Public Perceptions of Lake Mendota Water Quality

in Madison, Wisconsin

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Table of Contents

Abstract

Public perception is an important part of human geography and affects how citizens approach environmental issues. We researched differences in public perception of water quality on Lake Mendota in Madison, Wisconsin. Specifically, we used an online survey and social theory analysis to examine how and why perceptions differ between two key demographics, professors of UW-Madison and the general public, and what respondents are willing to do in rehabilitation efforts. We found visible water quality issues such as presence of trash to be most important to citizens, while non-visible effects like water temperature were least important. Professors also had a narrower view of water quality, while public views were much more diverse. Our study shows the importance of applying public perceptions to environmental management plans in order to effectively increase environmental quality.

Introduction

There is no doubt the world as we know it today is governed and shaped by humans. Humans are a major factor in environmental quality, for better or for worse. In the realm of human geography, perception is many times reality. The interesting aspect is how perceptions can affect environmental health. It is important to understand public perceptions in order to promote governmental change or action in the future. Human geography and environmental science are generally not thought of as one, but the reality is that human geography actually shapes environmental science, through the vector of public perception. Using these perceptions, management actions and strategies can be developed around them. This is the interface in which our study focuses.

We researched the public perceptions on water quality, related to agricultural practices, industrial and sewer outputs, invasive species, and urban waste, surrounding Lake Mendota in Madison, Wisconsin. We were curious to know how the public perceives these issues depending on a variety of factors, and what they are willing to do about water quality issues in their community. Our research questions were as follows: first, do perceptions of water quality in Lake Mendota vary based on someone's demographic background in Madison, Wisconsin?

Second, how does the public rank environmental issues that affect the lake water quality of Lake Mendota relative to each other? And finally, what are the people in Madison willing to do to help rehabilitate Lake Mendota? The focus of our research was to get a better understanding of the public's awareness and attitudes about Lake Mendota and to explore ways in which the people are willing to help improve the lake's water quality. To tackle these questions, we surveyed different public groups who live and work around Lake Mendota to enhance our knowledge base on how these figures perceive the lake's quality. We wanted to compare and contrast different groups' priorities of environmental issues based on their interaction with Lake Mendota. For example, do our participants have a higher level of concern for water quality because they fish or swim in Lake Mendota? Or, do their relations to the lake have a negligible impact on whether they consider the water quality good or bad? Using their answers to our survey, we gauged their opinions on each issue.

Our study took place mainly on UW-Madison's campus and the downtown area. Our primary demographics included professors in environmental studies/science, limnology, geography, etc., as well as the general public, including other students around campus affiliated with these majors. We were also interested in getting the perspectives of staff members and owners of boating companies like the Betty Lou Cruises and the Hoofers Club located on Lake Mendota. We also relied heavily on the concept of 'eutrophication', something that not all groups of people may have familiarity with. By definition, eutrophication of aquatic environments is the build-up of chemical nutrients in the water, which promotes harmful plant growth like algae and eventually leads to a depletion of oxygen in the system. We also bring up the concept of Cultural Theory (Fath 2014, 491), as well as a variety of other social perception theories, to help explain common results with our study and other similar ones.

The Setting

Lake Mendota, located in south-central Wisconsin, is the largest of five lakes in the Yahara Lakes watershed (Carpenter et al. 2015, 3). The watershed is greatly affected by human-related interventions in present day, consisting largely of agriculture and urban/suburban city sprawl (Carpenter et al. 2015, 3). By the late 1840s, the city of Madison, Wisconsin's state capital, and the development of the University of Wisconsin-Madison were underway and clearing land around the city and the shoreline of Lake Mendota, where the university is located (Carpenter et al, 2006, 236). In 1995, the watershed land use was approximately 86% agricultural, 9% urban, 4% wetlands, and 1% forests (Bennett et al. 1999, 70).Throughout time, the major urban center around Lake Mendota has shifted its land use from agricultural land to urban uses. Agriculture is a major factor in the past, present, and future health of the lake, as is the large number of people who live in close proximity. The rapid population growth in this region created consequences of increased runoff from construction sites, agricultural runoff, and pressures from growing political and economic management for lake restoration (Carpenter et al., 2006, 238). Lake Mendota has been the most heavily managed and studied lake of the Yahara Watershed since the 1950s because of the subsequent effects urban growth have on it. The changes in the lake are linked to both

Source: www.danewaters.com/articles/historyandsetting

changes in society and the landscape over time. Managing the lake for its services and natural systems is up to the attitudes of people in Madison.

Lake Mendota and the surrounding lakes have been woven into the lives of the groups of people in Madison. Whether for the people who live in the vicinity of the lake or for those coming from afar, the lake is a place for recreation and aesthetic pleasure for all. If you take a quick walk along the lake in the summer, you will realize just how important Lake Mendota is to the residents. On any given summer day, you can stand on the Mendota shoreline and see throngs of people boating, fishing, or conversing with one another as they sit on the shore. On a winter day, there is no shortage of people ice fishing or playing pickup hockey games on the frozen lake. The lake itself means a lot to the people of Madison, whether directly in contact with it by swimming or boating, or indirectly by admiring it from views of the terrace or hiking down a lakeshore path. Limnologists and ecologists from around the country have come to the University of Wisconsin-Madison to do their research and to dedicate their lives to learning about Lake Mendota and the surrounding watershed. In recent history, however, Lake Mendota has begun to crack under the ecological pressures put on it by humans.

Literature Review

Environmental Issues

Agriculture runoff, industry and sewage outputs, urban waste, and invasive species are all factors that are contributing to the decline of Lake Mendota's environmental health. As a result, algal blooms are increasing in frequency and eutrophication is becoming more of a problem. Lake Mendota also suffers from both point source pollution and nonpoint source pollution. Invasive or non-native species were not a priority for managing the lake in the past because repairing the chemical composition was a bigger problem (Carpenter et al., 2006, 238).

Now, invasive species are becoming overabundant and destroying habitats. In fact, Adam Hinterhuer showed that a group of student in a UW limnology class recently found zebra mussels for the first time in Lake Mendota (Hinterthuer, 2015). The first zebra mussels in the Yahara Watershed were found in Lake Monona in 2002 but there was no evidence that the species had been living in Lake Mendota until now (Yahara Portal, 2015).

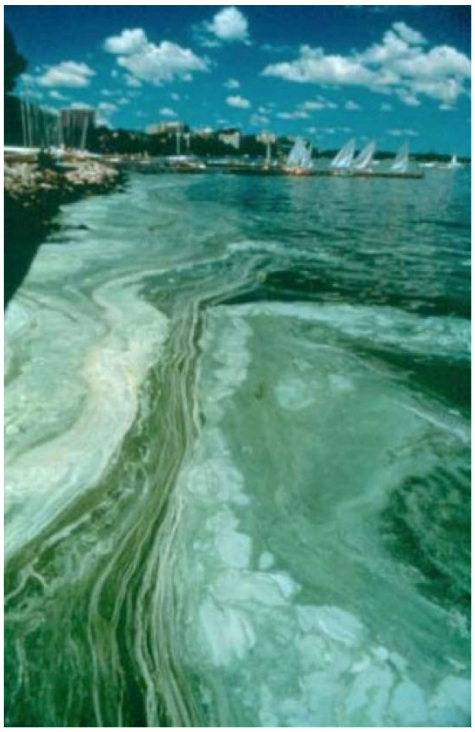
Photo: Bryce Richter.
From Source: http://www.engr.wisc.edu/cee/cee-information-for-current-graduates.html

We focus mainly on the pollution sources associated with Lake Mendota that lead to large-scale problems for the lake and its ecosystems. We then lead into the importance of management and how society plays a role in Lake Mendota.

Agriculture Runoff

Since primarily farms surround Lake Mendota, agricultural runoff from things such as fertilizers and manures, pesticides, and herbicides (an example of nonpoint source pollution) is an important contributing factor to lake pollution (Carpenter et al. 1998, 560). Agriculture is the predominant cause of nonpoint source nutrient pollution in the U.S. (Carpenter et al. 1998, 562). The most detrimental agricultural nutrients to lacustrine environments are nitrogen and phosphorus, which derive from fertilizers and manure and leach out of soils to water bodies. Agriculture also increases atmospheric nitrogen deposition (Carpenter et al. 1998, 564, Sobota et al. 2015, 3). Gases formed from combustion of burning fossil fuels release nitrogen into the air, which can then be deposited into aquatic ecosystems by precipitation (Carpenter et

al. 1998, 564). All of these nutrients lead to the problem of eutrophication, which is harmful to plant growth. For example, phosphorus in water is actually not harmful to humans directly, but it is the cause of most toxic algal blooms that contribute to eutrophication (Carpenter et al. 1998, 562). As early as 1880 in fact, newspapers reported fish kills in Lake Mendota as well as the first visible blooms of blue-green algae (Carpenter et al, 2006, 236-238).



http://homepages.cae.wisc.edu/~chinwu/CEE514_Coastal_Engineering/2009_Students_web/Matt_Rob/Tropic%20Status.html

Besides the poor aesthetic quality that algal blooms produce, there are other consequences as well. Other concerns associated with blue-green algae can be reduced light penetrations, odor, and dissolved oxygen (DNR, 2015). Increased algal bloom growth also contributes to oxygen depletion that can develop degradation of ecosystems that can result in fish kills (Bennett et al., 1999, 69). These are examples of concerns that nutrient runoff can produce in Lake Mendota that can restrict use for activities like fishing and recreation for the city of Madison.

Point Source Pollutions

Aside from chemical introductions from nonpoint source runoff, direct release of toxic chemicals from sewage, industrial factories, or urban waste is a potential type of point source pollution to Lake Mendota. With a large urban city like Madison surrounding its shores, Lake Mendota has been exposed to frequent industrial dumping of waste throughout its modern history. Nitrogen, phosphorus, and other chemicals that come from waste compound the problems of eutrophication set up by agricultural practices. Industrial and sewage waste seems

to be less of a problem in the present day. However, in the 1880s there was a huge issue of dumping raw sewage into the Madison lakes due to the lack of education on the consequences dumping waste would bring (Mollenhoff, 2007). The lake had a terrible stench, disturbed the public, and was contaminating drinking water. Due to the excessive amount of waste and high cost to remove the sewage, the city of Madison had to look for alternative methods to clean up this mess. In 1901, the city and university came together to build a sewage treatment plant to reduce the accumulated bacteria (Mollenhoff, 2007). Madison was one of the first cities in the country to develop a successful sewage system. Although dumping raw sewage is not a practice today, industrial waste and sewage slip into Lake Mendota from time to time but does not affect the lake nearly as much as it did in pre-industrial times.

Environmental Perceptions

There has been a lot of research on the public's perceptions to certain environmental issues (Beardmore 2015; Carpenter et al. 2015; Davenport et al. 2014; Fath, 2004; Hanley et al. 2009). To uncover and understand the city of Madison's environmental perceptions, we compare and contrast their perceptions to others from different study areas. Davenport et al.'s (2014, 3-4) study of Minnesota lakes found that an overwhelming majority of respondents from two watersheds expressed concern over water pollution. An overwhelming majority (97%) agreed that it is their own personal responsibility to not contribute to water pollution. Similarly, Beardmore's survey found point source pollution as the biggest issue of concern to northern Wisconsin boaters (2015, 544-45). There seemed to be a slight difference in perceptions between consumptive lake users vs. non-consumptive users. People who fish or hunt waterfowl (consumptive users) are much more likely to care about fish and other biota quality rather than recreational activities (Beardmore 2014, 546). On the other hand, non-consumptive users were

much more likely to have primary concerns reflect general conservation goals. We believe this divide between consumptive and non-consumptive recreation could be at play on Lake Mendota. In another study regarding outdoor recreation and environmental concern, it was stated that "strong personal attachment to an outdoor-recreation activity can lead to an equally strong commitment to protect those features of the environment which contribute directly to enjoyment of the activity" (Dunlap, 1975, 26). This theory shows that those who are closely associated with the lake environment will have a greater concern for its quality and a better attitude toward willing to contribute to protect the lake. To reflect this, one of our survey questions asked users what activities they partake in around the lake (Appendix A, question 2), and in another question we asked respondents whether or not they'd be in favor of different clean-up strategies (Appendix A, question 8). Our survey closely outlined other published aquatic environmental surveys researched in order to maximize our ability to compare previous results to our own. We also used geographic theories to assist our further discussion of the differing perceptions of people in Madison.

Cultural Theory

Cultural Theory is a positive feedback loop that hypothesizes that one's worldviews shape one's social relations and perceptions (Fath 2004, 491; also mentioned vaguely in Hanley et al. 2009). There are four archetypes within Cultural Theory: Egalitarian, Hierarchist, Individualist, and Fatalist. *Egalitarians* believe all perturbations to the environment affect its ecological health. *Individualists* see the environment as resilient to any and all perturbations. *Hierarchists* split the middle between Egalitarians and Individualists. *Fatalists* see nature and its transactions as out of their control. We believe these four viewpoints are probably illustrated in our own study of Lake Mendota, because Cultural Theory has previously

successfully been applied to environmental applications, and because similar surveys to our own, such as Brian Fath and M.B. Beck's (2004) or Ben Beardmore's (2014), have found results that adhere to Cultural Theory. Beardmore's (2014) study showed that some users worried more about certain aspects (pollution, habitat degradation) of lake health than others, possibly showing an *egalitarian* viewpoint. On the other hand, some respondents were not worried at all about the health of the study lake, indicating they likely adhere to a *fatalist* or *individualist* view. Our survey questions are not directed enough to explicitly show what view a respondent adheres to, but we can use these general categories to make predictions. For example, one of our survey questions asked respondents whether or not they believe greater regulation of Lake Mendota would result in better water quality. Based on their responses, it seems reasonable to assume what viewpoint they would lean towards more.

Other Theories

Place attachment is another factor that could play a role in the perception of environmental issues (Beardmore 2014, 538; Fath 2004, 487; Hanley et al. 2009, 1405). The personal geographic connection people have to certain places is a strong motivating force, and it has been shown to impact the extent people care about a location. As stated earlier, from simple observation the people of Madison, Wisconsin have a strong attachment to Lake Mendota. The lake is used and studied extensively, even being called the most studied lake in the U.S. (UW Center for Limnology). You can see people swimming, hiking, boating, or biking around the lake any time the weather permits. Two of our survey questions (Appendix A, Q2) gauged what specific activities respondents take part in. Time is another factor in perception, and many other surveys have found that, time has an impact on environmental thought process (Beardmore 2014, 545-46; Davenport 2014, 4-5; Fath 2004, 494; Hanley et al. 2009). Most people across

published surveys were more likely to be in favor of environmental clean-up in the short term rather than long-term initiatives. We found similar results in our own survey (Appendix B, questions 6 and 8), highlighted later in our discussion. In the case of Hanley et al. (2009), they found that knowledge of the past has an influence on preferences for the future, and that people who know the landscape has changed over time are more willing to accept changes to the current landscape in the future. We question whether or not this latter point is valid, especially concerning our own study of Lake Mendota, because despite a large historical agriculture presence around the lake, residents were not shown to be more willing to accept changes. In a study of the public perception on rangeland management, researchers found that more successful appeals are likely to be from those that use the public's preferences for resource management and those that direct policies toward newer, resource-friendly practices (Brunson, 1994, 81).

Finally, the idea of a social norm in conservation behavior could play a factor (Davenport 2014, 5). Davenport et al.'s (2014, 5) study from Minnesota lakes asked people whether or not other people's decisions and behaviors influence their own, and if they think there is a social norm to conservation practices. A large majority of people admitted to being influenced by friends' or neighbors' actions. Our survey questions did not explicitly ask about ideas of social norms, but further research would benefit from using social norms as an environmental perception tool.

Source: http://althouse.blogspot.com/2008/06/lake-mendota-brimming.html . June 17, 2008

Photo from: https://www.cleanlakesalliance.com/2011/09/23/lake-o-gram-volume-1-issue-4/

Future Management Planning

Along with uncovering public perceptions of Lake Mendota, we also tried to understand how far citizens are willing to go to manage the lake in the present and into the future. Using some of the theories discussed, like place attachment, temporal factors, and Cultural Theory to aid our discussion, we assess how likely it is for citizens to be in favor of rehabilitation projects in Lake Mendota and the Yahara watershed. Every survey that was looked at, and including our own, had questions relating to conservation efforts for the future. Davenport et al. (2014, 6) found that respondents were most in favor of voluntary adoption of conservation practices through education and outreach, as well as coordinating land use and water planning across communities. They found the least support for increasing regulations on private property owners. Beardmore (2014, 546-47) found that people who were more environmentally engaged had more general attitudes towards environmental management, which seems to make intuitive sense. They also found the more bio-centric (environmental value orientation) someone was, the more likely they were to report intentions of engagement in conservation behaviors. Furthermore, Riley Dunlap and Robert Heffernan found greater association for environmental concern in people who were involved in appreciative rather than consumptive outdoor activities (Dunlap 1975, 19-20). The literature in general seems to point to a positive feedback between environmental involvement and support for management.

Many ideas are thrown around for just how to manage environmental resources such as lakes. Hanley suggests that managers should consider how landscapes have changed over time but also suggests to consider how people's perceptions of a landscape's natural history helps determine what they want to see happen to it in the future (Hanley, 2009). The practicality of Hanley's argument is vague, but he does bring up potential thought processes for managers to

engage with the public. The single most important suggestion seems to be that civic dialogue and community connection around water resources should be supported (Carpenter et al. 2015, 6,9; Davenport et al. 2014, 9-10; Fath 2004, 485, 496). Engagement with stakeholders (Carpenter et al. 2015, 9) and increasing public awareness (Fath 2004, 496) seem to be paramount to managing water resources. Davenport (2014, 9-10) and others have shown that there is a significant disconnect, or gap, between public-sphere behavior and private-sphere behavior dealing with water resources. People tend to have greater concern when the visual pollution is actually present on nearshore waters; but if the public can't see it, they don't associate concern for water quality (West, 1989, 570). Communication about environmental problems, the concerns that those problems generate and what management policies mean are all important educational concepts to keep in mind when trying to decrease the gap in uncertainty between the public and management officials.

Importance of Engaging the Public

The importance of engaging the public discourse in environmental issues like water quality in Lake Mendota is crucial to influence governmental and management corporations. The "power of the people" demonstrates a push that these forces need in order to take the next step for the government or businesses to change (Novacek, 2008, 11571). On the other hand, the public needs to be up-to-speed with their current awareness of environmental issues. Typically, there is a disconnect between experts on the matter or management officials and the public, as noted by Niels West of the University of Rhode Island (1989, 563). West also states that for a resource (like water quality) to be well managed, the resource management has to incorporate the views of the user when implementing regulations (West, 1989, 564). These are incentives that

we believe will be brought on by having an increased general public attitude toward environmental problems.

Furthermore, engaging people in environmental problems is slightly different than having the knowledge to follow through with that interest. Having both public knowledge and engagement on environmental issues is key to increasing involvement in actions toward environmental relief (Novacek, 2008, 11572). By having better educational resources for the public, the better they will understand local concerns and global issues as well. A study by Michael Novacek recommends scientists to invest more in the dialogue they use for public education and policies, greater use of the media and web-based resources to reach expanded audiences, and better ways of connecting with government policymakers and leaders (2008, 564). These suggestions are all ways to promote public education so that more people can have a clear understanding of what issues mean and in approachable ways that everyone can generally understand.

After gaining knowledge of environmental problems, the involvement of the community to take action is the next step. In the case of better water quality, communities can take action in their own homes and neighborhoods as well as the direct site of the problem (DNR, 2015). The DNR suggests that communities should conserve fertilizer use and make sure grass clippings and leaves don't clog storm drains (2015). Other actions like advocating for changes in policies and regulations are a key form of the “power of the public” that they can promote (Novacek, 2008, 11571). For example, in a study of public attitudes toward rangeland management, the public wanted increased fees for instigators of overgrazing (Brunson, 1994, 81). In the case of water quality though, it can be hard to distinguish where exactly nutrient runoff and other harms come from. One study showed that urban areas like constructions sites are an increasingly important

source of phosphorous runoff to Lake Mendota (Magnuson et al., 2006, 238). One way of circumventing this potential problem is to ask the public if they would be willing to pay a tax to improve lake quality. We wanted to ask our survey participants if they would be in favor of paying a fee for management practices and policies to improve the lake quality of Lake Mendota in order to test this idea.

For decreasing the future risks of Lake Mendota's water quality, Scheffer et al. suggests that local management is a way to build climate resilience by creating safe operating spaces for ecosystems (2015, 1317). This study states that a lot of the public may not understand the idea that one problem, like nutrient runoff, can have various consequences other than the firsthand pollution problem for entire ecosystems. Safe operating spaces are defined boundaries based on fundamental characteristics of the planet that humans should operate within (Steffen et al. 2011). Global climate change and local pressures like the nutrient pollution in Lake Mendota are two pressures Madison's lakes and ecosystems are facing right now. By controlling our local pressures we can help offset the impacts of climate change now and in the future. For example, reducing the nutrient load going into the lakes can compensate for effects of climate warming (Scheffer et al., 2015, 1317). In a study by Scheffer et al. they found that "data from lakes across continents and climate zones suggest that a reduction in nutrient concentrations by one-third can compensate for the effect of a 1°C increase in water temperature" (2015, 1317). This information demonstrates how the public can be involved and how important local communities can be. Creating safe operating spaces for ecosystems associated with the lake is more conducive to control through local environments rather than global initiatives (Scheffer et al., 2015, 1319). By engaging and educating the public about these concepts in our study, we are hoping to advance this knowledge into community application to benefit Lake Mendota and its ecosystems.

Methods

For our research we administered an online survey to particular demographics of the community of Madison around Lake Mendota. We aimed to contact many of the staff members of the Geography Department, Nelson Institute, the Center for Sustainability and the Global Environment and professionals of the College of Agricultural and Life Sciences. With this, we also planned to reach out to professors who teach classes in geography, environmental studies/science, limnology, etc. to ask if they could administer our survey to their classes to get the perspectives of students with an environmental background. These two groups give us results with regards to professional staff and students with a knowledge base of these environmental concerns.

Furthermore, we wanted to get the perceptions of the general public that live in the area of Madison around Lake Mendota. We administered surveys by contacting coworkers, friends and classmates through social media sources and providing a link to our survey to keep results anonymous. This demographic was used to get a perspective of the general perceptions of people living in Madison, whether they have a background on the topic or not.

Lastly, we planned on contacting public figures like the staff of Betty Lou Cruises and members of the Hoofers Club on Madison's campus. Our thought was that by interacting with different demographics who are highly interactive with the lake, we could see if their perceptions are inherently stronger and more "lake friendly" than those who do not have as much hands-on experience with Lake Mendota. Unfortunately our response rates were very slim due to the offseason for staff members of Betty Lou and participation in water activities for Hoofers. For lack of response we chose to take these few surveys out of our analysis and focus on other demographics with better response rates.

Every demographic group received a different link to our online survey. We used averages and graphs from each link to compare and contrast the perceptions of the different demographic groups. This strategy preserved the anonymity of individual responses while allowing us to compare aggregated results.

Results and Analysis

Our goal with our analysis was to look into our results in both qualitative and quantitative perspectives. We wanted to find out generally how the public uses Lake Mendota, how they perceive the lake's water quality, what they think contributes to good or bad water quality, and what they would be willing to do to contribute to better overall quality of the lake. We decided to compare the results of the general public vs. results of the professors. Our 'students' section of our survey only received eight complete surveys so we included these results with our general public demographic. Our results illuminate our first research question about finding differences between demographics. In general, professors were more likely to rate Lake Mendota's water quality as fair (69%) than the public were (57%), and the public had a much more diverse range of answers to water quality. We received at least one response from the public for every category of water quality rating, while professors only responded with 'three' or 'two' on our scale (see survey questions in appendix A). Additionally, many professors were more likely to support an environmental tax on Lake Mendota up to $10 (77% of them) than the public (30%). A majority of the public (55%) said only up to $5. This is likely due to the fact that professors have a higher disposable income than students and don't mind paying as much, as well as the fact that college students are generally low on money.

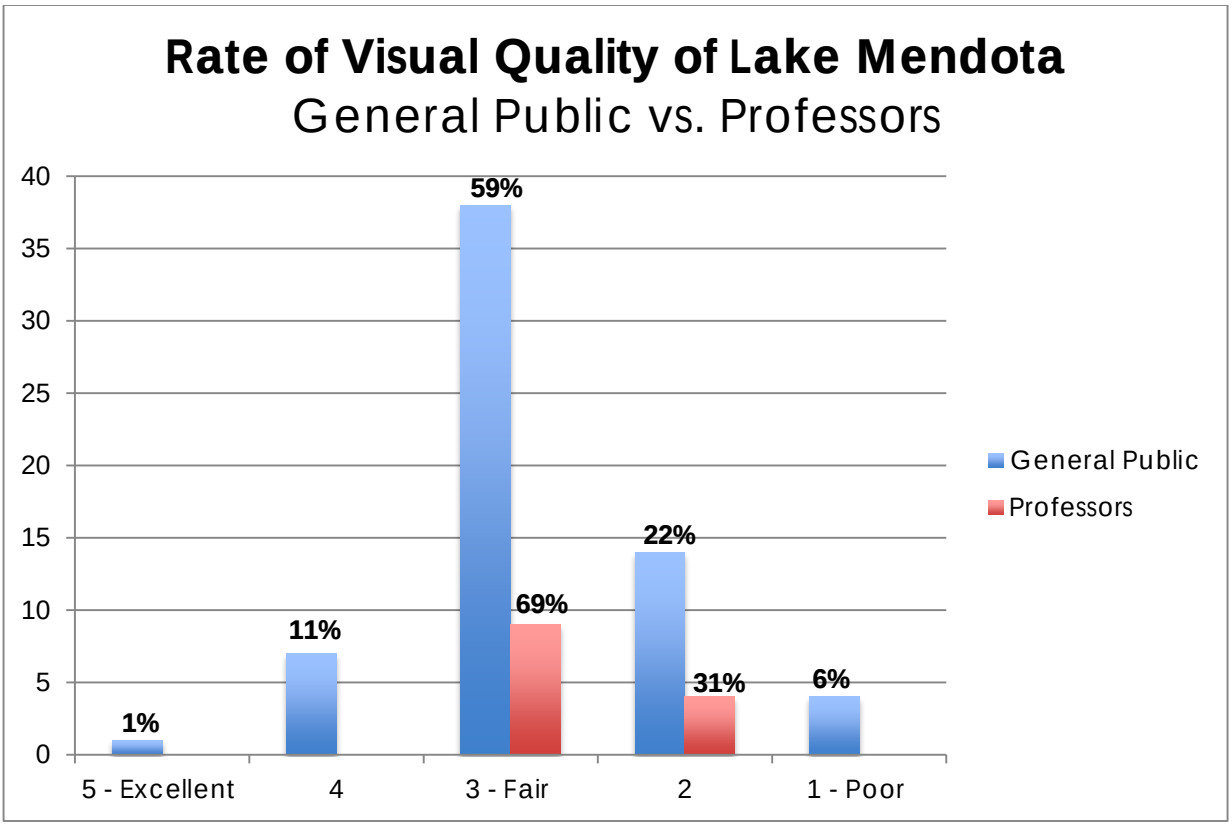


Figure 1
How would you rate the water quality of Lake Mendota?

Secondly, we used a Fisher's Exact analysis to find a correlation between the rating of water quality and whether respondents believe water quality can be improved in the future (Appendix B, Q4 and Q6). A majority of people (56%) rated water quality as fair while also saying greater regulation would help in the long term. Of the respondents who answered yes to greater regulation, only 6% believed it would help in the short term. Not a single respondent said the lake does not need greater regulation, yet eight respondents rated the water quality as near excellent (4 or 5).

	1-poor	2-	3- fair	4-	5- excellent	total
no, its fine	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
yes, short term	0 (.208)	0 (.935)	3 (2.44)	1 (.364)	0 (.052)	4
yes, long term	4 (3.43)	13 (15.4)	43 (40.3)	5 (6.00)	1 (.857)	66
no, too complicated	0 (.364)	5 (1.64)	1 (4.27)	1 (6.00)	0 (.857)	7
total	4	18	47	7	1	77

Figure 2: Fisher's Exact calculation for public rating of water quality (columns) versus whether they believe greater regulation will clean up lake (rows). p-value= 0.00012. Sum of probabilities of "unusual" tables: p=0.055. Shows statistical significance.

One analysis we investigated was the comparison between participation of outdoor activities and rank of the overall water quality between the general public and professors on campus. Figure 1 shows the distribution between the 64 responses we received from our general public survey and the distribution of results from our 13 professor responses. We compared these results to the distribution of participation in outdoor activities for each demographic as seen in Figure 3.

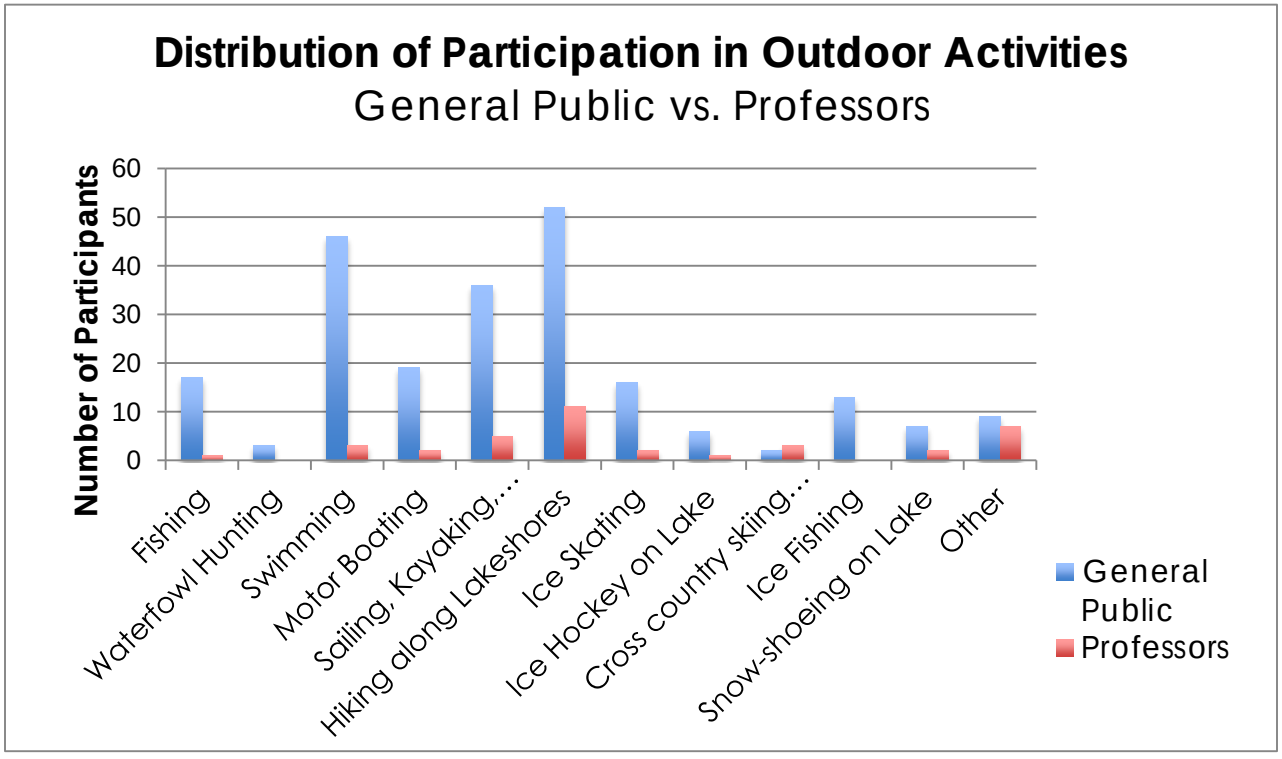


Figure 3
What recreational activities do you do in/around the lake?

The general public were more likely to partake in all lake recreation activities (except for cross country skiing) than professors. The two groups differed widely in their perception of Lake Mendota's water quality. The general public's perception varied from poor (1) to excellent (5). Professors consistently rated the lake's water quality as fair (2 or 3). One reason for the general public's wide range of responses with respect to water quality could be their lack of research activity on Lake Mendota. Professors consistently noted 'research' as a recreational activity. We guess that, overall, professors have a better understanding of environmental processes and thus a more directed perception of water quality.

We asked participants to rank their perception of Lake Mendota's water quality based on seven different factors: water temperature, water clarity, presence or absence of algae, excessive weeds, presence of trash, odor and fish kills . We also asked respondents to rank environmental issues affecting the lake's water quality, including urban waste (grass clippings, litter, etc.), pollution (sewage, industrial runoff, acidification), nutrient runoff from farms and lawns, loss of native species and invasive species. We combined the responses for perceptions of important factors of Lake Mendota's water quality (Appendix B, Q3). Overall the least important factor to Lake Mendota's water quality was water temperature (41% of responses) while the most important factor was presence of trash (38%). Due to the fact that results varied, we kept the environmental issues that affect the lake separate for our two demographic groups (Appendix B, Q5). For the general public, the most problematic factor to water quality was pollution (53%) and the least problematic was loss of native species (27%). Finally, an interesting result for the professors was that nutrient runoff from farms and lawns was both the overall most (43%) and least (33%) problematic factor pertaining to the lake's water quality.

Lastly, we compared how likely participants are willing to change their habits in order to reduce the risk of damage to water quality. We asked participants what they are willing to do at home to help offset issues that lead to poor water quality in Lake Mendota (Appendix A, Q8). As seen in Figures 4 and 5, both of our general public and professor results had very positive reactions towards all examples of preventative measures. Moreover, there was a larger percentage of negative responses (15%), or people who responded 'not likely', for the general public survey compared to those responses for the professors (8%). Additionally, the habit the general public was most 'highly likely' to support was participation in community trash pickups at 53% of respondents, while the habit the professors were most 'highly likely' to participate in was reducing lawn fertilizers at 62% of the respondents (Appendix B, Q8).

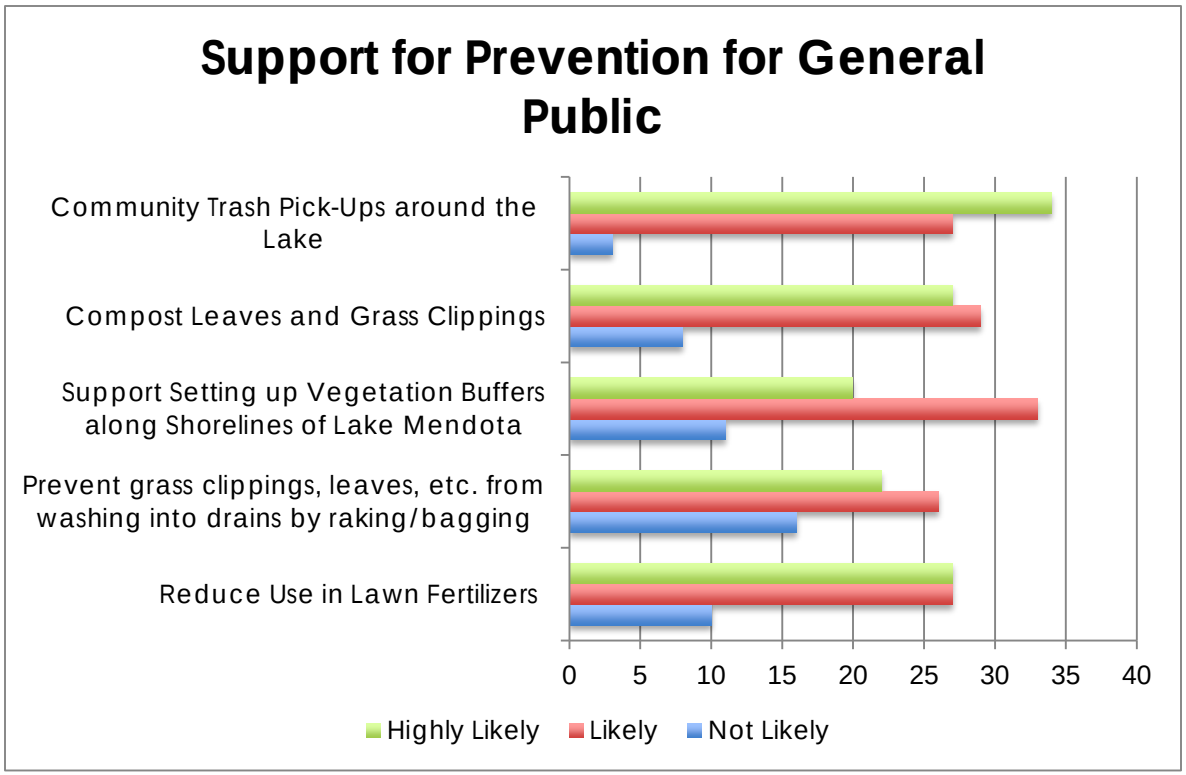
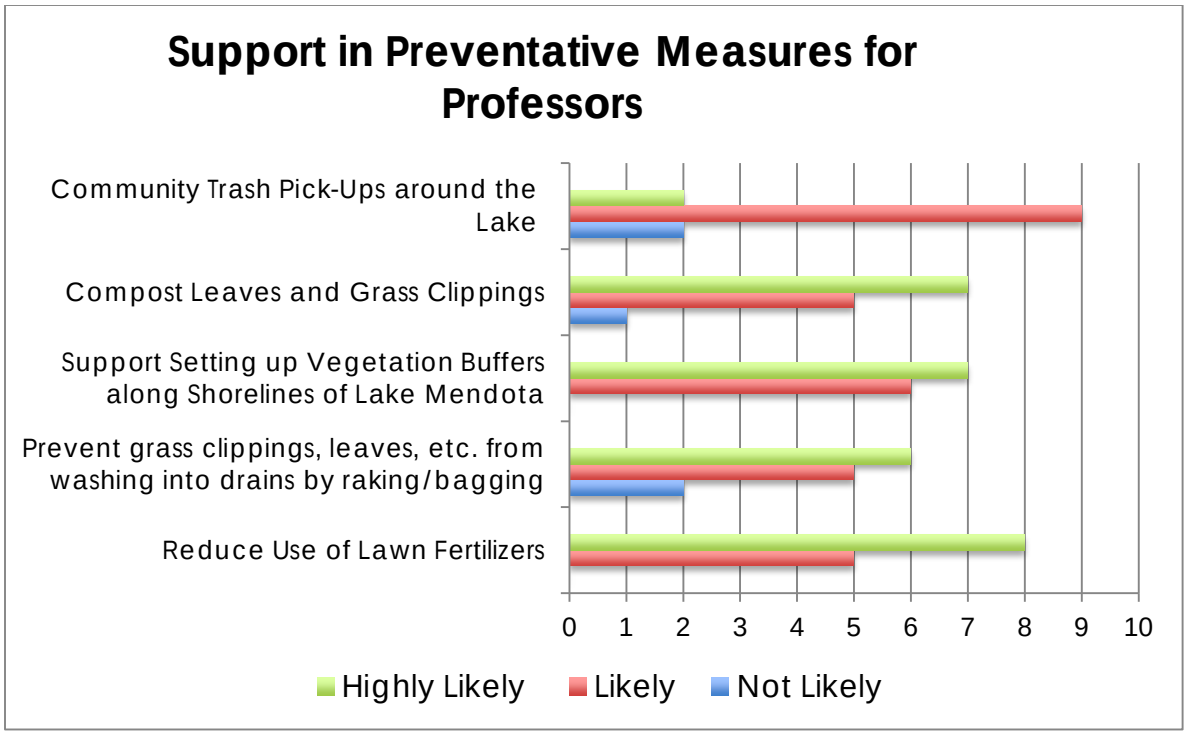


Figure 4 (top) and 5 (bottom)
To help prevent the intensity of issues creating poor water quality in Lake Mendota, how likely would you be willing to help promote the following practices in your community



Discussion

It is clear from our results that there are slight differences in environmental perceptions between professors and the general public. In general, professors seem slightly more pessimistic about water quality and what can be done to improve it (Appendix B, Q4 and Q6). On the other hand, the general public are less likely to adopt rehabilitation strategies than professors. Since many participants of our general public survey are students on campus, they may live in an apartment complex, dorm or house that is maintained by a realtor company. In these situations, our surveys show that participants are generally not as inclined to participate in raking, composting, or bagging grass clippings because they are not living in a situation that needs to do that. As seen in Figure 6, about 80% of our survey participants fell between the range of 18-29 years old and are most likely students on campus or young professors. This is consistent with our result that more students were involved in outdoor activities than professors in general. Students

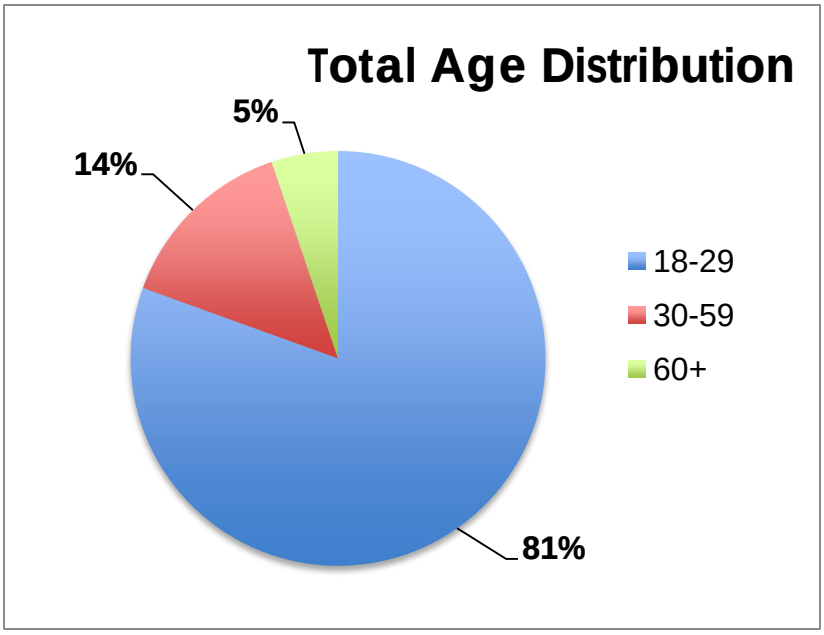


Figure 6
What age range do you fall in?

may use Lake Mendota more easily because they live on or close to campus, which is directly affiliated with the lake itself.

We suspect Cultural Theory was prevalent throughout our study, though no means were made to explicitly group respondents into the four archetypes. It is more important to realize that people fit into all four Cultural Theory archetypes (*Egalitarians, Individualists, Hierarchists, and Fatalists*). We observed clear possible examples of all four groups with regards to their thinking on Lake Mendota. Knowing this information, however, should enable environmental managers to better plan strategies for Lake Mendota clean up.

The social theory of time clearly has an impact on how people view environmental concerns. From our results, we showed that a large majority of people believes the water quality of Lake Mendota can be improved in the long term. Far fewer respondents believed it could be improved in the short term. This exposes a social barrier showing that while people generally believe water quality could be improved, they only believe in a long-term outlook. Despite an overwhelming majority of people rating Mendota's water quality as simply fair, there does not seem to be an urgent feeling for change. This result highlights a greater need for engagement

with the public and more direct action plans. The public is willing to see improved water quality, but it will take greater action to see this in the short-term.

Additionally, we expected students to have more diverse results than the professors regarding their ranking of important environmental issues and what qualities can affect water quality. This is mostly due to the fact that we targeted professors with an environmental background as well as their general higher knowledge base, and the younger age of the students in general. We also assumed professors would have a better background knowledge base about these issues than students. We found that generally, student's results were similar to those of professors regarding environmental issues and the factors that affect water quality. This was surprising to see such similar perceptions for both demographics. We believe there are a couple reasons for this. For one, the university is in close proximity to the lake and generally a large portion of the community is engaged in local issues like the debated conditions of Lake Mendota's water quality. Secondly, the similar result could be due simply to students having taken the professor's classes who lecture on environmental events.

Furthermore, there was correlation in our results to the statement of West (1989) about future management planning for Lake Mendota and its visual water quality. Again, West stated that people tend to have greater concern when the pollution is visible and present on nearshore waters. If people can't see the pollution, there is less of a concern that water quality is a problem. Correlated to this, we found that water temperature is considered the least important factor to Lake Mendota's water quality, while the most important factor was presence of trash (Appendix B, Q3). In this case, the perceptions of the general public and professor groups agree that presence of trash is the most problematic source of water quality because they can clearly see it on nearshore waters. Counteractively, the largest problem to Lake Mendota's water quality is

actually agricultural runoff, as stated by Carpenter et al. (1998, 2015). This observation also confirms West's (1989) statement that the concerns for a problem such as agricultural runoff isn't vocalized by the public because it is hard to visually see.

Future Research

Our research looked at important environmental ethics around Lake Mendota's communities, but we were limited in time and space. There is certainly more that could be teased apart within these issues. For one, being able to survey a much larger community base would go a long way in revealing what their exact perceptions are. Our survey responses were very limited, and we could only reach a certain number of Madison residents. A subsequent study could use our results as a baseline for what they should expect to find. Future studies could also reach the groups that we were unable to, including Betty Lou Cruises, Hoofers club, or the UW-Madison rowing team, in order to get additional perspective. Another obstacle to our research was the inability to extensively interview a large number of people or to interview "experts" on Lake Mendota. Supplementing interview answers with survey data would help elucidate environmental perceptions better. Further, getting advice or opinions from researchers who actively study Lake Mendota's processes would be helpful for a future study. Along the same lines, it would be beneficial to use a stratified random sample when sampling respondents. A stratified random sample would help because the differing demographics are a major point of emphasis in our research and we suspect the demographics are too distinct.

Another factor to be included in future research is the season in which we administered the surveys. It is reasonable to expect not only a different number of responses depending on the season but also different results altogether. A larger study where data from all seasons is combined would enable the analysis to yield more precise results. Additionally, we were unable

to get specific demographic data from the city of Madison and surrounding area. In order to accurately compare Lake Mendota to the environmental perception theories described, a future study should utilize this demographic data.

Conclusion

This study found perceptions of the public to be valuable in the process of determining future management planning for environmental concerns of the water quality in Lake Mendota. Our data confirms that outreach is needed in order for the general public to get educated on problems associated with poor water quality in the future. Social and cultural theories are highly influential, specifically regarding spatial and temporal factors associated with Lake Mendota. Our research shows that perceptions of water quality in Lake Mendota do vary based on demographic in Madison, but to analyze this further future studies should be done to gain stronger insight into a larger range of demographics. Secondly, the ranking of environmental issues varied based on different exposures to the lake through consumptive and non-consumptive activities. This shows that educational outreach for the general public is needed in order to bridge the gap between science and public knowledge. Finally, we discovered age and economic status were influential in the level of support for preventative measures to help rehabilitate Lake Mendota. This study, along with others, are examples of how public perceptions are essential to the management of property, its uses, and the effects on the public.

Acknowledgements

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Appendix

A. Survey Questions

1. What age group do you fall in?
   a. 18-29 b. 30-59 c. 60+

2. What recreational activities do you do in/around the lake? (Check all that apply)

Summer Activities	Winter Activities
a. Fishing	h. Ice Skating
b. Waterfowl Hunting	i. Ice Hockey on Lake
c. Swimming	j. Cross Country Skiing on Lake
d. Motor Boating	k. Ice Fishing
e. Sailing, Kayaking, Canoeing, etc.	l. Snow-Shoeing on Lake
f. Hiking along lakeshores	m. Other: please define _____
g. Other: please define _____	

3. Rate the following on how important they are to water quality: 1 being least important and 7 being most important
   a. Water clarity
   b. Water temperature
   c. Presence or absence of algae
   d. Excessive weeds
   e. Presence of trash
   f. Odor
   g. Fish kills

4. How would you rate the water quality of Lake Mendota?
   a. 1 - Poor
   b. 2
   c. 3 - Fair
   d. 4
   e. 5 - Excellent

5. Rank the following environmental issues on how threatening they are to water quality from most problematic (5) to least problematic (1):

   a. Nutrient runoff from farms and lawns
   b. Invasive species
   c. Loss of native species
   d. Pollution (sewage, industrial runoff, acidification)
   e. Urban waste (grass clippings, litter, etc.)

6. Do you think that greater regulation of Lake Mendota would result in better water quality?
   a. No, the water quality is fine.
   b. Yes, in the short term.
   c. Yes, in the long term.
   d. No, it's too complicated.

7. Would you be willing to pay more in taxes or fees to improve Lake Mendota's water quality?
   a. No, I would not.
   b. $1.00 per year or less
   c. Up to $5.00 per year
   d. Up to $10.00 per year

8. To help prevent the intensity of issues creating poor water quality in Lake Mendota, how likely would you be willing to help promote the following practices in your community:
   a. Reduce use of lawn fertilizers
      Not likely Likely Highly Likely

   b. Prevent grass clippings, leaves, etc. from washing into drains by raking, bagging, and taking them to a waste management facility
      Not likely Likely Highly Likely

   c. Support setting up vegetative buffers along shorelines of Lake Mendota
      Not likely Likely Highly Likely

   d. Compost leaves and grass clippings
      Not likely Likely Highly Likely

   e. Community trash pick-ups around the lake
      Not likely Likely Highly Likely

B. Tables of Results of Surveys

Q1. What age group do you fall in?

	General	Professors	Total
18-29	61 (95%)	1 (8%)	62 (81%)
30-59	3 (5%)	8 (61%)	11 (14%)
60+	0	4 (31%)	4 (5%)

Q2. What recreational activities do you do in/around Lake Mendota?

Summer Activites	General	Professors	Winter Activities	General	Professors
Fishing	17 (27%)	1 (8%)	Snow-shoeing on lake	7 (11%)	2 (15%)
Waterfowl Hunting	3 (5%)	0 (0%)	Ice fishing	13 (27%)	0 (0%)
Swimming	46 (72%)	3 (23%)	Cross country skiing	2 (3%)	3 (23%)
Motor Boating	19 (30%)	2 (15%)	Ice hockey on lake	6 (9%)	1 (8%)
Sailing, Kayaking, Canoeing, etc.	36 (56%)	5 (38%)	Ice skating	16 (25%)	2 (15%)
Hiking along lakeshore	52 (81%)	11 (69%)			
Other:	6 (9%)	5 (38%)	Other:	3 (5%)	2 (15%)
Other: Biking, birdwatching, running, research			Other: Walking, research		

Q3. Rate the following on how important they are to water quality with 1 being least important and 7 being most important.

**Numbers in column correspond to number of times that attribute was ranked at that number.*

All Groups							
	1	*2*	*3*	*4*	*5*	*6*	*7*
Water clarity	9	9	7	7	13	10	9
Water temperature	**26**	8	5	6	7	4	8
Presence or absence of algae	6	4	11	9	8	17	9
Excessive weeds	4	14	12	11	13	6	4
Presence of trash	5	5	3	4	9	14	**24**
Odor	5	8	10	8	8	14	11
Fish Kills	2	7	9	13	12	12	9

Q4. How would you rate the water quality of Lake Mendota?

	General	Professors	Total
1- Poor	4 (6%)	0 (0%)	4 (5%)
2	14 (22%)	4 (31%)	18 (23%)
3- Fair	38 (59%)	9 (69%)	47 (61%)
4	7 (11%)	0 (0%)	7 (9%)
5- Excellent	1 (1%)	0 (0%)	1 (1%)

Q5. Rank the following environmental issues on how threatening they are to water quality from most problematic (5) to least problematic (1)

**Numbers in column correspond to number of times that attribute was ranked at that number.*

General					
	1	***2***	***3***	***4***	***5***
Nutrient runoff from farms and lawns	7	11	13	17	8
Invasive Species	9	16	12	13	6
Loss of Native Species	**15**	11	12	7	10
Pollution (Sewage, industrial runoff, acidification)	6	6	5	9	**29**
Urban waste (grass clippings, litter, etc.)	13	9	15	17	2

Q5. Rank the following environmental issues on how threatening they are to water quality from most problematic (5) to least problematic (1)

**Numbers in column correspond to number of times that attribute was ranked at that number.*

	Professors				
	1	***2***	***3***	***4***	***5***
Nutrient runoff from farms and lawns	**7**	2	2	1	**9**
Invasive Species	4	6	2	6	3
Loss of Native Species	2	4	4	6	5
Pollution (Sewage, industrial runoff, acidification)	2	4	5	4	6
Urban waste (grass clippings, litter, etc.)	4	3	8	4	2

Q6. Do you think that greater regulation of Lake Mendota would result in better water quality?

	General	Professors	Total
No, it's fine	0 (0%)	0 (0%)	0 (0%)
Yes, short term	3 (5%)	1 (8%)	4 (5%)
Yes, long term	56 (87%)	10 (77%)	66 (86%)
No, too complicated	5 (8%)	2 (15%)	7 (9%)

Q7. Would you be willing to pay more in taxes or fees to improve Lake Mendota's water quality?

	General	Professors	Total
No	1 (1%)	1 (8%)	2 (3%)
Up to $1.00/year	8 (13%)	0 (0%)	8 (10%)
Up to $5.00/year	35 (55%)	2 (5%)	37 (48%)
Up to $10.00/year	20 (31%)	10 (77%)	30 (39%)

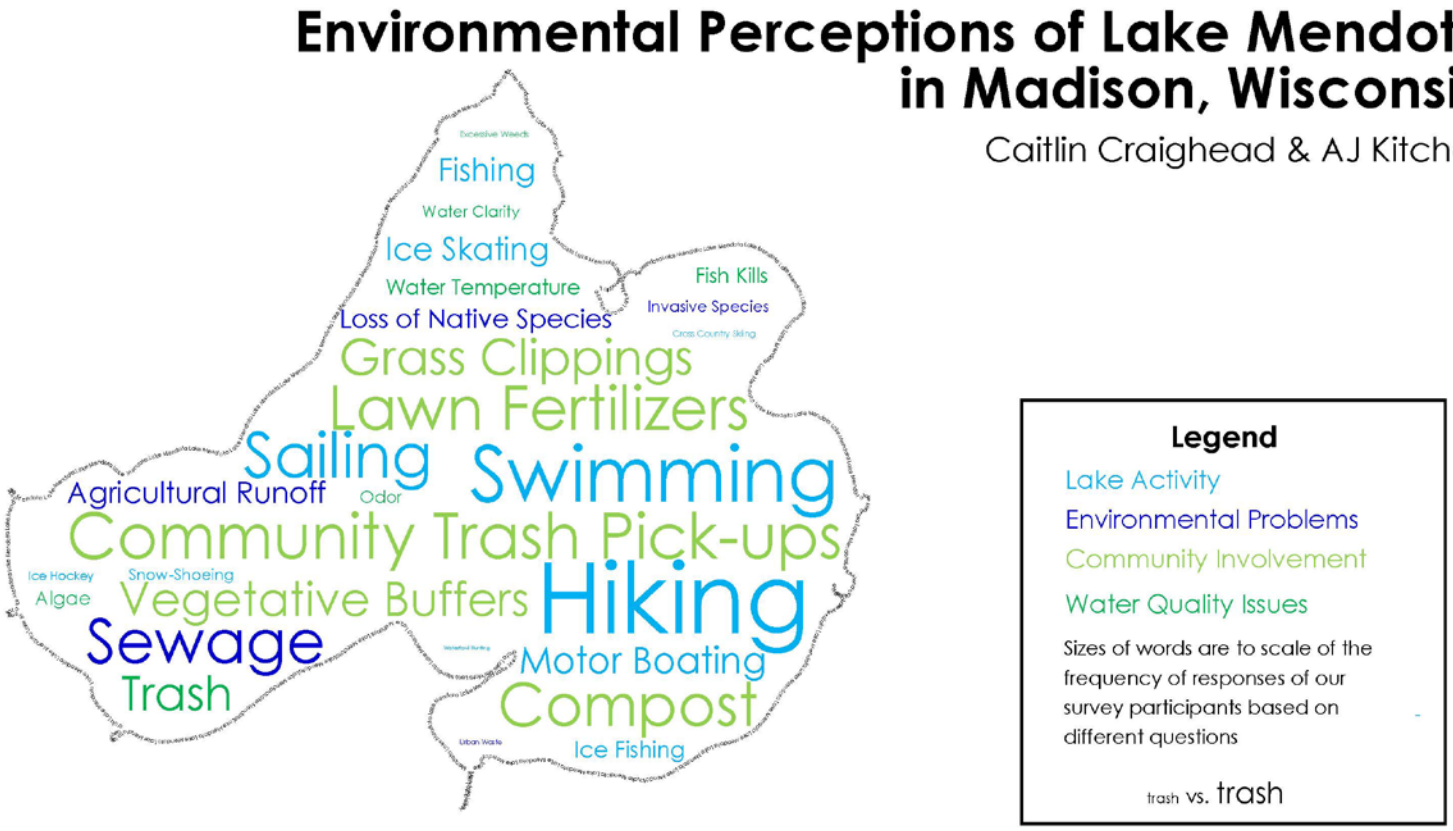
Q8. Would you be willing to support…?

General			
	Not likely	Likely	Highly likely
Reduced use of lawn fertilizers	10 (16%)	27 (42%)	27 (42%)
Prevent grass clippings, leaves, etc. from washing into drains by raking, bagging, and taking them to a waste management facility	16 (25%)	26 (41%)	22 (34%)
Support setting up vegetative buffers along shorelines of Lake Mendota	11 (17%)	33 (52%)	20 (31%)
Compost leaves and grass clippings	8 (13%)	29 (45%)	27 (42%)
Community trash pick-ups around the lake	3 (5%)	27 (42%)	34 (53%)

Q8. Would you be willing to support…?

Professors			
	Not likely	Likely	Highly likely
Reduced use of lawn fertilizers	0 (0%)	5 (38%)	8 (62%)
Prevent grass clippings, leaves, etc. from washing into drains by raking, bagging, and taking them to a waste management facility	2 (15%)	5 (38%)	6 (47%)
Support setting up vegetative buffers along shorelines of Lake Mendota	0 (0%)	6 (47%)	7 (53%)
Compost leaves and grass clippings	1 (8%)	5 (38%)	7 (53%)
Community trash pick-ups around the lake	2 (15%)	9 (70%)	2 (15%)

C. Original Graphic



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