The Art and Science of Integrated Lake Management:

MAPLE LAKE, VAN BUREN COUNTY, MICHIGAN

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Maple Lake Overview:

Maple Lake is located in Sections 1,11,12,13, and 14 (T.3S, R.14W) of the Village of Paw Paw and Paw Paw Township in Van Buren County, Michigan (Figure 1). The lake surface area is approximately 192 acres (Michigan Department of Natural Resources, 2001) and the lake is classified as a eutrophic (nutrient-rich) riverine impoundment with a dam at the north end of the lake. Maple Lake has a maximum depth of 15.0 feet and an average depth of 7.0 feet (MDNR, 2005). The lake bottom consists primarily of sandy substrate, silt, and organic matter deposits. The lake perimeter is developed and is approximately 5.74 miles (MDNR, 2005). The hydraulic residence time is approximately seven days (Southwest Michigan Planning Commission, 1978), which is common for a riverine system. The short retention time is due to the shallow lake depth and fast inflow of water from the Paw Paw River. Furthermore, there is a fetch of 1.32 miles which results in sizeable waves during high north and south winds.

Figure 1.
Maple Lake, Van Buren County, Michigan.

Figure 2. Maple Lake, 2008

Figure 3. Maple Lake, 2012

Maple Lake currently utilizes multiple methods of lake improvement including inversion oxygenation (aeration) with bioaugmentation (the use of microbes and enzymes), aquatic herbicide treatments, mechanical harvesting, lake drawdown, Diver Assisted Suction Harvesting (DASH), watershed management, and shoreline Best Management Practices (BMP's). The village of Paw Paw, Maple Lake Association, Three Rivers Coalition, and lake experts work together each year for the betterment of Maple Lake. What was once a turbid riverine system of canopied aquatic vegetation and algae (Figure 2) has become an improved clear-state lake system (Figure 3) with controlled aquatic vegetation and algae growth and improved water quality.

The use of multiple lake improvement strategies (integrated management) executed in Maple Lake involves the combined use of chemical, mechanical, biophysical (aeration), and watershed (spatial) methods for the management of nutrients, sediments, and nuisance aquatic vegetation and algae growth. Integrated management is becoming increasingly necessary for many lake systems since aquatic ecosystems are multi-dimensional and have different vegetation communities and watershed characteristics in both space and time.

Management Method #1: Watershed Management

The Maple Lake immediate watershed is approximately 362 times the size of the lake. The areas within the watershed determined to be the highest probability of sediment and nutrient contributions to the lake (Critical Source Areas) were delineated (Figure 4). Many of the impairments consisted of elevated total nitrogen, total phosphorus, and high dissolved solids, presence of easily ponded and erodible soils, and relative position in the landscape to drains and other watercourses. A total of seven CSA's with highest management priority were identified in 2012 through aerial imaging, ground-truthing, and sampling of drains that traversed problem areas and emptied into Maple Lake.

Figure 4. Location of CSA's around Maple Lake

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After heavy rainfall, water enters the lake along with soils that are deposited as sediment in shallow areas. This deposition of sediments from the surrounding watershed into the lake has created multiple problems: 1) Silt deltas that interfere with navigation and alter riverine flow, 2) Transport of nutrient-rich sediments to various locations that result in increased submersed and emergent aquatic plant growth, 3) Increased turbidity of the lake water which has resulted in increased water temperatures near shore and declines in dissolved oxygen concentrations. Site-specific BMP's for each CSA were recommended and are being mitigated to reduce problematic sediment loads. Drains are being monitored with time to determine sediment and nutrient loading rates and to determine BMP efficacy

Management Method #2: Aquatic Vegetation Management

Over the past decade, most of the improvement focus on Maple Lake has been on aquatic vegetation management with the use of aquatic herbicides to treat invasive, exotic plants such as Eurasian Watermilfoil (Myriophyllum spicatum) and Curly-leaf Pondweed (Potamogeton crispus), and nuisance native aquatic vegetation which consists of multiple species. Dense filamentous algae have also been problematic, resulting in dense mats that formed canopies on the lake surface and the creation of strong odors. Previously, algaecides were used to address the algae problem which occurred multiple times per year. The use of mechanical harvesting has been used to remove dense colonies of Coontail (Ceratophyllum demersum) that exploits the high water column nutrients for growth. Removal of the Coontail through harvesting prevents excessive plant decay that leads to accumulation of muck on the lake bottom. In areas where submersed vegetation has created deltas, the use of Diver Assisted Suction Harvesting (DASH) is being pursued since harvesters cannot operate in very shallow areas. Lastly, exotic emergent aquatic vegetation is being removed and replaced with native natural shoreline aquatic vegetation that reduces erosion and protects the biodiversity of the Maple Lake ecosystem.

Management Method #3: Inversion Oxygenation (Aeration)

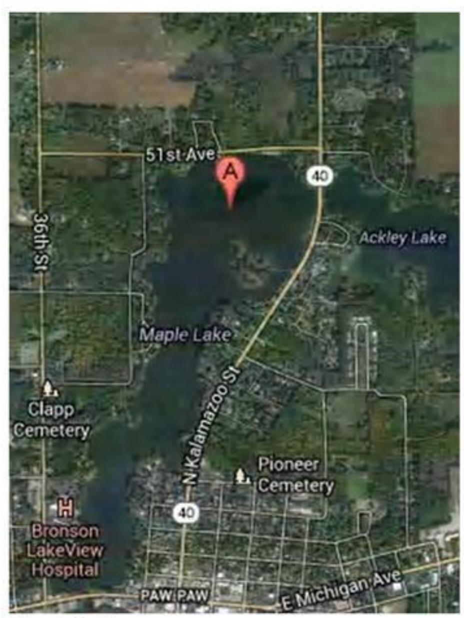
In 2010, an inversion oxygenation (destratification) aeration system was installed into the south and mid-sections of the lake to create more uniform water movement in previously stagnant areas. Additionally, microbes and enzymes were added to the lake bottom to reduce organic sediments and result in greater water depths and less sediment nutrients for aquatic vegetation growth. Multiple water quality parameters such as dissolved oxygen, water temperature, conductivity, water column phosphorus and nitrogen, pH, water transparency, oxidative reduction potential, total dissolved solids, aquatic vegetation relative abundance, algae composition and abundance, sediment phosphorus, and organic matter and percentage of fines were measured in the aeration and control zones of the lake. The aeration system has been evaluated over the past few years and has shown modest increases in dissolved oxygen, reduced filamentous and planktonic algae growth and reduced submersed aquatic vegetation growth. In particular, Eurasian Watermilfoil and Curly-leaf Pondweed were significantly reduced throughout the aerated regions of the lake.

Management Method #4: Lake Drawdown

The lowering of lake levels has been used in the past to control the growth of nuisance aquatic plant tubers such as Hydrilla and several other native aquatic plant species including pondweeds (Cooke, 2007; Doyle and Smart 2001), and is a cost-effective strategy for large, shallow lakes that possess a water level control structure (i.e. a dam). The drawdown process requires a Part 301 permit from the Michigan Department of Environmental Quality (MDEQ) who works closely with the Michigan Department of Natural Resources (MDNR) Fisheries and Wildlife Division to assure that impacts to wildlife from lowering water levels will be minimal. Maple Lake has historically conducted lake drawdowns to minimize damages from ice on near shore structures during winter and also excessive aquatic vegetation growth. To determine if the lake drawdown has any negative impacts on the biota of both Maple Lake and Ackley Lake (the receiving water body), sediment macroinvertebrates, aquatic vegetation communities, and fishery spawning habitat are being evaluated over an annual lake drawdown cycle. This evaluation will assist both the State and local stakeholders with future drawdown recommendations.

Current Conclusions:

The efficacy of all lake improvement methods must be determined for the best long-term management outcomes. Use of integrated approaches such as those described above allow for the lake ecosystem to be managed at the "site" level. Much spatial heterogeneity exists around lake shorelines, in lake sediments, within immediate watersheds, and within and among aquatic vegetation communities. Such spatial differences require precise management methods that most efficiently address problematic lake issues. An integrated program such as this involves the commitment of multiple stakeholder groups, thorough and novel site-specific research, development of unique BMP's, and the analysis of long-term data sets that singular future decision-making for optimum improvements.



Maple Lake