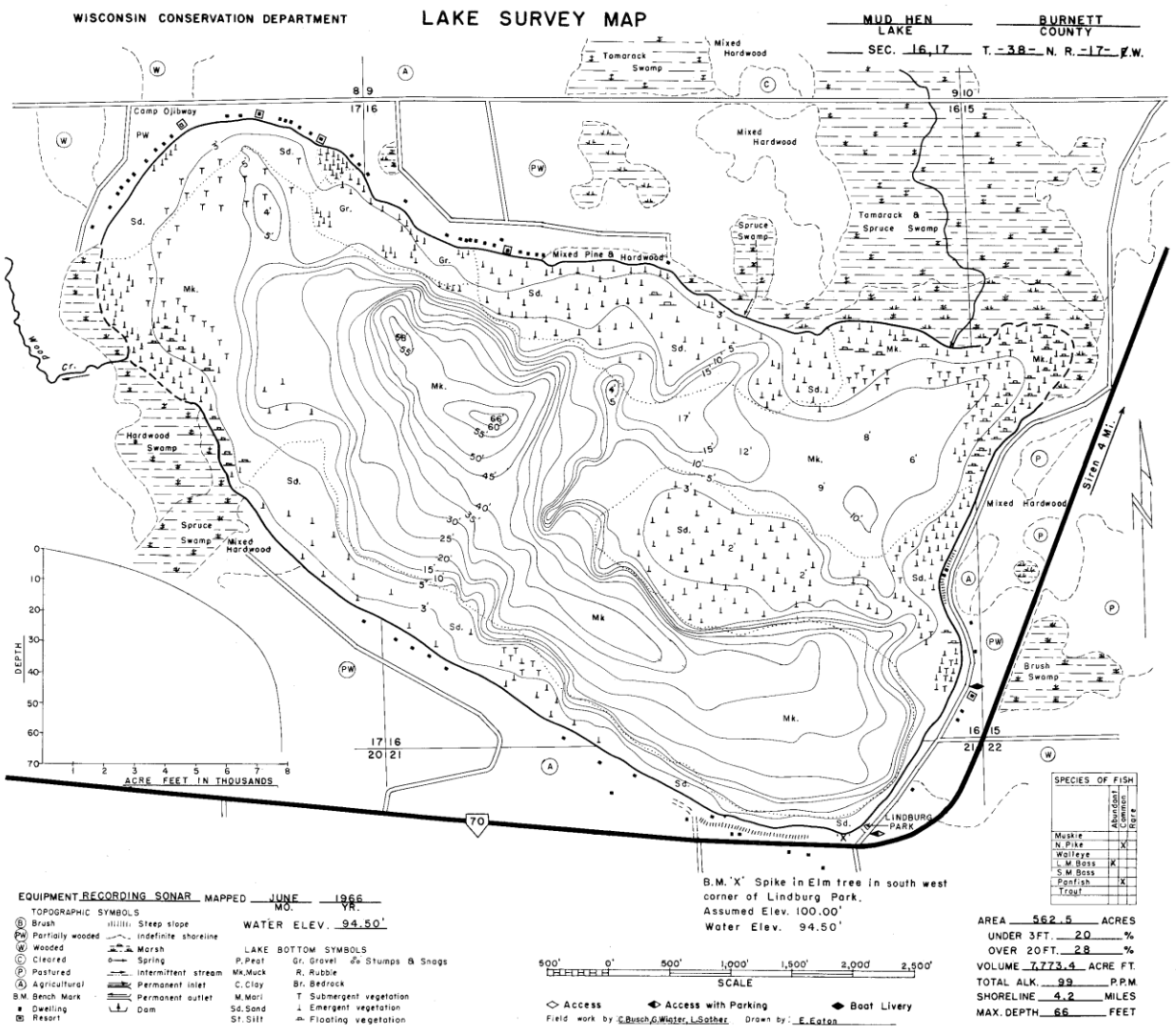
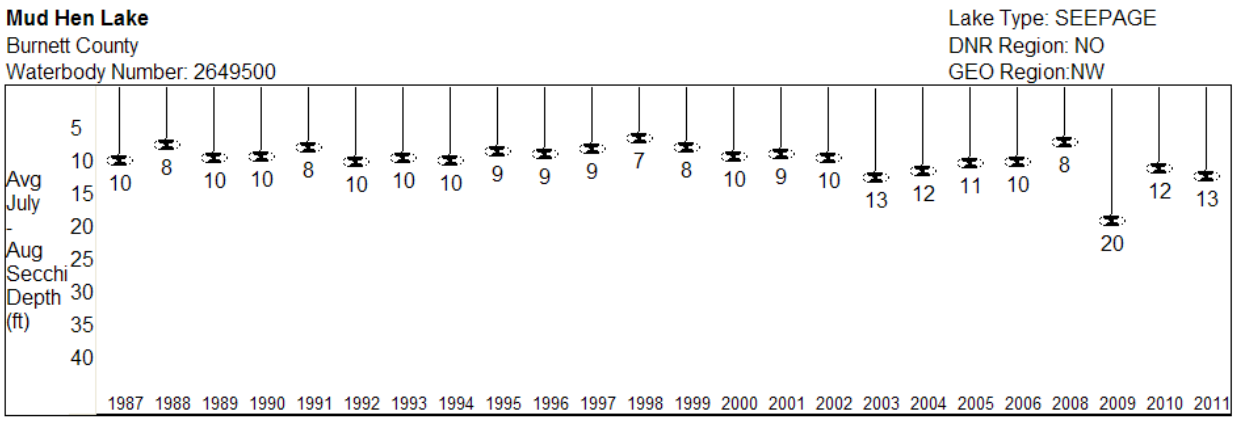


Figure 1: Mudhen Lake Map[1]

Citizen lake monitoring volunteers have collected lake data annually since 1987. The average summer (July-Aug) secchi disk reading for Mudhen Lake - Deep Hole (Burnett County, WBIC: 2649500) was 11.5 feet. The average for the Northwest Georegion was 7.5 feet.

Chemistry data was collected on Mudhen Lake - Deep Hole. The average summer Chlorophyll was 4.1 µg/l (compared to a Northwest Georegion summer average of 19.1 µg/l). The summer Total Phosphorus average was 18 µg/l. Lakes that have more than 20 µg/l and impoundments that have more than 30 µg/l of total phosphorus may experience noticeable algae blooms.

The overall Trophic State Index (based on chlorophyll) for Mudhen Lake - Deep Hole was 45. The TSI suggests that Mudhen Lake - Deep Hole was **mesotrophic**. Mesotrophic lakes are characterized by moderately clear water, but have an increasing chance of low dissolved oxygen in deep water during the summer.[2]

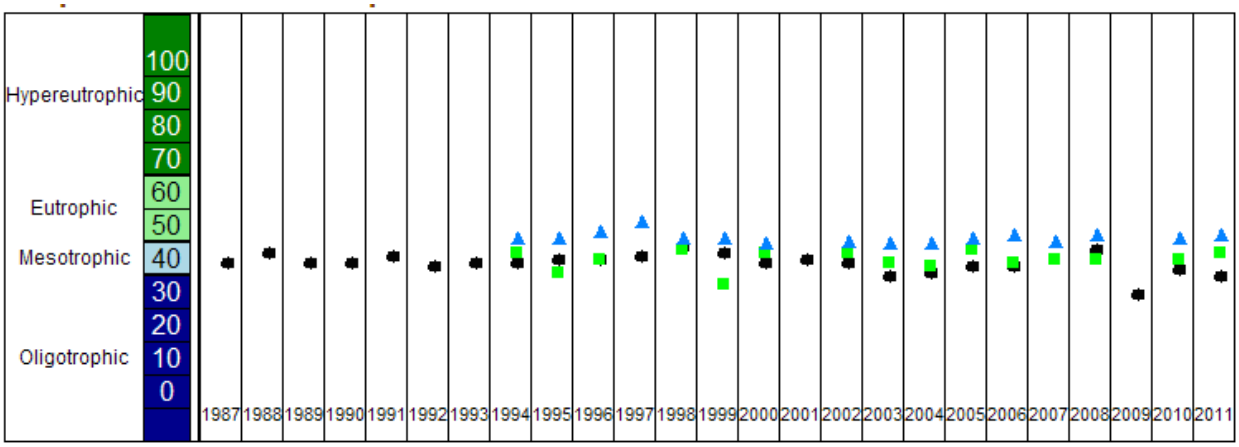


Past secchi averages in feet (July and August only).

Figure 2: Secchi Readings on Mudhen Lake[2]

Table 2: Secchi Readings on Mudhen Lake from 1987-2011[2]

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1987	10.3	9.75	10.75	2
1988	8	7	9	5
1989	10	9.5	10.5	5
1990	9.7	9	11	5
1991	8.4	7	10	5
1992	10.5	10	11	2
1993	10	10	10	1
1994	10.3	8.5	18	6
1995	9	8.5	10	4
1996	9.3	9	10.25	4
1997	8.6	7.75	10.25	4
1998	7	7	7	1
1999	8.3	7.5	9	3
2000	9.8	9	10.5	5
2001	9.3	9.25	9.25	1
2002	9.9	9.75	10	2
2003	13	9	17	2
2004	12	11	13	2
2005	10.8	10	11.5	2
2006	10.5	10.5	10.5	1
2008	7.5	7.5	7.5	3
2009	19.5	19.5	19.5	2
2010	11.5	11.5	11.5	1
2011	12.8	11	15.5	4



TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

TSI	TSI Description
TSI < 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
TSI > 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Figure 3: Trophic State Index for Mudhen Lake Deep Hole[2]

Watershed

Mudhen Lake is part of the Wood River Watershed (SC11). "The Wood River Watershed lies in southwestern Burnett County and includes a small portion of northern Polk County. It is approximately 140,951 acres in size and contains 197 miles of streams and rivers, 5,461 acres of lakes and 34,321 acres of wetlands. It is dominated by forests (37%), wetlands (24%) and grassland (21%), and is ranked low for nonpoint source issues. Mud Hen Lake is considered an Impaired Lake and is on the 303(d) list due to mercury from atmospheric deposition."[4]

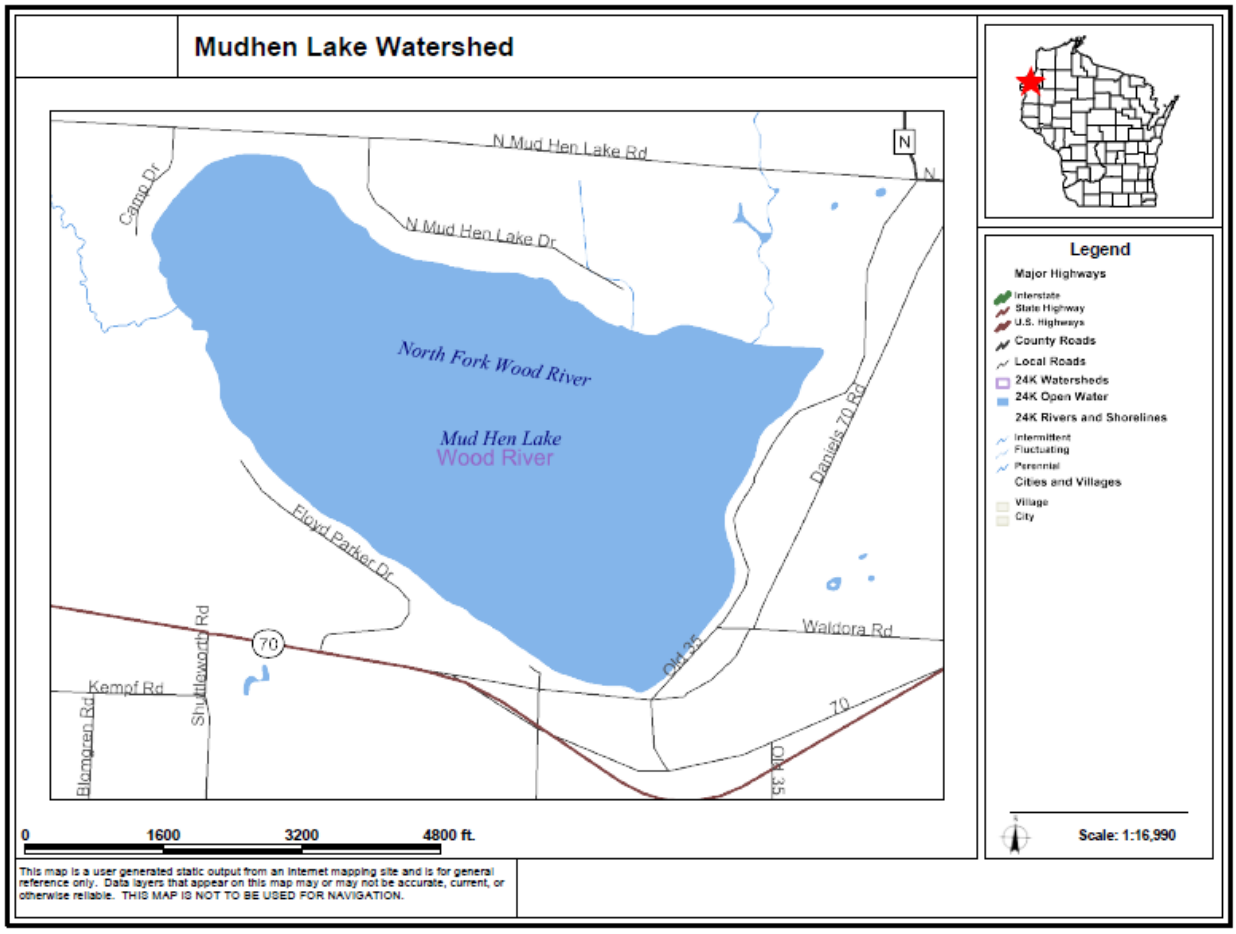


Figure 4: Wood River Watershed[3]

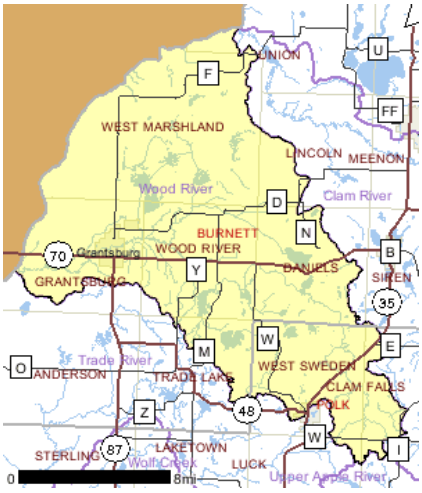


Figure 5: Wood River Watershed[3]

Watershed Runoff

Land cover plays a critical role in a watershed. The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and

eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, overabundant macrophyte populations, and decreased dissolved oxygen levels.[5] Land that is maintained in a natural, vegetated state is beneficial to soil and water quality.

A 2002 State of the St. Croix River Basin report, identified four key priorities for the basin, all of which are directly associated with water quality:[4]

1. Protection and restoration of shoreland habitat
2. Control of nonpoint source runoff contamination of surface waters
3. Restoration of grasslands, prairies, and wetlands to protect soil and water quality, and to enhance wildlife habitat
4. Implementation of a Northwest Sands Integrated Ecosystem Management Plan

Below is a list of Land Cover Classifications and percentages for each found in the St. Croix Basin(see St. Croix Basin Land Cover Map 2), followed by a short discussion of the major land cover types.

Table 3: Land Cover Classification found in the St. Croix Basin[4]

Forest -	48.01%
Grassland -	16.64%
Wetland -	14.02%
Agriculture-	12.85%
Water-	4.55%
Shrubland-	3.18%
Urban/Developed-	0.43%
Barrens-	0.32%

The majority of Burnett County's land cover is made up of forest, while grassland, open water and wetlands make up approximately one-third. Figure 6 below represents the land cover of the Wood River Watershed.

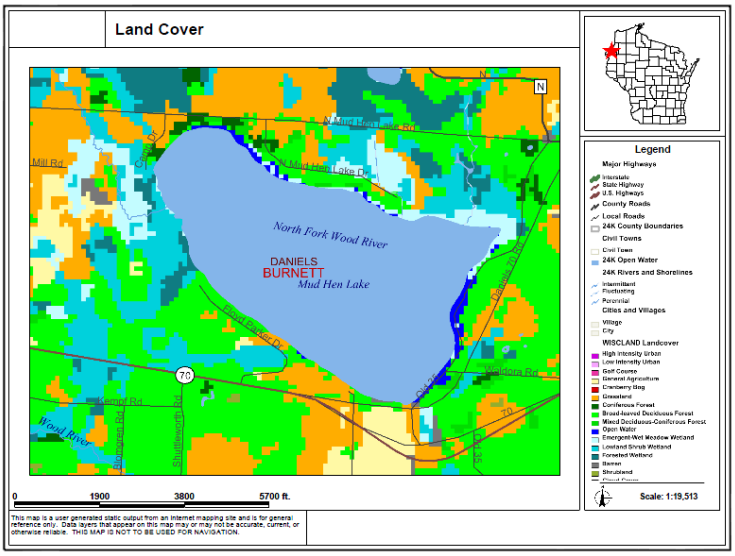


Figure 6: Wood River Watershed Land Cover[3]

Functions and Values of Native Aquatic Plants

Naturally occurring native plants are extremely beneficial to the lake. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Water Quality

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline. The shoreline plant populations around Mudhen Lake are particularly important to reducing erosion along the shoreline, but these populations are also vulnerable to the nutrient loading and the resultant algae growth in the lakes.

Fishing

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish such as bluegills graze directly on the plants themselves. Plant beds, such as bulrush present on both Mudhen Lake, provide important spawning habitat for many fish species.

Waterfowl

Plants offer food, shelter, and nesting material. Birds eat both the invertebrates that live on plants and the plants themselves.[6]

Protection against Invasive Species

Non-native invasive species threaten native plants in Northern Wisconsin. The most common are Eurasian water milfoil (EWM) and curly leaf pondweed (CLP). These species are described as opportunistic invaders. This means that they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established in the lake. This concept of opportunistic invasion can also be observed on land, in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but it increases the risk of non-native species invasion and establishment. Invasive species can change many of the natural features of a lake and often lead to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.[7]

Aquatic Invasive Species Status

Purple loostrife (Lythrum salicaria), reed canary grass (Phalaris arundinacea), and curly leaf pondweed (Potamogeton crispus) have been observed on Mudhen Lake. No Eurasian water milfoil (Myriophyllum spicatum) was found on the lake, but it has been found in three nearby lakes in Burnett County: Ham Lake, Round Lake and Trade Lake. It is therefore of paramount importance that the Mudhen Lake Rehabilitation District takes measures to avoid the introduction of EWM into the lake.

Sensitive Areas

The Wisconsin Department of Natural Resources has completed sensitive area surveys to designate areas within aquatic plant communities that provide important habitat for game fish, forage fish, macroinvertebrates, and wildlife, as well as important shoreline stabilization functions. The Department of Natural Resources is transitioning to designations of critical habitat areas that include both sensitive areas and public rights features. The critical habitat area designation will provide a holistic approach to ecosystem assessment and protection of those areas within a lake that are most important for preserving the very character and qualities of the lake.

One other species of interest exist in Mudhen Lake: Chinese mystery snails (*Bellamya chinensis*). At this time, no negative effects to the aquatic plant community have been observed. Future monitoring of this species should continue to ensure a healthy population of native aquatic plants.

Critical habitat areas include sensitive areas that offer critical or unique fish and wildlife habitat (including seasonal or lifestage requirements) or offer water quality or erosion control benefits to the area (Administrative code 107.05(3)(1)(1)). The Wisconsin Department of Natural Resources is given the authority for the identification and protection of sensitive areas of the lakes. Public rights features are areas that fulfill the right of the public for navigation, quality and quantity of water, fishing, swimming, or natural scenic beauty. Protecting these critical habitat areas requires the protection of shoreline and in-lake habitat. The critical habitat area designation will provide a framework for management decisions that impact the ecosystem of the lake.

Mudhen Lake is designated as having critical habitat areas (see Figure 7 below). Also, see Appendix A for a detailed summary of the Critical Habitat Designation Program Rule Summary.

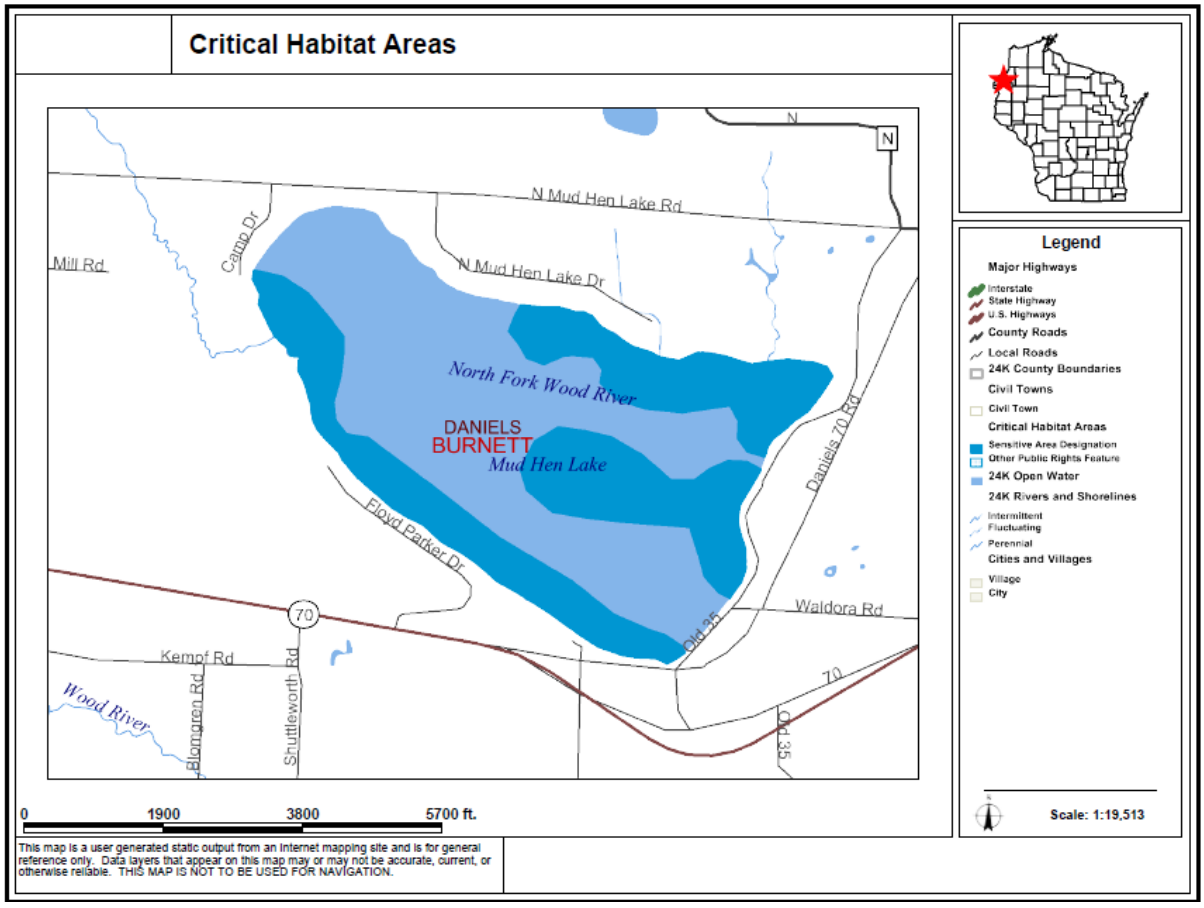


Figure 7: Critical Habitat Areas for Mudhen Lake

Table 4: Natural Heritage Inventory (NHI) Species Found in Mudhen Lake Area (T.38N. – R.17W.)[8]

Common Name	Scientific Name	WI State Status
Red-Shouldered Hawk	*Buteo lineatus*	THR
Gray Wolf	*Canis lupus*	SC/FL
Blanding's Turtle	*Emydoidea blandingii*	THR
Lake-soft bog	*Lake – Soft bog*	NA
Tamarack (poor) swamp	*Tamarack (Poor) Swamp*	NA
Northern mesic forest	*Northern Mesic Forest*	NA
Bald Eagle	*Haliaeetus leucocephalus*	SC/P
Weed Shiner	*Notropis texanus*	SC/N
Slender Bulrush	*Scirpus heterochaetus*	SC

WDNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:

Key: **END** = endangered **SC/P** = fully protected
THR = threatened **SC/N** = no laws regulating use, possession, or harvesting
SC = Special Concern **SC/H** = take regulated by establishment of open /closed seasons
SC/FL = Federally protected as endangered or threatened, but not so designated by state
SC/M = fully protected by federal and state laws under the Migratory Bird Act

Mudhen Lake Fishery

Table 5: Mudhen Lake Fish Species List

Common Name	Scientific Name	Relative Abundance
Gamefish		
Northern pike	Esox lucius	Abundant
Largemouth Bass	Micropterus salmoides	Abundant
Panfish		
Bluegill	Lepomis macrochirus	Abundant
Black crappie	Pomoxis nigromaculatus	Abundant
Pumpkinseed	Lepomis gibbosus	Common
Rock bass	Amblopites rupestris	Common
Yellow perch	Perca flavecens	Common
Green sunfish	Lepomis cyanellus	Present
Warmouth	Lepomis gulosus	Present
Brown bullhead	Ictalurus nebulosus	Present
Yellow bullhead	Ictalurus natalis	Present
Forage and other species		
Bowfin	Amia calva	Common
White sucker	Catostomus commersoni	Common
Common Carp	Cyprinus carpio	Present

Golden shiner	Notemigonus crysoleucas	Present
Common shiner	Notropis cornutus	Present
Spottail shiner	Notropis hudsonius	Common
Blacknose shiner	Notropis heterolepis	Present
Blackchin shiner	Notropis heterodon	Present
Log perch	Percina caproides	Present
Iowa darter	Etheostoma exile	Present
Johnny darter	Etheostoma nigrum	Present
Brook silverside	Labidesthes sicculus	Common
Bluntnose minnow	Pimephales notatus	Present
Banded killifish	Fundulus diaphanous	Present

Plant Community

METHODS:

Using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth and total lake acres, Michelle Nault (WDNR) generated a sampling grid for Mudhen Lake (Figure 9). In May, we conducted a Curly-leaf pondweed survey to check for the presence of this invasive species. During this survey, we went to each of the 498 points on Mudhen Lake. We sampled just for Curly-leaf pondweed at each site. This type of survey should result in both detection and approximate mapping of any infestation that may have occurred. During the May survey, no Curly-leaf pondweed was detected. It was during the July survey that Curly-leaf pondweed was discovered.

During the May survey, a general idea for the lake and plant communities was established and more detailed summary during the July survey. All plants found were identified (Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006), and two vouchers were pressed and retained for herbarium specimens – one to be retained by the Mudhen Lake Rehabilitation District, and one to be sent to the state for identification confirmation. During the point intercept survey, we located each survey point using a handheld mapping GPS unit (Garmin 76CSx). At each point, we recorded a depth reading with a Hummingbird depth finder unit. After sampling numerous depths at numerous sites, we were able to establishment the littoral zone at a maximum of 17ft. We sampled for plants within the depth range of plant growth. At each of these points, we used a rake (either on a pole or a throw line depending on depth) to sample an approximately 2.5ft. section of the bottom. All plants on the rake, as well as any that were dislodged by the rake were identified, and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of plants within six feet of the sample point. Substrate (lake bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

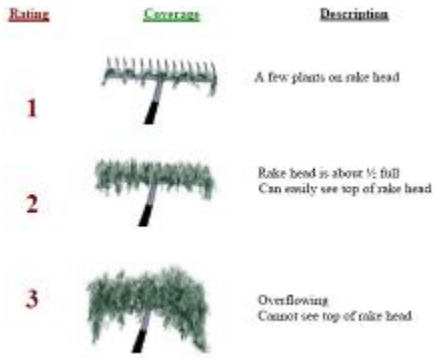


Figure 8: Rake Fullness Ratings (UWEX, 2007)

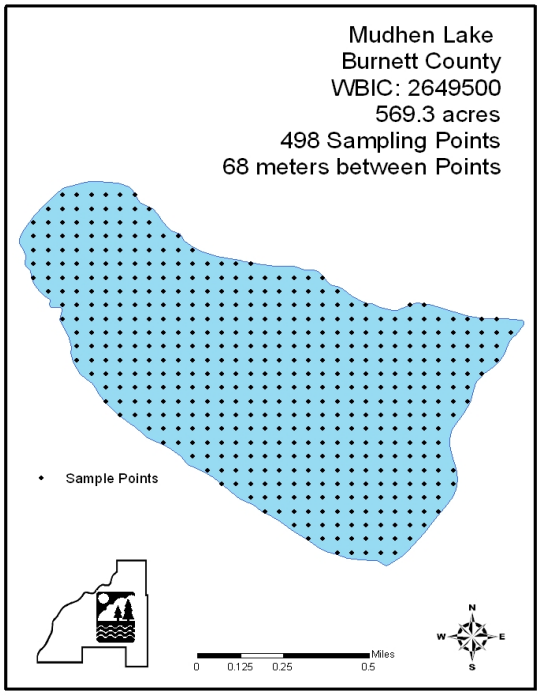


Figure 9: Mudhen Lake Sample Grid

DATA ANALYSIS:

We entered all data collected into the standard APM spreadsheet (UWEX, 2007). From this, we calculated the following:

Total number of points sampled: This included the total number of points on the lake coverage that were within the littoral zone (0-maximum depth where plants are found) Initially, we continued to sample points whose depth were several feet beyond the littoral zone, but once we

established this maximum depth with confidence, most points beyond this depth were not rake sampled.

Total number of sites with vegetation: These included all sites where we found vegetation after doing a rake sample. For example, if 20% of all sample sites have vegetation, it suggests that 20% of the lake has plant coverage.

Total number of sites shallower than the maximum depth of plants: This is the number of sites that are in the littoral zone. Because not all sites that are within the littoral zone actually have vegetation, we use this value to estimate how prevalent vegetation is throughout the littoral zone. For example, if 60% of the sites shallower than the maximum depth of plants have vegetation, then we estimate that 60% of the lake's littoral zone has plants.

Frequency of occurrence: The frequency of all plants (or individual species) is generally reported as a percentage of occurrences at all sample points. It can also be reported as a percentage of occurrences at sample points within the littoral zone.

Frequency of occurrence example:

Plant A is sampled at 70 out of 700 total points = 70/700 = .10 = 10%
This means that Plant A's frequency of occurrence = 10% considering the entire lake sample.

Plant A is sampled at 70 out of 350 total points in the littoral zone = 70/350 = .20 = 20%
This means that Plant A's frequency of occurrence = 20% when only considering the littoral zone.

From these frequencies, we can estimate how common each species was throughout the lake, and how common the species was at depths where plants were able to grow. Note the second value will be greater as not all the points (in this example, only ½) occur at depths shallow enough for plant growth.

Simpson's diversity index: A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's diversity index, the index value represents the probability that two individuals (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse

lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be **more resistant** to invasion by exotic species.

Maximum depth of plants: This indicates the deepest point that vegetation was sampled. In clear lakes, plants may be found at depths of over 20ft, while in stained or turbid locations, they may only be found in a few feet of water. While some species can tolerate very low light conditions, others are only found near the surface. In general, the diversity of the plant community decreases with increased depth.

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. Protocol suggests a 15ft pole rake, and a 25ft rope rake for sampling (Wagoner personal communication).

Average number of species per site: This value is reported using four different considerations. 1) **shallower than maximum depth of plants** indicates the average number of plant species at all sites in the littoral zone. 2) **vegetative sites only** indicate the average number of plants at all sites where plants were found. 3) **native species shallower than maximum depth of plants** and 4) **native species at vegetative sites only** excludes exotic species from consideration.

Species richness: This value indicates the number of different plant species found in and directly adjacent to (on the waterline) the lake. Species richness alone only counts those plants found in the rake survey. The other two values include those seen during the point intercept survey and the initial boat survey.

Mean and median depth of plants: The mean depth of plants indicates the average depth in the water column where plants were sampled. Because a few samples in deep water can skew this data, median depth is also calculated. This tells us that half of the plants sampled were in water shallower than this value, and half were in water deeper than this value.

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value (Table 2) gives us an idea of which species are most important within the macrophyte community.

Relative frequency example:

Suppose that we sample 100 points and found 5 species of plants with the following results:

Plant A was located at 70 sites. Its frequency of occurrence is thus 70/100 = 70%

Plant B was located at 50 sites. Its frequency of occurrence is thus 50/100 = 50%
Plant C was located at 20 sites. Its frequency of occurrence is thus 20/100 = 20%
Plant D was located at 10 sites. Its frequency of occurrence is thus 10/100 = 10%
To calculate an individual species' relative frequency, we divide the number of sites a plant is sampled at by the total number of times all plants were sampled. In our example that would be 150 samples (70+50+20+10).

Plant A = 70/150 = .4667 or 46.67%
Plant B = 50/150 = .3333 or 33.33%
Plant C = 20/150 = .1333 or 13.33%
Plant D = 10/150 = .0667 or 6.67%

This value tells us that 46.67% of all plants sampled were Plant A.

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. Species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each species found in the lake. Consequently, a higher index value indicates a healthier macrophyte community. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Mudhen Lake is in the Northern Lakes and Forests Ecoregion.

RESULTS:

Aquatic Plant Survey Results for Mudhen Lake

An aquatic plant survey was completed for Mudhen Lake in 2011. Prior to the whole lake monitoring, a curly leaf pondweed (CLP) survey was conducted to confirm the presence of this aquatic invasive species. Since CLP grows earlier than native species, it typically dies in early July; therefore, the CLP survey is done in May or early June while the plant is still robust. A general boat survey was also conducted prior to the point intercept survey to gain familiarity with the lake and the plant species found on the lake. The results discussed below are taken from these two surveys.

Using a standard formula based on a lake's shoreline shape and distance, islands, water clarity, depth, and size in acres, the Wisconsin Department of Natural Resources (WDNR) generated the

sampling point grid of 498 points for Mudhen Lake. Figure 9 above shows the locations of these sampling points.

As mentioned before, Mudhen Lake survey grid is comprised of 498 points. Of these points, we found plants at 218 sites in less than 17 feet of water (Figure 11: littoral zone). Areas that were shallow and had a mucky substrate supported more plants than those with sandy or rocky bottoms. Figure 10 below illustrates the substrate of Mudhen Lake. Plants were found growing on approximately 44% of the entire lake bottom, and in 87.4% of the littoral zone. Diversity was very high with a Simpson Diversity Index value of 0.89. Species richness was also high with 43 total species found growing in and immediately adjacent to the lake. The majority of aquatic macrophytes were found growing in moderately deep water with an average depth of 4.15ft, and a median depth of 5.0ft. These 4-10ft areas of Mudhen, especially the east, west and northwest bas, supported diverse plant beds that provide important underwater habitat. Tables 9, 10, and 11 summarize data from the completed survey.

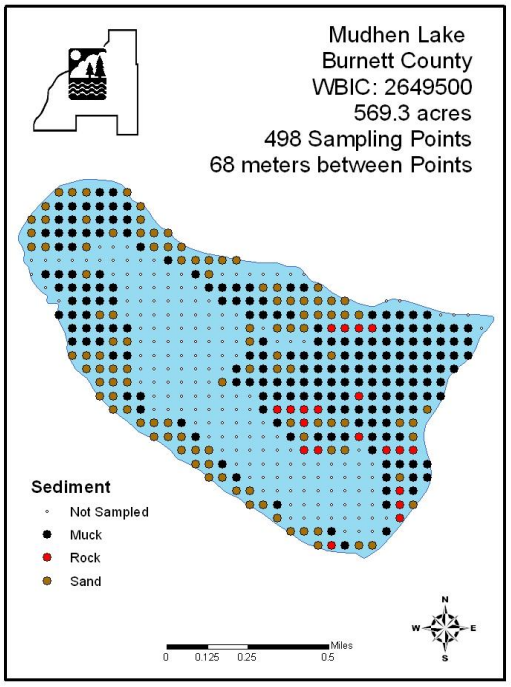


Figure 10: Sediment Types

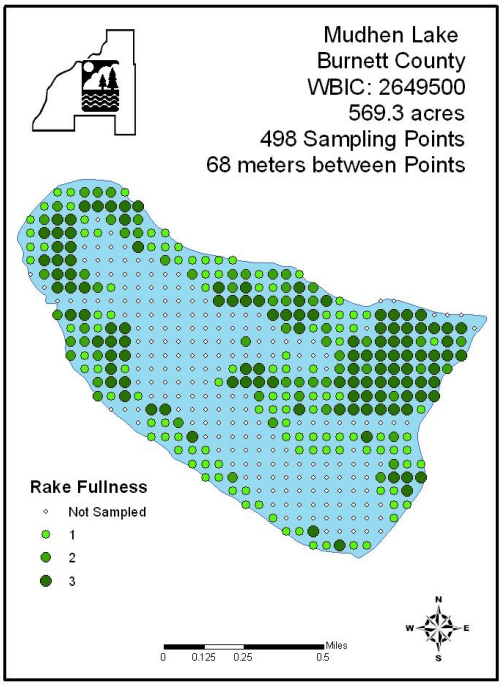


Figure 11: Littoral Zone of Mudhen Lake – Region of Plant Growth

Flat-stem pondweed (*Potamogeton zosteriformis*), Clasping-leaf pondweed (*Potamogeton richardsonii*), Muskgrass (*Chara* sp.) and Fern pondweed (*Potamogeton robbinsii*) were the most common species (Table 9). We found them at 44.5%, 36.7%, 17.9%, and 16.97% of survey points with vegetation respectively (Figure 12). All four species were widely distributed

throughout the lake over muck bottoms (Figure 10). Although many other species were widely distributed, we did not find any with a relative frequency over 11%.

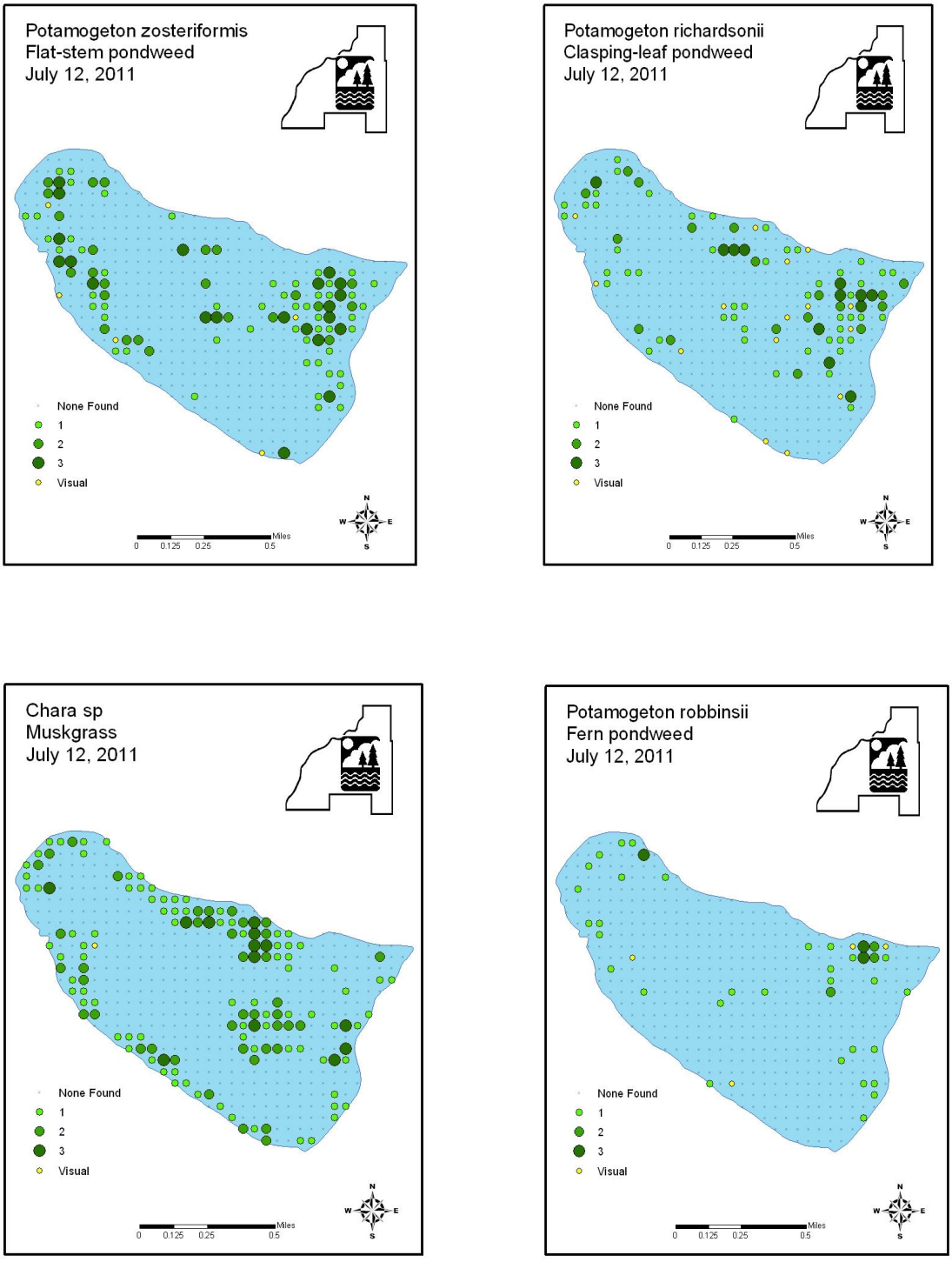


Figure 12: Four Most Common Aquatic Plant Species in Mudhen Lake

On May 29, 2011, we conducted a point intercept survey for Curly-leaf pondweed. We did not find any Curly-leaf pondweed (CLP), an exotic invasive species; throughout Mudhen Lake. During the full survey in July, we found CLP at several sites and no large beds of the invasive plant. All of the sites with Curly-leaf pondweed had a rake fullness rating of 1.00 with the exception of one site where we only had a visual identification. Below is a map of the July survey which indicates the locations of the know CLP sites (Figure 13)

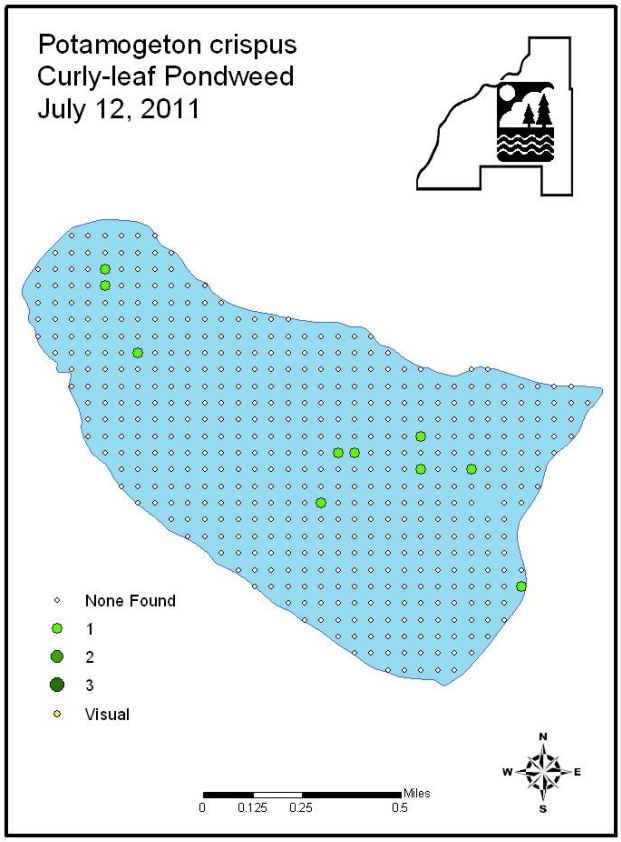


Figure 13: Curly-leaf Pondweed Distribution July 2011

During the May and July survey, no Eurasian water-milfoil (*Myriophyllum sibiricum*) was detected. Several sites adjacent to the littoral zone had Reed canary grass, a common invasive species. Although we did not find any Purple loosestrife (PLS) in the littoral zone, we did find plants on the north end of the lake. Prior to the survey, we knew PLS was in an adjacent wetland, however, we were not aware that it was in the riparian zone of the lake. In the past, Galerucella beetles have been released in the roadway off from Mudhen Lake road. The success of the beetles was limited, so in the past few years cutting and spraying efforts were used to control PLS along the road and wetland. The amount of Purple loosestrife along the road has been greatly reduced; however, there is still a small amount of plants remaining. Each year, staff members from Burnett County Land and Water Conservation Department (BC LWCD), conduct

a check for the presence of Purple loosestrife. In the past, if PLS is discovered, the plant is cut and sprayed by BC LWCD. Last year, during the July lake survey, we discovered beetles on the plants along the lake. Beetles have not been released on the lake; therefore, they relocated from the release site along Mudhen Lake road. The plants that were discovered on the lake were covered with beetles. Yearly monitoring for beetles should be considered or efforts to cut and spray the plants should be done as an alternative.

Summary of Recommendations:

- Preserve and maintain Mudhen Lake's diverse native plant community.
- Continue to educate lakeshore owners and boaters about the importance of aquatic plants and the negative impacts AIS can have on the entire lake ecosystem.
- Preserve the lake's many rush/reed/rice beds and the lake's sensitive habitat areas.
- Whenever possible, refrain from removing native plants from the lake.
- Reduce and, wherever possible, eliminate fertilizer and pesticide applications near the lakeshore.
- Encourage shoreline restoration.
- Establish native vegetation buffer strips along the lakeshore.
- Consider transect monitoring for aquatic invasive species at and near the boat landing at least once a month during the summer months.
- Complete a full shoreline inspection in mid-August to locate and eliminate any beds Purple loosestrife plants where beetles are not present.
- Establish a Clean Boats/Clean Water program.
- Conduct Citizen Lake Monitoring for aquatic invasive species from May through October.

Table 6: Mudhen Lake Aquatic Macrophytes Survey Summary Statistics

Summary Statistics	
Total number of sites visited	**489**
Total number of sites with vegetation	**221**
Total number of sites shallower than maximum depth of plants	**322**
Frequency of occurrence at sites shallower than maximum depth of plants	**68.63**
Simpson Diversity Index	**0.89**
Maximum depth of plants (ft)**	**17.00**
Number of sites sampled using rake on Rope (R)	**332**
Number of sites sampled using rake on Pole (P)	**0**
Average number of all species per site (shallower than max depth)	**1.36**
Average number of all species per site (veg. sites only)	**1.99**
Average number of native species per site (shallower than max depth)	**1.33**
Average number of native species per site (veg. sites only)	**1.97**
Species Richness	**37**
Species Richness (including visuals)	**44**
Mean Depth of Plants (ft)	**4.15**
Median Depth of Plants (ft)	**5**

Table 7: Mudhen Lake FQI Species and Conservatism Values

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Chara	Muskgrasses	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Nitella	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Phragmites australis	Common reed	1
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton diversifolius	Water-thread pondweed	8
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton obtusifolius	Blunt-leaf pondweed	9

Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
Zizania palustris	Northern wild rice	8
N		33
mean C		6.42
FQI		36.90

We identified a total of 33 native species in Mudhen Lake. They produced a mean Coefficient of Conservation 6.42 and a Floristic Index of 36.90 (Table 7). Nichols (1999) reported an Average mean C for the Northern Lakes and Forest Region of 6.7 putting Mudhen Lake slightly below average for this part of the state. However, the FQI was higher than the mean FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). The below average mean C is a result of having fewer than normal sensitive plants. This may be a reflection of excessive nutrients from runoff, being out competed by other more aggressive plants or good water quality and clarity are not the best conditions for plant growth (Nichols 1999). The high FQI is a result of Mudhen Lake's above average plant diversity.

Table 8: Frequencies and Mean Rake Sample of Aquatic Macrophytes Mudhen Lake, Burnett County July, 2011

		Total Sites	Relative Frequency (%)	Frequency of occurrence vegetated (%)	Frequency of occurrence Littoral	Mean Rake Fullness
Potamogeton zosteriformis	Flat-stem pondweed	97.00	22.56	44.50	87.39	1.68
Potamogeton richardsonii	Clasping-leaf pondweed	80.00	18.60	36.70	72.07	1.53
Chara sp.	Muskgrasses	39.00	9.07	17.89	35.14	1.44
Potamogeton robbinsii	Fern pondweed	37.00	8.60	16.97	33.33	1.24
Ceratophyllum demersum	Coontail	24.00	5.58	11.01	21.62	1.75
Elodea canadensis	Common waterweed	21.00	4.88	9.63	18.92	1.24
Myriophyllum sibiricum	Northern water-milfoil	21.00	4.88	9.63	18.92	1.29
Potamogeton gramineus	Variable pondweed	15.00	3.49	6.88	13.51	1.00
Potamogeton friesii	Fries' pondweed	14.00	3.26	6.42	12.61	1.07
Schoenoplectus acutus	Hardstem bulrush	13.00	3.02	5.96	11.71	1.00
Najas flexilis	Slender naiad	11.00	2.56	5.05	9.91	1.00
Potamogeton crispus,	Curly-leaf pondweed	10.00	3.31	4.59	9.01	1.00
Lemna trisulca	Forked duckweed	8.00	1.86	3.67	7.21	1.13
Vallisneria americana	Wild celery	8.00	1.86	3.67	7.21	1.00
Nymphaea odorata	White water lily	6.00	1.40	2.75	5.41	1.67
Potamogeton praelongus	White-stem pondweed	5.00	1.16	2.29	4.50	1.00
Stuckenia pectinata	Sago pondweed	5.00	1.16	2.29	4.50	1.00
Nuphar variegata	Spatterdock	3.00	0.70	1.38	2.70	1.67
Sagittaria sp.	Arrowhead	3.00	0.70	1.38	2.70	1.00
Bidens beckii	Water marigold	2.00	0.47	0.92	1.80	1.00
Filamentous algae	Filamentous algae	2.00		0.92	1.80	1.00
Brasenia schreberi	Watershield	1.00	0.23	0.46	0.90	1.00
Carex comosa	Bottle brush sedge	1.00	0.23	0.46	0.90	1.00
Eleocharis acicularis	Needle spikerush	1.00	0.23	0.46	0.90	1.00
Heteranthera dubia	Water star-grass	1.00	0.23	0.46	0.90	1.00
Myriophyllum tenellum	Dwarf water-milfoil	1.00	0.23	0.46	0.90	1.00
Nitella sp.	Nitella	1.00	0.23	0.46	0.90	1.00

Phragmites australis	Common reed	1.00	0.23	0.46	0.90	1.00
Pontederia cordata	Pickerelweed	1.00	0.23	0.46	0.90	1.00
Potamogeton amplifolius	Large-leaf pondweed	1.00	0.23	0.46	0.90	1.00
Potamogeton diversifolius	Water-thread pondweed	1.00	0.23	0.46	0.90	1.00
Potamogeton foliosus	Leafy pondweed	1.00	0.23	0.46	0.90	1.00
Potamogeton illinoensis	Illinois pondweed	1.00	0.23	0.46	0.90	1.00
Potamogeton obtusifolius	Blunt-leaf pondweed	1.00	0.23	0.46	0.90	1.00
Potamogeton pusillus	Small pondweed	1.00	0.23	0.46	0.90	1.00
Ranunculus aquatilis	White water crowfoot	1.00	0.23	0.46	0.90	1.00
Spirodela polyrhiza	Large duckweed	1.00	0.23	0.46	0.90	1.00
Zizania palustris	Northern wild rice	1.00	0.23	0.46	0.90	1.00
Freshwater sponge	Freshwater sponge	1.00		0.46	0.90	1.00
Eleocharis erythropoda	Bald spikerush					
Juncus pelocarpus	Brown-fruited rush					
Lemna minor	Small duckweed					
Lythrum salicaria	Purple loosestrife					
Potamogeton natans	Floating-leaf pondweed					
Schoenoplectus pungens	Three-square bulrush					

Aquatic Plant Management

This section reviews the potential management methods available, and reports recent management activities on the lakes. The application, location, timing, and combination of techniques must be considered carefully.

Discussion of Management Methods

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin. Additional requirements exist when a lake is considered an ASNRI (Area of Special Natural Resource Interest) due, in the case of Mudhen Lake, to the presence of wild rice.

The requirements for manual and mechanical plant removal are described in NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline up to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal refers to the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power (WDNR).

Manual Removal[13]

Manual removal—hand pulling, cutting, or raking—will effectively remove plants from small areas. It is likely that plant removal will need to be repeated more than once during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants with rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for

private landowners who wish to remove small areas of curly leaf pondweed growth. Raking is recommended to clear nuisance growth in riparian area corridors up to twenty feet wide.

SCUBA divers may engage in manual removal for invasive species like Eurasian water milfoil. Care must be taken to ensure that all plant fragments are removed from the lake. Manual removal with divers is recommended for shallow areas with sporadic EWM growth.

Mechanical Control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms of mechanical control available. WDNR permits under Chapter NR 109 are required for mechanical plant removal. (APIS, Army Corps of Engineers)

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cut to depths from one to six feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

The size, and consequently the harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1000 cubic feet (by volume) or 1 to 8 tons (by weight).

In some cases the plants are transported to shore by the harvester itself for disposal, while in other cases a barge is used to store and transport the plants in order to increase the efficiency of the cutting process. The plants are deposited on shore, where they can be transported to a local farm (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate, and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

Aside from the obvious effort and expense of harvesting aquatic plants, there are many environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area.

This loss of plants results in a subsequent loss of the functions they perform, including sediment stabilization and wave absorption. Shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the enjoyed results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation, in terms of time as well as cost.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, it should also be before the plants form turions to avoid spreading of the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, there may be too much plant matter on the surface of the lake for the harvester to cut effectively.

If the harvesting work is contracted, be sure to inspect the equipment before and after it enters the lake. Since these machines travel from lake to lake, they may carry plant fragments with them, and facilitate the spread of aquatic invasive species from one body of water to another. One must also consider prevailing winds, since cut vegetation can be blown into open areas of the lake or along shorelines.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against the pioneering establishment of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology can be considered. To be effective, the entire plant, including the subsurface portions, should be removed.

Plant fragments can result from this type of operation, but fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated more than once to be effective. When applied to a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates play an important part in the effectiveness of a diver dredging operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment.

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling contaminated sediments could possibly release toxins into the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine the potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions such as trees and stumps. If operations are releasing large amounts of plant material, harvesting equipment should be on hand to collect this material and transport it to shore for disposal.

Biological Control[13]

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or progeny through predation or parasitism, or cause severe or debilitating diseases. With the introduction of native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

Weevils[14]

Weevils have potential for use as a biological control agent against Eurasian water milfoil. There are several documented "natural" declines of EWM infestations. In these cases, EWM was not eliminated but its abundance was reduced enough so that it did not achieve dominance. These declines are attributed to an ample population of native milfoil weevils (Euhrychiopsis lecontei). Weevils feed on native milfoils but will shift preference over to EWM when it is present. Lakes where weevils can become an effective control have an abundance of native Northern water milfoil and fairly extensive natural shoreline where the weevils can over winter. Because native milfoils are susceptible to higher doses of herbicides, any control strategy for EWM that would also harm native milfoil may hinder the ability of this natural bio-control

agent. Lakes with large bluegill populations are not good candidates for weevils because bluegills feed on the weevils. The presence and efficacy of stocking weevils in EWM lakes is being evaluated in Wisconsin lakes. So far, stocking does not appear to be effective.

The effectiveness of biocontrol efforts varies widely (Madsen, 2000). Beetles are commonly used to control Purple loosestrife populations in Wisconsin with good success. As mentioned above, weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations, but grass carp introduction is not allowed in Wisconsin.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, and plant-specific control. On the other hand there are several disadvantages to consider, including very long control times (years instead of weeks), a lack of available agents for particular target species, and relatively specific environmental conditions necessary for success.

Biological control is not without risks; new non-native species introduced to control a pest population may cause problems of its own. Biological control is not currently proposed for management of aquatic plants in Mudhen Lake, although it will be considered for Purple loosestrife control.

Re-vegetation with Native Plants

Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by nonnative species, a propagule (seed) bank probably exists that will restore the community after nonnative plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant removal is probably not necessary on Mudhen Lakes because a healthy, diverse native plant population is present.

Physical Control[13]

In physical management, the environment of the plants is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 DNR permit would be required.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are very shallow due to sedimentation tend to have excess plant

growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be very long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a lake remediation technique. Dredging is not suggested for the Mudhen Lake as part of the aquatic plant management plan.

Benthic barriers or other bottom-covering approaches are another physical management technique. The basic idea is to cover the plants with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and various combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984). The problem with synthetic sheeting is that the gasses evolved from plant and sediment decomposition collect underneath and lift the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill the plants under them within 1 to 2 months, after which time they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A WDNR permit would be required for a benthic barrier.

Shading or light attenuation reduces the light plants need to grow. Shading has been achieved by fertilization to produce algal growth, by application of natural or synthetic dyes, shading fabric, or covers, and by establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are of only limited applicability. Physical control is not currently proposed for management of aquatic plants in Mudhen Lake.

Herbicide and Algaecide Treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (Madsen, 2000).

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. WDNR permits under Chapter NR 107 are required for herbicide application.

General descriptions of herbicide classes are included below.[15]

Contact herbicides[16]

Contact herbicides act quickly and are generally lethal to all plant cells that they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants directly. They are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides, but they quickly resprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat,** and **copper** are contact aquatic herbicides.

Systemic herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides and those that are absorbed by leaves are referred to as foliar active herbicides. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the part of the plant where their site of action is. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, endothall, and fluridone** are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances.

Selective herbicides

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community, and in turn affect other organisms or weed control operations. These operations can also impact water chemistry which may result in further implications for aquatic organisms.

Copper

Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment, but it forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as an herbicide. Because it is not broken down, it can accumulate in bottom sediments after repeated or high rates of application. Accumulation rarely reaches levels that are toxic to organisms or significantly above background concentrations in the sediment.

2,4-D

2,4-D photodegrades on leaf surfaces after being applied to leaves, and is broken down by microbial degradation in water and in sediments. Complete decomposition usually takes about 3 weeks in water but can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection levels 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and bound tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When diquat is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly, it

is degraded to some extent on the leaf surfaces by photodegradation. Because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall

Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water and 1 week in bottom sediments.

Fluridone

Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs, and microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter, when the sun's rays are less direct and days are shorter, result in longer half-lives. Fluridone usually disappears from pondwater after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate

Glyphosate is not applied directly to water for weed control, but when it does enter the water it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Copper Compounds

Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Herbicide Use to Manage Invasive Species

Eurasian water milfoil

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: 2,4-D, diquat, endothall, All of these herbicides with the exception of diquat are available in both granular and liquid formulations. It is possible to target invasive species by using the appropriate herbicide and timing. The herbicide 2,4-D is most commonly used to treat EWM in Wisconsin. This herbicide kills dicots including native aquatic species such as northern water milfoil, coontail, water lilies, spatterdock, and watershield. Early season (April to May) treatment of Eurasian water milfoil is recommended to limit the impact on native aquatic plant populations because EWM tends to grow before native aquatic plants.

Granular herbicide formulations are more expensive than liquid formulations (per active ingredient). However, granular formulations release the active ingredient over a longer period of time. Granular formulations, therefore, may be more suited to situations where herbicide exposure time will likely be limited, as is the case in small bands or blocks. In large, shallow lakes with widespread EWM, a whole lake treatment with a low rate of liquid herbicide may be most cost effective because exposure time is greater. Factors that affect exposure time are size and configuration of treatment area, water flow, and wind.

Application rates for liquid and granular formulations are not interchangeable. A rate of 1 to 1.5 mg/L 2,4-D applied as a liquid is a middle rate that will require a contact time of 36 to 48 hours. Application rates recommended for Navigate (granular 2,4-D) are 100 pounds per acre for depths of 0 to 5 feet, 150 pounds per acre for 5 to 10 feet, and 200 pounds per acre for depths greater than 10 feet.

Curly leaf pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three herbicides for control of curly leaf pondweed: diquat, endothall, and fluridone. Fluridone requires exposure of 30 to 60 days making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1-3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 – 25 days, swimming 0 days, fish consumption 3 days.

Studies have demonstrated that curly leaf pondweed can be controlled with Aquathol K (a formulation of endothall) in 50 to 60 degree F water, and that treatments of CLP this early in its life cycle can prevent turion formation.[17] Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are still dormant, early season treatment selectively targets curly leaf pondweed. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development Center is conducting trials of this method.

Because the dosage is at lower rates than the dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[12]

Burnett County Land and Water Conservation (LWCD)[12]

Burnett County assists the Mudhen Lake Rehabilitation District in management of aquatic invasive species. They have individuals available to assist with the following tasks:

- Conduct watercraft inspection at public access points.
- Complete in-lake monitoring for EWM and other invasive species.
- Carry out public outreach and education events related to invasive species including lake meetings, fishing tournaments, county fairs, and local festivals.
- Post signs at boat landings and other public lake access points to inform residents of the new Burnett County "do not transport" ordinance.
- Train local lake residents and others to monitor their own boat landings as part of the WDNR "Clean Boats, Clean Waters" (CBCW) program.
- Train lake residents and others in Citizen Lake Monitoring, which includes CBCW, Secchi, Water Chemistry, and Aquatic Invasive Species identification.
- Assist in "rapid response" actions to identify and respond to new invasive species infestations reported by the public.
- Conduct integrated pest management for purple loosestrife control including beetle rearing and release, and offer assistance with clipping and herbicide application for individual infestations.

In-lake monitoring focuses on searching for potential establishment of Eurasian water milfoil and other aquatic invasive species at boat landings and other areas with high public use. Grab samples are taken at regular intervals at these high public use areas and at random locations around the littoral zone. All Burnett County boat landings are monitored each year.

Workshops and trainings include Clean Boats, Clean Waters training, plant identification, and whole lake monitoring workshops. Staff generally travels to local lakes to encourage participation and provide more focused training.

The Rapid Response Plans will involve a team of resource professionals from various agencies who can directly assist the lake organization in managing newly discovered invasive species and develop a plan to restore the native plant community. This Rapid Response SWAT team will assist with identifying appropriate management methods, coordinating and, in some instances, carrying out control measures, grant writing, and completing or hiring consultants to complete aquatic plant surveys and management plans.

Plan Goals and Strategies

Overall Purpose

This section of the plan lists goals for aquatic plant management for Mudhen Lake. It also presents a detailed strategy of actions that will be used to reach Aquatic Plant Management Plan goals. Educational strategies that outline audience, messages, and methods are included under each goal.[37]

Plan Goals

1. Prevent the introduction and spread of aquatic invasive species.
2. Reduce and control the population of purple loosestrife and monitor and control the spread of curly leaf pondweed.
3. Maintain and improve water quality conditions.
4. Enhance and maintain the diverse populations of native aquatic plants.
5. Educate the Mudhen Lake community and guests regarding aquatic plant management, management strategies found in the plan and appropriate plant management actions.

Goal 1: Prevent the introduction and spread of aquatic invasive species

Objectives

A. 100% enforcement of Burnett County's and State's Do Not Transport Ordinance and Statewide regulations.
B. Mudhen Lake is monitored regularly for AIS introduction.
C. Mudhen Lake Rehabilitation District is ready to rapidly respond to identified AIS in the lakes and river.
D. 100% of boaters inspect, clean, and drain boats, trailers and equipment.
E. Encourage members of the MLRD and community members to participate in the Clean Boats Clean Waters program.
F. Maintain the ILIDS camera at the public landing as long as feasible.

***Actions*:**

1. Train members of the MLRD to conduct Clean Boats Clean Waters monitoring at public boat landings.
2. Work with Burnett County and the Burnett County Sheriff's Department to encourage increased enforcement and potentially increased fines for the Do Not Transport Ordinance.
3. Hire a Consultant/to conduct Clean Boats Clean Waters Surveys at the public boat landings on Mudhen Lake.
4. Develop a rapid response plan for Eurasian water milfoil.

5. Train members of the MLRD, using the Citizen Lake Monitoring Network, Aquatic Invasive Species training manual, to conduct whole lake monitoring on a yearly basis.
6. Maintain the I-Lids camera at the public landing as long as feasible.

Goal 2: Reduce and control the population of existing invasive species.

Objective. Using GPS coordinates; the MLRD will conduct yearly monitoring of the existing beds of Curly leaf pondweed.

Action. Monitor each year, using existing GPS coordinates of known locations through volunteers of CLMN AIS.

Objective. Minimize populations of purple loosestrife on Mudhen Lake.

Action. Control with beetles and cut and spray as needed. Before cutting and spraying, consult with either the Board members of the Lake Association or Burnett County Land and Water Conservation Department for assistance.

Objective. Identify and remove purple loosestrife plants from any newly colonized areas on Mudhen Lake.

Action.

Provide information and training to Mudhen Lake community so they can identify purple loosestrife and they know who to contact if they have a suspected plant.

Action.

Cut and spray individual plants where identification is confirmed by Lake association Board members or Burnett Land and Water conservation Department.

Action.

Work with adjacent property owners to control the spread of PLS.

Action.

Note each area where plant is sprayed and monitor in subsequent years and continue to monitor with CLMN AIS.

NOTE: NEED TO GET INPUT FROM BRAD MORRIS, BURNETT COUNTY REGARDING MOST APPROPRIATE PL CONTROL METHODS FOR VARIOUS AREAS.

Goal 3: Maintain and improve water quality conditions.

Objectives

A. Continue to sample and record both water samples and Secchi readings to ensure water quality.
B. Encourage lake residents to restore and preserve shoreline buffers of native vegetation.

Messages

1. Shoreline buffers protect water quality and provide fish and wildlife habitat. Describe ways to restore shoreline buffers (natural recovery, stop mowing, and plant natives).
2. Cost sharing for restoration shoreline buffers is available from Burnett County.
3. Describe the Burnett County shoreline buffer requirements and how to report violations of these requirements.
4. Highlight good examples of shoreline buffers on private waterfront property.

C. Reduce phosphorus and sediment loads from immediate watershed.

D. Encourage Riparian land owners to adopt and implement storm water runoff controls for existing structures and all new constructions.

Adaptive Management Approach

Mudhen Lake share watersheds draining into them and as a result, the impacts that are most controllable at this time originate along the lake's immediate shoreline. These sources include faulty septic systems, the use of phosphorus-containing fertilizers, shoreland areas that are maintained in an unnatural manner, and impervious surfaces. To reduce these impacts, the Mudhen Lake Rehabilitation District will conduct an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at Association meetings. This Management Action will be completed in conjunction with the Shoreland Restoration Action listed below.

Action Steps:

1. Recruit facilitators
2. Facilitators summarize educational material collected from WDNR, UW-Extension, and County Land and Water Conservation sources for the creation of informative materials
3. Facilitators disperse materials to stakeholders

***Actions*:**

1. Continue to monitor water quality through WDNR Citizens Lake Monitoring Network advanced water chemistry program and Secchi disk sampling and record data in the Surface Water Integrated Monitoring System (SWIMS) system. (OBJ A)
2. Incorporate the Adaptive Management Approach to reduce phosphorus and sediment loads from immediate watershed. (OBJ B, C)
3. Educate and assist Mudhen Lake community members in the restoration and preservation of shoreland buffers and shoreland vegetation. Continue implementation of shoreline owners' education program. (OBJ B, C, D)

Goal 4: Enhance and maintain the diverse populations of native aquatic plants.

Objectives

A. Implement strict adherence with treatment standards and monitoring methods prior to and following herbicide treatment.
B. Prevent removal of native plants using herbicides, with special consideration to wild rice beds.
C. Increase Mudhen Lake community's understanding of the role and importance of aquatic plants and their impacts on them.

Discussion

The plant community in the Mudhen Lake is very diverse and extensive. It is important to understand that these plants play a very important role in the lake ecosystem. Aquatic plants in the lake provide habitat for a diverse fish population. They also provide protection from shoreline erosion. Removing native plants could lead to adverse effects in the lakes. Healthy native plant populations prevent colonization by invasive plants. Erosion and runoff from waterfront property may alter sediment characteristics encouraging spread of invasive plants. Boating disturbance near the shoreline can remove aquatic plants and the valuable functions they provide. Boating disturbance near shore also creates sediment disturbance and the release of excess phosphorus, which can lead to access algal blooms.

Actions

1. Consider alternative methods for removing native plants, other than using herbicide treatment. (OBJ B)
2. Conduct a point intercept survey of the lake every five to ten years, or as needed. (OBJ C)
3. Update the aquatic plant management plan every five to ten years, or as needed. (OBJ A, B and C)

   Educational activities are detailed in the discussion for Goal 4.

Goal 5: Educate the Mudhen Lake Residents, if any, who treated waterfront with herbicides in the past regarding aquatic plant management, management strategies found in the plan and appropriate plant management.

Audience: Mudhen Lake Community

A. All lake residents
B. Business owners
C. Lake users
D. Residents, if any, who treated waterfront with herbicides in the past
E. Mudhen Lake Sportsman Club

Messages

1. Summary of APM plan, notice of public meeting, and how to get full APM plan
2. List of APM dos and don'ts
3. Contact list for APM include web resources
4. Native aquatic plant values
5. Limit impacts to native aquatic plants by traveling with no wake in shallow areas, using hand removal methods near docks and swimming areas, etc.
6. Explain procedure for individual corridor herbicide applications and describe conditions where herbicide treatment may be allowed.
7. Identification of CLP and methods for removal (include illustrations)
8. Identification of PLS and methods for removal (include illustrations)
9. Identification of EWM and contact if suspected (include illustrations)
10. Locations of nearby lakes with EWM
11. Describe new potential invasive species and why they are a threat
12. Native plant identification
13. Inspect, clean, and drain boats and equipment.
14. Burnett and as well as the State of Wisconsin have an ordinance that makes it illegal to transport aquatic plants on public roads.

Methods

Summary of APM plan

AIS education workshops for all lake users

Improvements to signage at boat landings

Updates to AIS handouts

Mailings and/or handouts to lake residents

Clean boats, clean waters monitoring/education

Annual meeting/special meetings

Door-to-door distribution of information

Plastic peel-off stickers for boats and cars

Attend Mudhen Lake Sportsman's Club meeting/s

Method	Audience	Message
APM plan summary	A - D	1
AIS workshops	A – C	4, 8-15
Signage	A – C	14, 15
AIS handouts	A – D	4, 6-15
Mailings	A – B	1 –15
Clean Boats, Clean Waters	C	8-11, 14, 15
Annual and special meetings	A – B	1-15
Door-to-door distribution	A	4-15
Plastic peel-off stickers	A – C	14, 15

Implementation Plan[38]

Action Items	Timeline	Cost 2012	Cost 2013	Cost 2014	Responsible Parties
Prevent AIS Introduction					
Identify and organize volunteer workers/employers for CBCW program	Ongoing	10 Hours	10 Hours	10 Hours	MLRD
Conduct CBCW program	Ongoing	10 Hours	10 Hours	10 Hours	MLRD
Increase enforcement of BC/WC Do Not Transport Ordinance	Ongoing	3 Hours	3 Hours	3 Hours	MLRD/Dan Heintz/BC Sheriff
Monitor Boat Landings	Ongoing	60 Hours	70 Hours	70 Hours	MLRD/BC LWCD
Train Volunteer monitors in CLMN	As needed	0 Hours	0 Hours	0 Hours	BC LWCD
Rapid Response plan review	Ongoing	1 Hour	1 Hour	1 Hour	MLRD/BC LWCD
Maintain ILIDS	Ongoing	$3125.00	$3125.00	$3125.00	MLRD
Monitor Video from ILIDS	Ongoing	160 Hours	160 Hours	160 Hours	MLRD
AIS Reduction and Prevention					
Provide Identification information and encourage volunteer monitoring	May - August	20 Hours	20 Hours	20 Hours	MLRD/BC LWCD
Monitor Lake for PL growth	July/August	10 Hours	10 Hours	10 Hours	MLRD
Cut and Spray plants as needed	July/August	15 Hours	15 Hours	15 Hours	MLRD/BC LWCD
Track and monitor previously sprayed areas in previous years	Ongoing	10 Hours	10 Hours	10 Hours	MLRD/BC LWCD
Monitor & map all CLP beds every two years or more often if warranted.	Mid May-Mid June	10 Hours	10 Hours	10 Hours	MLRD/BC LWCD
Consider if CLP control is warranted	September	TBD			

Action Items	Timeline	Cost 2012	Cost 2013	Cost 2014	Responsible Parties
Water Quality					
Water chemistry and Secchi sampling	Ongoing	15 Hours	15 Hours	15 Hours	MLRD
Reduce phosphorus and sediment loads from immediate watershed	Ongoing	TBD			
Educate and assist Mudhen Lake community members in the restoration and preservation of shoreland buffers and shoreland vegetation	Ongoing	5 Hours	5 Hours	5 Hours	MLRD/BC LWCD
Continue implementation of shoreline owners' education program	Ongoing	TBD			
Preserve Native Plants					
Conduct a point intercept survey of the lake	2016		TBD		
Update APM plan	2017		TBD		
Educate Mudhen Lake Community					
AIS workshops	Ongoing	$0	$0	$0	BC LWCD
AIS signage	Ongoing	$0	$0	$0	BC LWCD
Handouts, mailings, door-to-door distribution	As needed	$200.00	$200.00	$200.00	MLRD

Monitoring and Assessment

Aquatic Plant Surveys

Aquatic plant (macrophyte) surveys are the primary means for tracking achievement toward plan goals.

Action: Conduct whole lake aquatic plant surveys approximately every five years to track plant species composition and distribution.

The whole lake surveys will be conducted in accordance with the guidelines established by the Wisconsin DNR. Any new species sampled will be saved, pressed, and mounted for voucher specimens.

Aquatic Invasive Species Grants

Department of Natural Resources Aquatic Invasive Species Grants are available to assist in funding the action items in the implementation plan. Applications are accepted twice each year with postmark deadlines of February 1 and August 1.

Appendix A

MUD HEN LAKE
SENSITIVE AREA SURVEY REPORT
AND MANAGEMENT GUIDELINES

This document is to be used
with its companion document
"Guidelines for protecting, maintaining,
and understanding lake sensitive areas"

Mud Hen Lake (Burnett Co.)
Integrated Sensitive Area Survey Report

Date of Survey: 28 July 1998 Number of Sensitive Areas: 4
Site Evaluators: Jim Cahow, Water Resources Biologist
Frank Koshere, Water Resources Biologist
Larry Damman, Fisheries Manager

Lake Sensitive Area Survey results identified four areas that merit special protection of the aquatic habitat. These areas of aquatic vegetation on Mud Hen Lake offer critical or unique fish and wildlife habitat. These habitats provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water.

Wild rice (Zizania sp.) was documented in sensitive area "B, C and D" occurring on the northwestern shoreline of the lake. Wild rice holds very important niche in the lake ecosystem from both a human and wildlife standpoint. Care should be taken to allow for the proliferation of this rice stand.

During this survey there were no documented occurrences of Purple Loosestrife. However, the threat of Purple Loosestrife is always a concern and should be dealt with immediately. Methods for control are to remove the entire plant before it produces seeds or by cutting the flower head and spraying with and approved herbicide. You should contact the Department before any of these methods are implemented.

The reader should consider that any buffer that does not extend back from the waters edge at least 35' is not providing adequate protection for water quality and should be expanded to at least 35'. Local zoning ordinances and lakes classification systems have tried to provide better guidelines pertaining to buffer widths and set backs based on lake type. Landowners are encouraged to go beyond the minimum requirements laid out by zoning and consider extending buffer widths to beyond 35' and integrating other innovative ways to capture and reduce the runoff flowing off from their property while improving critical shoreline habitat. Berms and low head

retention areas can greatly increase the effective capture rate from developed portions in addition to that portion captured within the buffer.

Site conditions may dictate that a buffer has to be much wider than 35' to be effective at capturing the sediments and nutrients running off the developed portions of the shoreline. If the shoreline is steeply sloped (>7%slope) greater widths should definitely be used.

No mowing should take place within the buffer area (with the exception of a narrow access trail and small picnic area), and trees and shrubs should not be cut down even when they become old and die; because they provide important woody debris habitat within the buffer zone as well as aquatic habitat when they fall into the lake.

The following is a brief summary of the Mud Hen Lake sensitive area sites and the management guidelines. Also, the "Guidelines for Protecting, Maintaining, and Understanding Sensitive Areas" provides management guidelines and considerations for different lake sensitive areas (Attached).

I. Aquatic Plant Sensitive Areas

Sensitive areas contain aquatic plant communities, which provide important fish and wildlife habitat as well as important shoreline stabilization functional values. Sensitive areas provide important enough habitat for the Mud Hen ecosystem that conservation easements, deed restrictions, or zoning should be used to protect them. Management guidelines for aquatic plant sensitive areas are (unless otherwise specifically stated):

1. Limit aquatic vegetation removal to navigational channels no greater than 25 feet wide where necessary, the narrower the better. These channels should be kept as short in length as possible and it is recommended that people do not completely eliminate aquatic vegetation within the navigation channel; but instead only remove what is necessary to prevent fouling of propellers to provide access to open water areas. Chemical treatments should be discouraged and if a navigational channel

must be cleared, pulling by hand is preferable over mechanical harvesters where practical.

2. Prohibit littoral zone alterations covered by Wisconsin Statutes Chapter 30, unless there is clear evidence that such alterations would benefit the lake's ecosystem. Rock riprap permits should not be approved for areas that already have a healthy native plant community stabilizing the shoreline and property owners should not view riprap as an acceptable alternative in these situations.
3. Leave large woody debris, logs, trees, and stumps, in the littoral zone to provide habitat for fish, wildlife, and other aquatic organisms.
4. Leave an adequate shoreline buffer of un-mowed natural vegetative cover and keep access corridors as narrow as possible (preferable less than 30 feet or 30% of any developed lot which ever is less).
5. Prevent erosion, especially at construction sites. Support the development of effective county erosion control ordinances. The proper use of Best Management Practices (BMP's) will greatly reduce the potential of foreign materials entering the waterway (i.e. silt, nutrients).
6. Strictly enforce zoning ordinances and support development of new zoning regulations where needed.
7. Eliminate nutrient inputs to the lake caused by lawn fertilizers, failing septic systems, and other sources.
8. Control exotic species such as purple loosestrife.

Resource Value of Site A

Sensitive area A is located along the southern shoreline of Mud Hen Lake. This area encompasses approximately 3,500 feet of shore.

This area provides important habitat for centrarchid (bass and panfish) and esocid (northern pike) spawning and nursery areas. This area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.

The emergent, floating and submergent plant community structure of Sensitive area A includes: **Emergents;** pickerelweed (Pontederia cordata), arrowhead (Saggitaria sp.), hardstem bulrush (Scirpus acutus) and river bulrush (Scirpus fluviatilis). **Floating;** yellow pond lily (Nuphar advena). **Submergents;** wild celery (Vallisneria americana), coontail (Ceratophyllum demersum), muskgrass (Chara sp.), northern milfoil (Myriophyllum sibiricum), bushy pondweed (Najas flexilis), large leaf pondweed (Potamogeton amplifolius), variable leaf pondweed (P. gramineus), floating leaf pondweed (P. natans), clasping leaf pondweed (P. richardsonii), robbin's pondweed (P. robbinsii) and flat stem pondweed (P. zosteriformis).

Chemical treatments and mechanical removal efforts should be limited to navigation channels only.

Resource Value of Site B

Sensitive area B is located along the eastern shoreline of Mud Hen Lake. This area encompasses approximately the headwaters of Wood Creek and 2,500 feet of shore.

This area provides important habitat for centrarchid (bass and panfish) and esocid (northern pike) spawning and nursery areas. This area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.

The emergent, floating and submergent plant community structure of Sensitive area B includes: **Emergents;** wild rice (Zizania aquatica), sedges (Carex sp.), pickerelweed (Pontederia cordata), hardstem bulrush (Scirpus acutus), river bulrush (Scirpus fluviatilis), broadleaf cattail (Typha latifolia) and arrowhead (Sagittaria sp.). **Floating;** watershield (Brassenia schreberi), forked duckweed (Lemna trisulca), yellow pond lily (Nuphar advena) and white water lily (Nymphaea odorata). **Submergents;** wild celery (Vallisneria americana), coontail (Ceratophyllum demersum), muskgrass (Chara sp.), elodea, northern milfoil (Myriophyllum sibiricum), bushy pondweed (Najas flexilis), large leaf pondweed (Potamogeton amplifolius), variable leaf pondweed (P. gramineus), floating leaf pondweed (P. natans), white stem

pondweed (P. praelongus), clasping leaf pondweed (P. richardsonii), robbin's pondweed (P. robbinsii) and horned pondweed (Zanichellia palustris).
Chemical treatments and mechanical removal efforts should be limited to navigational channels only.

Resource Value of Site C

Sensitive area C is located in along the northeastern shore of Mud Hen Lake. This area encompasses the approximately 3,500 feet of shoreline.
This area provides important habitat for centrarchid (bass and panfish) and esocid (northern pike) spawning and nursery areas. This area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.
The emergent, floating and submergent plant community structure of Sensitive area C includes: **Emergents;** wild rice (Zizania aquatica), giant reed grass (Phragmites sp.), pickerelweed (Pontederia cordata), hardstem bulrush (Scirpus acutus), river bulrush (Scirpus fluviatilis), broad leaf cattial (Typha latifolia), bur-reed (Sparganium sp.) and arrowhead (Sagittaria sp.). **Floating;** yellow pond lily (Nuphar advena) and white water lily (Nymphaea odorata). **Submergents;** wild celery (Vallisneria americana), coontail (Ceratophyllum demersum), elodea, water marigold (Bidens beckii), northern milfoil (Myriophyllum sibiricum), bushy pondweed (Najas flexilis), large leaf pondweed (Potamogeton amplifolius), variable leaf pondweed (P. gramineus), floating leaf pondweed (P. natans), sago pondweed (P. pectinatus), white stem pondweed (P. praelongus), clasping leaf pondweed (P. richardsonii), robbin's pondweed (P. robbinsii), flat stem pondweed (P. zosteriformis) and horned pondweed (Zanichellia palustris).
Chemical treatments and mechanical removal efforts should be limited to navigational channels only.

Resource Value of Site D

Sensitive area D is located eastern shore of Mud Hen Lake. This area encompasses approximately 1,500 feet of shoreline, extending out approximately 2,000 feet from the shore.

This area provides important habitat for centrarchid (bass and panfish) and esocid (northern pike) spawning and nursery areas. This area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.

The emergent and submergent plant community structure of Sensitive area D includes: **Emergent;** wild rice (Zizania aquatica). **Submergents;** coontail (Ceratophyllum demersum), elodea, northern milfoil (Myriophyllum sibiricum), bushy pondweed (Najas flexilis), large leaf pondweed (Potamogeton amplifolius), variable leaf pondweed (P. gramineus) and sago pondweed (P. pectinatus).

Chemical treatments and mechanical removal efforts should be limited to navigational channels only.

Appendix B

1981 Feasibility Report

Swenson Land Surveying, Inc.
Telephone (715)-349-LAND (5263)
Thomas E. Swenson, LS
25070 State Road 35
Siren, WI 54872

July 7, 2011

Kandice Unger, Treasurer
9703 North Mudhen Lake Dr.
Siren, WI 54872

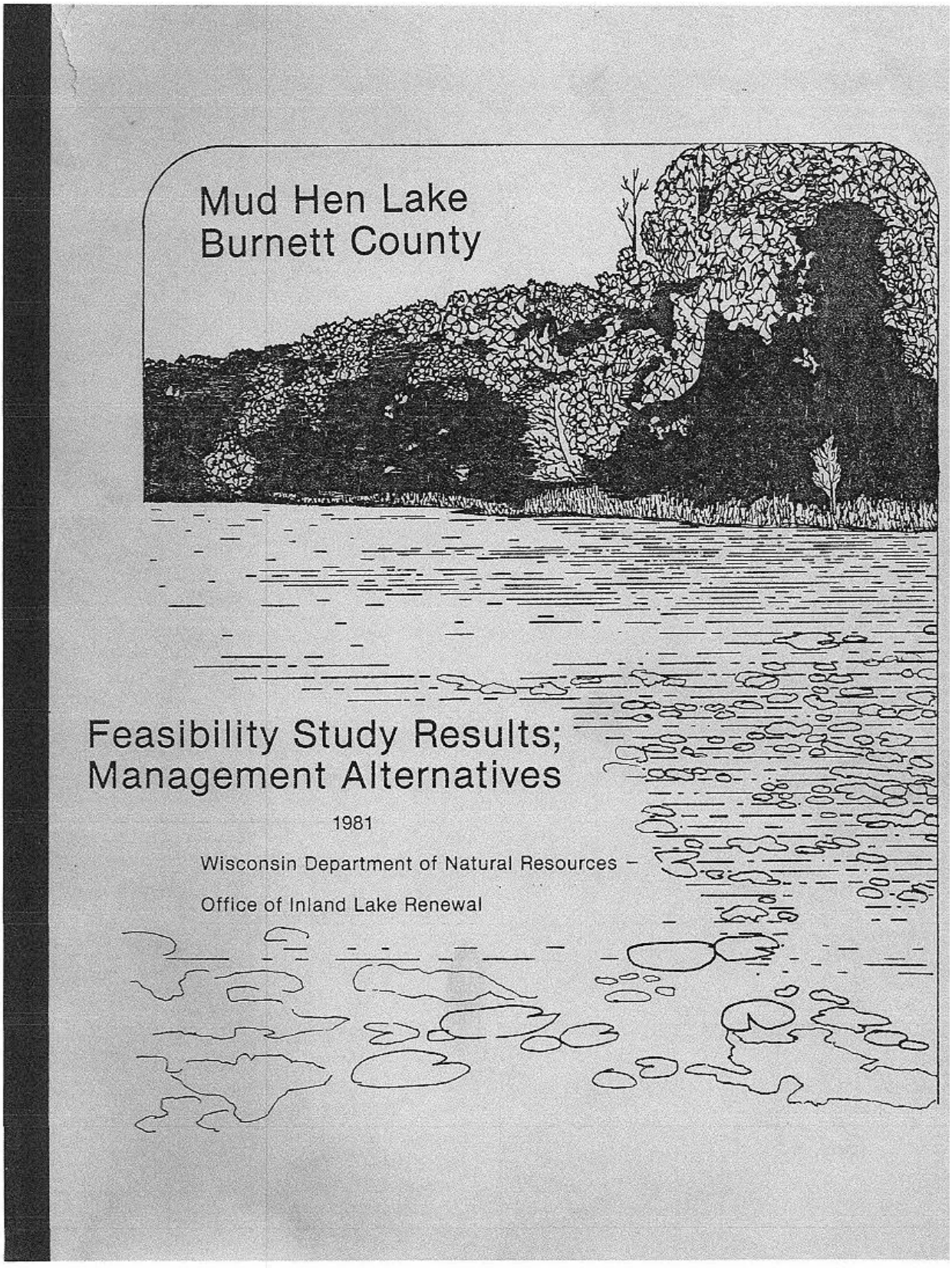
Dear Ms. Unger:

On June 30, 2011 the elevation of Mud Hen Lake was 97.9 feet based on DNR bench 771-D near Lindberg Park. The bench is a brass cap set in a concrete post, with an assumed elevation of 103.1 feet. The elevations during previous years were as follows:

July 5, 2010: 97.9 feet
July 2, 2009: 97.7 feet
July 3, 2008: 97.9 feet
June 27, 2007: 97.1 feet
July 25, 2006: 98.3 feet
June 30, 2005: 98.4 feet
July 2, 2004: 98.0 feet
Aug. 21, 2003: 97.9 feet
July 11, 2002: 98.1 feet
June 30, 2001: 98.1 feet
July 19, 2000: 98.4 feet
July 02, 1999: 97.9 feet
June 30, 1998: 97.7 feet
June 27, 1997: 97.8 feet
July 3, 1996: 98.4 feet (note 5.1" rainfall 6/26/96)
June 27, 1995: 98.0 feet
July 1, 1994: 98.3 feet
July 9, 1993: 97.7 feet
July 3, 1992: 97.8 feet
July 3, 1991: 98.1 feet
June 29, 1990: 97.9 feet
June 28, 1989: 97.7 feet
July 7, 1988: 96.9 feet
June 8, 1987: 97.1 feet
July 1, 1986: 97.3 feet
June 8, 1984: 98.1 feet
July 21, 1984: 97.6 feet

Sincerely,

Thomas E. Swenson


Mud Hen Lake
Burnett County
Feasibility Study Results;
Management Alternatives
1981
Wisconsin Department of Natural Resources –
Office of Inland Lake Renewal

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MUD HEN LAKE
BURNETT COUNTY

INTRODUCTION

Lakes exist on a time continuum; that is, they are constantly progressing through a natural aging process (eutrophication). Soon after formation they are unproductive and pristine but over many years become more productive and shallow until eventually the lake becomes a marsh and finally dry land. Although all lakes are somewhere in this progression, within the last century this process has been accelerated by man as a result of increased agricultural practices, industrialization, lake front cottages, and a general increase in the population. Increased lake productivity generally has the benefit of increasing fish production; however, when it reaches certain levels, problems occur in the form of nuisance algal blooms and large stands of aquatic weeds which result in more rapid infilling of the lake.

Recently, as man has recognized his role in stimulating eutrophication, he has tried to reverse or retard this process through lake rehabilitation. Reversing the effects has often proven to be very expensive and sometimes unsuccessful. If a lake has not yet reached the point where it has nuisance algal blooms and/or aquatic weed problems it is much easier and cheaper to maintain the lake in its present condition. This can often be done by judicious planning of land developments and good conservation practices in the watershed.

In 1974, the State of Wisconsin created a law (Chapter 33 of the State Statutes) that enabled lake communities to approach lake restoration in a positive way by creating a special purpose unit of government called lake districts. A lake district may request technical and financial assistance from the Department of Natural Resources in an effort to improve or protect lake water quality.

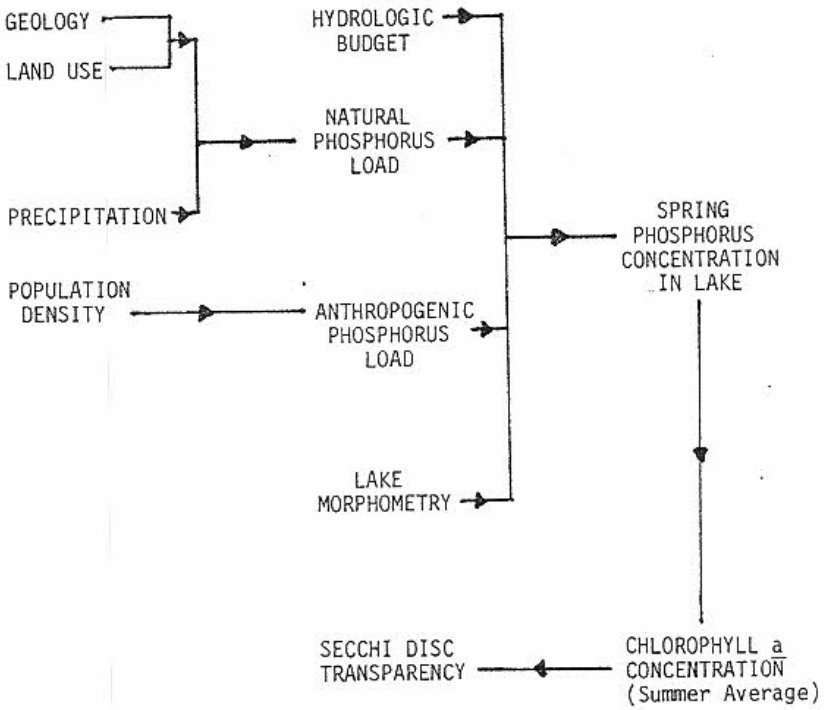
Mud Hen Lake formed a lake district in 1977 and applied for technical and financial assistance from the Department. As a result of that application, a study of Mud Hen Lake and its watershed was performed from November 1978 through October 1979.

The immediate objective of the one year "feasibility study" at Mud Hen Lake was to define the nutrient budget and the existing water quality in order to identify a set of management alternatives for the lake.

Once the amount and sources of nutrient flux to Mud Hen Lake were established, various control practices could be examined as to their overall effectiveness in protecting or restoring lake water quality. Figure 1 represents the typical empirical model approach used in an attempt to document the various sources and amounts of phosphorus reaching Mud Hen Lake.

FIGURE 1

A SIMPLE EMPIRICAL MODEL USED TO ASSESS EFFECTS OF DEVELOPMENT ON TROPHIC STATUS OF LAKES[1].



1. After Dillon, P.J. and F.H. 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. J. Fish. Res. Bd. Canada. 32:1519-1531.

BACKGROUND

The lakes in Burnett County are within an ancient lake bed predating glacial time. This ancient lake is known as glacial Lake Grantsburg. The topography around Mud Hen Lake is a result of the Wisconsin Glacier which receded from the area about 10,000 to 15,000 years ago. As the glacier deteriorated the meltwater left glacial debris in the form of stratified sands and gravels which were scattered over clays of the old lake bottom.

In the region around Mud Hen Lake these pitted outwash plains are less than 150 feet thick overlying Keweenawan igneous rock in the eastern half of the watershed and St. Croixan sandstone in the western half. Most of the watershed basin is covered with sandy soils.

The climate in Burnett County is classified as continental with an average annual temperature of 41.5 degrees Fahrenheit. The winters are long, cold, and snowy, while summers are relatively short and warm with only brief periods of hot, humid weather. The average annual precipitation for the county is 30.4 inches although during the study year 29.3 inches was recorded at Webster.

Mud Hen Lake is a hard water lake which has a small stream entering on the northeast corner. The lake is generally considered the headwaters of the

North Fork of the Wood River. The lakeshore is mostly upland hardwoods except for an area of tag alder, tamarack, and spruce swamp in the northeast end and near the outlet. Table 1 lists the morphometric data for Mud Hen Lake. The lake has a surface area of 562.5 acres and a maximum depth of 66 feet (Figure 2).

The watershed of Mud Hen Lake is 3,594 acres which gives a watershed to lake ratio of 6.4:1. A ratio greater than 10:1 is considered likely to produce lake problems. The watershed contains Blomberg Lake and three unnamed lakes (Figure 3). Blomberg Lake is a 68-acre, acid, bog lake with a maximum depth of 4 feet. It has an outlet which flows into one of the unnamed lakes and then to Mud Hen Lake. The stream which enters Mud Hen Lake drains 57 percent of the lake's watershed or 2,036 acres. Forests make up 48 percent of the total watershed of the lake followed by wetland (29%) and agriculture (23%). There are approximately 50 homes around the lake and four resorts.

TABLE 1. Morphometric Data For Mud Hen Lake

Surface Area	562.5 ac	227.6 ha
Maximum Depth	66 ft	20 m
Mean Depth	13.9 ft	4.2 m
Volume	7773 ac - ft	9.6 x 10^6 m^3
Watershed Area	3594 ac	1454 ha
Surface Water (Blomberg & Unnamed Lakes)	80.8 ac	32.7 ha
Ratio of Watershed to Lake	6.4	
Hydraulic Retention Time (yrs)	1.4	

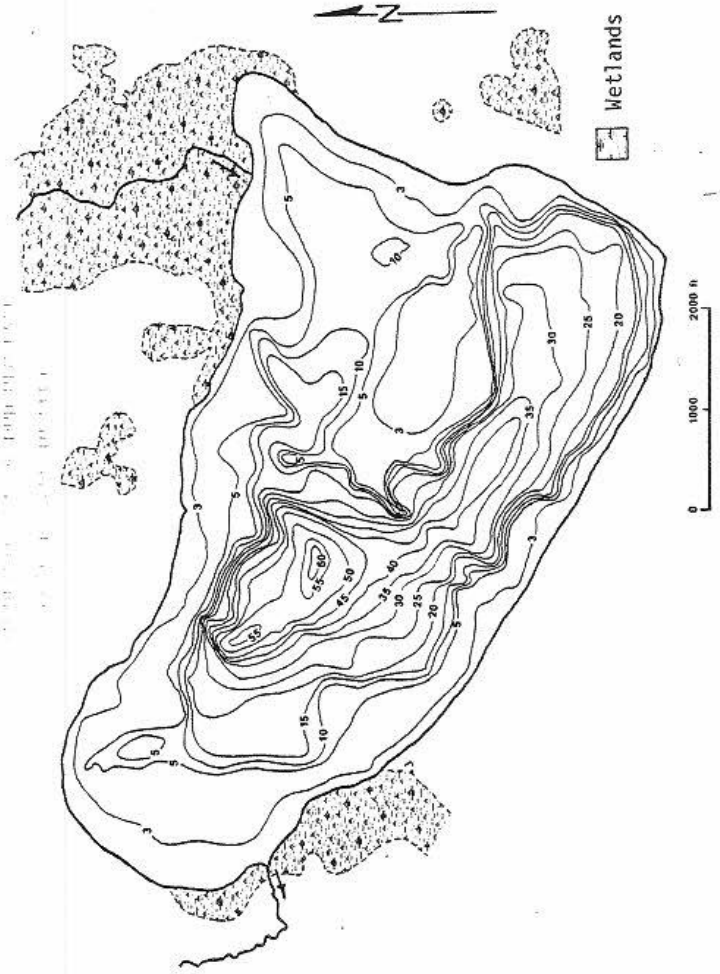


FIGURE 2

BATHYMETRIC MAP OF MUD HEN LAKE
CONTOURS ARE IN FEET

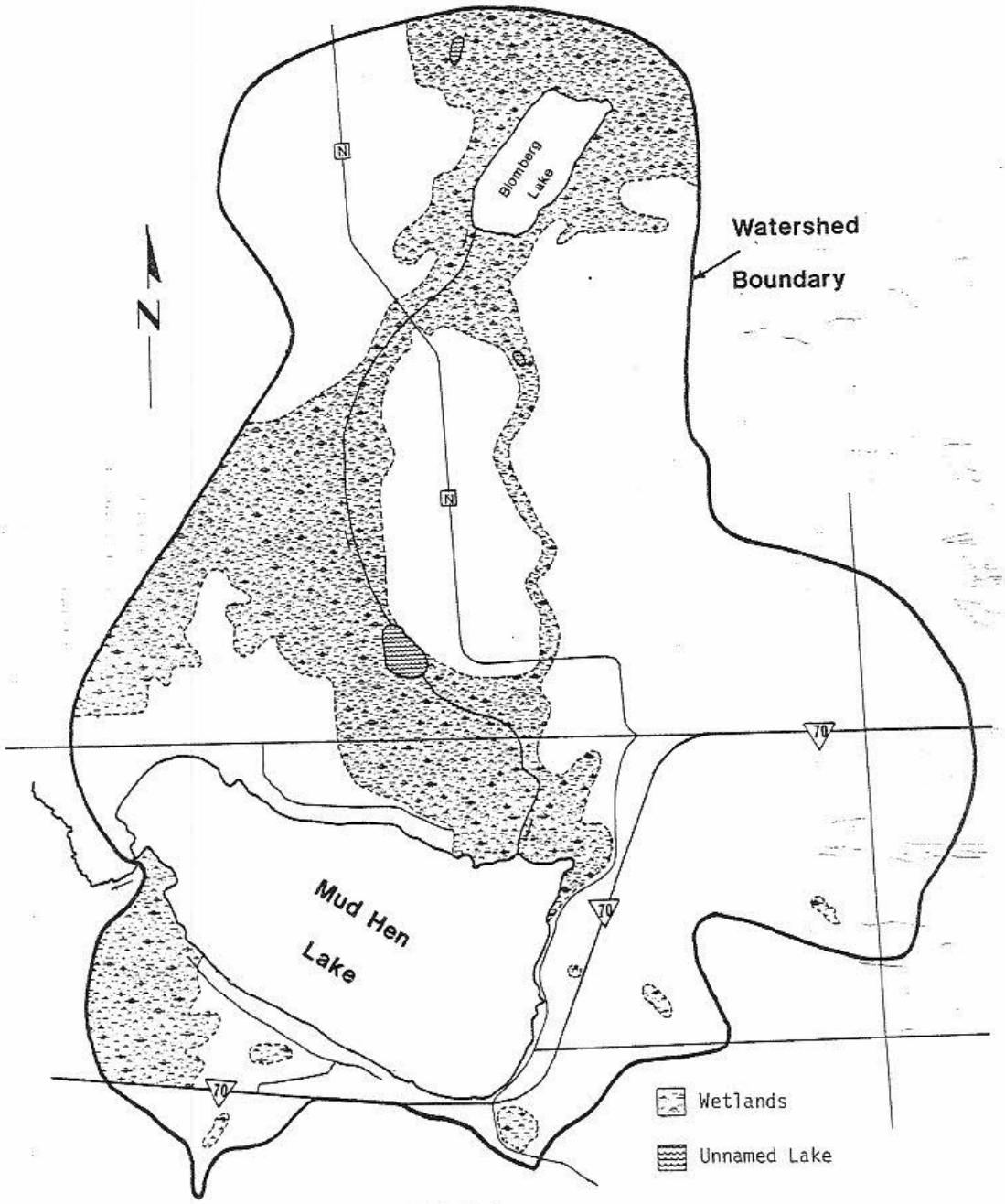


FIGURE 3
THE WATERSHED OF MUD HEN LAKE

STUDY RESULTS

Groundwater

In order to determine the direction of groundwater flow and the quality of that water, 23 observation wells at ten sites were placed around the lake. As shown in Figure 4 groundwater flows into the lake on the northern, eastern, and southeastern sides, and it weakly flows out on the southwestern and western ends of the lake. Groundwater inflow is especially strong on the eastern end. In general groundwater flows into the lake at a rate of 0.70 cubic feet per second (cfs) and out of the lake at 0.04 cfs.

The levels of phosphorus and nitrogen were generally low in the wells indicating no major pollution sources. The average total phosphorus concentration in the inflowing wells was 0.012 mg/l. The average total nitrogen concentration was 1.8 mg/l. One of the wells in the inflow area was located between a barnyard and the lake. Although phosphorus values were not very high, nitrogen and chlorides were elevated, indicating that some animal waste residue may be reaching the lake. Some of the nitrate values in this well exceeded 10 mg/l. The highest nutrient levels were recorded in two wells located on the outflow side of the lake. Since water in this area is flowing away from the lake these probably do not impact the lake.

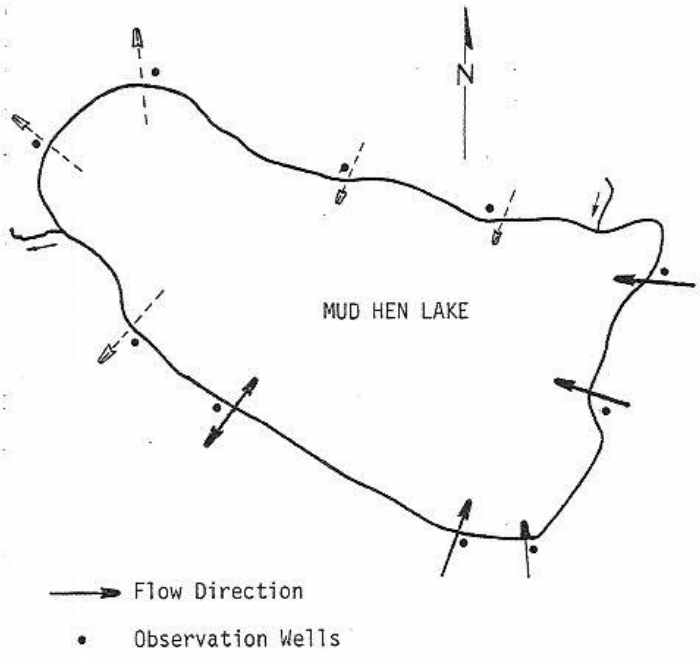


FIGURE 4

GROUNDWATER FLOW PATTERN FOR MUD HEN LAKE

Solid lines indicate higher rates of flow,
dashed lines lower rates of flow.

Phosphorus Loading

The nitrogen to phosphorus ratio at spring turnover was 30:1. A ratio greater than 10:1 indicates that algal growth will be controlled by the availability of phosphorus. Because of this, the report will emphasize the status of phosphorus. The annual phosphorus input to Mud Hen Lake is presented in Table 2. The following data sources, extrapolations, and assumptions were used in the process of constructing the phosphorus load:

1. The amount of phosphorus entering the lake from the stream was calculated from monthly flow measurements and the phosphorus concentrations reported by the consultant. The loading from that portion of the watershed that was not monitored (43%) was estimated from literature values, assuming 75 percent retention by marsh land.

2. Groundwater flow into the lake was measured by the use of a series of observation wells installed and monitored during the course of the study. The average phosphorus concentration in the groundwater was 0.012 mg/l.

3. The septic system contributions assumed a worst case situation with 50 homes about the lake contributing phosphorus. (The study showed that the groundwater was moving away from the lake on the southwest and west sides, and therefore, the homes along this shoreline may not be contributing nutrients via septic system leachates). Ninety percent of

the homes were considered seasonal and 10 percent permanent. A phosphorus sorption of 90 percent was used for the soils. An average number of people occupying each home was assumed to be four, with each person contributing 2.2 gP/day for permanent occupancy and 1.8 gP/day for seasonal occupancy. Although the assumptions made for the septic systems are probably an overestimate of the actual values, this may be offset by phosphorus contributions from systems that experience periodic flooding. This may occur in some of the installations close to the lake.

4. Atmospheric phosphorus loading to the surface of Mud Hen Lake was estimated using a conservative figure of 0.3 kg P/ha/yr. Phosphorus is not a volatile substance, but it does attach to small particles that become windblown and may eventually fall upon a lake surface.

TABLE 2. Phosphorus Loading for Mud Hen Lake During the Study Period

Source	kg/yr	lbs/yr	Percent
Surface Runoff	132	292	62
Monitored Watershed	(29)	(64)	
Nonmonitored Watershed	(103)	(228)	
Atmospheric	68	150	32
Groundwater	7	15	3
Septic Systems (R_S=0.9)	6	13	3
TOTAL	213	470	100

The cumulative phosphorus loading has been plotted in Figure 5 which illustrates the potential trophic position of Mud Hen Lake with respect to three major trophic categories. Mud Hen Lake is in the mestrophic range. Lakes exist on a trophic continuum ranging from oligotrophic (nutrient poor--no algae problems) through mesotrophic (moderate amount of nutrients--very seldom an algae problem) to eutrophic (nutrient rich--algae problems). As the amount of nutrients reaching the lake increases the more nutrient rich (eutrophic) the lake will become. As the lake becomes more eutrophic larger and more frequent algal problems will occur.

Inlake Water Quality

The range and mean values of the chemical parameters measured during the study are given in Table 3. The alkalinity and pH values indicate that the lake is well buffered and in no danger from acid rain. Figure 6 shows the pH and alkalinity values at which lakes may be impacted by acid rain. Lakes with an alkalinity above 30 mg/l are not susceptible to acid rain. The lowest reported value (39 mg/l) during the study occurred during late winter immediately under the ice cover.

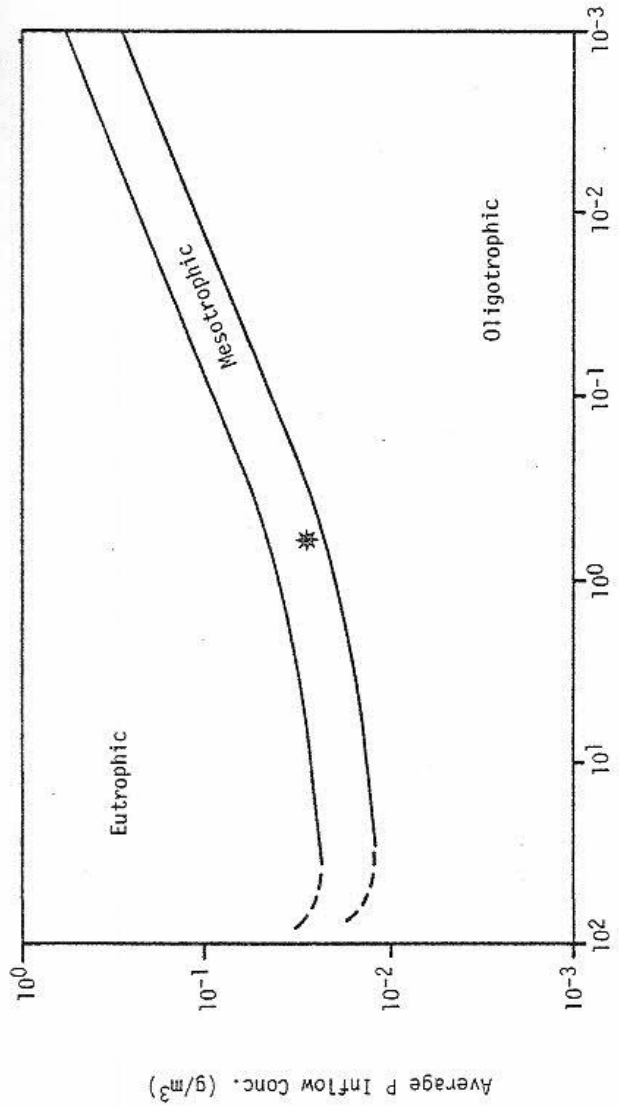


FIGURE 5

TROPHIC PLACEMENT OF MUD HEN LAKE (*) BASED ON PHOSPHORUS LOADING
(After: R.A. Vollenweider, 1976, Advances in defining critical loading levels for phosphorus in lake eutrophication, Mem. Ist. Ital. Idrobiol. 33:53-83).

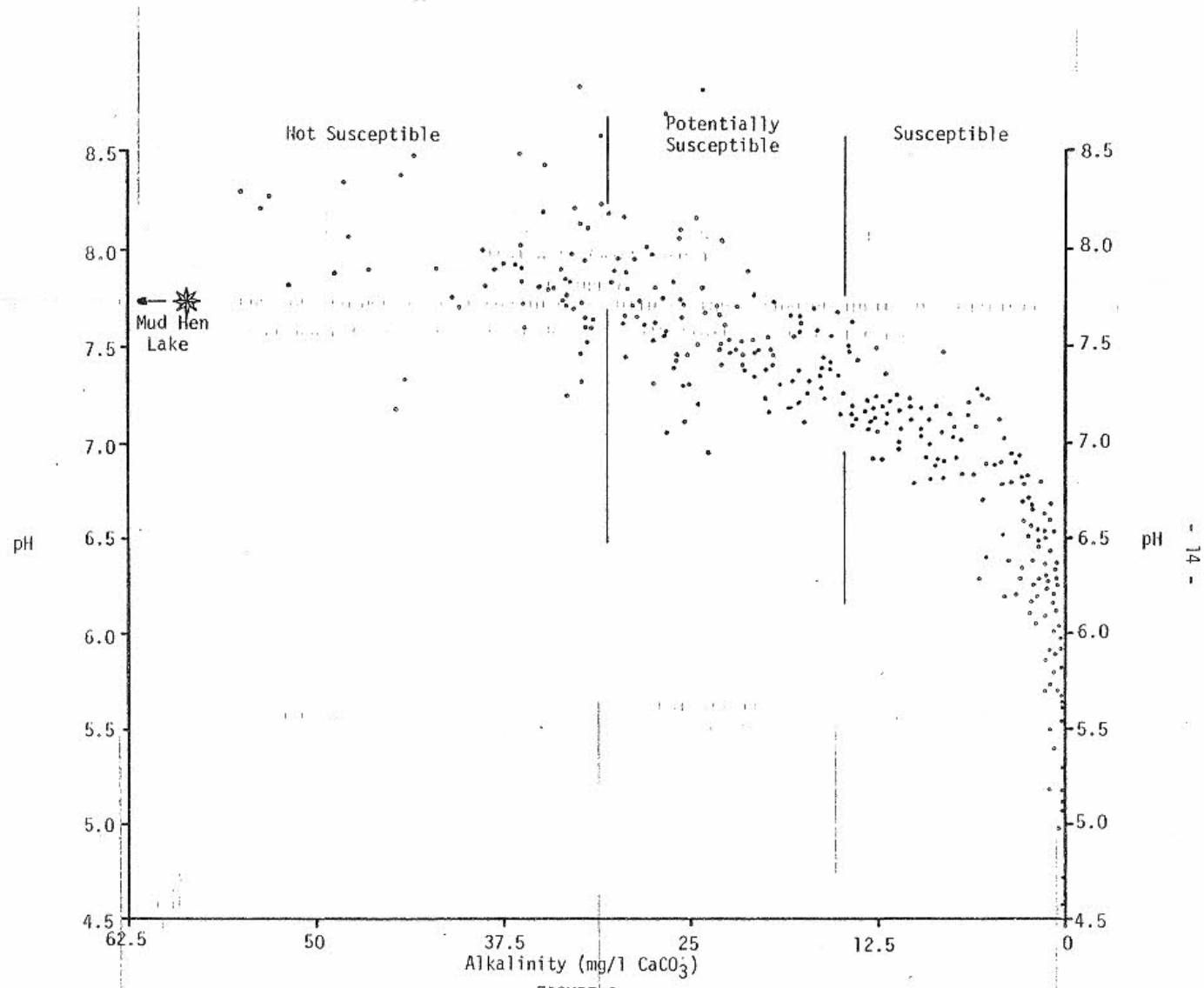


FIGURE 6

THE ALKALINITY AND pH VALUES OF 350 NORTHERN WISCONSIN LAKES WITH AN INDICATION OF THEIR SUSCEPTIBILITY TO ACID RAIN

Mud Hen Lake is off scale with a mean alkalinity of 97 mg/l $CaCO_3$.

TABLE 3. Ranges and Volume Weighted Mean (n=12) of Some Chemical Parameters in Mud Hen Lake from November 1978 to October 1979. Concentrations are reported in mg/l unless otherwise stated.

Parameter	Range	Mean
Total Phosphorus	.01-0.13	0.013
Dissolved Reactive Phosphorus	.01-0.080	.010
Alkalinity (mg/l as $CaCO_3$)	39-125	97
pH	6.7-8.4	7.7
Nitrate-Nitrogen	0.01-0.47	0.10
Ammonium-Nitrogen	.10-1.08	0.18
Organic Nitrogen*	0.14-0.34	0.18
Specific Conductance (μmhos/cm)*	18-210	200

* Samples only taken at spring turnover.

Phosphorus and nitrogen values are representative of a moderately fertile lake. Based on studies of 17 Wisconsin lakes, Sawyer[1] suggested that excessive growths of algae could be expected if at spring overturn dissolved reactive phosphorus concentrations exceeded 0.01 mg/l and inorganic nitrogen (nitrate - N + ammonium - N) was greater than 0.3 mg/l. These values are close to those present in Mud Hen Lake.

Algae

The composition and numbers of algae are presented in Figure 7. The algal community has a good diversity and low numbers which are typical of a

[1]Sawyer, C. N. 1947. Fertilization of lakes by agricultural and urban drainage. J. New Engl. Waste Works Assoc. 51:109-127.

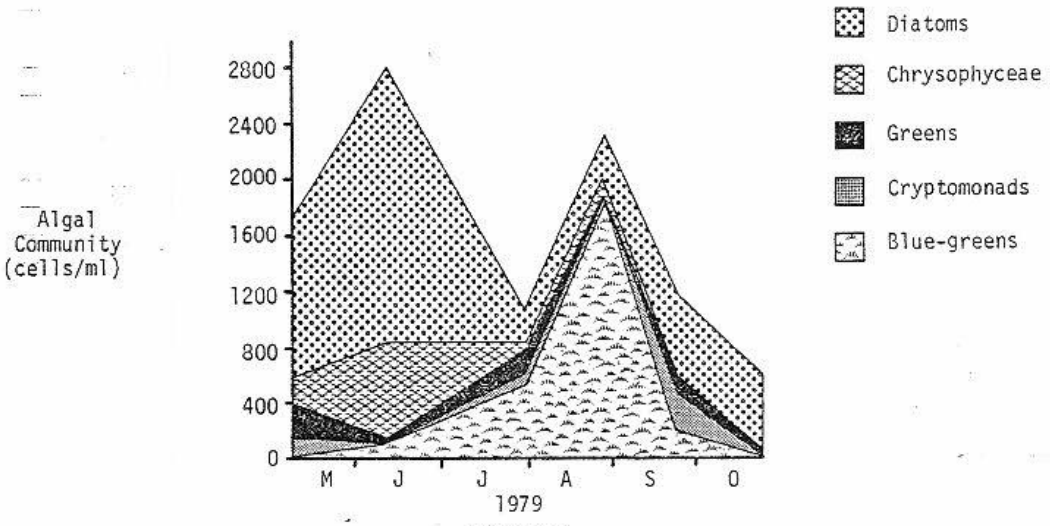


FIGURE 7
ALGAL COMMUNITY IN MUD HEN LAKE DURING THE STUDY PERIOD

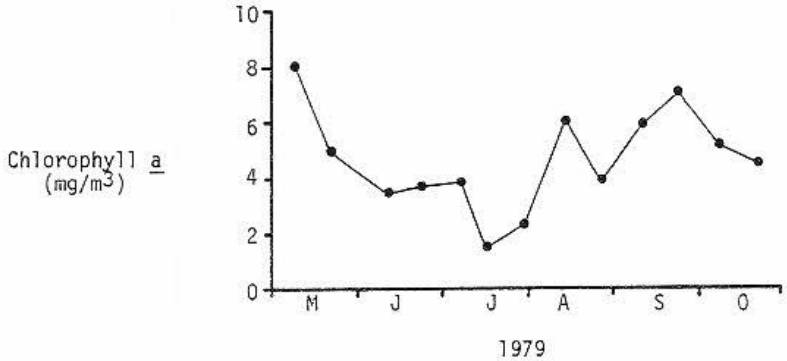


FIGURE 8
CHLOROPHYLL a TREND IN THE SURFACE WATERS DURING THE STUDY PERIOD

mesotrophic lake. Diatoms (principally Fragilaria crotonensis and Synedra spp.) are the dominant algae during much of the summer and fall except in late July and during August when blue-green algae dominate the community. It is common for diatoms to dominate in the spring and fall when the water temperature is low and the lake is mixing. The increase of blue-green algae in August is not uncommon in lakes of moderate fertility (mesotrophic). Most of the species present will not form surface scums, but if the lake becomes more fertile this could become a problem. Although no algal blooms were reported, if the weather conditions are favorable short blooms may occur. There is some evidence of this happening from other observers and samples taken in other years. This could be especially true following the die off of the aquatic vegetation in late summer. Table 4. gives a list of phytoplankton encountered during the study period.

Because of the varying sizes of individual algal species, a better indicator of the entire algal community is chlorophyll a which measures algal biomass. The highest biomass was observed at spring overturn during the diatom pulse when the chlorophyll a value was 8 mg/m^3 (Figure 8). Although blue-green algae dominated the community in August, chlorophyll a was relatively low at 6 mg/m^3. The average summer (June-August) chlorophyll a value was 3.7 mg/m , while during the entire open water period (May-October) it was 4.8 mg/m^3. These values are indicative of a mesotrophic lake. Water transparency, as measured with a Secchi disc, was also indicative of a mesotrophic lake with a summer average of 9.5 feet (2.9 m).

Table 4. Phytoplankton Taxa for Mud Hen Lake.

Chrysophyta
- Bacillariophyceae
  - Achnanthes minutissima
  - Asterionella farmosa
  - Cocconeis placentula
  - Cyclotella comta
  - C. stelligera
  - Fragilaria crotonensis
  - Melosira ambigua
  - M. granulata
  - Navicula radiosa
  - Rhizosolenia eriensis
  - Stephanodiscus astreae
  - Synedra acus
  - S. ulna

Chysophyceae
- Dinobryon cylindricum
- D. sociale
- Mallomonas acaroides
- M. pseudocoronata

Chlorophyta
- Ankistrodesmus falcatus
- A. falcatus var. mirabilis
- Asterococcus limneticus
- Chlamydomonas sp.
- Crucigenia rectangularis
- Kirchneriella lunaris

Chlorophyta (Con't.)
- Oocystis borgei
- Micractinum pusillum
- Scenedesmus bijuga
- Sphaerocystis schroeteri

Cyanophyta
- Anabaena flos-aquae
- Aphanocapsa delicatissima
- Aphanotheca clathrata
- A. microspora
- Aphanizomenon flos-aquae
- Arthrospira
- Chroococcus dispersus
- Coelosphaerium naegelianum
- Gomphosphaera lacustris
- Merismopedia tenuissima
- Microcystis aeruginosa
- Oscillatoria geminata
- O. tenuis

Pyrrhophyta
- Dinophyceae
  - Ceratium hirundinella
  - Glenodinium borgei

Cryptophyta
- Cryptophyceae
  - Cryptomomas ovata

Aquatic Macrophytes

The macrophyte community in Mud Hen Lake is diverse, abundant, and extensive. It is now providing excellent habitat to a wide array of fish and wildlife.

The survey documented the presence of at least two floatingleaf species, seven species of emergents, and 16 submergents. The common to abundant species are shown in Table %. The majority of these species are reportedly important to either fish or waterfowl, or both (Fassett, 1960)[2]. For fish they furnish excellent cover, spawning substrate, and/or harbor for fish food organisms.

During 1979, floatingleaf plants occupied 8 percent of the lake surface area, emergents 22 percent, and submergents 58 percent (Figure 9). These were, however, coincident so that the total area involved was about 60 percent of the lake surface area. The submergents grew to a depth of 15 feet (the predicted maximum depth of growth was 14 feet based on a mean summer water clarity of 9.5 feet), and were able to reach the surface from the 8 foot depth at some select locations.

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[2]Fassett, N. C. 1960. A manual of aquatic plants. University of Wisconsin Press. Madison, Wis. 405 p.

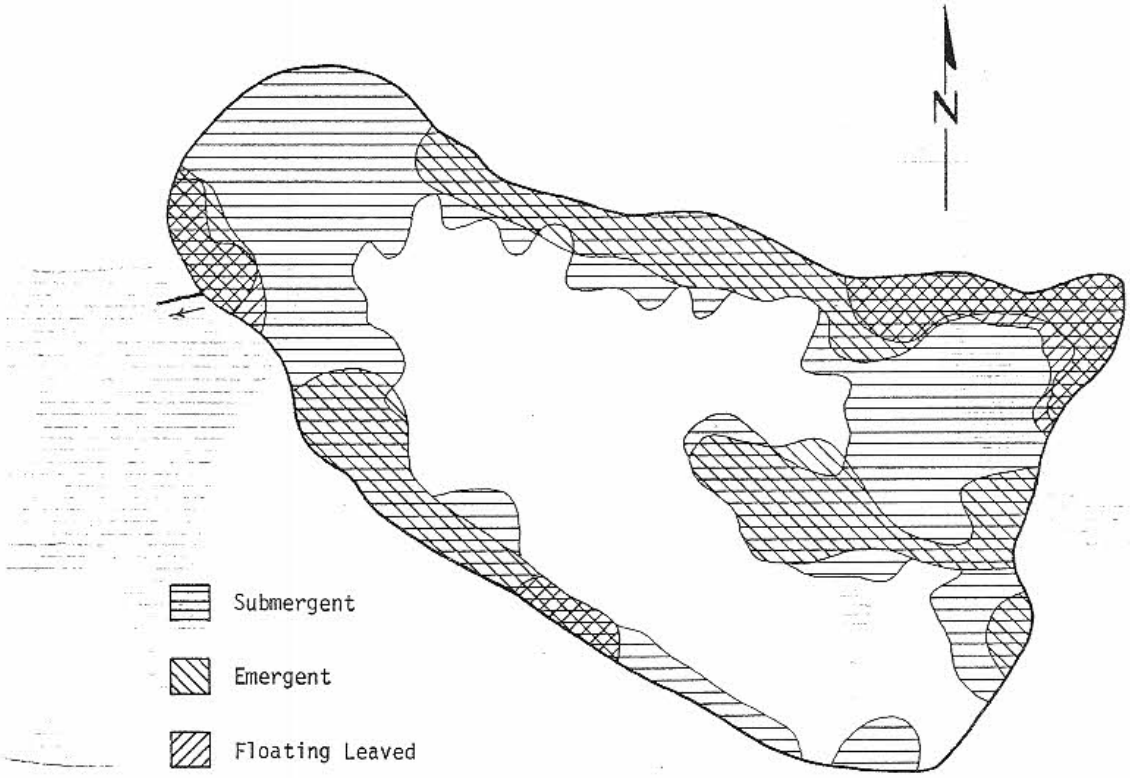

FIGURE 9

MACROPHYTE COMMUNITY IN MUD HEN LAKE

From an ecological standpoint the macrophytes are playing a key role in the lake's high diversity of fish and wildlife. It is important to maintain the quality of this resource, and therefore the plant community should be altered only if necessary. Although the macrophytes are now dense and extensive, the fish population is in excellent health. Panfish, in particular, often grow slowly under weedy conditions. Nonetheless, the dominant panfish species--bluegill--was above average in rate of growth and degree of plumpness. The lake supports a quality fishery for several species, especially largemouth bass, without any special management effort. As a result of the macrophytes the lake also is used by waterfowl of many types.

TABLE 5. Prevalent Macrophytes in Mud Hen Lake, 1979

Macrophyte Species	Common Name	Abundance*	Important to: Waterfowl	Fish
Floatingleaf:				
Nymphaea sp.	white water lily	C	X	
Emergents:				
Zizania aquatica	wild rice	A	X	
Scirpus validus	softstem bulrush	A	X	X
Submergents:				
Chara sp.	stonewort	A	X	X
Najas sp.	bushy pondweed	C	X	X
Elodea canadensis	waterweed	C		
Vallisneria americana	wild celery	C	X	X
Ceratophyllum demersum	coontail	A	X	X
Myriophyllum sp.	milfoil	A		X
Potamogeton Robbinsii	Robin's pondweed	A		X
P. praelongus	whitestem pondweed	C	X	X
P. natans	floatingleaf pondweed	C	X	X
P. Richardsonii	claspingleaf pondweed	A	X	X
P. alpinus	------	C		
P. zosteriformis	flatstem pondweed	A	X	

*A = abundant
C = common

Trophic Status

One of the objectives of this study was to determine the "health" or trophic state of Mud Hen Lake. Although the trophic state idea is based on a continuum from unproductive to very productive, to facilitate its understanding it has been divided into three classifications: oligotrophic, mesotrophic, and eutrophic. To help determine a lake's placement on the tropic state continuum, an index called Carlson's Trophic State Index (TSI)

has been developed[3]. Three parameters, total phosphorus, chlorophyll a, and Secchi disc, are used in this index. The Secchi disc is a standard sized disc which is lowered into the water to measure water transparency. Carlson's original equation for chlorophyll has been modified for Wisconsin lakes. The following formulae are utilized to calculate the TSI:

$$TSI\ (Secchi) = 60 - 33.2 \log SD$$

$$TSI\ (Chlorophyll) = 36.25 + 15.55 \log chl\ a$$

$$TSI\ (Phosphorus) = 60 - 33.2 \log \left(\frac{40.5}{TP}\right)$$

Figure 10 illustrates the seasonal trends of TSI for all three indices. All three classify Mud Hen Lake in the mesotrophic range. This agrees with the rate of phosphorus loading (Figure 5) and the algal biomass and community present during the study period. In many ways the present trophic status of Mud Hen Lake is desirable. Although the lake is not pristine the water clarity is good and this level of productivity supports a good fish population. Care should be taken that the lake does not proceed past this point and become eutrophic as many other lakes have done. Procedures to retard the lake from sliding upwards along the trophic scale will be detailed in the management alternatives section.

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[3]Carlson, R. E. 1977. A tropic state index for lakes. Limnol. and Oceanogr. 22:361-369.

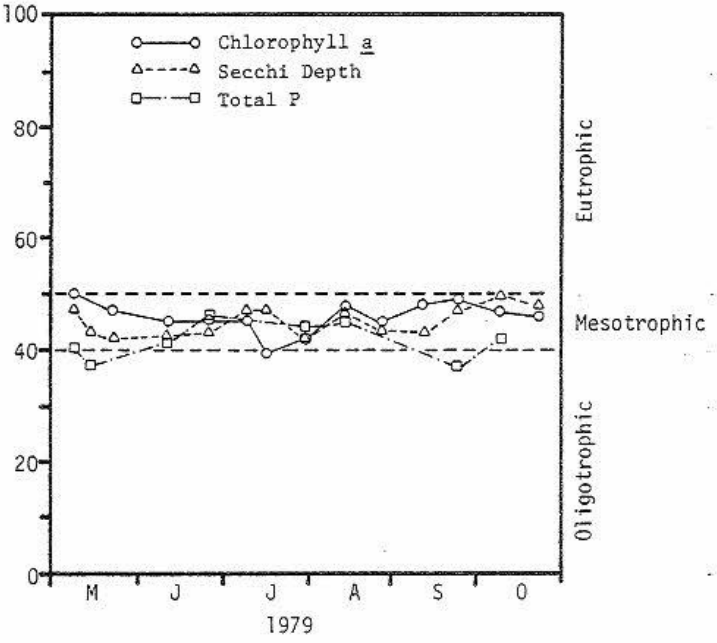


FIGURE 10

TROPHIC STATE INDEX (TSI) FOR MUD HEN LAKE

Dissolved Oxygen

Mud Hen Lake is a dimictic lake meaning that it mixes twice a year, during the spring and in the fall. Complete mixing of deep lakes such as Mud Hen Lake is restricted by thermal stratification during the summer, and by ice cover during the winter. Thermal stratification is a result of differential heating of the lake water. As summer begins, the surface water of the lake absorbs the sun's energy. As the upper layer of water is heated by the sun's energy, a barrier begins to form between it and the lower, heavier, colder water. This "barrier" is marked by a sharp temperature gradient known as the thermocline, which separates the warmer, less dense, upper layer of water--called the epilimnion--from the cooler, more dense, lower layer--called the hypolimnion. Although this barrier is easily crossed by fish, it essentially prohibits the exchange of water between the two layers, a condition which has a great impact on both chemical and biological conditions in Mud Hen Lake. This statification period lasts until the fall, when air temperatures cool the surface water.

When the lake stratifies, the deeper waters are cut off from the atmospheric exchange of oxygen. If oxygen consuming processes are great enough both at the sediment surface and in the water column, much of the hypolimnion becomes devoid of oxygen. This indeed happens in Mud Hen Lake both during summer stratification and also during winter ice cover (Figure 11). During the summer most of the area below 25 to 30 feet is devoid of oxygen. This

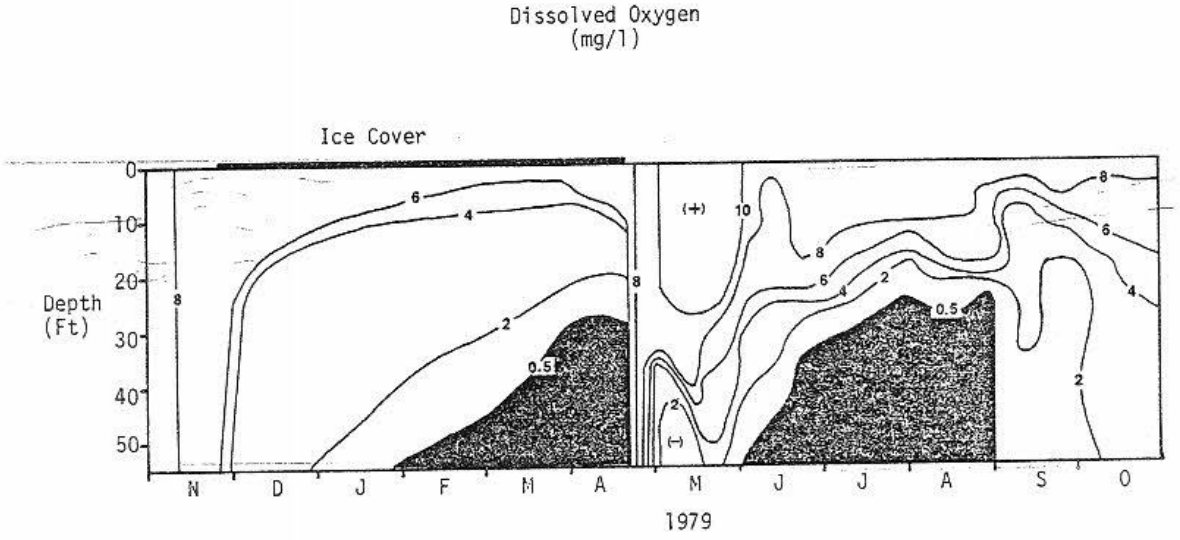


FIGURE 11

DISSOLVED OXYGEN ISOPLETHS FOR MUD HEN LAKE DURING THE STUDY PERIOD

The shaded area represents DO concentrations less than 0.5 mg/l.

corresponds to about 19 percent of the lake's volume. As a result, fish and benthic invertebrates are not able to inhabit this area during much of the summer stratification period. Another detriment of the anaerobic (without oxygen) conditions is that chemical reactions occur which cause release of phosphorus and nitrogen from the bottom sediments. This nutrient release is not currently a problem, but if the lake becomes more eutrophic, the increased algal production will intensify the current anaerobic conditions and also enrich the bottom sediments with nutrients. Consequently more phosphorus will be released from the sediments and become entrained into the surface waters during spring and fall mixing. This additional phosphorus will increase and prolong algal blooms.

Fish

Mud Hen Lake historically has not had much fish stocking. Prior to 1954 some stocking of northern pike and largemouth bass was done, but since 1954 no stocking has occurred. A fish survey was conducted in 1966. This survey found that largemouth bass and bluegills were abundant and northern pike, pumpkinseeds, yellow perch, black crappie, white sucker, and black bullhead were common. Carp, green sunfish, and rock bass were also present in low numbers.

As part of the feasibility study, the Department conducted a fish survey in 1978. All the species reported in the 1966 survey were present plus yellow and brown bullhead and bowfin. The 1978 survey found that the panfish population was dominated by bluegills followed in decreasing order of relative abundance by pumpkinseed, yellow bullhead, yellow perch, brown bullhead, green sunfish, and black crappie. The survey found that bluegill, rock bass, and black crappie exhibited growth rates which were above the northern Wisconsin average whereas the two gamefish, northern pike and largemouth bass, along with pumpkinseed and yellow perch, had growth rates well below the northern Wisconsin average. Although growth rates varied, all fish species appeared to be in excellent condition. Since the fish population seems to be doing reasonably well, the survey report concluded "all fish species present have been and can be expected to continue to maintain themselves without any supplemental stocking." A copy of the report is in Appendix A.

MANAGEMENT ALTERNATIVES

The management alternatives presented here are based on the results of the feasibility study and designed to provide information and direction to the Lake District for the protection and management of Mud Hen Lake. The lake exhibits few nuisance problems, therefore most of the discussion will concentrate on preserving the lake in its present condition. Reversing the effects of eutrophication is difficult and costly. It is desirable to prevent a lake from becoming eutrophic through a proper lake and watershed management program.

Protection of the Present Resource

As detailed in the study results section, Mud Hen Lake is classified as a mesotrophic lake, i.e., moderate fertility. In order to maintain the lake in its present condition, the Lake District should take an active leadership role in a protection program.

Although runoff from the watershed is usually a major concern in the eutrophication of a lake, Mud Hen Lake is fortunate in that there seem to be few detrimental land use practices in its watershed. Agricultural areas seem to be mainly hay meadows and pastureland with few barnyards near the lake or stream course.

Perhaps the most significant beneficial factor in the watershed is the wetlands, especially along the stream. It has been estimated that wetlands

are able to retain 75 percent of the nutrients which enter them. This greatly reduces the nutrient loading to the lake. If these are channelized, they become much less efficient. The Lake District should encourage the protection of these wetlands through town or county enactment of effective local zoning ordinances and/or strong lobbying efforts.

Another area of concern is construction activities. These activities can increase surface water runoff over the bare ground, thereby increasing the amount of sediment and nutrients delivered to the lake. It is important to prevent this by covering all bare ground with mulch and using settling basins, underground absorption fields, or straw bale retention dikes. Agencies such as the Burnett County office of the Soil Conservation Service and the Agricultural Stabilization and Conservation Service can provide guidance in designing and building these systems.

An additional concern for preventing the degradation of Mud Hen Lake are private sewage disposal systems. While there is some question as to just how detrimental these systems are to the lake at present, under certain conditions they can become harmful. Appendix B describes the working of septic systems and potential problems. Nutrients from a malfunctioning septic systems can reach the lake, especially on the eastern side where the groundwater flows into the lake. At times when the groundwater level is close to the land surface, phosphorus is either dissolved off the soil particles or it does not have time to become adsorbed before it reaches the groundwater. It will then be transported into the lake. Even on the side of the lake where the groundwater flow is away from the lake, septic systems can be a problem. If the system becomes overloaded, "ponding" occurs and nutrients may reach the

lake during runoff events, or possibly due to a localized reversal of the groundwater flow direction. It is important that future systems be installed properly, taking in account soil characteristics, depth to groundwater, and anticipated level of usage. Routine maintenance of all systems is also essential for the long term protection of water quality in Mud Hen Lake. The Lake District should communicate its concerns to the town and county, and could consider acquisition of sanitary district powers in order to gain some enforcement authorities.

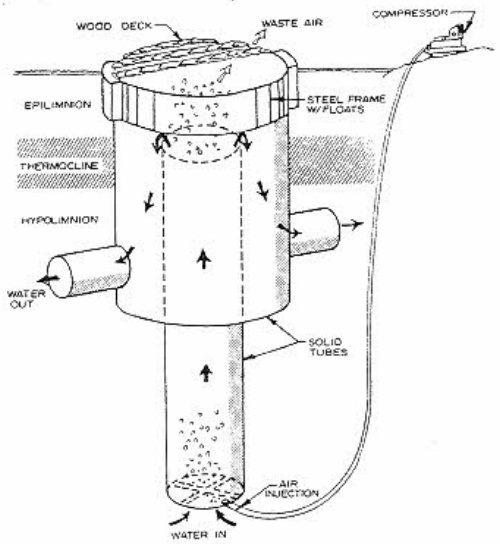
The basic principle behind the working of a septic system is that phosphorus released through the tile system will be adsorbed by soil particles. Their adsorption capacity is limited by the type of soils present. When this capacity is saturated, phosphorus will no longer be retained. One action that shortens the life of a septic system is overuse of lawn fertilizers. With overfertilization, phosphorus in the fertilizers is also adsorbed on the soil particles, thus limiting the capacity to retain phosphorus from septic systems. Another bad effect of overfertilization is that during heavy rains, the nutrients will flow overland to the lake. Proper use of lawn fertilizers is detailed in Appendix C.

The Lake District should also discuss the implementation of a water quality monitoring program. This should include measurement of at least water clarity, phosphorus, and dissolved oxygen. A program of this type would alert the Lake District to any degradation in water quality, thereby stimulating further investigation of causes. If the Lake District is interested, the Office of Inland Lake Renewal will provide assistance in the development of a specific monitoring plan.

Hypolimnetic Aeration

At the present time, Mud Hen Lake suffers from a seasonal dissolved oxygen depletion in the hypolimnion. A method to rectify the problem would be installation of a hypolimnetic aeration unit. This type of aerator would provide oxygen to the bottom waters without disrupting the thermal stratification. Typically, bottom water is airlifted up a vertical tube, oxygenated, and returned to the hypolimnion (Figure 12). The benefits derived from an oxygenated hypolimnion include increased habitat for benthic invertebrates and fish, with the possibility of establishing a coldwater fishery. With oxygen in the deep waters, zooplankton populations may also increase, causing greater predation on and reduction in numbers of certain species of algae. A further benefit of hypolimnetic aeration would be to maintain an oxidized sediment surface. This would reduce the release rates of phosphorus and nitrogen from the sediments, and further restrict the availability of these nutrients for growth of algae.

There are several systems available to accomplish this task. Based on a German design, a compressor would be required to produce an airflow of at least 40 cubic feet per minute (cfm) at a pressure of 25 pounds per square inch (psi). The design and fabrication of such a unit in addition to a compressor could approach a cost of $50,000 - $75,000. Installation and operation of an aeration system requires a permit from the Department of Natural Resources at Spooner.



Source: A. W. Fast, "The Effects of Artificial Aeration on Lake Ecology," U. S. EPA Water Pollution Control Research Series 16010EXE, 1971.

FIGURE 12

ILLUSTRATION OF A TYPICAL HYPOLIMNETIC AERATOR THAT MIGHT BE SUITABLE FOR MUD HEN LAKE

Macrophyte Harvesting and Herbicide Use

Macrophytes are abundant around much of the lake and are somewhat impairing recreational usage of the lake. One method of removing the plants is by harvesting. Harvesting has several desirable attributes: 1) discrete areas can be treated, 2) deposition of organic sediments will be reduced by removing the plant material, 3) nutrients in the plant tissue will be removed from the lake thereby preventing their release into the water during decomposition, 4) all species present will be cut and removed, and 5) the area can be used immediately after treatment. It isn't, however, a panacea and there are some problems: 1) annual retreatment will be required, 2) adequate control may necessitate two cuttings per summer, 3) macrophytes will continue to grow below the maximum cutting depth, 4) high initial purchase and later operation/maintenance costs will be involved, and 5) a disposal site may be needed for the harvested plants.

A variety of equipment is available to fit each situation. Small harvesters can be purchased primarily for shoreline cleanup. They will operate in water six inches or more deep and will cut the macrophytes down to 4-5 feet. The cutting rate is normally 2-4 acres per day. Harvester costs are roughly $13,000-16,000. Large harvesters are usually used for the deeper, offshore locations. These machines require at least 12 inches of water and will cut down to 5-8 feet. The cutting rate is about 4-8 acres per day, depending on

plant density. Costs will be approximately $60,000 and up. Intermediate sized harvesters are also available, and often are best suited where a combination of near and offshore sites are in need of harvesting. Additional major operating needs include: 1) manpower--usually two men are needed to harvest and dispose of the plants, 2) conveyor system--some mechanism is needed to take the plants from the harvester, 3) transportation--dump trucks may be required to take the plants to a disposal site, and 4) disposal--it will be necessary to find an adequate disposal site. This may be a problem, although application to cropland or gardens has proven to be beneficial elsewhere.

A few private companies advertise macrophyte harvesting services. Prices vary between companies and will be influenced by lake location and macrophyte density. Anticipated costs would, however, be $150-300 per acre. Disposal of the macrophytes is usually, but not always, included in the service available.

It would be neither necessary nor desirable to harvest all of the area inhabited by macrophytes. The emergent and floatingleaf communities should, in particular, be left alone. Submergent macrophytes are used by fish for cover and are inhabited by many of the prey species that the fish feed upon. About one-half of the present macrophyte area could be harvested without negative side effects to the fishery. Emphasis could be placed on needed recreational usage areas (e.g., navigation channels, swimming areas, boating, fishing, water skiing, etc.). If the Lake District wishes to pursue this type

of implementation plan, Department of Natural Resources resource managers are available for assistance in identifying areas that could be harvested and areas that should be left intact.

Herbicides such as 2,4-D, diquat, and endothal have been used to control macrophyte growth. They can be effective but also chemical control is not recommended unless other practices prove to be impractical or ineffective. All chemical treatment programs require a permit from the Department of Natural Resources. Chemical control generally ranges from $150-300 per acre and, as with macrophyte harvesting, is not eligible for cost-sharing under the Inland Lake Renewal program.

Lake Level Modification

Water levels in lakes typically fluctuate up and down on a seasonal basis as well as from year to year. Lakes such as Mud Hen Lake with a large groundwater input and some surface runoff from a small stream usually have their highest water levels in the spring and early summer, and lowest in late summer and fall. Additional fluctuation may occur due to heavy storm events or during drought periods.

During the feasibility study, Mud Hen Lake fluctuated 0.50 feet (Figure 13). Highest levels were found in late April following spring runoff and the lowest levels occurred in August and mid-October. The lake level also exhibited a noticeable rise following large rain events, e.g., mid-July and early September. The lake level fluctuations during the study year were probably average since precipitation was near normal.

While it is possible to modify water levels with a control structure such as a dam, fluctuations will still occur. A dam, if designed correctly, should reduce the occurrence of low water levels; however, it would do nothing to reduce--and may in fact increase--high water levels. If it is decided that a control structure is feasible, a water level should be chosen that will not increase shoreline erosion or flood septic systems. A fixed-crest dam may be the best type for Mud Hen Lake, but emplacement of any dam in Wood Creek will require a permit from the DNR office in Spooner.

Any management alternative selected by the Lake District that requires Department of Natural Resources permits and/or more than $25,000 of state funds will evaluated by completion of an Environmental Impact Assessment (EIA). The EIA will provide an opportunity for public review and comment on its findings and will determine the need for an Environmental Impact Statement (EIS). If the EIA demonstrates that the selected management alternative will significantly affect the quality of the human environment, the Department will prepare an EIS prior to project approval.

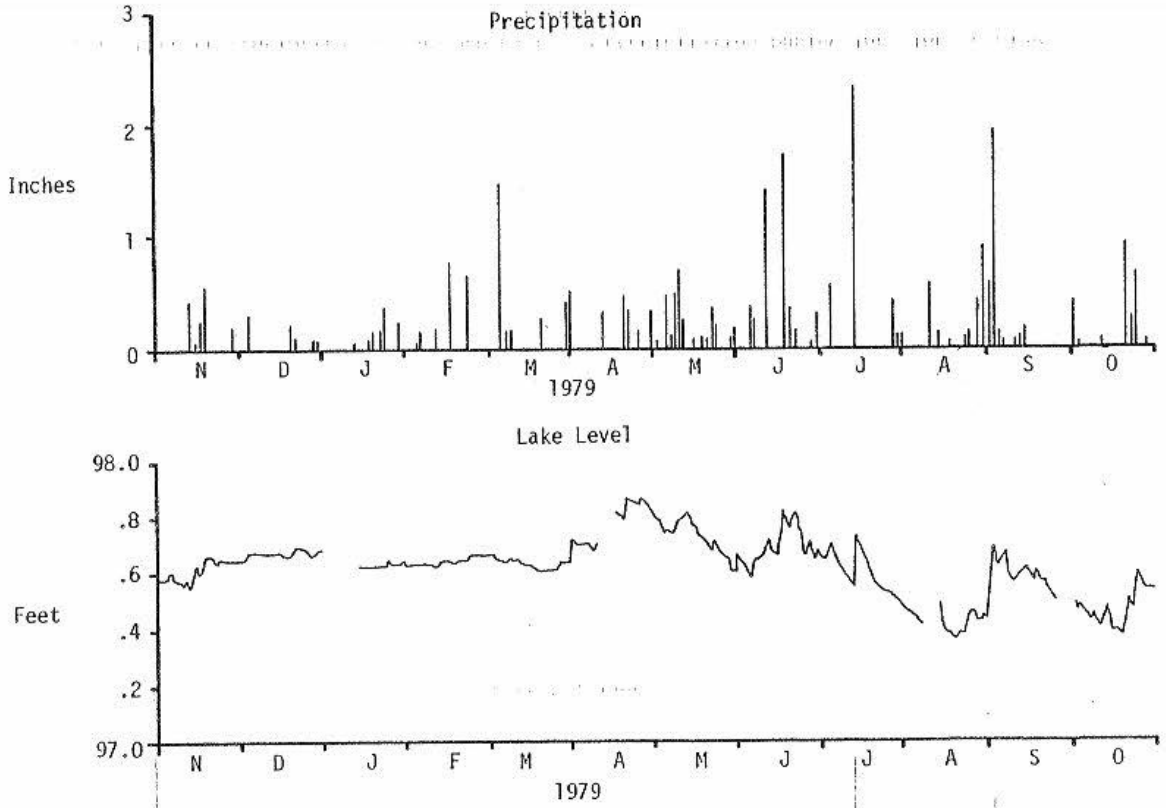


FIGURE 13
LAKE LEVEL FLUCTUATION IN MUD HEN LAKE AND PRECIPITATION DURING THE STUDY PERIOD

Appendix A

May 25, 1979 3610-1

D. A. Jacobson

Stan Johannes SJ

Lake Survey - Mud Hen Lake, Burnett County

Location: Sections 16, 17, and 21, T38N, R17W
Dates Investigated: July 11 and 12, August 7 and 16, September 7, 1978
Purpose: Basic Fish and Resource Inventory

Lake Characteristics

Mud Hen Lake, located west of Siren along State Highway #70, is one of the largest (562.5 Acres) and deepest (66 ft. max. depth) lakes in Burnett County (Figure I). It is a mesotrophic, hard water, drainage lake having a normal outlet flow of 3.3 cubic feet per second. The lakes outlet also serves as the headwaters of the North Fork of Wood River.

As its name implies, Mud Hen Lake is attractive to waterfowl, especially puddle ducks and mud hen (coots). This is probably due to the rather large acreage of undeveloped wetlands and the abundant growth of wild rice and several other aquatic vegetation species which are attractive to waterfowl as food. In addition to wild rice, bullrushes, spikerushes, pickerelweed, several pondweed species, water lilies and water shield also inhabit the shallow littoral zone of the lake. The littoral bottom is mainly sand with soft muck and detritus overlying sands adjoining wetlands in shallow bay areas. The east end of the lake also has a large lobe of bullrushes and wild rice which extends west almost one-third the length of the lake. The 184 acres of adjoining wetlands also provide excellent habitat for nesting mallards, blue-winged teal, and wood ducks. In addition, a pair of loons was also observed to be successful in fledging a young loon during 1978.

Only ten percent of the lakes 5.0 square mile watershed land area is being farmed. Shoreline frontage amounts to 4.21 miles of which only 0.02 miles is public. Development consists of five resorts, 44 cottages and dwellings, and one church camp around the perimeter of the lake. Lindberg Park, a town park owned and maintained by the Town of Daniels at the southeast end of the lake, provides public access, picnicking and swimming facilities. This combination park and access is the only public frontage on the lake.

The water of Mud Hen Lake, is clear, alkaline (pH 8.4) and rather fertile (MPA 35 ppm). It does experience algal blooms, however, blooms reaching nuisance proportions have never been reported. The lake thermally stratifies annually with the top of its thermocline usually starting somewhere around 15 feet below the surface. The depth of the thermocline is quite variable but usually extends down to about 30 feet.

Past Management and Fishing History

Mud Hen Lake's early management consisted mainly of stocking northern pike and largemouth bass. No other species of fish has ever been stocked and the last plant took place back in 1954.

Prior to 1978, information on Mud Hen Lake's fish population was based entirely on an electroshocking survey conducted in June of 1966. This survey was an inventory designed to sample fish species present and determine their relative abundance. The survey showed the following species to be present: Largemouth bass (A), northern pike (C), bluegills (A), pumpkinseeds (C), yellow perch (C), rock bass (P), black crappie (C), green sunfish (P), white sucker (C), black bullhead (C), carp (P), and brook silverside, common shiner, golden shiner, and creek chub minnows.

Following this electroshocking inventory in 1966, a one day creel census was conducted on June 10, 1967. A total of 12 anglers were interviewed and four of the five resorts on the lake were contacted. Overall, angler comments were favorable for largemouth bass, northern pike, and panfish angling. A few fishermen indicated that they felt crappie fishing had declined in recent years although a few nice catches had been made that year. The electroshocking survey data collected in 1966 and the one day creel census information collected in 1967, forms the sum total inventory base presently available for Mud Hen Lake. Mud Hen Lake was mapped in June of 1966 with recording sonar. An excellent hydrographic lake map has been available since 1967.

Water levels on Mud Hen Lake have been the subject of considerable discussion by property owners over the years. Evidently, a beaver dam on the lake's outlet has agitated this problem. In 1974, Mr. and Mrs. Ted Schoquist representing the Mud Hen Lake Property Owners Association, complained to the DNR, that lake levels had dropped the past two years. The association was interested in seeing a water control structure installed at the lake's outlet to raise and stabilize the lake's level. DNR advised the Mud Hen Lake Association regarding permits and requirements that would have to be met in order for a lake stabilization structure to be placed at the outlet of Mud Hen Lake. Lack of land control and the unwillingness of Daniels Township to serve as the applicant for a permit from DNR to construct a Lake stabilization structure at the outlet of Mud Hen Lake pretty well stopped the proposed project from becoming a reality.

In 1977, the Mud Hen Lake Property Owners Association formed an Inland Lake Protection and Rehabilitation District. Then in March, 1978 the Mud Hen Lake Rehabilitation District was issued a state grant of $7,098.00 to carry out a feasibility study for the protection and rehabilitation of Mud Hen Lake, Burnett County. The following specific data collection program was set-up and is being collected at this time. 1). Surface water flows and chemistry analysis. 2). Groundwater monitoring. 3). Nutrient determinations. 4). Bottom sediment analysis. 5). Clorophyll analysis. 6). Algae identification to species and enumeration. 7). Macrophyte survey. 8). Fish survey. All of the above data except the fish inventory data will be collected by a responsible consultant through competitive bidding. A request of Cumberland Area Fish Management personnel to conduct a basic inventory of Mud Hen Lake's fish population was made by the DNR Office on Inland Lake Renewal in Madison. It was agreed that the survey would be completed sometime prior to November 1, 1979. This report is the basic inventory of Mud Hen Lake's fish population as requested by the DNR Office of Inland Lake Renewal.

Wildlife Resources

Overall, wildlife values of Mud Hen Lake can be considered to be excellent. The adjoining wetlands provide nesting habitat for mallards, blue-winged teal, wood ducks and loon. Since the lake is late in freezing over each year, large numbers of northern diving ducks and some puddle ducks, coots, canada geese and swans are also able to congregate here when other lakes have become ice covered. Fall hunting of diving ducks on Mud Hen Lake is considered to be good. Beaver use of Mud Hen Lake is sporadic while muskrat use can be considered to be significant.

Public Use Opportunities

A rather high percentage of the Mud Hen Lake upland shoreline is developed with five resorts, 44 homes or seasonal dwellings, and one church camp located on upland areas. The lake is probably one of the most important recreational lakes in Burnett County used for fishing (both winter and summer), swimming, pleasure boating, water skiing, trapping, waterfowl hunting and wild ricing. Overall use observations document light fishing and boating pressure. The average observed boating use recorded in 1975 (most recent aerial boating observation year) was 1 boat per 74 acres of water or about 8 boats on the lake per observation.

There is only one developed public boat landing with parking to Mud Hen Lake (Figure 1). Lindberg Park, as it is known, is located at the southeast end of the lake and is owned and maintained by the Town of Daniels. This combination, town access and park, provides pulic access, picnicking, and swimming facilites for local townspeople. Lindberg Park provides the only public frontage on the lake which amounts to 0.02 miles.

Present Fishery Resources

The present status of the Mud Hen Lake fish population is based on fyke net sampling conducted in July, electroshocker sampling conducted in August and September and shoreline seining conducted in August of 1978. Sampling effort consisted of 12 fyke net lifts, 5.27 hours of electroshocking and five midsummer seine hauls. All fish captured were measured to the nearest one-tenth inch. A representative scale sample was taken from the more important species, pressed on acetate slides and aged with the use of a Bausch and Lomb Micro-Projector.

Fyke net sampling showed the Mud Hen Lake panfish population to be dominated by bluegills with pumpkinseed, yellow bullhead, yellow perch, brown bullhead, green sunfish, and black crappie next in relative abundance respectively. Fall electroshocking sampling showed that Mud Hen Lake was also populated with two popular gamefish species, the northern pike and largemouth bass. An effort was also made to sample the lake's forage (minnow) population. A 50' small mesh (1/4") seine was used to sample five locations (see Figure I) with mainly yellow perch, bluegills, weed shiners, and banded killifish being taken. Juvenile largemouth bass and brook silversides were also taken although their abundance was very low. Other species found to be present during the survey were rock bass, white suckers, bowfin, carp, common shiner and golden shiner minnows. These speices all appear to be present in such small numbers that they probably play a very limited role in the overall fish population dynamics of Mud Hen Lake.

A representative sample of northern pike, largemouth bass, bluegill, pumpkinseed, yellow perch, rock bass, and black crappie were aged to determine growth rates (see Table I). In this table, growth rates are compared to average growth rates of fish from other northern Wisconsin lakes. This is done in order to determine relative growth rates of the individual speices listed. An unpublished research report entitled "Age and Growth of Fish in Northwestern Wisconsin" by Thomas D. Beard in 1976 was arbitrarily chosen as the best study reflecting average growth rates of warm water fish from northern Wisconsin lakes. Close examination of Table I shows that bluegill, rock bass, and black crappie exhibit growth rates which are above the northern Wisconsin average whereas the northern pike, largemouth bass, pumpkinseed and yellow perch exhibit growth rates which are well below the northern Wisconsin average. All species sampled appeared to be in excellent condition.

Management Recommendations

Examination of the attached temperature - dissolved oxygen profile, fish length frequency summaries, and age and growth data indicates that Mud Hen Lake is a very deep, thermally stratified, mesotrophic lake populated with a fairly high quality warm water fish population. The survey sample seems to substantiate the many compliments registered by fishermen annualy concerning the fine largemouth bass fishing. The largemouth

bass sample taken with electroshocking gear shows that a quality bass population does exist with many size (age) classes represented (Table I). This data also suggests a bass population having good sustaining natural recruitment. The fact that only three largemouth bass were taken during the netting operation gives a very distorted picture of the relative abundance of this species. This is due to the fact that largemouth bass generally will not follow a lead into a trap or fyke net. For this reason, electroshocker sampling gives a far more accurate measurement of the relative abundance of this species. It is expected that largemouth bass should continue to maintain themselves without any supplemental stocking.

Fair numbers of northern pike were also sampled with several size (age) classes represented (Table I). Fishermen report that northern pike fishing is fairly good with several 30.0"+ fish taken each year. In addition, anglers report that a few extremely large pike, probably 40.0"+ tackle busters, also roam the lake. No fish this large were taken during this survey however, a nice sample of 15.0 to 22.0" fish were taken. All fish appeared to be in excellent condition. This species should also continue to maintain itself without any supplemental stocking, just as it has in the past.

Although, only a portion of the overall sampling effort was directed at panfish species, the bluegill appears to be the dominant panfish specie present. Based on numbers of panfish sampled, the bluegill outnumbers all other panfish species combined. The population is dominated with fairly small (5.0-6.0") individuals which do not generate a whole lot of angler interest. Pumpkinseeds, next in relative abundance, also have a rather small average size (5.5 to 6.0") and again generate very little angler interest. Black crappie, green sunfish, rock bass and yellow perch are also persent, however, their abundance is quite low. Here again, due to their small average size, little angler interest is generated by these species. Good numbers of fairly large yellow and brown bullheads are also present. However, even with a large average size (11.0 to 12.0") angler interest in these two species is also very low.

Mud Hen Lake's forage fish community appears to be quite diverse made up mainly of small yellow perch, bluegills, banded killifish and several minnow species. Small bullheads may also constitute a major forage item. Carp are present in the lake. However, the data indicates that their numbers are very low at this time. No serious management problems are anticipated in the near future.

✔ Public access to Mud Hen Lake at the present time is felt to be adequate. The site meets the recommended minimum access parking standard of one car trailer unit per 50 acres of water. In addition, the site has recently been repaired to improve the boat landing and correct a parking situation which presented a serious traffic hazard. Lindberg Park, as the site is known, also provides picnicking and swimming facilities for local townspeople.

All fish species present have been and can be expected to continue to maintain themselves without any supplemental stocking.

SJ:ja
cc: Office of Inland Lake Renewal

Approved:

James Schweiger _____ Date

Noted: _____ Date

Table I. Age-Length Relationships, Mudhen Lake, Burnett County. July 11, 12, 1978.

Age (Summers)	Sample Size	Size Range (Inches)	Mean Size (Inches)	N. Wis.* Avg.	Growth Factor
Species: Northern Pike					
3	3	15.0-16.7	15.7	16.0	- .3
4	16	15.5-18.7	17.1	19.0	-1.9
5	9	17.1-20.4	19.2	21.6	-2.4
6	1	21.8	21.8	24.0	-2.2
Species: Largemouth Bass					
2	2	3.9- 4.5	4.2	6.0	-1.8
3	5	5.3- 6.2	5.8	8.8	-3.0
4	2	7.3- 7.5	7.4	11.4	-4.0
5	7	7.9- 9.5	8.5	14.0	-5.5
6	16	10.0-12.9	11.6	15.8	-4.2
7	3	13.2-13.7	13.5	16.5	-3.0
8	2	16.6-17.2	16.9		
10	1	18.6	18.6		
Species: Bluegill					
1	3	2.1- 2.8	2.3	1.6	+ .7
3	19	3.0- 5.1	3.8	4.2	- .4
4	31	4.1- 6.9	5.2	5.2	0
5	22	5.3- 7.5	6.5	6.2	+ .3
7	1	7.8	7.8	7.6	+ .2
Species: Pumpkinseed					
3	19	3.2- 4.3	3.7	4.4	- .7
4	10	4.0- 6.4	5.1	5.4	- .3
5	15	4.5- 6.3	5.4	6.3	- .9
6	11	5.9- 8.1	6.7	6.9	- .2
7	5	6.8- 7.7	7.1	7.1	0
Species: Yellow Perch					
2	8	3.7- 4.9	4.4	4.5	- .1
3	7	4.1- 5.1	4.6	5.9	-1.3
4	10	5.1- 5.9	5.5	7.1	-1.6
5	1	7.7	7.7	8.2	- .5
7	1	10.0	10.0	10.0	0
Species: Rock Bass					
3	2	4.2- 6.1	5.2	4.4	+ .8
4	1	6.6	6.6	5.6	+1.0
5	2	6.7- 8.0	7.4	6.8	+ .6
Species: Black Crappie					
3	3	7.4- 7.5	7.4	6.6	+ .8
4	2	9.6-10.1	9.8	8.0	+1.8
5	1	9.9	9.9	8.9	+1.0

*Unpublished Research Report, 1976 - Age and Growth of Fish in Northwestern Wisconsin by Thomas D. Beard.

APPENDIX B

The proper maintenance of private disposal systems is an important issue for preserving the water quality of Mud Hen Lake. The primary method of handling domestic sewage in unsewered areas is on-site treatment. The success of the conventional septic tank-soil absorption field system varies according to the design, construction, and maintenance of the system.

The two basic components of a septic system are the septic tank and the soil absorption field. In the septic tank, the solids settle to the bottom as sludge. This partially decomposed sludge must be pumped from the tank periodically to avoid clogging the soil absorption field. The liquid or septic effluent from the tank enters the soil absorption field. This liquid then is filtered down through the soil to the water table.

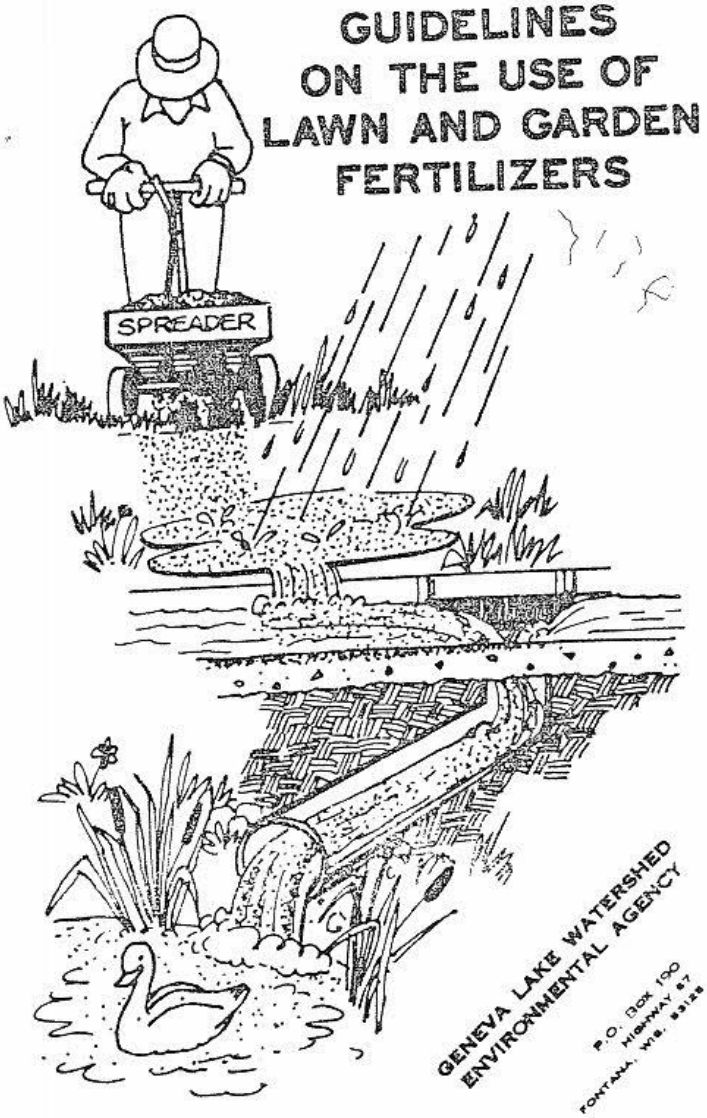
What happens to the effluent after it leaves the septic tank is important to Mud Hen Lake. The effluent contains organic material, solids, nutrients, bacteria, and occasionally viruses. From a personal health standpoint, bacteria and viruses can be harmful, especially if they get into the drinking water supply. Homeowners with shallow wells should be concerned about this possibility. Well water should be tested and septic sytems inspected and maintained regularly.

In terms of the lake, increased nutrient input, especially phosphorus can degrade the water quality. In a properly functioning system, phosphorus is absorbed onto soil particles as the liquid percolates through the soil. However, if the depth from the soil absorption field to the groundwater is not sufficient, much of the phosphorus will not be absorbed onto the particles. Once in the groundwater, phosphorus will be transported in solution. In addition, if regular maintenance is not done, e.g., pumping the sludge from the tank periodically, the system becomes overloaded and the soil becomes saturated and clogged, resulting in seepage onto the land surface. When the seepage surfaces, the nutrients are washed to the lake during spring runoff and during rainstorms.

Another problem is the construction of septic systems in floodways. Floodwaters interfere with the functioning of the absorption field and may carry away unfiltered sewage.

Appendix C

GUIDELINES ON THE USE OF LAWN AND GARDEN FERTILIZERS



Improper application of fertilizers and herbicides to lawns, shrubs, and gardens results in a natural loss of these compounds, which can ultimately find their way to the streams and to Geneva Lake. The fertilizer nutrients promote excessive water weeds and algae, thus reducing the recreational and aesthetic value to our waterways. In order to maintain and promote clean waters, it is therefore important to avoid any careless, improper or excessive application of fertilizers.

PRECAUTIONS TO BE TAKEN WHEN APPLYING FERTILIZERS TO LAWNS OR GARDENS

1. DO NOT MAKE LARGE SINGLE APPLICATIONS OF SOLUBLE FERTILIZER.

Large single applications increase the possibility of nutrient runoff causing excess algae growth and also produces lush growth which increases susceptibility to attack by insects and disease. Extremely large single applications may cause salt burn which will kill the grass.

To get maximum benefit of nitrogen fertilizer, it is better to apply it to lawn grasses at regular intervals (2-3 applications) during the growth season, rather than to apply it all at one time.

2. MAKE SURE THE TOTAL AMOUNT OF FERTILIZER DURING EACH GROWING SEASON IS APPROPRIATE.

To obtain maximum ecological and economic benefits, use only the quantity and type of fertilizer recommended by the soil test for the area of concern. Don't waste your money!

3. USE A CALIBRATED SPREADER.

Use of a calibrated spreader not only permits uniform fertilization but helps control over-use.

4. SWEEP UP ANY FERTILIZER SPILLED OR SPREAD ON WALKS OR DRIVEWAYS.

Do not sweep or wash this material into the gutter since it will wash into the storm sewer and then into the streams and Geneva Lake.

5. DO NOT WASH THE SPREADER (OR HERBICIDE OR OTHER PESTICIDE APPLICATOR) IN THE GUTTER OR ON WALKS OR DRIVEWAYS.

6. WATER THE LAWN SOON AFTER APPLYING THE FERTILIZER.

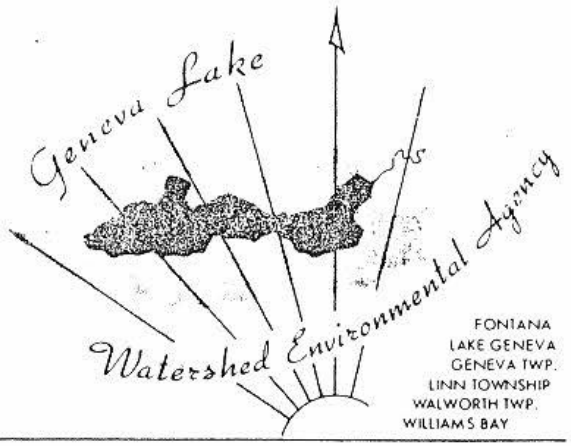
Use only enough water to wash the fertilizer off the grass leaves and into the soil, thus eliminating any possible danger of salt burn. This watering process brings the fertilizer into contact with the soil, promoting faster utilization of the nutrients and preventing loss of nutrients through runoff. However, remember it is also important to conserve water.

Depositing fertilizers and herbicides on sidewalks, driveways, and roadways pollutes our streams and Geneva Lake, as these compounds find their way through storm sewers and ditches to the waterways. Grass clippings, leaves, and dog droppings deposited on sidewalks and roadways contribute additional nutrients and pollutants to our waters.

SOIL TESTING IS RECOMMENDED

Soil tests are a practical way of telling whether fertilizers are needed and for determining what quantities should be applied in order to obtain maximum benefits and minimum fertilizer losses. Representative soil samples should be taken and submitted to a soil testing laboratory. The UNIVERSITY SOIL TESTING LABORATORY is located at 806 South Park Street, Madison, Wisconsin. The fee for the routine lawn or garden soil test is $2.00 per sample.

Instructions and methods of sampling lawns and gardens for soil test and assistance in interpreting soil test results may be obtained from:

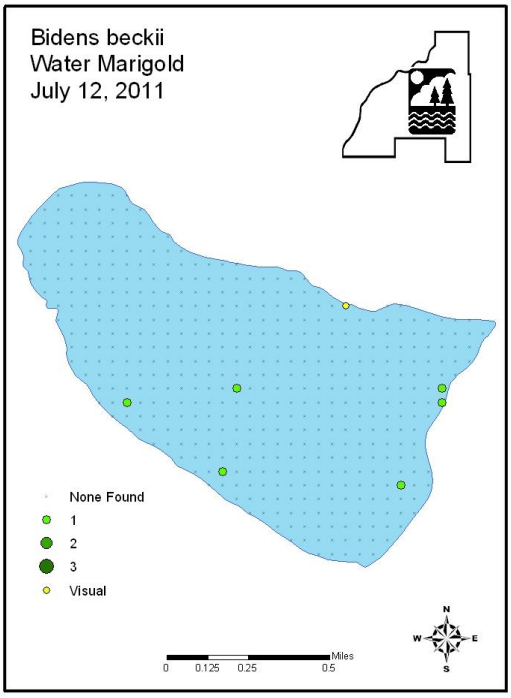


HIGHWAY 67 - P.O. BOX 190 FONTANA, WIS. 53125

PHONE 1 - 414 - 275-6310

Appendix C

Aquatic Plant Map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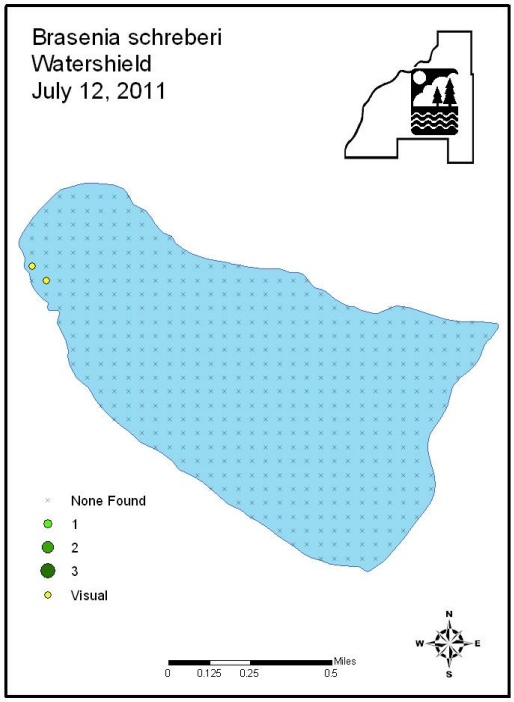
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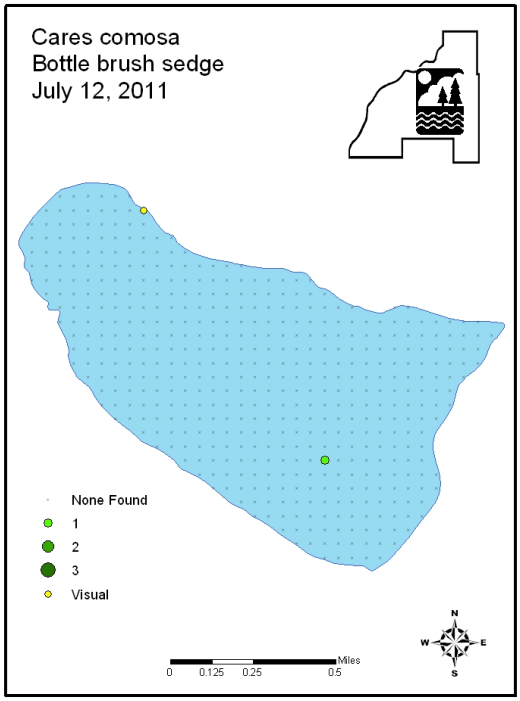
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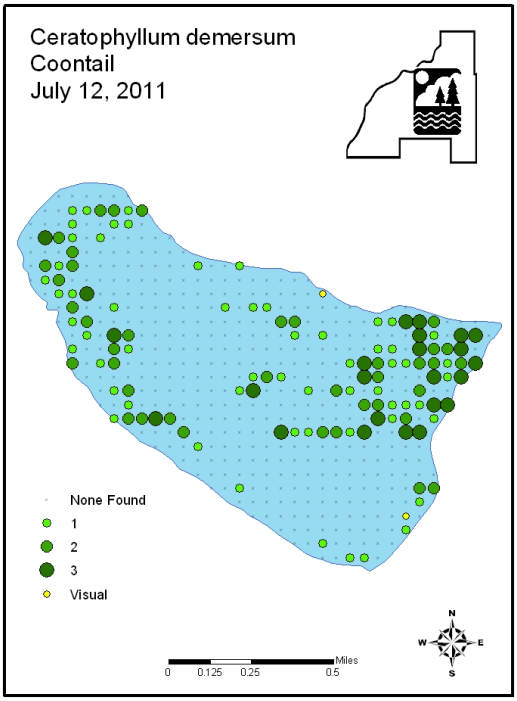
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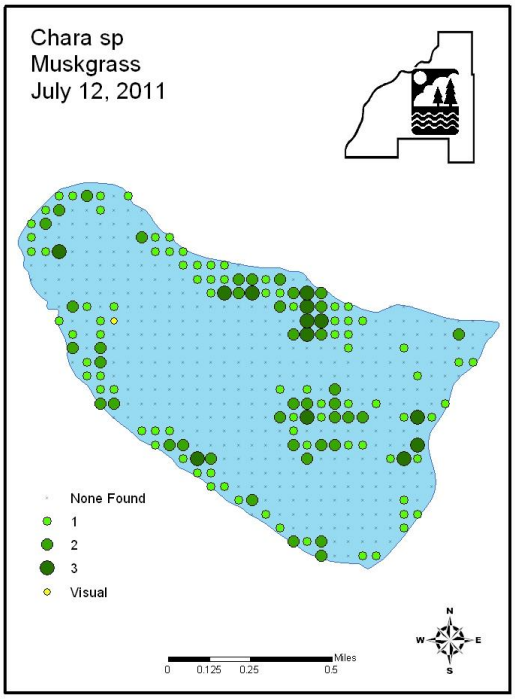
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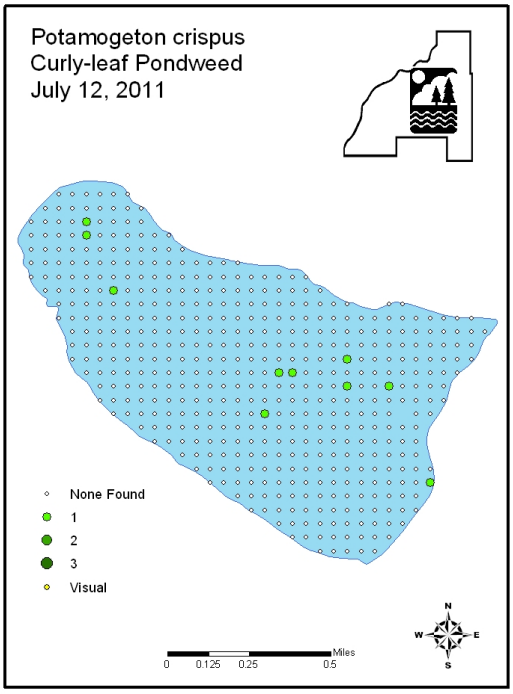
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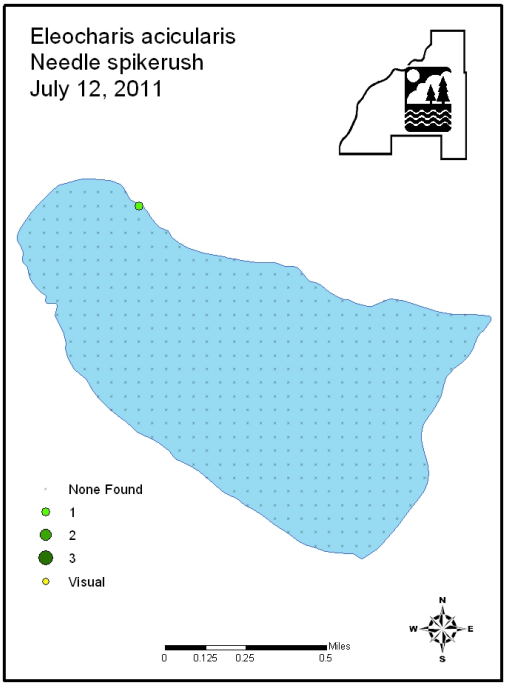
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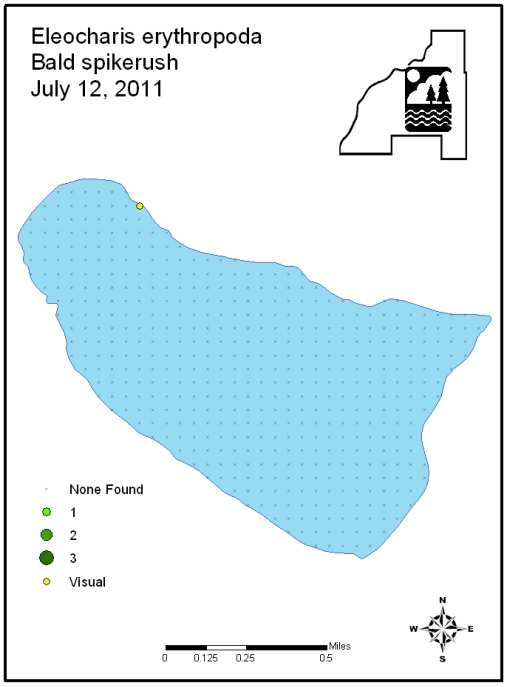
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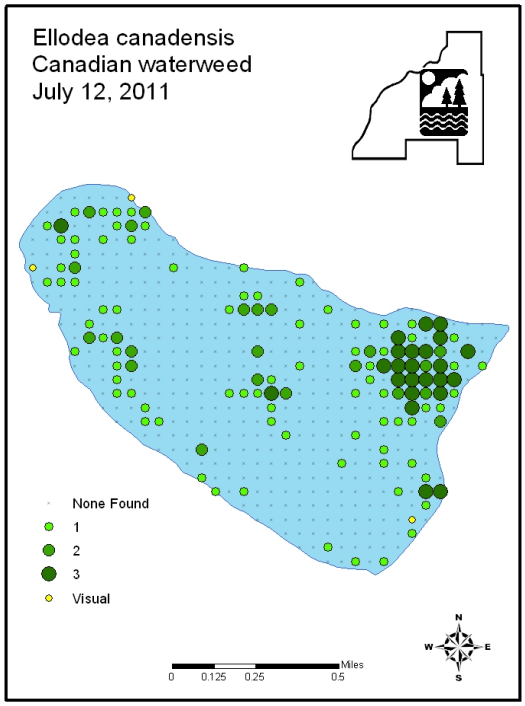
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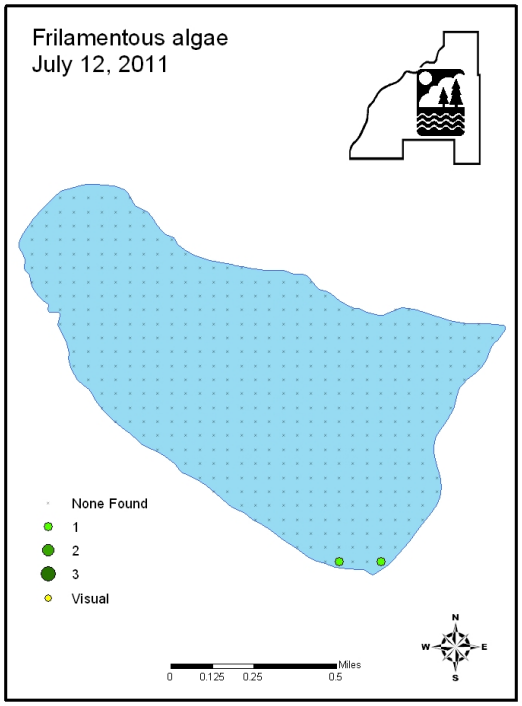
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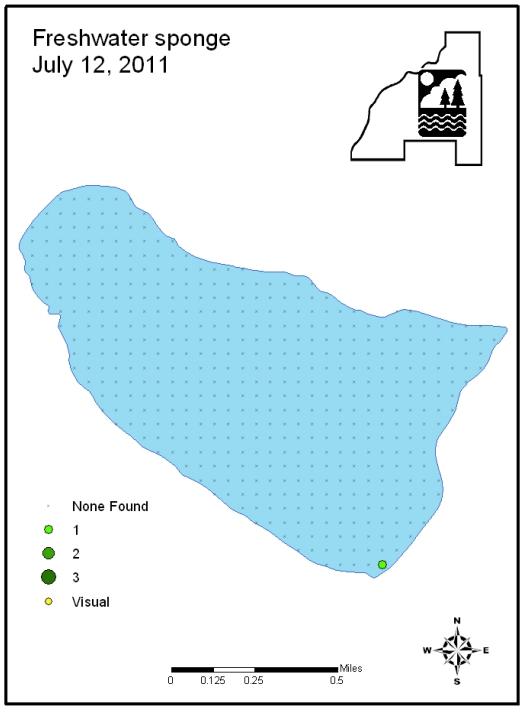
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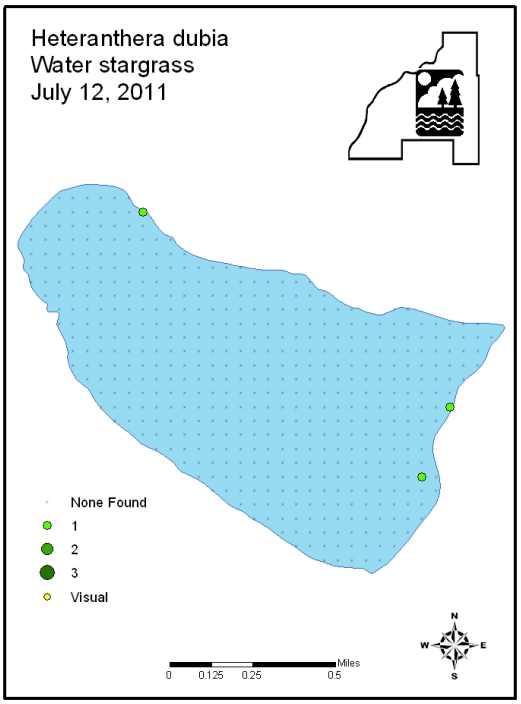
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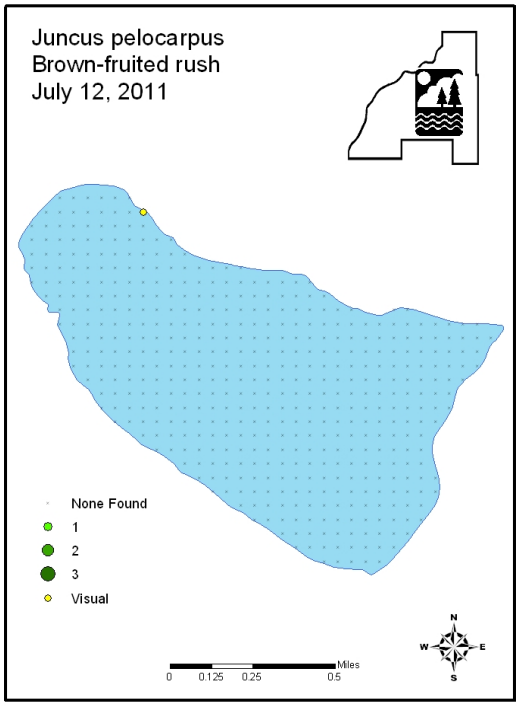
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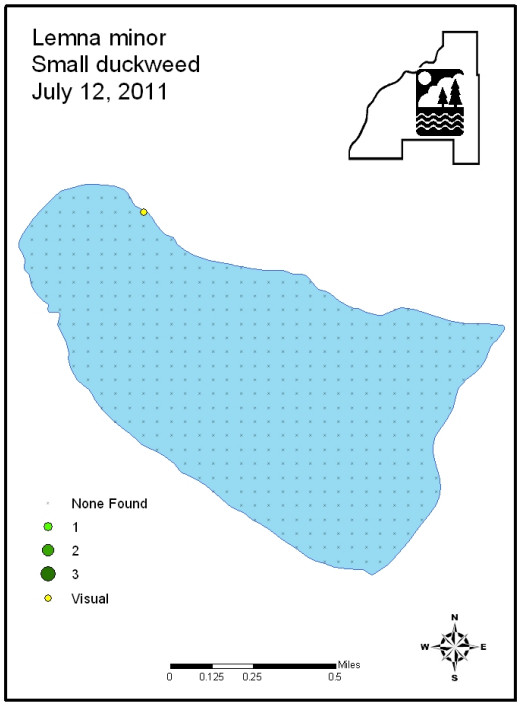
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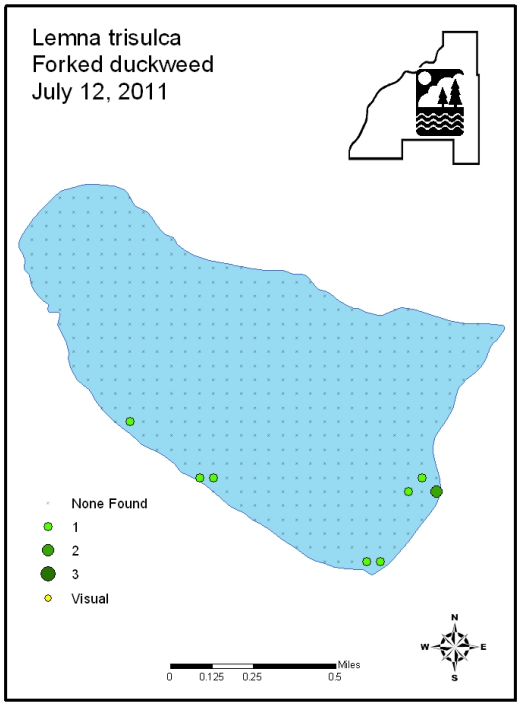
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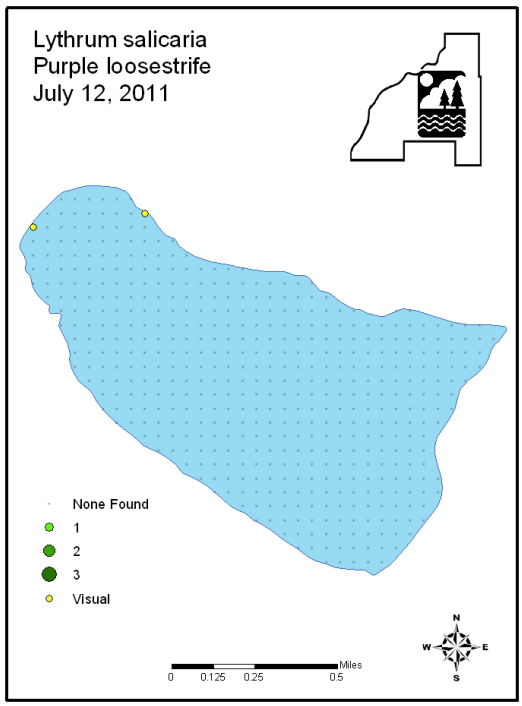
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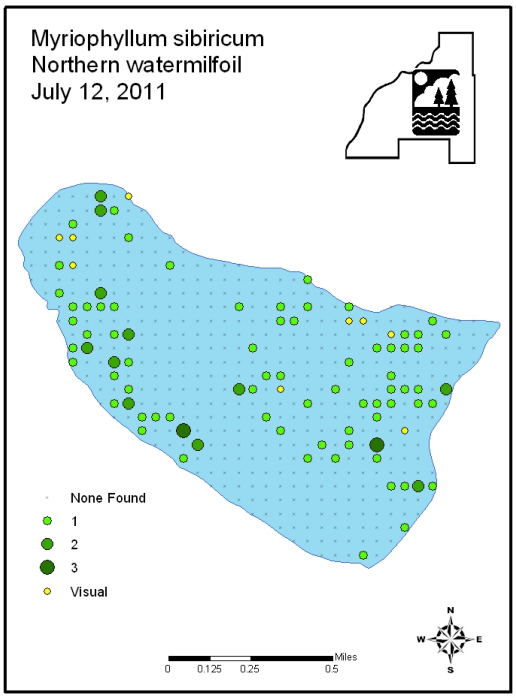
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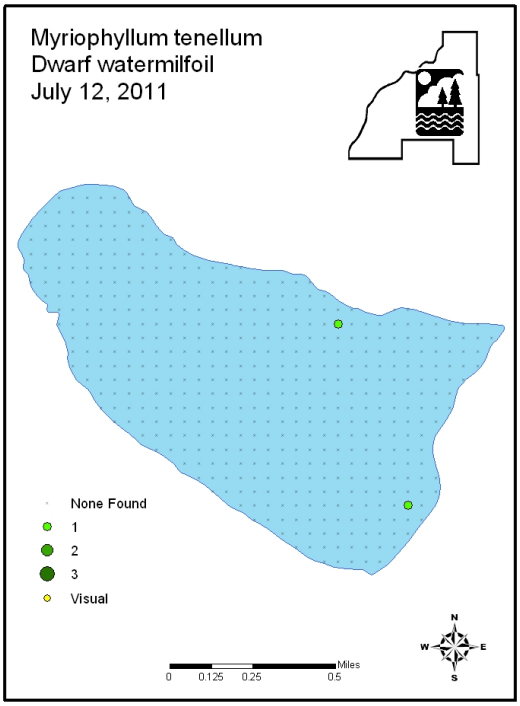
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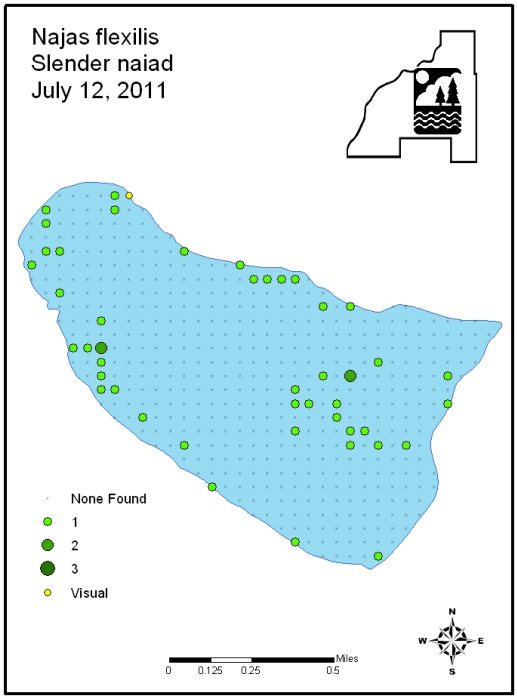
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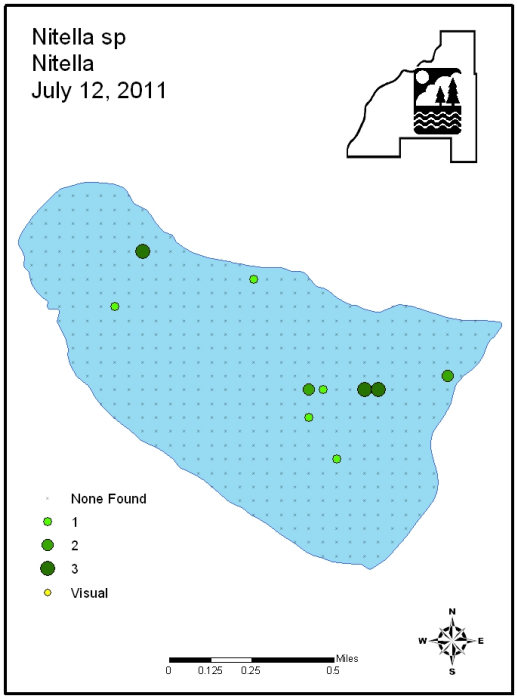
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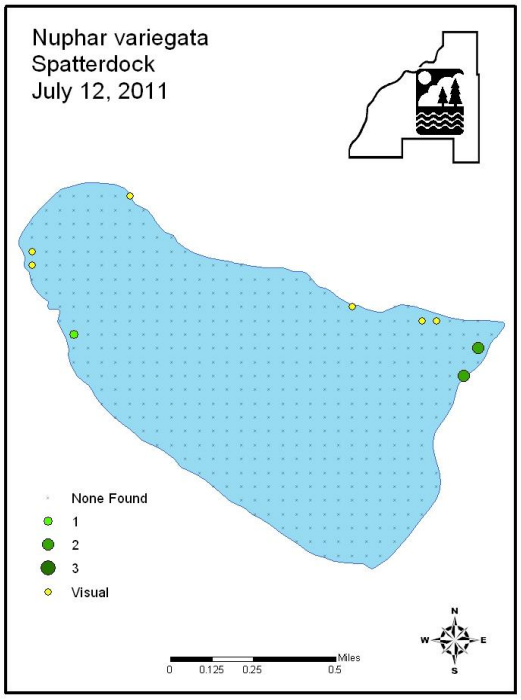
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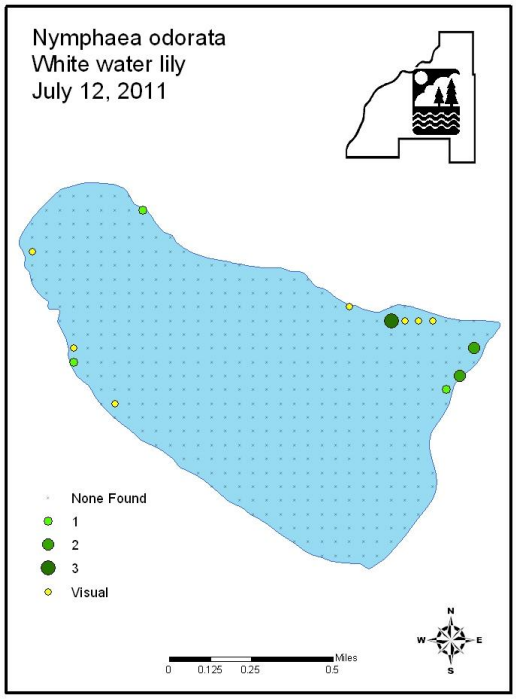
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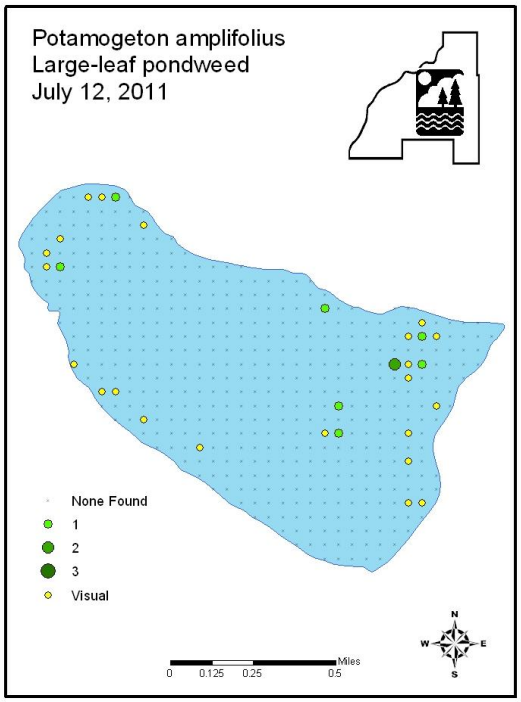
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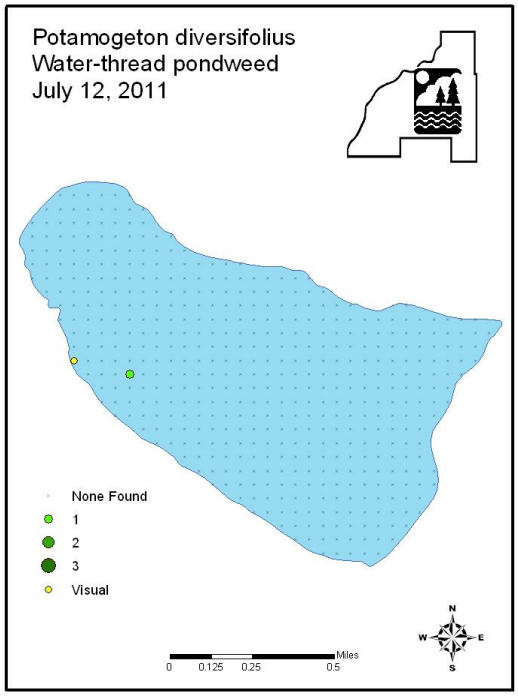
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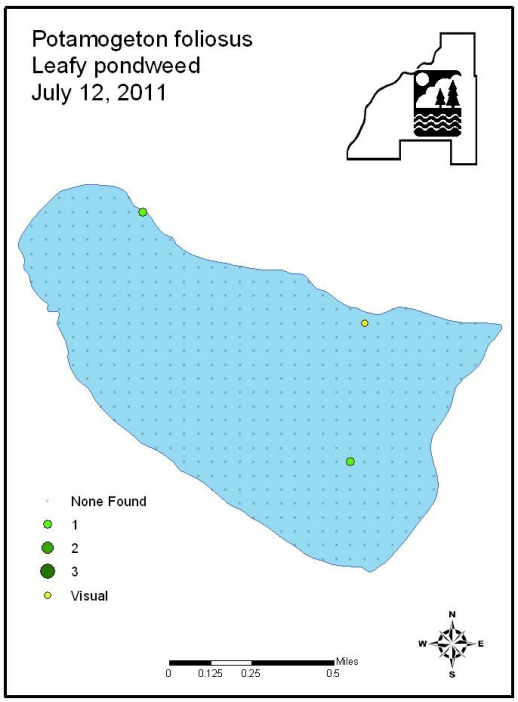
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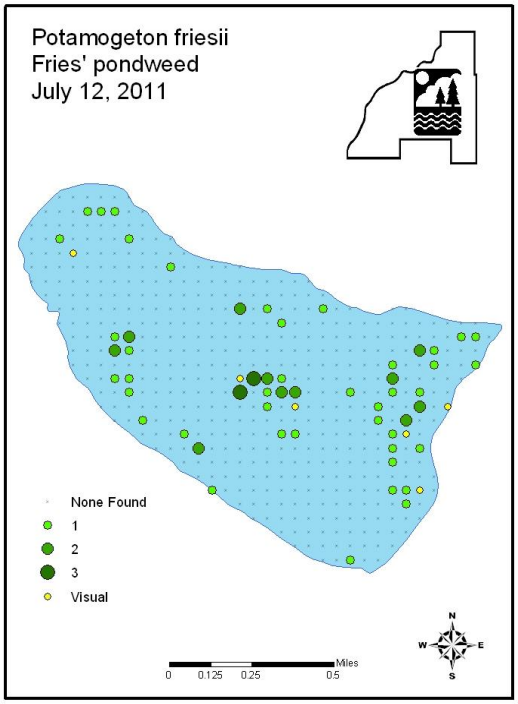
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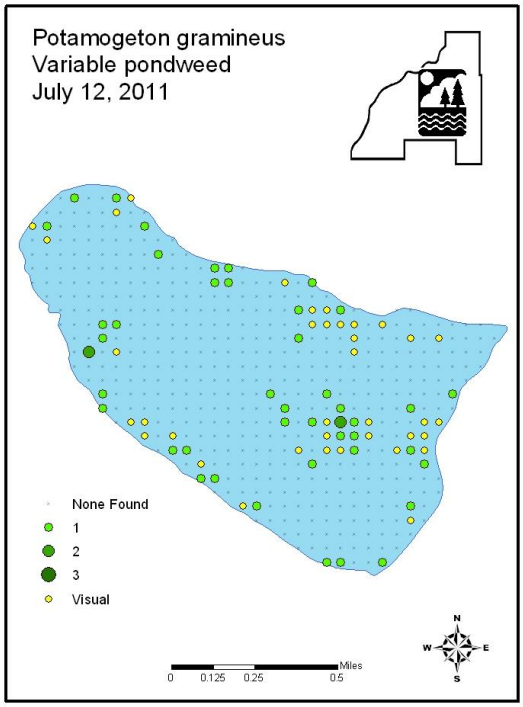
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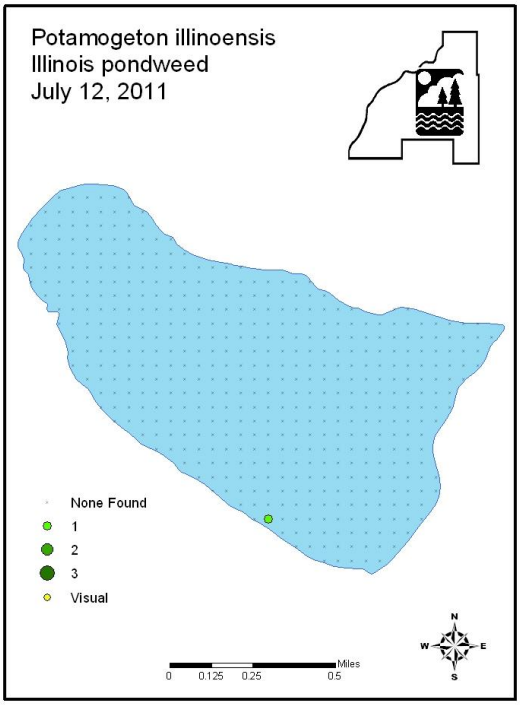
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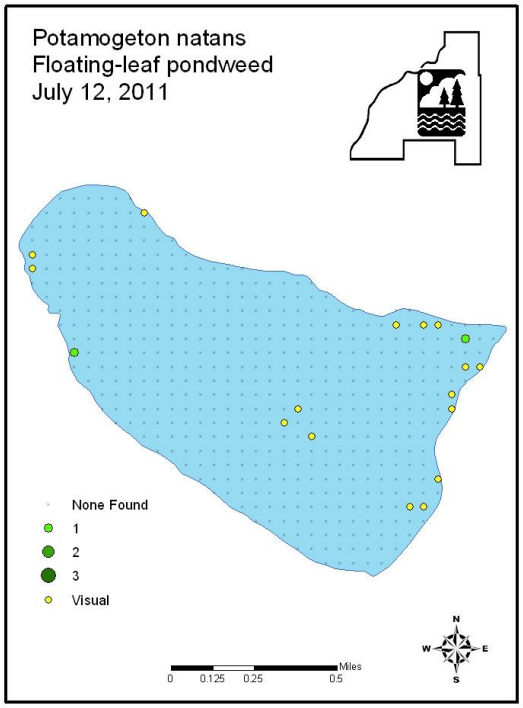
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Floating-leaf pondweed
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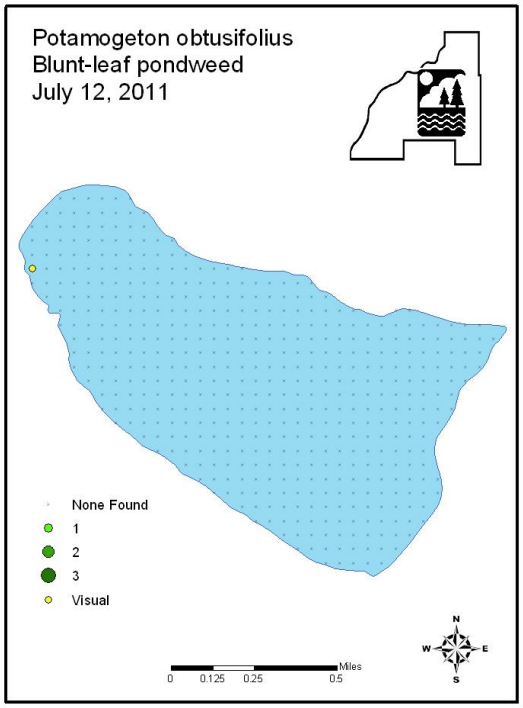
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Blunt-leaf pondweed
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None Found
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Visual
Miles
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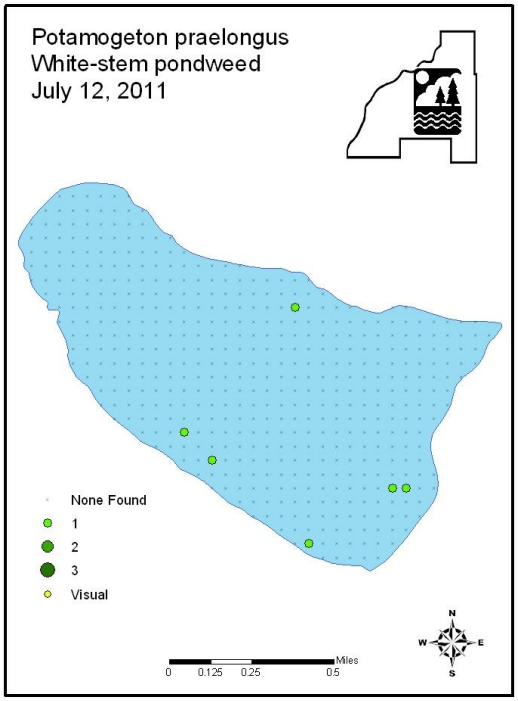
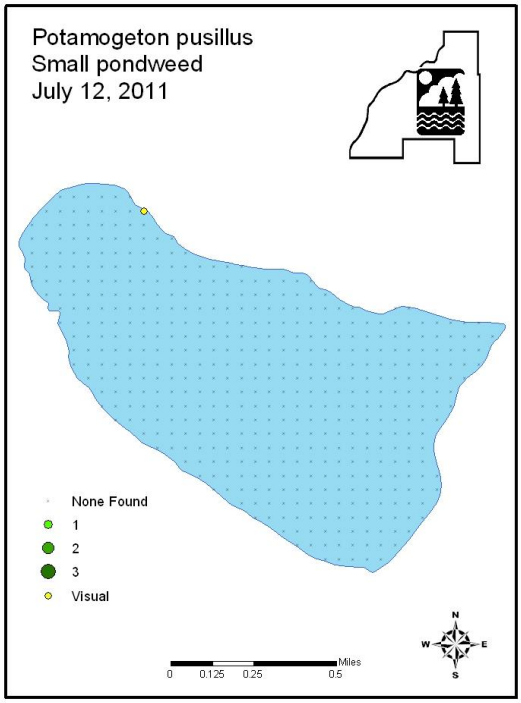

Potamogeton praelongus
White-stem pondweed
July 12, 2011
None Found
1
2
3
Visual
Miles
0 0.125 0.25 0.5
N
W
E
S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Miles
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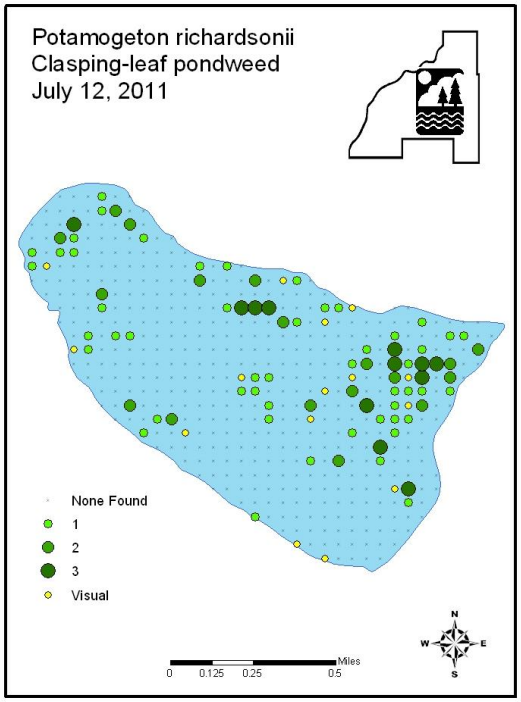
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Clasping-leaf pondweed
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Visual
N
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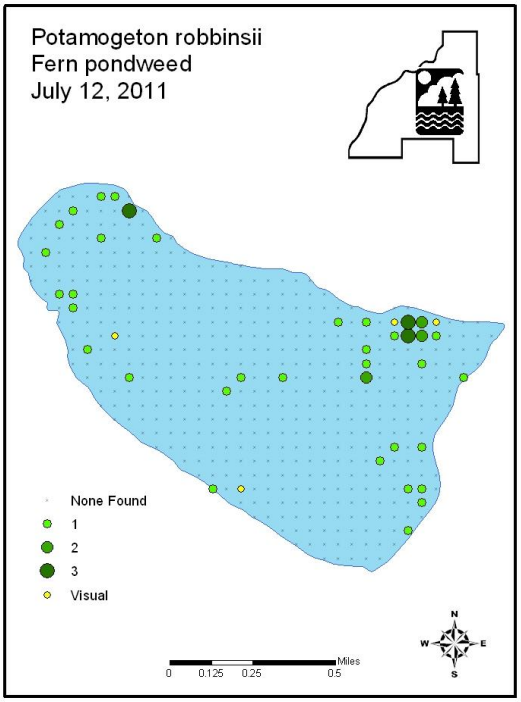
Miles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Fern pondweed
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Visual
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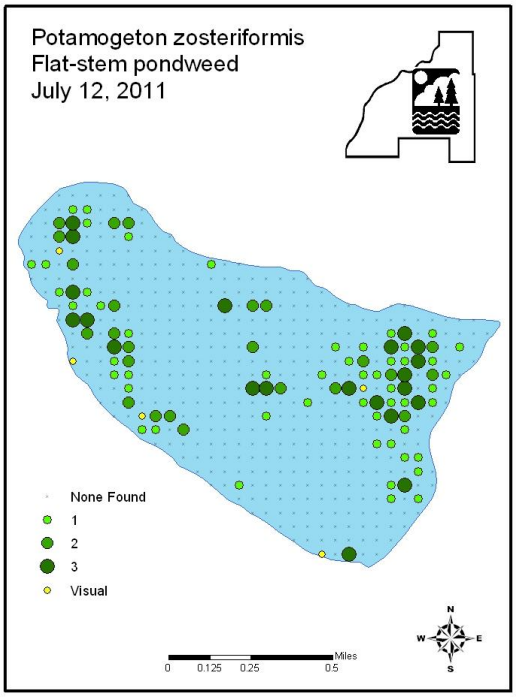
Miles


Potamogeton zosteriformis
Flat-stem pondweed
July 12, 2011
None Found
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2
3
Visual
N
W
E
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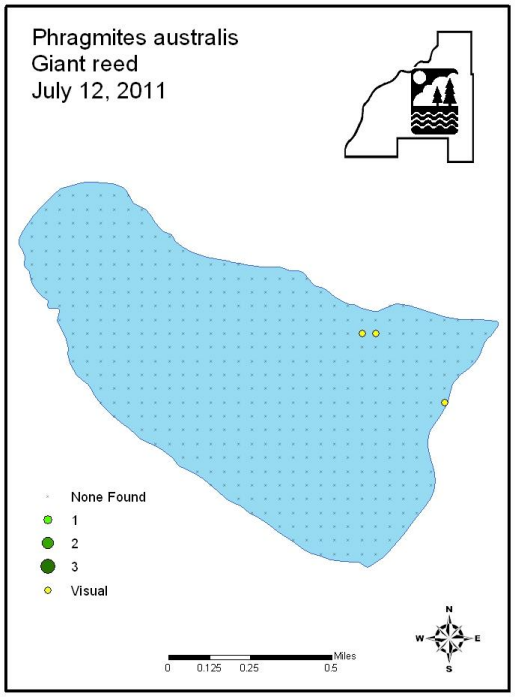
Miles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Visual
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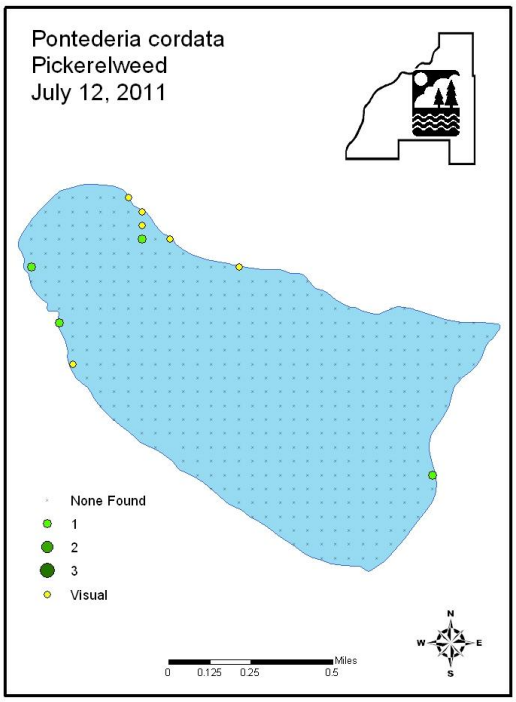
Miles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Pickerelweed
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None Found
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2
3
Visual
Miles
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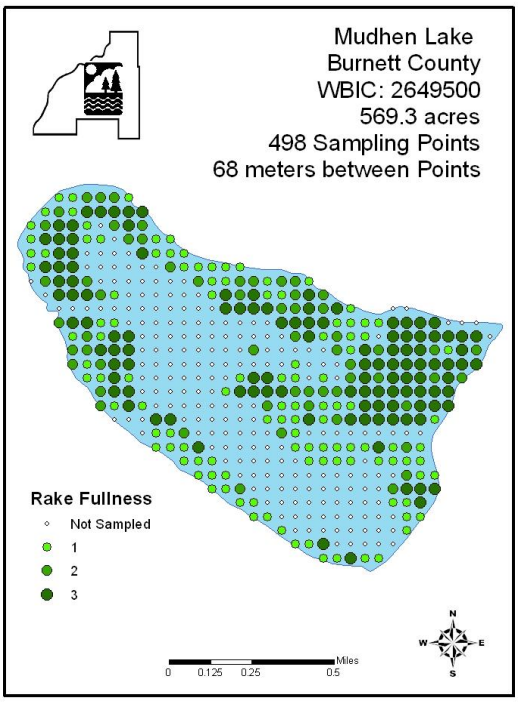
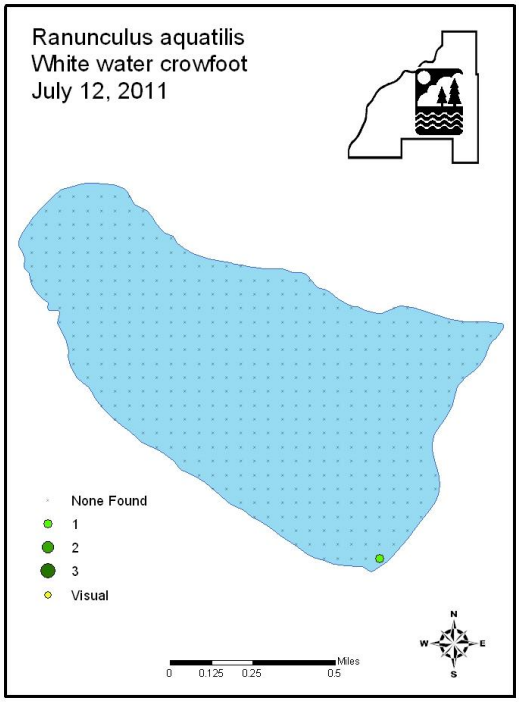

Mudhen Lake
Burnett County
WBIC: 2649500
569.3 acres
498 Sampling Points
68 meters between Points
Rake Fullness
Not Sampled
1
2
3
Miles
0 0.125 0.25 0.5
N
W
E
S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Miles
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E
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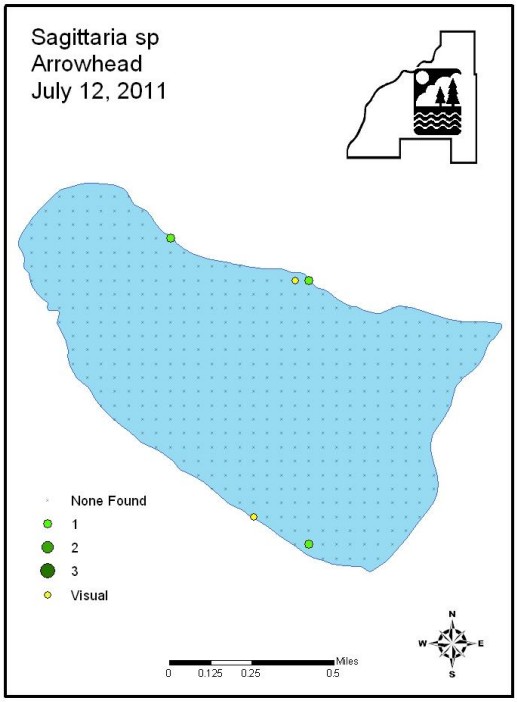
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Arrowhead
July 12, 2011
None Found
1
2
3
Visual
Miles
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N
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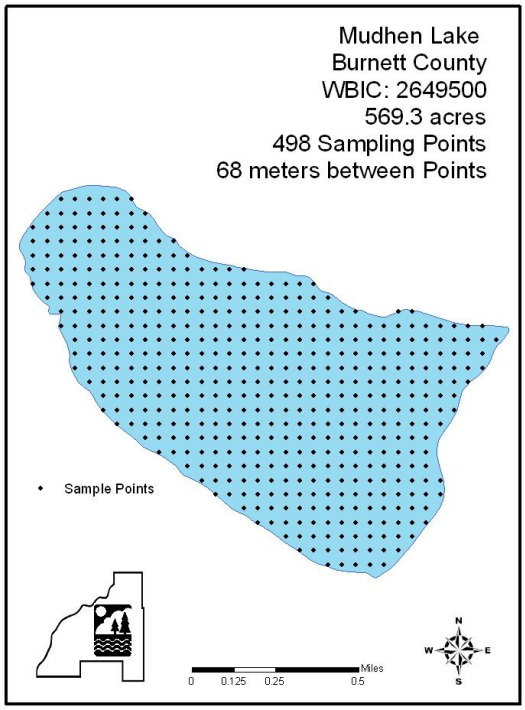
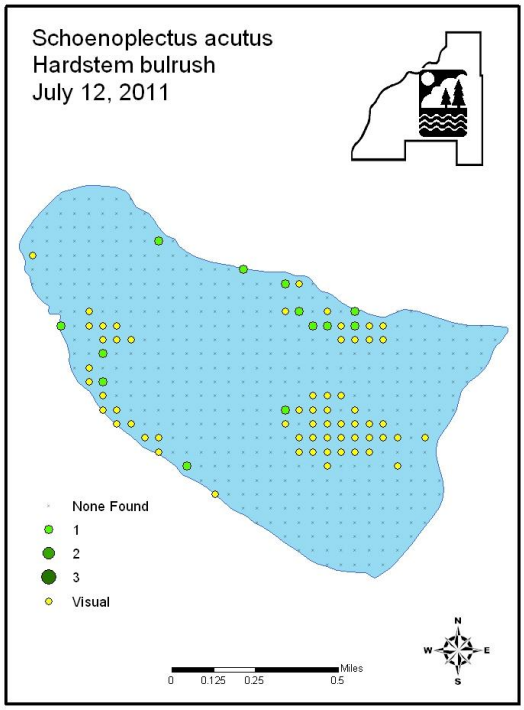
E
S


Mudhen Lake
Burnett County
WBIC: 2649500
569.3 acres
498 Sampling Points
68 meters between Points
Sample Points
Miles
0 0.125 0.25 0.5
N
W E
S


Schoenoplectus acutus
Hardstem bulrush
July 12, 2011
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1
2
3
Visual
Miles
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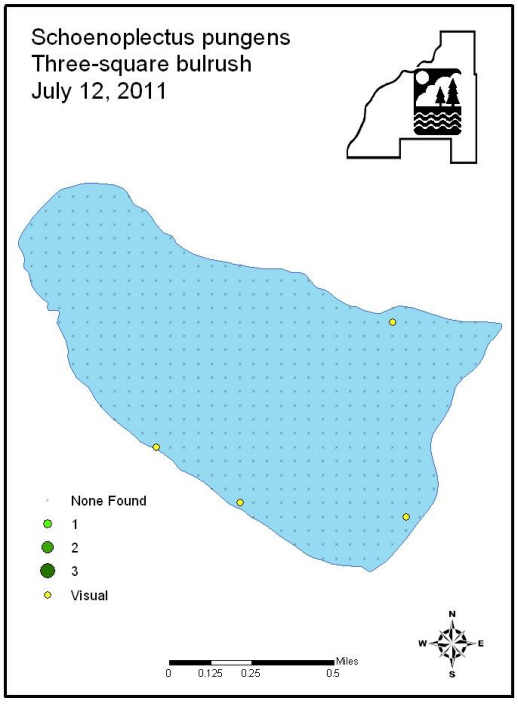
N
W E
S


Schoenoplectus pungens
Three-square bulrush
July 12, 2011
None Found
1
2
3
Visual
Miles
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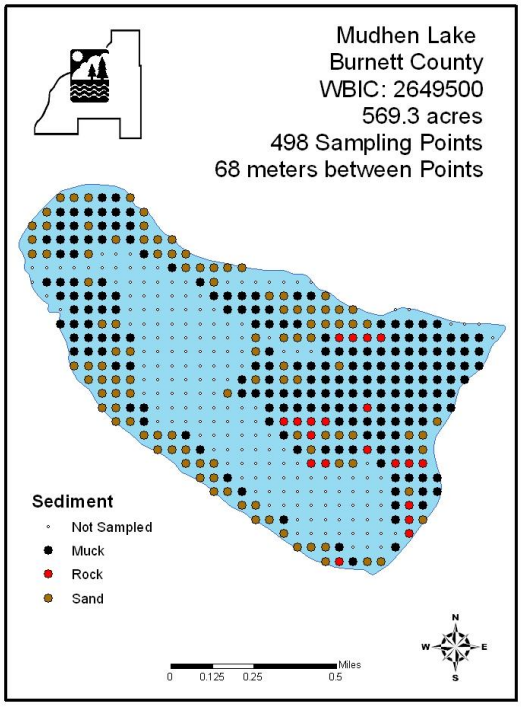
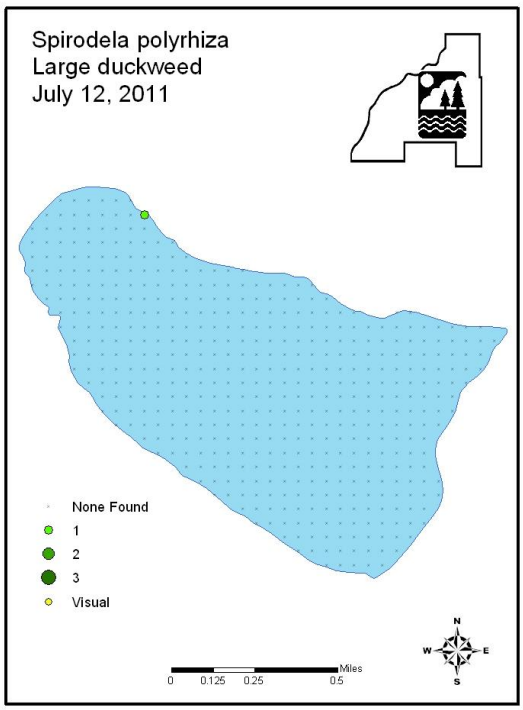
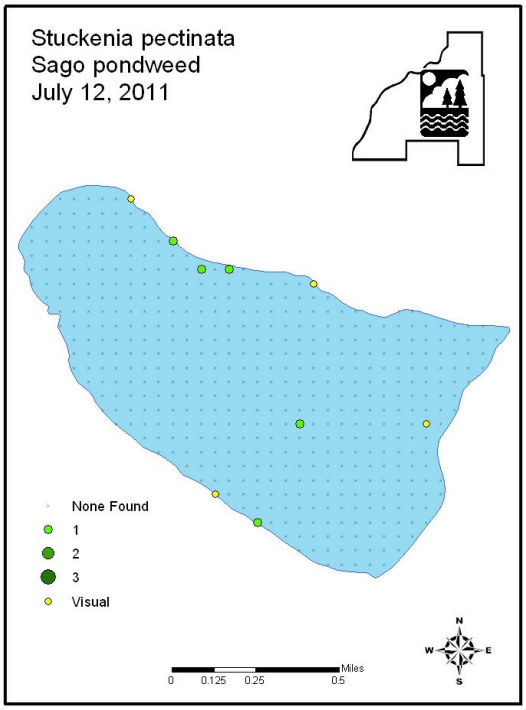
N
W E
S


Mudhen Lake
Burnett County
WBIC: 2649500
569.3 acres
498 Sampling Points
68 meters between Points
Sediment
Not Sampled
Muck
Rock
Sand
Miles
0 0.125 0.25 0.5
N
W E
S


Spirodela polyrhiza
Large duckweed
July 12, 2011
None Found
1
2
3
Visual
Miles
0 0.125 0.25 0.5
N
W
E
S


Stuckenia pectinata
Sago pondweed
July 12, 2011
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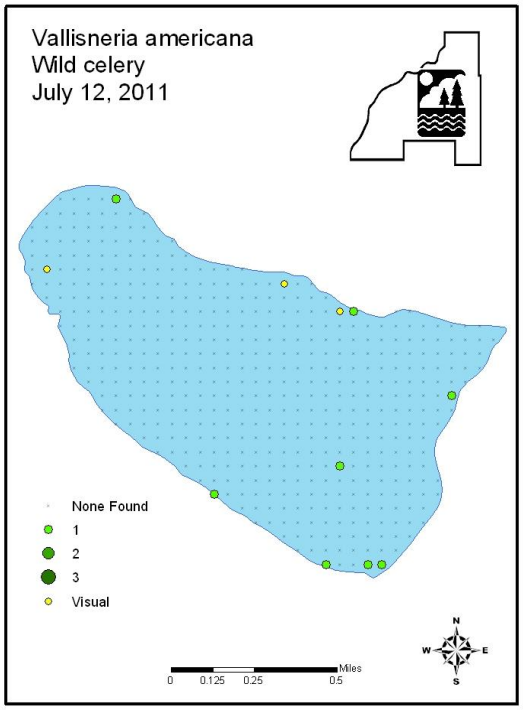
1
2
3
Visual
Miles
0 0.125 0.25 0.5
N
W
E
S


Vallisneria americana
Wild celery
July 12, 2011
None Found
1
2
3
Visual
Miles
0 0.125 0.25 0.5
N
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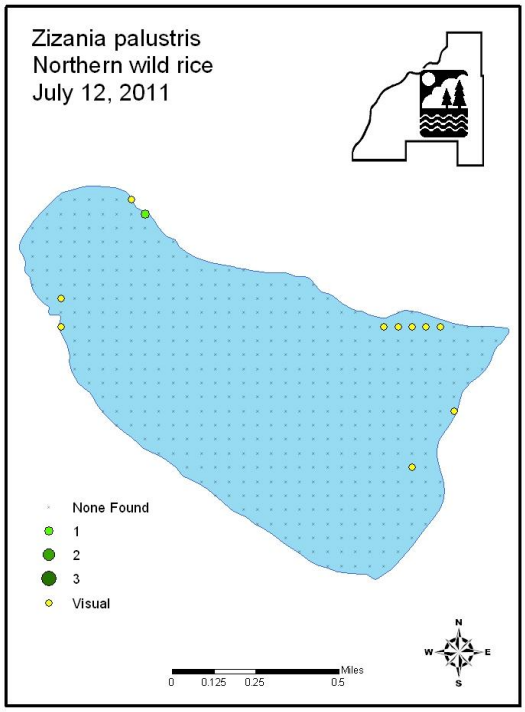
E
S


Zizania palustris
Northern wild rice
July 12, 2011
None Found
1
2
3
Visual
Miles
0 0.125 0.25 0.5
N
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Appendix D

Rapid Response for Early Detection of Eurasian Water Milfoil

1. The Mudhen Lake Rehabilitation District (MLRD)) community will be directed to contact the EWM identification (ID) lead Dan Heintz, if they see a plant in the lakes they suspect might be Eurasian water milfoil (EWM). Signs at the public boat landings, web pages, and newsletter articles will provide contact information and instructions.

2. If the plant is likely to be EWM, the AIS ID lead will confirm identification with WDNR and inform the rest of the MLRD board.

3. Mark the location of suspected EWM (AIS ID Lead). Use GPS points, if available, or mark the location with a small float.

4. Confirm identification of EWM (or other AIS) with the WDNR (within 72 hours) (AIS ID Lead). Two entire intact rooted adult specimens of the suspect plants will be collected and bagged and delivered to the WDNR. WDNR may confirm identification with the herbarium at the University of Wisconsin – Stevens Point or the University of Wisconsin – Madison.

5. If the suspect plants are determined to be EWM, the location of EWM will be marked with a more permanent marker. (AIS ID Lead).

6. If identification is positive, inform the board, Burnett County LWCD, herbicide applicator, the person who reported the EWM, lake management consultant, and all lake residents. (AIS ID Lead).

7. If identification is positive, post a notice at the public landing and include a notice in the next newsletter. These notices will inform residents and visitors of the approximate location of EWM and provide appropriate means to avoid spread. (MLRD board)

8. Contact Burnett County LWCD to seek assistance in EWM control efforts. The county has a rapid response plan in place that includes assisting lakes where EWM is discovered. Request that the county determine the extent of the EWM introduction and conduct initial removal efforts. If unavailable to assist within two weeks, proceed to step 9.

9. Hire a consultant to determine the extent of the EWM introduction. A diver may be used. If small amounts of EWM are found during this assessment, the consultant will be directed to identify locations with GPS points and hand pull plants found. All plant fragments will be removed from the lake when hand pulling.

10. Select a control plan in cooperation with Burnett County AIS Coordinator and WDNR (board of directors). Additional guidance regarding EWM treatment is found in DNR's *Response for Early Detection of Eurasian Water Milfoil Field Protocol*.

    Control methods may include hand pulling, use of divers to manually or mechanically remove the EWM from the lake bottom, application of herbicides, and/or other effective and approved control methods.

    The goal of the control plan will be eradication of the EWM.

11. Implement the selected control plan including applying for the necessary permits. Regardless of the control plan selected, it will be implemented by persons who are qualified and experienced in the technique(s) selected.

12. MLRD funds may be used to pay for any reasonable expense incurred in implementing the selected control plan, and implementation will not be delayed by waiting for WDNR to approve or fund a grant application.

13. The President of the MLRD will work with the WDNR to confirm, as soon as possible, a start date for an Early Detection and Rapid Response AIS Control Grant. Thereafter, the MLRD shall formally apply for the grant.

14. MLRD shall have the authority to accept donations or borrow money for the purpose of paying for control of EWM.

15. Frequently inspect the area of the EWM to determine the effectiveness of the treatment and whether additional treatment is necessary.

16. Contract for professional monitoring to supplement volunteer monitoring in years following EWM discovery.

EXHIBIT A[1]

Mudhen Lake Rehabilitation District

President	Dan Heintz
EWM ID Lead	Dan Heintz – 715-248-7271

Burnett County Land and Water Conservation Department – 715-349-2186

Brad Morris, AIS Coordinator

Dave Ferris, County Conservationist

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Grants	Pamela Toshner: 715-635-4073
Permits	Mark Sundeen: 715-635-4074
EWM Notice	Kathy Bartilson: 715-635-4053

LAKE MANAGEMENT CONSULTANT

Endangered Resource Services	Burnett County Land and Water Conservation Department: 715-483-2847

DIVERS

Endangered Resource Services	Matt Berg: 715-483-2847

[1] This list will be reviewed and updated each year.

Appendix E

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
No Management	N	Do not actively manage plants	Minimizing disturbance can protect native species that provide habitat for aquatic fauna; protecting natives may limit spread of invasive species; aquatic plants reduce shoreline erosion and may improve water clarity	May allow small population of invasive plants to become larger, more difficult to control later
			No immediate financial cost	Excessive plant growth can hamper navigation and recreational lake use
			No system disturbance	May require modification of lake users' behavior and perception
			No unintended effects of chemicals	
			Permit not required	
Mechanical Control	May be required under NR 109	Plants reduced by mechanical means	Flexible control	Must be repeated, often more than once per season
		Wide range of techniques, from manual to highly mechanized	Can balance habitat and recreational needs	Can suspend sediments and increase turbidity and nutrient release
a. Handpulling/Manual raking	Y/N	SCUBA divers or snorkelers remove plants by hand or plants are removed with a rake	Little to no damage done to lake or to native plant species	Very labor intensive
		Works best in soft sediments	Can be highly selective	Needs to be carefully monitored
			Can be done by shoreline property owners without permits within an area <30 ft wide OR where selectively removing exotics	Roots, runners, and even fragments of some species, particularly Eurasian watermilfoil (EWM) will start new plants, so all of plant must be removed
			Can be very effective at removing problem plants, particularly following early detection of an invasive exotic species	Small-scale control only

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
b. Harvesting	Y	Plants are "mowed" at depths of 2-5 ft, collected with a conveyor and off-loaded onto shore	Immediate results	Not selective in species removed
		Harvest invasives only if invasive is already present throughout the lake	EWM removed before it has the opportunity to autofragment, which may create more fragments than created by harvesting	Fragments of vegetation can re-root
			Minimal impact to lake ecology	Can remove some small fish and reptiles from lake
			Harvested lanes through dense weed beds can increase growth and survival of some fish	Initial cost of harvester expensive
			Can remove some nutrients from lake	
Biological Control	Y	Living organisms (e.g. insects or fungi) eat or infect plants	Self-sustaining; organism will over-winter, resume eating its host the next year	Effectiveness will vary as control agent's population fluctates
			Lowers density of problem plant to allow growth of natives	Provides moderate control - complete control unlikely
				Control response may be slow
				Must have enough control agent to be effective
a. Weevils on EWM	Y	Native weevil prefers EWM to other native water-milfoil	Native to Wisconsin: weevil cannot "escape" and become a problem	Need to stock large numbers, even if some already present
			Selective control of target species	Need good habitat for overwintering on shore (leaf litter) associated with undeveloped shorelines
			Longer-term control with limited management	Bluegill populations decrease densities through predation

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Pathogens	Y	Fungal/bacterial/viral pathogen introduced to target species to induce mortalitiy	May be species specific	Largely experimental; effectiveness and longevity unknown
				May provide long-term control	Possible side effects not understood
				Few dangers to humans or animals	
c.	Allelopathy	Y	Aquatic plants release chemical compounds that inhibit other plants from growing	May provide long-term, maintenance-free control	Initial transplanting slow and labor-intensive
				Spikerushes (*Eleocharis* spp.) appear to inhibit Eurasian watermilfoil growth	Spikerushes native to WI, and have not effectively limited EWM growth
					Wave action along shore makes it difficult to establish plants; plants will not grow in deep or turbid water
d.	Planting native plants	Y	Diverse native plant community established to repel invasive species	Native plants provide food and habitat for aquatic fauna	Initial transplanting slow and labor-intensive
				Diverse native community may be "resistant" to invasive species	Nuisance invasive plants may outcompete plantings
				Supplements removal techniques	Largely experimental; few well-documented cases
					If transplants from external sources (another lake or nursury), may include additional invasive species or "hitchhikers"

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Physical Control	Required under Ch. 30 / NR 107	Plants are reduced by altering variables that affect growth, such as water depth or light levels		
a. Fabrics/ Bottom Barriers	Y	Prevents light from getting to lake bottom	Reduces turbidity in soft-substrate areas	Eliminates all plants, including native plants important for a healthy lake ecosystem
			Useful for small areas	May inhibit spawning by some fish
				Need maintenance or will become covered in sediment and ineffective
				Gas accumulation under blankets can cause them to dislodge from the bottom
				Affects benthic invertebrates
				Anaerobic environment forms that can release excessive nutrients from sediment
b. Drawdown	Y, May require Environmental Assessment	Lake water lowered with siphon or water level control device; plants killed when sediment dries, compacts or freezes	Winter drawdown can be effective at restoration, provided drying and freezing occur. Sediment compaction is possible over winter	Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling
		Season or duration of drawdown can change effects	Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction	May impact attached wetlands and shallow wells near shore
			Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization, and increased water quality	Species growing in deep water (e.g. EWM) that survive may increase, particularly if desirable native species are reduced
			Success demonstrated for reducing EWM, variable success for curly-leaf pondweed (CLP)	Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning
			Restores natural water fluctuation important for all aquatic ecosystems	Winter drawdawn must start in early fall or will kill hibernating reptiles and amphibians
				Navigation and use of lake is limited during drawdown

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
c.	Dredging	Y	Plants are removed along with sediment	Increases water depth	Severe impact on lake ecosystem
			Most effective when soft sediments overlay harder substrate	Removes nutrient rich sediments	Increases turbidity and releases nutrients
			For extremely impacted systems	Removes soft bottom sediments that may have high oxygen demand	Exposed sediments may be recolonized by invasive species
			Extensive planning required		Sediment testing may be necessary
					Removes benthic organisms
					Dredged materials must be disposed of
d.	Dyes	Y	Colors water, reducing light and reducing plant and algal growth	Impairs plant growth without increasing turbidity	Appropriate for very small water bodies
				Usually non-toxic, degrades naturally over a few weeks	Should not be used in pond or lake with outflow
					Impairs aesthetics
					Effects to microscopic organisms unknown
e.	Non-point source nutrient control	N	Runoff of nutrients from the watershed are reduced (e.g. by controlling construction erosion or reducing fertilizer use) thereby providing fewer nutrients available for plant growth	Attempts to correct source of problem, not treat symptoms	Results can take years to be evident due to internal recycling of already-present lake nutrients
				Could improve water clarity and reduce occurrences of algal blooms	Requires landowner cooperation and regulation
				Native plants may be able to better compete with invasive species in low-nutrient conditions	Improved water clarity may increase plant growth

Management Options for Aquatic Plants

Draft updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Chemical Control	Y, Required under NR 107	Granules or liquid chemicals kill plants or cease plant growth; some chemicals used primarily for algae	Some flexibility for different situations	Possible toxicity to aquatic animals or humans, especially applicators
		Results usually within 10 days of treatment, but repeat treatments usually needed	Some can be selective if applied correctly	May kill desirable plant species, e.g. native water-milfoil or native pondweeds; maintaining healthy native plants important for lake ecology and minimizing spread of invasives
		Chemicals must be used in accordance with label guidelines and restrictions	Can be used for restoration activities	Treatment set-back requirements from potable water sources and/or drinking water use restrictions after application, usually based on concentration
				May cause severe drop in dissolved oxygen causing fish kill, depends on plant biomass killed, temperatures and lake size and shape
				Often controversial
a. 2,4-D	Y	Systemic[1] herbicide selective to broadleaf[2] plants that inhibits cell division in new tissue	Moderately to highly effective, especially on EWM	May cause oxygen depletion after plants die and decompose
		Applied as liquid or granules during early growth phase	Monocots, such as pondweeds (e.g. CLP) and many other native species not affected	May kill native dicots such as pond lilies and other submerged species (e.g. coontail)
			Can be selective depending on concentration and seasonal timing	Cannot be used in combination with copper herbicides (used for algae)
			Can be used in synergy with endotholl for early season CLP and EWM treatments	Toxic to fish
			Widely used aquatic herbicide	

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Endothall	Y	Broad-spectrum[3], contact[4] herbicide that inhibits protein synthesis	Especially effective on CLP and also effective on EWM	Kills many native pondweeds
			Applied as liquid or granules	May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Not as effective in dense plant beds; heavy vegetation requires multiple treatments
				Can be selective depending on concentration and seasonal timing	Not to be used in water supplies; post-treatment restriction on irrigation
				Can be combined with 2,4-D for early season CLP and EWM treatments, or with copper compounds	Toxic to aquatic fauna (to varying degrees)
				Limited off-site drift	
c.	Diquat	Y	Broad-spectrum, contact herbicide that disrupts cellular functioning	Mostly used for water-milfoil and duckweed	May impact non-target plants, especially native pondweeds, coontail, elodea, naiads
			Applied as liquid, can be combined with copper treatment	Rapid action	Toxic to aquatic invertebrates
				Limited direct toxicity on fish and other animals	Must be reapplied several years in a row
					Ineffective in muddy or cold water (<50°F)
d.	Fluridone	Y; special permit and Environmental Assessment may be required	Broad-spectrum, systemic herbicide that inhibits photosynthesis	Effective on EWM for 1 to 4 years with aggressive follow-up treatments	Affects non-target plants, particularly native milfoils, coontails, elodea, and naiads, even at low concentrations
			Must be applied during early growth stage	Some reduction in non-target effects can be achieved by lowering dosage	Requires long contact time at low doses: 60-90 days
			Available with a special permit only; chemical applications beyond 150 ft from shore not allowed under NR 107	Slow decomposition of plants may limit decreases in dissolved oxygen	Demonstrated herbicide resistance in hydrilla subjected to repeat treatments
			Applied at very low concentration at whole lake scale	Low toxicity to aquatic animals	In shallow eutrophic systems, may result in decreased water clarity
					Unknown effect of repeat whole-lake treatments on lake ecology

Management Options for Aquatic Plants

Draft updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
e.	Glyphosate	Y	Broad-spectrum, systemic herbicide that disrupts enzyme formation and function	Effective on floating and emergent plants such as purple loosestrife	RoundUp is often incorrectly substituted for Rodeo - Associated surfactants of RoundUp believed to be toxic to reptiles and amphibians
			Usually used for purple loosestrife stems or cattails	Selective if carefully applied to individual plants	Cannot be used near potable water intakes
			Applied as liquid spray or painted on loosetrife stems	Non-toxic to most aquatic animals at recommended dosages	Ineffective in muddy water
				Effective control for 1-5 years	No control of submerged plants
f.	Triclopyr	Y	Systemic herbicide selective to broadleaf plants that disrupts enzyme function	Effective on many emergent and floating plants	Impacts may occur to some native plants at higher doses (e.g. coontail)
			Applied as liquid spray or liquid	More effective on dicots, such as purple loosestrife; may be more effective than glyphosate	May be toxic to sensitive invertebrates at higher concentrations
				Control of target plants occurs in 3-5 weeks	Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm)
				Low toxicity to aquatic animals	Sensitive to UV light; sunlight can break herbicide down prematurely
				No recreational use restrictions following treatment	Relatively new management option for aquatic plants (since 2003)
g.	Copper compounds	Y	Broad-spectrum, systemic herbicide that prevents photosynthesis	Reduces algal growth and increases water clarity	Elemental copper accumulates and persists in sediments
			Used to control planktonic and filamentous algae	No recreational or agricultural restrictions on water use following treatment	Short-term results
			Wisconsin allows small-scale control only	Herbicidal action on hydrilla, an invasive plant not yet present in Wisconsin	Long-term effects of repeat treatments to benthic organisms unknown
					Toxic to invertebrates, trout and other fish, depending on the hardness of the water
					Clear water may increase plant growth

[1]Systemic herbicide - Must be absorbed by the plant and moved to the site of action. Often slower-acting than contact herbicides.
[2]Broadleaf herbicide - Affects only dicots, one of two groups of plants. Aquatic dicots include waterlilies, bladderworts, watermilfoils, and coontails.
[3]Broad-spectrum herbicide - Affects both monocots and dicots.
[4]Contact herbicide - Unable to move within the plant; kills only plant tissue it contacts directly.
Specific effects of herbicide treatments dependent on timing, dosage, duration of treatment, and location.
References to registered products are for your convenience and not intended as an endorsement or criticism of that product versus other similar products.
This document is intended to be a guide to available aquatic plant control techniques, and is not necessarily an exhaustive list.
Please contact your local Aquatic Plant Management Specialist when considering a permit.

Appendix F

AQUATIC PLANT MANAGEMENT STRATEGY

Northern Region WDNR
Summer, 2007

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

ISSUES

- Protect desirable native aquatic plants.
- Reduce the risk that invasive species replace desirable native aquatic plants.
- Promote "whole lake" management plans
- Limit the number of permits to control native aquatic plants.

BACKGROUND

As a general rule, the Northern Region has historically taken a protective approach to allow removal of native aquatic plants by harvesting or by chemical herbicide treatment. This approach has prevented lakes in the Northern Wisconsin from large-scale loss of native aquatic plants that represent naturally occurring high quality vegetation. Naturally occurring native plants provide a *diversity of habitat* that *helps maintain water quality*, helps *sustain the fishing* quality known for Northern Wisconsin, supports common lakeshore wildlife from loons to frogs, and helps to provide the *aesthetics* that collectively create the "up-north" appeal of the northwoods lake resources.

In Northern Wisconsin lakes, an inventory of aquatic plants may often find 30 different species or more, whereas a similar survey of a Southern Wisconsin lake may often discover less than half that many species. Historically, similar species diversity was present in Southern Wisconsin, but has been lost gradually over time from stresses brought on by cultural land use changes (such as increased development, and intensive agriculture). Another point to note is that while there may be a greater variety

of aquatic vegetation in Northern Wisconsin lakes, the vegetation itself is often *less dense*. This is because northern lakes have not suffered as greatly from nutrients and runoff as have many waters in Southern Wisconsin.

The newest threat to native plants in Northern Wisconsin is from invasive species of aquatic plants. The most common include Eurasian Water Milfoil (EWM) and CurlyLeaf Pondweed (CLP). These species are described as *opportunistic invaders*. This means that these "invaders" benefit where an opening occurs from removal of plants, and without competition from other plants may successfully become established in a lake. Removal of native vegetation not only diminishes the natural qualities of a lake, it *may increase the risk that an invasive species can successfully invade onto the site where native plants have been removed*. There it may more easily establish itself without the native plants to compete against. This concept is easily observed on land where bared soil is quickly taken over by replacement species (often weeds) that crowd in and establish themselves as new occupants of the site. While not providing a certain guarantee against invasive plants, protecting and allowing the native plants to remain may reduce the success of an invasive species becoming established on a lake. Once established, the invasive species cause far more inconvenience for all lake users, riparian and others included; can change many of the natural features of a lake; and often lead to *expensive annual control plans*. Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.

To the extent we can maintain the normal growth of native vegetation, Northern Wisconsin lakes can continue to offer the water resource appeal and benefits they've historically provided. A regional position on removal of aquatic plants that carefully recognizes how native aquatic plants benefit lakes in Northern Region can help prevent a gradual decline in the overall quality and recreational benefits that make these lakes attractive to people and still provide abundant fish, wildlife, and northwoods appeal.

GOALS OF STRATEGY:

1. Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds.
2. Prevent openings for invasive species to become established in the absence of the native species.
3. Concentrate on a" whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
4. Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.
5. To be consistent with our WDNR Water Division Goals (work reduction/disinvestment), established in 2005, to "not issue permits for chemical or large scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities." This process is similar to work done in other WDNR Regions, although not formalized as such.

BASIS OF STRATEGY IN STATE STATUTE AND ADMINISTRATIVE CODE

State Statute 23.24 (2)(c) states:

"The requirements promulgated under par. (a) 4. may specify any of the following:

1. The **quantity** of aquatic plants that may be managed under an aquatic plant management permit.
2. The **species** of aquatic plants that may be managed under an aquatic plant management permit.
3. The **areas** in which aquatic plants may be managed under an aquatic plant management permit.
4. The **methods** that may be used to manage aquatic plants under an aquatic plant management permit.
5. The **times** during which aquatic plants may be managed under an aquatic plant management permit.
6. The **allowable methods** for disposing or using aquatic plants that are removed or controlled under an aquatic plant management permit.
7. The requirements for plans that the department may require under sub. (3) (b). "

State Statute 23.24(3)(b) states:

"The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled."

Wisconsin Administrative Code NR 109.04(3)(a) states:

"The department may require that an application for an aquatic plant management permit contain an aquatic plant management plan that describes how the aquatic plants will be introduced, controlled, removed or disposed. Requirements for an aquatic plant management plan shall be made in writing stating the reason for the plan requirement. In deciding whether to require a plan, the department shall consider the potential for effects on protection and development of diverse and stable communities of native aquatic plants, for conflict with goals of other written ecological or lake management plans, for cumulative impacts and effect on the ecological values in the body of water, and the long-term sustainability of beneficial water use activities."

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

APPROACH

1. After January 1, 2009* no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan, and only if the plan clearly documents "impairment of navigation" and/or "nuisance conditions". Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of "impairment of navigation" and/or "nuisance conditions". No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report.

3. Invasive species must be controlled under an approved lake management plan, with two exceptions (these exceptions are designed to allow sufficient time for lake associations to form and subsequently submit an approved lake management plan):

    a. Newly-discovered infestations. If found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan. If found on a lake without an approved management plan, the invasive species can be controlled under the WDNR's Rapid Response protocol (see definition), and the lake owners will be encouraged to form a lake association and subsequently submit a lake management plan for WNDR review and approval.

    b. Individuals holding past permits for control of *invasive* aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual permit until January 1, 2009 if "impairment of navigation" and/or "nuisance conditions" is adequately documented, unless there is an approved lake management plan for the lake in question.

4. Control of invasive species or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on Spring treatment. (typically, a water temperature of less than 60 degrees Fahrenheit, or approximately May 31st, annually).

5. Manual removal (see attached definition) is allowed (Admin. Code NR 109.06).

** Exceptions to the Jan. 1, 2009 deadline will be considered only on a very limited basis and will be intended to address unique situations that do not fall within the intent of this approach.*

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DOCUMENTATION OF IMPAIRED NAVIGATION AND/OR NUISANCE CONDITIONS

Navigation channels can be of two types:

- Common use navigation channel. This is a common navigation route for the general lake user. It often is off shore and connects areas that boaters commonly would navigate to or across, and should be of public benefit.

- Individual riparian access lane. This is an access lane to shore that normally is used by an individual riparian shore owner.

Severe impairment or nuisance will generally mean vegetation grows thickly and forms mats on the water surface. Before issuance of a permit to use a regulated control method, a riparian will be asked to document the problem and show what efforts or adaptations have been made to use the site. (This is currently required in NR 107 and on the application form, but the following helps provide a specific description of what impairments exist from native plants).

Documentation of *impairment of navigation* by native plants must include:

a. Specific locations of navigation routes (preferably with GPS coordinates)
b. Specific dimensions in length, width, and depth
c. Specific times when plants cause the problem and how long the problem persists
d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem
e. The species of plant or plants creating the nuisance (documented with samples or from a Site inspection)

Documentation of the *nuisance* must include:

a. Specific periods of time when plants cause the problem, e.g. when does the problem start and when does it go away.
b. Photos of the nuisance are encouraged to help show what uses are limited and to show the severity of the problem.
c. Examples of specific activities that would normally be done where native plants occur naturally on a site but cannot occur because native plants have become a nuisance.

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DEFINITIONS

Manual removal: Removal by hand or hand-held devices without the use or aid of external or auxiliary power. Manual removal cannot exceed 30 ft. in width and can only be done where the shore is being used for a dock or swim raft. The 30 ft. wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed. Wild rice may not be removed under this waiver.

Native aquatic plants: Aquatic plants that are indigenous to the waters of this state.

Invasive aquatic plants: Non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Sensitive area: Defined under s. NR 107.05(3)(i) (sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water).

Rapid Response protocol: This is an internal WDNR document designed to provide guidance for grants awarded under NR 198.30 (Early Detection and Rapid Response Projects). These projects are intended to control pioneer infestations of aquatic invasive species before they become established.

Appendix G

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