

**Effects of Invasive Macrophytes on Species Diversity of Mesotrophic Aquatic
Ecosystems**

By:

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Effects of Invasive Macrophytes on Species Diversity of Mesotrophic Aquatic Ecosystems in Kenosha County, WI

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Abstract

Monitoring the abundance of invasive macrophytes is important for many municipalities which are interested in preserving the quality of their freshwater lakes for economic and ecological reasons. Understanding how these invasive species propagate on a yearly scale is crucial to successfully treat and remediate vulnerable lakes. Four lakes in Kenosha County, Wisconsin were sampled over three years (2009-2012) for their macrophyte abundance by the Invasive Species Working Group (ISWG). Sampling was conducted using the rake-throw method at the four lakes. Macrophyte species were identified and abundance was recorded. Using the abundance data, comprehensive statistics and figures were created to investigate the speed at which invasive species recover from treatment and how they interact with native species. The results indicated that abundance of invasive macrophytes and native macrophytes are inversely related; however species-rank abundance did not correlate with populations of invasive macrophytes.

Introduction

One of the most valued natural systems in the Northern United States is our fresh water lakes. Not only are fresh water lakes rare on a global scale, but they also provide desirable amenities to people who live nearby. Negative effects on such systems can result in economic damages and water quality impairment. These systems can be severely affected by urban sprawl and agricultural development, increasing the nutrient load into the lake

along with other pollutants. Lentic ecosystems can also be severely impacted by the presence of non-native or “invasive” species. These non-native species lack natural competitors and can compete for habitat and resources unchecked. Water recreation can introduce these species to new ecosystems by getting stuck to a boat or fishing gear. These invasive species can alter the water chemistry and ecosystem of a lake by out competing native species and being more tolerant of pollutants. It is important to monitor changes in lakes with a presence of invasive species in order to track the short term and long term effects on native species and diversity. Developing methodologies and encouraging research on the changes that these lakes experience as a repercussion of invasion can lead to better remediation and protection of lentic systems. This studies objective was to challenge generally accepted ideas about how invasive species behave in lakes. These conventions being that invasive species outcompete natives and reduce species richness. Looking at the data provided by ISWG; do invasive species exhibit an inverse relationship with natives? Do invasives lower species richness, just by being abundant in an ecosystem? This study, using Invasive Species Working Group data, will investigate whether or not native and invasive species abundance is inversely related and if the abundance of invasive impacts species richness over time. The information will provide a unique perspective on how different sized lakes are resistant or vulnerable to the presence of invasive species.

Literature Review

Invasive Macrophyte Species: Eurasian Milfoil

Eurasian Milfoil or *Myriophyllum spicatum* was introduced to North America between 1950 and 1980 (DNR, 2014). The species could have been transported to North America through a number of different dispersal methods. It could have been transported to the inland lakes of North America by water fowl or boats. Two of the more popular beliefs of its origin are that it may have been intentionally introduced by federal authorities in the 1940’s or that it was carried over through ballast waters and left to propagate in the Chesapeake Bay Area. The exact story of the introduction of Eurasian Milfoil is not known,

but popular theories such as these provide us with an idea how of it began to propagate in the North America (DNR, 2014).

The species became more established through the United States as more people recreated in lakes which had Eurasian Milfoil. Introduced species lack predators or diseases allowing these species to out compete many native species (Czarapata 2005). The species has the incredible ability to reproduce from fragments of the plant. A portion of the stem and leaf can take root and form new colonies (DNR, 2014).

Fragmentation allows this species to repopulate very quickly and render most mechanical control methods ineffective. Pieces of the plant may have gotten caught in boat rudders, fishing lines, or even in the feathers of birds. Once these fragments come into contact with a body of water it can begin to establish itself. It is the plants ability to reproduce so quickly and without needing to seed that makes it such a tolerant and troublesome species.

Milfoil can cause many problems due to its prolific nature. Once Milfoil is introduced to a lake with a native population of macrophytes, it can colonize itself and begin to crowd out other plants with its dense floating canopy (DNR, 2014). Not only this, but in shallower lakes its sheer size can disrupt recreational activities. The reason it is such a problem is due to its ease of expansion and its ability prevent light from reaching other native species. “Native species richness has been found to be inversely related to invasive species richness in small-scale manipulative experiments (Naeem et al. 2000; Engelhardt and Ritchie 2002), suggesting an antagonistic, probably competitive relationship” (Capers, 2009). The expanding territory and damages caused to lakes has caused national and local governments to take action and try to prevent further damages.

Milfoil begins to grow in the early spring, typically much sooner than most native plants. It grow rapidly, producing seeds and dying off in the early fall. The species creates mats which can rob dissolved oxygen from the system when the plant begins to decompose. This can affect other types of animals, such as fish, which require dissolved oxygen to be successful. Eurasian Milfoil thrives in disturbed environments with high amounts of

nutrients, such as nitrogen and phosphorus, in the lentic system. Lakes which have high amounts of human activity tend to make matter worse often by increasing the amount of fragmentation that occurs.

This plant can cause economic damage for a number of reasons. As stated before this macrophyte can interfere with recreation which may reduce tourism or lakeside real-estate appeal. It can interfere with boats by choking up their rudders and motor. It can disrupt the natural ecosystem, potentially causing game fish to become less common. In order to control the expansion of this species, local governments and agencies must employ methods to remove or reduce its presence.

Invasive Macrophyte Species: Curly-Leaf Pond Weed

Another species of invasive is *Potamogeton crispus* or Curly-Leaf Pondweed. This species was first discovered in Minnesota in 1910 and was likely transported to the state along with the introduction of the Common Carp (Minnesota DNR, 2009). It is native to Eurasia, Africa and Australia but it now has been documented in every state except Maine and South Carolina (Indiana DNR, 2009). Curly-Leaf Pondweed is through the transfer of turions on boat trailers, fishing gear, or other watercrafts. A turion is the hardened stem tip on the fragments of the plant (Minnesota DNR, 2009).

Curly-leaf has the ability to colonize a variety of different locales, sediment types, and depths. It can tolerate low light environments and even near freezing water. In the winter months when most plants are dormant the pondweed actively grows. It blooms in the early spring and dies back when most native species have hit their peak seasonal growth (Indiana DNR, 2009). Curly-leaf disperses itself through seed and turion. A single plant can produce hundreds of turions which in turn are dispersed by water currents (Indiana DNR, 2009).

Much like Eurasian water-Milfoil, Curly-leaf Pondweed disturbs natural ecosystems due to its early bloom in spring which can form dense mats. This disturbs not only the ability for the native species to compete with it, but also disrupts boating and other recreational activities. When the Curly-leaf dies it can result in large amounts of plant matter floating and

piling up on shorelines, which is followed by an increase in phosphorus which can lead to blooms of algae (Minnesota DNR, 2009).

Native Macrophyte Species: Coontail

One of the most prominent native species that was found in highest abundance throughout many of the sampled lakes was Coontail, or *Ceratophyllum*. This species can be found through much of the United States and is considered a native. This plant is free floating with no roots, and can be found in ponds, lakes, and other slow moving bodies of water (Department of Ecology). This plants role within the ecosystem is typically habitation for young fish which are seeking cover from predators. It can also serve as food for macro-invertebrates and the seeds can be eaten by water fowl. Coontail grows rapidly can be considered a “nuisance species” in locations where it grows to rapidly. It can create dense mats along the surface of the water much like Eurasian Milfoil. Coontail propagates through its seeds or through fragmentation, much like other native species, such as Chara.

Native Macrophyte Species: Chara spp.

Although Chara appears to look and behave like many aquatic plants it is technically classified as an algae. Chara can grow in a diverse range of depths from 4m to 20m water (Department of Ecology). Chara grows at the bottom of most ponds and lakes and does not create mats at the surface as Milfoil and Coontail do. This algae stays submerged and acts as an important food source for water fowl, mostly ducks, and provides protection for fish and macro-invertebrates (Department of Ecology). Chara has an advantage against invasives such as Eurasian Milfoil because it can thrive at increased depths where milfoil cannot. It also is resilient to many types of chemical control methods because it is not a plant. These factors only truly help the species when in deep lakes, or in lakes which are being chemically treated. Aside from species interactions and chemical treatments, there are many other factors which can affect the chemical composition and ecology of a lake. Things such as urban sprawl and nutrient run-off contribute to changes that may be seen through this study. Although these types of factors are not being specifically examined, their impacts should be understood.

Agricultural and Residential Development

Non-point source pollution from development surrounding lakes can alter the water chemistry and influence blooms of algae and macrophytes. Non-point source pollution refers to pollution which did not come from one direct source, but rather a multitude of sources. Agricultural and residential development contributes to higher storm water runoff, physical changes to the watershed, and alteration of many natural filters such as wetlands (Ballinger, 2004). “On average suburban land contributes up to four times the phosphorus per unit area than either agricultural or forested land” (Ballinger, 2004). Urban business and residential development contributes 11.1 kg/ha of nitrogen and 0.9 kg/ha of phosphorus and agricultural development contributes 2 kg/ha of nitrogen and 25.2 kg/ha of phosphorus (Shuyler, 1995). Sources of agricultural nutrient runoff are commercial fertilizers, livestock manure, and soil erosion. Urbanization contributes higher amounts of runoff and foreign chemicals due to the density of impermeable pavements (Ballinger, 2004).

Not only does development contribute nutrient runoff but toxic substances as well. Pesticides or herbicides which may have been used in agricultural practice can find their way into nearby waterways. Urban development can contribute oils picked up off of impervious pavements or soaps used to wash cars (Ballinger, 2004). Run-off that cannot be linked back to its source is called non-point source pollution and can account for the majority of nutrient pollution in fresh water lakes.

Non-Point Source Pollution

Non-point source pollution refers to the run off of drainage basin which typically carries nutrients and other pollutants. Run off flows over agricultural land, urbanized land, or natural land and ultimately ending up in a lake, river, stream or wetland (UNEP). Sources of non-point nutrient pollution are agriculture, storm water, waste water, fossil fuels and homes (EPA, 2014). Non-point source pollution represents the nutrient impact of a large area. “All activities in the entire drainage area of a lake or reservoir are reflected directly or indirectly in the water quality of these water bodies” (UNEP). This makes it difficult to point

to one source of the nutrient pollution in a body of water. Instead, one must look at the drainage basin in its entirety and examine the land use of the area.

Rain water also contains nitrogen and phosphorus which can be obtained from air pollution. However, nitrogen “over 20 times more concentrated than phosphorus” (UNEP).

Both Curly –leaf Pond Weed and Water Milfoil excel in areas which have a high input of nitrogen and phosphorus, especially because both of these species begin growing earlier than most species. The only thing that is capable of limiting the exponential growth of these species, aside from human intervention, is limitation of nutrients. Nitrogen is more commonly found in run off as it does not bind to the soil in the same manner as phosphorus. Nutrients such as nitrogen and phosphorus are key players in aquatic ecosystems, and can often change an ecosystem through its abundance or scarcity.

Aquatic Nutrients

Nutrients such as nitrogen and phosphorus play a big role in aquatic ecosystems. They are naturally occurring nutrients which are essential in aquatic ecosystems (EPA, 2014). Nitrogen can be found in great abundance in the air, where phosphorus tends to bind to soil. These nutrients sustain algae and aquatic plants which in turn supports other species such as fish, shellfish and other organisms (EPA, 2014). Submerged vegetation uses these types of nutrients for sustenance and their growth is typically limited by the amount of these nutrients which are readily available. There is a delicate balance, however, between too little and too much of these nutrients. Too much and a lentic system could experience algae blooms which could potentially eutrophy a lake. Eutrophication of a lake occurs when the lake is covered in a mat of algae or other aquatic vegetation that grows rapidly, dies in mass, and saps most oxygen from the system potentially causing a fish kill (UNEP). Nutrient pollution can render water unpalatable as well, requiring nitrate-removal which increases the cost of water treatment (EPA, 2014). These nutrients can enter the system naturally through erosion or rainfall. Most commonly they enter the system through non-point source pollution. In lentic systems which are exposed to heavy levels of nutrients, algae and macrophyte

blooms typically follow. Many municipalities react by treating their lakes in some manner to maintain the lakes natural levels of macrophytes.

Invasive Macrophyte Control Methods

There are three categories of control methods for aquatic macrophytes: mechanical, chemical and biological. Mechanical control methods involve physically changing the environment, whether that be tearing it out by the stem or dyeing the lake. Raking and seining can be a popular method for removing macrophytes, but in the case of the Milfoil these methods are not the most successful. When raking it is unlikely to keep each stalk intact, meaning that stem fragments would still remain in the water and be allowed to reestablish. Another mechanical method is to fertilize the lake to encourage algal blooms which would shade out the Milfoil. This method has serious effects on the lake as a whole, having the potential to severely reduce the dissolved oxygen in the lake. The last mechanical method is to dye the lake. Much like lake fertilization, this method aims to reduce sunlight penetration into the lake. The dye is non-toxic, but shading out a whole lake will affect many other species aside from the Milfoil (ArgiLife, 2014).

Biological control efforts involve the introduction of a species which will feed on the Milfoil in order to reduce its population and density. The animal that is mostly used for this type of process is usually either Grass Carp. Unfortunately, this species will consume Milfoil but it isn't preferred. This treatment method is not the most effective for addressing the issue (ArgiLife, 2014)

Lastly is chemical treatment. This control method is the most commonly used to control the presence of Eurasian Milfoil. The active ingredients in common Milfoil treatments are: "copper complexes, 2,4-D, diquat, endothall, fluridone, imazamox, penoxsulam, triclopyr, bispyribac, and flumioxazin"(AgriLife, 2014). Compounds like 2, 4-D systematic herbicides, meaning that they must be absorbed into the plant to take effect. These compounds, unlike contact herbicides, require time to activate. Diquat is a contact herbicide which means it kills all plant cells it comes into contact with. These are two of the more popular options. Unfortunately neither of these options are free from negative effects.

When chemically treating a lake one major risk is oxygen depletion on a large scale. When all the plants die, they begin to decompose. This decomposition siphons a lot of the oxygen from the system, potentially causing fish kills. Beyond ecological impacts, it also affects water usage. For some period of time after treatment the lake is typically unsafe for drinking, swimming, and watering lawns. This renders the lake useless for a few days depending on the compound (AgriLife, 2014).

It is concerning that there is no clear method to address this issue, especially as population in the United States continues to increase. With increase population and urban sprawl, people desire water side property. This fosters increased expansion of the species as urbanization occurs around the lake. It increases the chances of a fragment of Milfoil entering the system, disrupting the ecology and eventually effects the recreation.

Milfoil is incredibly adaptable and tolerant of climate, pH, and nutrient availability. As climate changes, native plant species will have a harder time adjusting to abnormal temperatures. This slights the odds in the favor of the already prolific and tolerant Milfoil. This creates a sense of urgency to avoid allowing this invasive to further expand its territory.

Although there are control methods in place, it is critical that methods to reduce the prolific nature of Milfoil are investigated. Not only should the methods of prevention, but also the effects of Milfoil on lentic systems. As climate change and urbanization pick up speed, so too does the potential for Milfoils success. Using a combination of some of the prevention methods Eurasian Milfoil can be kept at manageable levels to continue to protect native ecosystems.

The presence and control of these species has an economic impact which can be seen in many different ways. One interesting way that these costs can present themselves is through real estate. The massive blooms of invasive marcophytes, such as Water Milfoil, can interrupt and deter recreational activities. This too has a tangible cost as a result. C. Zhang conducted an experiment in which he examined lake front properties with invasive marcophytes vs properties without. He discovered that properties with invasive species were cheaper and not as desirable in the marketplace (Zhang, C. (2010). This serves as an example

as to why so much money is spent to remove and control these species from lakes which have housing developments adjacent. It also shows that the loss of the ability to pursue recreational activities has an economic impact.

Methods

The raw data were collected by the Carthage College Invasive Species Working Group (ISWG), which monitors invasive species within Kenosha County. The data were collected over four years in four different locations. The objective of their sampling efforts are “To improve our understanding of the ecology and management of invasive species, and to increase public awareness and prevention of establishment of new invasives, our group has established a long-term invasive monitoring and outreach program in the Kenosha community. (ISWG)” The goal of this study is not too dissimilar. The methodology was designed to examine the data that has been collected by ISWG and attempt to identify invasive macrophyte trends in the sampled lakes in the years 2009, 2010, 2011, and 2012.

Sites

The four lakes sampled were George Lake (Bristol, WI), Mud Lake (Bristol, WI), Silver Lake (Silver Lake, WI), and Rock Lake (Trevor, WI), all of which are located within Kenosha County.

George Lake is a 59 acre lake (DNR, 2014) with public boat access and residential building surround nearly three-fourths of the lake. George Lake is also exposed to some agricultural development as well. Both Eurasian water-milfoil and curly-lead pondweed have had a presence in this lake since 1977(DNR, 2014). George Lake is treated via chemical and mechanical methods.

Mud Lake is a 22 acre lake (DNR, 2014) and lacks boat access. Mud Lake has less urban development with about one-fourth of the lake being exposed to residential development. Both of George and Mud Lake drain into the Dutch Gap Canal (I.S.W.G, 2009-2014).

Silver Lake is a 464 acre lake with boat access (DNR, 2014). A presence of Curly-lead pondweed was documented in 1977 and Eurasian water-milfoil in 1994 (DNR, 2014). Half of silver lake is exposed to housing development. Kull Lake is a 15 acre lake without boat access (DNR, 2014). Kull Lake remains free of residential or agricultural development (I.S.W.G, 2009-2014). Silver Lake remains untreated.

Rock Lake is 49 acre private lake which prohibits motorized boat traffic (DNR, 2014). Three-fourths of Rock Lake is surrounded by extensive residential development (I.S.W.G, 2009-2014). The presence of Eurasian water-milfoil was documented in 1998 (DNR, 2014).

Field Sampling Methods

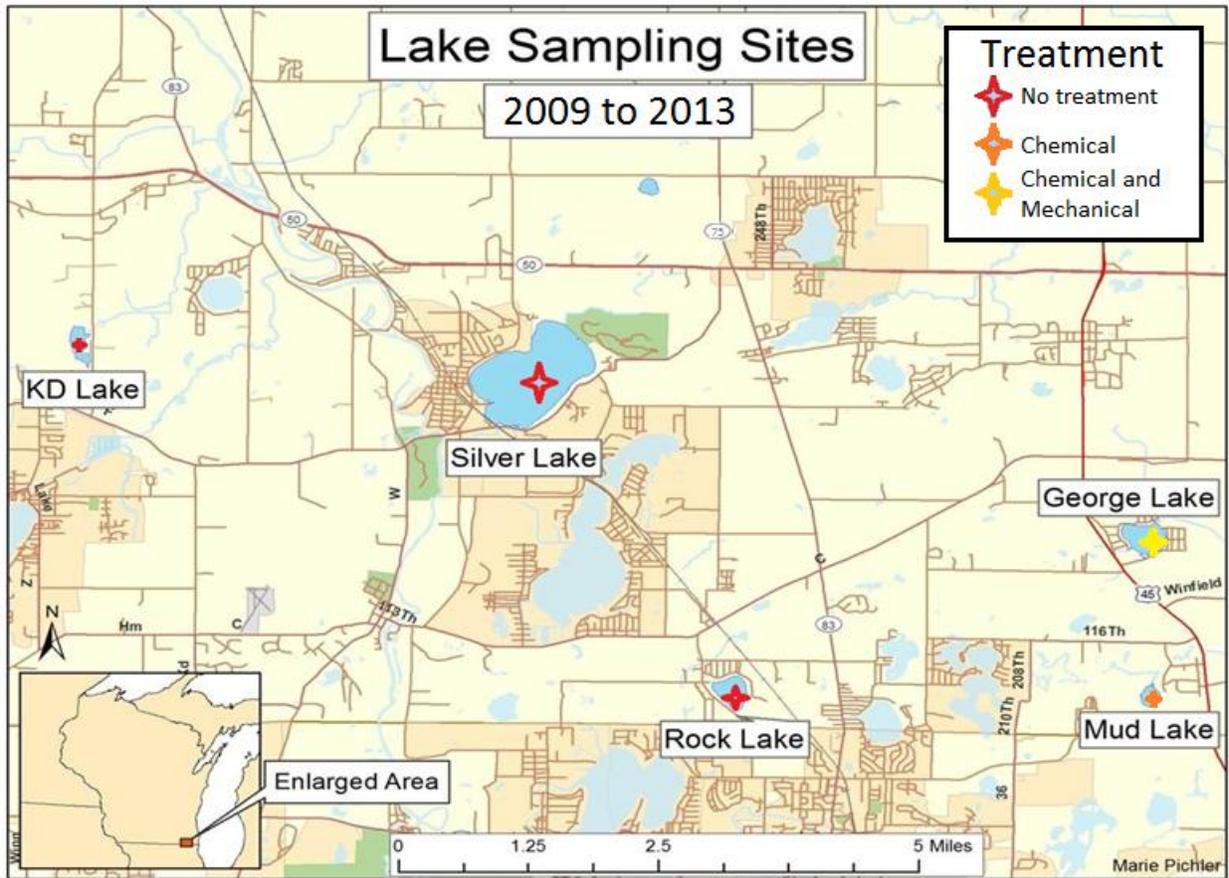
All sampling procedures were conducted by the Invasive Species Working Group from 2009 to 2012.

The prominent sampling method used for submerged macrophytes was the rake technique. Rake sampling refers to the use of a double sided rake which is thrown into the water at a randomly generated location, which was determined by dice roll. The rake is pulled in by string and species caught on the rake are separated and identified. Percent of total sample was estimated for native and non-native species sampled. The fullness of the rake is given on a scale of 1-3, 3 being the most full and 1 being the least. From this type of data information such as species richness and species abundance can be obtained.

Data Analysis

Using the data provided by the Carthage College Invasive Species Working Group (ISWG), the data were compiled into a single excel file. The data were used to create figures which show percent invasion over four years for each lake. Sample data were entered into SPSS for statistical analysis. Rank abundance, Univariate General Linear Modeling (GLM) and Shannon Weiner Index (H') were run to confirm statistical significance.

GIS was used to create land use maps for the area surrounding the lakes. Focus was on agricultural, urban, and undeveloped land usage.



(Pichler, 2013)

Figure 1: Mapped sample sites and their treatment in 2009-2013

Results

Results: Species Rank Abundance

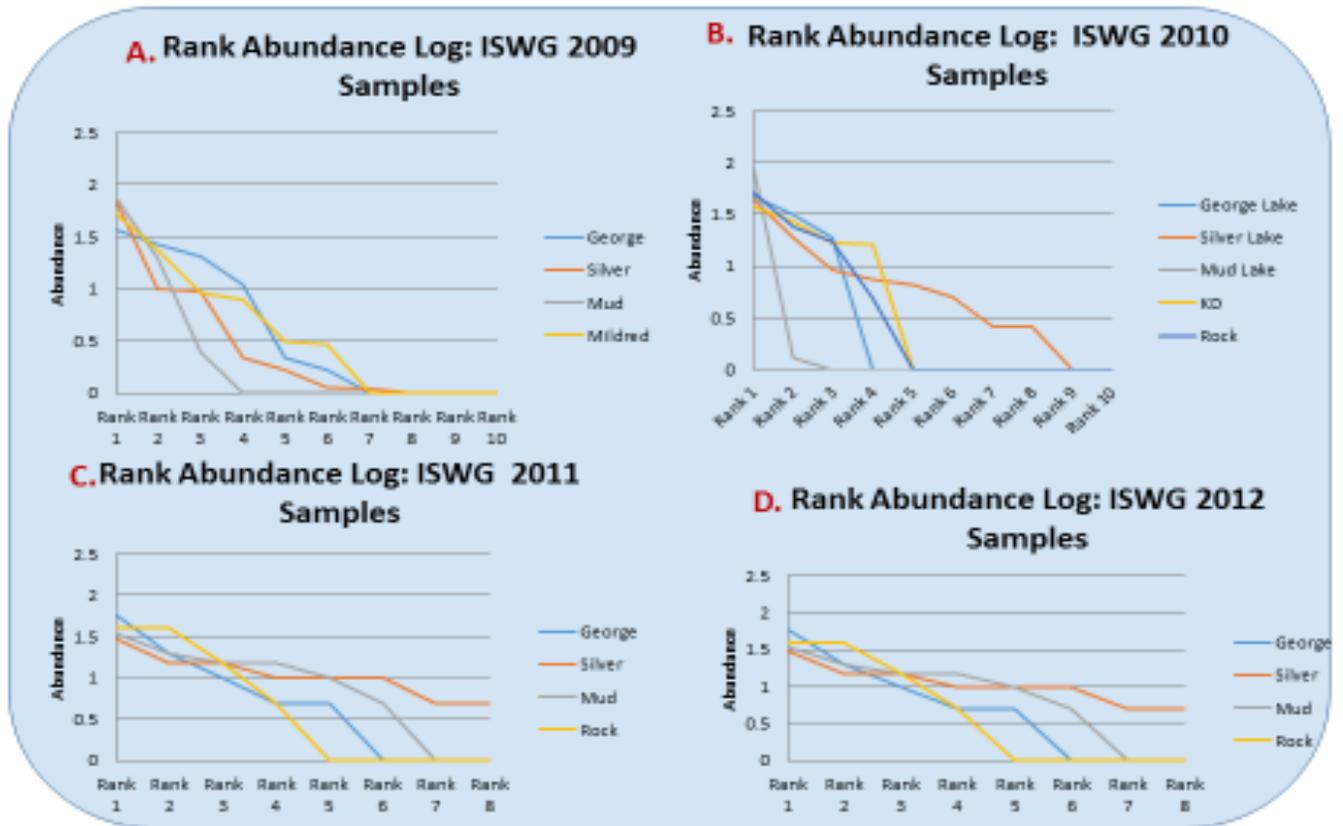


Figure 1: Four logged rank abundance charts for each sample year. Each rank signifies the most to least abundant species (From 1 being most abundant to 10 being the least) in each lake. A steep line indicates a low abundance of species, a long sloping line indicates an abundance of species.

Species Richness Statistics: Univariate GLM

Richness	P Value
Lake	0.04
Year	<0.001
Lake*Year	0.279

Table 1: P-values resulting from a univariate in which species

richness was the response variable, while lake and year were the treatment variables.

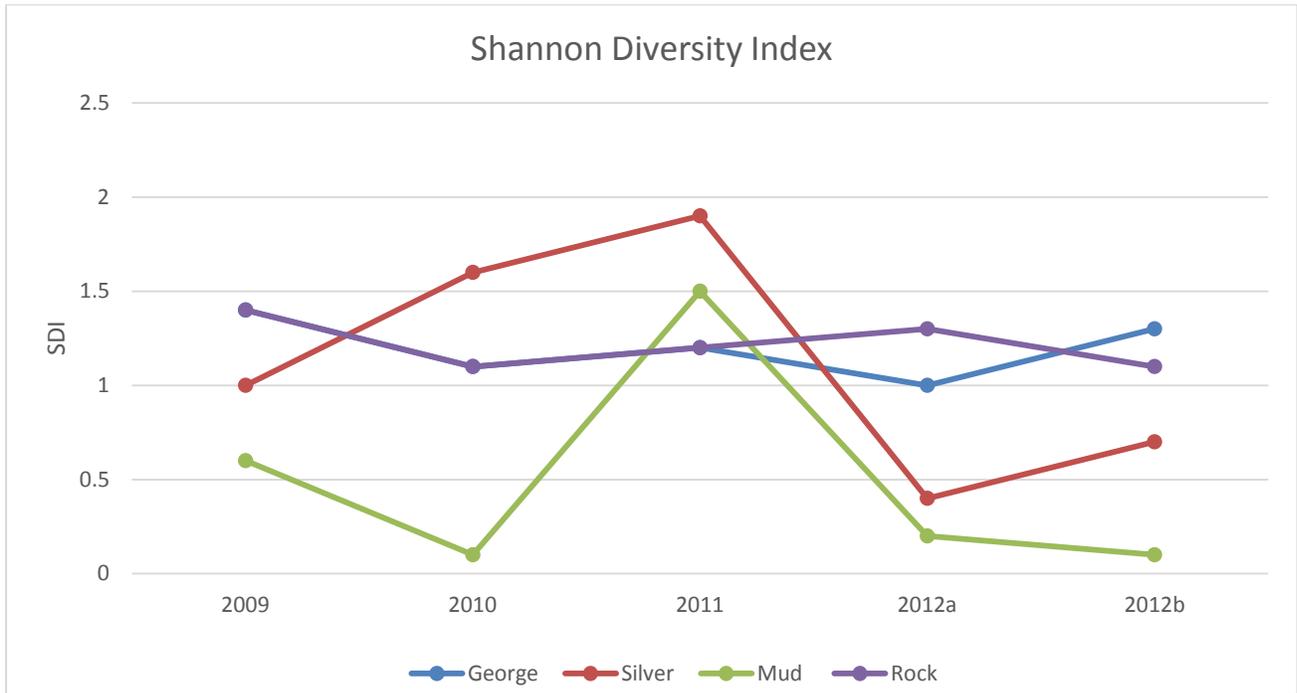


Figure 2: Shannon Diversity Index shows how species rich each lake was on a year to year basis.

Species Richness over Time

The graphs represented in Fig. 1 show how abundant each lake was each year. The expected or hypothesized result was that there would be lower species richness over time in lakes with a presence of invasive species. On a rank abundance chart such as these, lakes which were invaded would have been expected to show steeper lines in each progressing graph to show a loss of species diversity. In the graphs there is no distinguishable trend, or loss of richness over time. Therefore these figures do not support the hypothesis. The Shannon Diversity Index gives a more condensed view of species richness overtime in a standardized fashion. Although there is a noticeable loss of diversity in 2012a in Fig. 2, it is not enough of a trend to support the hypothesis that species richness would decline over time.

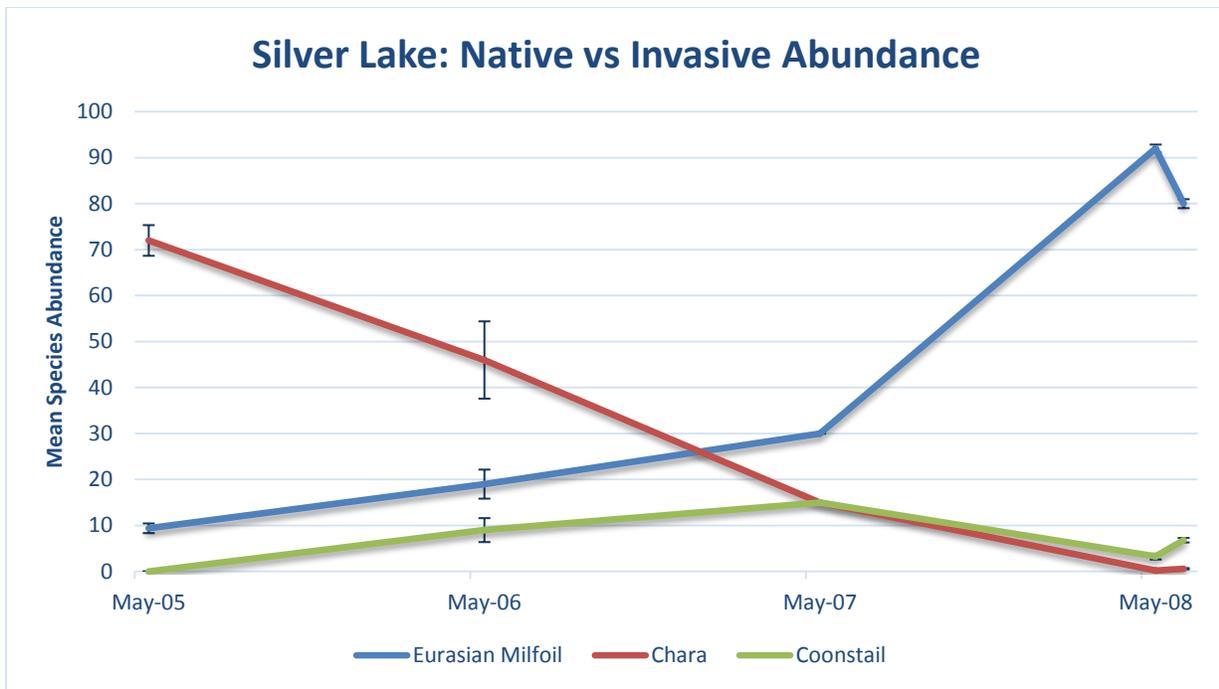


Figure 3: Mean percent abundance of native macrophytes (Chara and Coonstail) vs. abundance of invasives (Eurasian Milfoil) over a 4 year period in Silver Lake. (Error bars represent Standard Error.)

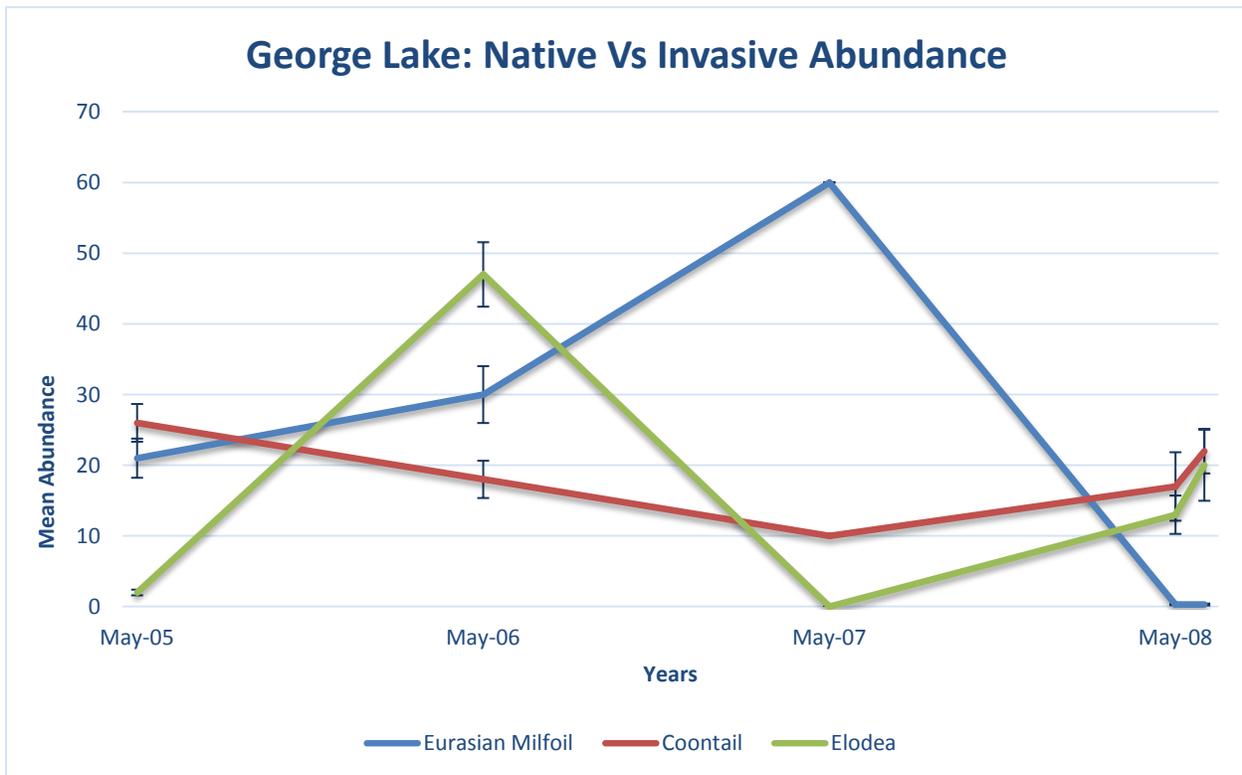


Figure 4: Mean percent abundance of native macrophytes (Coontail and Elodea) vs. abundance of invasives (Eurasian Milfoil) over a 4 year period in Silver Lake. (Error bars represent Standard Error.)

Species Abundance
GLM

Statistics: Univariate

Abundance	P Value
Lake	0.686
Species	<0.001
Year	0.326
Lake*Species	<0.001
Lake*Year	0.654
Species*Year	<0.001

Table 2: P-Values resulting from statistical analysis in SPSS univariate model with Abundance as the response variable, and lake, year and species as treatment variables.

Abundance of Native Macrophytes and Invasive Macrophytes

The hypothesis predicted that there may be an inverse relationship between abundance of invasive macrophytes and the abundance of native macrophytes which occupy similar niches within an ecosystem. As evident by fig. 3 and fig. 4, abundance of native aquatic tends to plummet when abundance of invasive species increases. It should be noted that George Lake chemically treated in 2011 post-sampling.

Discussion

There are certain effects that ecologists and environmental scientists tend to expect when investigating how invasive or non-native species interact with their ecosystem. These effects are typically thought of as the species ability to edge of native species for habitat and resources, and to lower species richness over time due to the invasive species ability to occupy multiple different niches which may have required native specialist species formerly. These accepted ideas about how invasive species interact with vulnerable ecosystems is what fueled the hypotheses behind this project. It is important to put these accepted ideals to the test to monitor how the presence of invasive species influence things like species richness and native abundance.

Species Richness over Time

Using data collected by the invasive species working group, these ideas about how invasive species behave were tested. In figures 1 and 2 the species richness of each sampled lake in Kenosha County is tracked over four years. These graphs address the question of how the

presence of Eurasian Milfoil impacted the species diversity and richness in each lake. I hypothesized that there would be a loss of species richness over time, after the lake was identified with a presence of invasive species. In figure 1 the trend lines for the lakes with an invasive species present would become steeper year progressive year. For example, in Fig. 1A Silver Lake's trend line would be long and slowly sloping and by Fig. 1D it would be much steeper representing much fewer species. This was simply not the case, and no true trends were noted. It is likely that there are many other factors which influence species richness, such as lake size, lake depth, and how native macrophytes interact with those facts. Chara, for instance, can grow at incredible depths of beyond 30 ft., while most other species cannot occupy such deep habitats. The ecology of a lake also has a heavy impact on this type of study. Along the same lines as Chara and its ability to occupy deeper niches, other native species may be better suited and established in certain areas of the lake, allowing them some sort of resiliency to invasives. For reasons such as these, it is hard to attribute a notable impact on species richness to the presence of invasive species. The hypothesis that species richness would decline over time in lakes identified with a presence of invasive macrophyte was not supported.

Native vs. Invasive Abundance

The hypothesis about the inverse relationship between native and invasive macrophytes which occupy a similar niche was supported in this instance. This displays that many species compete directly with Eurasian Milfoil and typically are not very successful in doing so. To put this in ecological terms, when Milfoil is dominating it leaves very little room for other species to establish themselves leaving them with lower abundance. It should also be noted that the methodology can have an impact here. If the rake sampling method is thrown, by chance, into Milfoil rich areas near the shore then the data would be skewed towards milfoil. The sampling method is by no means the most comprehensive but it allows a good, random, sampling of species and abundance. In both figure 3 and figure 4 Eurasian Milfoil becomes more abundant over time as it out competes native species. The exception, however, is after George Lake chemically and mechanically treats in 2011. This causes the abundance of Eurasian Milfoil to drop to near zero. The effect of the treatment can be deemed successful in ridding the lake of Eurasian Milfoil temporarily. George Lake has been treating regularly for several years, so this trend is assumed to be cyclical. Treatment allows for native species to regain a foothold on lost

habitat and curbs the chance of Eurasian Milfoil reaching such abundance that it begins to cause damage to the environment and prevent water recreation.

Methodology and Future Studies

The methodology for this experiment was not perfect. The rake throw method may not have captured a completely accurate representation of the population of the lake, and because macrophytes bloom and subside at different time in the season more rigorous sampling will do a lot to help correct for this. In the future, sampling in late May, June, and July at each site will account for the seasonal ebb and flow of macrophytes through the seasons in the experiment. Collecting data about the water quality at each site can also provide insight on other variable which may impact macrophyte populations. This would help to understand how much nutrient pollution from development plays a role, and if the macrophytes populations are causing lower dissolved oxygen. Lower dissolved oxygen could mean that remediation tactics are impacting oxygen levels, and need to be carried out sooner. With these factors investigated it will be much easier to understand how these lakes are similar and different on a chemical level, and also better understand the factors which are influencing the populations of macrophytes to vary.

Conclusion

Of the lakes sampled by the Invasive Species Working Group, the abundance of invasive macrophytes was inversely related to that of the abundance of native macrophytes. This indicates direct competition. The presence of invasive macrophytes did not seem to have an impact on the species richness in sampled lakes, but this is likely due to other confounding factors such as size and depth. Further monitoring of lakes in Kenosha County should be conducted to continue to follow and identify new trends.

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