Designation of Critical Habitat
Lake Redstone, Sauk County, Wisconsin

Donna Sefton & Susan Graham
South Central Region
Wisconsin Department of Natural Resources
Fitchburg, Wisconsin
Final Report
January 5, 2009

Designation of Critical Habitat
Lake Redstone, Sauk County, Wisconsin

By Donna Sefton & Susan Graham
South Central Region
Wisconsin Department of Natural Resources
Fitchburg, Wisconsin

Final Report
January 5, 2009

Acknowledgements

The following individuals assisted with field work, data assessment and editing of this report:

Susan Graham, DNR SCR Lakes Management Coordinator
Donna Sefton, DNR SCR Lakes Specialist
Aaron Johnson, DNR SCR Lakes Specialist
Paul Cunningham, DNR, Fisheries Policy Ecologist
Tim Larson, DNR SCR Fisheries Biologist
Jeff Schure, DNR SCR Water Management Specialist
Bryan Woodbury, DNR SCR Wildlife Biologist
Rebecca Roth, DNR SCR Wildlife Biologist
Pam Biersach, DNR Region Aquatic Habitat Expert
Ken Johnson, DNR SCR Water Leader

Thanks also to Steve Bolssen, DNR Data Services Specialist, for creating the Critical Habitat site maps.

Table of Contents

I. EXECUTIVE SUMMARY

A Critical Habitat study was conducted from 2005-2007 on Lake Redstone, Sauk County, Wisconsin by lakes, fisheries, wildlife, ecology and water management specialists with the Wisconsin Department of Natural Resources.

Lake Redstone was chosen for the study for two primary reasons:

1) To protect areas within the lake that are most important for preserving the character and qualities of the lake; and
2) To preserve the reaches of shore that are predominately natural in appearance or that screen man-made or artificial features for the enjoyment of lake residents and visitors.

Lake Redstone has fragile areas that support fish and wildlife, harbor quality plant communities that protect water quality in the lake, as well as unique natural scenic beauty for south central Wisconsin.

The Department has determined that specific locations in Lake Redstone contain Critical Habitat that ensure a healthy aquatic system and maintain the cultural and aesthetic values of the lake. Figure 1 shows the location of important near-shore and shallow water habitat about which Critical Habitat designations are most concerned. For details about the ecology of these places, see Appendix C.

Critical Habitats are called Public Rights Features in Wisconsin Administrative Code NR1.06. They are characteristics of a lake that fulfill the rights of the public for quality and quantify of water, fishing, swimming, navigation and reaches of shore which are predominately natural in appearance or that screen man-made or artificial features.

The Critical Habitats (Public Rights Features) for Lake Redstone include:

- Fish and wildlife habitat, including specific sites necessary for breeding, nesting, nursery and feeding,
- Plant communities and physical features that help protect water quality,
- Reaches of bank, shore or bed which are predominately natural in appearance or that screen man-made or artificial features.

Designation as Critical Habitat may affect the decision process on Waterway and Wetlands Permits under Ch. 30, Wis. Statutes. These include activities such as grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, or shoreline erosion control (subject to appropriate site-specific wave energy calculations). This DOES NOT mean these activities will be prohibited, but that they will undergo more careful review to ensure that the activity does not adversely affect the critical habitat in the area. Currently, these reviews are routinely done for Ch. 30 permits on Lake Redstone, so substantial changes in permit decisions in Critical Habitats are not expected.

Designation as Critical Habitat may also affect decisions on permitting of Aquatic Plant Management (APM) under Ch. NR107 and NR109 of the Wis. Adm. Code. These activities will undergo careful review to ensure that the activity does not adversely affect the sensitive ecosystem in the area. This is already routinely done for Lake Redstone, so few if any changes in APM permit decisions should be expected unless an updated APM plan specifies changes.

There were 20 areas designated as Critical Habitat for Lake Redstone (Figure 2). Fourteen of these were classified as Sensitive Areas for their aquatic vegetation and 6 were classified as Other Public Rights Features for containing reaches of shore that are predominately natural in appearance or that screen man-made or artificial features, and/or fish and wildlife habitat values. All are classified as Public Rights Features.

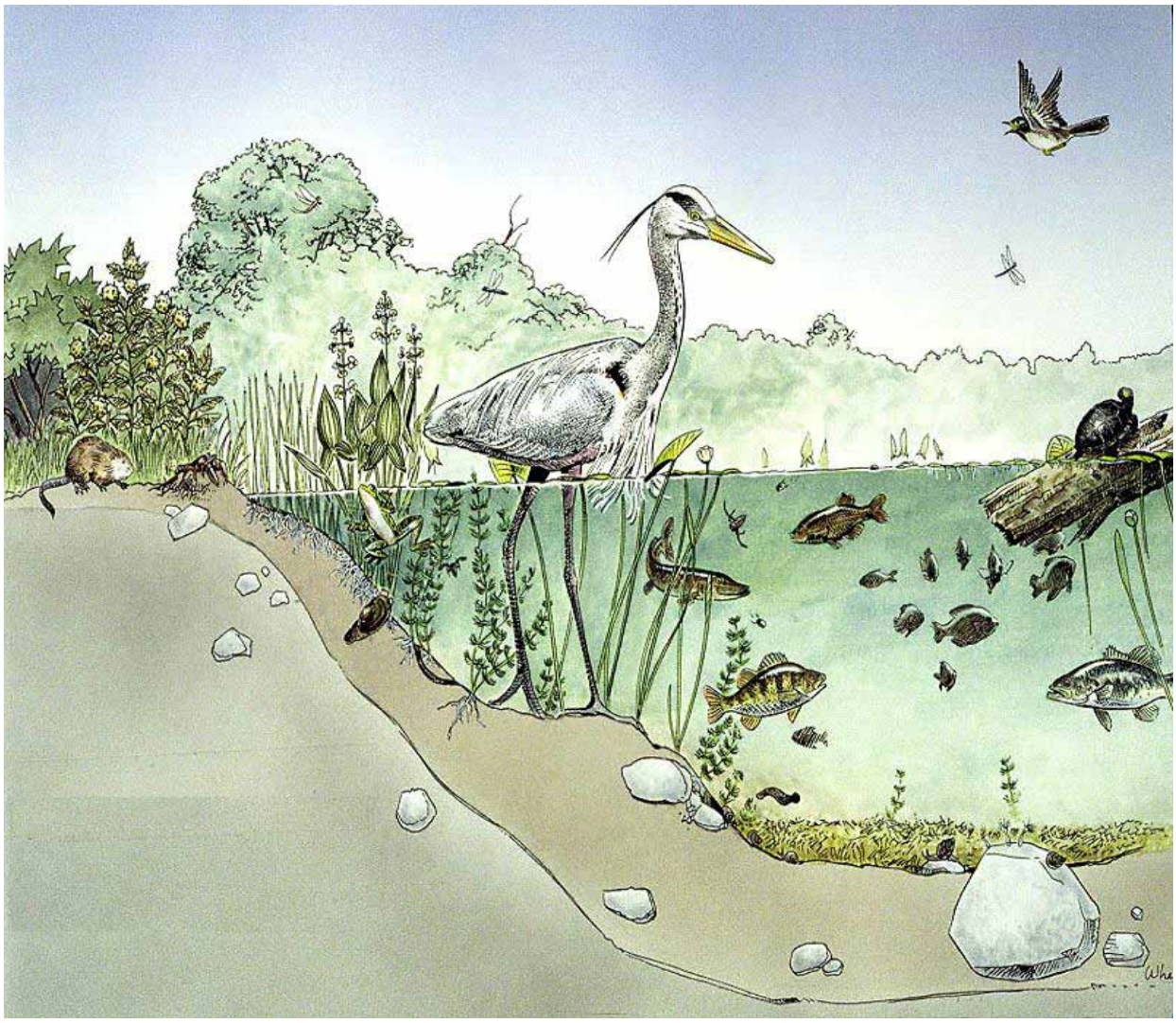


Figure 1. Location of important near-shore and shallow water habitat about which Critical Habitat designations are most concerned.

General Recommendations for Lake Redstone

The following are the general recommendations of the study to promote and protect the health of Lake Redstone:

1) Maintain natural shoreland buffers of native vegetation to protect water quality, fish and wildlife habitat and areas with predominantly natural appearance;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain the unique natural appearance of the sandstone cliffs and rock outcrops;
4) Maintain hemlock-white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
5) Maintain overhanging trees and shrubs, fallen trees along the shoreline and large woody cover and boulders in the water for fish and wildlife habitat;
6) Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce shoreline erosion and runoff of nutrients and other pollutants that affect water quality;
7) Minimize removal of native aquatic vegetation to protect fish and wildlife habitat;
8) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming or fishing areas;
9) Update the Aquatic Plant Management Plan every 5 years to reflect current lake conditions and emerging management techniques;
10) Control invasive plants;
11) Maintain aquatic invasives signs at all boat landings to educate lake users about protecting the lake from introduction of new exotic species and consider establishing a Clean Boats, Clean Waters watercraft inspection program;
12) Assess location and dimensions of proposed grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, new or replacement piers, recreational devices such as rafts or trampolines, and shoreline erosion control (subject to site-specific wave energy calculations) to protect water quality, fish and wildlife habitat and natural appearance;
13) Encourage use of biologs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations; and
14) In locations of actively eroding shoreline, consider expanding slow-no-wake buffer zones to reduce erosion caused by boating.

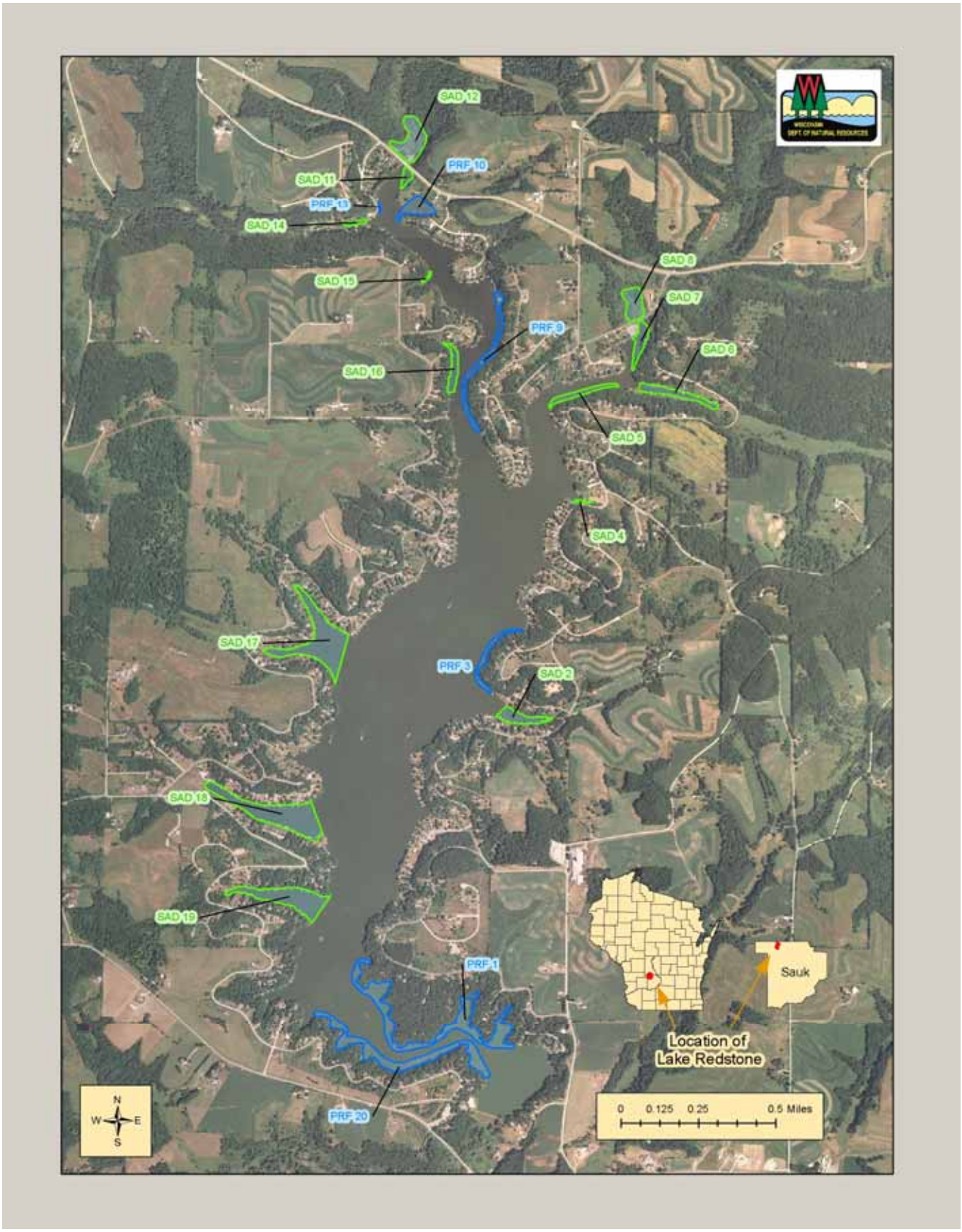


Figure 2. Location of Lake Redstone Critical Habitat: Sensitive Areas (SAD) and Other Public Rights Features (PRF).

II. LAKE REDSTONE CRITICAL HABITAT STUDY

A Critical Habitat study was conducted from 2005–2007 on Lake Redstone, Sauk County. Lake Redstone was chosen for the study for two primary reasons:

1) To protect areas within the lake that are most important for preserving the character and qualities of the lake; and
2) To preserve the reaches of shore that are predominately natural in appearance or that screen man-made or artificial features for the enjoyment of lake residents and visitors.

Lake Redstone has fragile areas that support fish and wildlife, harbor quality plant communities that protect water quality in the lake, as well as unique natural scenic beauty for south central Wisconsin.

Purpose of the Study and Definitions

Critical Habitat Designations are intended to identify areas, which if disturbed, would adversely affect public use and enjoyment of the lake. Such areas include locations important in maintaining fish and wildlife habitat, water quality, water quantity, or reaches of shore that are predominately natural in appearance or that screen man-made or artificial features. As described in the state administrative code (specifically, NR 1.06), examples of applicable areas include stands of aquatic plants, shorelines with abundant large woody material lying in the water, shorelines with overhanging shrubs or trees like snag trees, areas with substrate necessary for fish spawning, or reaches of shore that are predominately natural in appearance or that screen man-made or artificial features.

Areas fulfilling these criteria are designated as **Public Rights Features (PRFs)**, which include two groups:

> **Sensitive Areas** are Public Rights Features defined specifically for stands of aquatic vegetation that provide critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offer water quality or erosion control benefits to the area.
>
> **Other PRFs** are all Public Rights Features that provide fish and wildlife habitat, water quality protection, or that have reaches of shore that are predominately natural in appearance or that screen man-made or artificial features, and are not necessarily dependent on the presence of aquatic vegetation. For example, these areas may include mature forest or cliff faces, natural streambed features such as riffles or pools, or areas of lake or streambed where fish nests are visible.

How will this affect waterfront owners?

Designation of Critical Habitat does not prohibit activities such as habitat structures, piers, or shoreline protection activities in a designated area. Many will find that exemptions are still available for shoreline protection activities and piers as long as certain construction specifications are followed. In addition, general permits still remain available for grading, ponds, certain dredging activities and shoreline protection activities not meeting exemption standards. Please see Table 1 and Appendix 1 for more information.

The reason there may be little change to the regulatory framework surrounding shoreline protection, piers, grading and others is mostly related to the fact that the construction specifications attached to these exemptions and general permits are designed to protect near shore areas. If a project is designed in a manner that will not meet exemption or general permit criteria, individual permits are available. The necessity of an individual permit should not be equated with a prohibition or impediment to a project, but should instead be recognized as thorough review to ensure protection of the fish and wildlife habitat, water quality, navigation and natural or screened shorelines that make Lake Redstone a high quality water resource.

Critical Habitat Designations may also provide information for the DNR, other state agencies, local agencies, such as Sauk County Planning and Zoning, or the Lake Redstone Protection District. This information may be used to guide future management and regulatory decisions made by these organizations. Ultimately, the goal of this study is to protect public rights on Lake Redstone, including water quality, healthy fish and wildlife, natural or screened shorelines and beneficial aquatic plants that help water quality, prevent erosion, reduce invasion by new exotic plants and support a healthy fishery.

Methods

The Critical Habitat designations for Lake Redstone were based on data from a complete aquatic plant survey conducted during August, 2005 (more below), a detailed lakeshore inventory by DNR lakes, fisheries, wildlife, ecology and water management specialists on October 4 - 5, 2006, previous fish surveys, Natural Heritage Inventory reports, the Wisconsin Wetlands Inventory, and Department staff knowledge of the wildlife that inhabits the area. Public input on the factual information relating to the location or presence of Critical Habitats (Public Rights Features) was welcomed at the public meeting held on May 3, 2008 in LaValle, and at the public hearing in Reedsburg on July 24, 2008, including written comments until August 7, 2008.

One comment expressed concern that critical habitat site conditions may have changed as a result of the flooding in June. This prompted a final field visit on September 22, 2008 to evaluate each site for flood damage that would impact public rights features. Also, the Town of LaValle Comprehensive Plan was reviewed. The Plan largely focuses on different issues than the CHD Report and, therefore, no changes were made to this report.

Flood Impacts

The flood that began on June 8, 2008 in Sauk County caused Lake Redstone to rise rapidly, creating concern about the integrity of the dam. Water flushed down through ditches along roads, gouging out gullies on the way, and depositing the sediments into the lake. While the damage to structures like piers was extensive, most shoreline vegetation was submersed, but not torn out. Shoreline erosion specifically from the flood was mainly restricted to the inlets. The most apparent site of deposition was a large sand delta at the tip of the bay in site 18. Less severe delta formation was documented at inlets in sites 1 and 15. Deposition of finer-grained sediments certainly occurred, resulting in reduction of depth to these bays, but the extent of this deposition is unknown. Since all the plant species growing in these areas are known to be tolerant of disturbance such as this (turbidity and soft sediment deposition), there is no reason to believe the plant composition will change enough to have lost this feature (beneficial aquatic plants) of these critical habitat sites.

Table 1. Impact of Critical Habitat Designation on Proposed Activities (also see Appendix A).

Activity	Relevant Administrative Code	Impact of Critical Habitat Designation (Sensitive Areas and Other Public Rights Features (PRF's)) on Activity
New Riprap, Biostabilization	NR 328	Inside and Outside a PRF – No exemptions available; general permits available for moderate to high energy sites For more information, see our website: http://dnr.wi.gov/org/water/fhp/waterway/erosioncontrol.html
Riprap Repair or Replacement where permit was previously issued	NR 328	Inside a PRF - Exemptions available; general permits available Outside a PRF – Exemptions available; general permits available For more information, see our website: http://dnr.wi.gov/org/water/fhp/waterway/erosioncontrol.html
Riprap Repair or Replacement where NO permit was previously issued	NR 328	Inside a PRF – No exemptions available; general permits available Outside a PRF – Exemptions available; general permits available For more information, see our website: http://dnr.wi.gov/org/water/fhp/waterway/erosioncontrol.html
Piers, Boat Shelters, and Swim Rafts	NR 326	Piers, shelters and swim rafts meeting certain construction specifications do not require permits as long as they do not interfere with public rights in navigable waters regardless of location. For more information, see http://dnr.wi.gov/org/water/fhp/waterway/
Fish and Wildlife Habitat Structures	NR 323	General permits are required for fish and wildlife structures proposed for placement in a PRF site. Otherwise these structures may be placed without permits as long as certain standards are met. http://dnr.wi.gov/org/water/fhp/waterway/fishhabitat.html
Bank Grading	NR 341	If grading is to occur in or next to a PRF site, the area of bank disturbance (used to determine permit requirements) is calculated using the amount of grading to occur within 300 feet from OHWM (more for steep slopes) instead of within 75 feet from OHWM (more for steep slopes). http://dnr.wi.gov/org/water/fhp/waterway/grading.html
Maintenance Dredging of a previously authorized area	NR 345	Inside and Outside a PRF – No exemptions available; general permits available For more information, see our website: http://dnr.wi.gov/org/water/fhp/waterway/dredging.html
Dredging – New activity with no previous permit		Inside a PRF – No exemptions or general permits available; individual permit only Outside a PRF – No exemptions available; general permits available For more information, see our website: http://dnr.wi.gov/org/water/fhp/waterway/dredging.html
Public boat landings, weed rakes, pea gravel blankets, intake/ outfall structures	NR 329	No exemptions currently exist for boat landings, weed rakes or pea gravel blankets regardless of location, however, general permits are available for these activities. Individual permits are required if proposed for placement within a PRF site. Permit exemptions and general permits are not available for intake/outfall structures proposed within PRF sites and individual permits would be necessary for this activity as well. http://dnr.wi.gov/org/water/fhp/waterway/peagravelblankets.html and http://dnr.wi.gov/org/water/fhp/waterway/intakeoutfall.html
Chemical treatment	NR 107	If treatment is to occur in a designated sensitive area, permit applicants must demonstrate that treatment will not affect the ecological value of the sensitive area before a permit will be issued. This can be accomplished by using an herbicide selective for invasive species, timing the application to avoid the growing season of native species, or reducing the treated area. http://dnr.wi.gov/org/water/fhp/waterway/aquaticplantcontrol.html (Table continued next page)

Mechanical/manual plant removal	NR 109	Riparian owners manually removing rooted plants from the lake next to their property are not exempt from permit requirements and must obtain a general permit before removing plants within a designated sensitive area. If removal is to occur in a sensitive area, permit applicants must demonstrate that plant removal will not reduce the ecological value of the area. This can be achieved using techniques such as conducting selective removal, timing removal to avoid the growing season of native plants, or reducing the area of removal. http://dnr.wi.gov/org/water/fhp/waterway/aquaticplantcontrol.html
Boat access standards	NR 1.91	Alternative access plans must consider the effects of the plan on designated sensitive areas. An alternative access plan is required in order to obtain natural resources enhancement services for waters that have less boating access than described in NR 1.91 and for waters that have more boating access than described in 1.91. http://www.legis.state.wi.us/rsb/code/nr/nr001.pdf

Lake Redstone Background

Lake Redstone is located in northern Sauk County, Wisconsin near the Village of LaValle. The lake was created in 1965 with the construction of a dam on Big Creek, a tributary of the Baraboo River. The project created a 650 acre impoundment with a maximum depth of 45 feet and a mean depth of 14 feet. The lake is 4.5 miles long and has a 10,000+ acre watershed draining from the north (Juneau County). The dam is located at the south end of the lake and has a top draw spillway. The southern area of the lake's shoreline has beautiful red sandstone cliffs that give the lake its name. There are two major arms in the headwaters, the Northeast Arm where the East Branch of Big Creek enters and the Northwest Arm where the West Branch of Big Creek enters (Figure 3).

Lake Redstone has good fishing and a large area for water sports. Offshore or lakeview properties have access to the lake by way of beach clubs, boat landings and a 60 foot opening for every 0.5 mile of shoreline. The southern part of the lake has stunning sandstone cliffs and little littoral habitat, while the many bays and remainder of the shoreline of the lake are generally less steep with more littoral habitat. The 16.4 miles of lake shoreline is developed with approximately 450 homes and cottages. Beautiful and rare in Southern Wisconsin, native glacial relict vegetation and habitat (mostly notably mature white pine and hemlock tree communities) grace some locations on the lakeshore.

Aquatic Plants

Because of the steep slopes under water, aquatic vegetation is sparse in the lake except in the shallower inlet bays of Lake Redstone, where it can be dense. The 1.5 to 5-foot depth zone supports the most plant growth. Generally, plants were not found deeper than the 10 foot contour. This is consistent with the average depth of the photic zone as reflected by approximately two times the average Secchi disk clarity of 4 to 5 feet.

Lake Redstone has fair diversity of aquatic plant species compared to other lakes in the state, but a diversity and community similar to other lakes in the Driftless Area. The aquatic plant community in Lake Redstone is characterized by an above average tolerance to disturbance. The Floristic Quality Index (Nichols, 1999) is 13.8 as compared to an average of 14.2 for other lakes in the Driftless Area, and 22.2 statewide.

DNR conducted an aquatic plant survey in early August after herbicide treatments for Eurasian watermilfoil (EWM) and other nuisance aquatic vegetation. Therefore, the plant frequency and diversity near shore was greater earlier in the season (as is typical for south central and south-western Wisconsin impoundments), especially before the curly-leaf pondweed died back (which it does naturally in late June and early July). This was confirmed by aquatic plant management pre-treatment reports.

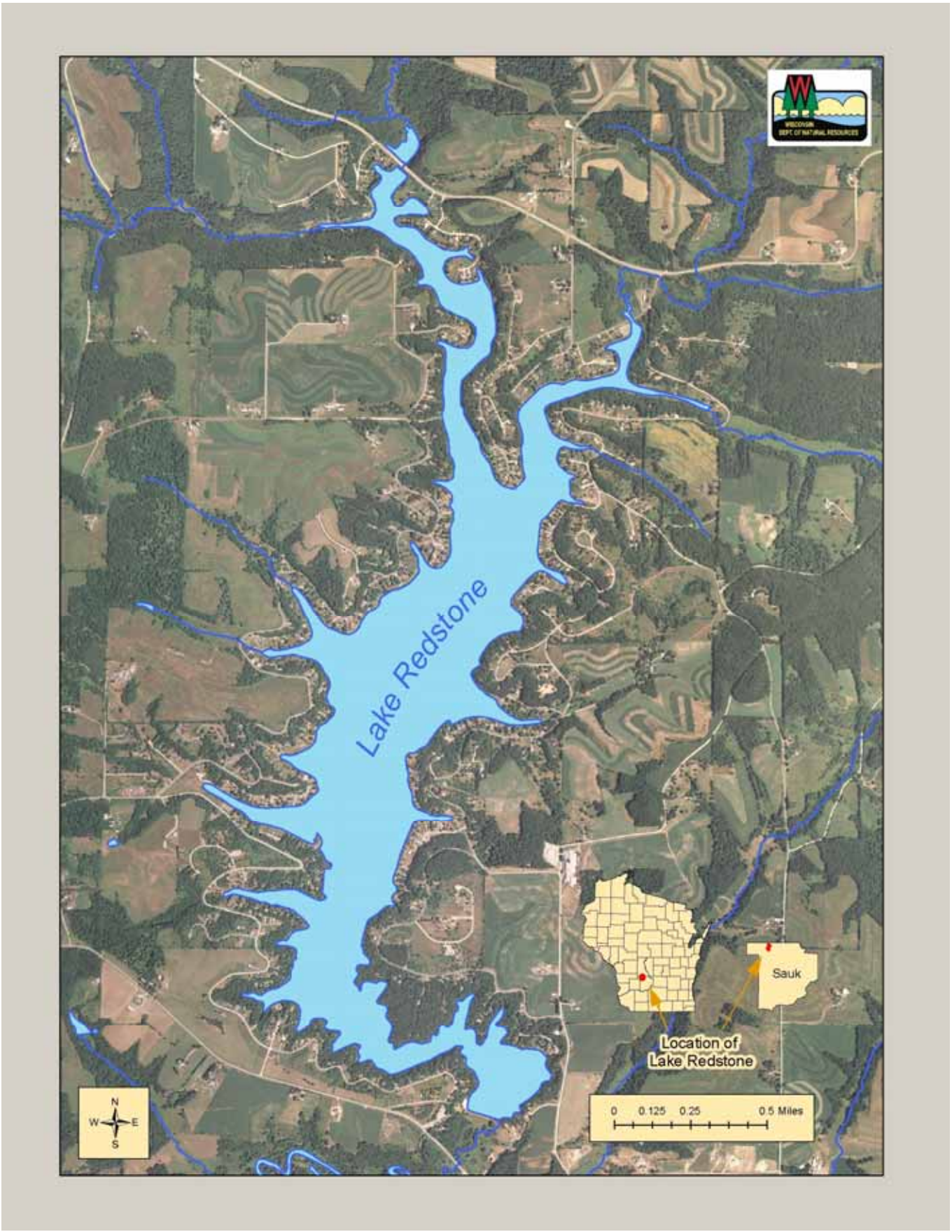


Figure 3. Lake Redstone, Sauk County, Wisconsin

There were 11 species of plants recorded in Lake Redstone during the 2005 survey (Table 2). This is average for Driftless Area lakes (Hauxwell, et al, 2007). There were 8 species of native plants and 3 species of exotics (Eurasian watermilfoil, curly-leaf pondweed and pink water lily).

Coontail was the dominant aquatic plant species in Lake Redstone and common waterweed was the sub-dominant species. Other submergent species included: sago pondweed, small pondweed, curly leaf pondweed and Eurasian watermilfoil. Floating-leaved plants included: white and pink water lily, floating-leaf pondweed, long-leaf pondweed and duckweed. Emergent plants, such as iris, cattails and reed canary grass, were observed during the October, 2006 site visit, but were not recorded during the 2005 aquatic plant survey. Some filamentous algae was also recorded.

Eurasian watermilfoil and curly-leaf pondweed were chemically treated in 2005 prior to the survey, and they were only seen in small patches visually in a few bays. EWM was not collected on the sampling rake in 2005. Aquatic Plant Management pre-treatment reports noted that their frequency and distribution was greater earlier in the summer.

Figure 4 shows the distribution of all aquatic plant species combined, and maps of the distribution of most of the individual species recorded during the August, 2005 survey are found in Appendix B. The water quality and fish and wildlife benefits of these plants are summarized in Table 3.

Scientific Name	**Common Name**	**Relative Frequency (%)**
Ceratophyllum demersum	Coontail	23.3
Elodea Canadensis	Elodea	31.8
Lemna minor	Duckweed	0.8
Myriophyllum spicatum	Eurasian watermilfoil	6.2
Nymphaea odorata	White water lily	1.6
Nymphaea spp.	Pink water lily	0.1
Potamogeton crispus	Curly-leaf pondweed	0.1
Potamogeton natans	Floating-leaf pondweed	0.1
Potamogeton nodosus	Long-leaf pondweed	0.8
Potamogeton puscillus	Small pondweed	28.7
Stuckenia pectinata	Sago pondweed	1.6

Table 2. Relative Frequency of Aquatic Plants in Lake Redstone, August 2005.

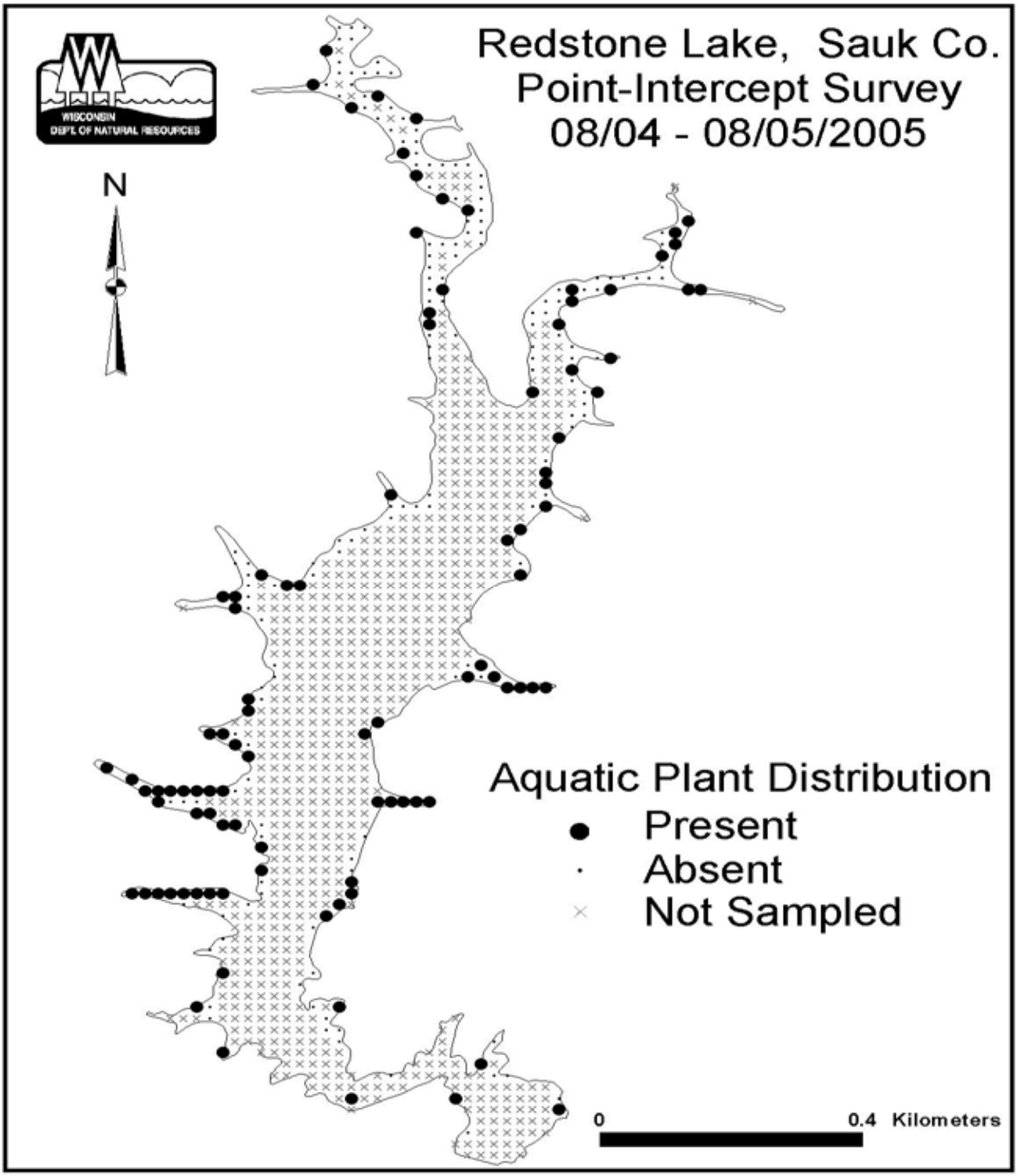


Figure 4 . Lake Redstone aquatic plant distribution, August, 2005. Presence and density of plants was higher earlier in the summer according to Aquatic Plant Management pre-treatment survey notes.

Table 3. Fish and Wildlife Uses of Aquatic Plants in Lake Redstone.

Plants	Fish	Waterfowl	Song/Shore Birds	Upland Birds	Muskrat	Beaver	Deer
Submergent Plants							
Ceratophyllum demersum (coontail)	F,I*, C, S	F(Seeds*), I, C			F		
Elodea canadensis (common waterweed)	C, F, I	F(Foliage), I					
Myriophyllum spicatum (Eurasian watermilfoil)	C, F, I	F(Foliage), I					
Potamogeton crispus (curly-leaf pondweed)	F, C, S	F(Seeds, Turions)					
Potamogeton pusilus (small-leaved pondweed)	F, I, S*,C	F*(All)			F*	F	F
Stuckenia pectinata (sago pondweed)	F, I, S*,C	F*(Seeds)			F*	F	F
Submergent and Floating-leaf Plants							
Potamogeton natans (floating-leaf pondweed)	F, I, S*,C	F*(Seeds)			F*	F	F
Potamogeton nodosus (long-leaf pondweed)	F, I, S*,C	F*(Seeds)			F*	F	F
Floating-leaved Plants							
Lemna minor (duckweed)	F	F*, I	F	F	F	F	
Nymphaea odorata (white water lily)	F, I, S, C	F(Seeds)	F		F	F	F

F=Food, I= Shelters Invertebrates, a valuable food source C=Cover, S=Spawning *=Valuable Resource in this category

III. LAKE REDSTONE CRITICAL HABITAT SITES

There were 20 sites designated as Critical Habitat for Lake Redstone (Figure 2). Fourteen of these were classified as Sensitive Areas for their aquatic vegetation and associated fish, wildlife and water quality benefits (Critical Habitats 2, 4-8, 11-12, 14-19). Six were classified as Other Critical Habitat for their natural or screened shoreline and fish and wildlife habitat values (Critical Habitats 1, 3, 9-10, 13 and 20). All are classified as Public Rights Features.

A summary of Public Rights Features, including Sensitive Areas, and an overview of applicable activity-based laws is found in Appendix A. Because of the scarcity of aquatic vegetation in Lake Redstone, those areas with native aquatic plants were classified as Sensitive Areas.

All areas designated as Critical Habitat were geo-referenced and mapped (Figure 2). These areas are described in the following sections.

General Recommendations for Lake Redstone

The following actions are recommended to promote and protect the health of Lake Redstone and should be considered during review of regulated activities:

1) Minimize removal of native aquatic vegetation to protect fish and wildlife habitat;
2) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming or fishing areas;
3) Assess location and dimensions of proposed grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, and shoreline erosion control (subject to site-specific wave energy calculations) to protect water quality, fish and wildlife habitat and reaches of shore which are predominately natural in appearance or that screen man-made or artificial features; and
4) Follow recommended methods for stabilization in locations with active bank erosion.

Additionally, the following actions are not independently regulated by the state but are encouraged to promote and protect the health of Lake Redstone:

1) Maintain natural shoreland buffers of native vegetation to protect water quality, fish and wildlife habitat and natural scenic beauty;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain the unique natural appearance of the sandstone cliffs and rock outcrops;
4) Maintain hemlock-white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
5) Maintain overhanging trees and shrubs, fallen trees along the shoreline and large woody cover and boulders in the water for fish and wildlife habitat;
6) Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce shoreline erosion and runoff of nutrients and other pollutants that affect water quality;
7) Update the Aquatic Plant Management Plan every 5 years to reflect current lake conditions and emerging management techniques;
8) Control invasive plants;

9) Maintain aquatic invasives signs at all boat landings to educate lake users about protecting the lake from introduction of new exotic species and consider establishing a Clean Boats, Clean Waters watercraft inspection program; and
10) In locations of actively eroding shoreline, consider expanding slow-no-wake buffer zones to reduce erosion caused by boating.

Lake Redstone Critical Habitat 1 – SSE Shoreline, Main Lake

This Critical Habitat encompasses a stretch of shoreline along the south-southeast side of the main lake along East Redstone Drive (Figure 5). It is adjacent to Original Lots 38-72, East Redstone Drive & cul-de-sac Lots 201-218, Certified Survey 32 Lots 1-4, and the Public Access Lot between Certified Survey 32 Lot 1 and Raven Lot 1. This site contains steep cliffs of red and green sandstone with rocky outcroppings. White pine, hemlock and sugar maple trees grace the cliffs. The shoreland area is 100% wooded and is very natural in appearance despite a few piers, stairways and benches. Large woody cover is present in the shallow water. This woody cover provides important habitat for fish and wildlife areas. This area is known smallmouth bass habitat. A small delta of sediment was formed by the June, 2008 flood at the tip of the easternmost, sharp finger off East Redstone Drive near Fox Court, and permitted repair work has been done.

This site was designated for its stretches of shore with shore which is predominately natural in appearance or that screen man-made or artificial features, and fish and wildlife habitat value. It is classified as Other Public Rights Feature. Photos of the area are shown in Figures 6-9.

Fish Habitat

Large woody material and boulders at this site provide critical fish habitat for feeding of smallmouth bass, walleye, and other adult gamefish.

Wildlife Habitat

Shoreline shrubs and brush, large woody cover, mature evergreen trees and sandstone cliffs provide critical habitat at this site. This site provides shelter, cover, nesting and feeding areas for cliff swallows, wood ducks, hooded mergansers, songbirds, eagles and osprey.

Recommendations for Critical Habitat 1

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
3) Minimize areas of disturbance on the cliffs to maintain the predominantly natural appearance and habitat for cliff swallows.

Encouraged, but activity is not independently regulated by DNR permits:

1) Maintain hemlock - white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain overhanging trees and shrubs and fallen trees along the shoreline; and
4) Minimize removal of native shoreline and shoreland vegetation to protect water quality by reducing runoff of nutrients and other pollutants.

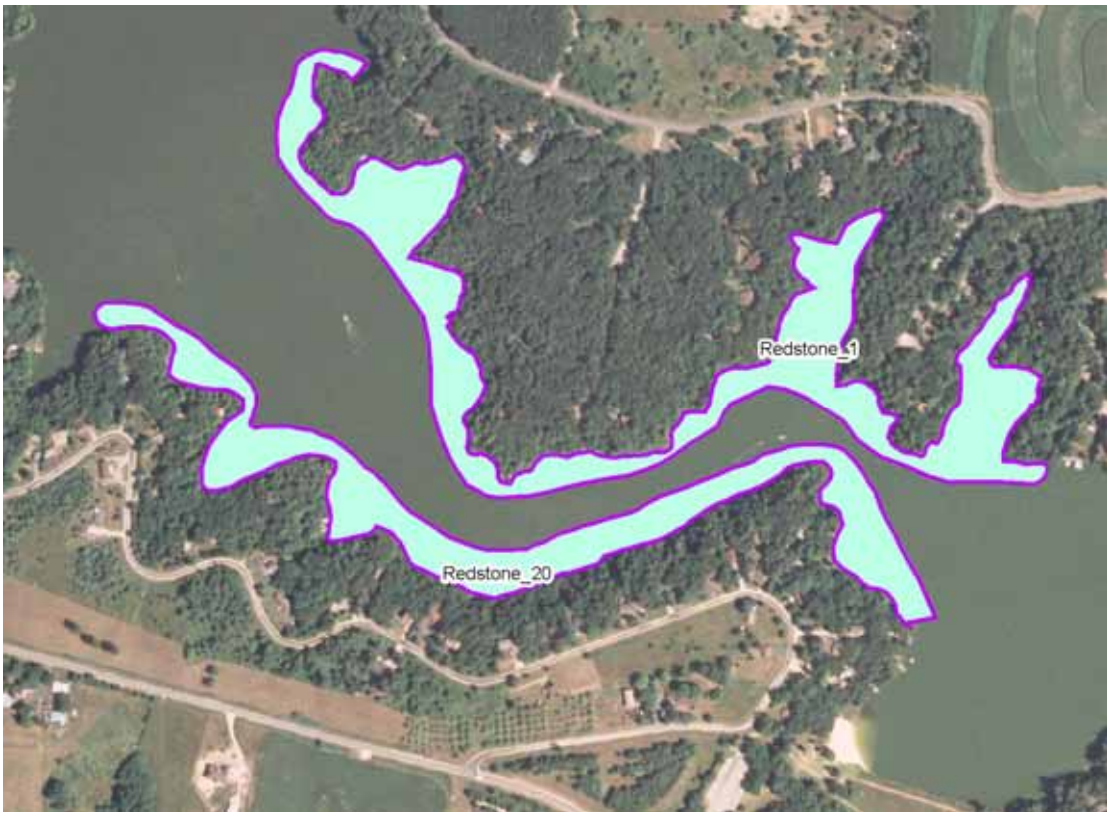


Figure 5. Location of Lake Redstone Critical Habitats 1 and 20.

Figure 6. Lake Redstone Critical Habitat 1.

Figures 7, 8 and 9. Lake Redstone Critical Habitat 1.

Lake Redstone Critical Habitat 2 – E Bay, Main Lake

This Critical Habitat is a bay near the center of the east side of the main lake along East Redstone Drive and Eagle Court (Figure 10). It is adjacent to Eagle Lots 7-41 and the Outlot between Eagle Lot 41 and Mockingbird Lot 1. The area is 90% developed, with many piers. The shoreline primarily consists of lawns, riprap and interspersed trees. There are also showcase areas of shoreline restoration with native vegetation. Submergent vegetation is common. (No close up photo of the area).

This site was selected for its aquatic plant community and associated water quality benefits and fish and wildlife habitat values. It is classified as a Sensitive Area.

The Plant Community:
This bay has a diverse aquatic plant community for Lake Redstone. It contains native floating-leaf white water lilies. It also supports four species of native submergent plants (coontail, common waterweed, small pondweed and sago pondweed) that provide many water quality and fish and wildlife benefits. Exotic Eurasian watermilfoil is also present.

Fish Habitat
Submergent and floating-leaved vegetation at this site provide nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Wildlife Habitat
Submergent and floating-leaf vegetation is an important food source for waterfowl. Low banks and terrestrial vegetation provides shelter, cover, nesting and feeding areas for songbirds, muskrats, otter, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Water Quality
The aquatic plant community at this site provides:

1) a physical buffer that provides protection against wave action and shoreline erosion;
2) a biological buffer that reduces the likelihood of invasions by exotic species;
3) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbances; and
4) micro-habitat which increases the likelihood of higher biodiversity.

Figure 10. Location of Lake Redstone Critical Habitats 2 and 3.

Recommendations for Critical Habitat 2

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation, course woody material and other near-shore structure for wildlife habitat, fish cover and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or to for navigation channels and reasonable swimming or fishing areas;
4) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
5) Encourage use of biologs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations.

Encouraged but not independently regulated by DNR permits:

1) Maintain native shoreline and shoreland vegetation to reduce erosion and runoff of nutrients and other pollutants that affect water quality; and
2) Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to protect water quality.

Lake Redstone Critical Habitat 3 – Point, E Side, Main Lake

This Critical Habitat is on the eastern shore of the main lake along Kingfisher Road. It is adjacent to Kingfisher Lots 3 - 21 (Figure 10). The shoreland consists of low cliffs and rock outcrops with white pine relicts and birch. There are some overhanging trees. Photos of the area are shown in Figures 11 and 12.

This site was selected for its fish and wildlife values and lengths of shoreline with predominantly natural appearance. It is classified as Other Public Rights Feature.

Fish Habitat

Overhanging trees and boulders at this site provide critical fish habitat for feeding of smallmouth bass, walleye and other adult gamefish.

Wildlife Habitat

Shoreline shrubs and brush, large woody cover, mature evergreen trees and sandstone cliffs provide critical habitat at this site. This site provides shelter, cover, nesting and feeding areas for cliff swallows, wood ducks, hooded mergansers, songbirds, eagles and osprey.

Recommendations for Critical Habitat 3

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
3) Minimize areas of disturbance on the cliffs to maintain the predominantly natural appearance, and habitat for cliff swallows.

Encouraged but not independently regulated by DNR permits :

1) Maintain white pine relicts and native trees, minimize tree removal and maintain vegetative visual buffers to screen development;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Minimize removal of native shoreline and shoreland vegetation to protect water quality by reducing runoff of nutrients and other pollutants; and
4) Maintain overhanging trees and shrubs and fallen trees along the shoreline.

Figures 11 and 12. Lake Redstone Critical Habitat 3.

Lake Redstone Critical Habitat 4 – E Bay S Edge, NE Arm

This Critical Habitat is the east inlet on the south edge of the northeast arm near Bob O Link Court (Figure 13). It is adjacent to Tanager Outlots 1 and 2. The shoreline at this Critical Habitat Area is 100% wooded, with trees and shrubs dominant and herbaceous cover abundant. Bracken fern and dogwood, along with willows, sugar maples and birch were noted on the slopes. Some snags were also present. Turtles and ducks were observed. Large woody cover from some fallen trees is present in the shallow water. This woody cover provides important habitat for fish and wildlife areas. A photo of the area is shown in Figure 14.

This site was selected for its fish and wildlife habitat value as well as aquatic vegetation and associated water quality benefits. It is classified as a Sensitive Area.

The Plant Community:
The plant community at this site includes native floating-leaved white water lilies that dampen wave action and provide important fish habitat.

Wildlife Habitat
Shoreline trees. shrubs and brush provide this critical habitat. This site provides:

1) shelter, cover, feeding and nesting areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for otter, muskrats, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
The floating-leaved vegetation and large woody cover at this site provide nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality
The aquatic plant community at this site provides:

1) a biological buffer, reducing the possibility of invasions by exotic species; and
2) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbance; and provides a physical buffer that protects the shoreline against erosion.

Recommendations for Critical Habitat 4

To be considered during review of regulated activities :

1) Maintain native aquatic vegetation, course woody material and other near-shore structure for wildlife habitat, fish cover and as a buffer for water quality protection;
2) Limit aquatic plant management to methods specific to exotics and/or navigation channels and reasonable swimming and fishing areas; and
3) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
2) Minimize removal of native shoreline and shoreland vegetation to protect water quality by reducing erosion and nutrient runoff; and
3) Maintain overhanging trees and shrubs and fallen trees along the shoreline.

Figure 13. Location of Lake Redstone Critical Habitat 4.

Figure 14. Lake Redstone Critical Habitat 4.

Lake Redstone Critical Habitat 5 – SE Point, NE Arm

This Critical Habitat is located along the northern shore of the big point in the southeast portion of the Northeast Arm along East Redstone Drive (Figure 15). It is adjacent to the Public Access lot between Tanager Lot 28 and Swallow Outlot 1, and includes Swallow Outlot 1 and Lots 15-22. The shoreline at this Critical Habitat is composed primarily of trees, with very minimal development apparent. Trees overhanging the water provide a unique feature. Hemlocks, sugar maple and birch are found on top of the cliffs. A photo of the area is found in Figure 16.

This site was selected for its aquatic vegetation and associated water quality benefits, its fish and wildlife habitat value and its shore with predominantly natural appearance. It is classified as a Sensitive Area.

The Plant Community:

The plant community at this site includes native floating-leaved white water lilies that dampen wave action and provide important fish habitat. The submergent plant community consists of native coontail, common waterweed and small-leaved pondweed, which provide fish and wildlife benefits.

Wildlife Habitat

Shoreline shrubs and brush and overhanging trees provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for otter, muskrats, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat

The submerged and floating-leaf vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality

The aquatic plant community and natural shoreline vegetation at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbance; and
4) a physical buffer that protects the shoreline against erosion.

Recommendations for Critical Habitat 5

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Encourage use of biologs and native vegetation for shoreline erosion control, subject to appropriate review of site-specific wave energy calculations;
3) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
4) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees and overhanging trees;
3) Minimize removal of native shoreland and shoreline vegetation to reduce erosion and runoff of nutrients and other pollutants that affect water quality; and
4) Maintain overhanging trees and shrubs and fallen trees for fish and wildlife habitat;
5) Consider possible restoration of culverts that extend far out into the water.

Figure 15. Location of Lake Redstone Critical Habitat 5.

Figure 16. Lake Redstone Critical Habitat 5.

Lake Redstone Critical Habitat 6 – E Bay, NE Arm

This Critical Habitat encompasses the south side of the bay on the east side of the Northeast Arm along East Redstone Drive (Figure 17). It is adjacent to Swallow Lots 23-38, Outlot 2 and Woodpecker Lots 10-19. It supports important shallow water and shoreland habitat, including aquatic vegetation. A perched wetland overflows into the bay and provides a thermal refuge and cool water microhabitat. A 600 feet stretch of shoreline on the south side of the bay has an overhanging and dense alder thicket and also contains old meadow, grass and sumac.

The north shore of the bay is 80% developed. The shoreline of the developed area either contains natural herbaceous vegetation or riprap. There is very little natural vegetation buffer on the north shore, although this was probably a result of prior herbicide applications to allow use near piers and for navigation. Dense vegetation has been documented here, which can obstruct use, resulting in herbicide permit requests. Photos of the area are shown in Figures 18-20.

This site was selected for its aquatic vegetation and associated water quality benefits and its fish and wildlife habitat value. It is classified as a Sensitive Area.

The Plant Community:
The plant community at this site includes native floating-leaved water lilies and submergent coontail, common waterweed and small-leaved pondweed.

Wildlife Habitat
This bay provides good habitat for waterfowl shelter and feeding. Emergent wetland vegetation, floating-leaf vegetation, and shoreline shrubs and brush provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl and songbirds; and
2) shelter, cover and feeding areas for otter, muskrat, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
The floating-leaf vegetation and submerged vegetation at this site provide critical fish habitat. The cool water from the perched wetland outflow provides a thermal refuge and microhabitat. Macroinvertebrates associated with the vegetation provide fish food. This site provides year-round nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish.

Water Quality
The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) a physical buffer that protects the shoreline against erosion;
4) stability to the sediments, which reduces turbidity and nutrient cycling and the likelihood of algae blooms;
5) microhabitat and temperature fluctuations which increase the likelihood of higher biodiversity at the site; and
6) temperature gradients that increase the likelihood of higher biodiversity.

Figure 17. Location of Lake Redstone Critical Habitat 6.

Recommendations for Critical Habitat 6

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming or fishing areas;
4) Encourage use of biologs and native vegetation rather than riprap for shoreline erosion control, subject to review of site-specific wave energy calculations; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain natural shoreland buffers of native vegetation to protect water quality and fish and wildlife habitat;
2) Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce erosion and runoff of nutrients and other pollutants that affect water quality;
3) Minimize removal of native shoreline and shoreland vegetation; and
4) Maintain overhanging and fallen trees for fish and wildlife habitat.

Figures 18 and 19. Lake Redstone Critical Habitat 6.

Figure 20. Lake Redstone Critical Habitat 6.

Lake Redstone Critical Habitat 7 – E Br Big Creek Downstream of Bridge, NE Arm

This Critical Habitat is the East Branch of the Big Creek inlet downstream of the LaValle Road bridge in the northeast arm of the lake (Figure 21). It is adjacent to Woodpecker Lots 1-8, the Public Access lots and Certified Survey 46 Lot 3. It is approximately 80% wooded, 10% wetland and 10% developed. The shoreland buffer is predominantly trees, with shrub and herbaceous cover also common. Hemlocks are found on the slopes.

This site supports important near-shore terrestrial habitat, shoreline habitat and shallow water habitat. Large woody cover from some fallen trees is present in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. It is known to provide nursery, feeding areas and protective cover for panfish and crappies. Ducks were observed. Anglers were also observed. Photos of the area are found in Figures 22 and 23.

This site was selected for its aquatic and terrestrial vegetation and associated water quality benefits, fish and wildlife value and its shoreline with predominantly natural appearance. It is classified as a Sensitive Area.

The Plant Community:

The plant community at this site includes native emergent vegetation and duckweed that protects the shoreline and provides important food sources, cover and fish spawning habitat. The submergent plant community primarily consists of native coontail, but also includes native common waterweed. Exotic curly-leaf pondweed and Eurasian watermilfoil are also found.

Wildlife Habitat

This bay provides good wildlife cover. Emergent vegetation, shoreline shrubs, brush and fallen logs provide this critical habitat. This site provides:

1) shelter, cover, feeding and potential nesting areas for waterfowl and songbirds; and
2) shelter, cover, and feeding areas for otter, muskrat, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat

The large woody cover, emergent vegetation and submerged vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality

The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species; and
3) a physical buffer that protects the shoreline against erosion

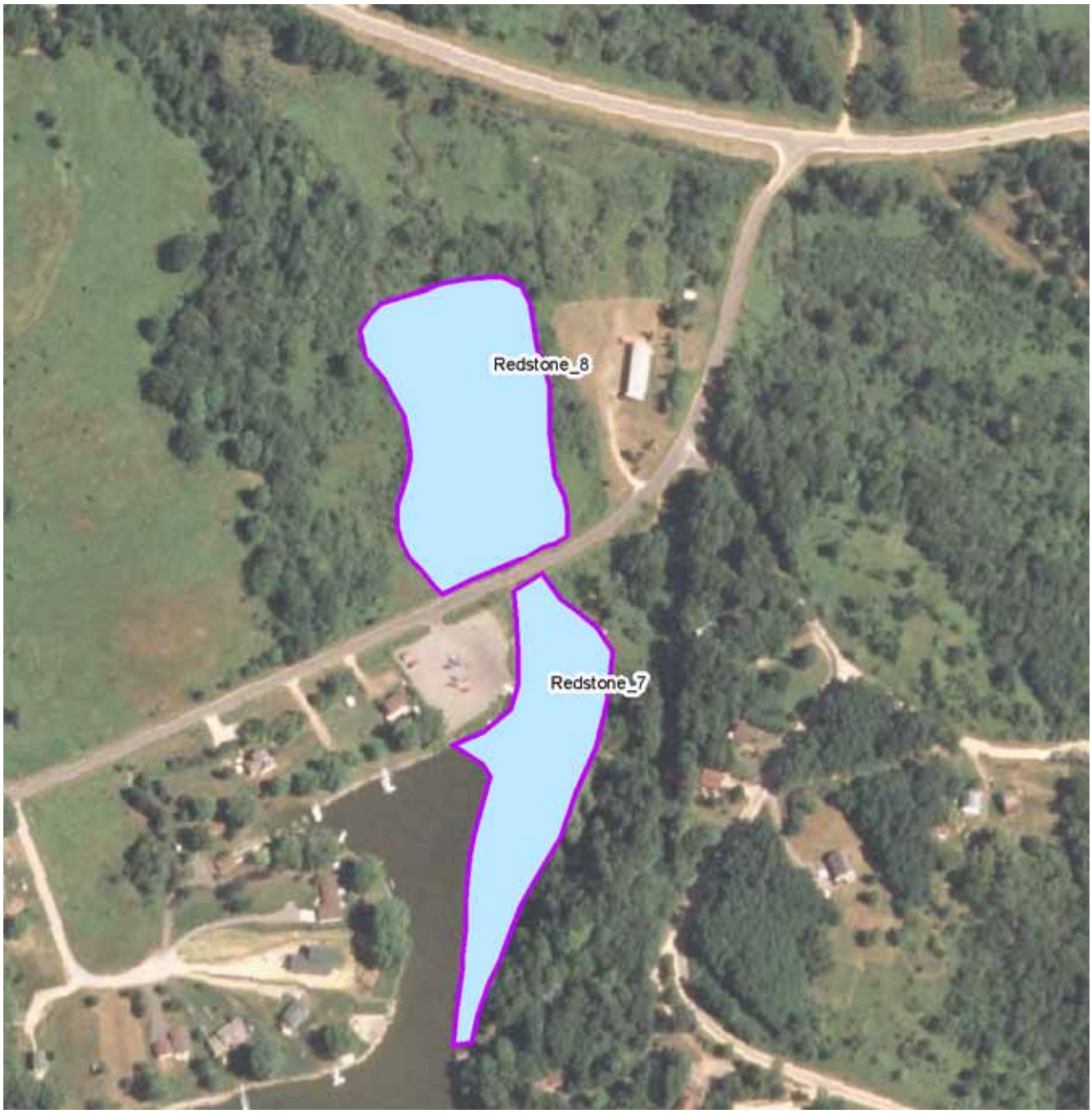


Figure 21. Location of Lake Redstone Critical Habitats 7 and 8.

Recommendations for Critical Habitat 7

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Encourage use of biologs or native shoreline vegetation to control shoreline erosion; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
2) Minimize removal of native shoreline and shoreland vegetation for wildlife habitat and to reduce runoff of nutrients and other pollutants that affect water quality;
3) Maintain overhanging and fallen trees along the shoreline for fish and wildlife habitat; and
4) Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce erosion and runoff of nutrients and other pollutants that affect water quality.

Figures 22 and 23. Lake Redstone Critical Habitat 7.

Lake Redstone Critical Habitat 8 – E Br Big Creek & Wetland, NE Arm

This Critical Habitat is the East Branch of Big Creek inlet upstream of the LaValle Road bridge in the northeast arm (Figure 21). It is bounded by LaValle Road, East Redstone Drive, and County Highway F. It contains important shallow water habitat and high quality and diverse wetlands. It is a mapped wetland on the Wisconsin Wetland Inventory. The shoreline at this Critical Habitat is composed of tag alder thicket and wetland vegetation. Larger canopy trees are located in back of the alder thicket. Human influence is not evident. Fish congregate in this area in the spring. Photos of the area are found in Figures 24-26.

This site was selected for its aquatic plant community and associated water quality benefits and fish and wildlife value. It is classified as a Sensitive Area.

The Plant Community

The plant community at this site includes emergent wetland vegetation such as cattails and reed canary grass that protect the shoreline and provide important food sources, cover and fish spawning habitat. Native emergent vegetation is rare on this lake. Floating leaved plants such as native white water lilies and duckweed dampen wave action and provide important fish and wildlife food and habitat. The native submergent plant is primarily coontail. Filamentous algae was present. Some Eurasian water milfoil was also observed.

Wildlife Habitat

This bay provides good habitat for waterfowl shelter and feeding. Emergent wetland vegetation, floating-leaf vegetation, and shoreline shrubs and brush provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey;
2) shelter, cover and feeding areas for otters, muskrats, beaver, mink, frogs, toads, salamanders, turtles and snakes; and
3) feeding and watering areas for deer.

Fish Habitat

The floating-leaf vegetation and submerged vegetation at this site provides critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provides fish food.

Water Quality

The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) a physical buffer that protects the shoreline against erosion;
4) stability to the sediments, which reduces turbidity and nutrient cycling and the likelihood of algae blooms;
5) microhabitat and temperature fluctuations which increase the likelihood of higher biodiversity at the site; and
6) temperature gradients that increase the likelihood of higher biodiversity.

Recommendations for Critical Habitat 8

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Require permits for any aquatic plant management;
4) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable fishing areas;
5) Maintain wetland and shallow water habitat;
6) Protect sensitive wetland area; and
7) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain snag tree and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat; and
2) Maintain native shoreline and shoreland vegetation for fish and wildlife habitat and to protect water quality by reducing runoff of nutrients and other pollutants.

Figure 24. Lake Redstone Critical Habitat 8.

Figures 25 and 26. Lake Redstone Critical Habitat 8.

Lake Redstone Critical Habitat 9 – E Shoreline, NW Arm

This Critical Habitat is the shoreline on the east shore of the northwest arm along Whip Poor Will Court and Mockingbird Court (Figure 27). It is adjacent to Mockingbird Lots 11-42. The shoreline consists primarily of wooded cliffs with hemlock, white pine, oak and birch. The north segment of the shoreline is developed, but has been protected with vegetated biologs. There are also some wetlands with cattails and iris. Woody cover from fallen trees is present in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. Some lengths of the shoreline are eroding. Figure 28 shows a photo of the area.

Great Blue Herons, ducks and turtles were observed using the area. Turkeys and deer have also been reported in the area.

This site was selected for its fish and wildlife habitat value, as well as for its stretches of shoreline with predominantly natural appeance. It is classified as Other Public Rights Feature.

The Plant Community

Floating-leaved native white water lilies dampen wave action and provide important fish and wildlife food and habitat.

Wildlife Habitat

This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey;
2) shelter, cover and feeding areas for otter, muskrats, beaver, mink, frogs, toads, salamanders, turtles and snakes; and
3) Feeding and watering areas for turkey and deer.

Fish Habitat

The large woody cover and overhanging trees at this site provide critical fish habitat. This site provides nursery, cover and feeding area for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish. Macroinvertebrates associated with the woody cover and vegetation provide fish food.

Water Quality

The aquatic plant community and natural shoreline vegetation at this site provides:

1) a physical buffer that protects the shoreline against erosion;
2) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
3) a biological buffer, reducing the possibility of invasions by exotic species; and
4) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbance.

Recommendations for Critical Habitat 9

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
5) Recommend methods for stabilization in locations with active bank erosion.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock-white pine relicts, minimize tree removal and maintain vegetated visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed and overhanging trees;
3) Maintain natural shoreland buffers of native vegetation to protect wildlife habitat as well as water quality by reducing runoff of nutrients and other pollutants; and
4) Maintain overhanging trees and shrubs and fallen trees along the shoreline for fish and wildlife habitat.

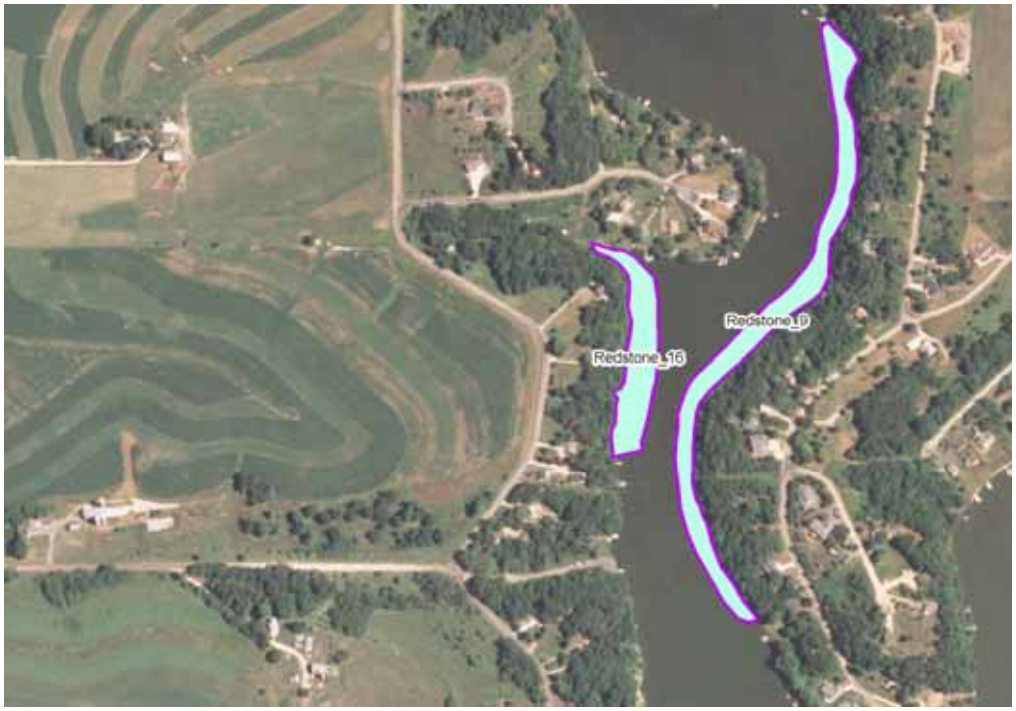


Figure 27. Location of Lake Redstone Critical Habitats 9 and 16.

Figure 28. Lake Redstone Critical Habitat 9.

Lake Redstone Critical Habitat 10 – Bay, NNE Side, NW Arm

This Critical Habitat encompasses the bay along County Highway F and C Survey No. 54 Road in the Northwest Arm (Figure 29). It is adjacent to Certified Survey 54 Lots 2-5 and Certified Survey 55 Lot 1. It has a shoreline that is approximately 40% wooded, 20% wetland and 40% developed. The shoreland buffer includes trees (primarily willows), herbaceous cover and lawn. There is some bank erosion on the lawn areas that do not have vegetated shoreline buffer. Overhanging trees and large woody cover from fallen trees is present in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. Ducks were observed at the site. Photos of the area are found in Figures 30 and 31.

This site was selected for its fish and wildlife value and stretches of shoreline that are predominantly natural in appearance. It is classified as Other Public Rights Feature.

Wildlife Habitat

Shoreline shrubs and brush and fallen logs provide:

1) shelter, cover, nesting and feeding areas for waterfowl and songbirds; and
2) shelter, cover and feeding areas for otter, muskrat, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat

Large woody cover at this site provides critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish.

Water Quality

The natural shoreland vegetation at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species; and
3) a physical buffer to prevent bank erosion.

Recommendations for Critical Habitat 10

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Encourage use of biologs and native vegetation to control shoreline erosion; and
3) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain snag and cavity trees for cavity nest species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
2) Maintain overhanging and fallen trees for fish and wildlife habitat;
3) Minimize removal of native shoreline and shoreland vegetation; and
4) Encourage landowners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce erosion and runoff of nutrients and other pollutants affecting water quality.

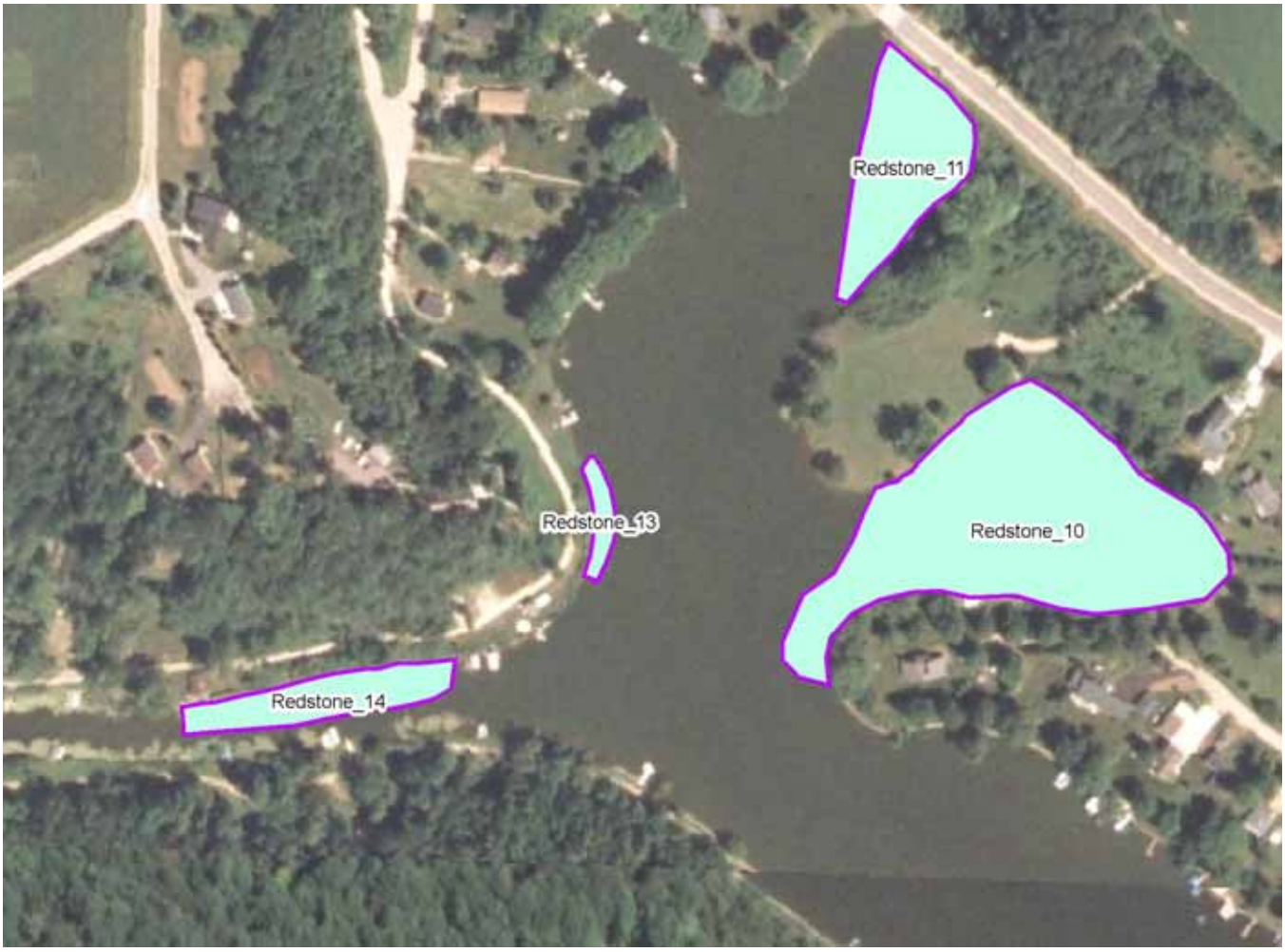


Figure 29. Location of Lake Redstone Critical Habitats 10, 11, 13 and 14.

Figures 30 and 31. Lake Redstone Critical Habitat 10.

Lake Redstone Critical Habitat 11– Inlet Bay, NW Arm, Downstream of CTH F Br

This Critical Habitat includes the east side of the bay just downstream and southwest of the County Highway F bridge where the West Branch of the Big Creek enters the Northwest Arm (Figure 29). It is adjacent to Certified Survey 55 Lot 2 and County Highway F. It supports important near-shore aquatic, terrestrial, shoreline, shallow water and wetland habitat. The shoreline is 100% wooded, with shrubs and willow trees. Large woody cover from some fallen trees is present in the shallow water. This wood provides important habitat for fish cover and wildlife resting areas. It is known to be muskellunge habitat. Anglers were observed catching crappies. A photo of the area is found in Figure 32.

This site was selected for its aquatic and terrestrial vegetation and associated water quality benefits and fish and wildlife habitat value. It is classified as a Sensitive Area.

The Plant Community:
The aquatic plant community consists primarily of native submergent coontail, which provides fish, wildlife and water quality benefits.

Wildlife Habitat
Shoreline trees, shrubs and brush provide critical habitat at this site. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for otter, muskrat, mink, beaver, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
Large woody cover and submerged vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for gamefish and feeding areas for adult gamefish. Macroinvertebrates associated with the woody cover and vegetation provide fish food.

Water Quality
The aquatic and shoreland plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species; and
3) a physical buffer that protects the shoreline against erosion.

Recommendations for Critical Habitat 11

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain the aquatic vegetation in an undisturbed condition for fish and wildlife and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific for exotics and/or for navigation channels and reasonable fishing areas;
4) Maintain shallow water and wetlands habitats;
5) Protect sensitive wetlands; and
6) Maintain the littoral zone except for possible improvement of fish habitat.

Encouraged but not independently regulated by DNR permits:

1) Maintain snag and cavity trees for cavity nest species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
2) Maintain overhanging and fallen trees along the shoreline for fish and wildlife habitat values; and
3) Maintain native shoreline and shoreland vegetation to protect water quality by reducing runoff of nutrients and other pollutants.

Figure 32. Lake Redstone Critical Habitat 11.

Lake Redstone Critical Habitat 12 – W Br Big Creek & Wetland, NW Arm

This Critical Habitat is the West Branch of Big Creek inlet stream and associated wetland upstream of the bridge in the Northwest Arm along County Highway F (Figure 33). The area contains shallow water with submergent, floating leaved and emergent vegetation. The shoreline on the east side consists of rocky outcroppings and cliff faces with herbaceous vegetation and shrubs, including willow, alder thickets, dogwood, impatiens and ironweed. There is no development and there are hemlocks and white pine on top of the cliffs. Photos of this site are shown in Figures 34 and 35.

Upstream and to the west are wetlands, including iris and cattails. This is a mapped wetland in the Wisconsin Wetlands Inventory. Large woody cover from fallen trees is found in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. This is known muskellunge habitat. Great Blue Herons were observed in the wetlands.

This site was selected for its aquatic and shoreline vegetation and associated water quality benefits and fish and wildlife values, as well as its lengths of shoreline that are predominantly natural in appearance. It is classified as a Sensitive Area.

The Plant Community:
The plant community consists of native submergent coontail and elodea and floating-leaf pondweed with duckweed and some filamentous algae. The native emergent plant community includes cattails and iris.

Wildlife Habitat
Emergent vegetation, floating-leaved vegetation, shoreline shrubs and brush and fallen logs provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for muskrat, otter, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
Large woody cover and emergent, submergent and floating-leaf vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality
The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) a physical buffer that protects the shoreline against erosion
4) stability to the sediments, which reduces turbidity and nutrient cycling and the likelihood of algae blooms;
5) microhabitat and temperature fluctuations which increase the likelihood of higher biodiversity at the site; and
6) temperature gradients that increase the likelihood of higher biodiversity.

Figure 33. Location of Lake Redstone Critical Habitat 12.

Recommendations for Critical Habitat 12

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable fishing areas;
4) Protect sensitive wetlands;
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
6) Minimize areas of disturbance on the cliffs to maintain the natural appearance and habitat for cliff swallows.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock - white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nest species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain overhanging and fallen trees along the shoreline for fish and wildlife habitat values; and
4) Minimize removal of native shoreline and shoreland vegetation to protect water quality by reducing runoff of nutrients and other pollutants.

Figures 34 and 35. Lake Redstone Critical Habitat 12.

Lake Redstone Critical Habitat 13 – W Cliffs, NW Arm

This Critical Habitat is located on the west side of the northwest arm near Crow Court (Figure 29). It is adjacent to Killdeer Lots 1-2 and Martin Lots 17-18. It consists of a prominent bluff topped with white pine. The shoreline is trees, shrubs and herbaceous cover, including willow, dogwood and iris. Large woody cover from fallen trees is present in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. A photo of the site is shown in Figure 36.

This site was selected for its terrestrial plant communities, fish and wildlife habitat value and its length of shoreline that is predominantly natural in appearance. It is classified as Other Public Rights Feature.

Wildlife Habitat
This site provides:

1) shelter, cover and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for muskrat, otters, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
Large woody cover provides nursery, cover and feeding area for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish.

Water Quality
The shoreland buffer at this site provides:

1) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbance; and
2) a physical buffer that protects the shoreline against erosion.

Recommendations for Critical Habitat 13

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed; and
3) Minimize areas of disturbance on the cliffs to maintain natural appearance and habitat for cliff swallows.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock - white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nest species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain overhanging and fallen trees along the shoreline for fish and wildlife habitat values; and
4) Minimize removal of native shoreline and shoreland vegetation.

Figure 36. Lake Redstone Critical Habitat 13.

Lake Redstone Critical Habitat 14 – NNW Inlet, NW Arm

This Critical Habitat encompasses the inlet and tributary corridor on the north-north west side of the northwest arm (Figure 29). It is adjacent to Martin Lots 13-16. Much of the shoreline is in natural vegetation, with approximately 40% wooded, 45% in shrubs and 15% developed. There are a few piers and associated lawns and riprap in the developed areas. The shoreland buffer is mostly herbaceous and shrub cover, with trees and lawn present as well. White pines, maples and other large trees provide a third story canopy in the shoreland area. A photo of the area is shown in Figure 37.

Large woody cover from fallen trees is present in the shallow water. This woody cover provides important habitat for fish cover and wildlife resting areas. White water lily and long-leaved pondweed provide fisheries and wildlife benefits. The shrubs consist of alder thickets, raspberries, willow, elderberry and grape. There are white pines, sugar maple and birch further up the slopes. Frogs, ducks, and kingfishers were observed using the habitat.

This site was chosen for its aquatic and terrestrial vegetation and associated water quality benefits and fish and wildlife habitat values, as well as its stretches of shoreline with predominantly natural appearance. It is classified as a Sensitive Area.

The Plant Community

The native floating-leaf white water lilies and long-leaved pondweed that dampen wave action and provide important fish habitat. The submergent plant community contains native coontail, common waterweed and small-leaf pondweed that provide important fish and wildlife benefits.

Wildlife Habitat

Emergent vegetation, floating-leaf vegetation, shoreline shrubs and brush, snag and perch trees and fallen logs provide critical habitat at this site. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and ospreys; and
2) shelter, cover, nesting and feeding areas for otter, muskrats, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat

Large woody cover, emergent cattail vegetation, submerged vegetation and floating-leaf vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality

The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species; and
3) a physical buffer that protects the shoreline against erosion.

Recommendations for Critical Habitat 14

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain the native aquatic vegetation for fish and wildlife habitat values and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Encourage use of biologs and native vegetation on the shoreline to reduce erosion, subject to site-specific wave energy calculations; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nesting species; canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Minimize removal of native shoreline and shoreland vegetation;
4) Maintain overhanging and fallen trees on the shoreline for fish and wildlife habitat values; and
5) Encourage landowners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to protect water quality by reducing shoreline erosion and runoff of nutrients and other pollutants.

Figure 37. Lake Redstone Critical Habitat 14.

Lake Redstone Critical Habitat 15 – W Bay & Tributary Corridor, NW Arm

This Critical Habitat is a small bay and tributary corridor on the west side of the Northwest Arm along West Redstone Drive (Figure 38). It is adjacent to Lot 34. The shoreland area of the bay is 100% wooded, with abundant tree, shrub and herbaceous cover. Shrubs include alder and willow. Trees on the hillside include sugar maple, white pine and oak. Herbaceous cover includes bracken fern, iris, goldenrod and cattails. The tributary corridor is a sedge meadow. A photo of the area is found in Figure 39. The flood in June, 2008 deposited a delta of sediment at the inlet, filling in a small area of this finger, but most of the shoreline vegetation is unchanged from before the flood, and the aquatic plants are not expected to change since the species present are fairly tolerant of disturbance.

This site was selected for its aquatic and shoreline vegetation and associated water quality benefits and fish and wildlife values. It is classified as a Sensitive Area.

The Plant Community:

The plant community at this site includes native floating-leaved pondweed and white water lilies that dampen wave action and provide important fish habitat and wildlife food. The submergent plant community consists of native coontail, common waterweed and small-leaved pondweed which provide important fish and wildlife benefits.

Wildlife Habitat

Shoreline shrubs, brush, emergent plants and overhanging trees provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for otter, muskrat, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Fish Habitat

The submerged and floating-leaf vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality

The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbance; and
4) a physical buffer that protects the shoreline against erosion.

Figure 38. Location of Lake Redstone Critical Habitat 15.

Recommendations for Critical Habitat 15

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Minimize removal of native aquatic vegetation to protect fish and wildlife habitat and protect water quality;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels;
4) Maintain sedge meadow wetland area and associated wildlife corridor;
5) Encourage use of biologs and native woody vegetation for shoreline erosion control, subject to site-specific wave energy calculations; and
6) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nest species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Minimize removal of native shoreline and shoreland vegetation to reduce erosion and runoff of nutrients and other pollutants; and
4) Maintain overhanging and fallen trees for fish and wildlife habitat.

Figure 39. Lake Redstone Critical Habitat 15.

Lake Redstone Critical Habitat 16 – SW Shoreline & Bay, NW Arm

This Critical Habitat encompasses a stretch of shoreline and bay along the southwest side of the northwest arm of the lake (Figure 27). It is adjacent to Certified Survey Lots 1-2, Outlot 1 and Robin Lots 4-11. Figure 40 shows a photo of this site.

The northern portion of the site includes cliffs with mossy rocks and ferns, sensitive aquatic vegetation (white water lily), boulders and woody tree falls. The shoreland buffer is 80% developed, 20% cliffs and 5% inlet corridor. The shoreland buffer consists of herbaceous, shrub, tree and lawn cover.

The southern portion of the site contains steep cliffs and rocky boulders, with white pines, hemlocks and sugar maples. The shoreland area is 100% wooded. On top of the cliffs, the area is approximately 50% developed, but not densely, and has at least a 35 feet buffer. The shoreland buffer consists of herbaceous plants and abundant trees.

Site 16 was selected for its aquatic, terrestrial and shoreline vegetation and associated water quality benefits, fish and wildlife habitat value and its shoreline with predominantly natural appearance. It is classified as a Sensitive Area.

Rare Community Type

The hemlock and white pine on top of the vertical sandstone cliffs is rare in Southern Wisconsin, and is classified as a natural ecological community (white pine-hemlock relict) deemed worthy of special protection by the Wisconsin Natural Heritage Inventory. The interspersed boulders and sugar maples also contribute to the predominantly natural appearance of this shoreline. There is minimal visible human disturbance.

The Plant Community:

The aquatic plant community at consists of native emergent species (Iris and Bidens), floating-leaf species (white water lily and long-leaf pondweed) and submergent species (coontail, sago pondweed and small leaved pondweed). These provide water quality benefits, as well as cover for fish and food sources for wildlife.

Fish Habitat

Large woody cover, boulders and aquatic vegetation at the northern portion of this site provide critical fish habitat. This site provides nursery, cover and feeding area for panfish, juvenile gamefish and forage fish and feeding areas for adult gamefish. Macroinvertebrates associated with the vegetation provide fish food.

Wildlife Habitat

Shoreline shrubs and brush, large woody cover and mature evergreen trees provide critical habitat at this site. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl, songbirds, eagles and osprey; and
2) shelter, cover and feeding areas for otter, muskrat, beaver, mink, frogs, toads, salamanders, turtles and snakes.

Water Quality

The aquatic plant community at this site provides:

1) a physical buffer that protects the shoreline against erosion;
2) a biological buffer, reducing the possibility of invasions by exotic species; and
3) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbances.

Recommendations for Critical Habitat 16

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Minimize removal of native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Minimize areas of disturbance on the cliffs to maintain the predominantly natural appearance, and habitat for cliff swallows;
5) Encourage use of biologs and native vegetation for shoreline erosion control, subject to appropriate review of site-specific wave energy; and
6) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock – white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees;
3) Maintain overhanging and fallen trees along the shoreline to protect fish and wildlife habitat;
4) Minimize removal of any native shoreline and shoreland vegetation to reduce shoreline erosion and runoff of nutrients and other pollutants that affect water quality; and
5) Plant native perennial vegetation as a buffer zone to reduce runoff of nutrients and other pollutants.

Figure 40. Lake Redstone Critical Habitat 16.

Critical Habitat Lake Redstone 17 – W Center Bay, Main Lake

This Critical Habitat is a bay near the center of the west side of the lake along West Redstone Drive where two unnamed streams enter the lake (Figure 41). It is adjacent to Chickadee Lots 15-62. The area is 90% developed, with many piers. The shoreline primarily consists of lawns, riprap and interspersed trees. Submergent vegetation is common. There is no close-up photo of this site.

This site was selected for its aquatic plant community and associated water quality benefits and fish and wildlife habitat and is classified as a Sensitive Area.

The Plant Community:
This bay has a relatively diverse native aquatic plant community for Lake Redstone. It supports five native species of submergent plants: coontail, common waterweed, small pondweed, sago pondweed and floating-leaf pondweed. These plants provide many water quality, fish and wildlife benefits.

Wildlife Habitat
Submergent and floating-leaf vegetation is an important food source for waterfowl. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl and songbirds; and
2) shelter, cover and feeding areas for muskrat, otter, beaver, mind, frogs, toads, salamanders, turtles and snakes.

Fish Habitat
Submergent and floating-leaved vegetation provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality
The aquatic plant community at this site provides:

1) a physical buffer that provides protection against wave action and shoreline erosion;
2) a biological buffer that reduces the likelihood of invasions by exotic species;
3) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbances; and
4) micro-habitat which increases the likelihood of higher biodiversity.

Figure 41. Location of Lake Redstone Critical Habitat 17.

Recommendations for Critical Habitat 17

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Encourage use of biologs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain and restore shoreline and shoreland buffer of native perennial vegetation for fish and wildlife benefits and to reduce erosion and runoff of nutrients and other pollutants that affect water quality; and
2) Maintain overhanging and fallen trees for fish and wildlife habitat.

Lake Redstone Critical Habitat 18 – WSW Bay, Main Lake

This Critical Habitat is the second long bay to the north off West Redstone Drive on the west-southwest side of the main lake (Figure 42). It is adjacent to Mourning Dove Lots 1-35 and Oriole Lots 30-44. It supports important shallow water and shoreland habitat. The shoreline on the southwest side of the bay is undeveloped, with old field, willow thickets, trees and other natural vegetation. White pines and sugar maples are found on the slopes. There is wetland and prairie on the west side of the bay. The flood in June, 2008 gouged out a significant gully before depositing a significant, sandy delta of sediment at the inlet. This filled in an area of this finger, but restoration of the site through dredging is currently being planned. The aquatic plants in this bay are not expected to change since the species present are fairly tolerant of disturbance. Figure 43 shows a photo of this area.

This site was selected for its aquatic vegetation and associated water quality benefits and fish and wildlife habitat values. It is classified as a Sensitive Area.

The Plant Community:
The plant community is one of the most diverse in Lake Redstone. It includes native floating-leaf water lilies that dampen wave action and protect the shoreline, as well as the native submergent plants coontail, common waterweed, small-leaved pondweed and sago pondweed. These plants provide many water quality, fish, and wildlife benefits. Exotic Eurasian watermilfoil is also found in this bay.

Wildlife Habitat
This bay provides good habitat for waterfowl shelter and feeding. Floating-leaf vegetation, and shoreline shrubs and brush provide this critical habitat. This site provides:

1) shelter, cover, nesting and feeding areas for waterfowl and songbirds; and
2) shelter, cover and feeding areas for muskrat, otter, beaver, mink, frogs, toads, salamanders, turtles and snakes; and
3) Feeding and watering areas for deer and turkeys.

Fish Habitat
The floating-leaf vegetation and submerged vegetation at this site provide critical fish habitat. This site provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality
The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a biological buffer, reducing the possibility of invasions by exotic species;
3) a physical buffer that protects the shoreline against erosion; and
4) stability to the sediments, which reduces turbidity and nutrient cycling and the likelihood of algae blooms.

Recommendations for Critical Habitat 18

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming or fishing areas;
4) Protect sensitive wetland areas;
5) Encourage use of biologs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations; and
6) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
2) Maintain overhanging and fallen trees for fish and wildlife habitat;
3) Encourage landowners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to protect water quality by reducing shoreline erosion and runoff of nutrients and other pollutants; and
4) Consider possible restoration of a culvert extending out into the water.

Figure 42. Location of Lake Redstone Critical Habitat 18.

Figure 43. Lake Redstone Critical Habitat 18.

Critical Habitat Redstone 19 – SW Bay, Main Lake

This area is the first long bay off West Redstone Drive and Sauk Court on the southwest side the main lake (Figure 44). It is adjacent to Oriole Lots 1-21 and Canary Lots 55-69. The area is 80% developed and 10% wooded. Submergent vegetation is abundant. There is no photo of this site.

This site was selected for its aquatic plant community and associated water quality benefits and fish and wildlife habitat values. It is classified as a Sensitive Area.

The Plant Community:
This bay has a diverse aquatic plant community for Lake Redstone. It supports native floating-leaved white water lilies that dampen the waves and protect the shoreline. It also supports 4 species of native submergent plants (coontail, common waterweed, small pondweed and sago pondweed) that provide water quality, fish and wildlife benefits. Exotic Eurasian watermilfoil is also present.

Wildlife Habitat
Submergent and floating-leaf vegetation, especially the Potamogeton (pondweed) family, are important food sources for waterfowl.

Fish Habitat
Submergent and floating-leaved vegetation provides nursery, cover and feeding areas for panfish, juvenile gamefish and forage fish. Macroinvertebrates associated with the vegetation provide fish food.

Water Quality
The aquatic plant community at this site provides:

1) a nutrient buffer, with the plants at the shore and in the water acting as a nutrient sink, absorbing nutrients and reducing algae blooms;
2) a physical buffer that provides protection against wave action and shoreline erosion;
3) a biological buffer that reduces the likelihood of invasions by exotic species;
4) stability to the sediments, holding the sediments to reduce the resuspension by waves and other disturbances; and
5) micro-habitat which increases the likelihood of higher biodiversity.

Recommendations for Critical Habitat 19

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Maintain native aquatic vegetation for fish and wildlife habitat and as a buffer for water quality protection;
3) Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming and fishing areas;
4) Encourage use of biologs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations; and
5) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain and restore shoreline and shoreland buffer of native perennial vegetation for fish and wildlife benefits and to reduce erosion and runoff of nutrients and other pollutants that affect water quality;
2) Maintain overhanging and fallen trees for fish and wildlife habitat; and
3) Encourage landowners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to protect water quality by reducing shoreline erosion and runoff of nutrients and other pollutants.

Figure 44. Location of Lake Redstone Critical Habitat 19.

Critical Habitat Redstone 20 – SSW Shoreline, Main Lake

This Critical Habitat encompasses a stretch of shoreline along the south-southwest side of the main lake along West Redstone Drive (Figure 5). It is adjacent to Canary Court Lots 1-2 and Bluebird Lots 1-41. This site contains steep cliffs of red and green sandstone with rocky outcroppings, with white pines, hemlocks and sugar maples. The shoreland area is 100% wooded and has an undisturbed appearance despite a few piers, stairways and benches. Large woody cover is present in the shallow water of the coves. This woody cover provides important habitat for fish cover and wildlife resting areas. It is known to provide smallmouth bass habitat. The area is very similar to that of Critical Habitat 1. Photos of the area are shown in Figures 45 and 46.

This site was chosen for its stretches of shoreline that are predominantly natural in appearance, and fish and wildlife habitat. It is classified as Other Public Rights Feature.

Rare Community Type

The hemlock and white pine on top of the vertical red sandstone cliffs is classified as a natural ecological community (white pine - hemlock relict) deemed worthy of special protection by the Wisconsin Natural Heritage Inventory. The interspersed boulders and sugar maples also contribute to the natural appearance of the area. There is minimal visible human disturbance.

The Plant Community

The native submergent plants small-leaf pondweed and sago pondweed provide fish and wildlife benefits.

Fish Habitat

Large woody cover and boulders at this site provide critical fish habitat. This site provides feeding areas for adult gamefish such as smallmouth bass and walleye.

Wildlife Habitat

Shoreline shrubs and brush, large woody cover, mature evergreen trees and sandstone cliffs provide critical habitat at this site. This site provides shelter, cover, nesting and feeding areas for cliff swallows, wood ducks, hooded mergansers, songbirds, eagles and osprey.

Recommendations for Critical Habitat 20

To be considered during review of regulated activities:

1) When associated with grading or shoreline protection permits, minimize removal of vegetation along shorelines that are natural in appearance or that screen man-made or artificial structures;
2) Minimize areas of disturbance on the cliffs to maintain natural appearance, and habitat for cliff swallows; and
3) Protect the water quality, fish and wildlife habitat currently present in the littoral zone (near shore area), which includes encouraging the maintenance of course woody material and boulders on the lakebed.

Encouraged but not independently regulated by DNR permits:

1) Maintain hemlock - white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;

2) Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
3) Maintain overhanging trees and shrubs and fallen trees along the shoreline; and
4) Minimize removal of native shoreline and shoreland vegetation to protect water quality by reducing runoff of nutrients and other pollutants.

Figures 45 and 46. Lake Redstone Critical Habitat 20.

IV. LITERATURE CITED

Engel, Sandy. 1990. Ecosystem Response to Growth and Control of Submerged Macrophytes: A Literature Review. Technical Bulletin #170. Wisconsin Department of Natural Resources. Madison, WI.

Engel, Sandy. 1985. Aquatic Community Interactions of Submerged Macrophytes. Wisconsin Department of Natural Resources. Technical Bulletin No. 156. Madison, WI.

Fassett, Norman C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, WI.

Graczyk, David, R. Hunt, S. Greb, C. Buchwald and J. Krohelski. 2003. Hydrology, Nutrient Concentrations and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999-2001. USGS Water Resources Investigations Report 03-4144.

Hauxwell, Jennifer. 2007. Presentation at Black River Falls. Wisconsin Department of Natural Resources, Madison.

Hunt, Randall, S. Greb and D. Gracyzk. 2006. Evaluating the Effects of Nearshore Development on Wisconsin Lakes. USGS Fact Sheet 2006-3033.

Nichols, S.A. 1999. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management 15:133-141.

Nichols, Stanley A. and James G. Vennie. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Information Circular 73.

Valley, Ray, T. Cross and P. Radomski. 2004. The Role of Submersed Aquatic Vegetation as Habitat for Fish in Minnesota Lakes, Including the Implications of Non-Native Plant Invasions and Their Management. Minnesota Department of Natural Resources Special Publication 160.

APPENDIX A

SUMMARY OF PUBLIC RIGHTS FEATURES INCLUDING SENSITIVE AREAS AND THEIR APPLICABLE ACTIVITY-BASED LAWS

Appendix A. Summary of Public Rights Features including Sensitive Areas and Their Applicable Activity-Based Laws

Critical Habitat Designation Overview

Assuring Public Rights in Waters of the State

Our state Constitution guarantees that the waters of Wisconsin are held in trust for all of the state's citizens. All Wisconsin citizens have the right to boat, fish, hunt, ice skate, and swim on navigable waters, as well as enjoy the natural scenic beauty of navigable waters, and enjoy the quality and quantity of water that supports those uses.

Wisconsin has developed broad regulations related to structures in and alterations to our public waters. These regulations have been developed to make sure that we comply with our state Constitution, statutes and relevant legal case law. In 2004 the Legislature restructured the State's water regulations. These simplified regulations allowed:

- Exemptions – activities that do not need permits
- General Permits – establishes standards and minimizes Department review
- Individual Permits - complex projects that require more detail review


Courtesy of MN DNR

Critical Habitat Designation – The Program

Every waterbody has critical habitat – those areas that are most important to the overall health of the aquatic plants and animals. Remarkably, eighty percent of the plants and animals on the state's endangered and threatened species list spend all or part of their life cycle within the near shore zone. As many as ninety percent of the living things in lakes and rivers are found along the shallow margins and shores. Wisconsin law mandates special protections for these critical habitats. Critical Habitat Designation is a program that recognizes those areas and maps them so that everyone knows which areas are most vulnerable to impacts from human activity. A critical habitat designation assists waterfront owners by identifying these areas up front, so they can design their waterfront projects to protect habitat and ensure the long-term health of the lake where they live.

Areas are designated as Critical Habitat if they have Public Rights Features, Sensitive areas or both. Public rights features (defined in NR 1.06, Wis. Adm. Code) include the following:

(1) Fish and wildlife habitat;
(2) Physical features of lakes and streams that ensure protection of water quality;
(3) Reaches of bank, shore or bed that are predominantly natural in appearance;
(4) Navigation thoroughfares; and
(5) Sensitive Areas. Sensitive Areas are defined in Ch. NR 107 as: areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat to the body of water.

Critical Habitat Designation – The Process

Selection of waters for Critical Habitat Designation is generally done as part of the Department's biennial work planning process. This selection contemplates three basic factors:

(1) quality of the resource;
(2) amount of knowledge and information the Department holds regarding the water body; and
(3) current and future risks of the resource to riparian development and in-lake activities.

After a lake is selected, DNR field staff, compile and review the most current scientific data about the water body. Data is also solicited from local units of government, conservation organizations, federal agencies, local businesses and anyone who may have resource knowledge and information. This information is used to assemble maps to identify targets of focus related to fish, wildlife, endangered resources, and their habitats.

Next, DNR staff conduct field work and surveys to identify public rights features on the lake and delineate their extent. The resulting maps and supporting data are compiled into a draft Critical Habitat Designation report, which is posted on the

Department's website for public review. DNR must also give notice of the draft report to the local media, the county clerk, and legislators. If requested or if concerns are anticipated, DNR typically holds informational meetings to answer questions and receive comments. Once public comment is received and the report is complete, Critical Habitat Designations are posted on the DNR website.

How does this program affect Waterfront Owners?

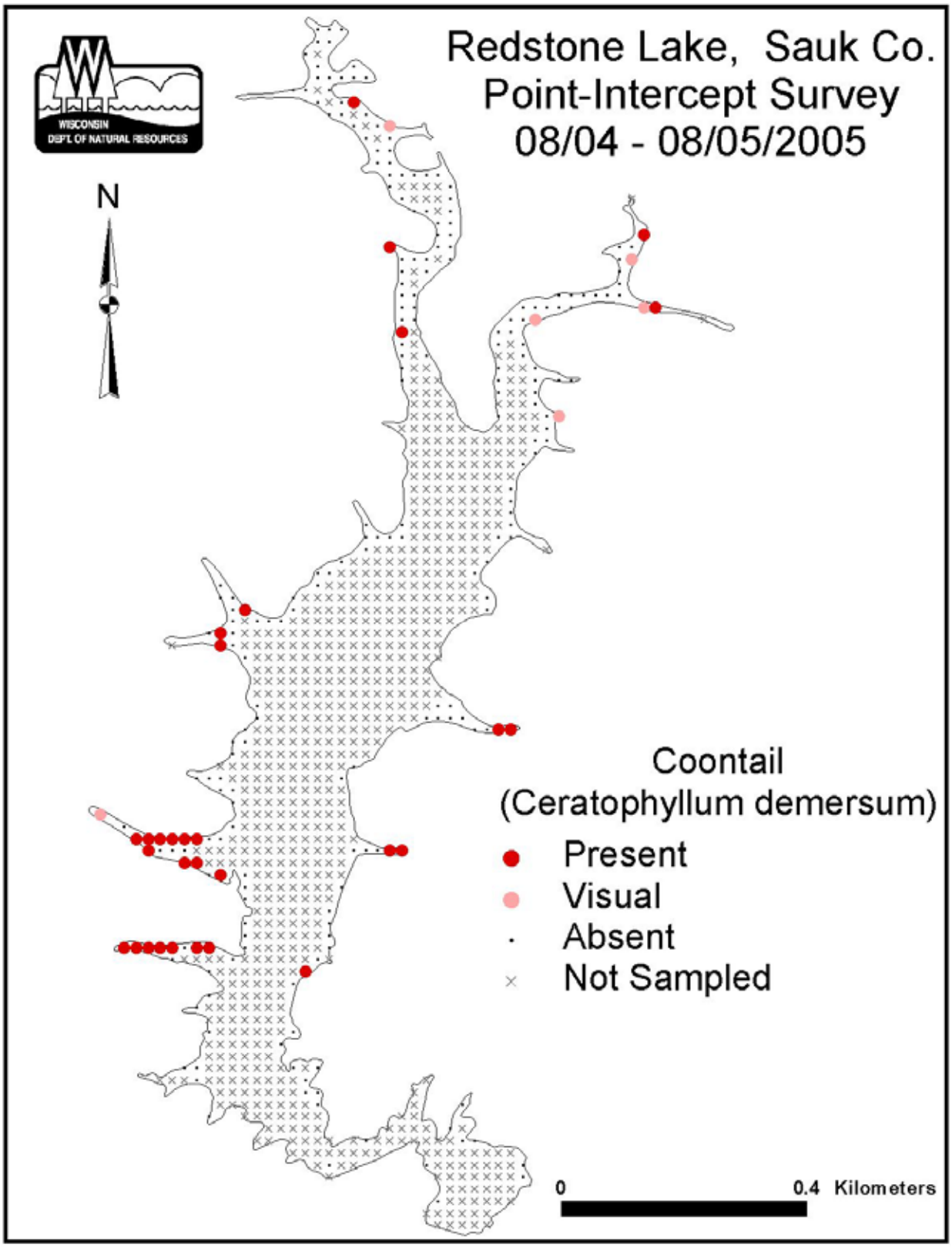
Critical Habitat Designations provide advance information to waterfront owners, to clarify the regulations that will apply when they want to do a construction project or activity along their shoreline. If a project is proposed in a designated Critical Habitat area, the permit jurisdiction or the permit process may change. This allows DNR to ensure that proposed projects will not harm these sensitive resources. Here are some simple examples:

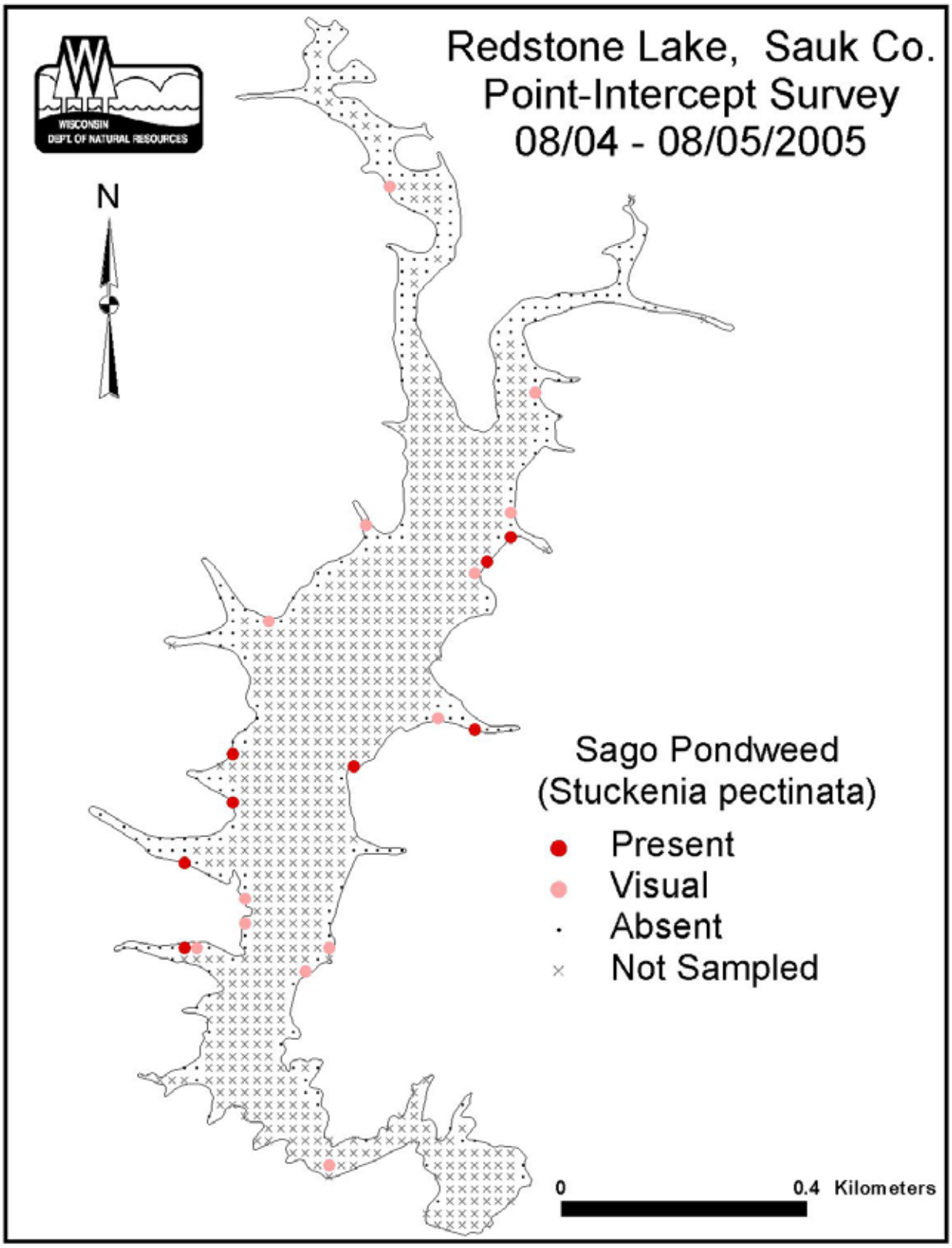
- **Grading** – Permits are required for any project that involves more than 10,000 square feet of land disturbance on the bank of a waterway (typically within 75 feet of the bank). If the project is located in a designated Critical Habitat area, the permit jurisdiction changes to include all areas within 300 feet of the shoreline.
- **Structures** – Some projects to place structures in a waterway are exempt, and don't require a permit. However, if the project is located in a designated Critical Habitat area, a general permit or individual permit may be required. For example, riprap repair or replacement is generally exempt from permitting if specific design criteria are met. However, repair or replacement of existing riprap within or adjacent to a sensitive area is not exempt and requires a permit. Additionally, sensitive area designations are a consideration in the analysis of individual permit applications.
- **Aquatic Plant Management** - DNR may deny permits for chemical treatment for aquatic plant management if the proposed chemical application is in a sensitive area, unless DNR determines that it can occur without ecological impacts. Manual removal of plants is normally exempt from permit. However, manual removal within a sensitive area is not exempt and is subject to permit requirements. *(Note, this regulation preceded the 2004 change in waterway regulations noted above)*

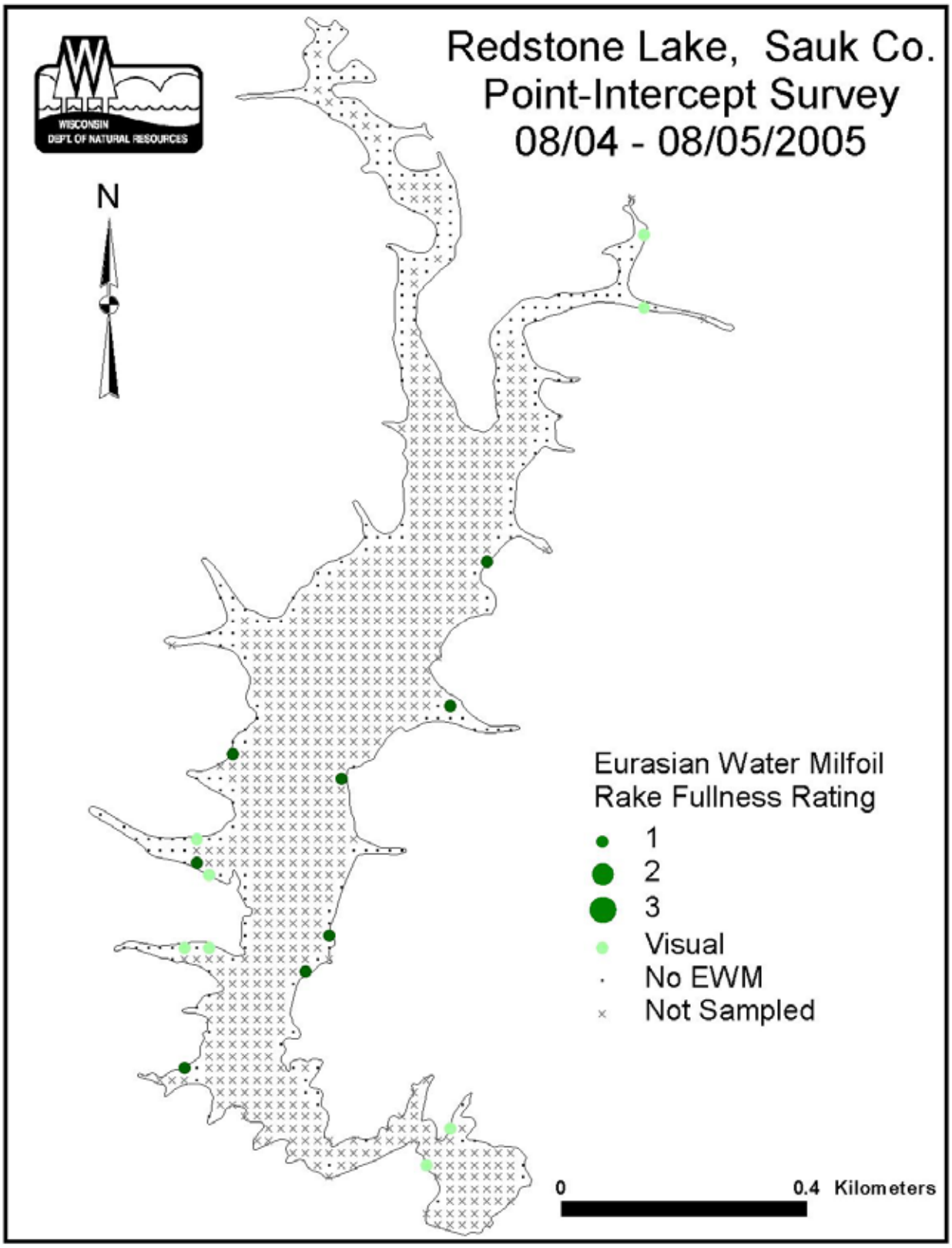
APPENDIX B

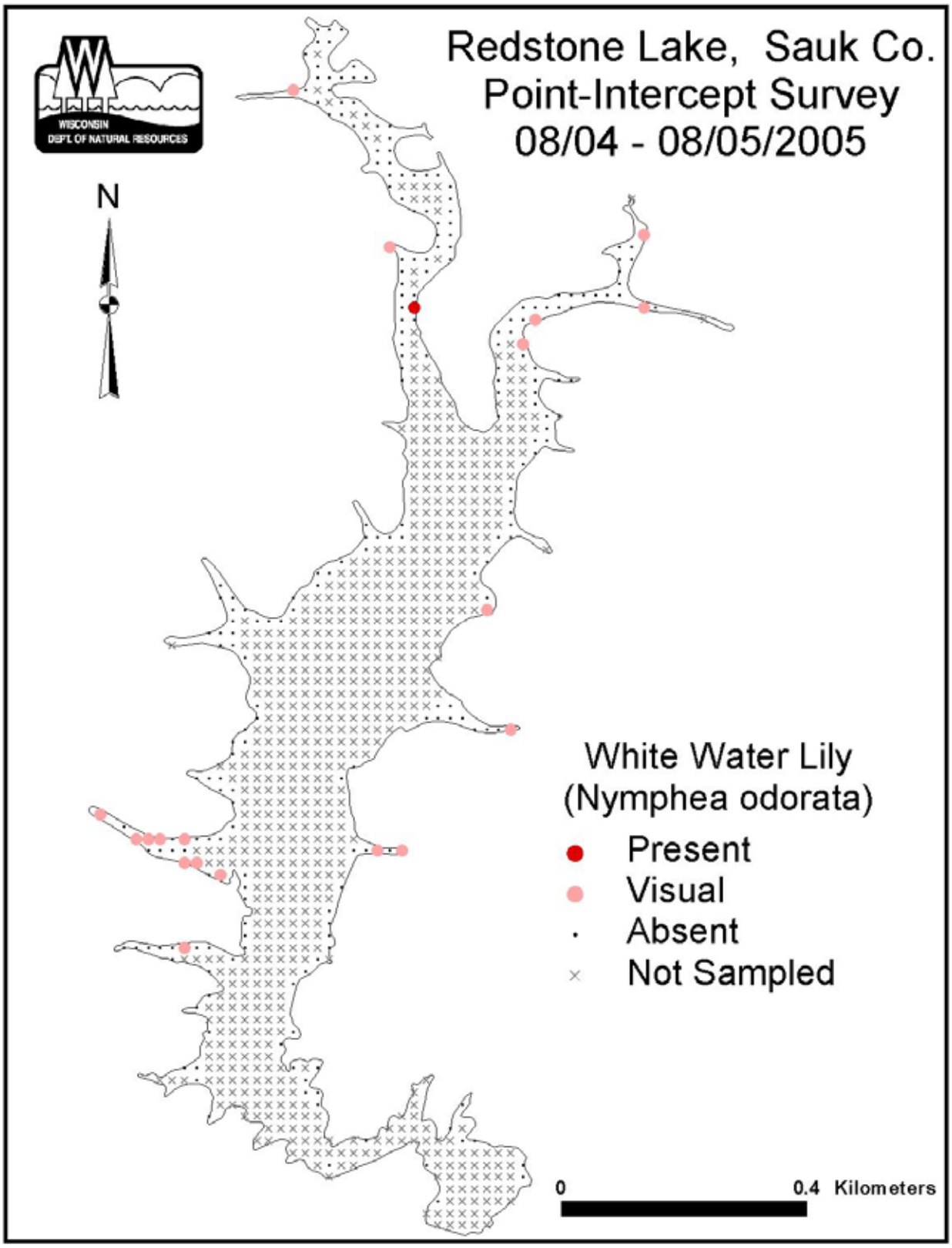
AQUATIC PLANT DISTRIBUTION BY SPECIES
LAKE REDSTONE, SAUK COUNTY, WISCONSIN

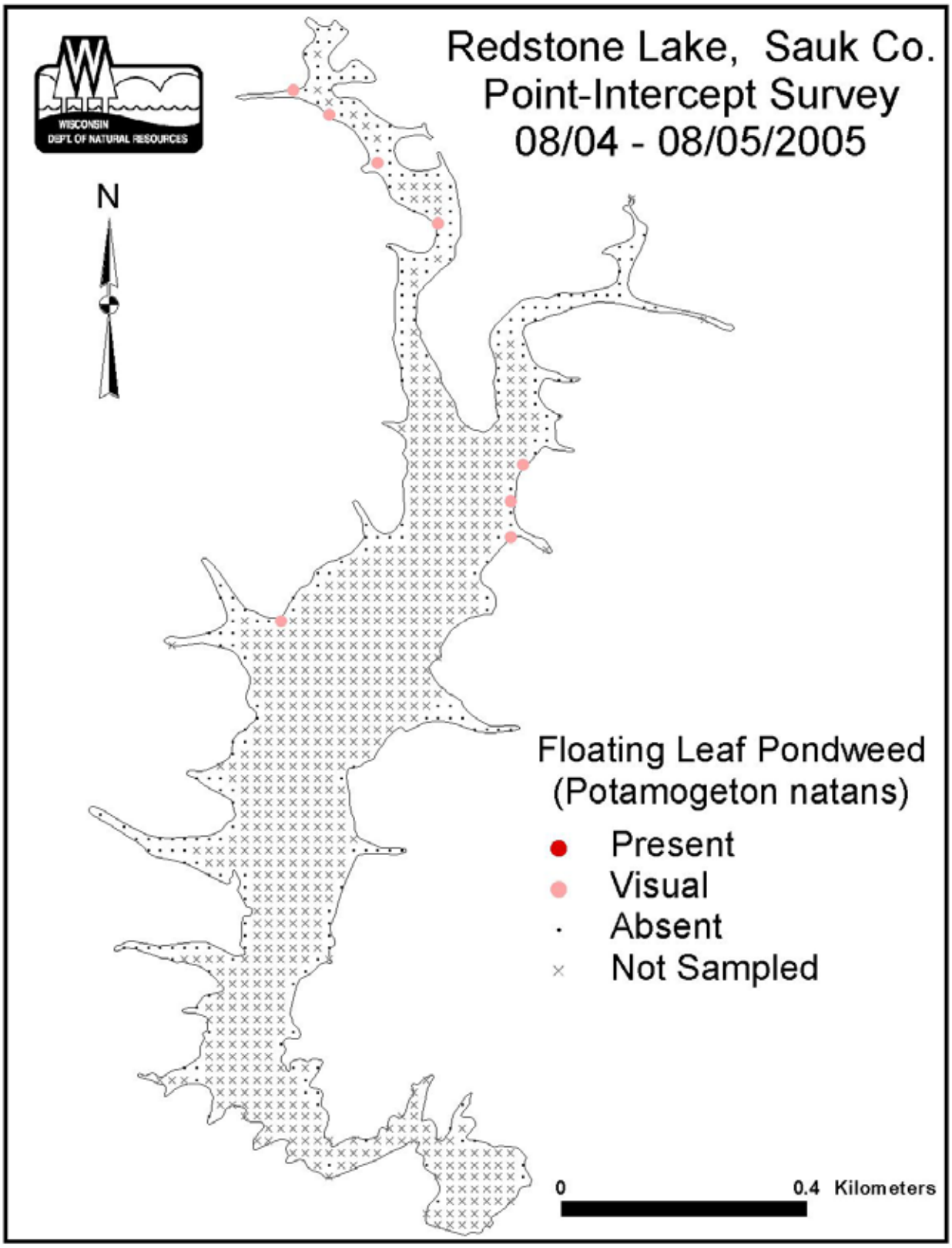
August, 2005


Redstone Lake, Sauk Co.
Point-Intercept Survey
08/04 - 08/05/2005
WISCONSIN
DEPT. OF NATURAL RESOURCES
N
Coontail
(Ceratophyllum demersum)
Present
Visual
Absent
Not Sampled
0
0.4 Kilometers


Redstone Lake, Sauk Co.
Point-Intercept Survey
08/04 - 08/05/2005
WISCONSIN
DEPT. OF NATURAL RESOURCES
N
Sago Pondweed
(Stuckenia pectinata)
Present
Visual
Absent
Not Sampled
0
0.4 Kilometers


Redstone Lake, Sauk Co.
Point-Intercept Survey
08/04 - 08/05/2005
WISCONSIN
DEPT. OF NATURAL RESOURCES
N
Eurasian Water Milfoil
Rake Fullness Rating
1
2
3
Visual
No EWM
Not Sampled
0
0.4 Kilometers


Redstone Lake, Sauk Co.
Point-Intercept Survey
08/04 - 08/05/2005
WISCONSIN
DEPT. OF NATURAL RESOURCES
N
White Water Lily
(Nymphea odorata)
Present
Visual
Absent
Not Sampled
0
0.4 Kilometers


Redstone Lake, Sauk Co.
Point-Intercept Survey
08/04 - 08/05/2005
WISCONSIN
DEPT. OF NATURAL RESOURCES
N
Floating Leaf Pondweed
(Potamogeton natans)
Present
Visual
Absent
Not Sampled
0
0.4 Kilometers

APPENDIX C

AN INTRODUCTION TO LAKESHORE CRITICAL HABITATS

Appendix C. An Introduction to Lakeshore Critical Habitats

By Paul Cunningham

The Wisconsin DNR is concerned about the growing number of threats to sustainable healthy lakes in the state. While many positive measures have been initiated within Wisconsin over the past few decades, habitat and water quality continue to be impacted. Conversion of lakeshore to residential development has greatly accelerated over the past 30 years Over the past 20-years, the upper Great Lakes states of Michigan, Minnesota, and Wisconsin, each rich in natural inland lakes, have experienced extremely high increases in population (Figure 1). Patterns of growth tend to be away from agriculture and urban core areas and toward suburbs and lake rich areas such as central and northern Minnesota, northern Wisconsin, and the upper peninsula and lake regions of lower Michigan.

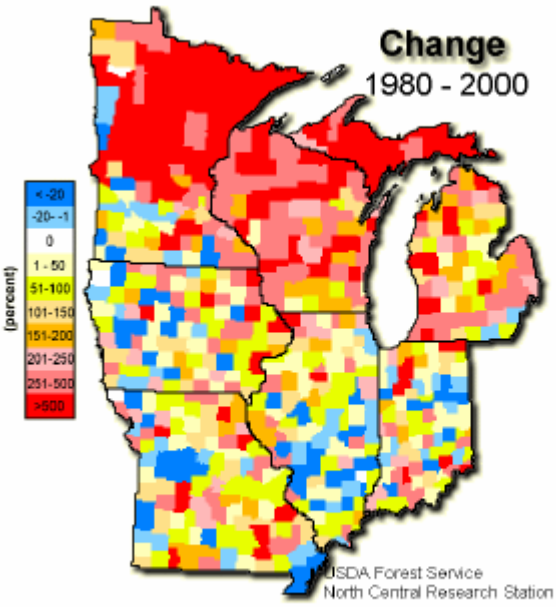


Figure 1

Increases in shoreland development are changing lake ecosystems. Development pressure is increasing with more dwellings per lake each year (Kelly and Stinchfield 1998). Human habitation along the shore has a cumulative effect on fish and wildlife habitat, water quality, and biota of lake ecosystems (Engel and Pederson 1998, Ramstack et al. 2004). Christensen et al. (1996) found significantly less coarse woody material along developed shorelines in Wisconsin and Michigan, predicting that recent losses in developed lakes will affect littoral communities for about two centuries. Meyer et al. (1997) concluded that housing development along shores of northern Wisconsin lakes dramatically altered native vegetation, especially shrubs, and reduced frog populations. Elias and Meyer (2003) found that the mean number of plant species and the percent of native species were both greater at undeveloped sites than along developed Wisconsin lakeshores for upland, shoreline, and shallow water. areas. Jennings et al. (1996) noted changes in nearshore substrate composition in Wisconsin lakes due to human activity. In an Iowa lake, Byran and Scarnecchia (1992) found significant reductions in aquatic macrophyte abundance in developed compared with undeveloped shorelines. Jennings et al. (2003) also found that the amount of littoral wood remains and emergent and floating-leaf vegetation was lower at developed sites and lakes with greater development density. Radomski and Goeman (2001) estimated a 20-28% loss of emergent and floating-leaf coverage from human development for a class of Minnesota lakes by comparing vegetation abundance along undeveloped and developed shorelines for 44 lakes. Alteration of natural littoral zone habitats has negative consequences to fish and wildlife. Walleye spawn on wave-washed nearshore gravel areas (Becker 1983), and these areas are sensitive to nutrient and sediment runoff. Littoral zone vegetation is important
for amphibians, ducks, loons, herons, and other wildlife (Meyer et al. 1997; Lindsay et al. 2002; Woodford and Meyer 2003). Floating-leaf and emergent vegetation provides fish with foraging areas and refuge from predators (Killgore et al. 1993; Casselman and Lewis 1996; Valley et al. 2004). Many fish depend on this habitat for some part or most of their life (Becker 1983). Floating-leaf vegetation, such as white water lily *Nymphaea odorata*, provides shade and overhead cover for largemouth bass *Micropterus*

salmoides and other centrarchids. Emergent vegetation, such as hardstem bulrush *Scirpus acutus*, provide spawning habitat, cover, and colonization sites for aquatic invertebrates and protection from shore erosion by dampening wave energy. Perhaps as important, the native flora, more than anything else, defines the ecological character of our lakes. Numerous fish species use protected embayments and vegetative cover disproportionately to their availability (Wei et al. 2004). Human activities that change vegetative cover can alter ecological processes and energy flow within lakes, thereby reducing their ability to support diverse and healthy fisheries (Schindler and Scheuerell 2002).

Shorelines along lakes may vary greatly with a variety of ecological characteristics that provide varying habitats for wildlife and fish species, and performing different water quality functions. Yet without Critical Habitat Designations; the Department has been essentially treating all shorelines within a lake the same--from shoreland development, to APM, piers and water regulation permits.

Within lakes, littoral regions (Figure 3) are extremely important to the structure, function, and integrity of lake ecosystems (Hall and Werner 1977, Gelwick and Matthews 1990, Benson and Magnuson 1992). Evidence suggests that transfer of food energy from the littoral zones of lakes may influence overall fish production and biomass (Boisclair and Leggett 1985). Most lake-resident fish in Wisconsin, including those that inhabit cool- or coldwater offshore habitats in summer in northern temperate lakes, seasonally rely on littoral areas for spawning and rearing (Becker 1983). Moreover, many of these species make diel and seasonal use of littoral regions for foraging (Scott and Crossman 1973, Becker 1983). In addition to species that use these areas seasonally, many species use littoral regions throughout the year, and many use littoral regions throughout their entire life cycle (Becker 1983). The relationships between fish and habitat have been the subject of numerous ecological investigations. The fact that fish are habitat specialists (Gorman and Karr 1978) has been well established by studies conducted in a variety of freshwater habitats. For instance, northern pike require dense mats of short aquatic vegetation in shallow water (< 0.5 m) for spawning (Clark 1950, Forney 1968); fry use these mats during early rearing for protection from predators and for feeding (Franklin and Smith 1963, Frost and Kipling 1967). White suckers, an important native forage fish in Wisconsin, utilize shallow (20-25 cm) gravel substrates in inflowing or outflowing streams or in shallow, nearshore littoral regions of lakes (Krieger 1980). Yellow perch broadcast strands of eggs in shallower water (1-3 m) where moderate levels of vegetation help capture the egg strands and increase their potential survival (Clady and Hutchinson 1975).

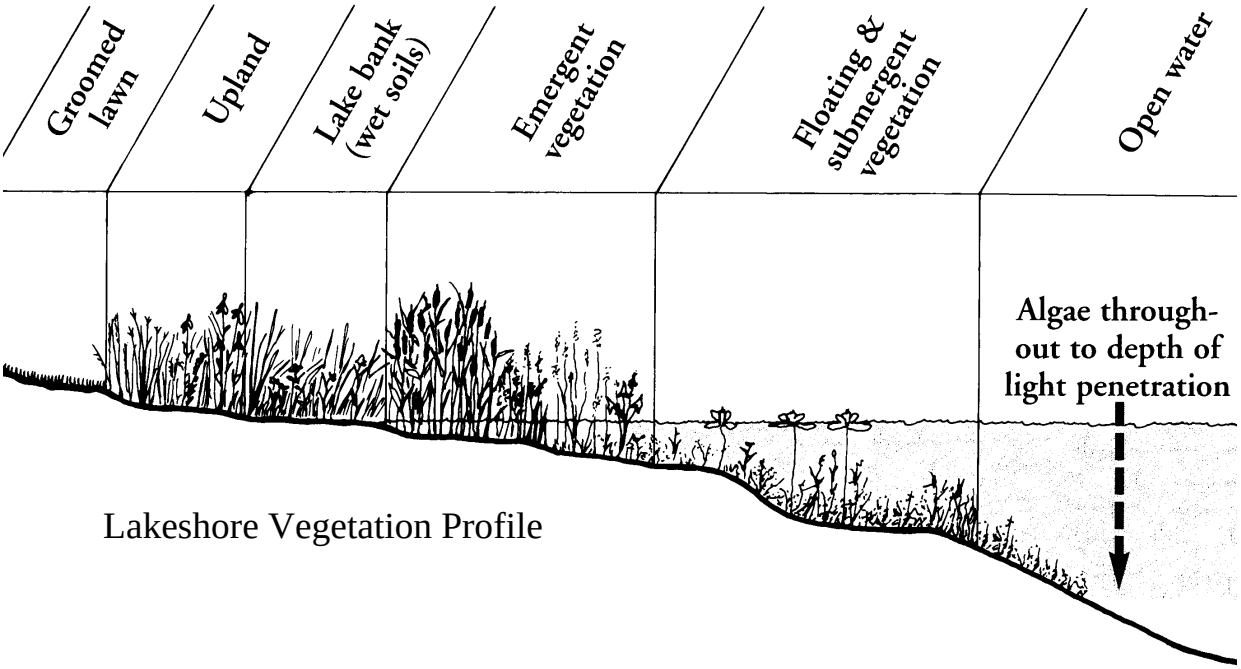


Figure 3. Littoral region of a lake from lake bank to maximum depth of rooted plants.

The most extensive literature on fish-habitat relations and effects of habitat alterations on fish populations is from streams where two general areas relevant to shoreland management have been particularly well studied, including the role of complex in-water habitat and the role of riparian vegetation. Many of the concepts developed in stream systems are equally relevant to lake systems. The importance of structurally complex habitat has been demonstrated to affect a wide range of fishes and other stream biota, including salmonids (reviewed by Marcus et al. 1990), insects (Minshall 1984), and salamanders (Hawkins et al. 1983). Woody material and complex bottom substrates directly provide cover and habitat for food production and also affect the hydraulics that shape the stream channel (Hawkins et al. 1993). Angermeier and Karr (1984) demonstrated that removal of complex woody habitat on one-half of a warmwater stream led to a reduction in the number of fish, while no change was observed in the other half, where no habitat was removed. Schlosser (1982) observed similar results in a comparative study of two warmwater streams, one of which was subject to modifications including removal of riparian vegetation and channel straightening. Removal of complex substrates from streams not only eliminates spawning habitat and refuge cover but also changes the processes (hydraulics, channel formation) to which natural communities are adapted.

Activities in the riparian zone can also affect the habitat available to fish by directly eliminating overhanging cover, removing shade that moderates temperature regimes (reviewed by Marcus et al. 1990), and limiting the source of woody material (Christensen et. al., 1997). Ecologically, the shoreland, or riparian zone, is a living bridge between interdependent aquatic and terrestrial worlds. Shallow near-shore waters, known as the littoral zone in lakes, are the most biologically productive part of lake ecosystems. Stream, lake, and wetland ecosystems are inextricably linked to adjacent uplands through both structural habitat and food chain connections between the aquatic system and the riparian area. The role of habitat in the maintenance of healthy fish and aquatic life is as important as the role of water quality. Riparian zones have unique physical and biological conditions that allow them to host a great variety of wildlife. The shoreland buffer is intended to protect the habitat of both species that are totally aquatic, such as fish; and those that rely on the unique habitat found in riparian areas, such as waterfowl, fish-eating birds, amphibians and reptiles, and mammals.

There are many different types of habitat found in a shoreland buffer and many different ways in which the shoreland buffer affects aquatic systems. Along larger rivers, wetland complexes such as floodplain forests are found with many associated backwater sloughs and ponds that host a wide variety of habitats for amphibians, reptiles, birds, mammals, and fish. Smaller rivers and streams with narrower floodplains flow through a wide variety of vegetative communities, from large upland forests to large wetland complexes composed of meadow, shrub, and forest communities. In agricultural landscapes, riparian corridors along streams may be fairly narrow or nonexistent. Smaller river-edge wet meadows (sometimes referred to as backswamps) lie in the floodplain. Similarly, lakeshore topography varies from steep cliffs and slopes, to gently sloping uplands, to flat wetlands, and vegetation displays varying combinations of forest, shrub, or herbaceous cover. The enormous variety of habitat types created by the combination of topography, soil, and vegetation along shorelines leads to a wide variety of ways in which habitat functions are performed along different shorelines.

Large Woody Cover

Coarse woody material in the littoral zone protects lakeshores. The material blunts waves and ice action that scour the lake bed and keep seeds from sprouting or shoots from rooting. Lorang and Stanford (1993) measured shoreline reconfiguration along a forest and beach zone on Flathead Lake, northwestern Montana. Their study site was perpendicular to the lake's maximum fetch of 33 km. Shoreline morphology and vegetation determined the type of erosion process and the rate of shoreline retreat. Shoreline retreat was offset by localized and dramatic accretion caused by sediment entrapment by drift logs bordering the shoreline. Drift logs naturally protected the shoreline from direct wave attack and stimulated sediment accretion, providing new recruitment area for riparian vegetation. The density of wood drift logs (>5cm) at 0.5 m depths along undeveloped northern Wisconsin lakes averages 555 logs/km of shoreline, whereas wood logs along dense residential -developed shorelines are essentially absent (Christensen et al. 1996). Drift logs may accumulate along northeast and east shorelines in greater density (Guyette and Cole 1999), given prevailing wind conditions. This natural and compensatory shore protection can result from greater recruitment rates of drift logs along these exposed shorelines.

Tree-falls and woody cover is a dynamic and ancient component of nearshore aquatic habitat of lakes. Tree-falls are not a static structural component of lakes, but are dynamic, with typically slow input and depletion rates. How long woody material lasts in water depends on the size and type of wood, water temperature, and sedimentation rate (Harmon et al. 1986; Bilby et al. 1999). Logs outlast branches, red cedars (*Juniperus virginiana* L.) outlast birches (*Betula*), and buried or water submerged wood outlasts exposed wood. Conifer species contain higher levels of compounds that retard decomposition of there heartwood (Scheffer and Cowling 1966). Guyette and Cole, 1999) used dendrochonological methods to analyze age characteristics of eastern white pine in the littoral zone of Swan Lake, Ontario. Eastern white pine decays very slowly; the average date of the outer rings of sampled Swan Lake white pine logs was year 1661, and residence time in the littoral zone ranged between 100 to 900 years. Decay rates increase with water temperature, especially in aerobic environments.

Adding new woody material or uncovering old material is needed to maintain prey density and fish refuge sites (Harmon et al. 1986).

Woody cover, known as *snag habitat* in streams because it traps a variety of drifting particles, the material in lakes collects sediment and becomes coated with algae and detritus (animal and plant remains) that macroscopic invertebrates consume (Harmon et al. 1986). Woody material thus supports high densities of midge (Chironomidae) larvae and pupae, including species that tunnel into bark or the heartwood of submersed pulpwood logs. Although few aquatic insects are known to eat wood (Harmon et al. 1986), their tunneling hastens decomposition by fungi (Basidiomycetes) and bacteria (McLachlan 1970).

Removing woody material by dragging submerged trees and stout logs onto shore can trample lakeshore vegetation and the nests of fishes and shorebirds. Shore erosion can increase directly from shore damage and indirectly from wind and wave action on the newly exposed shore. Water turbidity then increases from shore erosion and particles of soil and wood falling off the material into the water. In extreme cases, stirring bottom sediments during woody material removal can raise biochemical oxygen demand enough to deplete dissolved oxygen (Sproul and Sharpe 1968), killing sedentary invertebrates.

Studies of the water quality impacts of lakeshore development point to the importance of reducing the cumulative impact of lakeshore development, both in terms of the impacts to habitat and in terms of phosphorus loading. A study in Maine (Dennis 1986) of paired watersheds of similar size and physical characteristics compared an undeveloped, forested watershed to an adjacent watershed with 40% forest and a subdivision developed with one acre lots. The more developed watershed showed an increase of

720% in phosphorus export, the main nutrient of concern in lakes because of its role in the eutrophication process.

Landowner practices, in terms of construction activities and yard-care practices, will greatly affect the ability of the shoreline buffer to trap and retain sediments, nutrients, and toxicants. On average, the typical lakeshore or streamshore home setting can be expected to have a smaller contributing area and considerably less soil disturbance than the agricultural or logging activities which most of the buffer research has evaluated. However, research studies typically assume an unbroken buffer, and the current shoreland standards allow for a clear-cut area along the shoreline. If this area is highly disturbed and runoff flow begins to be channelized through it, sediment trapping and nutrient retention functions will be lost. Other site circumstances that can reduce the effectiveness of the 35-foot shoreline buffer for runoff pollution control are erodible and fine-grained soils, steep slopes, construction disturbance, large impervious surfaces or compacted soils, and heavy use of fertilizers and pesticides.

When shoreland vegetation is disturbed or removed by human activities, aquatic plants and animals will be affected by elevated sediment, nutrient, and toxicant loads. A recent study modeling land use pattern and topography in the Lake Mendota watershed found that increases in phosphorous loading were strongest with conversions of undisturbed riparian (shoreland) areas to either urban or agriculture uses (Soranno, et al 1996). Toxic materials, such as pesticides, herbicides, and heavy metals, can cause acute mortality of aquatic life. Most commonly, however, they cause chronic effects by affecting reproduction and degrading habitat.

Preserving wetlands maintains an essential water quality buffering agent for associated lakes and streams. The water quality function of a wetland is closely tied to its position in the landscape and on the wetland type (Brinson 1993, Beilfuss and Siebert 1996). Wetlands that have organic soils, saturated soil or shallow water depths, and longer retention times experience the predominantly anaerobic (oxygen-free) conditions needed for nutrient transformation. In addition, those that have dense vegetation and are located between upland pollutant sources and lakes and rivers, offer the greatest amount of sediment and nutrient retention. These types of wetlands, such as sedge meadows, fresh wet meadows, wooded swamps, and shallow marshes, have both the opportunity and advantageous soil conditions to facilitate the processes of denitrification, sulfate reduction, and transformation of nutrients to more soluble forms for plant uptake. Wetlands can permanently remove metals and organic compounds if they remain adsorbed to sediments and the sediments eventually become buried below the root uptake zone of wetland plants (Elder 1987).

The Submergent Plant Community and its Biota (Birds, Mammals, Fish, Amphibians, Reptiles, Invertebrates, Endangered, Threatened, and Species of Special Concern)

Habitat preferences differ among fish species. Inshore fish sampling in Lake St. Clair found 11 species along wetlands, 10 species along undeveloped shores, 6 species along developed shores, and 5 species along beaches (Brazner and Magnuson 1994). Bluegills (*Lepomis macrochirus* Rafinesque) and black bass in this lake preferred altered (dredged and bulkheaded) shores, whereas minnows and darters (*Etheostoma* and *Percina*) preferred unaltered shores (Poe et al. 1986). In lakes with sparse rooted vegetation, more nearshore fishes use rocky and bouldery shores than use sandy and gravelly ones (Emery 1978, Beauchamp et al. 1994). Only occasionally do sandy and rocky shores attract more fishes, if fewer species, than bouldery or well-vegetated shores (Guillory et al. 1979).

Plant habitat attracts fishes in variety and abundance. Plant beds harbored 11 fish species—beach habitat, only seven species—in central Florida's Lake Conway (Guillory et al. 1979). Plant cover was positively

correlated ($P < 0.05$) with fish abundance in Florida's Lake Okeechobee (Chick and McIvor 1994), Iowa's Spirit Lake (Bryan and Scarnecchia 1992), and 25 central Ontario lakes (Hinch and Collins 1993). Plant species diversity was positively correlated ($P < 0.05$) with fish species diversity among six Wisconsin lakes, especially when depth was considered (Benson and Magnuson 1992). Plant beds enable bluegills and pumpkinseed sunfish to coexist despite predation pressure from largemouth bass (Mittelbach and Chesson 1987).

Many small fishes seek plant beds as refuge from predators but will use piers, boulder spits, rock outcrops, and woody material especially when plant beds are scarce. Young fishes, including those of black bass and northern pike (*Esox lucius* L.), hide among thick foliage when piscivores (fish eaters) are present but stay outside thick foliage or seek sparse foliage when such predators are absent (Johnson et al. 1988, Lynch and Johnson 1989). Stocked fingerling muskellunge use emersed, floating-leaf, and submersed foliage as nursery areas for hiding and feeding (Hanson and Margenau 1992). Log perch (*Percina caprodes* [Rafinesque]) and mottled sculpins (*Cottus bairdi* Girard) seek crevices between rocks and boulders in lakes with sparse vegetation. Rock bass (*Ambloplites rupestris* [Rafinesque]) seek underwater brush piles by day but leave them by night (Rodeheffer 1940).

Some large fishes are also attracted to plant beds. Adult muskellunge (*Esox masquinongy* Mitchill) and northern pike with ultrasonic transmitters have been tracked to plant beds, especially pondweeds on sunny days (Crossman 1977, Diana et al. 1977). Largemouth bass switch hunting tactics from cruising to ambushing prey as plant density increases (Savino and Stein 1989). Even walleyes (*Stizostedion vitreum* [Mitchill]) cruise plant beds for such prey fish as yellow perch (Engel 1997).

Fishes also seek boulder spits, rock outcrops, and woody material for prey, though fish species differ in what prey they capture. Specialized feeders like black crappies (*Pomoxis nigromaculatus* [Lesueur]) select a few small prey, such as midwater zooplankton, whereas more generalized feeders (opportunists) like bluegills select a broad array of larger prey, such as bottom- or plant-dwelling midge and caddisfly larvae (Keast 1970). Plant-dwelling rock bass and pumpkinseed sunfish (both 2.2–3.7 inches in total length) in Lake St. Clair ate insects on or beneath plant shoots, though rock bass took fewer but larger ones than did pumpkinseed sunfish (French 1988).

A Wisconsin shore protection study found that fish were significantly affected by shoreline type. Fish and habitat were measured in 354 shoreline sites. Because habitat attributes were measurably different among the shoreline types and because fish respond to habitat, fish distribution also differed among the three types of shorelines. Differences in species richness, as well as abundance of fish with taxonomic or functional groups were related to features of habitat such as aquatic vegetation, overhanging cover, particle size of bottom material, level of embeddedness of interstitial spaces of bottom material, and water depth. As result of these relationships, the number of species found at shoreline sites with rock riprap was greater than the number found at other sites. Groups of fishes that were more abundant at rock riprap included intolerant species (fishes sensitive to degradation of habitat), benthic fishes (darters, sculpins, and other fishes that are usually found on the lake bottom) and some centrarchids.

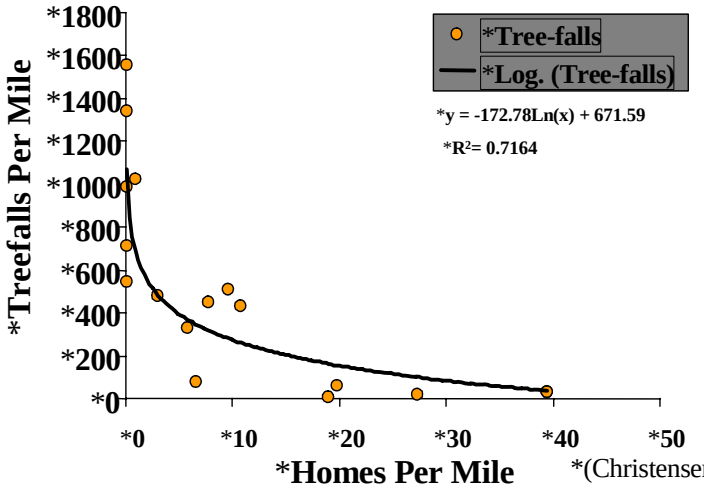
The differences in fish community structure and abundance occurring among shoreline types were statistically significant. These differences were detected despite considerable variation in sampling season, geographic region, lake type, and the fish community in a particular lake. In other words, the results clearly reflected robust differences that persisted under a wide range of conditions.

Some fishes can shift diet and habitat as food competition and prey availability change (Mittelbach 1983). For example, bluegills shift to eating smaller prey as large ones dwindle during summer (Mittelbach 1981) and shift from plant-dwelling prey to open-water ones when bottom-feeding pumpkinseed sunfish

are present (Werner and Hall 1977). They also shift to open-water or bottom-dwelling prey when the plant beds or woody material they inhabit are decimated (Bettoli et al. 1993), though small bluegills then face increased predation.

The value of plant beds to fishes differs with plant density. Dense plant beds in aquaria (46 stems/ft^2), for example, afford age-0 bluegills (1.7–2.5 inches in total length) maximum protection against fish predators but hinder bluegill feeding on insects (Gotceitas 1990*a*). Plant beds of modest density (10 stems/ft^2) afford plant-dwelling bluegills a better compromise between food and safety (Wiley et al. 1984). However, age-0 bluegills(>2.0 inches in total length) kept for 117 days in lake enclosures differing in artificial plant density (0, 37, 89, and 324 stems/ft^2) showed no significant ($P > 0.05$) difference in growth (Hayse and Wissing 1996), because the bluegills could eat zooplankton outside the plants and dart for cover when threatened.

Fish use of woody material varies with the type and arrangement of material and the age and species of fishes (Wege and Anderson 1979, Moring et al. 1986). Bluegills prefer woody material built of evergreen trees to brush piles, especially when the trees are compacted (Johnson and Lynch 1992). Tree tops sunk with cinder blocks attract bluegills and largemouth bass mostly shorter than 5.9 inches in total length (Graham 1992). Adult largemouth bass also visit woody material as well as piers but seldom linger (Prince and Maughan 1979, Colle et al. 1989). Male smallmouth bass (*Micropterus dolomieu* Lacepède) in Wisconsin lakes, however, excavated nests near logs and boulders for their own cover and that of newly hatched fry (Baylis et al. 1993). Largemouth bass in an Arkansas reservoir preferred to nest in coves with artificial brush piles, though smallmouth bass showed no such preference (Vogele and Rainwater 1975). However, similar to aquatic plants and shoreland habitat the amount of woody material and tree falls decreases as development increases, thereby decreasing fish and animal habitat (Figure 4; Christensen et al. 1996).

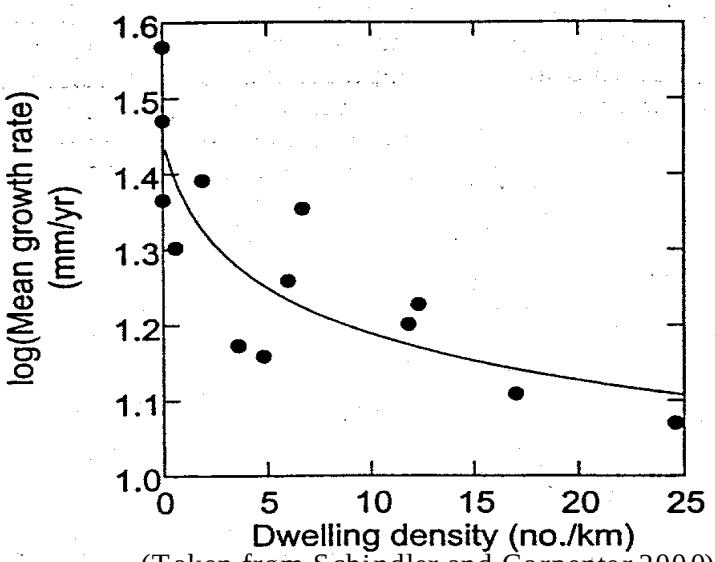


*(Christensen et al. 1996)

Figure 4. Impacts of Residential Development on Treefalls into Lakes.

Removal of fallen trees even can affect bluegill and bass populations. Schindler and Carpenter (2000) examined largemouth bass and bluegill growth across a residential development gradient in 14 lakes near Boulder Junction, Wisconsin. Growth rates of bluegill in lakes surrounded by cottages were slower, by one-third, than growth rates of bluegill in lakes with no cottages around the shore (Figure 5). Bluegill populations of undeveloped lakes were more than twice as productive as those of lakes surround by

cottages. Largemouth bass growth showed similar trends, but were not as clear-cut as those for bluegill, however. The main habitat change associated with these lakes are up to ten-fold declines in tree-falls (these nutrient-poor lakes contain few aquatic plants) as a consequence of cottage development.



(Taken from Schindler and Carpenter 2000)

Figure 5. Development Impacts on Bluegill Growth Rate.

Floating-Leafed and Emergent Plant Community and its Biota (Birds, Mammals, Fish, Amphibians, Reptiles, Invertebrates, Endangered, Threatened, and Species of Special Concern)

Emergent and floating plants are important habitat elements for fishes. These plants provide surfaces on which periphyton and invertebrates colonize, affecting availability of food for fishes, and also provide hiding cover. Tonn and Magnuson (1982) and Benson and Magnuson (1992) found that species richness increased with increasing macrophyte diversity in littoral regions of lakes.

While the role that macrophytes play in the ecology of fishes is generally understood, few studies have addressed how specific attributes of macrophyte morphology influence habitat use by fish. Quantification of macrophyte density using these three categories was based on broad morphological and functional (i.e., relative to fish usage) similarities found in aquatic plants within each of these categories (see Hotchkiss 1972). Floating macrophytes such as pond lilies (e.g., Lemna sp., Nuphar sp., and Nymphaea sp.) provide shading and overhead cover that attract certain species of fish (Helfman 1979), but their narrow and widely spaced (or absent) stems provide little lateral underwater structural cover or complexity. Emergent vegetation, such as sedges and bulrush (e.g., Scirpus and Carex sp.) also have long slender stems but are more closely spaced than floating vegetation because they have no floating leaves that reduce available sunlight. As such, they would provide little overhead cover, but provide some lateral underwater cover. Many species of submersed vegetation such as broad-leafed Potamogeton spp. and narrow-leaved submergents such as Myriophyllum sp. and Ceratophyllum sp. provide both lateral underwater and overhead cover.

Several amphibians also use the shallow littoral zone for breeding, foraging, metamorphosing and overwintering. Development of lakeshores often degrades these habitats for these species in a number of ways. The loss of emergent and floating vegetation coupled with the loss of coarse woody material (CWD), reduces egg deposition structure and may concentrate egg deposition to unaffected areas, potentially increasing predation rates on eggs and larvae at those sites. Flat eggs masses laid on the

surface and attached to floating vegetation are more susceptible to being fragmented by wave action when plant densities are reduced and subsequently can wash ashore where they perish. In a study that compared habitats between developed and undeveloped lakeshores, Meyer (1999) found that in the shallow water areas, percent cover of floating vegetation was significantly greater at undeveloped compared to developed sites.

The relative amount of CWD was significantly greater at undeveloped sites, compared to developed sites (Figure 4). The majority of undeveloped sites contained an abundant amount of CWD, while the majority of developed sites contained no CWD. Downed trees and floating logs are used for basking by Blanding's, musk, map and painted turtles. If these structures are removed because of development, turtles are forced to either concentrate in suitable habitat or bask on the shore--which often makes them more susceptible to predation due to exposure and the inability to quickly escape into deep water.

Shoreline Edge and Bank and its Biota (Birds, Mammals, Fish, Amphibians, Reptiles, Invertebrates, Endangered, Threatened, and Species of Special Concern)

Amphibians are a crucial link between aquatic and terrestrial ecosystems because of their significant contribution to the vertebrate biomass of these systems. In many aquatic habitats, freshwater turtles represent the majority of the vertebrate biomass (Congdon et al. 1986). Because of their large biomass and their movement between terrestrial and aquatic systems, amphibian populations can influence important ecosystem functions such as primary and secondary productivity, nutrient influx, and competition (Seale 1980, Osborne and McLachlan 1985, Cunningham and Brooks 1995).

Most of Wisconsin's amphibian species and many of the reptile species rely on riparian habitat in some way. Riparian habitat quality is critical for those species that are considered shoreline dependent including two endangered herptiles. Five frogs and two reptiles are considered shoreline-dependent species in Wisconsin because they spend most or all of their life history in a relatively narrow band which includes both near-shore aquatic habitat and the near-shore riparian habitat (Vogt 1981, Oldfield and Moriarty 1994). The frog species include: Blanchard's cricket frog, a state endangered species, the bullfrog and pickerel frog, both special concern species, and the green and mink frogs. The two reptiles include the queen snake, a state endangered species, and the northern water snake.

Although habitat requirements for these frog species vary somewhat, most require moist soil and moderate to dense vegetative cover in the immediate shoreline area. These features provide a cooler microclimate and cover for predator avoidance. Bullfrogs and green frogs spend much of their time basking, resting, or foraging in fringe wetlands with tall dense cover, or in tall grassy cover along the shoreline (Flemming 1976). Mink frogs spend most of their time in shallow near-shore water, especially near the inlets and outlets of northern lakes and streams, resting on floating mats of vegetation. All 12 Wisconsin's frog and several salamander species lay their eggs in shallow water among submerged or floating vegetation or attached to coarse woody material, primarily to submerged tree branches. The larvae or tadpoles of these species prefer to live in shallow water that is structurally diverse because it offers cover for predator avoidance and because this structure supports their food sources (i.e. algae and invertebrates).

Woodford and Meyer (Figure 6; In Press) found that adult green frog populations were significantly lower on lakes with varying degrees of shoreline house and cottage development than lakes with little or no development. A negative linear relationship existed between shoreline development densities and the number of adult green frogs (Figure 6).

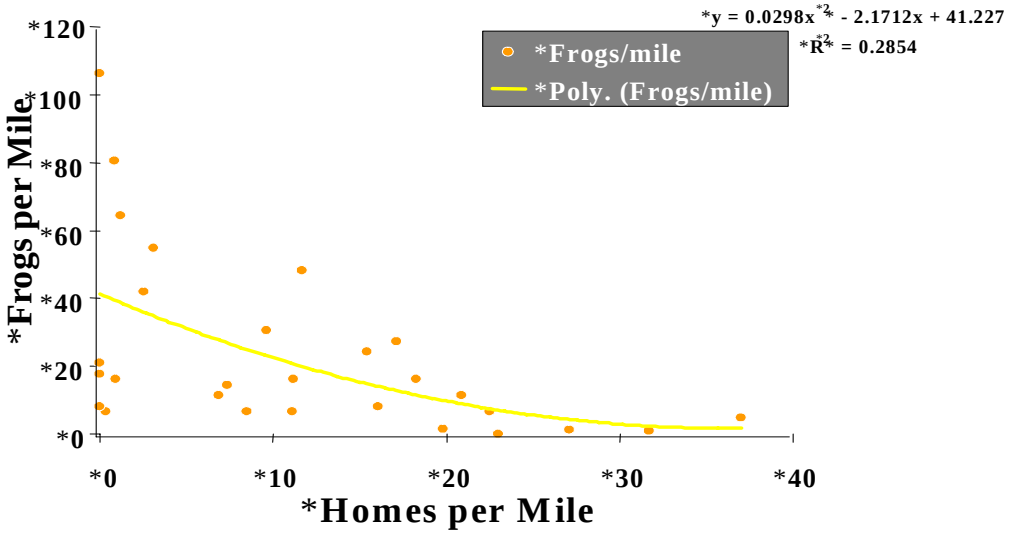


Figure 6. Response of Green Frog Populations to Lakeshore Residential Development

Thus, suggesting that greater development densities significantly decrease breeding habitat, resulting in lower adult green frog abundance. These and other findings suggest that current shoreline protection measures are not protecting sensitive amphibian species.

Changes to lake fringe habitats associated with lawns also reduce the usage of the nearshore edge (<.2 m depth) by small fish. Collins et al. (1997 Midwest Fish and Wildlife Conference, Milwaukee) monitored fish use (traffic levels and feeding rates) using underwater video cameras along the nearshore edge for small oligotrophic Ontario Lakes. These unproductive shield lakes contain sparse vegetation along the lake fringe. Daytime small fish traffic levels were 2.5 times higher in undeveloped than in developed sites. Feeding rates were eight times higher in undeveloped than in developed sits. Effects of development were less marked during dawn and dusk.

Eutrophication and Water Quality

Studies of the water quality impacts of lakeshore development point to the importance of reducing the cumulative impact of lakeshore development, both in terms of the impacts to habitat and in terms of phosphorus loading. A study in Maine (Dennis 1986) of paired watersheds of similar size and physical characteristics compared an undeveloped, forested watershed to an adjacent watershed with 40% forest and a subdivision developed with 1-acre lots. The more developed watershed showed an increase of 720% in phosphorus export, the main nutrient of concern in lakes because of its role in the eutrophication process described below.

When shoreland vegetation is disturbed or removed by human activities, aquatic plants and animals will be affected by elevated sediment, nutrient, and toxicant loads. A recent study modeling land use pattern and topography in the Lake Mendota watershed found that increases in phosphorous loading were strongest with conversions of undisturbed riparian (shoreland) areas to either urban or agriculture uses (Soranno, et al 1996). Toxic materials, such as pesticides, herbicides, and heavy metals, can cause acute mortality of aquatic life. Most commonly, however, they cause chronic effects by affecting reproduction and degrading habitat.

Studies of Cumulative Water Quality Impacts

One technique to measure the relative eutrophication of a lake is to measure the rate at which water in the hypolimnion of a lake basin loses oxygen and the volume of anoxic water in the hypolimnion. Water quality problems associated with eutrophication are indicated by a greater relative volume of anoxic water in the hypolimnion. A study on a single forested, hourglass-shaped lake in northern Wisconsin, with two distinct basins of sharply differing levels of development, found that the more developed basin had a larger volume of anoxic water than the lesser developed basin, the opposite of what the physical conditions in these two basins would predict (Ganske 1990). A 20-year study of a Michigan lake with three distinct basins used similar oxygen deficit methodology to track the rate of eutrophication at ten year intervals. The most developed basin was found to be the most eutrophic (greatest oxygen deficit) over time, and a lesser developed basin had a consistently lower oxygen deficit, while one basin showed wide anomalous fluctuations (Lind and Davalos-Lind 1993). Two basins showed an increasing rate in eutrophication during the time period of the study (1971 to 1991). By extrapolating their data backward and comparing with a measure of eutrophication in 1922, the authors approximate that the rate of eutrophication began increasing in about 1950, coincident with an increase in summer home construction during the postwar economic boom.

These two studies are insightful because they were able to control for some of the many variables besides the level of shoreland development that also influence water quality in lakes by looking at separate basins of the same lake. Even in these studies however, some physical factors such as the shape, size, and orientation of the basin interact with level of shoreland development to determine water quality.

Modeling studies of sediment and nutrient delivery to two different lakes in northern Wisconsin also show increases of from 200% to 700% in phosphorus loading as lots are cleared and developed (J. Panuska, Wisconsin Department of Natural Resources, to P. Sorge, internal memorandum Nov. 16, 1994; E&S Environmental Chemistry, Inc. 1992). Dillon, et al. (1995) found that phosphorus delivery from on-site sewage disposal systems associated with shoreline development accounted for a significant portion of the observed total phosphorus level in four Ontario lakes. On two of the lakes with thinner soils all total phosphorus transported into and out of septic systems reached the lakes. About one-third of the total phosphorus from septic systems reached the third lake, which had a thicker layer of till/soil, while the fourth lake was undeveloped. Weber (1994) found significantly greater nitrogen and phosphorus concentrations in the seepage water, sediment, and plant tissues in the near-shore waters of Legend Lake, along shorelands with septic systems where groundwater flowed toward the lake, compared to groundwater outflow sites and sites with no septic system.

The amount of phosphorus loading can be reduced by best management practices directed to minimize soil compaction and control erosion and sediment delivery during construction. However, it is clear from these studies that more densely settled shorelands can contribute greater phosphorus loading.

Paleolimnological studies offer the opportunity to look at a historical record that documents the response of a lake to land-use changes in its watershed. This technique involves taking sediment cores from the lake, dating core layers, and examining the chemical and fossil record preserved in the cores. A sharp increase in the sedimentation rate soon after European settlement and clearing for agriculture, logging, or town establishment in the watershed has been thoroughly documented throughout Wisconsin (E&S Environmental Chemistry, Inc. 1992, Garrison 1993, Garrison and Hurley 1993). Although each lake has a unique history, these studies all show increasing water quality degradation related to increased phosphorus loading, starting in the 1960s and 1970s, and continuing to the present, apparently related to increasing levels of lakeshore development.

The record for Lake Ripley, a highly developed lake in a watershed that is shifting from agricultural to residential land use, showed a slight decrease in phosphorus in the 1960s when land was beginning to be

taken out of agriculture for homesite development, but since the mid-1970s, phosphorus loading has increased even though the rate of erosion in the watershed has decreased (Garrison 1993). The author concludes that lakeshore homes are now the largest source of nutrient loading to the lake. The record for Lac La Belle, shows that lake productivity (excessive productivity is an indication of eutrophication) dropped for a time after sewer installation in 1980, but has begun to increase again in recent years, with recent phosphorus concentrations at levels similar to those just prior to sewer installation (P. Garrison, Wisconsin Department of Natural Resources, letter to L. Conley, Sept. 6, 1995). This suggests that providing sewer service to lake subdivisions, while providing major water quality benefits, does not control all the important sources of phosphorus to a lake. The benefits of sewer service may be offset by increases in phosphorus loading and habitat degradation due to increased residential density.

By way of contrast, deep sediment in Little Bearskin Lake, a lightly developed lake in Oneida County with 12% residential development, has not shown an increase in phosphorus concentration in the last century (Garrison and Winkelman 1995). Although phosphorus loading has likely increased, phosphorus appears to be taken up by aquatic plants along the shoreline. This has resulted in a less diverse but denser aquatic plant community with increased density of coontail, which is becoming a nuisance to lake homeowners at some sites.

Differences between cores from two nearby lakes demonstrate the importance of lake and watershed characteristics in determining how a particular lake's water quality is affected by land-use changes. Garrison (in press) compared the cores of Long Lake, a deep 1,050-acre stratified drainage lake, to nearby Round Lake, a 215-acre softwater shallow seepage lake that does not stratify. Long Lake water quality began to decline in the 1880s in response to added sediment and nutrients delivered to the lake by inflowing streams, caused by erosion from logging in the watershed. Round Lake was not as affected by the initial land clearing, because its lack of inflowing streams meant that it did not receive as large a nutrient load. However, water quality has declined in recent years, evidenced by a profound change in the algal community. The increased nutrient loading is most likely the result of cottage development around the shoreline. Today, Round Lake suffers from algal blooms during years of high rainfall while Long Lake does not.

This comparative study has some important implications for lake planning because it lends support to the notion that smaller, shallower seepage lakes are likely to receive a larger portion of their nutrient inputs from the immediate shoreland, while drainage lakes receive a larger portion of their inputs from the larger watershed (Shaw et al. 1994). This implies that shoreland zoning along lakeshores, as a water quality tool, may be more effective in buffering seepage lakes. However, any measure that can reduce phosphorous loading to any lake type will contribute to water quality. Buffers along streams, along with other best management practices, are essential to control nutrient inputs to drainage lakes and impoundments, especially in agricultural watersheds.

The Need

The growing interest in land use and demand for waterfront property has been a catalyst for review of the effectiveness of NR115. Most studies suggest that under ideal site conditions current standards may only meet minimums for controlling runoff of sediments and nutrients. The 35-foot buffer, if it contains undisturbed vegetation, will provide only minimal habitat for some species (T. Bernthal, J. Barrett, S. Jones, DNR Publ-WT-505-97 & Publ-WT-508-97).

As more and more of us move near the water, we change the shore area’s natural features by building structures and removing the natural vegetation. We slowly but surely change the very nature of the lake ecosystem. Small seasonal cabins are being converted to large year-round homes, increasing their impact to the shores and lake.