

EXPLORING THE FACTORS THAT INFLUENCE THE DECISION-MAKING PROCESS BEHIND AQUATIC INVASIVE SPECIES CONTROL METHODS

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Abstract. Lake organizations are important management entities that manage lakes on a small, local scale, including creating and maintaining management plans, monitoring boat landings for AIS, and creating a community environment around the lake. A major issue that a lake organization may have to address is the presence of aquatic invasive species (AIS). AIS pose many threats to native plants and wildlife, as well as negatively affecting the coupled human-natural systems incorporated with these lakes. Lake organizations can have input on how to control AIS in their respective lakes, but they have many endogenous and exogenous (internal and external) factors or considerations to take into account when deciding which control methods to use. While there has been research done on the effects of AIS, the control methods best suited to control them, and on decision making processes, there is little known about how these lake organizations operate and ultimately choose a control method. Through interviews with board members of lake organizations in Vilas County, WI, it was found that organizations considered endogenous economic, exogenous governmental, and exogenous environmental factors the most when choosing a control method. Social and endogenous governmental factors were considered the least. Lake organizations can be more effective at aiding in lake management if there is better communication within and between organizations, and if these organizations have more representation in local government. These lake organizations need to be as effective as possible because they are the first line of defense against AIS and can see the changes on the lake before others.

INTRODUCTION

Overall, this paper is looking into the factors that influence the decision-making process involved in selecting an AIS control method to understand why certain control methods are used more than others are. Understanding the decision-making process will help lake organizations make better-informed decisions regarding AIS and stay better connected to their organization's goals.

A lake is classified as a body of water surrounded by land, but can vary drastically in size, composition, and formation. For example, many of the lakes in the Northern Hemisphere were formed by glaciers and are freshwater. Lakes can also be formed by tectonic plate movement and be saline. The variety of lake ecosystems makes them crucial to the survival of many different species because of the different habitats created by them. Different species of fish live in these lakes, deer and other mammals drink the water in the lakes, many different species of birds will nest nearby the water or even in the water, and some insects need the water to live (National Geographic Society 2012). These lakes are important not only because of their ability to sustain diverse ecosystems, but also because of the many ecosystem services they provide humans. People use lakes to fish, swim, and for many recreational activities like boating, canoeing, or kayaking. In some freshwater lakes, people will use the water for drinking or agriculture. Despite many people depending on lake for support, people have inadvertently harmed lake ecosystems through the runoff of pollutants, destruction of wetlands for developments, overharvesting of fish and other species, and through the introduction of non-native species that potentially could become invasive (Peterson et al. 2003).

As more people began to use and depend on these lakes, different organizations formed in order to help with the local management of these lakes on differing levels of involvement (Source: interviews with lake organizations).

Vilas County is in Northern Wisconsin, on the border with Michigan. It is part of the Northern Highland Lake District (NHLD), a region of Northern Wisconsin that expands into several counties and is characterized by the high density of lakes formed by glacier movement (Peterson et al. 2003; Carpenter et al. 2007). Vilas County alone has more than 1,300 lakes (“Lakes & Waterways” 2019) and recreation and fishing of these lakes constitutes a major component of the county’s economy (Peterson et al. 2003). The water in the lakes in Vilas County is Wisconsin public property and is managed mainly by the state while the land surrounding the lakes can be private property (“Waterway protection” 2013). Many people come to Vilas for fishing, retirement, or have their summer homes on the lakes. Vilas County was the chosen study site because of the large density of lakes and voluntary organizations that have formed to help with the management of these lakes. Vilas County is a good place to have many observations of how these organizations operate in a small area.

A lake organization is a self-organized group of people who manage the lake in partnership with the state and the Department of Natural Resources, or DNR. Back in the early 1970s, a partnership between the DNR, the University of Wisconsin (UW) Extension, and the Wisconsin Alliance of Lakes was formed to manage better lakes on multiple scales. The UW Extension program links lake stakeholders and provides educational material for lake users. The Wisconsin Alliance of Lakes is comprised of local people that form lake organizations on their individual lakes (“Wisconsin Lakes Partnership” n.d.). These organizations are typically divided into lake associations and lake districts. A lake association is a voluntary group of people who get together to manage the lake on varying levels of structure that intends to maintain, protect, and improve these lakes and the surrounding areas (“What is a lake association?” n.d.). A lake district is a governmental organization that has been formed by the town or state via a formal petition by lake area owners. These districts serve similar purposes as associations—maintain, protect, and improve lakes—but have elected or appointed leaders, budgets, and the ability to regulate lake use (“Lake Districts” n.d.). Outside of an individual lake scale, some towns have formed town lakes committees. These town lakes committees are small government committees that have the ability to apply for grants and create town wide management plans. These committees have representatives from different lake organizations in their respective townships and are a safe space for them to share problems, ideas, and solutions (“Lakes committee meetings” n.d.). Additionally, the county is involved with these lake organizations through the Vilas County Land and Water Conservation Committee. This committee helps lake organizations through promoting shoreline restoration, applying for grants, manage monitoring boat landings, and through helping them create their organizations in the first place and keep them running (“Land & Water Conservation” n.d.).

AIS are non-native species that enter waterways whose presence causes damage to the ecosystem, tourism, and any industry dependent on the land (“Aquatic Invasive Species” 2015). Some of the restricted AIS in Vilas County are rusty crayfish, banded mystery snails, Chinese mystery snails, Eurasian watermilfoil, purple loosestrife, and curly leaf pondweed, but there are many others found in the county (“Invasive Species – Regulated animals” 2015; “Invasive Species – Regulated plants” 2015). When discussing AIS, it is crucial to understand what they are and the impacts they have on the lake system overall. AIS have been introduced to Vilas County through a multitude of ways, but the biggest cause of introduction has been through ballast water on ships to the Great Lakes and then brought to Vilas through smaller personal watercrafts. AIS have spread between lakes through the improper cleaning of boats, equipment, and motors by lake users such as anglers or motorists (McFarlane 2011).

Individually, each species has its own unique impact on local ecosystems. For example, Eurasian watermilfoil outcompetes native species for light (“Eurasian water-milfoil” 2019) whereas curly leaf

pondweed not only outcompetes native species, but will also change phosphorus concentrations in the water contributing to algae blooms (“Curly-leaf pondweed” 2019). When choosing a control method, a lake organization must take into consideration the different impacts and effects each species has on the environment in order to determine how to best treat it (“Controlling Invasive Species” 2019). Furthermore, recreational activity can be greatly harmed by the presence of AIS. Aquatic invasive plants like Eurasian watermilfoil and purple loosestrife make it difficult for boats and other motors to pass over the dense mats (“Eurasian water-milfoil” 2019; “Purple loosestrife” 2019). Different species of snails and mussels can damage boat motors and clog water intakes. Additionally, it can cost a significant amount of money to repair any damage AIS cause and to control AIS in general—the United States overall spends approximately \$100 billion on controlling invasive species each year. AIS also have the potential to harm or decrease property value around these lakes (Lake-Link, n.d.). Overall, AIS decrease the value of the experience for recreational users and residents around these lakes.

As reported from the Wisconsin DNR, there are four typical categories for AIS control methods: manual, mechanical, chemical, and biological. Manual methods are anything done by hand, such as pulling, digging, and smothering. Manual methods must be done frequently and are most effective on small populations; if the population is too large or too persistent, manual methods can become too expensive (“Controlling Invasive Species” 2019). Mechanical methods include using tools and machines to remove AIS, with the most popular being harvesting (Madsen 1993; “Controlling Invasive Species” 2019). When used with chemical treatments, mechanical treatments become more effective than on their own and are fairly resource effective when treating small populations (“Controlling Invasive Species” 2019). Chemical treatments are popular across the country, often the preferred method of treating AIS (Madsen 1993). Chemical control methods are the application of pesticide, herbicide, and insecticides in accordance to their labels. The biggest note about chemical control methods is that it requires a certification for knowledge of application (“Controlling Invasive Species” 2019) and often comes with before and after examinations of the ecosystems to see the effects of the chemicals on the ecosystem as a whole (Madsen, 1993). Chemical treatments are not always effective and often require follow up treatments depending on the species. For example, Eurasian watermilfoil, when treated with chemical in a group of lakes in Wisconsin, always came back to pretreatment levels or higher (Wagner et al. 2007). Lastly, biological control methods involve the use of other organisms to control the invasive population. Biological control methods require permits at both the state and federal levels. Furthermore, biological control methods do not completely eradicate the invasive species but merely slow it down (“Controlling Invasive Species” 2019). An issue with biological control methods is that they can be very expensive: one weevil used to control Eurasian watermilfoil can cost up to a dollar (“KLSA’s Guide” 2004). Additionally, the biological agent must be able to establish an adequate population in order to control the AIS. If the agent’s population fails, then the investment is gone and the AIS can continue to spread. This was the case with populations of the milfoil weevil when it was introduced to lakes in Minnesota for a study (Newman et al. 2001). Each control method has its own merits, yet overall are dependent on the situation and are used most effectively when combined with other control methods (Mullin 1998; “Controlling Invasive Species” 2019).

Outside of control methods, there are many prevention methods for lake organizations to implement. One of these methods is Clean Boats Clean Waters, or CBCW. CBCW is a monitoring program where monitors stand at the boat landing and will inspect boats and trailers before and after they use the lake, looking for AIS. Organizations in Vilas County can opt to do CBCW through volunteers in their organizations or they can hire monitors as a paid position, often through the University of Wisconsin Oshkosh. Organization can apply for grants to pay for these services where the grant will cover 75% of the cost and they have to pay the difference through funding or volunteer hours (“Department grant programs” 2019). Another prevention methods that organizations implement are management plans, lake studies, education programs on the boat landings or at meetings, and sending out flyers or newsletters to members and lake users about how to stop aquatic invasive hitchhikers (Source: interviews with lake organizations).

When it comes to deciding how to control AIS, lake organizations are faced with many considerations. They first have to decide how worthy of control the AIS is and how successful the control method could be against the AIS (Maguire 2004). When it comes to controlling AIS, it is only economically worth it if the damage the AIS causes outweighs the cost of controlling the AIS (Lovell et al. 2006). Furthermore, the organization has to predict the effects of the AIS on different ecological, social, and economic values, which will vary among different organizations (Maguire 2004). However, an important thing to remember when it comes to protecting against the entry of AIS is that every lake is vulnerable even with proper precaution and control, especially if other nearby lakes are not taking the proper precaution (Lovell et al. 2006).

Understanding the factors and rationale behind what influences people to make decisions regarding AIS is important to know because it will help these organizations run more efficiently. For example, if they truly are limited by economic means, they can resolve this limitation by applying for more grants and working more closely with the DNR to attain more funding. However, if they chose their control method based on which method has the most support from their community, then having more communal education about AIS would help them make better informed decisions. Analyzing these factors will reveal patterns about which factors are prioritized more often compared to others, which will reveal where management plans are least effective. Ultimately, these lake organizations can greatly influence what happens in the lakes overall and knowing how they are making their decisions can keep them well informed.

All of this background leads to the question of what factors do lake organizations consider or prioritize when deciding on an AIS control method? This paper will delve into how lake organizations make their decisions when it comes to selecting a control method by analyzing responses collected through interviews with board members of lake organizations. The initial hypothesis as to why lake organizations choose the control methods they do is because of economic limitations, such as lack of grant funding by the DNR. For each incorporated lake organization, the DNR will list out on their websites what grants the organization has reported to receive. Initially, it was believed that these grants were not sufficient to control the organizations' AIS problems but this was not the case. Additionally, it was thought that organizations would have high input from members and high social participation. It was thought that these organizations would operate in a manner where money and society was prioritized because those would be the most prevalent factors; however, this was found not to be the case. There are many other factors that may be contributing to these decisions, such as the social support, environmental concerns, and governmental regulations surrounding the control methods and impacts of the AIS.

METHODS

To collect data on why lake organizations chose one control method over others, we conducted interviews with board members of lake organizations in Vilas County that manage three or fewer lakes with a public landing. Organizations that managed three or less lakes were selected because their answers could be more specific when answering about fewer lakes than many lakes all together. If they managed more lakes, the harder it was for them to answer questions, as each lake is unique. Additionally, the lakes needed to have a public landing, which is a public boat dock that everyone including non-residents can use, so the dynamics between the lake, the organization, and different lake users could be understood. In Vilas County Wisconsin, there are approximately 120 lake organizations and 52 of them fit the necessary criteria. The goal was to interview between 30 and 50 of the organizations, with all 52 reached out too via phone call, email, or postal mail depending on the information provided on the UW Extension Website. By the end of the study, 31 lake organizations had been interviewed. Not all of them were interviewed because of the time constraint, they were not interested in participating, or they could not be reached from incorrect or outdated contact information.

It was chosen to interview people so information on the factors behind their decision-making process, their stories, their values, and the rationale behind their decision could be collected directly from the source.

Interviews are more appropriate than questionnaires for this study because the information being collected is more qualitative data in order to build a narrative surrounding these lake organizations and their decisions. Interviews also provide more detail than questionnaires. Interviews also enable us to follow up and ask clarifying questions (Rowley 2012). These semi-structured interviews will guide the interviewee through a series of questions that are meant to engage them in a discussion where they can talk about their opinions, attitudes, and experiences.

Overall, each interview lasted between one to three hours, with open-ended questions and chances for discussions with the questions on AIS taking only a couple minutes at the end of each interview. These interviews were part of a larger research project titled FishScapes and the AIS questions were a subsection of the overall interview. AIS was addressed throughout the interview as management options were discussed; yet to ensure AIS was covered in the conversation, a checklist of questions was created to ask at the end of the interview regarding the factors surrounding AIS control methods as well. The questions asked were:

- What AIS have you observed in your lake?
- Was AIS a major concern when developing your management plan and goals?
- Do you think the currently management plan is effective at controlling AIS?
- Which control methods are currently being implemented?
- Why did you choose these methods?
- How do you decide which methods to choose? (i.e. frameworks, models, etc.)
- Are certain control methods preferred more than others?
- Why are these preferred?

In each interview, it was asked what AIS they have observed in their lake even though the DNR has a list of the report and verified AIS in each lake in Vilas County. However, it was important to collect the information on which AIS the residents think they have to get a better understanding of what they this an AIS is, which ones they think are important to talk about, and if they noticed any AIS that the DNR has not openly reported yet.

A thematic analysis was used for this study rather than quantitative because there was not a large amount of quantitative data collected but rather more stories and reflections from the participants (Rowley 2012). Based on the answers given in these interviews, responses were grouped according to which themes and factors they align best with and analyze how often each factor came up in the interviews.

A factor in this study is something the organization considered when making their decision. During the interviews, the members talked about the things they considered while making their decisions and to make it consistent across all the interviews, these considerations, or factors, were categorized into economic, social, environmental, and governmental categories. These categories were chosen based off the concept of sustainability and that there are many stakeholders involved in sustainability that need to be represented in every decision (“Learn About Sustainability” 2019). Each of these categories were further subdivided into individual categories (Tables 1-4).

Once the responses were accounted for, they were sorted into endogenous and exogenous factors within these four main categories using tested definitions from the interviews, exemplified by Table 5. Exogenous factors are aspects that are outside the control of the organization, like grants awarded by the DNR. Endogenous factors are aspects that are internal to the organization, like social support from members or their ability to apply for grants.

Lastly, all the exogenous factors and endogenous factors were combined to calculate a grand total of

exogenous and endogenous factors. Using the frequency of responses in the endogenous and exogenous categories, it was tested to see whether there are significant differences using the Wilcoxon test.

RESULTS

A total of 31 organizations were interviewed over the course of 9 weeks during May to July 2019, with 5 lake districts and 26 lake associations being interviewed. Between one and eight people were interviewed at a time. During the interviews, participants' responses were sorted into the individual factors after being divided into economic, social, environmental, or governmental categories. There is a plethora of factors that organizations have to consider when making these decisions, and the factors included in the analysis were ones the lake organizations listed or spoke about in the interviews but may not be an exhaustive list.

Some organizations implemented more than one control method depending on the combination of AIS in their lake or the lack thereof. Often, control methods are more effective when used in combination with others; for example, many organizations that chemically treated their lakes chose to manually treat the lake in between chemical treatments to help control the AIS (source: interviews with lake organizations).

All but five organizations had prevention plans including CBCW, education, and monitoring. Prevention is not always effective because the water in the lakes is publicly owned and managed even though the land surrounding the lake can be private property ("Waterway protection", 2013). On lakes with public access boat launches, residents and members cannot legally exclude people from using the lake. Some organizations had prevention plans in place, but the programs they had were not always effective because constant monitoring is often difficult for these organizations due to labor intensity and high costs. For example, they could have funded CBCW, which would mean they have prevention in place, but they did not have coverage at all times when people were using the lake effectively to prevent AIS. Yet other lakes had prevention plans in place that seemed to work for them. One lake organization funded CBCW every day, had their boat members educate lake users while inspecting their boats and trailers, and sent out newsletters. This lake did not have any AIS in it yet, but the lake organization did have extensive funding and directed most of their time and money toward prevention.

The lakes organizations dealing with Eurasian water milfoil often chose to treat the lake chemically because they thought that chemicals were the only relatively effective treatment and did not know what else to do. One lake chose to treat their milfoil issue with weevils, a native beetle like creature that eats Eurasian watermilfoil. The other biological control methods included the organizations changing or maintaining a smallmouth bass population in their lake to help control rusty crayfish. Chemical and biological treatments were often cited as too expensive or they were too unsure of the long-term consequences of implementing these control methods.

No organization used mechanical control methods. Through the interviews, it was discovered that the DNR often prohibits mechanical harvesting until the situation is desperate. Mechanical harvesting was often thought to spread the AIS and perpetuate the issue, so organizations would only get a harvester if they could not control the AIS any longer and needed to cut navigation paths through the weeds (Source: interviews with lake organizations).

However, some organizations chose not to control the AIS if they viewed them as unproblematic or did not know how they could be controlled. This was often the response to rusty crayfish, banded mystery snail, or the Chinese mystery snail because the organizations did not think these species did much negatively to affect their use of the lake. It is important to note that the species that they deemed as relatively unproblematic were still changing the ecology of the lake, but not to an extent where it was worthy of their time and money. Furthermore, some organization simply did not know how to treat for these species. Some organizations manually trapped crayfish or aided the smallmouth bass population but there was nothing to

treat the snails. Even trapping crayfish was ineffective, as one organization mentioned that professional trapper could throw crayfish back into the water to always ensure they could come back and work the lake again. Yet, only the species that were unproblematic went untreated: the problematic AIS were always treated, even if the organizations were unsure on which control method to choose.

The average number of factors lakes stated they considered per interview was 5.32; with the median being six factors (Figure 2). Those with the more problematic AIS, like Eurasian Watermilfoil, tended to have to make more considerations. The average number of factors for those organizations with Eurasian Watermilfoil was 7.25 for the seven organizations having Eurasian watermilfoil. Furthermore, those without problematic AIS, the average was 4.565 factors per interview.

Based on this figure, the Mann-Whitney test could be used and found that for a two-tailed test and using a p-value for significance of 0.05, there is a significant difference between the average number of factors between lakes with Eurasian Watermilfoil and all lakes in the study overall. Using this test, the p-value is 0.0114 and the z-score is -2.53249.

This is an important distinction to make because it shows that those that have problematic AIS consider more in order to make an already difficult decision compared to those without because they need to consider factors like expenses, the most effective control methods, and how long the control method is effective. Those without problematic AIS typically picked the cheapest control method or just chose not to treat it. It shows the importance of preventing the appearance of problematic AIS for these lake organizations so they have less to consider in the long term.

Organizations considered endogenous and exogenous factors relatively equally, but the endogenous category was recorded slightly more. This means that these organizations had to consider their own responsibilities, limitations, and abilities when making decisions. Using the Wilcoxon test and a two-tailed hypothesis, we get a p-value of 0.45326, meaning that there is not a statistically significant difference between the exogenous and endogenous distributions.

The overall exogenous and endogenous factors were further split into the economic, social, environmental, and governmental categories to see which categories organizations were considering more or prioritizing.

When deciding on a control method for AIS, organizations typically consider endogenous economic (23.03%), exogenous governmental (21.21%), and exogenous environmental factors the most (20.00%).

Endogenous economic factors were the most frequently recorded with 38 responses. These organizations put a great deal of thought into how they were going to pay for treatments or management plans, whether it was through grants, creating an AIS control fund through member dues or donations, or taxes from the town or district. The grants received through the DNR only paid for 75% of the total cost so the organizations needed to come up with the difference (“Department grant programs” 2019).

Exogenous governmental and endogenous economic factors were often connected. The organizations occasionally went through their town board or town lakes committees to get funding aid. A town lakes committee is a voluntary organization at the town level that helps these organization apply for grants, do management plans, and share information between each other and more (“Lakes committee meetings” n.d.). Furthermore, the town with proactive town lakes committees (or committees in general) typically could be more proactive in their actions because the town could pay for the development of their management plans or help pay for the cost of installing cameras at the boat landings.

It is crucial that lake organizations have support from local, county, and state government levels because these lake organizations can see the immediate changes in the landscape and know what is best for the land.

Scenario planning done on the NHLD reveals that when there was a lack of input from the local organizations, there was no effective change done to help the land. The region, which was once an isolated sanctuary, became a modern suburb with abused resources (Peterson et al. 2003). The effects of these organizations being undermined has already been observed through these interviews. One lake organization wanted to install a holding pond for a stream to run into since the little stream was bringing run off into the lake. The local government system was inhibiting this organization from installing this holding pond even though it was for the benefit of the common resource. This same support is necessary for AIS control and prevention as well. Another lake organization that was struggling to control Eurasian watermilfoil was having difficulty attaining grants from the DNR to treat the lake chemically since they believed that was the only effective method of treatment. When the DNR came to visit the lake, they suggested mechanical harvesting navigation paths even though this could proliferate the issue.

For many of the environmental factors, both endogenous and exogenous, there was simply a lack of knowledge of the effects of the AIS or control method. Nine organizations cited that the AIS did not seem to be causing much harm to the environment so they decided not to treat them. Four organizations mentioned not knowing if anything could be done to treat the AIS, even if the AIS was not appearing to be harmful. Additionally, four organizations mentioned not knowing the long-term effects of the control method, mainly chemicals, on the environment but three decided to treat with chemicals regardless.

Consistently, social factors were considered the least and typically was dependent upon volunteer participation. Four organizations mentioned considering the public opinion of the control method when considering chemical treatments and once it was mentioned that mechanically harvesting AIS was too controversial within the membership. It was observed that most people were seemingly willing to do whatever it took to control these AIS and revert the lake back to its state before the invasion.

Each control method needed many factors to be considered and across the board, they all were fairly even in their considerations. This also means that the hypothesis could not be supported, as exogenous economic means are not driving these considerations. Their decisions on how to control the AIS present in their lake are not necessarily being driven by independent features unique to each control method, but rather are interpreting the same thing in different ways. Each organization is considering the same factors for each control method, but will not decide on control methods because of one concept alone, creating a “gray area” that these organizations must operate in rather than “black and white”.

DISCUSSION

The purpose of this study was to examine which factors lake organizations consider or prioritize when making decisions regarding AIS. Initially, it was believed that they would be limited by exogenous economic reasoning and would have difficulty funding their programs. While these economic factors were still of concern to these organizations, they considered endogenous economic concerns more frequently, as well as exogenous governmental and exogenous environmental concerns. An important note to make is that these factors are not necessarily limiting elements: they are merely concepts that lake organizations considered when making their decisions about AIS control methods. It was occasionally observed that organizations would consider something yet make their decision in spite of it. For example, one lake organization reported that they were chemically treating their lake, but one of their residents did not want chemicals in the lake anymore because she was going through chemo and did not want the chemicals to make her ill. The organization continued to treat the lake but attempt to alert all residents about the chemicals by putting signs up around the public landing.

Endogenous governmental factors were low on the list of factors, but these organizations need local and state governmental support. Many organizations mentioned DNR or state regulations and restrictions during the interview, but there was only one instance of an endogenous governmental factor when one lake

organization petitioned the DNR to change the bag limit for smallmouth bass: they had a rusty crayfish problem and since bass eat crayfish, they wanted more bass in their lake. Endogenous governmental factors are the result of the organization getting involved in the government and having representation. Having more government participation from these organizations would lead to them influencing their government and the rules as opposed to more external regulation and restriction from the local and state levels. Additionally, there needs to be a level of trust with these organizations because the members of these organizations have a personal interest to keeping these lakes healthy, potentially for a monetary investment or an intrinsic value connected to the lake. Smaller local government units like town lakes committees help lake organizations attain their goals and stay connected to each other. Furthermore, many of these organizations were harmed by the change in state regulation because more short-term rentals could come on the lakes when zoning changed. Organization members typically disapproved of rentals because they felt like renters did not have long-term investments in the lake and did not always follow the town ordinances or courtesy codes. Having lake organizations involved in the creation of ordinances, having state enforcement of these ordinances, and allowing the county to have more strict regulations help lake organizations protect their lakes.

Social factors were the least considered category overall which means there is poor communication and input both within the organization and between organizations. Many of the organizations explained that they had low participation in the organization: they had trouble getting people to join, getting people to attend meetings, and getting people to volunteer their time. Two organizations had programs where members were assigned a section of the shoreline to monitor and keep note of what was there: they found this program effective at identifying AIS early and enabled members to feel like they were contributing something useful to the organization.

Governmental support and social support often can be overlapped in town committees or lake conferences. A prime example of support both socially and governmentally are town lakes committees since the organizations are recognized by a town committee and have representative from the lake at the meetings. At a town lakes committee meeting, a member explained that these committees are useful because they then know what is happening to other lakes and can get help from other lake organizations. They are places to share ideas, suggestions, and problems. There are also conferences around the state and county already in place that lake organization members are invited to; however, these conferences do not typically have a high attendance, and those who do attend are normally lake organizations that are fairly well established. The lake organizations that need the most support are not usually the ones that have the means or funds to send members to these conferences. Additionally, very few of these lake organizations were in communication with each other since very few towns had town lakes committees where most communication occurred. The UW Extension website has the contact information for most lake organizations in Vilas County but the information was outdated. Having a more accessible local way for organizations to communicate and help each other is a simple way of helping these organizations succeed.

Factors were often connected to each other in some way showing that these decisions are not “black and white” decisions that can be made easily: it takes so many considerations to make these decisions. These organizations are trying to do right by the environment, the economy, and the lake users but it is not that simple. Some considerations that organizations made could be categorized in two or more ways creating a “gray area”, yet this gray area happened to almost every organization. With endogenous government and both social factors so low, they are not receiving input from the “people” so they are choosing to try to help the environment by eradicating AIS no matter what it takes. This thought process was occasionally beneficial for the lake organizations interviewed when the treatment of AIS was successful. However, this mentality sometimes leads to a radical form of thinking, where the organizations would unintentionally over treat the lake while on the pursuit of treating AIS and accidentally kill native weeds and organisms (Source: interviews with lake organizations).

Many organizations treated AIS as an inevitability but still wanted to keep them out as much as possible. Since AIS are difficult to prevent completely, it is important for organizations to have a balance between preventing them and treating them if and when they do appear. It is a good practice for organizations to have a management plan in place before having AIS so they can begin to treat as soon as it is discovered. Management plans through consulting firms often included a lake study over the course of a few years to create a baseline for the lake. Understanding what is normal for the lake will help lake organizations understand what is in the lake currently and what invasive species could thrive in the lake. These management plans and consulting firms can give recommendations on what future steps and opportunities are in front of the organization so they can protect the lake to the best of their ability. Organizations can receive grants in order to pay for these management plans or even can get funding through their town or town lakes committees. Some townships will even fund lake studies on the lakes in the town and create a town wide management plan so the individual lake organizations are not responsible for the funding difference, which is another reason having a strong relationship between these organizations and government is so important.

The biggest limitation of this study to be recreated in the future would be that different answers could be given to the questions based on who was being interviewed. Each individual had their own unique perspective of the lake and while the overall perception of the status of the lake was fairly consistent, each individual would give answers based on what they thought was important. Additionally, not every interviewee was well informed on what was happening in their lake in regards to AIS, so simple lack of knowledge could be a barrier for future studies. An effort was made to keep all questions consistent across all interviews but some interviewees answered the questions that were needed or needed new questions to prompt more response. As a result, some interviewees were able to give more information than others were because they were somewhat prompted to do so. For future studies, having a more structured question system but still enabling participants to have freedom in their answers would give the study more consistency. Additionally, asking more prompting questions to get participants to talk more about their considerations would give more detail and more to analyze.

Through organizations like the DNR, UW Extension, and other environmental groups, the ecology of these lakes are fairly well known, but not enough is known about the lake organizations that help manage them. There is very little literature on how these organizations operate, their best practices, and what they actually do for the lakes, and there is even less on how these organizations manage AIS. There are many opportunities for more research on AIS and on these lake organizations. For AIS research, there are many future potential opportunities to learn more about AIS and how lake organizations interact with them. There is future research on what the best monitoring and prevention method is for lakes, ranging from physical monitors at boat landings to cameras to an honor system but installing power washing stations so people can clean off their boats and trailers. Additionally, the development of more management plans that have a better balance between prevention and control is necessarily, especially since people are viewing AIS as more of an inevitability rather than a possibility. A new possibility for these management plans is to be town wide rather than by individual lakes so help save money and increase communication between these lakes. Additionally, some of these organizations need more help to be more organized and more structured so they can actually operate efficiently. Creating a plan for these organizations to follow while forming will give them the structure they need to be successful. An existing guide on how to structure the organization and opportunities for consultation is available through UW Extension but not every organization knows this guide and consultation exists.

These lake organizations need to be understood because they are the first line of defense against aquatic invasive species. Understanding them and giving them the support they need to be successful alleviates responsibility from other organizations like the DNR and can help protect the lakes even more since they see the changes and damages to the lake before anyone else. Allowing them to tackle AIS issues when they

are identified will help solve the problem early, potentially save money, and protect the water and the native species in the lake from future competition and damage.

ACKNOWLEDGEMENTS

A special thank you to my mentors Dane Whittaker, Marco Janssen, and Chris Solomon; my research partner Alise Crippen; The Cary Institute of Ecosystem Studies for this REU opportunity; and the NSF for funding this project. The National Science Foundation under Grant No. 1559769 supported this work.

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APPENDIX

TABLE 1. Economic Factors used in the consideration of AIS in lake organizations.

Economic	Description
Attaining grants	(from the DNR, state, or third party) Anything to do with grants: they are having difficulty applying for grants, they're applying for grants for treatment or management plans, they are not receiving grants, they cannot apply for grants, etc.
How damaging the AIS is to the local economy	They decided to treat the AIS because it was damaging to their economy: property values, dock maintenance, etc.
Most economical method	They considered which method was most economically viable.
Taxes	The lake organization receive money from the town that is collected through a room tax or the organization petitioned to be a district so they could collect taxes from lake residents.
Other	Other economic considerations the organization has made such as reimbursement rates, DNR financial contribution, membership donation, etc.

TABLE 2. Social Factors used in the consideration of AIS in lake organizations.

Social	Description
People don't want the AIS gone	People find the repelling factor of the AIS to be valuable or think the AIS is pleasing. They would rather just leave it than deal with treating it.
Overall approval from the control method from the community	They considered how members felt about the control method and the general support they had.
Labor Intensity	They considered how much labor it would take to implement the control method (workers, divers, volunteers, etc.)
Other	Other social considerations the organization has such as communication with other lake organizations or the lack of desire to have external evaluation of the lake.

TABLE 3. Environmental Factors used in the consideration of AIS in lake organizations.

Environmental	Description
Impacts on native species	(Both AIS and control method) Both control method and AIS; looks at how the AIS/control method impacts the existing species in the lake
Impacts on water quality	(Both AIS and control method) Both AIS and control methods and the impacts they have on the water
Effectiveness of control method	Whichever method eliminated or controlled the AIS the best
How damaging the AIS is to the ecosystem	This looks at overall how the AIS impacts the ecosystem and harms the current processes in place; this included geologic functions like mineral cycling, etc.
Lake Studies	The organization has taken part in lake studies to get a better understanding or what is in their lake through a consulting firm, DNR, their own monitoring, etc.
Other	Other environmental considerations such as there being no AIS in the lake or the existing ecosystem dynamics present in the lake.

TABLE 4. Governmental Factors used in the consideration of AIS in lake organizations.

Governmental	Description
Control method requires permits	The organization had to attain from the state or DNR to implement the control method
DNR regulations and restrictions	The DNR has certain regulations in place that the lakes have to abide by
Town and Town Lakes Committee Involvement	The township government or the town lakes committee has gotten involved to help the organizations apply for grants, organize studies, etc.
Other	Other governmental considerations such as actions of the DNR, consulting recommendations, state land presence, etc.

TABLE 5. Description of the exogenous and endogenous factors from each category.

Factor	Description
Exogenous Economic Factors	Economic factors the organization experienced that were outside the realm of the organization’s boundaries; for example, the DNR earmarking funds for an organization to use for treatment that they did not initially request.
Endogenous Economic Factors	Economic considerations the organization made that they had control over; for example, applying for grants, creating AIS treatment savings accounts, becoming a district so they could tax, etc.
Exogenous Social Factors	These a social or society factors that are external to the organization including labor demand or general opinion of the AIS or control method.
Endogenous Social Factors	Social considerations from within the organization such as member support of the control method, volunteer participation, etc.
Exogenous Environmental Factors	These are factors the organization considered that were outside of their perception or control, like there being no available control method, the DNR doing studies on their lake, or the negative effects of an AIS or control method.
Endogenous Environmental Factors	These are environmental concerns the organization had without consulting external information, such as believing a control method was proliferating the issue, thinking an AIS wasn’t enough of a problem to treat, or even doing lake studies themselves.
Exogenous Governmental Factors	External governmental factors influencing the organization such as town lakes committees or DNR regulations.
Endogenous Governmental Factors	Governmental considerations the organization made themselves, such as petitioning to change bag limits.

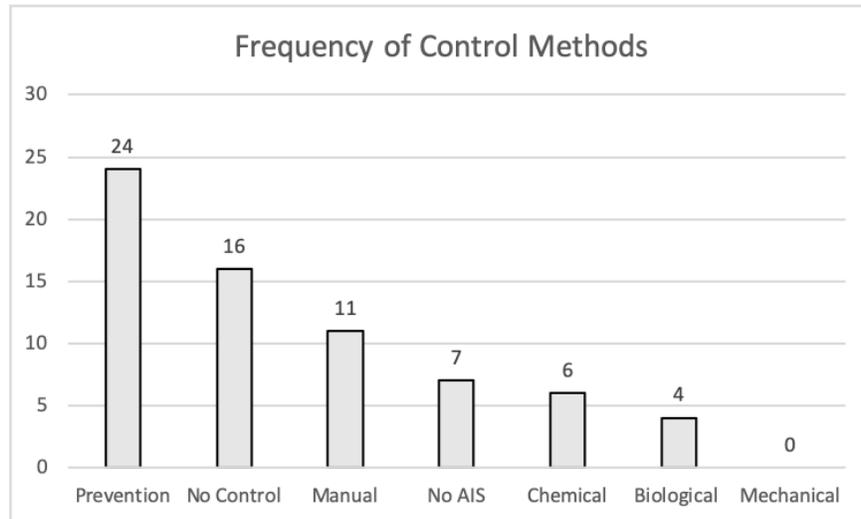


FIGURE 1. Frequency of each observed AIS control method across all lake organizations.

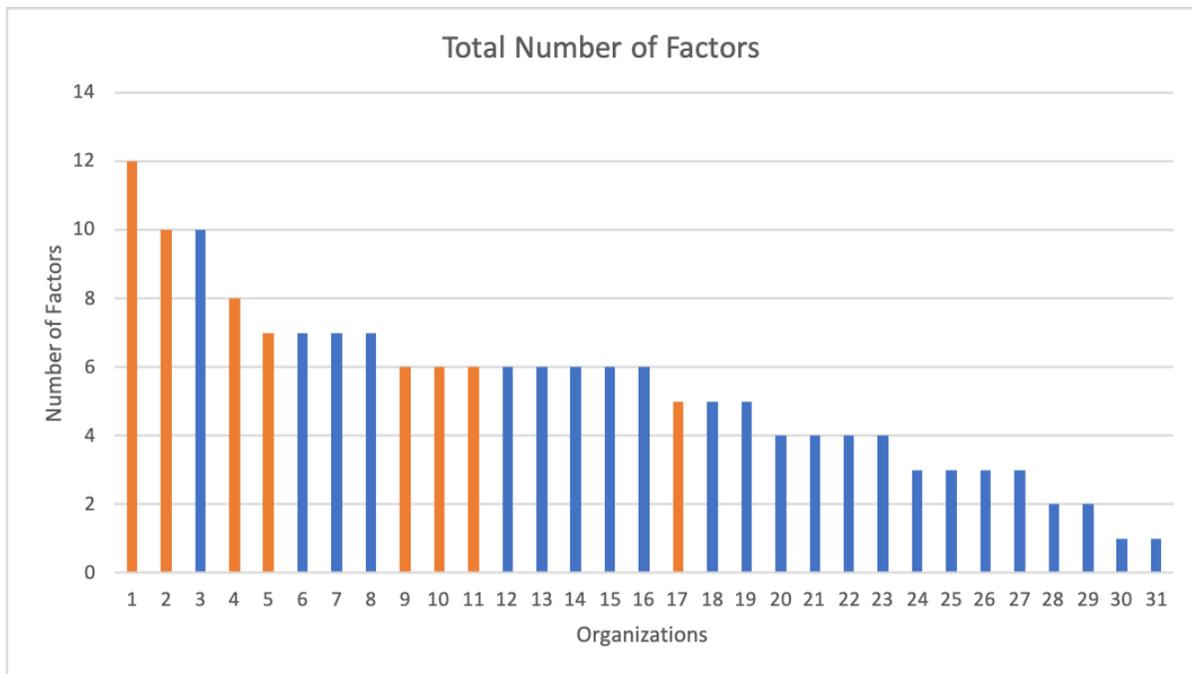


FIGURE 2. Total number of factors considered per each lake organization (orange lake organizations are those with Eurasian Water Milfoil).

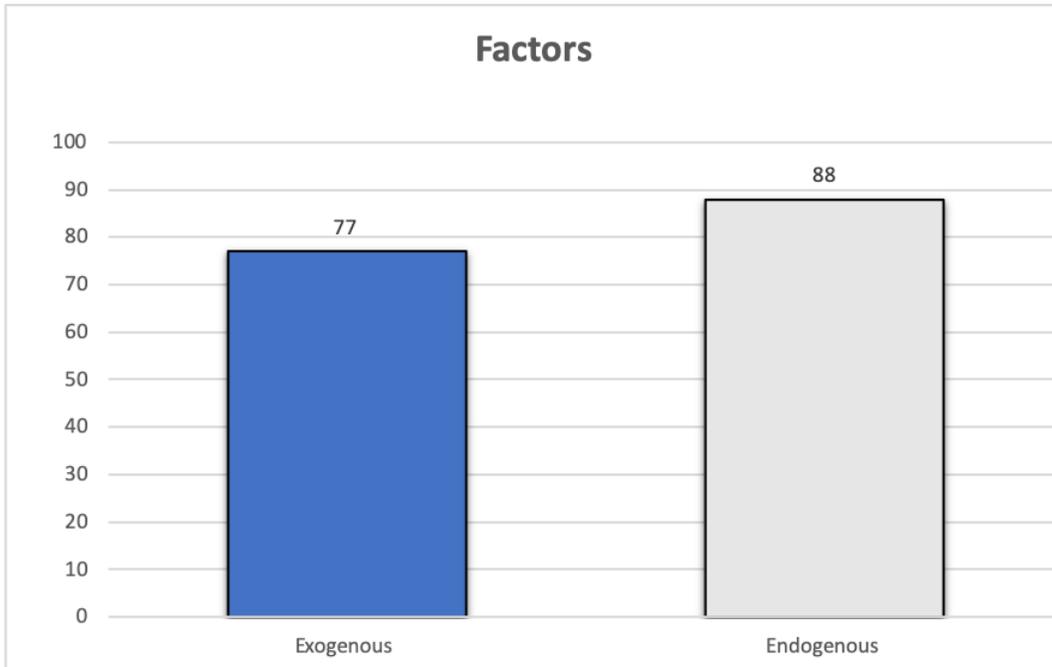


FIGURE 3. Total number of exogenous and endogenous factors.

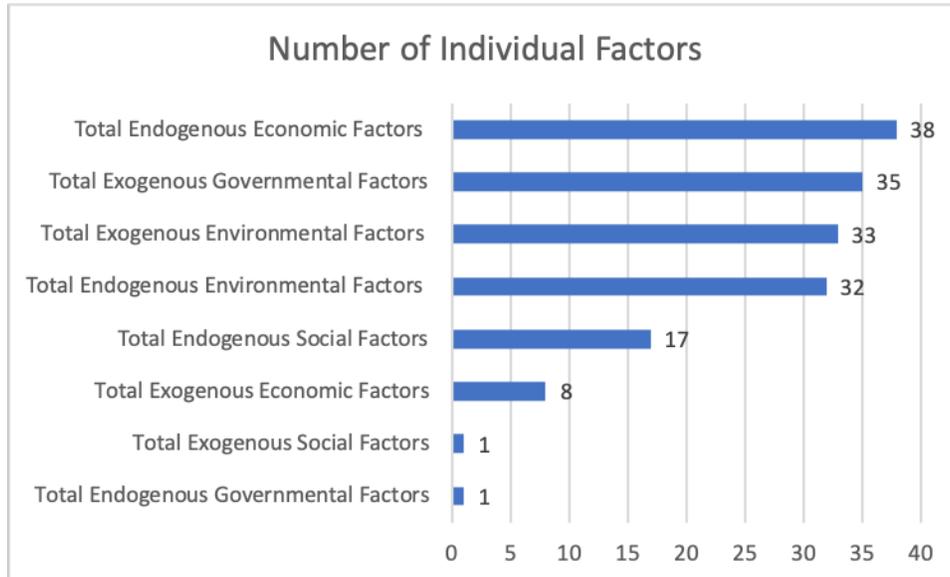


FIGURE 4. Frequency of each exogenous and endogenous factor across all lake organizations.

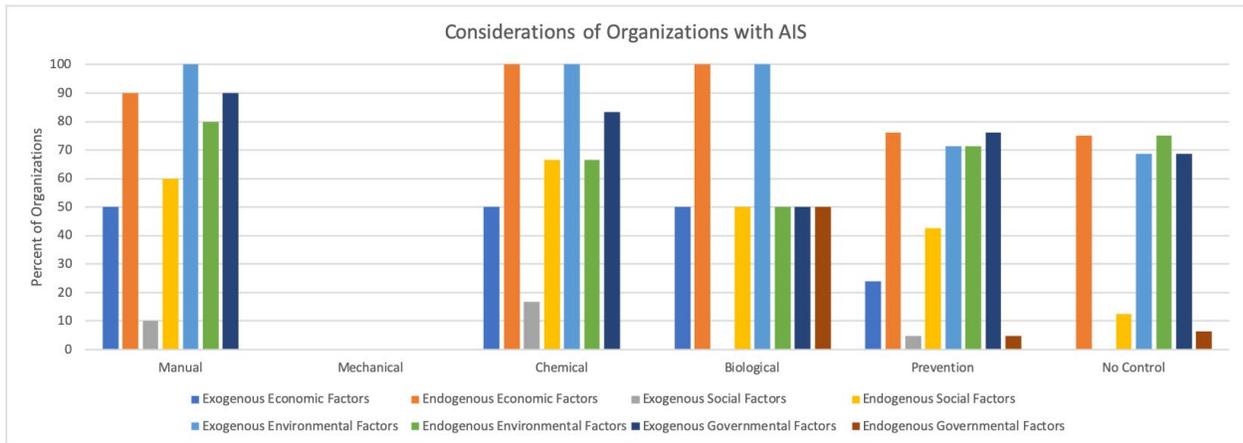


FIGURE 5. Factors considered per each AIS control method across all lake organizations.