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A Natural Solution to Algae Problems in Western Lake Erie

The western basin of Lake Erie receives nutrient-laden waters from agricultural watersheds in northwest Ohio, principally the Maumee River. The current landscape delivers highly enriched, silt-laden waters by means of drainage tiles and ditches, which fuel the algae blooms that have tainted the waters that millions depend on for drinking water and livelihood. Restoring the wetlands of the Great Black Swamp will be an essential part of the effort to reduce harmful algae blooms and cleaning up Lake Erie.

By Ray Stewart

The causes of harmful algal blooms (HABs) in Lake Erie and the recent drinking water ban in August of 2014 for Toledo, Ohio, started more than 200 years ago with European settlement and the draining of a vast wetland area known as the Great Black Swamp (GBS) (Figure 1). Just a few feet of elevation keep this area from becoming an extension of Lake Erie. In fact, for thousands of years, the Maumee River Basin was a shallow bay covering 1,500 square miles (Kaatz 1955). As the ice age ended, water drained out through Ft. Wayne, Indiana, into the Mississippi Watershed. The origin of the current Maumee River and of the GBS coincided with the lowering of water levels in what is now the Lake Erie Basin as the last glaciers retreated (Klotz & Forsyth 1993). Low relief and poor drainage is the natural state of this once monumental wetland.

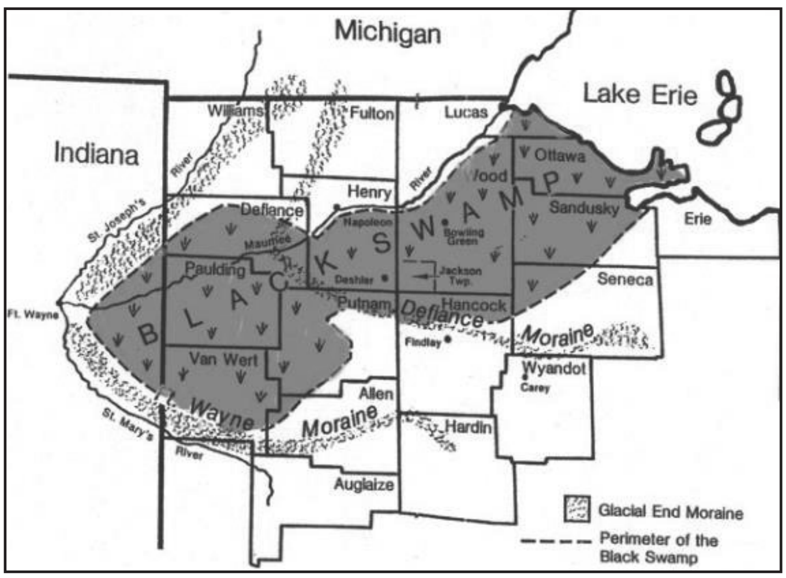

Figure 1: The Great Black Swamp. Image courtesy of the Black Swamp Conservancy.

During the period of 1780 to 1980, what is now the lower 48 states lost more than one-half of its wetlands. The rate of conversion of wetlands over this 200-year period factors out to 60 acres per hour (Dahl 1990). More than 95% of the wetlands in Ohio were lost to human endeavors, the first being agriculture (Andreas & Knoop 1992). Nearly all of the GBS in northwest Ohio was converted to drained agricultural land or hard urban surfaces.

In the first decades after Ohio achieved statehood, the GBS remained nearly impenetrable until the Toledo War of 1835. A border dispute between Michigan and Ohio resulted from poor surveying practices and the unresolved claim of Toledo by the governors of both states. Due to the impassible swamp, the militias from each state were too fatigued to fight. Following this near-skirmish, real progress was made on road building through the swamp (Kaatz 1955). The Ditch Law of 1859, combined with a market for forest products, hastened the transformation of the GBS into a vast and productive farmland. In 10 years, more than 2,000 miles of ditches were dug in northwest Ohio (Kaatz 1955). With a network of drainage ditches established, the demand for drain tiles soared.

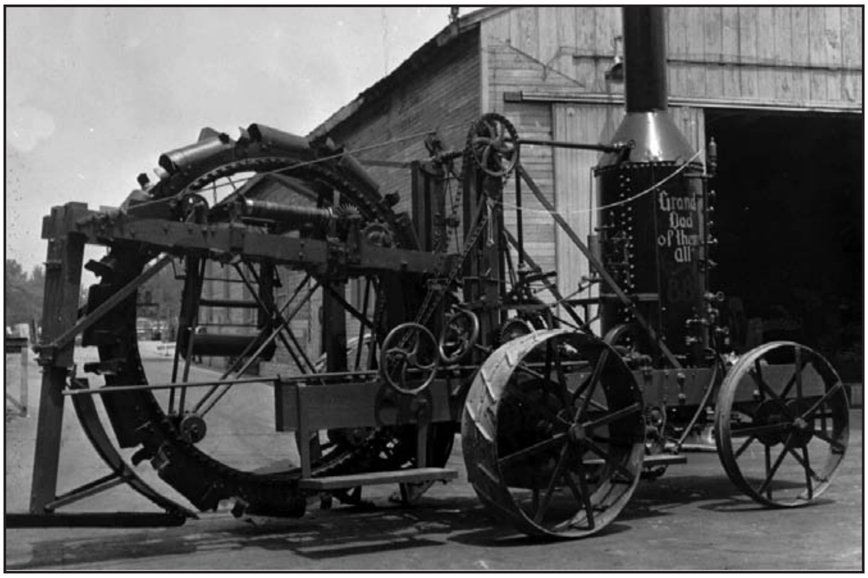

Image 1: The Buckeye Traction Ditcher, "Granddad of them all." Photo credit: Hancock Historical Museum, Findlay, Ohio

In 1870, deposits of clay were discovered under the rich, black soils of the swamp and a thriving clay tile industry commenced (Kaatz 1955). As the industrial revolution progressed on many fronts in the late 19th century, the steam engine was employed to do the hard labor of ditch digging. An engineering feat at the time, the Buckeye Traction Ditcher (Image 1) was introduced in Findlay, Ohio, in 1892. With steam-power drive, the Buckeye Traction Ditcher could cut a 4.5-foot-deep ditch up to 1,650 feet in length in a single day. In 1905, a mechanical ditcher raced a crew of 50 workers, digging 400 feet compared to the 300 feet dug by the hand labor ditchers.

As drainage of agricultural land increased, so did profits. The surplus was invested in better equipment and expanded drainage (Vileisis 1997). By the early 1900s, it was hard to imagine that the fertile fields of the Maumee River Basin had once been an impassible swamp.

The swamp forest was quickly cut, feeding the demand for virgin timber in Europe and America, leaving the slap wood to fuel the kilns of the many clay tile manufacturers (Prats 2014). Once the forests were cleared and cultivation commenced in the Maumee River Watershed, the river became highly turbid (Verduin 1969). Today, the input of turbidity into Lake Erie is much greater from the Maumee Watershed than that coming from the Detroit River or elsewhere (Verduin 1954). This is remarkable considering that at least 80% of the water entering Lake Erie comes through Detroit (Di Toro & Connolly 1980).

Forests and wetlands are natural filtering and buffering zones. As wetlands have been depleted, pollutants and excessive nutrients have more easily entered our waters (Woltemade 2000), where they can potentially fuel algal blooms (Howarth 2002).

Harmful Algal Blooms

Returning to the present day, we see the result of an intense and comprehensive transformation of the landscape—the western basin of Lake Erie and its tributaries have been dramatically altered. Water moves rapidly off the land taking the fertilizer, manure, pesticides, and general effluent of millions of people with it. Phosphorus (P) is the biggest contributor to the growth of algae (Zedler 2003). In the 1950s and 1960s, a five-fold increase in P was largely attributed to urban point sources and traced back to its use as a whitener in detergents (Verduin 1969). States instituted bans on phosphate detergent. Since the 1970s, the rate of P export by detergents has steadily dropped (Litke 1999). With less P in water treatment plant effluents, Lake Erie quickly recovered.

Advances in agricultural practices in recent decades, including improved drainage, has increased the nutrient load into our water systems. As a result, the P-induced algae problems in Lake Erie have returned. The mechanisms are well-understood. Nutrients are applied to agricultural land both in the form of mineral fertilizer and by manure applications. High demand for corn in recent years has prompted a more generous use of mineral fertilizers. The growth of industrial-scale livestock, especially concentrated animal feeding operations, has compounded the density of cattle and chickens beyond what the land would naturally sustain. The exaggerated accumulation of nutrient-rich manure is a major source of P in the watershed. In some cases, manure is spread on frozen ground where it is subject to rapid lateral movement into waterways. Even well-managed and carefully applied nutrients move downward into the soil only to escape by means of tiles and ditches meant to remove excess water.

Once in the water, nutrients stimulate the growth of many kinds of algae. As the foundation of the food web, these simple organisms are mostly beneficial. When highly concentrated, they can cloud the water and become unsightly. The type of organism that has been in the news lately, cyanobacteria (a.k.a. blue-green algae), is much different. The oldest life forms on earth are the bacteria. Those similar simple cells that first developed the capacity to harness sunlight for energy are the cyanobacteria that appeared on earth more than 3 billion years ago (Schopf 2006). Especially notorious, some types of cyanobacteria produce highly toxic substances, notably microcystin. It was the high concentration of this toxin that closed the city water supply for the people of Toledo, Ohio, in August 2014.

This kind of record-setting algal bloom is likely to recur. As global climate change is expected to further warm the shallow waters of western Lake Erie, algae and cyanobacteria will have a longer incubation period. Another consequence of climate change will be more frequent and heavier rain storms. These meteorological events wash large volumes of fertilizer and sediment off of agricultural fields. Algae blooms are stimulated by these events (Michalak et al. 2013). Although farms are not the only contributors to nutrient loading, they are the largest contributors. A study by the National Science and Technology Council (NSTC) showed that 65% of nutrients in the greater Mississippi River originate from agriculture (NSTC 2000).

There are some agricultural management practices that would help reduce the transport of nutrients off of farm land. Ohio lawmakers just passed legislation in Senate Bill 1 that prohibits the spreading of manure on frozen or saturated ground (Provance 2015; Siegel 2014). Scientific sampling of nutrient needs and minimal application of P fertilizer is effective at reducing nutrient use and, therefore, transport. Ohio recently passed legislation requiring certification for fertilizer application on farms over 50 acres (Kirk Hall 2014). Unfortunately, it did not include manure in the definition of fertilizer. Political half-measures will have little impact on reducing P in northwest Ohio waterways. It is doubtful that voluntary best management practices will go far enough to make significant improvements to nutrient pollution and HABs. Habitat restoration and the rejuvenating properties of natural systems must also be employed.

> "The return of natural functions in the basin will dampen the negative impacts that centuries of alteration have exacted."

Wetlands Will Remove Nutrients

Wetlands have long been called nature's "kidneys." Filtering and decontaminating water is only part of their function. Among the many benefits are flood control, which reduces erosion. Most wetlands have been protected in the interest of biodiversity. It has long been recognized that waterfowl thrive in healthy marshes (Richardson 1999; Zelder 2003). For our purposes, the ability to remove nutrients, especially nitrogen (N), P, and the sediments they often associate with, is of highest importance.

A study of riparian wetlands in Illinois showed that they retained an average of 85% of P (Wang & Mitsch 2000). A different study of these same experimental wetlands calculated a range of 0.5-3 g of P per square meter per year were retained (Mitsch et al. 1995). With this information, we can establish how much land needs to be converted back to wetlands to obtain P reduction in waterways. Once a total acceptable load is determined and compared with actual P concentrations in water, wetland restoration size budgets can be established for targeted watersheds.

In another experimentally restored wetland, water was received exclusively from agricultural drainage tile. It regularly removed 36% of N and 20% of P (Woltemade 2000). Many variables affect the ability of wetlands to remove nutrients. It was concluded that retention time was a key factor for improving water quality. At least one to two weeks retention time should be factored into restoration designs. Establishing a sufficient ratio of wetland size to water influx will improve performance.

The best system for nutrient removal is to divert stream water and surface runoff into restored wetlands where slow-moving, shallow waters will drop sediment and trap P (Woltemade 2000). Farmland would have to be returned to wetland for the sake of improved water quality (Mitsch & Wang 2000). The Task Force Reports "All practices that serve to trap, slow, store, infiltrate and filter runoff need to be encouraged and must be designed to suit the unique transport pathways from individual agricultural fields." (Ohio Lake Erie Phosphorus Task Force 2013).

With the natural history of the region in mind, an argument can be made to restore natural areas within the Maumee River Watershed, the GBS, and other waterways that drain the extensive cropland of northwest Ohio into the western basin of Lake Erie. The return of natural functions in the basin will dampen the negative impacts that centuries of alteration have exacted. Wetland restoration will not fix the nutrient problem nor will agricultural management practices alone. But wetlands have to be part of the formula and will provide a cost-effective and natural solution to HABs in Lake Erie. ■

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