MANAGEMENT OF AQUATIC VEGETATION IN PUBLIC LAKES AND RESERVOIRS
INDIANA DIVISION OF FISH AND WILDLIFE

Legal jurisdiction and objectives

The Division of Fish and wildlife (DFW) aquatic vegetation management philosophy is driven by laws under IC 14-22-9-10 and 312 IAC 9-10-3 and general vegetation management objectives adopted by the Division of Fish and Wildlife as follows:

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.
2. Direct efforts to prevent and/or control the negative impacts of aquatic invasive species.
3. Provide reasonable public recreational access while minimizing the negative impacts on plant, fish, and wildlife resources.

The purpose of this document is to present the scientific basis for ecological/biological positions taken by the Division of Fish and Wildlife.

Abstract

Because of the close relationship between aquatic macrophyte communities, water quality and clarity, and the fish species present, biologists and managers must be aware of the effects that aquatic vegetation control will have on the integrity of the lake or impoundment they are managing. Too much or too little aquatic macrophyte growth can result in algae blooms and many other problems. Optimal vegetation management goals on a given lake should be driven by the type of fish community being maintained. Bluegill require greater than 50% littoral zone vegetation coverage; largemouth bass require less than 50% coverage; northern pike require between 40 and 90% coverage; yellow perch require greater than 40% coverage; crappie require less than 30% coverage. Walleye and hybrid striped bass are maintained by stocking; therefore, their management has relatively little to do with aquatic vegetation coverage. Although muskellunge are stocked, their ability to forage successfully is dependent on their ability to hide in submersed vegetation. Aquatic vegetation coverage of more than 40% would most likely allow for a healthy population of stocked muskellunge. For most lakes, 50% littoral zone aquatic plant coverage seems to provide the best balanced aquatic habitat for most fish species.

Benefits of healthy aquatic plant communities

The aquatic macrophytes within the riparian and littoral zones provide more than just cover for fish, invertebrates, and terrestrial mammals, they also provide food for waterfowl, crayfish, and many other species, both aquatic and terrestrial (Carpenter and Lodge 1986; Weisner et al. 1997; Jones 2004). The plants of the riparian littoral zone filter out sediments and nutrients from runoff, stabilize lake sediments, and reduce erosion caused by waves on the shoreline (Howard-Williams 1981; Wilson and Keddy 1986; Randall et al. 1996; Höök et al. 2001). Currently, Indiana lakes and impoundments are managed for a variety of sport fish species including largemouth bass, bluegill, muskellunge, northern pike, walleye, hybrid striped bass, trout, and cisco. Because of the close relationship between aquatic macrophyte communities, water quality and clarity, and the fish community, biologists and managers must be aware of the effects aquatic vegetation control will have on the ecological integrity of the lake or impoundment they are managing.

Risks and benefits of aquatic plant management

With any method of control, chemical, mechanical, or biological, there are associated risks and benefits to the ecosystem of the lake. Macrophyte decay resulting from herbicide treatments causes a release of dissolved substances (including phosphorus), deoxygenation, and sediment accretion (Carpenter and Lodge 1986). The release of phosphorus and other nutrients into the lake is in turn assimilated by algae, which can lead to blooms and may decrease aesthetics and recreational use in the lake. The increase in nutrients in the open water may also cause a decrease in macrophyte production due to shading by algae (Barko et al. 1986; Morris et al. 2003a). Decreases in macrophyte production, in turn, can lead to less available habitat for fish that use the vegetated littoral zone (Carpenter and Lodge 1986).

When vegetation is removed through mechanical harvesting, phosphorus recycling from the sediment and available cover for fish is decreased (Carpenter and Lodge 1986; Morris et al. 2003b). The decrease in macrophyte biomass can result in a decline in fish biomass, causing an increase in zooplankton abundance and a commensurate decrease in phytoplankton, leading to an overall decline in the productivity of the lake (Carpenter and Lodge 1986). Mechanical control without harvesting can lead to fragmentation of macrophytes, which may allow new infestations of exotic species or new colonizations by natives elsewhere in the lake. Biological control typically refers to the introduction of grass carp, but in recent years, some experimental forms of control have been introduced (i.e., weevils for Eurasian watermilfoil control). The DNR requires a permit to stock any fish species in public waters, but non-nuisance species stocking in private waters are not regulated. Permits for stocking grass carp into public natural lakes are denied because of their potential adverse affects on native vegetation, but for private waters, lake managers may wish to stock grass carp based on the vegetation problem. For other methods of experimental biological control, it is up to the lake manager to determine the appropriate control methods.

Since all of these control methods carry some amount of risk and benefit to the ecosystem (van Nes et al. 2002), it is the responsibility of the lake manager to determine how much control is necessary and balance that with protecting the ecological integrity of the lake or reservoir. In order to do that, the manager must understand the processes and interactions that occur within the littoral zone and the effects of changing one piece of the system (i.e., the aquatic macrophytes).

Effects of aquatic vegetation on human uses of lakes and reservoirs

Lakes in both urban and agricultural watersheds are common throughout Indiana. Urban watershed lakes typically fulfill multiple, conflicting functions, including but not limited to drinking water supply, storm-water retention, flood mitigation, aesthetics, and recreation (Morris et al. 2003b). Lakes that are used for storm-water retention are usually prone to nutrient enrichment and contamination from heavy metals, hydrocarbons, and other pollutants. Agricultural watershed lakes typically serve the primary functions of flood control, water supply for livestock, wildlife habitat, recreation, and aesthetics. Because of the agricultural practices that take place within the watershed, they are also prone to nutrient enrichment that comes from animal waste and fertilizer runoff. The influx of nutrients into these types of lakes typically leads to eutrophication that allows aquatic macrophytes to proliferate and can cause algae blooms to occur (Crowder and Painter 1991). In the past few years, blue-green algae that produce taste and odor compounds have seriously impaired drinking water sources; concerns have increased about toxin-producing algae in water supplies and recreational lakes. Abundant aquatic macrophyte growth and prolific algae blooms on lakes also can impede recreation, and result in lake managers having to use mechanical or chemical methods in order to control aquatic vegetation and algae to improve the recreation and aesthetic quality of the lake. Managers and biologists reviewing permits for control of aquatic macrophyte communities should take into account the contribution of vegetation in the areas where control is to occur on the overall lake ecosystem (Crowder and Painter 1991).

While most of Indiana's lakes are located in either predominately urban or agricultural watersheds, there are a few lakes that do not fall into these two categories. These lakes typically have either a very small watershed or a watershed that contains mostly rural, forested lands with little agriculture. Typically, these lakes receive less nutrient enrichment from runoff and as a result, are considered oligotrophic. Unlike eutrophic lakes, oligotrophic lakes seldom have abundant aquatic macrophytes in the riparian littoral zone impeding lake access. Further, recreation and aesthetics are usually not affected and are typically better on oligotrophic lakes than eutrophic lakes. Oligotrophic lakes are deeper than eutrophic lakes and rarely have the same submersed vegetation problems because plant diversity is higher but plant density is lower with fewer plants that tend to canopy at the surface.

Since 1987, the Lake and River Enhancement (LARE) program has been amended to meet the shifting challenges facing aquatic resources in Indiana. Legislation in 2003 increased the scope of the LARE program by increasing boat fees (LARE's revenue source) to be used for sediment removal and control of exotic plants and animals. Applications for exotic aquatic vegetation management in public lakes are due annually by January 15. In 2006, a total of $682,265 in state cost share funds was distributed locally in 16 counties to support 45 aquatic plant management projects on over 70 lakes and reservoirs. Local sponsors are required to provide at least a ten percent match. Grants are competitive; requests total up to three times as much money as is available each year for LARE-funded projects.

Effects of aquatic vegetation on fish and wildlife communities

Several studies have been conducted in the last few decades that look at different types of lakes and debate the importance of the riparian littoral zone plant community and the effects of aquatic vegetation control on fish communities (Dibble et al. 1996; Maceina 1996; Hoyer and Canfield 1996a; Hoyer and Canfield 1996b; Barko et al. 1986; Carpenter and Lodge 1986; Carpenter and McCreary 1985). While it is generally known that aquatic vegetation is a necessary component of good ecosystem health, some of the studies that look at the relationship between aquatic macrophytes and fish are contradictory or have highly variable results. For instance, one study showed that shallow lakes less than 300 ha did not need any aquatic vegetation cover to produce a good population of largemouth bass in Florida (Hoyer and Canfield 1996). But, debate over the analysis in this study occurred and the other side pointed out that if the data were analyzed differently, according to lake size, it showed that age-1 largemouth bass declined from 100 fish/ha at vegetation coverages between 30 and 44% to 20 fish/ha when all vegetation was removed (Maceina 1996). In some Texas reservoirs, when submersed vegetation coverage fell below 20%, largemouth bass standing crop and recruitment declined (Durocher et al. 1984).

The importance of vegetation may increase under stressful environmental conditions. In a study in Alabama's Guntersville Reservoir, age-0 largemouth bass densities averaged 350 fish/ha in areas with submersed vegetation compared to 24 fish/ha in areas without vegetation during years with poor environmental conditions (Maceina 1996). So, if conditions in the water are poor (i.e., water is too warm, not enough dissolved oxygen) then submersed native vegetation may provide a "safe harbor" for species that become stressed during that time (Keast 1984;

Carpenter and Lodge 1986). That would be important in maintaining the fish community because according to Maceina (1996), bass production of less than 25 fish/ha will not likely sustain a viable fishery.

However, too much vegetation can have a negative impact on largemouth bass populations. Savino and Stein (1982) found that when the density of vegetation exceeded 250 stems/m^2, largemouth bass predation on bluegill was almost nonexistent, which led to decreased abundance and growth of bass. Similarly, in Lake Conroe, Texas, largemouth bass 100 mm and smaller did not prey on fish frequently at about 40% vegetation coverage, whereas, with no vegetation, bass 60 mm in length started frequently consuming fish (Bettoli et al. 1992). As a result, with no vegetation, bass grew faster than they did with about 40% vegetation coverage. So, as a general rule, largemouth bass growth rate increases with the removal of up to 80% submersed vegetation and abundance starts to decrease below 44% vegetation coverage (Trebitz et al. 1997). Unlike largemouth bass, when 30% of submersed vegetation was removed, bluegills exhibited the highest rate of growth. At more than 50% of vegetation removal, bluegill growth declined. Where submersed vegetation was not available for cover, young bluegill in Little Horseshoe Lake, Minnesota, used floating and emergent vegetation instead (Radomski et al. 1995). Based on these studies, when managing for largemouth bass and bluegill, it is best to maintain an intermediate amount (40 to 60%) of native vegetation in the lake or reservoir (Carpenter and Lodge 1986; Hoyer and Canfield 2001; Valley et al. 2004).

Most studies that evaluated the effects of aquatic vegetation on fish have shown that fish biomass is higher in vegetated areas than non-vegetated areas and vegetated sites have higher densities of fish, smaller fish, and greater species richness than non-vegetated sites (Crowder and Cooper 1982; Killgore et al. 1989; Randall et al. 1996; Weaver et al. 1997). In general, total yields of fish are positively correlated with the area of submersed vegetation; but, while fish production is lowered if vegetation is removed, foraging rates increase (Savino and Stein 1982; Crowder and Painter 1991).

Not only is the amount of vegetative cover important in the littoral landscape, but also the diversity of submersed plants. Chick and McIvor (1994) found that beds of different macrophyte types in Lake Okeechobee, Florida, comprised distinct microhabitats for both juvenile and forage fish species and significant differences in the relative abundance, biomass, and density of these fish were observed. This may be because the distributions of aquatic invertebrates are known to differ with macrophyte type and juvenile and forage fish feed on a wide variety of these invertebrates. Another study demonstrated that littoral fish spent more than 80% of their time in macrophyte beds (Hosn and Downing 1994). In this same study, it was also observed that 84% of small northern pike were found in vegetated areas. In a similar study, Casselman and Lewis (1996) found that young pike needed between 40 and 90% vegetation coverage. In addition, Gregory and Powles (1985) found that in Chemung Lake, Ontario, for both yellow perch (which are obligatory plant spawners) and darters, protection found in aquatic macrophytes is important in the early life stages.

In sharp contrast to most of the studies involving the relationship between aquatic macrophytes and largemouth bass, bluegill, pike, and/or other littoral species, black and white crappies exhibited increased growth in Lake Conroe, Texas, when all vegetation was removed using grass carp compared to growth rates when vegetation coverage was between 29 and 44% (Maceina et al. 1991). The authors suggested this was a result of an increase in abundance of the crappie's forage, threadfin shad, as a result of vegetation removal.

For lakes that are managed for a threatened or endangered species (i.e., cisco) or cold water species stocked in Indiana natural lakes (i.e., trout), different recommendations should be followed. For instance, the few Indiana lakes that still have a remnant population of cisco are managed specifically for that species. Cisco lakes are typically oligotrophic and not actively managed for any other species. Because of the delicate system in which these fish reside, aquatic vegetation control should only be permitted conditionally. Any release of nutrients into the lake as a result of aquatic macrophyte die-offs could result in unfavorable conditions for this species. The same holds true for the lakes that are stocked with trout. Although trout are stocked, due to the potential effects of vegetation control, it should only be permitted conditionally in order to maintain the integrity of the ecosystem and its ability to support a trout fishery. Based on three decades of research, it is obvious that vegetation control does have an effect on the trophic status of a lake, which affects water clarity and the amount of oxygen available at depths that cisco and trout use. As a result, permits to treat lakes with these species should be specially conditioned and reflect the sensitivity and importance of these fisheries.

While aquatic vegetation is necessary, exotic aquatic vegetation can be detrimental to the health of the ecosystem. Native plants are preferred by most fish, invertebrate, and waterfowl species that use aquatic vegetation, but are often unable to compete with exotics. For instance, Eurasian watermilfoil and hydrilla grow fast and spread rapidly compared to many native species, leading to problems with recreational use in shallow lakes and reservoirs (Smart et al. 1996). In addition, studies have shown that fish biomass in exotic vegetation is significantly lower than in native vegetation (Keast 1984; Weaver et al. 1997). As a result, control of these species may be necessary and important. However, in reservoirs and impoundments where native plants do not exist, exotic species may be the only viable option for littoral habitat unless native species can be successfully introduced. Determining the best course of action should be at the discretion of the lake manager.

Relationship between aquatic plants and lake trophic state

The depths at which submersed aquatic vegetation will grow is related to the trophic state of the lake, which in turn is related to the amount of light available at various depths (Herb and Stefan 2003; Van den Berg et al. 2003; Morris et al. 2004; Li et al. 2005). Based on calculations conducted using data from nearly 100 natural lakes in Indiana, vegetation in hypereutrophic lakes typically does not grow below 5 ft; in eutrophic lakes, vegetation typically does not grow below 10 ft; in mesotrophic lakes, vegetation typically does not grow below 15 ft; and in oligotrophic lakes, vegetation typically does not grow below 20 ft.

Objectives for coverage of submersed aquatic vegetation

According to the literature cited above, the following are the approximate levels of submersed aquatic vegetation required in the riparian littoral zone for each individual game species. Bluegill require greater than 50% vegetation coverage; largemouth bass require less than 50% coverage; northern pike require between 40 and 90% coverage; yellow perch require greater than 40% coverage; crappie require less than 30% coverage. Walleye and hybrid striped bass are maintained by stocking; therefore, their management has relatively little to do with aquatic vegetation coverage. However, since our lakes have few structural areas (i.e., boulders and logs) similar to those that walleye use in northern lakes, some anglers fish the edges of the littoral zone for them and this should be accounted for in the permitting process. Although muskellunge are stocked, their ability to forage successfully is dependent on their ability to hide in submersed vegetation. The amount of vegetation necessary for stocked muskellunge would probably be less than that required for naturally reproducing muskellunge (which is probably similar to that required for northern pike). Aquatic vegetation coverage of more than 40% would most likely allow for a healthy population of stocked muskellunge. In the absence of good plant coverage estimates, efforts should be made to maintain 50% aquatic plant coverage in the littoral zones of most lakes and reservoirs.

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