Lake Management or Lake Restoration

Which Approach is Best for Your Lake?

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Introduction

Our inland lakes are under a great deal of stressors in modern times due to the development of land surrounding them, the introduction of invasive species which threaten the native biodiversity, and overuse by a growing population, among other factors. The EPA Office of Water conducted a National Lakes Assessment in 2007 of over 1,028 inland lakes in the United States to determine the overall condition of them as a whole. Some of their key findings show that 30% of the studied lakes possess poor shoreline habitat and 20% had elevated nutrient (primarily nitrogen and phosphorus) levels that were associated with negative biological impacts. These percentages would likely be significantly higher if the same sample size of lakes was studied in Michigan or other states with a heavy agriculture and urbanization presence. Carpenter and Lathrop (1999) emphasize the critical need for a balance between lake use and conservation measures to ensure that lakes remain sustainable over time.

There are two dominant paradigms that exist to counter the negative impacts of these stressors–lake management and lake restoration. The purpose of this article is to discuss the key differences between the two areas of practice and to offer some practical insight to guide riparians toward a decision that is most beneficial for their unique lake ecosystem. Useful definitions for both lake management and restoration are as follows: lake management pertains to a "reactive" approach that aims to either prevent the lake from further ecological damage or to sustain the lake in its current state. Improvements here are limited to more prescriptive methods that have a goal of maintenance. Examples of lake management methods include the application of aquatic herbicides for nuisance aquatic plant control, the application of biological control vectors to organically control another nuisance species, mechanical harvesting of nuisance aquatic vegetation, utilization of benthic barriers or benthic mechanical devices for weed growth suppression, and lake drawdown.

Alternatively, lake restoration may be referred to as a "pro-active" approach that aims to bring the lake back to its original state or prevent it from entering another

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less desirable trophic state. Or, alternatively stated, to prevent a mesotrophic (moderate in nutrients) lake from becoming eutrophic (high in nutrients) or to transition a lake from the eutrophic state to a mesotrophic one, a pro-active approach is logical. With this approach, the implemented strategy is often long-term and may lead to a change in trophic (classification) status back to a desired state. Examples of lake restoration include planting beneficial native aquatic plants to increase biodiversity within the littoral (shallow) zone, food web manipulation, and laminar flow aeration with bioaugmentation to biodegrade organic muck on lake bottoms, among other methods. The restorative approach aims toward sustainability so that the lake ecosystem can eventually remain at an improved state with less maintenance.

How to Decide if Management is Enough or if Restoration is Needed:

Some lakes experience infestations of invasive, exotic aquatic plants such as Eurasian or hybridized Watermilfoil which can cause substantial impairments with navigation, recreation, and also decrease waterfront property values. If the lake in question contains at least moderately clear water, is moderate in nutrients, has a robust fishery, and does not experience nuisance algal blooms which create scums on the surface and emit strong odors, then the best and most cost-effective approach may be to control or manage the invasive milfoil with the use of aquatic herbicides, biological control, or spot-removal with suction harvesting.

The decision of what management method to use is just as philosophical as it is economical or biological. Some lake communities refuse to use aquatic herbicides and there are other approaches that have been successfully used on these lakes to manage invasive aquatic vegetation both short and long term. Figure 1 shows a northern Michigan lake that once contained nearly 300 acres of invasive milfoil but is now inventoried multiple times per season and any new growth is treated upon discovery. To date, the lake remains milfoil-free and has otherwise healthy water quality and a thriving lake fishery.

Lakes that are high in nutrients, low in water clarity, low in dissolved oxygen, and contain an impaired fishery due to these factors along with nuisance algal blooms are ideal candidates for lake restoration methods. Figure 2 shows a lake in west Michigan that experiences dissolved oxygen depletion and consequential phosphorus release, loading of nutrients from tributaries, ample runoff of pollutants and nutrients from the land during heavy rains, fish kills, toxic blue-green algal blooms, and invasive aquatic vegetation overgrowth. If the dissolved oxygen depletion is not addressed, then the phosphorus will continue to be released into the water column and lead to continued algal blooms which will continue to decrease dissolved oxygen in the upper water column upon decay. Alternatively stated, if the "root of the problems" is not addressed, then the lake will continue in what is referred to as an "alternate state" that is not necessarily favorable. When these sets of characteristics are observed on an inland lake, it is time to consider restoration over ordinary management. Another good example can be seen in Figure 3 which shows a shallow, hyper-eutrophic inland lake that requires continuous aquatic vegetation treatments but could also benefit from sediment removal, constructed wetlands to reduce incoming nutrient loads, among other methods. The management of the lake aquatic vegetation with herbicides and mechanical removal will allow for navigation within the lake; however, if long-term use of the lake is desired, more substantial restoration efforts will be necessary.

Figure 2. An inland lake in west Michigan that experiences heavy toxic blue-green algae blooms (RLS, 2010).

Figure 1: A thick canopy of Eurasian Watermilfoil in an inland Michigan lake (RLS, 2010).

Restorative Methods: Food Web Manipulation

Vadeboncoeur et al., (2002) emphasize the importance of the benthic (bottom) portion of a lake since it interacts with the

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Figure 3. A shallow, hyper-eutrophic inland Michigan lake that requires annual management but would benefit from restorative efforts (RLS, 2007).

water column (pelagic zones) for food web dynamics. Thus if food web manipulation is used to restore a lake fishery, detailed studies of both the sediment and lake water components (living and non-living) are essential. In fact, Wetzel (1990) noted that the majority of inland lakes contain a substantially larger littoral (shallow) zone with large benthic cover than pelagic area. Despite the differences in the relative size of these zones, a thorough understanding of the living and non-living components within them is critical for making functional restorative changes to the lake ecosystem. In the water column for example, the daily migration of zooplankton throughout the water column and co-existence of phytoplankton (algae) there are pivotal for the survival of the fish communities. Mills and Schiavone (1982) found that there is a strong correlation between the size of zooplankton and the growth and size structure of fish communities in many inland lakes dominated by warm-water fish species. Furthermore, the existence of both the zooplankton and phytoplankton are critical for feeding the benthic macroinvertebrates which are also consumed by bottom-dwelling fish and other higher organisms.

There is strong evidence that the diversity of submersed aquatic plants can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural shapes (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Cautious food web manipulation will not only consider the food reserves in the water column and sediment but also those attached the other life such as submersed or floating-leaved aquatic vegetation. Thus, the coupling of both habitats must be considered when conducting food web manipulations (changes) in a lake ecosystem that is being restored. This area of study is far from being an exact science and requires frequent trials to acquire the proper sustainable balance for the lake.

Nutrient Shifts and Reduction

The control of nutrients from a surrounding watershed or catchment to any lake is a proven necessity for long-term nutrient reduction. Although nutrients are a necessity for the primary production of algae and aquatic plants in a lake ecosystem, an overabundance of nutrients causes substantial problems as noted above. Lakes that lie within an agricultural watershed may experience acute and chronic influx of sediments, nutrients, and bacteria, among other pollutants. Those within urbanized watersheds face other stressors that include nutrient pollution but also influx of metals, dissolved solids, among other pollutants. In many areas, however, the watershed reduction approach is limited and restorative measures must begin within the lake basin. Annadotter et al., (1999) noted that even years after a sewage treatment plant was built along the shores of Lake Finjasjön (Sweden), the lake trophic status continued to decline. This was due to the existence of sediments that continuously leaked phosphorus into the overlying waters. A combination of intensive lake restoration methods was needed to significantly improve the water quality and consisted of sediment removal, constructed wetlands for watershed nutrient removal, and food web manipulation to improve the fishery. Their study proved that in cases of extreme water quality degradation, multiple techniques are often needed to bring a marked balance back to the lake ecosystem. In other words, one solution may not be enough to accomplish restoration.

Aeration and Bioaugmentation

The use of aeration to increase dissolved oxygen throughout a water column and reduce phosphorus release from sediments has been used for decades. This technology has also been used to decompose organic matter on the lake bottom which is a large fraction of "muck" in many lakes. In general, higher percentages of organic matter in lake sediments are associated with more effective removal by aeration systems. If the lake sediments contain an adequate population of sediment aerobic bacteria, then supplementation with additional microbes may not be necessary. The aerobic bacteria are the primary consumers of sediment organic matter but require adequate oxygen to increase their population size. Recently, the use of this technology using a custom design for the lake basin and supplemental microbes (bioaugmentation) has proven effective on inland lakes with the reduction of nuisance blue-green algal blooms (Jermalowicz-Jones et al., 2010), reduction of water column nutrients, and denitrification of lake sediments (Jermalowicz-Jones, 2014), among other measured benefits. Aeration is being widely used across the globe to accomplish lake restoration objectives. Birch and McCaskie (1999) noted that aerators placed throughout the bottom of Batterson Park Lake (London) halted further fish kills and reduced anoxic muds at the lake bottom which contributed phosphorus to the lake water. Although this area of research is not new, the understanding of functional mechanisms is not clearly understood and is a topic of intense study among lake scholars.

Conclusions:

Carpenter and Lathrop (1999) emphasize the critical need for the collaboration among project scientists and partners so that common objectives are co-created and the scope of the project is universally accepted. Furthermore, they state that determination of the efficacy of a restoration regime can only be attained if pre and post restoration parameters are studied for a significant length of time. It is also important to consider that any ecological restoration effort should mimic the natural system as much as possible to increase the probability of long-term success (Dobson et al., 1997). If watershed inputs are considered for the reduction of nutrients to a lake, then it is also critical to know how that specific watershed functions to prescribe appropriate successful reduction strategies (Johnes, 1999). One final note is that both political and economic forces often determine the fate of both lake restoration and lake management programs. It is often not practical to pursue restoration efforts that depend upon single granting opportunities or that are not compatible with the economic status of the local community. This is why so many lake projects today are involved with lake management and not restoration. Additionally, it is critical for influential policy makers to understand both the needs of the lake ecosystem and those of the riparian communities. These two factions are not mutually exclusive if lake ecosystem sustainability is desired.

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