Changes in the Aquatic Plant Community
of
Sidie Hollow Lake,
Vernon County, Wisconsin

1994-2005

Wisconsin Department of Natural Resources
Eau Claire, WI
June 2006

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Submitted by:
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EXECUTIVE SUMMARY

Sidie Hollow Lake is a 38-acre mesotrophic impoundment with very good water clarity and good water quality. Filamentous algae has increased since 1994.

Aquatic plant growth is distributed throughout Sidie Hollow Lake, at nearly all of the sample sites and more than half of the entire lake, to a maximum rooting depth of 15 feet. The 0-1.5ft depth zone supports the greatest amount plant growth. The plant community is characterized by fair diversity of plant species, an above average quality of the plant community for Wisconsin lakes, a very high quality for Driftless Region lakes, a high tolerance to disturbance and a disturbed condition.

Ceratophyllum demersum was the dominant species and *Eleodea canadensis* was sub-dominant, both occurring at more than three-quarters of the sites and growing at above average density. *Potamogeton crispus*, a non-native aquatic plant species, occurred at a low frequency and density in Sidie Hollow Lake.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.

Management Recommendations

1) DNR and County Park work with efforts in the watershed to reduce nutrient input (both phosphorus and nitrogen) to Sidie Hollow Lake.
2) County park and visitors practice best management on their lake properties.
3) County Park protect the natural shoreline around Sidie Hollow Lake.
4) Visitors protect the aquatic plant community in Sidie Hollow Lake.

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I. INTRODUCTION

Studies of the aquatic macrophytes (plants) in Sidie Hollow Lake were conducted during August 1994 and July 2005 by Water Resources staff of the Western Central Region - Department of Natural Resources (DNR).

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake due to the important ecological role of aquatic vegetation and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

Ecological Role: All other life in the lake depends on the plant life (including algae) - the beginning of the food chain. Aquatic plants provide food and shelter for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, impact recreation, and serve as indicators of water quality.

Characterize Water Quality: Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity and nutrient levels (Dennison et. al. 1993).

The present study will provide information that is important for effective management of the lake: including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulations. The data will be compared to past and future plant studies and offer insight into changes occurring in the lake. Recently, a few lakes in Vernon County had recently been invaded with an exotic plant species, Eurasian watermilfoil. The survey was also conducted to determine if the watermilfoil had been introduced to Sidie Hollow Lake also.

Background:

Sidie Hollow Lake is a 38-acre impoundment on Coe Hollow Creek and Sidie Hollow Creek, tributaries of the Bad Axe River, located in Vernon County, Wisconsin. The dam was built in 1965 for flood control and water recreation. The maximum depth of Sidie Hollow Lake is 22 feet. The 7-square mile watershed is mostly steep forest and agricultural land; this is a watershed to lake surface ratio of 118:1. Lakes with watershed area/lake size ratios greater than 10:1 tend to have water quality problems (Field 1994).

The lake is completely within Sidie Hollow County Park and provides lake-based recreation in an area of the state with few lakes and the lake is heavily used for fishing. The lake has been drawn down twice for dam maintenance, mot recently in 1969.

II.METHODS

Field Methods

The 1994 and 2005 study design was based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random placement of the transect lines. The shoreline was divided into 11 equal segments and within each segment, a transect was randomly placed, using a random numbers table (Appendix VII). The transects were mapped to be used for all plant surveys.

One sampling site was randomly located in each depth zone (0-1.5ft., 1.5-5ft., 5-10ft. and 10-20ft.) along each transect. Using a long-handled steel thatching rake, four rake samples were taken at each sampling site, one rake sample from each quarter of a 6-foot square quadrat. The aquatic plant species that were present on each rake sample were recorded. Each species was given a density rating (0-5) based on the number of rake samples on which it was present at that sampling site.

A rating of 1 indicates that a species was present on one rake sample at that site
A rating of 2 indicates that a species was present on two rake samples
A rating of 3 indicates that a species was present on three rake samples
A rating of 4 indicates that it was present on all four rake samples
A rating of 5 indicates that it was abundantly present on all rake samples at that sampling site.

The actual depth and sediment type at each sampling site was recorded. The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore, was evaluated. The percentage of each cover type within this 100' x 30' rectangle was estimated.

Visual inspection and periodic samples were taken between transects in order to record the presence of any species that did not occur at the sampling sites. Specimens of all plant species present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

Data Analysis

Each sampling year was analyzed separately and compared. The frequency of occurrence of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendix I, II). Relative frequency was calculated (number of occurrences of a species relative/sum of all species occurrences) (Appendix I, II). The mean density was calculated for each species (sum of a species' density ratings / number of sampling sites) (Appendix III, IV). Relative density was calculated (sum of a species' density ratings / sum of all plant densities) (Appendix III, IV). A "mean density where present" was calculated for each species (sum of a species' density ratings / number of sampling sites at which the species occurred) (Appendix III, IV). The relative frequency and relative density of each species was summed to obtain a dominance value for each species (Appendix V, VI).

Simpson's Diversity Index was calculated: $1-(\sum(\text{Relative Frequency}^2))$ (Appendix I, II). The sampling years were compared by a Coefficient of Community Similarity (Appendix VIII).

An Aquatic Macrophyte Community Index (AMCI), developed for Wisconsin lakes, was applied to Sidie Hollow Lake. Data in seven categories that characterize the aquatic plant community are converted to values 0 - 10 and summed as outlined by Nichols (2000).

Coefficients of Conservatism and Floristic Quality Indices were used to evaluate the closeness of the aquatic plant community to an undisturbed condition (Nichols 1998). A Coefficient of Conservatism is an assigned value, 0-10, the probability that a species will occur in a relatively undisturbed habitat. The Average Coefficient of Conservatism is the mean of the Coefficients of Conservatism for all species found in the lake and measures tolerance to disturbance. The Floristic Quality Index is calculated from the Average Coefficient of Conservatism and measures the closeness of the community to an undisturbed condition.

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, water clarity and water hardness) influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shoreline use also impact the aquatic plant community.

WATER QUALITY - The trophic state of a lake is a classification of its water quality. Phosphorus concentration, chlorophyll concentration and water clarity data are collected and combined to determine the trophic state.

Eutrophic lakes are high in nutrients and therefore support a large biomass.

Oligotrophic lakes are low in nutrients and support limited plant growth and smaller populations of fish.

Mesotrophic lakes have intermediate levels of nutrients and biomass.

Phosphorus is a limiting nutrient in many Wisconsin lakes. Increases in phosphorus in a lake can feed algal blooms and excess plant growth.

1994 Summer Mean total phosphorus in Sidie Hollow Lake was 20 ug/l.

The phosphorus concentration in Sidie Hollow Lake places it in the mesotrophic range (Table 1).

Table 1. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll ug/l	Secchi Discft.
Oligotrophic	Excellent	<1	<1	> 19
	Very Good	1-10	1-5	**8-19**
Mesotrophic	Good	**10-30**	**5-10**	6-8
	Fair	30-50	10-15	5-6
Eutrophic	Poor	50-150	15-30	3-4
Hypereutrophic	Very Poor	>150	>30	>3
Sidie Hollow Lake 1994	Very Poor	20	6.3	18.2

After Lillie & Mason (1983) & Shaw et. al. (1993)

Algae

Measuring the concentration of chlorophyll measures the amount of algae in the lake. Algae are natural and essential in lakes, but high algal levels can cause problems, contributing to turbidity and reducing the light available for plant growth.

1994 Mean summer chlorophyll a in Sidie Hollow Lake was 6.3 ug/l.

Lakes with chlorophyll in this range are considered mesotrophic (Table 1).

Filamentous algae was found at 12% of the sampling sites in 1994 and 39% of the sample sites in 2005 (Figure 1). In 1994, filamentous algae was not abundant and only common in the 0-1.5ft zone. In 2005, filamentous algae was abundant in the 0-1.5ft depth zone and commonly occurring in the 1.5-5ft depth zone.

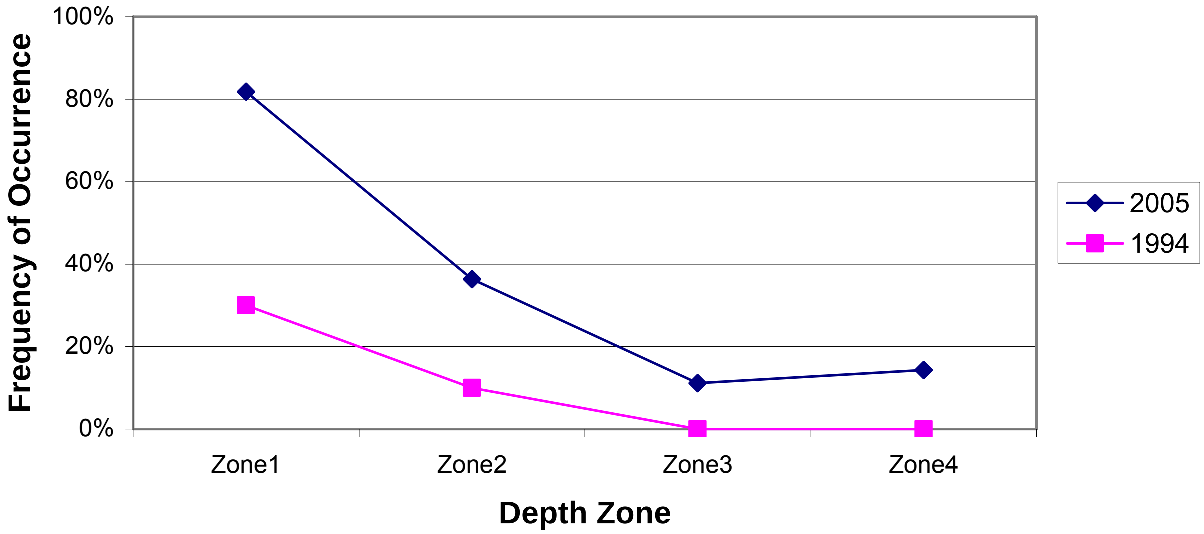


Figure 1. Occurrence of filamentous algae in Sidie Hollow Lake, by depth zone, 1994-2005.

Water Clarity

Water clarity is a critical factor for aquatic plants. When aquatic plants receive less than 1 - 2% of the surface illumination, they can not survive. Water clarity is reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color the water. Water clarity can be measured with a Secchi disc that shows the combined effect of turbidity and color.

1994 Mean Summer Secchi disc depth clarity was 18.2 feet.

The water clarity data indicates that Sidie Hollow Lake has very good water clarity and is in the oligotrophic range (Table 1).

The combination of the phosphorus, chlorophyll, and clarity values indicates that Sidie Hollow Lake is a mesotrophic lake (Table 1) with good water quality. This trophic state favors moderate plant growth and occasional algae blooms.

Volunteer lake monitors in the Self-Help Program, monitored Sidie Hollow Lake for water clarity, off and on during 1988-2005. Paul Krahn monitored in 1988 and 1990; Dave Hardt monitored in 1992-93; and Hugh Gilgenbach monitored water clarity in 2003-2005.

The water clarity data shows that there was no discernable trend in water clarity during 1988-2005, but there were wide variations (Figure 2). The best water clarity was in

1994 and the lowest clarity was in 1992. Water clarity in 2005 was in the mesotrophic range. Yearly variations in rainfall, temperature, run-off and erosion from the watershed, etc. can impact water clarity, especially in an impoundment.

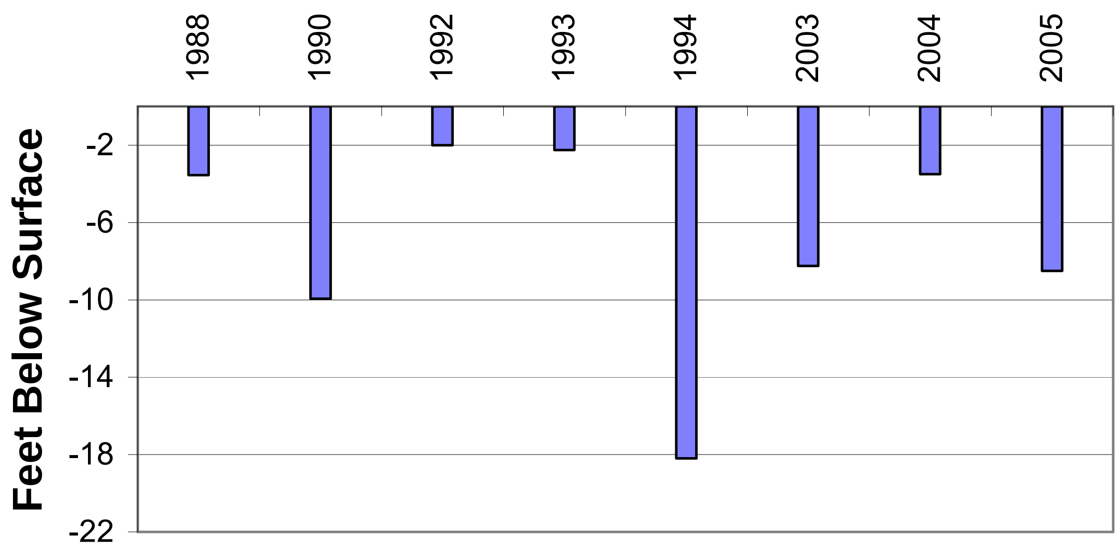


Figure 2. Summer mean water clarity in Sidie Hollow Lake, 1988-2005.

Averaging clarity data collected during the same time period each year shows that water clarity also varies during the growing season. Water clarity is usually very good during the spring before algal growth occurs (Figure 3). Clarity then decreases during the summer as the water warms and then increases slightly in the fall after the algae die back (Figure 3).

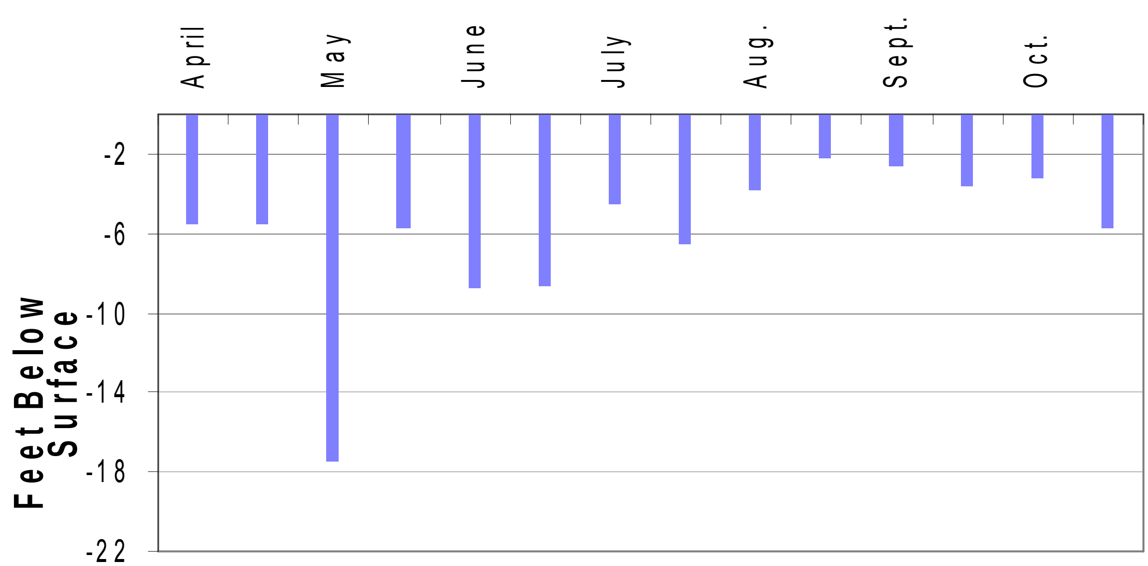


Figure 3. Variation in water clarity during the growing season in Sidie Hollow Lake, 1988-2005.

ALKALINITY

1990 Alkalinity in Sidie Hollow Lake was 240mg/l CaCO3.

Alkalinity values greater than 180mg/l CaCO3 indicate very hard water. Hard water lakes tend to have more plant growth.

LAKE MORPHOMETRY - The morphometry of a lake is an important factor determining the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support more plant growth than steep slopes (Engel 1985).

Sidie Hollow Lake is a reservoir with two narrow arms sheltered by steep forested hills. The narrow sheltered arms provide a more protected habitat that encourages plant growth. However, the littoral zone is steeply-sloped and may be less favorable for plant growth, especially when combined with the shade from overhanging trees.

SEDIMENT COMPOSITION -

Silt was the dominant sediment in the lake, found at all sites with depths greater than 5-feet (Table 2) (Figure 4). Silt mixed with sand or organic muck was abundant, especially at depths less than 5-feet.

Table 2. Sediment Composition: Sidie Hollow Lake, 2005

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Soft Sediment	Silt			100%	100%	49%
	Muck	36%	45%			24%
Mixed Sediments	Sand/Silt	45%	27%			22%
	Muck/Sand	9%				3%
	Silt/Rock	9%				3%

Many species of plants depend on the sediment in which they are rooted for their nutrients. The richness or sterility and texture of the sediment will determine the type and abundance of aquatic plant species that can survive in a location.

Silt, an intermediate-density sediment considered most favorable for plant growth, was the dominant sediment in the lake. The availability of mineral nutrients for growth is highest in sediments of intermediate density (Barko and Smart 1986). Silt mixed with

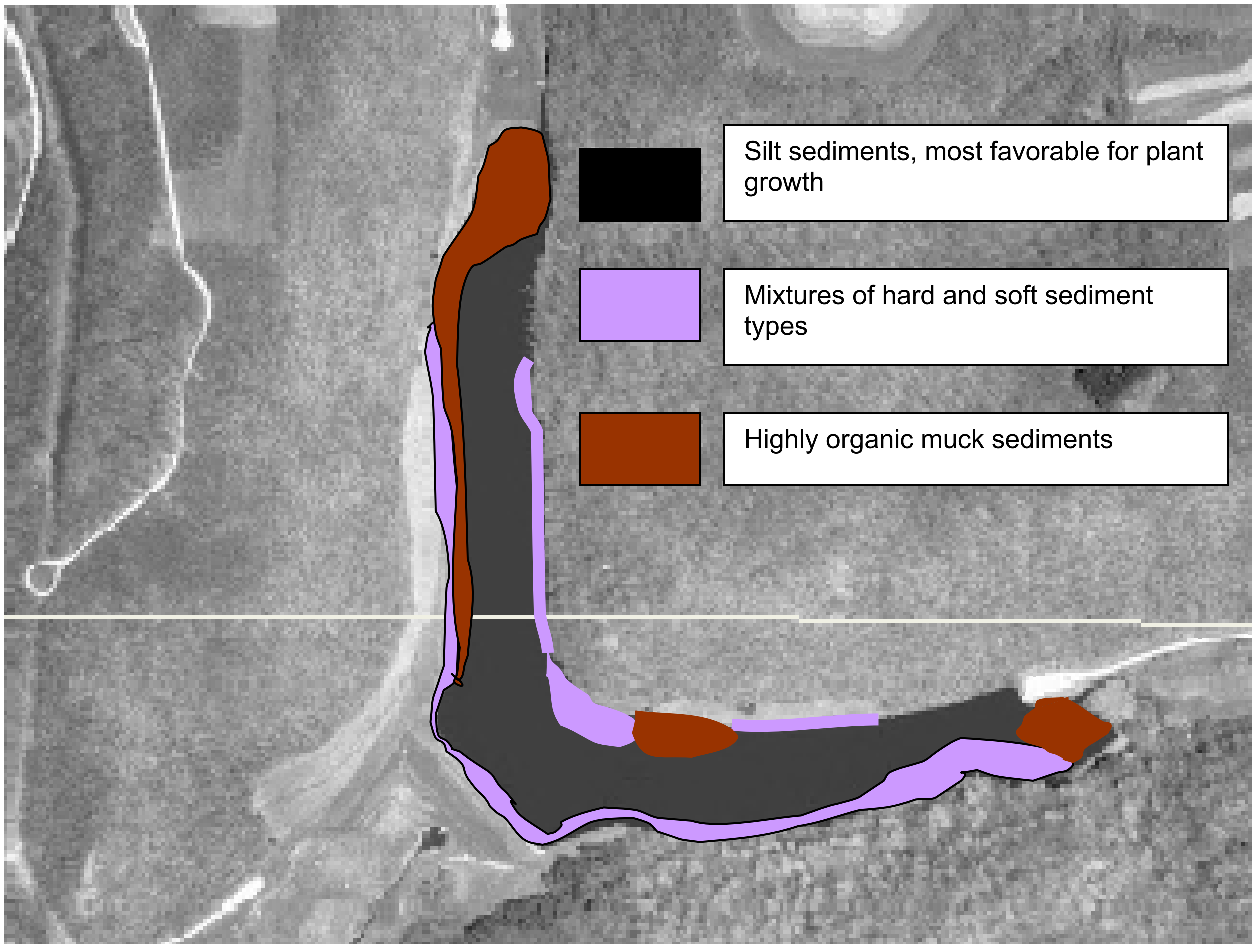


Figure 4. Distribution of sediment types in Sidie Hollow Lake, 2005.

sand and organic muck sediments were more abundant in the shallow zones.

However, all sediment types supported abundant plant growth and there fore sediment does not appear to be a major factor in determining plant growth in Sidie Hollow Lake.

SHORELINE LAND USE - Land use practices strongly impact the aquatic plant community and therefore the entire aquatic community. Practices on shore can directly impact the plant community through increased sedimentation from erosion, increased nutrient input from fertilizer run-off and soil erosion and increased toxics from farmland and urban run-off.

Shrub cover was the most frequently encountered cover at the shoreline transects and wooded cover had the greatest mean coverage (Table 3). Mowed areas were commonly occurring and covered approximately 18% of the shore.

Table 3. Shoreline Land Use on Sidie Hollow Lake, 2005

Cover Type		**Frequency of Occurrence at sample sites**	**% Mean coverage at sample sites**
Natural Cover	Wooded	64%	42%
	Shrub	82%	24%
	Herbaceous	73%	14%
Totals			**80%**
Disturbed Shoreline	Mowed Areas	36%	18%
	Eroded Areas	1%	1%
Totals			**19%**

Some type of natural shoreline occurred at all of the sites in 2005 and covered approximately 80% of the shore. Some type of disturbed shoreline occurred at 45% of the sites and covered approximately 19% of the shore (Table 3).

MACROPHYTE DATA

SPECIES PRESENT

A total of 18 species was found in Sidie Hollow Lake during 1994-2005. Of the 18 species, 7 were emergent species, 2 were floating-leaf species, and 9 were submergent species (Table 4).

No endangered or threatened species were found.
One non-native species, *Potamogeton crispus* was found.

Table 4. Sidie Hollow Lake Aquatic Plant Species, 1994-2005

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Carex* spp.	sedge	carsp
2) *Epilobium coloratum* Biehler.	willow herb	epico
3) *Impatiens capensis* Meerb.	spotted jewelweed	impca
4) *Phalaris arundinacea* L.	reed canary grass	phaar
5) *Sagittaria latifolia* Willd.	common arrowhead	sagla
6) *Scirpus validus* Vahl.	softstem bulrush	sciva
7) *Typha latifolia* L.	broad-leaf cattail	typla
Floating-leaf Species		
8) *Lemna minor* L.	small duckweed	lemmi
9) *Wolffia columbiana* Karst.	common watermeal	wolco
Submergent Species		
10) *Ceratophyllum demersum* L.	coontail	cerde
11) *Chara* sp.	muskgrass	chasp
12) *Elodea canadensis* Michx.	common waterweed	eloca
13) *Najas flexilis* (Willd.) Rostkov. & Schmidt.	slender naiad	najfl
14) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
15) *Potamogeton pectinatus* L.	sago pondweed	potpe
16) *Potamogeton pusillus* L.	small pondweed	potpu
17) *Ranunculus longirostris* Godron.	white watercrowfoot	ranlo
18) *Zosterella dubia* (Jacq.) Small.	water star grass	zosdu

FREQUENCY OF OCCURRENCE

The species with the highest frequency of occurrence in 1994 was *Ceratophyllum demersum* and in 2005 was *Elodea canadensis* (Figure 5). *Ranunuclus longirostris* and *Zosterella dubia* were commonly occurring species in both 1994 and 2005. *Lemna minor*, *Potamogeton crispus* and *Wolffia columbiana* were common species in 1994 only; *Potamogeton pectinatus* and *P. pusillus* were common species in 2005 only (Appendices I-II).

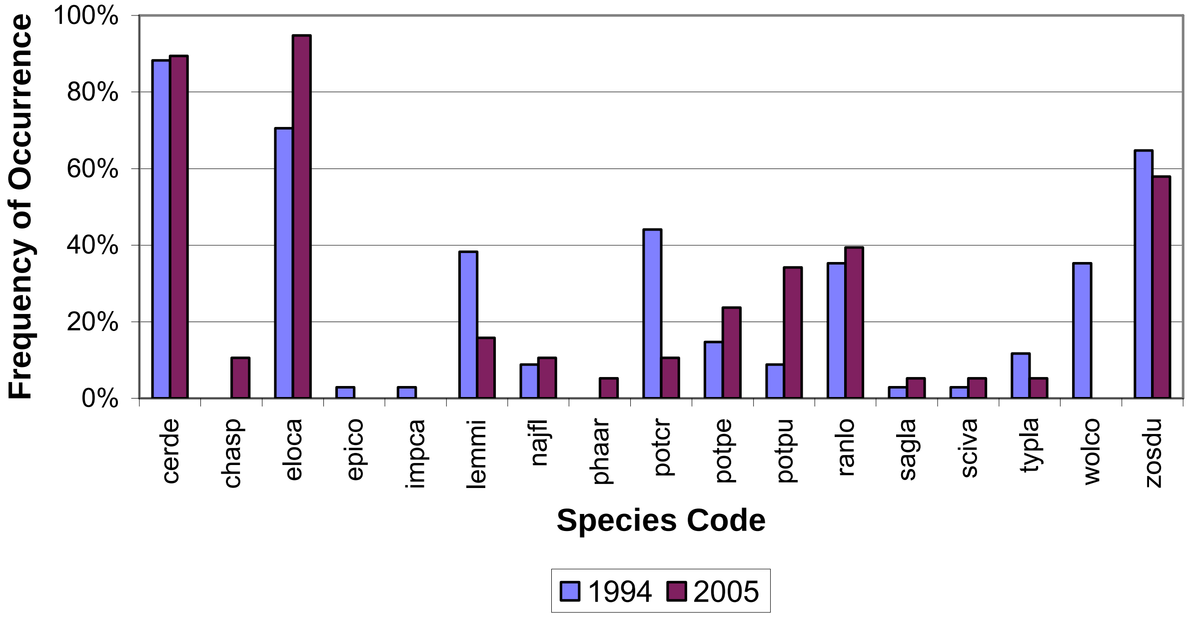


Figure 5. Frequency of aquatic plant species in Sidie Hollow, 1994-2005.

DENSITY

Ceratophyllym demersum was the species with the highest mean density in both 1994 and 2005 (2.62 and 3.08 on a density scale of 1-4) (Figure 6). Except for *Elodea canadensis* and *Zosterella dubia* other species occurred at much lower mean densities in Sidie Hollow Lake (Appendices III-IV).

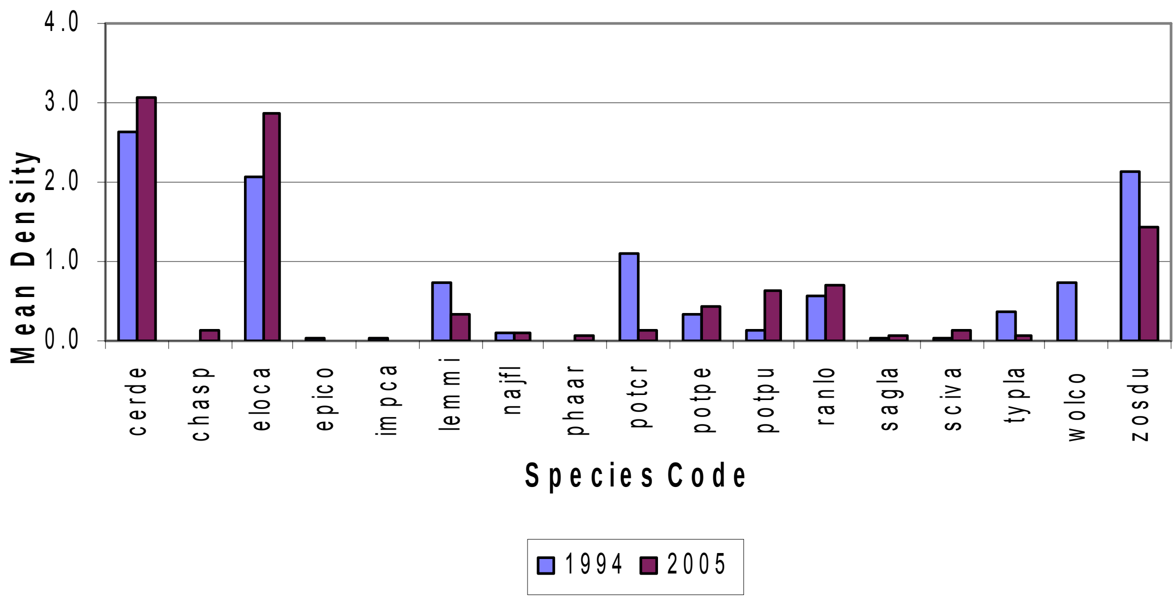
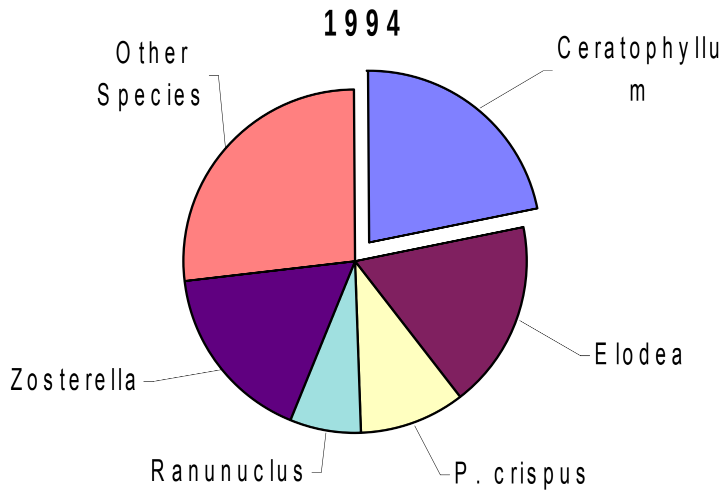


Figure 6. Mean density of aquatic plant species in Sidie Hollow, 1994-2005.

Ceratophyllym demersum and *Elodea canadensis* had a "density where present" of greater than 2.5 both years, indicating that they exhibited an aggregated or dense growth form in Sidie Hollow Lake (Appendices III, IV). *Typha latifolia* and *Zosterella dubia* also had a "density where present" greater than 2.5 in 1994 indicating that these species exhibited an aggregated or dense growth form in Sidie Hollow Lake in 1994 (Appendices III, IV).

DOMINANCE

Combining the relative frequency and relative density of species into a dominance value illustrates the dominance of a species in the plant community (Appendix V, VI). Based on the dominance value, *Ceratophyllum demersum* was the dominant species in Sidie Hollow Lake and *Elodea canadensis* was sub-dominant in 1994 and 2005 (Figure 7).



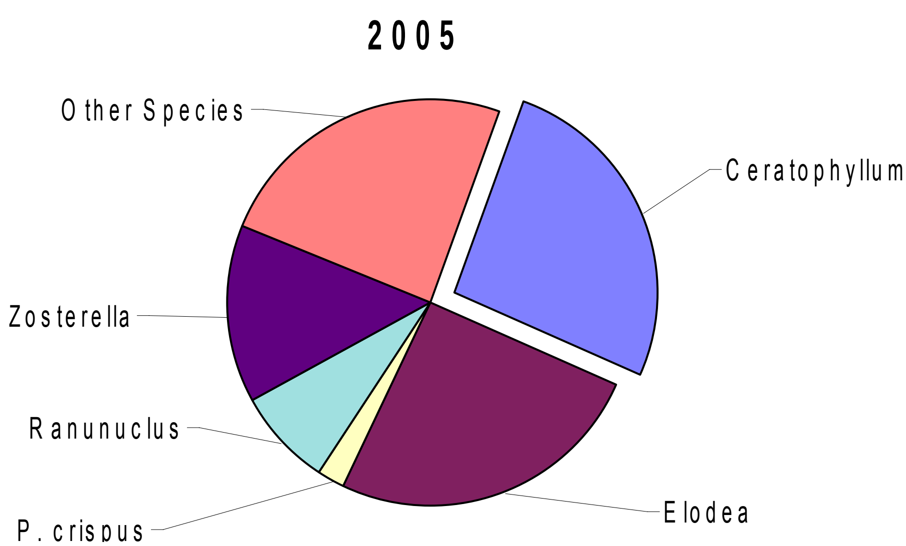


Figure 7. Dominance of the most prevalent plants within the plant community, based on Dominance Value, 1994-2005.

DISTRIBUTION

Aquatic plants were found growing at 97% of all sampling sites in both years, found throughout the lake, up to a maximum depth of 15 feet in both years. *Ceratophyllum demersum* and *Elodea canadensis* occurred at the maximum rooting depth. Over the whole lake, 25 acres were vegetated with submergent vegetation (66% lake surface); 1-acre was vegetated with emergent vegetation (3%) (Figure 8).

The dominant species were found throughout the lake. The other species that were common in 2005 were found scattered throughout the lake, except *Ranunuclus longirostris,* which did not occur in the southeast arm.

Secchi disc water clarity data can be used to calculate a predicted maximum rooting depth for plants in a lake (Dunst 1982).

Predicted Rooting Depth (ft.) = (Secchi Disc (ft.) * 1.22) + 2.73

The actual maximum rooting depth in Sidie Hollow Lake was less than the predicted in 1994 and greater than the predicted in 2005, based on the water clarity data (Figure 9).

Since water clarity has been variable from year to year in Sidie Hollow Lake during 1988 -2005, it is difficult for the aquatic plant community to adjust quickly to changing clarity.

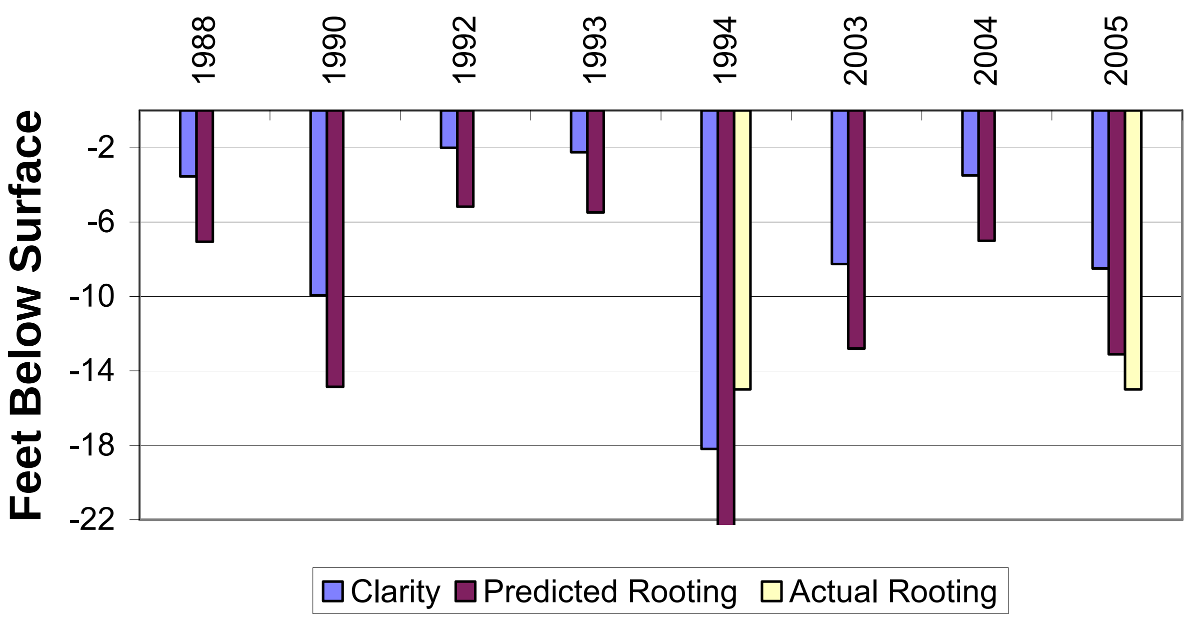


Figure 9. Actual rooting depth vs. predicted rooting depth based on water clarity, 1988-2005.

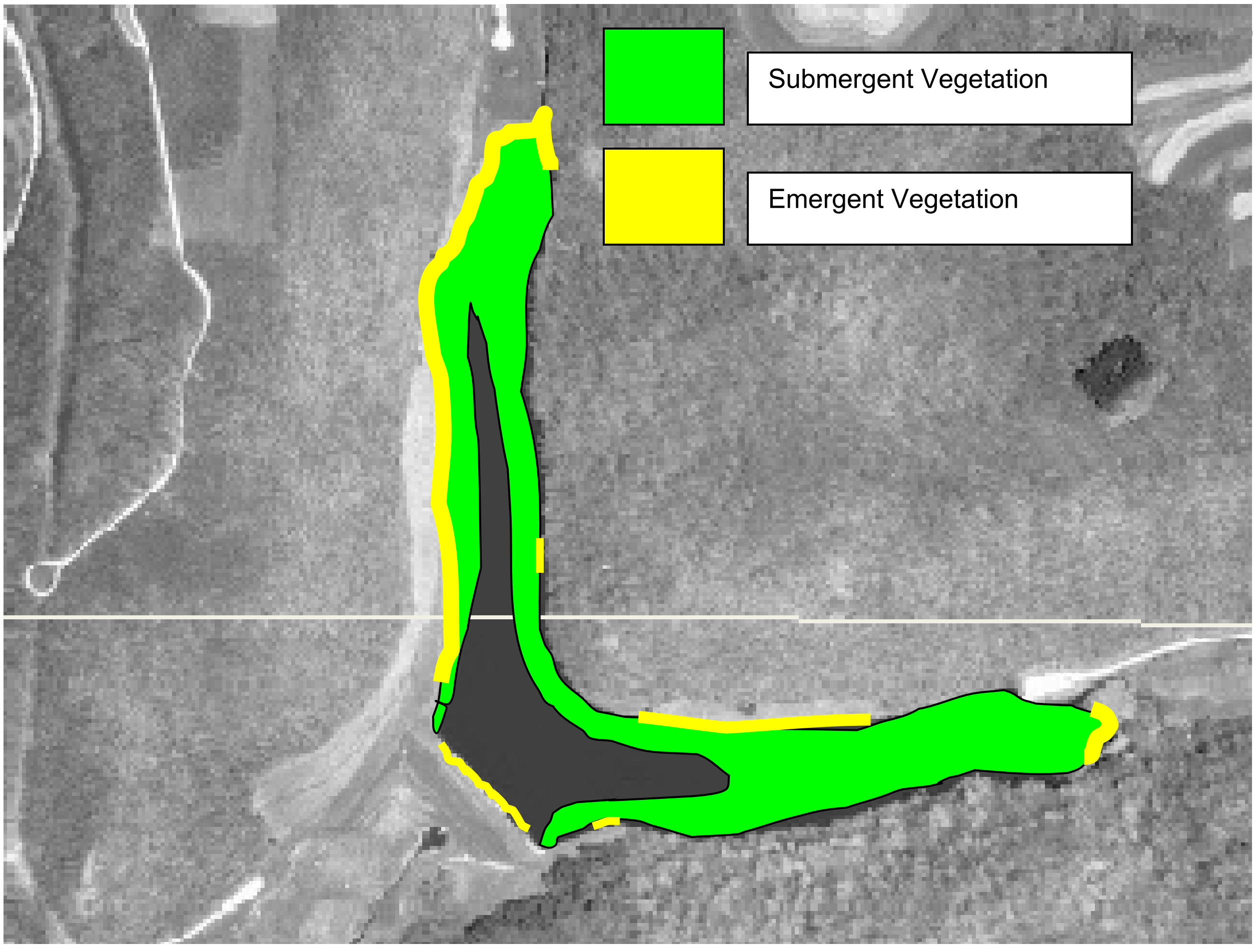


Figure 8. Distribution of aquatic vegetation in Sidie Hollow Lake, 2005.

Ceratophyllum demersum, the dominant species, dominated all depth zones in 1994. In 2004, both *C. demersum* and *Elodea canadensis* had increased. *C. demersum* was still dominant in most depth zones except the 1.5-5ft zone in which *E. canadensis,* the sub-dominant species was dominant (Figure 10, 11).

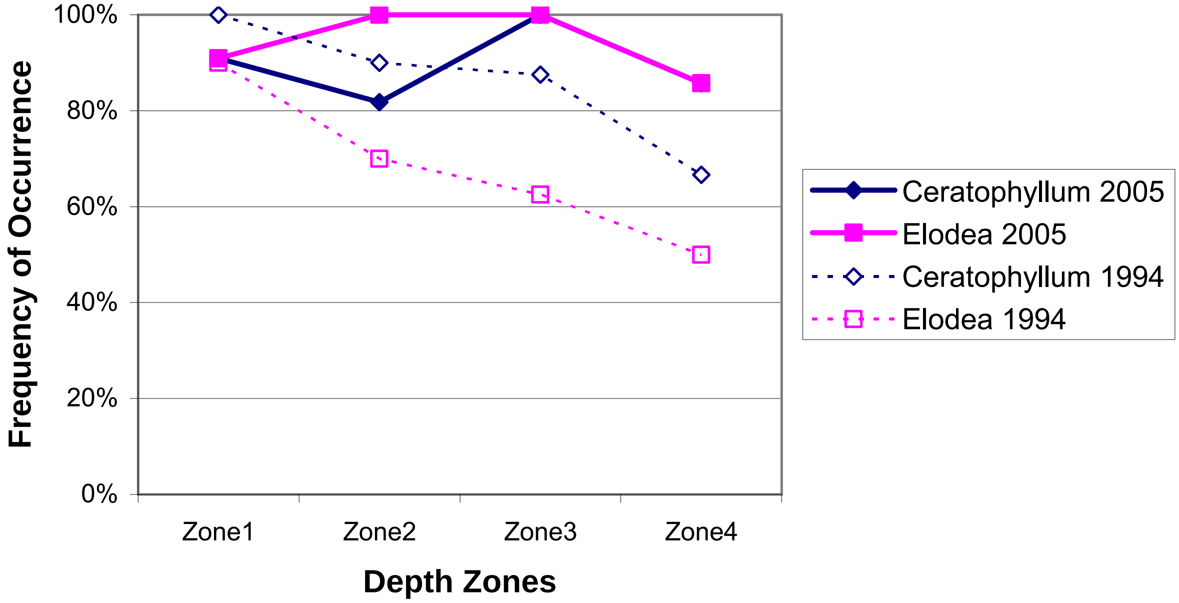


Figure 10. Change in frequency of the dominant aquatic plant species, by depth zone, 1994-2005.

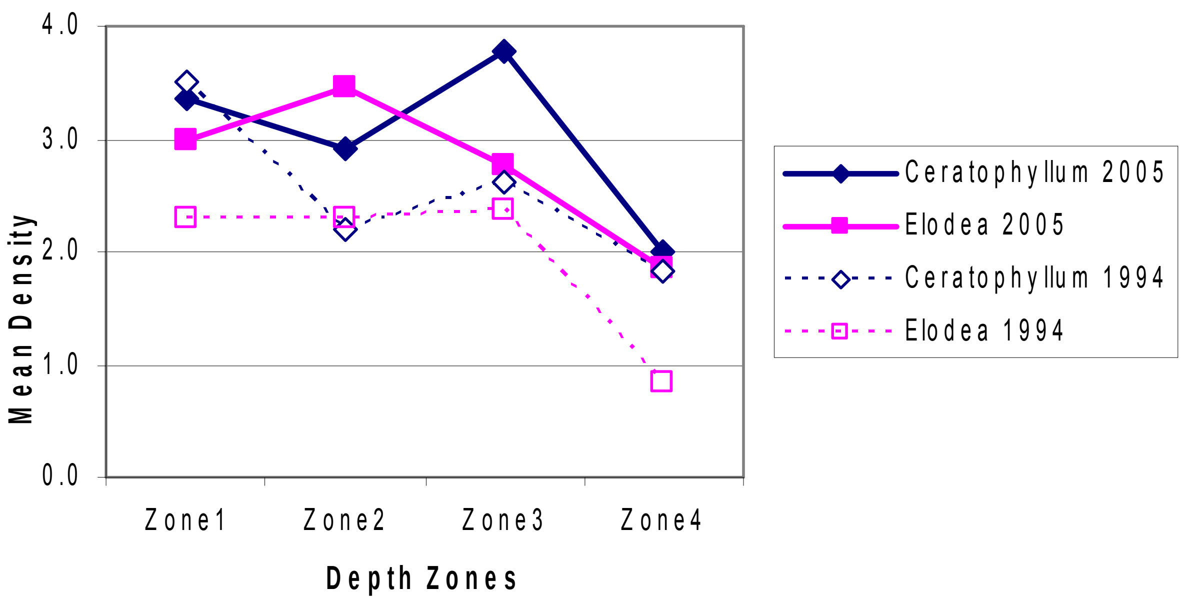


Figure 11. Change in mean density of the dominant aquatic plant species, by depth zone, 1994-2005.

The highest total occurrence and total density of aquatic plants occurred in the 0-1.5ft depth zone in both years (Figure 12), declining with increasing depth. Total occurrence and density of plant growth has not changed between 1994 and 2005.

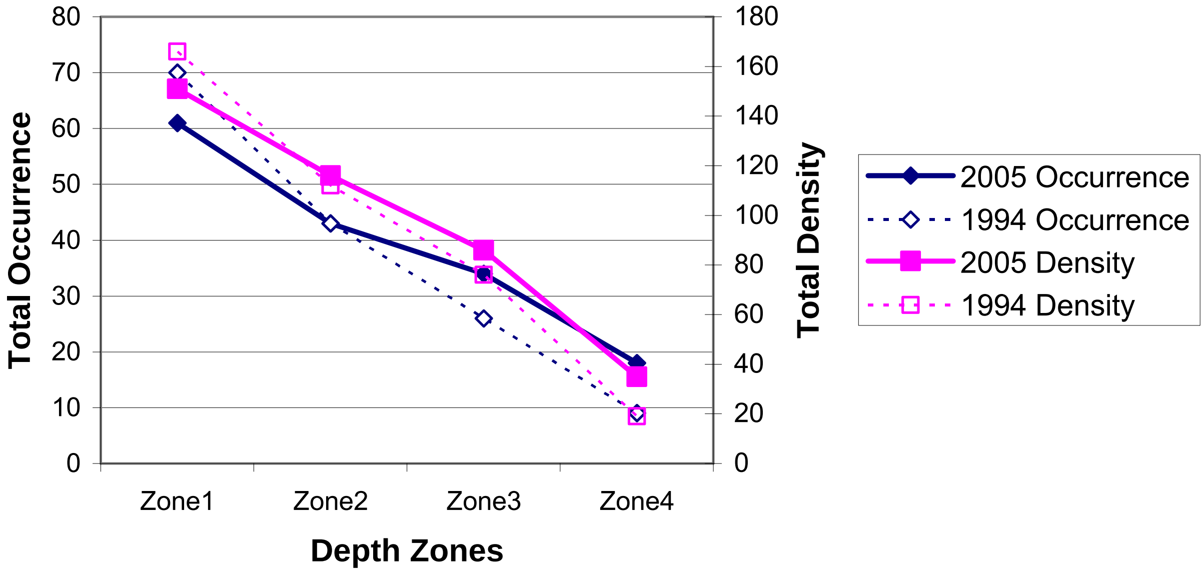


Figure 12. Total occurrence and density of aquatic plants by depth zone, 1994-2005.

The highest percentage of vegetated sites and greatest species richness (number of species per site) occurred in the 1.5-5ft depth zone in 1994 (Figure 13). In 2004, the highest percentage of vegetated sites was still in the 1.5-5ft depth zone, but the greatest species richness had shifted to the 0-1.5ft depth zone. Overall, species richness decreased substantially between 1994 and 2005 (Figure 13) and percentage of vegetated sites decreased slightly.

Lake wide species richness (mean number of species per sampling site) decreased between 1994 and 2005. Lake wide species richness was 4.4 in 1994 and 4.1 in 2005.

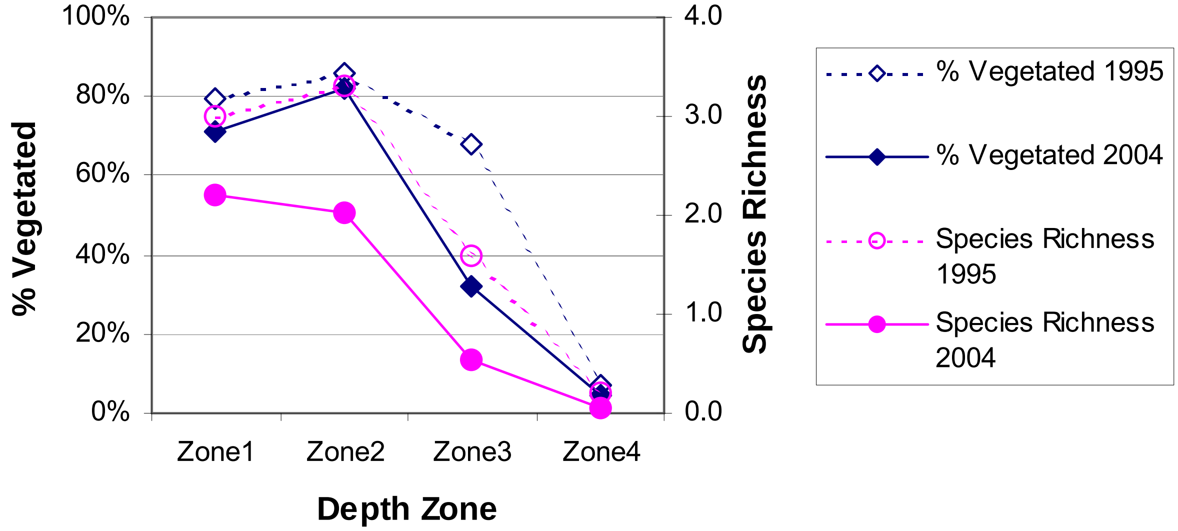


Figure 13. Percent of sites vegetated and Species Richness, by depth zone, 1994-2005.

THE AQUATIC PLANT COMMUNITY

The Coefficient of Community Similarity is a measure of the percent similarity between two communities. Coefficients less than 0.75 suggest that the two communities are less than 75% similar and considered to be significantly different. The Coefficient of Community Similarity for Sidie Hollow Lake indicates that the 1994 and 2005 aquatic plant communities were 76-77% similar, not significantly different (Appendix VIII).

Although not significant, some changes did occur. Changes in the aquatic plant community from 1994 to 2005 (Table 5) were:

1) A decrease in the number of species found at the transects
2) A decreases in the percentage of sites supporting submergent and emergent vegetation
3) A decrease in the Diversity Index and Species Richness
4) A decrease in the Floristic Quality Index (discussed later)
5) An increase in the Ave. Coefficient of Conservatism (discussed later)
6) An increase in the quality of the community as measured by the Aquatic Macrophyte Community Index (AMCI) (discussed later)
7) An increase in the cover of free-floating species (duckweeds and coontail)

The greatest decrease was in the cover of emergent vegetation (Table 5). The greatest increase was in the Average Coefficient of Conservatism (Table 5).

Table 5. Changes in the Sidie Hollow Lake Aquatic Plant Community, 1994-2005

	1994	**2005**	**Change**	**%Change**
Number of Species	16	15	-1	-6.3%
Maximum Rooting Depth	15.5	15.5	0	0.0%
% of Littoral Zone Vegetated	97	97	0	0.0%
%Sites/Emergents	18	11	-7	-38.9%
%Sites/Free-floating	88	89	1.0	1.1%
%Sites/Submergents	94	89	-5.0	-5.3%
AMCI Index (Quality)	48	52	4.0	8.3%
Species Richness	4.4	4.1	-0.3	-6.8%
Simpson's Diversity Index	0.88	0.86	-0.02	-2.3%
Average Coefficient of Conservatism	3.80	4.15	0.35	9.2%
Floristic Quality	15.67	14.97	-0.70	-4.5%

Simpson's Diversity Index decreased from 0.88 in 1994 to 0.86 in 2005, indicating a decline in species diversity from good to fair diversity. A rating of 1.0 would mean that each species in the lake was a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) (Nichols 2000) was applied to Sidie Hollow Lake. The AMCI for Sidie Hollow Lake increased from 48 in 1994 and 52 in 2005 (Table 6). This indicates that the quality of the plant community was below average for lakes in Wisconsin and in the upper quartile for lakes in the Driftless Region in 1994 and increased to above average quality for lakes in the state and one of the highest quality lakes in the Driftless Region in 2005.

Table 6. Aquatic Macrophyte Community Index: Sidie Hollow Lake, 1994-2005

Category	1994		2005	
Maximum Rooting Depth	4.7 meters	9	4.6 meters	9
% Littoral Zone Vegetated	97%	10	97%	10
Simpson's Diversity	88	8	86	7
# of Species	16	8	15	7
% Submergent Species	56% Rel. Freq.	4	70% Rel. Freq.	8
Exotic Species	10% Rel. Freq	5	3% Rel. Freq.	6
% Sensitive Species	2% Rel. Freq.	4	8% Rel. Freq.	5
Totals		48		52

The highest value for this index is 70.

The lack of sensitive species sensitive species in the community are limiting the quality of the plant community in Sidie Hollow Lake.

The Average Coefficient of Conservatism for Sidie Hollow Lake was in the lowest quartile both years for all Wisconsin lakes and lakes in the Driftless Region of Wisconsin (Table 7). This indicates that the aquatic plant community in Sidie Hollow Lake is among the group of lakes in Wisconsin and the North Central Hardwoods Region most tolerant of disturbance.

Table 7. Floristic Quality and Average Coefficient of Conservatism of Sidie Hollow Lake, Compared to Wisconsin Lakes and Driftless Area Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes	5.5, 6.0, 6.9 *****	16.9, 22.2, 27.5
Driftless Region	4.6, 5.0, 5.5 *****	10.2, 14.3, 18.1
Sidie Hollow Lake - 1994	3.80	15.67
Sidie Hollow Lake 2005	4.15	14.98

***** - Values indicate the highest value of the lowest quartile, the mean and the lowest value of the upper quartile.

† - Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (least disturbance tolerant).

‡ - lowest Floristic Quality was 3.0 (farthest from an undisturbed condition) and the high was 44.6 (closest to an undisturbed condition).

The Floristic Quality Index (FQI) of the plant community in Sidie Hollow Lake was in the lowest quartile of lakes in the state in 1994 and 2005. However, these FQI values were above the mean for lakes in the Driftless Region (Table 7). This indicates that the plant community in Sidie Hollow Lake was within the group of lakes in the state farthest from an undisturbed condition. Compared to lakes in the Region, the Sidie Hollow plant community was closer to an undisturbed condition than the average lake.

Disturbances can be of many types:

1) Physical disturbances to the plant beds result from activities such as boat traffic, plant harvesting, chemical treatments, the placement of docks and other structures and fluctuating water levels.
2) Indirect disturbances are the result of factors that impact water clarity and thus stress species that are more sensitive: resuspension of sediments, sedimentation from erosion and increased algae growth due to nutrient inputs.
3) Biological disturbances include competition from the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by a fish or wildlife population.

The major disturbances in Sidie Hollow Lake are run-off from the watershed and previous drawdowns.

There were some changes in individual species between 1994 and 2005 (Appendix IX).

Two (2) new species appeared in 2005: *Chara* spp. and *Phalaris arundinacea*.

Two (2) species were recorded in 1994, but not found in 2005. Two of those species were emergents that occurred in limited locations and changes in water level could have changed the aquatic status of these species. *Wolffia columbiana*, a duckweed species was not found in 2005, but had been abundant in 1994.

Besides the new species, 8 species increased in frequency, density and abundance: the dominant and sub-dominant species, *Najas flexilis,* two pondweeds, *Ranunculus longirostris* and two emergent species. The species that increased the most in frequency, mean density and dominance from 1994 to 2005 was *Potamogeton pusillus* with a doubling in frequency, a three-fold increase in density and a four-fold increase in dominance within the community.

Besides the species that disappeared, there were decreases in 4 species during 1994-2005: Another duckweed species, *Potamogeton crispus,* one emergent and *Zosterella dubia.*

DISCUSSION

Based on the water clarity and chlorophyll and phosphorus concentration, Sidie Hollow Lake is a mesotrophic lake with very good water clarity and good water quality. Filamentous algae was commonly occurring only in the 0-1.5ft depth zone in 1994, but increased to 39% occurrence in 2005, abundant in the 0-1.5ft depth zone and commonly occurring in the 1.5-5ft depth zone.

The trophic status (adequate nutrients), hard water, very good water clarity, dominance of favorable silt sediment, large areas of shallow depth and gradually sloped littoral zone in parts of the lake would favor aquatic plant growth. Nutrients from a relatively large watershed are being focused into a small waterbody. The moderately-to-steeply sloped littoral zone in other parts of the lake could limit aquatic plant growth in those areas.

Aquatic plant growth was found throughout the littoral zone of Sidie Hollow Lake, at 97% of the sites and 66% of the total lake area, up to the maximum rooting depth of 15 feet. Species that occurred at the maximum rooting depth were *Ceratophyllum demersum* and *Elodea canadensis.* These species are turbidity tolerant (Nichols and Vennie 1991) and can survive lower light levels.

The most abundant plant growth (highest total occurrence of plants, highest total density of plant growth, the greatest species richness) was found in the 0-1.5ft depth zone.

Eighteen (18) species of aquatic plants have been found in Sidie Hollow Lake. *Ceratophyllum demersum* was the dominant species in Sidie Hollow Lake. *Elodea canadensis* was the sub-dominant species. Both species occurred throughout the lake at more than three-quarters of the sites and exhibited growth forms of above average density. *Zosterella dubia* and *Typha latifolia* also exhibited growth forms of above average density.

Figure 14. Bed of *Zosterella dubia* (water stargrass) in Sidie Hollow Lake, 2005.

One non-native species occurred in Sidie Hollow Lake, *Potamogeton crispus*. However, *P. crispus* was not commonly occurring, occurred at a low density, made up only 2% of the Sidie Hollow Lake Plant community and has decreased since 1994.

Simpson's Diversity Index indicated fair diversity of species in 2005 (0.86). The quality of the aquatic plant community, as measured by the AMCI Index, was above average of Wisconsin lakes, but one of the highest quality lakes in the Driftless Region. The Average Coefficients of Conservatism indicate that Side Hollow has a high tolerance to disturbance. The Floristic Quality Index indicates that Sidie Hollow Lake is among the 25% of lake in the state farthest from an undisturbed condition, but in the Driftless Region is closer to an undisturbed condition than the average lake in the region. Past drawdowns and run-off from the watershed are likely the major disturbances in Sidie Hollow Lake.

Changes 1994-2005

The Coefficient of Community Similarity for Sidie Hollow Lake 1995 – 2004 indicates that the two communities are not significantly different. But there were some changes in various parameters between 1994 and 2005.

1) Decreased frequency and density of the exotic species, *Potamogeton crispus.*
2) Increased frequency and density of the dominant species.
3) Increased occurrence of filamentous algae.
4) Decrease in the number of species recorded and Species Richness.
5) Decrease in Diversity Index from good diversity in 1994 to fair diversity in 2005.
6) Increase in the percent occurrence of free-floating species
7) Decrease in the percentage of sites with emergent and submergent vegetation
8) Decrease in the Floristic Quality Index
9) Increase in the Average Coefficient of Conservatism

Shoreline Impacts

Sidie Hollow Lake has good protection by native shoreline buffers, woods, shrub and herbaceous growth. Mowed areas were commonly occurring and covered 18% of the shore. Mowed areas do not filter run-off to the lake as well as natural vegetation and can carry fertilizers, pesticides and pet wastes into the water if these are used on the lawns. Preserving this natural shoreline is critical to maintaining fish and wildlife habitat in the lake and for preserving water quality in the lake.

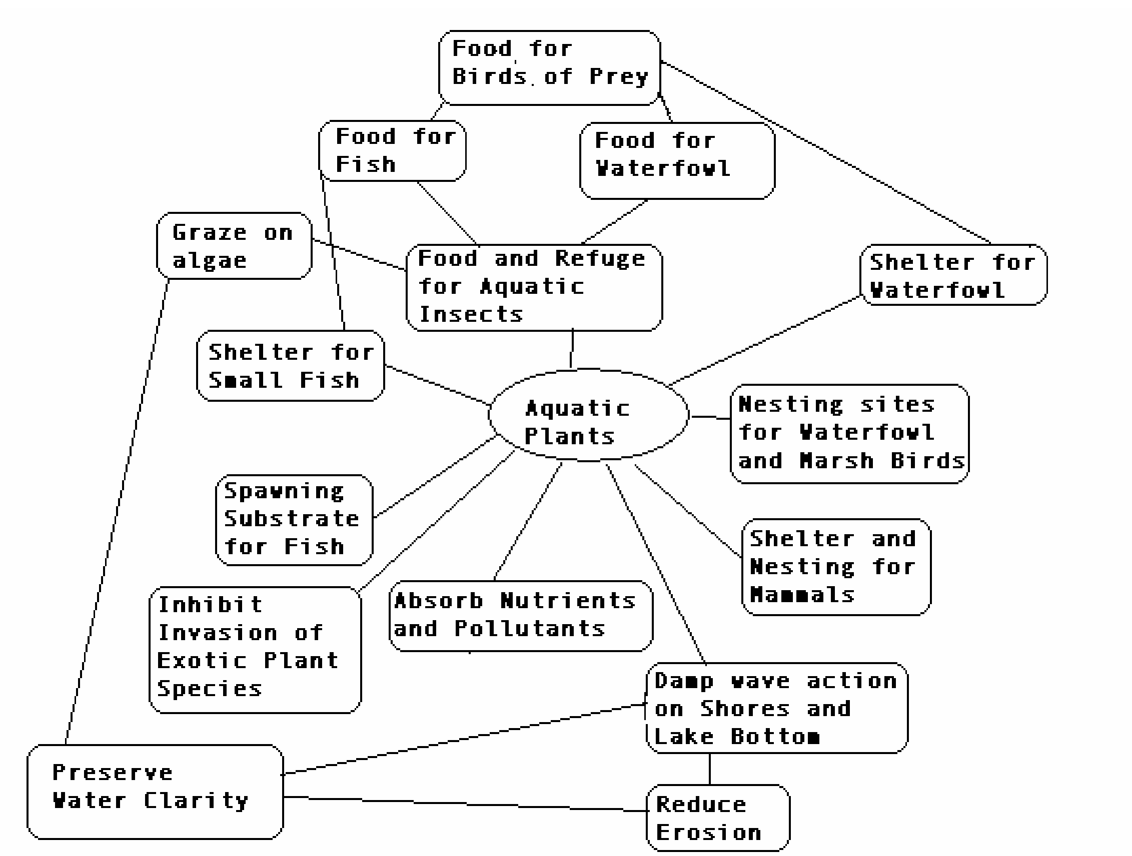
VI. CONCLUSIONS

Sidie Hollow Lake is a 38-acre mesotrophic impoundment with very good water clarity and good water quality. Filamentous algae has increased since 1994.

Aquatic plant growth is distributed throughout Sidie Hollow Lake, at nearly all of the sample sites and over 66% of the lake, to a maximum rooting depth of 15 feet. The 0-1.5ft depth zone supports the greatest amount plant growth. The plant community is characterized by fair diversity of plant species, an above average quality of the plant community for Wisconsin lakes, a very high quality for Driftless Region lakes, a high tolerance to disturbance and a disturbed condition.

Ceratophyllum demersum was the dominant species and *Eleodea canadensis* was sub-dominant, both occurring at more than three-quarters of the sites and growing at above average density. *Potamogeton crispus*, a non-native aquatic plant species, occurred at a low frequency and density in Sidie Hollow Lake.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in
1) improving water quality 2) providing valuable habitat resources for fish and wildlife 3) resisting invasions of non-native species and 4) checking excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.



Aquatic plant communities improve water quality in many ways:

- Plants trap nutrients, debris, and pollutants entering a water body;
- Plants absorb and break down some pollutants;
- Plants reduce erosion by damping wave action and stabilizing shorelines and lake bottoms;
- Aquatic plants remove nutrients that would otherwise be available for algae growth (Engel 1985).

Aquatic plant communities provide important fishery and wildlife resources. Plants and algae start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 8). Plant cover within the littoral zone of Sidie Hollow Lake is 54% and is appropriate (25-85%) to support a balanced fishery.

Compared to non-vegetated lake bottoms, plant beds support larger, more diverse invertebrate populations that in turn will support larger and more diverse fish and wildlife populations (Engel 1985). Additionally, mixed stands of aquatic plants support 3-8 times as many invertebrates and fish as monocultural stands (Engel 1990). Diversity in the plant community creates more microhabitats for the preferences of more species. Aquatic plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Management Recommendations

1) DNR and County Park work with efforts in the watershed to reduce nutrient input to Sidie Hollow Lake.
2) County park and visitors practice best management on their lake properties.
    a) Keep septic systems cleaned and in proper condition.
    b) Use no lawn fertilizers
    c) Clean up pet wastes.
    d) Do not compost near the water or allow yard wastes and clippings to enter the lake.
3) County Park protect the natural shoreline around Sidie Hollow Lake. Most of the shoreline of Sidie Hollow Lake was protected by native plant growth, woods, shrub and herbaceous growth. Disturbed shoreline does occur (mowed areas) and these should be managed to maintain buffers and ensure these areas do no add nutrients to the lake.
4) Visitors protect the aquatic plant community in Sidie Hollow Lake. The standing-water emergent community, floating-leaf community and submergent plant community are all important for fish and wildlife habitat and water quality protection. This diverse aquatic plant community will support a diverse fish and wildlife community.

Table 8. Wildlife and Fish Uses of Aquatic Plants in Sidie Hollow Lake

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
Submergent Plants							
Ceratophyllum demersum	F,I*, C, S	F(Seeds*), I, C			F		
Chara sp.	F*, S	F*, I*					
Elodea canadensis	C, F, I	F(Foliage) I					
Najas flexilis	F, C	F*(Seeds, Foliage)	F(Seeds)				
Potamogeton crispus	F, C, S	F(Seeds, Tubers)					
Potamogeton pectinatus	F, I, S*,C	F*			F*	F	F
Potamogeton pusillus	F, I, S*,C	F*(All)			F*	F	F
Ranunculus longirostris	F	F(Seeds, Foliage)		F			
Zosterella dubia	F, C, S	F(Seeds)					
Floating-leaf Plants							
Lemna minor	F	F*, I	F	F	F	F	
Wolffia columbiana		F			F		

Aquatic Plants	**Fish**	**Water Fowl**	**Song and Shore Birds**	**Upland Game Birds**	**Muskrat**	**Beaver**	**Deer**
<u>Emergent Plants</u>							
Carex spp.	S*	F*(Seeds), C	F*(Seeds)	F*(Seeds)	F	F	F
Sagittaria latifolia		F, C	F(Seeds), C	F	F	F	
Scirpus validus	F, C, I	F (Seeds)*, C	F(Seeds, Tubers), C	F (Seeds)	F	F	F
Typha latifolia	I, C, S	F(Entire), C	F(Seeds), C, Nest	Nest	F* (Entire), C*, Lodge	F	

F=Food, I= Shelters Invertbrates, a valuble food source C=Cover, S=Spawning
***=Valuable Resource in this category**

*Current knowledge as to plant use. Other plants may have uses that have not been determined.

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