DISCUSSION

Water Clarity

Water clarity is one of the most important factors influencing the survival of aquatic plants. Aquatic plants need at least 1% light penetration to grow. Water clarity is affected by suspended sediments, algae and dissolved organic chemicals. There was a wide range of variability in Secchi disc readings over each season. Measurements that have only marginal changes are most likely attributable to this variation. In most cases the difference in the mean readings between years was less than one foot. One area however showed a greater than one foot increase in 2005 and a greater than two foot decrease in 2009. This occurred at the southeastern shoreline location. There was a continued increase in the maximum actual rooting depth observed in 2009 even though the calculated rooting depth showed decreases in all areas except for Moon Bay. Importantly, in 1989/90 the actual maximum rooting depth was shallower than predicted by Secchi disc readings whereas it was deeper than predicted in 2005 and 2009.

Shoreland Use

The aquatic community of the littoral zone is closely tied to practices on shore. Light penetration is diminished by sediments from erosion and excessive nutrients from fertilizer runoff. Development of cultivated areas removes natural vegetation that holds soils in place and reduces erosion. There has been a positive shift in lake community with the increase in the percent of natural shorelines. The increase in natural shoreline types may indicate a shift towards maintaining more natural shorelines for those property owners with shoreline. It may indicate an increased recognition that trees, shrubs and herbaceous material are important to maintaining an ecologically sound body of water. The improvement in riparian buffers will allow for sediment filtration, provide habitat and control erosion.

Sediments

The distribution of sediments remained fairly constant with the exception of an increase in rock and decrease in sand/gravel substrates. There is some subjectivity in the assessment of substrates, however, as guidelines for classifying particle size per category were not established. For example, there was not a clear cut off point between rock and gravel. Given that different researchers conducted each survey, subjectivity in assessment could account for this variation. If these changes are not an artifact of sampling, then given the increase in natural shorelines they could be an indication of less sediment entering the water through erosion of shoreline properties. However, this is purely speculation. Sand remained the most frequently encountered substrate type in all three surveys and remained largely the same between the surveys when analysis of zone 4 was excluded. Silt substrates increased when all four zones were included in the analysis. However, silt was most commonly encountered in zone 4. Excluding zone 4 from the analysis shows a less pronounced increase in silt. The distribution of vegetation on each substrate revealed a trend of rock and gravel substrates increasing in vegetation while sand and silt decreased in vegetation.

The increase in vegetation in the 0-1.5 ft depth zone indicates that the plant community is moving towards the shore. Without the disturbance to the rooting systems caused by the drawdown, plants are better able to colonize these areas.

Aquatic Plant Community

There are several instances where plant frequencies or densities shifted one direction from 1989/90 to 2005 and then shifted the opposite direction in 2009. This confounds interpretation of these results. However, there are several cases of consistent growth or decrease in a category by a species that could be related to the reduction of the winter drawdown. *Vallisneria americana* for example showed a dramatic increase in percent frequency and percent frequency when vegetated. This species also increased in dominance value which takes into consideration frequency and density. *Vallisneria americana* is a species tolerant to water level fluctuations so the dramatic increase was unexpected. However, it was frequently found in the 0-1.5 ft depth zone which had an overall increase in vegetation. *Elodea canadensis* and *Najas flexilis* showed overall decreases in most categories in 2009. Both of these plants are considered resilient to water level disturbance (Konkel, 1998). *Pontaderia cordata*, *Potamogeton amplifolius* and *Ranunculus longirostris*, species that thrive with stable water level fluctuations (Konkel, 1998) have appeared on Lake Wissota. *Nymphaea odorata and Nuphar variegata*, both species sensitive to water level fluctuations, have increased in frequency. Other floating leaf species have also increased.

While densities of plants are decreasing, this does not necessarily indicate a negative trend. The aquatic plant community may be evening out across the lake. Dominant species are becoming less so and historically less prevalent plants are increasing. There is an increase in the number of quadrats with vegetation so while each plant bed is less dense, there are more plant beds. Plant beds that are less dense will also be beneficial to recreational users of the lake as they are easier to navigate through. Pollution from shoreline practices add to the nutrient enrichment of the water which can lead to an unbalanced amount of plant growth. The decrease in plant densities along with the improvement of the shoreline could be an indication of fewer pollutants entering the water.

There are certain areas of the lake that will likely not experience any changes over the long term due to the reduction of the drawdown. Wave action and lake morphometry will likely keep these areas uninhabitable. In areas that were protected from intense wave action and have less steeply sloping littoral zones, changes could be more indicative of what is actually happening in the lake system due to the reduction of the winter drawdowns. Two areas showed consistent decreases in the number of quadrats with vegetation, Little Lake Wissota and Pine Harbor. Three other areas increased, Moon Bay, O'Neil Creek Bay and State Park Bay. O'Neil Creek Bay increased to 100% in 2005 and 2009. Photographs from 2005 compared to visual inspection in 2009 showed this area has increased in vegetation between the two studies. Vegetation has increased in this area to the extent that navigation by motor boat is difficult. Residents have cleared paths to ease boat travel through the area. *Lemna minor*, *Wollfia columbiana* and *Spirodela polyrhiza* were dense enough through this area to obscure much of the submergent vegetation.

Zizania sp., an excellent addition to habitat for waterfowl and wildlife, was present in thick stands through this area in 2009. The number of quadrats with vegetation in the State Park Bay also increased to 100%. While this bay is subjected to high boat traffic, it occurs in a no-wake zone which protects the shoreline from wave action. Moon Bay also has thick stands of vegetation that impede boat traffic and is subject to blue-green algae outbreaks.

Based on the Coefficient of Community Similarity, the aquatic plant communities of all three year's are statistically similar (>0.75). This metric demonstrates that while there were a few differences in the plant communities, their overall species compositions remained similar.

The Simpson's Diversity Index decreased from 1989/90 to 2005 but then showed an increase over both years in 2009. Biological diversity depends on species richness and evenness. The increase in this index indicates that the species are more evenly distributed so dominant species are less so and non-dominant species are beginning to increase.

The average Coefficient of Conservatism and the Floristic Quality Index (FQI) both increased in each study. The Aquatic Macrophyte Community Index (AMCI) value also increased every year. The Coefficient of Conservatism, FQI and AMCI values show Lake Wissota falls within the median range for the North Central Hardwood Forest region of Wisconsin (Nichols 1999, 2000).

The continued increase in the frequency of two invasive species is a reason for concern on the lake. *Potamogeton crispus* has increased in frequency across all three years. *Myriophyllum spicatum* was first present in the 2005 study and has increased in frequency in the 2009 study. At this point the frequencies of both species are low relative to other prevalent plants. This, however, could change if methods of control are ineffective. *Potamogeton crispus* forms thick stands of vegetation that can outcompete native vegetation. *Potamogeton crispus* poses a problem in mid-summer when it begins to die off and releases excess nutrients into the water contributing to algal blooms. The increase in *Myriophyllum spicatum* is particularly troublesome on Lake Wissota. It has been described as one of the five most noxious plants in the United States (Mood and Les 2007). In lakes where this species is not controlled, thick stands form, inhibiting recreation, displacing native vegetation and changing fish and invertebrate communities. Many of the smaller patches of *Myriophyllum spicatum* on Lake Wissota are being held in check through mechanical harvesting (i.e. hand pulling). Chemical treatments have been effective in controlling *Myriophyllum spicatum* in some areas. The bay surrounding the State Park boat landing was treated for *Myriophyllum spicatum* in 2008 which was apparently effective as this species was not observed in 2009. Another area of the Yellow River, termed the Irrigation Bay, was effectively treated in 2009. While both mechanical harvesting and chemical treatments have shown some level of effectiveness against further encroachment of the plant, both have drawbacks. Hand pulling *Myriophyllum spicatum* is a labor intensive process that needs to be repeated throughout the summer. *Myriophyllum spicatum* breaks apart readily and can grow from fragments so care must

be taken to ensure complete removal of the plant. Chemical treatments are expensive and may be non-selective. The milfoil weevil, *Euhrychiopsis lecontei* has shown promise in controlling the plant in some lakes but may not be an appropriate method in this instance given the size and morphometry of Lake Wissota.

Moon Bay is an excellent example of an area that presents numerous problems in attempts to control *Myriophyllum spicatum*. Complete control through mechanical harvesting is nearly impossible in this area. *Myriophyllum spicatum* is found among thick stands of native vegetation. This makes it difficult to navigate to the plants by boat, to locate the plant among the other species and to achieve complete removal without fragments getting caught up in native plants. This area is also prone to blue-green algae outbreaks, the health risks of which prevent contact with the water and hence manual pulling during some parts of the year. The area covered by *Myriophyllum spicatum* is relatively large making chemical treatments prohibitively expensive. This area also has copious amounts of native vegetation particularly water lilies which are also killed by the non-selective chemical treatments for *Myriophyllum spicatum*. Drawdowns have been shown to be effective in the removal of *Myriophyllum spicatum* in some lakes. In Lake Wissota, the appearance and subsequent increase of *Myriophyllum spicatum* after the drawdown reduction lends anecdotal evidence that winter drawdowns on Lake Wissota may have prevented the establishment of this species. If other control measures prove to be ineffective at controlling the spread of this plant in the future, management decisions may need to include a reintroduction of some manner of drawdown.

Ecologically speaking, increased species diversity, and abundance are beneficial to an ecosystem. Plants provide shelter and food for organisms and the effect of this is felt through the entire food chain. While some of the changes in Lake Wissota seem ambiguous (e.g. inconsistent changes in frequencies of plants) the overall increases in the matrices used to assess the plant community indicate that the Lake Wissota aquatic plant community is shifting to a more desirable state from an ecological perspective. However, the condition of an ecosystem cannot be defined by one parameter of a community or by one type of organism. It would be unwise to assess Lake Wissota based solely on the aquatic plant community. A thorough assessment would include changes in the invertebrate, fish, waterfowl and mammalian populations. Unfortunately many of the communities were not surveyed prior to the reduction of the winter drawdown so changes due to the removal of disturbance cannot be assessed. The macroinvertebrate community, however, was surveyed in 1994/95, prior to the drawdown reduction (Delong and Mundahl 1995). This study is slated to be repeated in 2009/10. The results of that study in conjunction with the study reported here will give a clearer picture of the impact of reducing winter drawdowns. Documenting changes to Lake Wissota as a whole should give support to the notion that a series of studies on many different types of organisms should occur prior to major management decisions such as drawdown reduction or elimination.

Twenty years have passed between the first and final surveys of the aquatic plant community of Lake Wissota. Changes between the 2005 and 2009 studies were, for the most part, less pronounced than changes between 1989/90 and 2005. This could indicate

that few additional changes will occur in the lake due to the reduction of the winter drawdowns. However, the variables responsible for shaping an aquatic community are numerous; therefore, continued monitoring of Lake Wissota is warranted particularly in advance of any major management decisions, including any changes in dam operation or re-licensing. Annual monitoring and management of invasive species, those present as well as new additions, will be crucial to maintaining positive shifts in the Lake Wissota ecosystem.