

How Can Floating Gardens Mitigate Agricultural Runoff In Ponds and Lakes in Waynesville, Ohio?

Andrew (AJ) Bryant



Photo from Floating Island International



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Previous Experience and Identification



Photo taken by AJ Bryant (2022)

“What we do now echoes in eternity.”
— Marcus Aurelius, Meditations

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Abstract

This research shows the environmental benefits of implementing floating garden designs in ponds and lakes as floating treatment wetlands (FTWs). Research conducted by Virginia Tech, Rutgers, Floating Island International, and the International Institute for Sustainable Development indicates successful remediation and removal of nutrient runoff from agricultural production, wastewater treatment, and human and animal waste. Plants with different rooting depths and surface areas can phytoaccumulate phosphorus and nitrogen compounds. Like wetlands, FTWs create an environment for microbial life around the rhizosphere of plants and the island substrate, generating colonies of bacteria called biofilm that digest nutrients from water or sediment. Natural wetland habitats, one of humanity's most efficient biofilters, have been destroyed around the United States to make room for farmland and cities. This research has been aggregated to fuel an FTW design on a small farm in Waynesville, Ohio, and other lakes and ponds for people that this research may inspire.

Keywords: Rhizoremediation, aquaponics, phytoremediation, biofilter, green infrastructure, Floating Treatment Wetlands (FTW), Biofilm, Waynesville, Ohio

Project Statement

The agricultural industry is the backbone of civilization in the United States of America, yet its pollutants devastate aquatic ecosystems. How Can Floating Gardens Mitigate Agricultural Runoff In Ponds and Lakes In Waynesville, Ohio?

Project Justification

Water remediation is relevant to people who own a home, grow plants, or live near agriculture or waste. To illustrate, fertilizers are applied to keep plants healthy through plant propagation, growth, and maintenance. Nitrogen and phosphorus are macronutrients that horticulturalists and agriculturalists apply in mass quantities to fuel a variety of plant life, including kinds that applicators may not intend. When a farmer fertilizes their crop in July, not all of it is absorbed by the plants growing in his field. If heavy rain follows, that leftover nutrient becomes mobile, flowing downhill and eventually finding creeks, ponds, lakes, and oceans. When nutrients flow into a pond, simple life forms like algae grow uncontrollably, fueled by high-nutrient content and dissolved oxygen, also known as an algal bloom. Natural resource departments, horticulturalists, and homeowners try to control it with chemicals; however, the chemicals may hurt other organisms that share the water with algae.

Oxygen is dissolved and infused in the water through rain, plant respiration, waterfalls, or aerators. Fish also use dissolved oxygen to breathe and cannot survive when algae bloom heavily. When the water is anoxic, aquatic animals and other organisms cannot survive, jeopardizing the ecosystem. There is a way to absorb agricultural runoff while improving the food web of a pond or lake: biomimicry via floating wetlands. These wetlands balance a combination of plants, media, and microbiology to digest, filter, and absorb these excess nutrients. This keeps harmful algal blooms from happening while introducing a new biome for life to thrive in the water.

This project is inspired by a conversation with my boss about growing lettuce using existing nutrients in his pond, similar to aquaponics. Without knowledge of FTWs or floating gardens, my boss and I theorized that we could create some wicking system to pull water into a medium, irrigating the plants we wanted to grow passively. I could never elaborate on the idea by creating something, so I researched this as my capstone project to better understand systems like these and what they can do for our environment and waste. Through my research for this project, I have learned much about harmful algal blooms and the current state of water pollution in the United States. My questions have been answered as to why fish would turn up dead at my childhood home, where we lived in the country and kept a stocked pond. I remember my father, and I would have to install different fountains to keep the fish alive, and during the summer, I could not even go fishing because of how much algae covered the surface area of the water. To think I even swam in that water... Nevermind.

User-Client Description

Based on research for this paper, people working in environmental science, law, horticulture, and waste management will benefit most from implementing Floating Treatment Wetlands. Landfills can increase the efficiency of their operations by incorporating FTWs into retention ponds or nearby lakes to catch pollutants before they leach into creeks or into the watershed. Environmental scientists can rebuild the food web of a damaged local ecosystem, providing a habitat for wetland species of animals and plants, doubling as a cultural control of algal blooms. Homeowners and suburban developments with ponds can reduce their contribution to pollution and harmful algal blooms by implementing a floating wetland as an aesthetic feature while the plants and associated microbial life digest nutrient pollution, reducing harmful algal blooms and improving local water quality. In a study from Virginia Tech, researchers simulated runoff from agriculture and nursery plant production, as these were the main contributors of nitrogen and phosphorus fueling algal blooms in waterways. They found that floating wetlands can remove up to 60% nitrogen and phosphorus content if given enough space (Spangler et al., 2019). Because Ohio has lost most of its historical wetlands, the people of Ohio cannot utilize their environment's ability to filter water. However, by implementing floating wetland gardens, residents and wildlife can enjoy the benefits wetlands provide through biomimicry.



Figure 1: A homemade floating garden which I draw inspiration from for my design. (Taken from DIYMarta)

Major Project Elements

Island Materials

There are two different approaches to designing floating treatment wetlands. The first and most accessible way is to use recycled materials to create buoyancy. In a video posted on YouTube, DIYMarta explains her floating garden uses styrofoam boards about a foot wide around the perimeter and interior of the garden, with holes allowing water to get through below. This will be called the foundation from here on, and the foundation is wrapped in burlap to wick water, hold the soil, and keep the island together. Using recycled materials for buoyancy, about 48 two-liter bottles inflated to 15 psi around the island's perimeter will keep it afloat. Styrofoam will fill in the island and add support in the center to avoid sag. After this foundation is tied together, it is wrapped in old burlap bags, allowing root penetration and a surface area to spread a substrate to grow the plants.

Another option for creating a floating treatment wetland would be contacting businesses that are researching and engineering these islands to remediate water. One of the largest businesses in FTWs is Floating Islands International, which has been studying water remediation since the 90s. Bruce Kania, CEO of F.I.I., has developed the BioHaven matrix, an engineered substrate made 100% from recycled plastic and coated in polyurea to protect it from the sun and animals that may inadvertently damage the island. F.I.I. emphasizes the byproduct of a healthy wetland: biofilm, a layer of bacteria left behind from microbial activity that sticks to the matrix or substrate. This bacteria is very active and is responsible for removing most nitrogen and phosphorus from the water (Kania, 2018). The BioHaven islands are proven effective, featuring case studies and academic research to reinforce the legitimacy of their product.

Surface Area

A floating treatment wetland's success depends on the surface area covered and how long it will stay there. In a case study from Virginia Tech, researchers simulated agricultural runoff in small aquariums with an FTW covering 80% of the water, which was proven highly effective (Spangler et al., 2019). Covering that much space is not appropriate for the pond at Natural Horticulture, as the pond has aesthetic value to the company. Covering 1% of the water on this pond would require one twenty by twenty-foot floating wetland. However, this will be split into two theoretical designs: one island using the Floating Island International design and one using the recycled two-liter bottle design. Both designs will be ten by ten feet planted with the same species of plants with an analysis of cost, longevity, and productivity.

Plants

In phytoremediation, different plants can absorb or change the chemical composition of different contaminants. Both designs in this proposal will feature the same plants to absorb the primary contaminants: phosphorus and nitrogen. The first of the three plants featured on the

islands is *Panicum virgatum*, commonly known as Switchgrass. This plant showed the highest efficiency in the Virginia Tech FTW research as a remediator of phosphorus and nitrogen, with their experiment absorbing 60-80% of the phosphorus and nitrogen in the water while covering 80% of the surface (Spangler et al., 2019). Another study from the International Institute of Sustainable Development (IISD) concluded that cattails are very productive phytoaccumulators of phosphorus, where the dry weight of the cattail root consisted of 20-55% phosphorus (Grosshans, 2019). Cattails are not the most aesthetically pleasing plants however, they are easily propagated and can be sourced at the site. *Iris ensata*, or Japanese water iris, is the next choice for aesthetics and performance. In the Virginia Tech study, Iris is the runner-up to Switchgrass. This plant is a good choice for something that can be used on the island's borders to add purple flowers to the garden during the summer, creating seasonal interest along with its proven ability to remove nitrogen and phosphorus. Both the Iris and Cattail will spread their rhizomes to create a habitat for bacteria to thrive and produce biofilm, while the lengthy roots of Switchgrass tap deep into the water to do the heavy lifting.

Inventory

Quantitative:

Site: A pond at Natural Horticulture in Waynesville, OH.

Measurements: 43,611 sq feet. **Volume:** 4,504,470 Gal.

Sources of Contamination: Nearby large-scale agriculture.

Contaminants: Fertilizer: - Ammonium Nitrate (N33-P0-K0), Phosphorus Pentoxide (0-30-0), Potassium oxide (8-0-24), Cow manure (OSU, n.d)

Climate: Temperate region, 41 inches of rainfall on average. per year, elevation of 751 feet. The growing season is 7-8 months. 40-70% average humidity during the growing season (BestPlaces). Hardiness zone 6a.

Topography: The slope is about .8% from the nearby agriculture to the Southwest of the pond and 1.1% from the Northeast greenhouses.



Figure 1: Graph showing the slope traveling northeast. Facing North. (Google Earth, 2023)

Qualitative:

Site: The water from this pond flows downstream through a creek to the Northeast, eventually reaching Ceasars Creek State Park. From April to October, this pond is used for irrigation.

Solar: The sun covers all of the ponds from sunrise in the east, and a stand of trees blocks the last one to two hours of sunlight before sunset.

Climate: Surrounding the pond on the east side are open fields previously used for agriculture. Wind speeds are high during the spring and fall.

Habitat: The site connects to a preservation site (Ceasars Creek) that hosts threatened organisms.



Figure 2: Natural Horticulture pond, facing West. (Photo by AJ Bryant, Fall 2023)



Figure 3: Natural Horticulture pond, facing South. (Photo by AJ Bryant, Summer 2023)

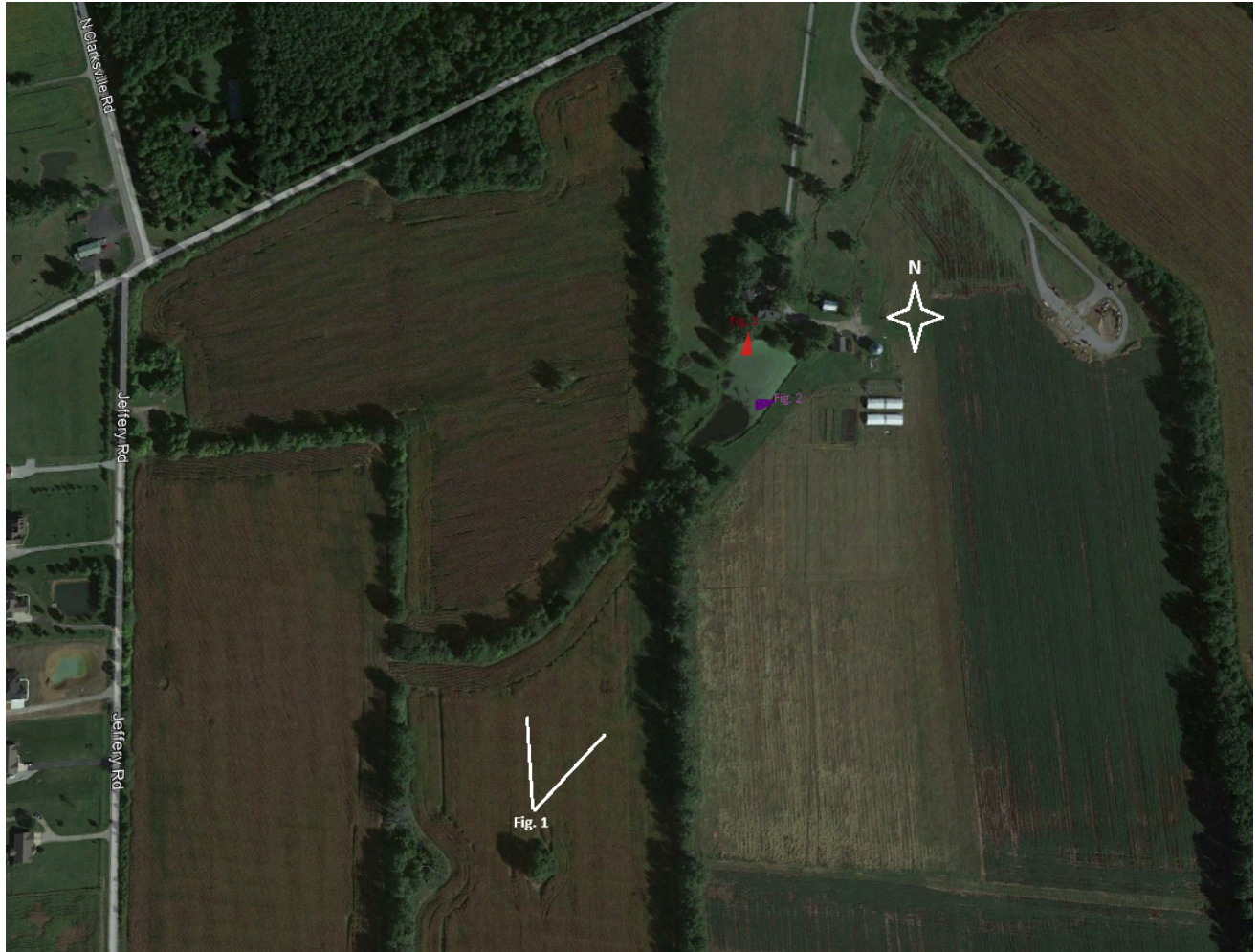


Figure 4: Natural horticulture aerial view depicting where other photos were taken. (Google Earth, 2023)

Site Summary:

The pond at Natural Horticulture is surrounded by agriculture, which follows a slope feeding nutrient-rich water into the pond during the growing season. Knowing that local farmers amend their soil with manure in the off-season, and the south and west areas flow water near the pond via drain tile, it is important to design a floating garden that can be implemented in the spring to allow for proper root growth, before algae can use the density of nutrients to bloom. Because natural horticulture is upstream from Ceasar's Creek, the floating wetland can be implemented to clean up nutrients before they flow near the preservation area while also improving the water used to irrigate crops in the greenhouses. A floating wetland will create a habitat for wood ducks, which the client values. Since the pond is not shaded, I anticipate designing the garden with various full-sun plants, from switchgrass for remediation to water hyacinth for aesthetic value. Considering wind speeds will be fast, strong plants with plenty of hardening-off time will be required. The only sightlines to the pond will be from the home on the farm, which is directly behind Figure three.

Historical Context:

The site at 7987 Oregonia Road, Oregonia, Ohio, has been used for agriculture for almost fifty years off and on. The oldest history goes back to the 1960s when this land was used for growing corn and soybeans. No records are kept for pesticides, herbicides, or fertilizers used on the site by previous owners. However, data collected from the USDA suggest that fertilizers used during this time would have been urea, ammonium nitrate, diammonium phosphate, and monoammonium phosphate (USDA ERS, n.d). These fertilizers are naturally occurring or already plant-available, so it is assumed that algal blooms were present. During the 2000s, agricultural production at this farm stopped, and it was occasionally leased for winter wheat. The most popular herbicide for this time would have been glyphosate for weed suppression. However, this chemical compound has decomposed, with a half-life of around 47 days (Henderson, 2010).

The most recent data associated with the site is from the last four years when it was used for organic agriculture. Three greenhouses produce tomatoes, cucumbers, leafy greens, and other market gardening crops three hundred feet from the site. Drainage tile connects all three greenhouses, and the water flows to the creek, downhill from the pond. As an employee of the site, I know that the only fertilizer used across all crops is Drammatic One Fish fertilizer (4-4-1), an OMRI-certified fertilizer high in plant-available nitrogen (DRAMM, n.d). Since Natural Horticulture only practices organics, no pesticides or herbicides have been used. Less than ten instances of copper fungicide use have been recorded in 2021 and 2022. Bordering Natural Horticulture to the west is another large farm, which broadcasts cow manure in the winter, potentially enriching the pond with nitrogen and phosphorus as the manure is slow to break down in cold temperatures.

Literature Review

Introduction

In rural America, a large portion of the food, textiles, and resources are grown in large fields fertilized with large applications of nutrients. Along with farms, suburban properties also use fertilizers to grow turfgrass as a common aesthetic feature of their landscape. Most rural farms and suburban developments have drainage ditches flowing to creeks, which flow to residential ponds or major waterways. When the excess nutrients flow into the water, it creates a habitat for a very simple life form, algae, which is present in all types of naturally occurring water, to thrive. When algae thrive, they use nutrients that mobilize in water from farms or lawns, like nitrogen and phosphorus, to grow and outcompete other types of life in the ecosystem. Ecosystems depend on algae; however, when algae are given too much room to grow, they consume most of the oxygen, creating an anoxic water environment and choking out other wildlife in the affected water. Along with choking out other organisms in the ecosystem, some forms of algae produce toxic byproducts that can poison or kill fish and plants. These algal blooms are very difficult to control because soluble oxygen is taken from the water very quickly, and adding oxygen to water takes a long time, especially for large bodies of stagnant water with no aerating features like waterfalls or aeration pumps.

Among the methods of controlling algal blooms with algicides or supplemental aeration, an overlooked alternative for cleaning water is floating treatment wetlands (FTWs). Wetlands are scarce in the midwest and even more threatened in Ohio, where only 10% of our historical wetland areas are left (ODNR, n.d). Wetlands are one of nature's organic ways of filtering water; pollutant nutrients such as nitrogen or phosphorus flow by the wetland plants, which trap nutrients in the root zone or soil. Horticulturalists and environmentally conscious people can leverage the benefits of wetland plants and microbial life in the rhizosphere by creating floating gardens that mimic this ecosystem on the water's surface to bring these benefits to ponds and lakes. This approach will passively reduce the levels of nitrogen and phosphorus in the water, removing the fuel for harmful algal blooms. Phytoaccumulation, a plant's capacity to accumulate and retain nutrients and contaminants, offers a sustainable disposal method. Additionally, phytodegradation, where plants break down pollutants, occurs within the plant or through enzymes released from the roots (rhizodegradation). Biodiversity is critical for the success of these floating wetlands, as different microorganisms living around different plants can degrade or digest excess nutrients, further enhancing the quality of the water.



Figure 5: Harmful Algae Bloom in South Carolina (Photo from SCDHEC, 2008)

Water Remediation Literature

In a 2023 research paper from Wuhan, China, researchers tested the efficiency of floating wetlands by removing nitrogen and phosphorus with two different types of floating wetlands. They isolated plants in their testing; each island consists of one plant species, its medium, and the water. They studied four plants: Canna, water hyacinth, water spinach, and calamus. The study found that the plant islands without biochar worked, pulling about 18-19 mg/L of Total Nitrogen out of the growing area in about 36-40 days (Qin, 2023). The islands, including biochar, helped important denitrifying bacteria survive in higher populations, causing an even more efficient nitrogen removal. The biochar composite islands removed 18 mg/L of total nitrogen in 24 days, showing how the population of bacteria increased considerably when amending the islands with biochar to help establish the microbiological community living in the rhizosphere (Qin, 2023).

“The Roles of Floating Islands in Aqueous Environment Remediation” by Qin et al. does a great job of testing four wetland plants specifically for their efficiency as a host for microorganisms to work in the rhizosphere. The research focuses on the different species of bacteria that play large roles in reducing the amount of nitrogen and phosphorus for water purification. The study could benefit from providing data on how much phosphorus or nitrogen the plants had accumulated by themselves after testing; this could add understanding to the contribution of the plants instead of focusing on just the microbe's efficiency. This research notably highlights how the chemical oxygen on demand (COD) directly affected how efficiently one community of microorganisms could remove organic compounds in the water. The authors of this paper believe that plants are the “tool” for the microbe's success, meaning they provide shelter and synergize with each other to remove and decompose organic compounds (Qin, 2023).

Floating Treatment Wetlands (FTW) Literature

“Floating Wetlands: A Sustainable Tool for Wastewater Treatment” By Munazzam Shahid, Muhammad Arsian, Shafaqat Ali, and Siddique Muhammad at the University of Faisalabad summarizes Floating Treatment Wetlands (FTWs) and their application as a wastewater treatment. This group of researchers studied natural floating wetlands (NFWs), composed of plants that grow on a mat of roots, both alive and dead, and “detritus,” also known as waste or debris from decomposition or erosion. The research shows how these wetlands have interacted with agricultural runoff, wastewater, and other waste produced by human beings in different scenarios. Munazzam suggests that plants dynamically uptake nitrogen and phosphorus from the body of water, storing them in the biomass of the root system and microbes that work to digest the organic pollutants. Phosphorus removal methods include sorption, precipitation, and microbial and plant tissue accumulation. The study notably suggests that through this research, they have found that plant harvesting is an active way to speed up the removal of nutrients and pollutants, directly influencing the nutrient cycle in the FTWs. They presented that an FTW system removed up to 60% of phosphorus from eutrophic water. (Shahid et al., 2018).

The Floating Wetlands research from the University of Faisalabad includes valuable research on natural floating wetlands for my project. Their research on naturally occurring floating wetlands is important for the history of FTWs. Shahid elaborated on plants' role in the water remediation process, which is valuable for my research as many have focused on microbiology. This research answers questions about how plants clean the water, such as phytoaccumulation and phytodegradation. Their data on harvesting the FTWs to stimulate the nutrient cycle is valuable; more data must be taken on how effective harvesting is for nutrient cycling and disposal. Harvesting is a variable I have not seen mentioned yet. However, maximizing efficiency in a temperate climate with a short growing season is important. Along with climate, this research also dives into site-specific factors in which the FTW will exist, accounting for the depth of the water with suggestions for different pollutants.

“Floating Treatment Wetlands and Plant Bioremediation: Nutrient Treatment in Eutrophic Freshwater Lakes,” Produced by the International Institute for Sustainable Development (IISD), is a comprehensive handbook featuring multiple case studies and analyses of FTWs impact on the chemistry and quality of the water. For the design of their FTWs, this group created an easily replicated raft made of synthetic, durable materials similar to a life raft. IISD has a detailed analysis of where pollutants are being stored and absorbed into the substrate and the plant tissues, which is valuable when deciding what type of plants to choose for a site and how they will remove pollutants from the water. For instance, on Page 13 in Table 1 of IISD, It is listed their nutrient-rich site (L227) and how many grams per tray of Total Phosphorus (TP) were absorbed during the growing season, as well as how many grams per square meter were retained within the roots, rhizome, or aboveground plant tissue of Cattail. Given that this data

was taken in Manitoba, Canada, the client will be provided with data on how much total phosphorus and total nitrogen can be absorbed using cattail on an FTW (Grosshans, 2019).

Case Studies

Case Study 1: Ontario, Canada. International Institute for Sustainable Development.

The International Institute for Sustainable Development (IISD) tested floating treatment wetlands in Manitoba, Canada at their Experimental Lakes Area (ELA). Pelican Lake and the surrounding lakes feeding into it faced a problem with eutrophication, the over-enrichment of nitrogen and phosphorus in a body of water, typically from agriculture or other byproducts of agriculture or industry (Grosshans, 2019). They tested floating treatment wetlands on two lakes with different concentrations of phosphorus, L227 being the most nutrient-rich and L114 being oligotrophic (nutrient-deficient), a natural reference or control group. IISD constructed four platforms twelve feet in diameter lined with foam to keep them buoyant. They created a frame on the top side of the platform, where they mounted perforated plastic trays to hang so that they were submerged 2-5 centimeters in the water. The trays are lined with a coconut fiber blanket, similar to a burlap bag, to keep their soil substrate from washing away. These floating platforms used cattail plants gathered from a nearby site to study their effect on removing phosphorus. The cattail plants were studied for sequestration in aboveground plant tissue, rhizome tissue, and root tissue. The most efficient phosphorous uptake was found in the root tissue of the cattail plants on L227, with a dry weight concentration of 25-55% of phosphorous. Compared to L114, which saw a concentration of 10-20% (Grosshans, 2019).

Table 2. Average uptake (% and ppm) per unit of dry weight of vegetation on FTWs on lakes 114 and 227 during August and September sampling, 2015

Site	Vegetation	TN (%)	TP (%)	K (%)	S (%)	Ca (%)	Mg (%)	Na (%)	Zn (ppm)	Fe (ppm)	Cu (ppm)
114	Cattail	1.8	0.1	2.2	0.2	1.0	0.2	0.0	27	144	2.8
	Rhizome	1.6	0.1	1.8	0.2	0.4	0.2	0.1	33	3500	3.8
	Root	1.9	0.1	2.8	0.3	0.5	0.4	0.2	103	2657	7.7
227	Cattail	1.4	0.1	1.7	0.1	1.0	0.2	0.0	14	51	1.6
	Rhizome	1.2	0.1	1.3	0.2	0.5	0.2	0.1	29	3508	3.4
	Root	4.1	0.4	1.9	0.4	0.4	0.4	0.4	80	4055	6.8

Figure 6: Accumulation of different chemicals in different plant tissues of the cattail tested (Grosshans)

The IISD's publication on Floating Treatment Wetlands is critical for the hardiness zone where they conducted research. There is less FTW research relative to their climate, making this handbook invaluable to people researching phytoremediation and bioremediation in the northern

hemisphere. The platform design from the Experimental Lakes Area is easy to replicate for researchers like myself who would like to produce a floating island. Their document also includes multiple case studies in the United States that feature tables displaying total nitrogen and phosphorus removal percentages for each study. Individuals studying floating treatment wetlands or phytoremediation need to have this on hand to reference the benefits of this organic solution to eutrophic water environments and nutrient removal.

Case Study 2: Wiconisco Township, Pennsylvania, USA. Floating Island International

Floating Islands International (FII) is a company that specializes in producing floating treatment wetlands with its unique proprietary design of synthetic floating wetlands. In 2005, the Wiconisco Wastewater Treatment Plant (WWTP) was approved for a grant to use an early FII's BioHaven FTW technology model to remove nutrients from municipal wastewater. Three FTWs were installed in one of their lagoons the following year, with a fourth added later. Four years after installing BioHaven islands and adding a solar-powered water circulation pump that flows water through the substrate or "matrix," they noted that the nitrogen removal rate was 17% higher than the control lagoon at 144 mg daily per square foot, and ammonia removal was 9% greater at 567 mg a day per square foot. Phosphorus removal was 3% greater than the control, covering only 2% of the surface area of the lagoon (Headley, n.d). Between training, operation, and maintenance, only one day is required for training, and two hours every week to maintain the island is required. Conventional nutrient removal techniques at WWTP averaged about \$250,000 annually (MFI).



Figure 7: Wiconisco's mature FTW's (Floating Island International, 2006)

The Wiconisco Wastewater Treatment Plant case study is useful for seeing how far FTW technology has come. It was thought that, at the time, the best way to circulate water was directly onto the island, and that idea has changed since FII conducted more research. In a dialogue with Bruce Kania in 2023, he explained that aeration of the water to create dissolved oxygen (DO) is vital to the success of the microbial life that lives within his islands, as they remove up to 80% of nitrogen when hosted by the matrix and root zone of the plants (Kania, 2018). In Bruce's TED talk, "Transition Water," he states that because of the modularity of Floating Treatment Wetlands, they can bring the wetland effect, specifically the production of bacteria via biofilm (the residue from microbes), to any body of freshwater they want. Biofilm is essential because the bacteria produced by microbes are more efficient at uptaking nutrients than any other life form (Kania, 2018). Knowing that users must establish a microbiome when designing a floating treatment wetland is critical when deciding the substrate and plants that will live on them.

Case Study 3: Virginia, USA. Virginia Tech Hampton Roads Agriculture Research and Extension Center.

In a study conducted in May of 2018 at the Virginia Tech Hampton Roads Agriculture Research and Extension Center, researchers investigated the efficiency of five different plant species' potential to remove nitrogen and phosphorus from the water as a floating treatment wetland (FTW). The site simulates the runoff from agricultural or nursery activities, simulating a nutrient-rich water environment (Spangler et al., 2019). The site uses a specially built tank system to mix water and fertilizer to create a nutrient-dense mesocosm or simulated habitat; in this case, they hold 302.8L of water to simulate a pond. Beemat (Beemat LLC) is the substrate or buoyant material used for plantings, covering 80.3% of the water surface area. They install biodegradable cups hosting each plant in the Beemat. Each mesocosm features a monoculture of each crop to find the most efficient remediator minus two mixed plantings. The plants in testing are *Agrostis alba* (Redtop perennial grass), *Canna x generalis* 'Firebird' (Canna lily), *Carex stricta* (Tussock Sedge), *Panicum virgatum* (Switchgrass), *Iris ensata* 'Rising Sun' (Rising sun Iris), an evenly mixed planting (Redtop grass, Tussock sedge, and Switchgrass), and a control group with no plants or Beemat. Each mesocosm receives 20 plants. After a week-long cycle, a new mixture of water and fertilizer replaces the old water, simulating runoff. Before draining the mesocosm every seven days, researchers take a 125mL sample to record progress. Water temperature, pH, dissolved oxygen, and electrical conductivity measurements reflect the post-treatment nutrient concentration for each week. The samples go through analysis using ion chromatography for nitrate, nitrite, ammonium (denitrified), and phosphate.

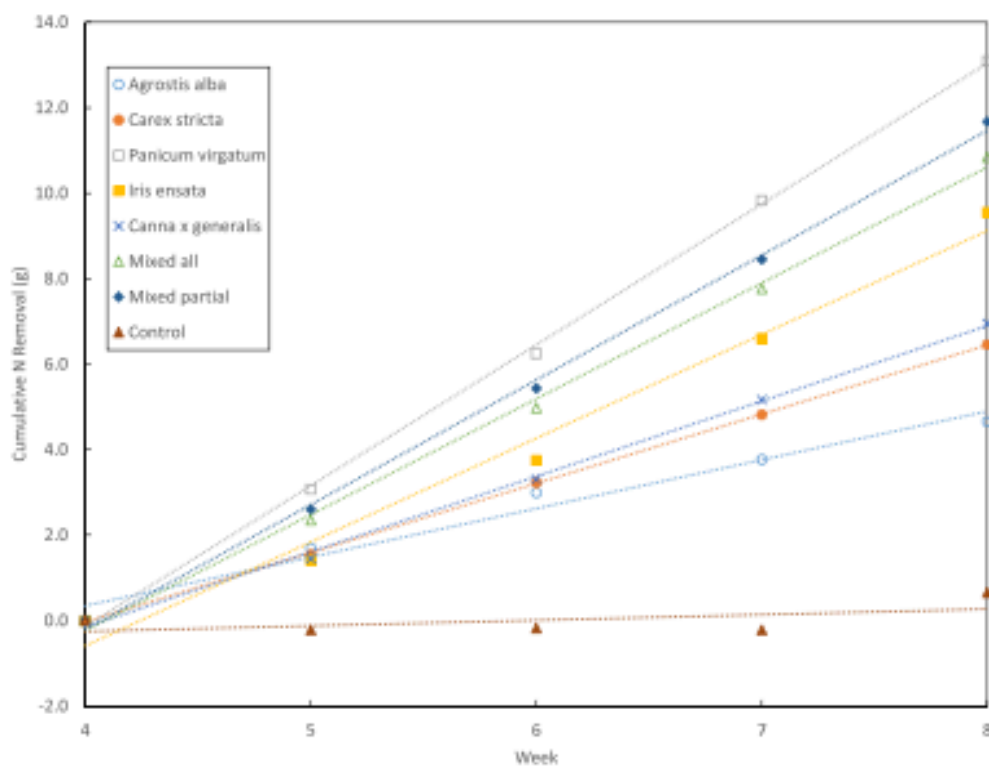
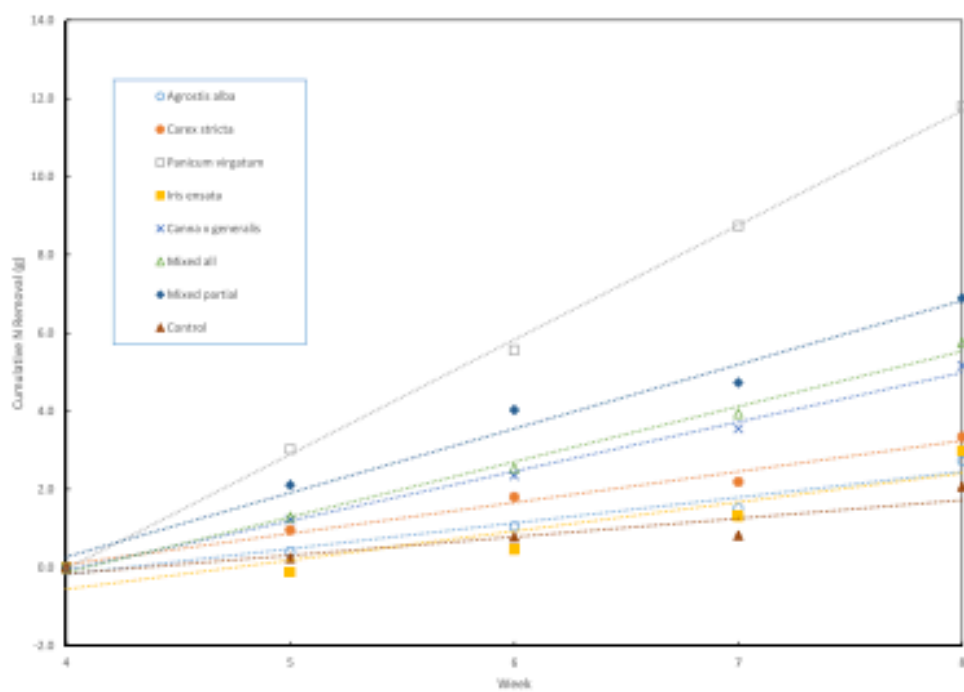
a**c**

Figure 8: Cumulative nitrogen (graph a) and phosphorus (graph c) removal rates in grams per species. (Spangler et al., 2019)

This Virginia Tech study finds that removal efficiency ranged from 21.9 to 64.7% of phosphorus and 4.8 to 82.4% of nitrogen. (Spangler et. al., 2019) The most efficient remediator for nitrogen and phosphorus is *Panicum virgatum*, which removes more than all other treatments, including mixed plantings, at 64.7% phosphorus and 82.4% nitrogen. The mixed mesocosms, or experimental aquariums with controlled variables, include 20-30% *Panicum virgatum*, explaining their efficiency as the runner-up to a monocultural mesocosm of *Panicum*. *Agrostis alba*, *Canna x generalis*, and *Carex stricta* mesocosm did not remove more phosphorus than the control treatment; however, all species removed more nitrogen than the control. Dissolved oxygen (DO) directly affects the denitrification process, as lower quantities of DO showed more denitrification by bacteria. The Virginia Tech researchers specify that if the goal of the FTW is to create a cleaner habitat, the FTW should not cover over 50% of the water surface (Spangler et al., 2019). If aesthetics are relevant, including a large percentage of switchgrass is vital to remove phosphorus and nitrogen from the water. Virginia Tech's research directly applies to my research, as phosphorus and nitrogen are the most significant pollutants at my site. *Panicum virgatum* is native to Ohio, and this study shows that it is one of the best remediators of water available in my hardiness zone.

Case Study Summary

Overall, these sources help describe what kind of plants are most effective in removing agricultural pollutants from the water. Virginia Tech seemed most valuable to this research, as they tested floating treatment wetlands in simulated conditions to see which plants were most effective. *Panicum virgatum*, or common switchgrass, seemed the most efficient at removing nitrogen and phosphorus, removing 60-84% of both contaminants in eight weeks of covering 80% of the water (Spangler et al., 2019). The Floating Island International study shows where FTW technology has been in the past, with a valuable lesson to be learned: dissolved oxygen is necessary to keep the microbial life working hard to remove nitrates, ammonia, and phosphorus. F.I.I. did not implement a water recirculation system until the last year or so of the project, which means it could have been more effective than it was in this study (Zeller, 2015). Lastly, the IISD shows ways to create an FTW at home, such as using a life raft and designing a system to submerge a planting tray in the water (Grosshans, 2019). They also show how a plant most people dislike serves a purpose: cattail. Cattail can be easily divided and propagated, making it an easy choice for tight budget situations. The IISD also features multiple case studies along with their experiment, making their publishing valuable to anyone studying phytoremediation or floating treatment wetlands.

Project Goals

This research aims to provide an alternative, organic, and accessible solution to water pollution in rural areas with ponds and lakes surrounded by agriculture, where nutrient-rich aquatic environments fuel algal blooms and leftover nutrients flush into major waterways or protected areas. Large algal blooms occur annually and are mostly related to agriculture or wastewater. However, it is not possible to force a change in the agricultural industry to disrupt our food supply. Nutrient pollution will remain constant as farmers and nurseries need to fertilize their crops. Floating treatment wetlands are not often considered as a treatment for water quality; instead, chemical applications are used to keep algae from growing while also further impacting the environment. Instead of going one step further and two steps back with chemicals, drawing attention to and implementing floating treatment wetlands for aesthetics or purpose will reduce algal blooms, all while creating wetland habitats for wildlife. Supplementing an ecosystem with a missing piece can fix these problems organically. Floating treatment wetlands can be implemented in most aquatic settings, like urban or rural ponds and lakes, and are a passive solution to a recurring problem that allows agriculture to remain efficient while reducing its environmental impact.

Programmatic Requirements

The Natural Horticulture FTWs are mobile at the site, where they could be moved or anchored to stay in a preferred area. This pond has a surface area of 43,611 square feet, and one island is 100 square feet. The two islands will only cover about half a percent of the pond's surface area; however, based on the Floating Island International Wiconisco case study, that does not determine their efficiency. They are planted with five cattail rhizomes, eight switchgrass transplants, and 15 iris rhizomes, all of which have research to validate them for their potential as remediators of phosphorus and nitrogen. The site's solar exposure is full sun, suitable for the switchgrass and cattails, which will provide enough shade for the iris to thrive.

Design Materials

Island One- DIY Recycled Bottle FTW

- 48-2L bottles/Milk jugs (Inflated to 15 psi)
- 4-10ft. PVC pipes, 4 PVC elbows
- 25 Burlap bags from Home Depot (Approx. 350 sq.ft.)
- 6 cubic yd of mushroom compost
- 5 Cattail rhizomes
- 8 switchgrass plugs/transplants
- 15 Iris rhizomes
- 200 ft. of rope for anchoring.

Island Two - Floating Island International

- 10x10ft section of FII BioHaven Matrix
- 5 Cattail rhizomes
- 8 Switchgrass plugs
- 15 Iris rhizomes
- 200 ft. of rope for anchoring.

Concept

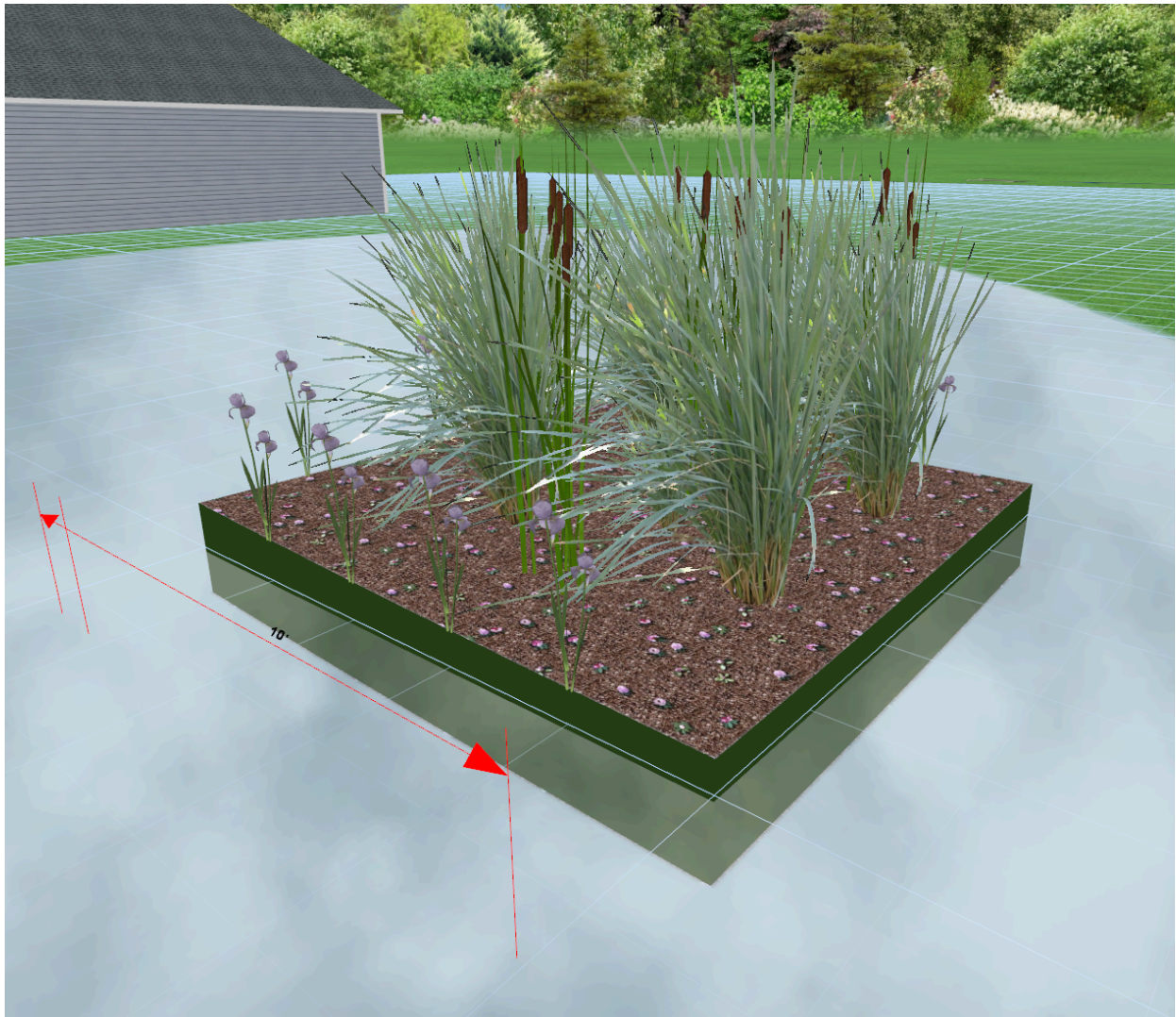


Figure 9: Digital concept of a F.I.I. FTW (By AJ Bryant using UVision)

Concept (Continued)

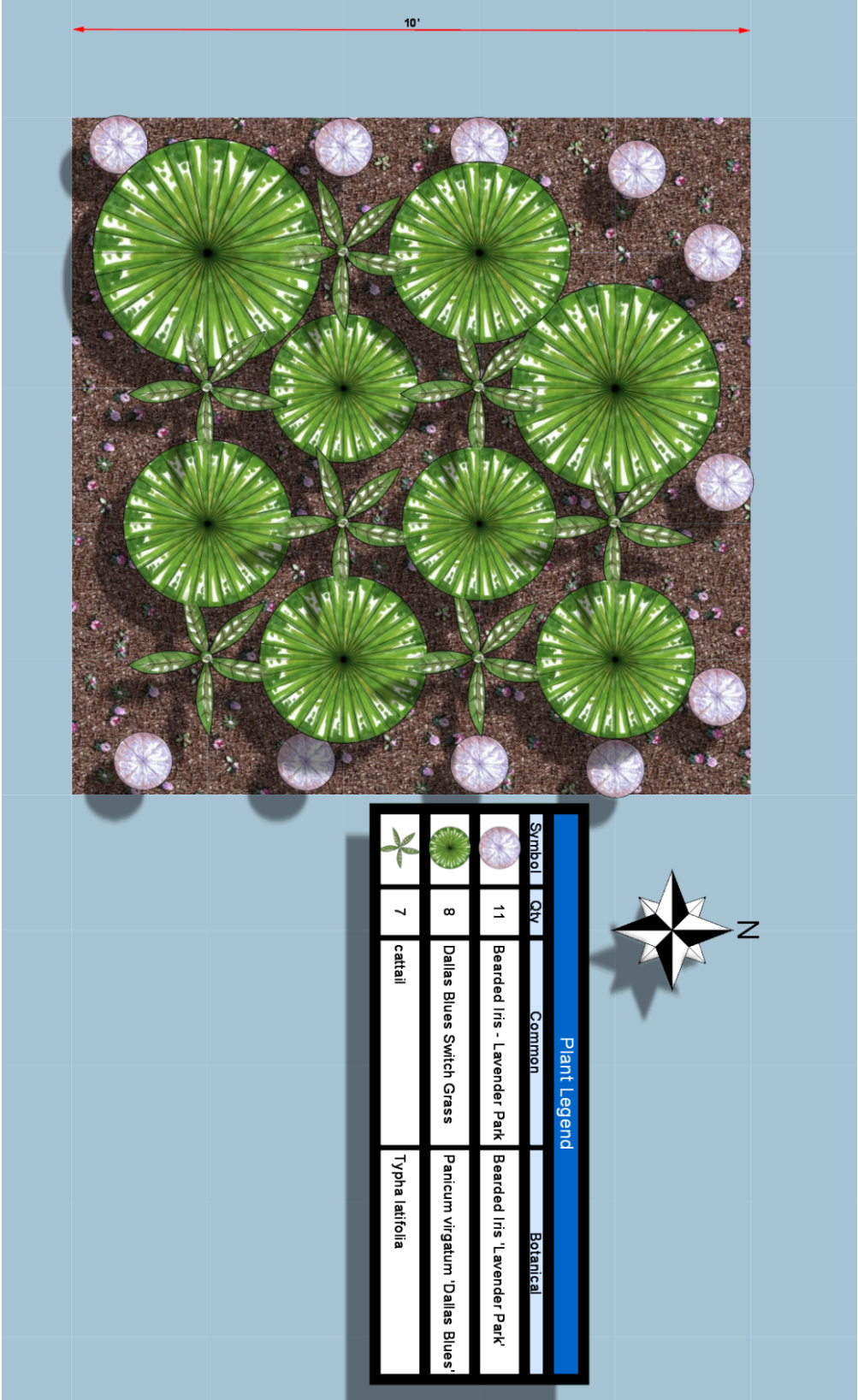


Figure 10: Plan view of the Natural Horticulture FTW (By AJ Bryant using UVision)

Project Solution

Floating Treatment Wetlands (FTWs) create an ecosystem that efficiently digests agricultural runoff while serving as a unique landscape on the water. The plants inhabiting an FTW use the existing nutrients to grow and serve as a host for microbial life. This design features strategically chosen plants for their varied root length and efficiency in removing nitrogen and phosphorus from water. The root types provide a platform for microbial life. This miniature wetland habitat attracts and hosts microorganisms that generate biofilm, a colony of multiple types of bacteria that sticks to surfaces from roots to polymers, with the goal of metabolic cooperation, which digests more than twice as many nutrients as plants (Kania, 2018). These microorganisms feed on macronutrients often associated with agriculture and nursery production, specifically nitrogen and phosphorus. FTWs provide an accessible and aesthetically pleasing solution to agricultural and nursery runoff. They passively fight harmful algal blooms induced by nutrient-rich aquatic environments by hydroponically growing plants and rebuilding the food web instead of destroying it with chemical treatments or mechanical removal.

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