The Aquatic Plant Community of Rock Lake, Chippewa County, Wisconsin 2006


Submitted by:

Deborah Konkel
Wisconsin Department of Natural Resources
Eau Claire, WI
March 2007

Executive Summary

Rock Lake is a mesotrophic lake with poor water clarity and fair water quality. Filamentous algae was very abundant in the Rock Lake, especially in the shallowest zone.

The aquatic plant community colonized nearly all of the littoral zone and more than one-third of the total lake area, to a maximum depth of 13 feet. The 0-5 ft. depth zone supported the most abundant aquatic plant growth. The aquatic plant community in Rock Lake is characterized by average quality, very good species diversity, an average tolerance to disturbance and a condition close to an undisturbed condition.

Ceratophyllum demersum (coontail) was the dominant species within the plant community, especially in the 1.5-20ft depth zones, occurring at more than three-quarters of the sample sites and exhibiting a dense growth form. *Nymphaea odorata* (white water lily) was sub-dominant, occurring at nearly half of the sites.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in 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 out-compete sensitive species, thus reducing diversity.

Management Recommendations

1) Lake property owners preserve the natural shoreline cover that is found around Rock Lake. Wooded cover, shrubs and native herbaceous growth protected 94% of the shoreline, but even the limited amount of disturbance appears to be impacting the lake. Analyses indicate that disturbance has impacted the aquatic plant community; this disturbance is impacting the quality of the aquatic plant community and the disturbance is impacting the habitat potential.
2) Lakes residents use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake. Nutrient enrichment is likely increasing filamentous algae growth and determining aquatic plant growth.
3) Lake residents begin monitoring the water quality through the Self-Help Volunteer Lake Monitoring Program.
4) DNR to designate sensitive areas within Rock Lake.
5) DNR and lake residents maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Rock Lake.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

The Aquatic Plant Community in Rock Lake, Chippewa County 2006

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Rock Lake was conducted during July 2006 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR). This was the first quantitative vegetation study of Rock Lake by the 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 in the lake ecosystem 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 and impact recreation.

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 wildlife areas, aquatic plant management and water resource regulations. The baseline data that it provides will be compared to future plant inventories and offer insight into any changes occurring in the lake.

Background and History: Rock Lake is a 94-acre drainage lake in northern Chippewa County, Wisconsin. Rock Lake has a maximum depth of 35 feet. The lake receives inflow from O'Neill Creek, drainage from Mud Lake and two other streams. Water flows out into O'Neill Creek.

In 1968, an aquatic herbicide treatment was conducted on 0.10 acres, along the north shore with 25 pounds of Aquathol +.

II.METHODS

Field Methods

The 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 16 equal segments and a transect, perpendicular to the shoreline, was randomly placed within each segment (Appendix IV), using a random numbers table.

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, taken from each quarter of a 6-foot diameter 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 each sampling site.

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

Visual inspection and periodic samples were taken between transect lines 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).

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on each side of the transect intercept with the shore and 30 feet deep was evaluated. The percentage of each shore cover type within this 100' x 30' rectangle was visually estimated and verified by a second researcher.

Data Analysis

The percent frequency of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendix I). Relative frequency was calculated (number of occurrences of a species/total occurrence of all species) (Appendix I). The mean density was calculated for each species (sum of a species' density ratings/number of sampling sites) (Appendix II). Relative density was calculated (sum of a species density/total plant density). A "mean density where present" was calculated for each species (sum of a species' density ratings/number of sampling sites at which that species occurred) (Appendix II). The relative frequency and relative density of each species are summed to obtain a dominance value for each species (Appendix III). Species diversity was measured by calculating Simpson's Diversity Index $1-(\sum(\text{Relative Frequency}^2))$ (Appendix I).

The Aquatic Macrophyte Community Index (AMCI) developed for Wisconsin Lakes by Nichols (2000) was applied to Rock Lake (Table 5) to quantify the quality of the plant community. Values between 0 and 10 are given for each of seven categories that characterize a plant community and summed.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated, as outlined by Nichols (1998), to determine disturbance in the plant community. A coefficient of conservatism is an assigned value, 0-10, the probability that a species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the Coefficients for all species found in the lake. The Floristic Quality Index is calculated from the Average Coefficient of Conservatism (Nichols 1998) and is a measure of a plant community's closeness to an undisturbed condition.

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, hardness and clarity) 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 an indication of its water quality. Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine the trophic state.
Eutrophic lakes are high in nutrients and 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.

Nutrients

Phosphorus is a limiting nutrient in most Wisconsin lakes and is measured as an indication of the nutrients in a lake. Increases in phosphorus in a lake can feed algae blooms and, occasionally, excess plant growth.
1995 Summer Mean Phosphorus in Rock Lake was 29.67ug/l.
This concentration of phosphorus is indicative of a mesotrophic lake (Table 1).

Table 1. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll a ug/l	Secchi disc ft.
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
Rock Lake – 1995	**Fair**	**29.67**	**20.51**	**5.6 ft.**

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

Algae

Chlorophyll a concentrations measure the amount of algae in lake water. Algae are natural and essential in lakes, but high algae populations can increase turbidity and reduce the light available for plant growth.
1995 Summer Mean Chlorophyll a concentration in Rock Lake was 20.51ug/l.

This concentration of chlorophyll is indicative of a eutrophic lake (Table 1) .

Filamentous algae was found at 56% of the sample site in Rock Lake, more frequent in the shallower zones of the lake (Figure 1).

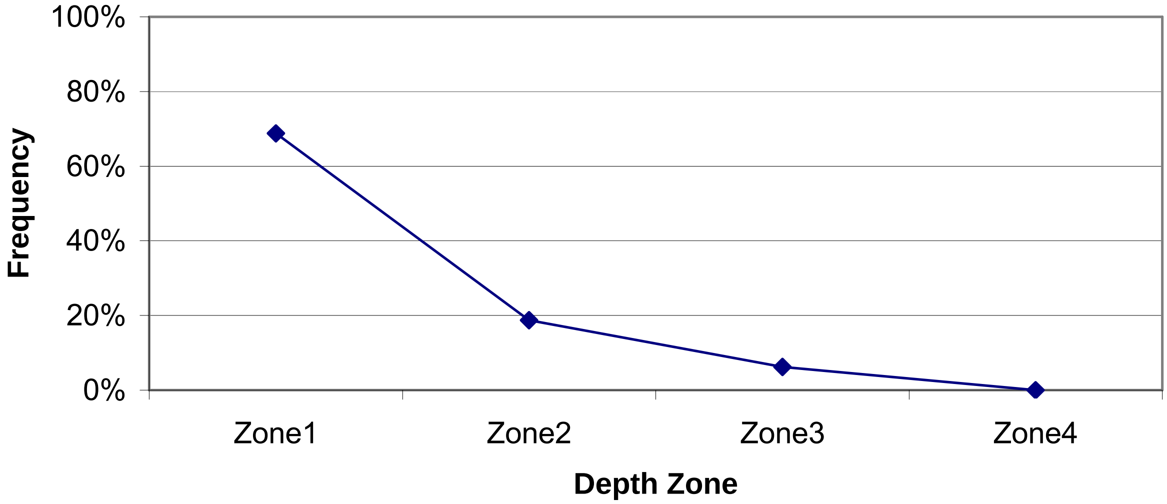


Figure 1. Occurrence of filamentous algae in Rock Lake, by depth zone.

Water Clarity

Water clarity is a critical factor for plants. When 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 which shows the combined impacts.

1995 Summer Mean Secchi Disc water clarity in Rock Lake was 5.6 ft.

Water clarity indicates (Table 1) that Rock Lake was a mesotrophic lake with poor water clarity.

Satellite data can be used to estimate water clarity. Satellite image data suggests that water clarity has increased slightly since 1995 (Figure 2).

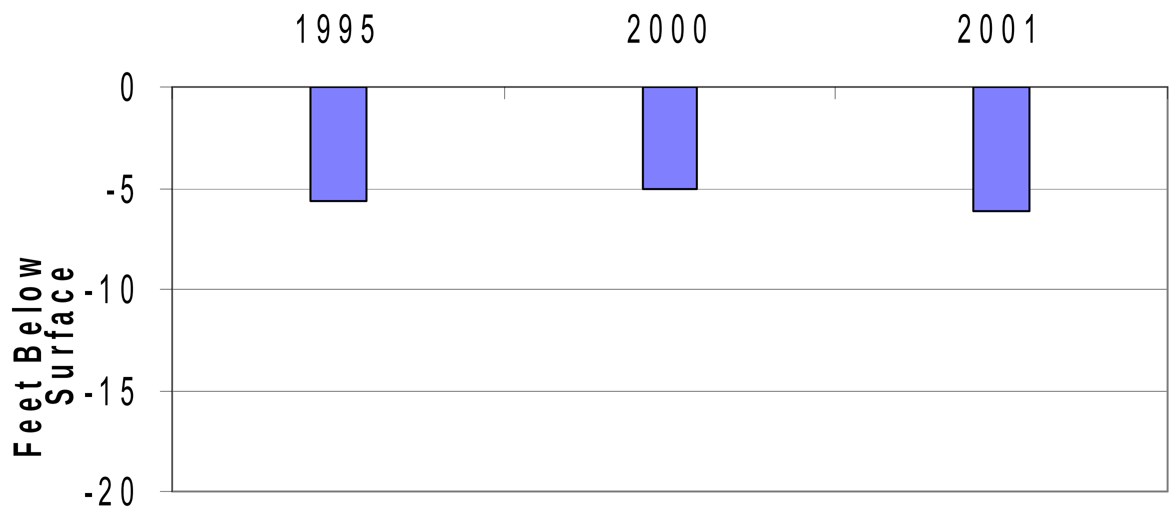


Figure 2. Change in water clarity as measured by satellite images, 2000-2001.

The combination of phosphorus, chlorophyll and water clarity data suggest that Rock Lake is a mesotrophic lake with fair water quality. This trophic state would favor adequate plant growth and occasional algae blooms.

Alkalinity

1995 alkalinity of Rock Lake was 82mg/l $CaCO_3$.

Lakes with an alkalinity between 61-120mg/l $CaCO_3$ are considered moderately hard. Hard water lakes tend to support more aquatic plant growth than soft water lakes (Shaw et. al. 1993).

LAKE MORPHOMETRY - The morphometry of a lake is an important factor in 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).

Rock Lake has an oval basin and a moderately-sloped littoral zone over most of the lake, except the south shore has a more gradually-sloped littoral zone (Appendix IV). Gradual slopes provide a more stable substrate for rooting and a broad band of water shallow enough for plant growth. This means the Rock Lake will tend to have a thin band of vegetation, except for the south shore, which will have a broader band of plant growth.

SEDIMENT COMPOSITION – Peat sediment was the dominant sediment in Rock Lake, dominating all depth zones (Table 2). A mixture of sand and silt was common in the 0-1.5ft depth zone and silt and rock mixture was common in the 1.5-5ft depth zone (Figure 3).

Table 2. Sediment Composition, 2006

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Soft Sediment	Peat	46%	40%	44%	50%	45%
	Silt/Peat		7%	19%	12%	10%
	Silt		13%	6%	19%	10%
	Muck			6%		2%
Mixed Sediment	Silt/Rock	13%	27%			10%
	Sand/Silt	20%	7%		6%	8%
	Rock/Peat			6%		2%
Hard Sediment	Sand/Rock	13%	7%	6%		6%
	Rock			13%	6%	5%
	Sand/Gravel	7%				2%
	Sand				6%	2%

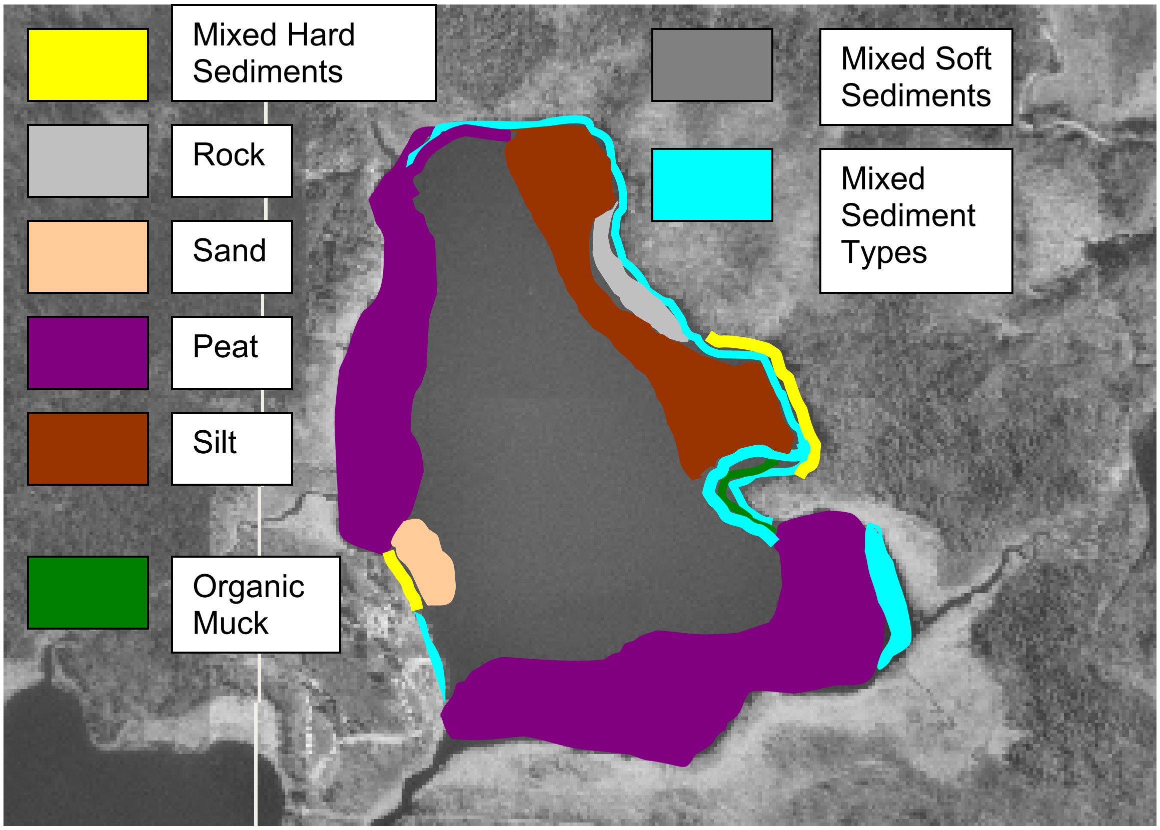


Figure 3. Sediment distribution in Rock Lake, 2006.

INFLUENCE OF SEDIMENT - Some 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 plant species that can survive in a location.

Silt sediments are intermediate density sediments and considered most favorable for plant growth because of their intermediate density. The availability of mineral nutrients for growth is highest in sediments of intermediate density (Barko and Smart 1986). Silt occurred in Rock Lake but was not commonly-occurring overall in the lake. In combination with sand or rock, however, silt was common in the shallowest zones. Peat was the dominant sediment in Rock Lake and can be limiting to plant growth due to it flocculent nature. All sediment types though, supported abundant vegetation in Rock Lake.

SHORELINE LAND USE – Land use can strongly impact the aquatic plant community and therefore the entire aquatic community. Land use can directly impact the plant community by increased erosion and sedimentation and increased run-off of nutrients, fertilizers and toxics applied to the land. These impacts occur in both rural and residential settings.

Herbaceous growth was the most frequently encountered shoreline cover at the transects and wooded cover had the highest mean coverage. The occurrence and cover of shrub was also high (Table 3). Hard structure was also commonly occurring and can be problematic because it allows faster run-off to the lake and does not filter the run-off.

Some type of natural shoreline occurred at all sites and covered approximately 94% of the shore. Disturbed shoreline (hard structure, mowed lawn, eroded) was found at 25% of the sites and covered 6% of the shore (Table 3).

Table 3. Shoreline Land Use, 2006

Cover Type		**Frequency of Occurrences at Transects**	**Mean % Coverage**
Natural Shoreline	Wooded	68%	47%
	Shrub	81%	24%
	Native Herbaceous	88%	23%
Total Natural			94%
Disturbed Shoreline	Hard Structure	25%	3%
	Mowed Lawn	6%	2%
	Eroded	6%	1%
Total Disturbed			6%

MACROPHYTE DATA
SPECIES PRESENT

Of the 29 aquatic plant species found in Rock Lake, 10 were emergent species, 6 were floating-leaf species and 13 were submergent species (Table 4).
No threatened or endangered species were found in the survey. One non-native species was found: *Potamogeton crispus,* curly-leaf pondweed.

Table 4. Rock Lake Aquatic Plant Species, 2006

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Acorus calamus* L.	sweet flag	acoca
2) *Bidens frondosus* L.	beggar's tick	bidfr
3) *Carex* spp.	sedge	carsp
4) *Leersia oryzoides* (L.) Swartz.	rice cut-grass	leeor
5) *Ludwigia palustris* (L.) Elliott	common water purslane	ludpa
6) *Oncolea sensibilis* L.	sensitive fern	onose
7) *Pontederia cordata* L.	pickerelweed	ponco
8) *Sagittaria* spp.	arrowhead	sagsp
9) *Scirpus validus* Vahl.	softstem bulrush	sciva
10) *Sparganium* spp.	bur-reed	spasp
Floating-leaf Species		
11) *Lemna minor* L.	small duckweed	lemmi
12) *Lemna trisulca* L.	forked duckweed	lemtr
13) *Nuphar variegata* Durand.	bull-head pond lily	nupva
14) *Nymphaea odorata* Aiton.	white water lily	nymod
15) *Spirodela polyrhiza* (L.) Schleiden.	great duckweed	spipo
16) *Wolffia columbiana* Karst.	water-meal	wolco
Submergent Species		
17) *Ceratophyllum demersum* L.	coontail	cerde
18) *Elodea canadensis* Michx.	common waterweed	eloca
19) *Myriophyllum heterophyllum* Michx.	variable-leaf water-milfoil	myrhe
20) *Myriophyllum sibiricum* Komarov.	common water milfoil	myrsi
21) *Najas flexilis* (Willd.) Rostkov & Schmidt.	slender naiad	najfl
22) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed	potam
23) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
24) *Potamogeton praelongus* Wulf.	white-stem pondweed	potpr
25) *Potamogeton pusillus* L.	small pondweed	potpu
26) *Potamogeton robbinsii* Oakes.	fern pondweed	potro
27) *Potamogeton zosteriformis* Fern.	flatstem pondweed	potzo
28) *Vallisneria americana* L.	water celery	valam
29) *Zosterella dubia* (Jacq.) Small	water stargrass	zosdu

FREQUENCY OF OCCURRENCE

Ceratophyllum demersum (coontail) was the most frequently occurring species in Rock Lake in 2006, (83% of sample sites) (Figure 4). *Nuphar variegata, Nymphaea odorata, Potamogeton pusillus* and *P. zosteriformis* were commonly occurring species, (33%, 45%, 38%, 38%) (Figure 4).

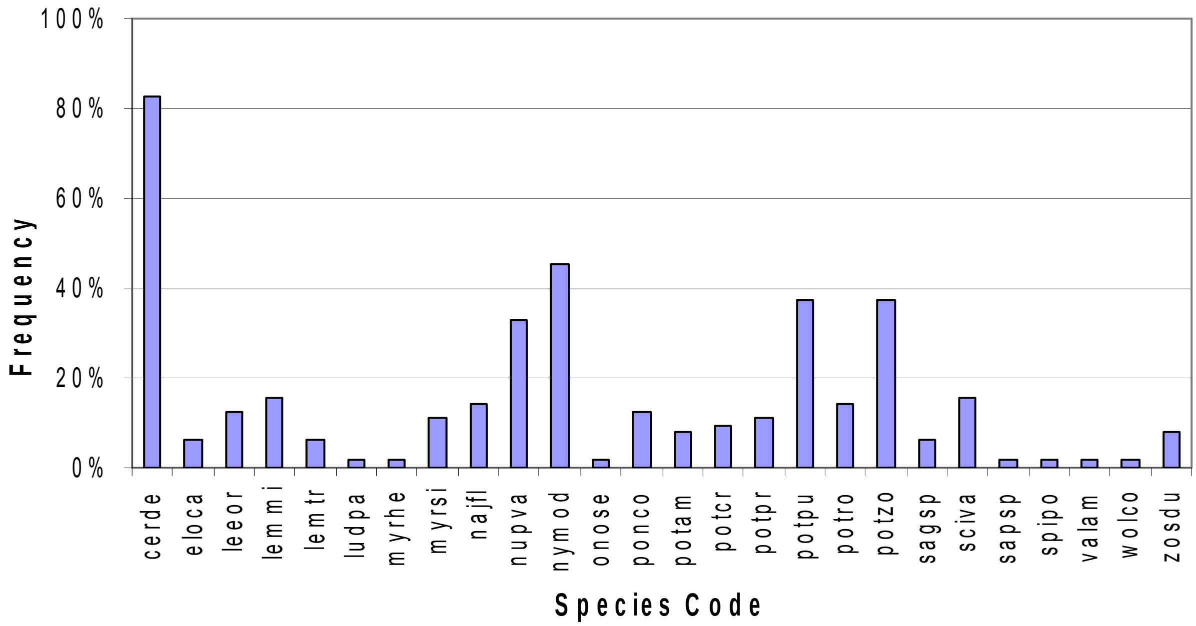


Figure 4. Frequency of aquatic plant species in Rock Lake, 2006.

DENSITY

Ceratophyllum demersum (coontail) was also the species with the highest mean density (2.97 on a density scale of 0-4) in Rock Lake (Figure 5). All other species were found at low mean densities in Rock Lake.

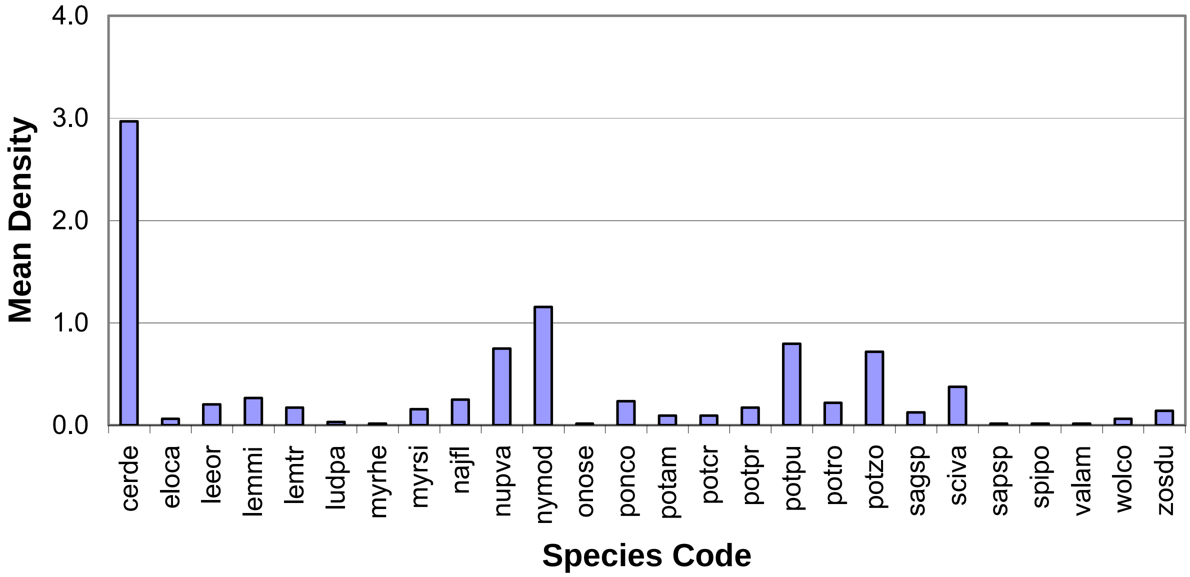


Figure 5. Densities of aquatic plant species in Rock Lake, 2006.

Ceratophyllum demersum (coontail) had a "mean density where present" of 3.58 (Figure 6). Its "mean density where present" indicates that *C. demersum* exhibited a dense growth form in Rock Lake (Appendix II). *Wolffia columbiana* (common watermeal) had a "mean density where present" of 4.0, indicating it also exhibited an aggregated or dense growth form (Figure 6). However, *W. columbiana* occurred in limited locations in Rock Lake.

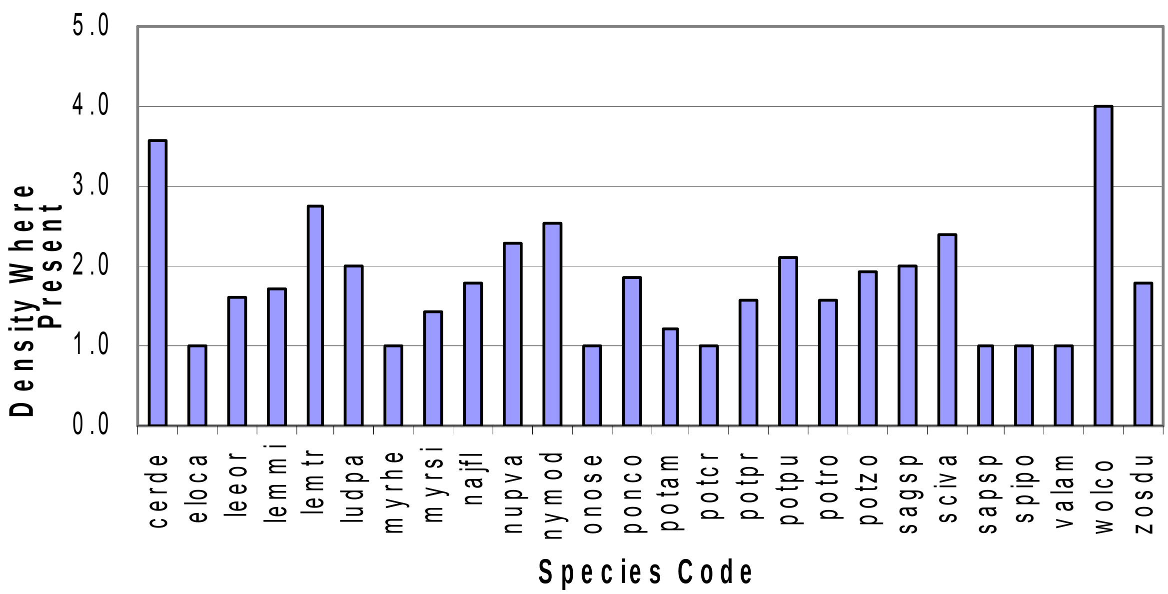


Figure 6. "Density where present", density of growth form in Rock Lake, 2006.

DOMINANCE

Combining the relative frequency and relative density of a species into a Dominance Value illustrates how dominant a species is within the plant community (Appendix III). Based on the Dominance Value, *Ceratophyllum demersum* (coontail) was the dominant aquatic plant species in Rock Lake (Figure 7). *Nymphaea odorata* (white water lily) was sub-dominant.

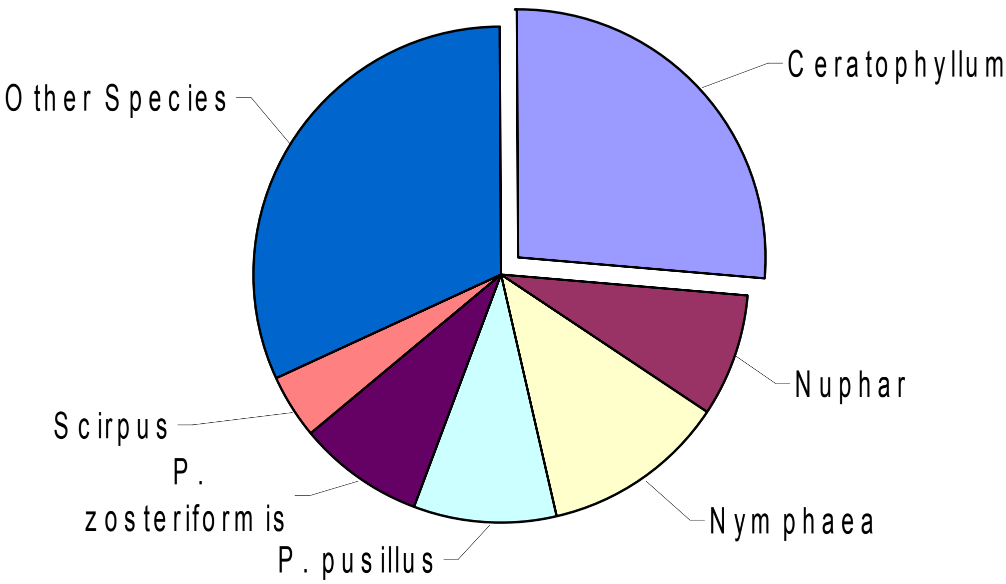


Figure 7. Dominance within the plant community, of the most prevalent aquatic plant species in Rock Lake, 2006.

Ceratophyllum demersum, the dominant species, dominated the 1.5-20ft depth zones and occurred at its highest frequency and density the 1.5-5ft depth zone (Appendices I, II) (Figure 8, 9). *Nymphaea odorata*, the sub-dominant species, was the most frequently occurring species in the 0-1.5ft depth zone, occurring at its highest frequency and density in the 0-5ft depth zone (Figure 8, 9).

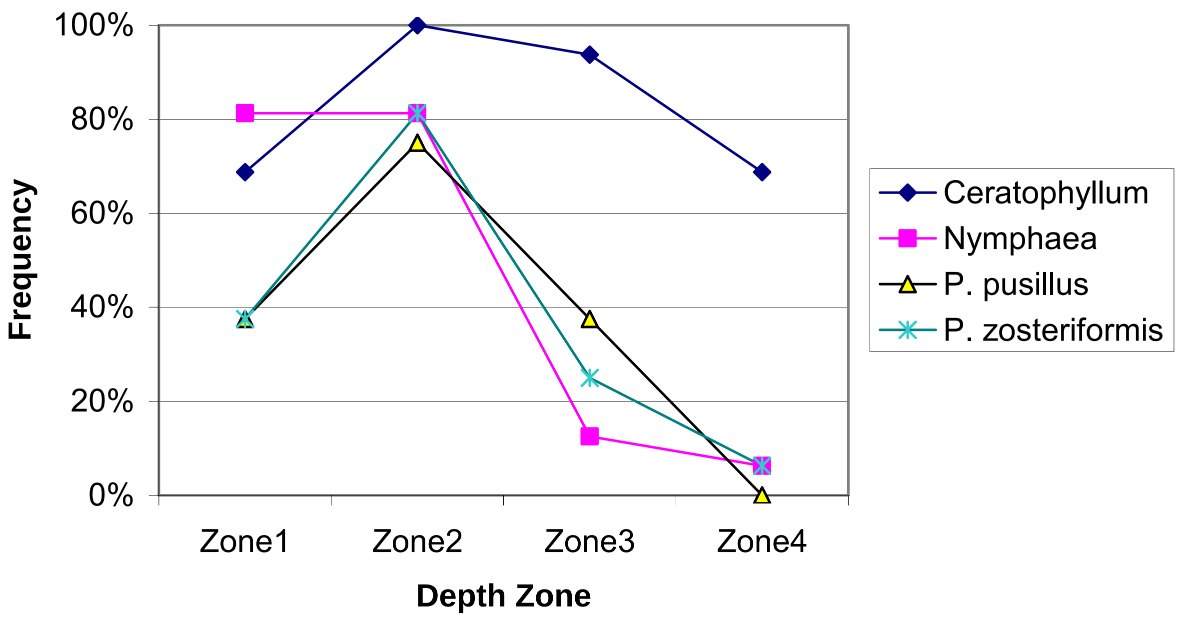


Figure 8. Frequency of most prevalent species in Rock Lake, by depth, 2006.

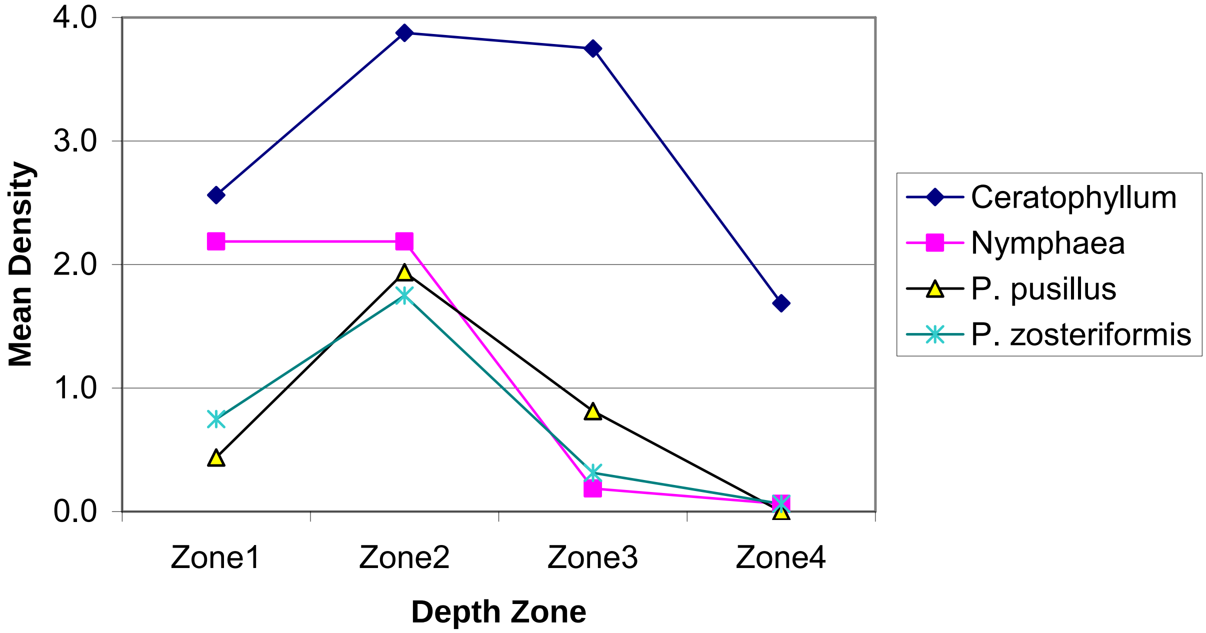


Figure 9. Density of the most prevalent plant species, by depth zone.

DISTRIBUTION

Aquatic plants occurred throughout the littoral zone of Rock Lake to a maximum rooting depth of 13 feet. *Ceratophyllum demersum* (coontail) and *Myriophyllum sibiricum* (northern watermilfoil) were found at the maximum rooting depth.

Vegetation colonized 91% of the littoral zone, 37% of the lake surface (35 acres). In 2006, approximately 35 acres (37% of the lake surface, 91% of the littoral zone) was vegetated with rooted submergent vegetation. Floating-leaf vegetation colonized about 17 acres (18% of the lake surface, 45% of the littoral zone) and emergent vegetation colonized about 2 acre (2% of the lake surface, 22% of the littoral zone) (Figure 10). Free-floating species colonized 66% of the littoral zone.

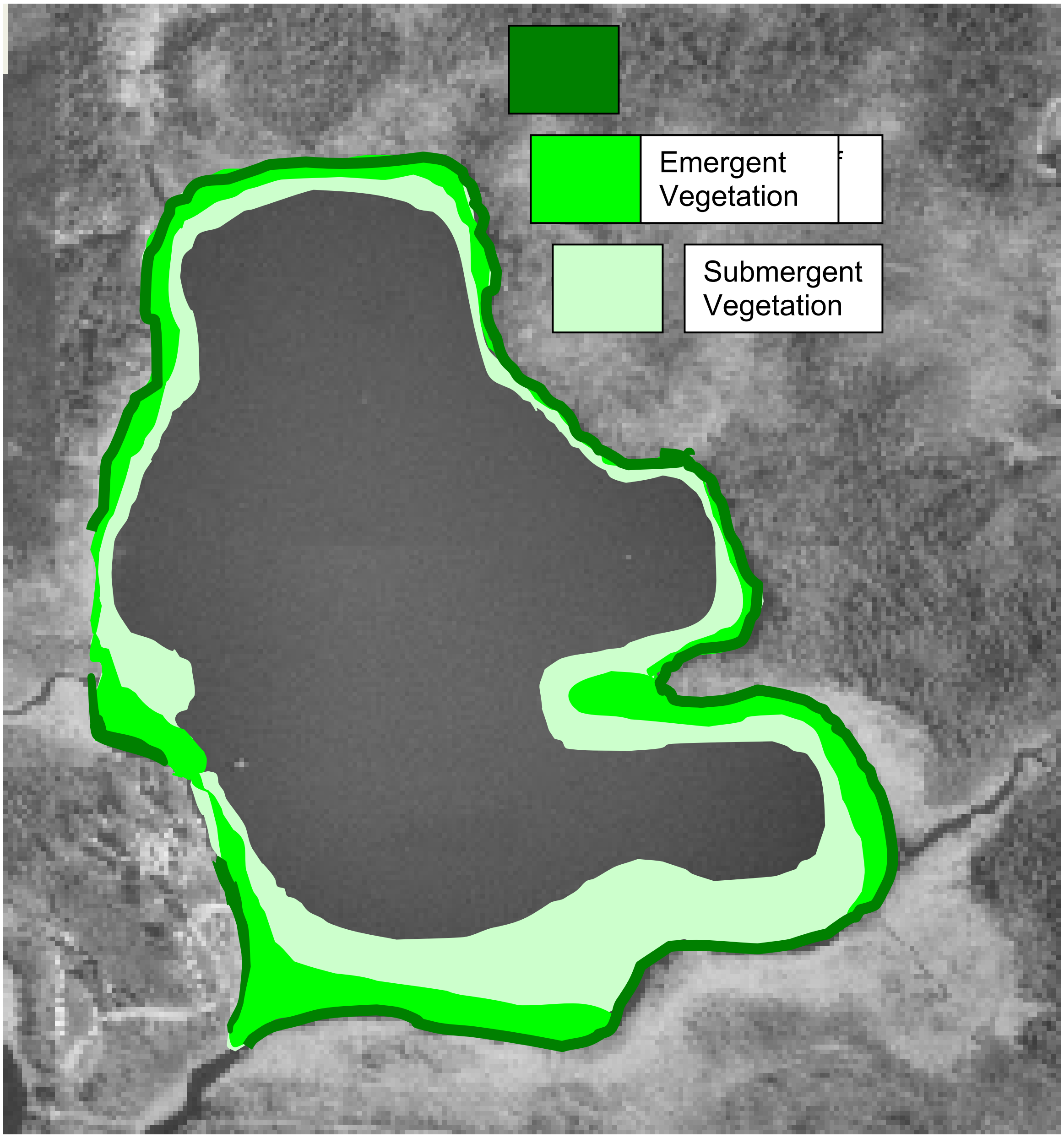


Figure 10. Distribution of aquatic plants in Rock Lake, Chippewa County, 2006.

The dominant and common species in Rock Lake were found distributed throughout the littoral zone, except *Nuphar variegata* (yellow pond lily) and *Potamogeton pusillus* (small pondweed) were not found along the south shore.

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

Based on the 1995 Summer Mean Sechi disc water clarity (5.6ft), the predicted maximum rooting depth in Rock Lake would be 9.5 ft.

The maximum rooting depth of 13 feet is greater than the predicted maximum rooting depth based on water clarity. This may be due to either using clarity data from a different year than the plant study was conducted or plant growth starting early in the year when clarity tends to be greater.

The highest total occurrence of plants was in the 0-1.5ft depth zone and the greatest total density of plant growth was in the 1.5-5ft depth zone (Figure 11).

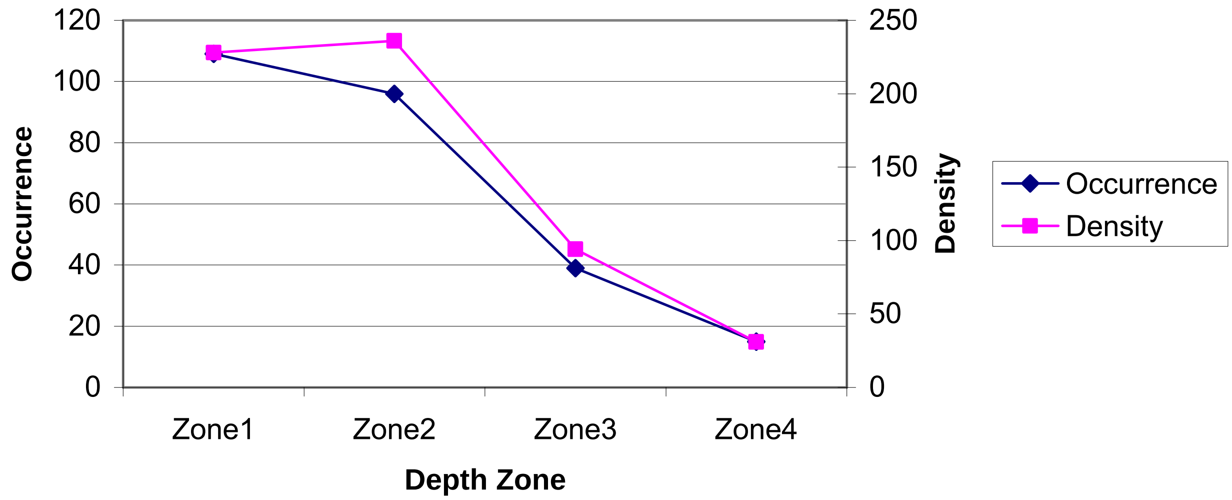


Figure 11. Total occurrence and total density of aquatic plants by depth zone in Rock Lake, 2006.

The highest percent colonization of the littoral zone was in the 0-5ft depth zone and the greatest species richness (mean number of species per site) were recorded in the 0-1.5ft depth zone, both declining with increasing depth (Figure 12). Overall Species Richness in Rock Lake was 4.04.

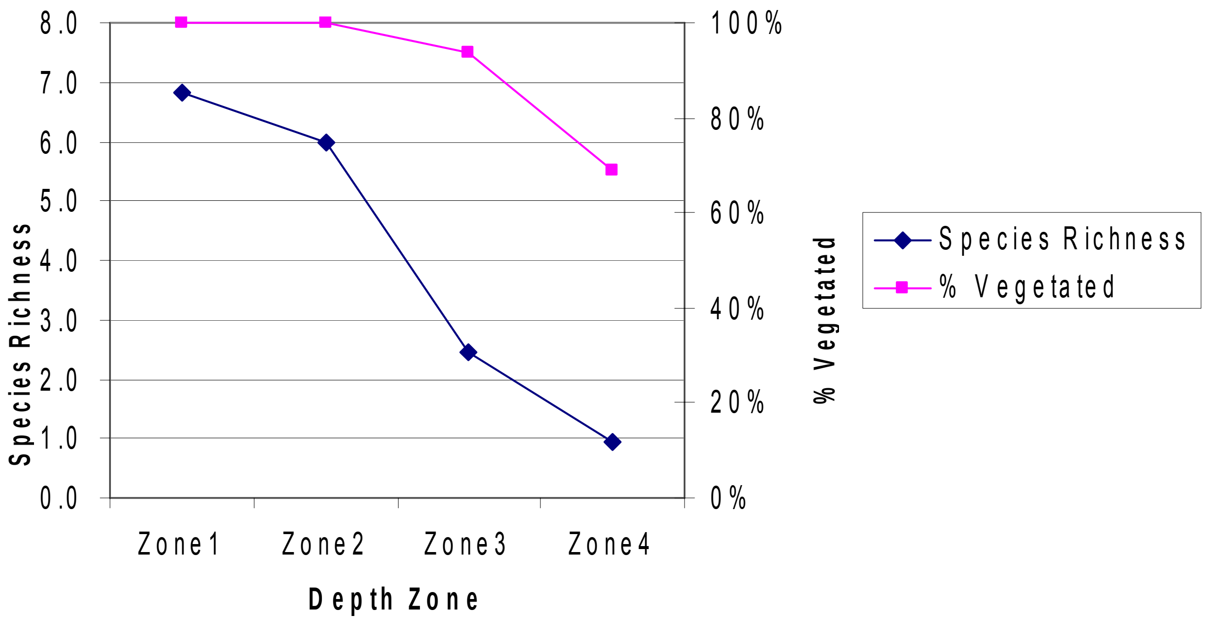


Figure 12. Percent of the littoral zone vegetated and Species Richness (mean number of species per sample site) by depth zone in Rock Lake, 2006.

THE COMMUNITY

Simpson's Diversity Index was 0.91, indicating very good species diversity. A rating of 1.0 would mean that each plant in the lake would be a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) for Rock Lake (Table 5) is 52, indicating an average quality plant community. This value places Rock Lake above average for lakes in Wisconsin and below average for North Central Hardwood Region lakes as far as quality of the aquatic plant community.

Table 5. Aquatic Macrophyte Community Index: Rock Lake 2006

Category		Value
Maximum Rooting Depth	3.96 meters	7
% Littoral Zone Vegetated	91%	10
% Submergent Species	41% Rel. Freq.	2
# of Species	29	10
% Exotic species	2%	6
Simpson's Diversity	0.91	9
% Sensitive Species	20% Relative Freq.	8
Totals		52

The highest value for this index is 70.

The Average Coefficient of Conservatism for Rock Lake was in the lowest quartile for lakes in Wisconsin and below average for North Central Hardwood Region lakes (Table 6). This suggests that the aquatic plant community in Rock Lake within the group of lakes in the state most tolerant of disturbance and with an above average tolerance to disturbance compared to lakes in the region. This is likely due to past disturbances.

Table 6. Floristic Quality and Coefficient of Conservatism of Rock Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes *	5.5, 6.0, 6.9	16.9, 22.2, 27.5
NCH Region *	5.2, 5.6, 5.8	17.0, 20.9, 24.4
Rock Lake 2006	5.38	28.99

* - 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 of the plant community in Rock Lake is in the upper quartile for lakes in the North Central Hardwood Lakes Region and Wisconsin lakes (Table 6). This suggests that the plant community in Rock Lake is within the group of lakes in the state and region closest to an undisturbed condition.

Disturbances can be of many types:

1) Direct 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 from wave action and boat traffic, sedimentation from erosion and increased algae growth due to nutrient inputs.
3) Biological disturbances include the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by the fish population.

Disturbance in Rock Lake is likely limited to shoreline development or past logging near the shore.

IV. DISCUSSION

Rock Lake is a 94-acre lake with a maximum depth of 35 feet. Based on 1995 water quality data, Rock Lake is a mesotrophic lake with poor water clarity and fair water quality. Filamentous algae occurred at 56% of sample sites, 69% of the sites in the 0-1.5ft depth zone.

The adequate nutrients (trophic state), moderately-to-gradually sloped littoral zone and moderately hard water in Rock Lake would favor plant growth. The poor water clarity and dominance of flocculent peat sediments in Rock Lake may limit plant growth. Herbicides were used one year in an attempt to reduce aquatic plant growth.

Aquatic plants colonized 91% of the littoral zone (37% of the lake surface), to a maximum depth of 13 feet. The greatest amount of plant growth occurred in the shallowest depth zones, 0-5ft. The highest total occurrence of plants, highest total density of plants, highest percent colonization of vegetation and the greatest species richness occurred in the 0-5ft depth zone.

Twenty-nine (29) aquatic plant species were recorded in Rock Lake. *Ceratophyllum demersum* (coontail) was the dominant plant species in Rock Lake, especially in the 1.5-20ft depth zones, occurring at more than three-quarters of the sample sites and exhibiting a dense growth form. *Nymphaea odorata* (white water lily) was sub-dominant in Rock Lake, occurring at nearly one-half of the sites. Half of the floating-leaf species and more than half of the submergent species are species known to grow to nuisance conditions with increases in nutrients (Nichols and Vennie 1991). This includes the dominant and sub-dominant species. One non-native species was found in Rock Lake, *Potamogeton crispus* (curly-leaf pondweed), but it was not common in the lake and occurred at low densities.

The Aquatic Macrophyte Community Index (AMCI) for Rock Lake was 52, indicating that Rock Lake’s aquatic plant community is of average quality compared to other Wisconsin lakes and lakes in the North Central Region. The Simpson's Diversity Index (0.91) for Rock Lake indicates that the aquatic plant community had very good diversity of species. Species Richness was 4.04 species per sample site.

The Average Coefficient of Conservatism suggests that Rock Lake is tolerant of disturbance. It is within the group of in Wisconsin most tolerant of disturbance and an above average tolerance compared to lakes in the North Central Hardwoods Region. The Floristic Quality Index shows Rock Lake to be within he group of lakes in the state and region closest to an undisturbed condition.

Rock Lake is protected by natural shoreline cover (wooded, shrub, native herbaceous growth) at 94% of the shore; all natural cover types were commonly occurring. Disturbed shoreline however, was common, especially hard structures. Hard structure speeds run-off to the lake and does not filter the run-off. Disturbed shore covered 6% of the shore. Preserving this natural shoreline is critical to maintaining water quality and wildlife habitat.

Although the disturbed shore is very limited on Rock Lake, even this limited amount may be having impacts to the lake. To quantify these impacts, transects at shoreline with 100% natural cover were separated from transects that had any amount of disturbed cover and these two sets were analyzed as separate communities (Appendices V-VI). A few measures of the aquatic plant community were different (Table 7).

The Floristic Quality Index measures a plant community's closeness to an undisturbed condition, therefore measuring the impact of disturbance on the community. In Rock Lake, the natural shoreline community Floristic Quality Index was higher than the disturbed shore community, suggesting more disturbance had impacted the disturbed shore community (Table 7). The natural shoreline community was in the upper quartile, within the 25% of lakes in the state and region closest to an undisturbed condition, while the disturbed shoreline community was closer than average to an undisturbed condition.

Another clue to disturbance as a cause is the decreased frequency of sensitive species at disturbed shoreline sites. The combined relative frequency of sensitive aquatic plant species (pickerelweed, large-leaf pondweed, white-stem pondweed and fern-leaf pondweed) was higher at natural shoreline sites than at disturbed shoreline sites (Table 7). Pickerelweed did not occur at disturbed shore sites.

The quality of the aquatic plant community was higher at the natural shoreline community, as measured by the AMCI (Table 7). The natural shoreline community was of below average quality, while the disturbed shore community was of low quality (Table 8).

The natural shoreline community in Rock Lake supported more cover of vegetation and a deeper maximum rooting depth (Table 7). This results in more habitat at natural shore sites. The cover of emergent vegetation, a particularly important component of quality habitat, was higher at natural shoreline sites (Table 7).

Diversity in the aquatic plant community has been impacted by disturbance. Number of species, the Simpson's Diversity Index, Species Richness overall and Species Richness in the shallowest zone (zone in which shoreline disturbance would have the most impact) were all slightly higher at the natural shoreline community (Table 7). Greater diversity in the plant community supports greater diversity in the fish and wildlife community and provides a more stable community.

Table 7. Comparison of the Rock Lake Aquatic Plant Community at Natural and Disturbed Shorelines.

	Natural	**Disturbed**
Floristic Quality Index	28.99	22.50
AMCI (quality of plant community) (Table 8)	49	44
% of Littoral Zone Vegetated	94%	81%
Maximum rooting depth	13 feet	10 feet
Simpson's Diversity Index	0.91	0.89
Number of species	29	17
Species Richness		
Overall	4.125	3.81
0-1.5ft depth zone	7.08	6.0
Cover of emergent vegetation	35%	12%
Relative Frequency of Sensitive Species	12%	8%

Table 8. Comparison of AMCI at Natural vs. Disturbed Shoreline.

Category	Natural Shore Community	Disturbed Shore Community
Maximum Rooting Depth	6	4
% Littoral Zone Vegetated	9	8
% Submergent Species	2	3
# of Species	10	8
% Exotic species	6	6
Simpson's Diversity	9	8
% Sensitive Species	6	5
Totals	49	44

The highest value for this index is 70.

V. CONCLUSIONS

Rock Lake is a mesotrophic lake with poor water clarity and fair water quality based on 1995 water quality data. Filamentous algae was very abundant in the Rock Lake, especially in the shallowest zone.

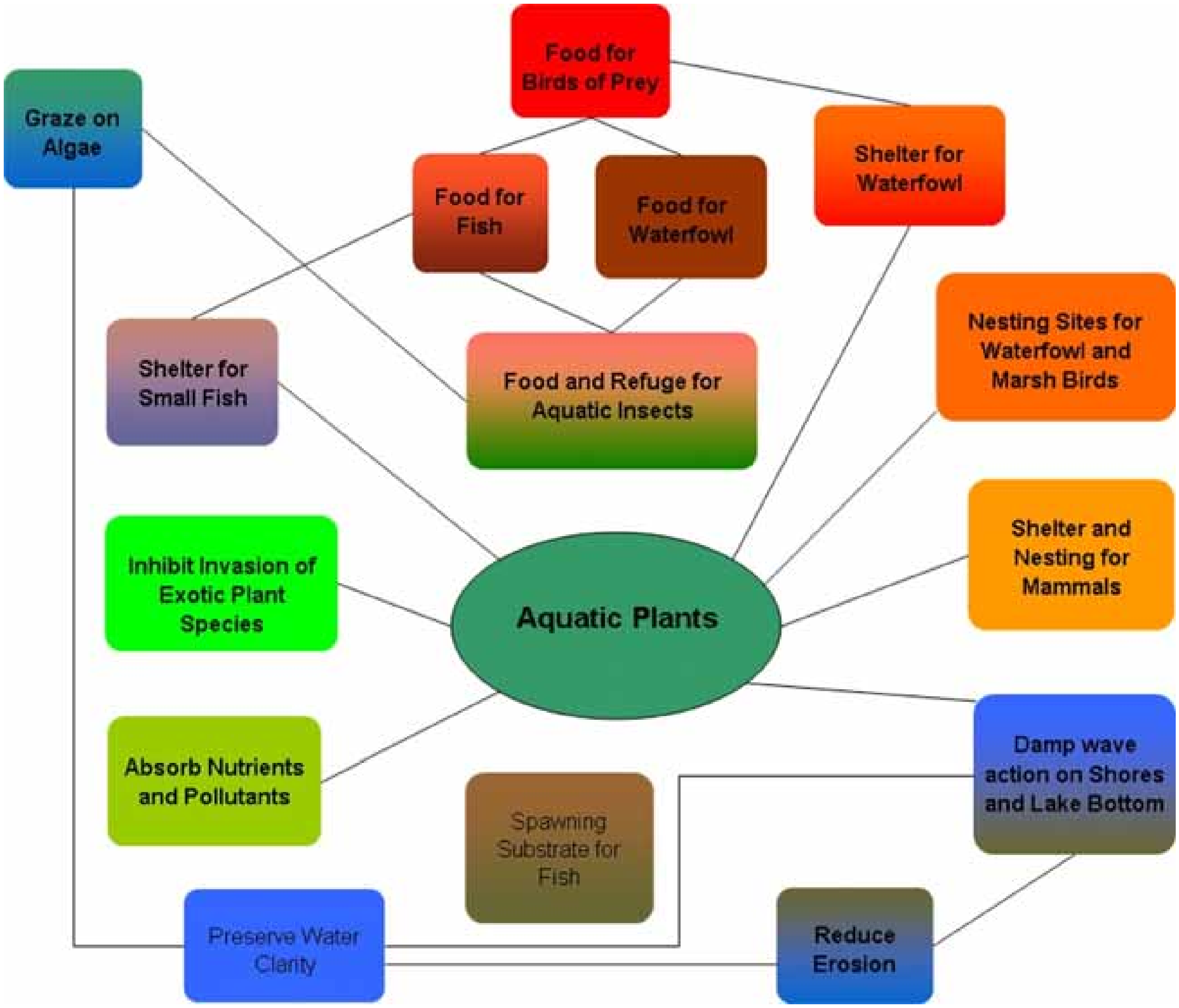
Aquatic plant community colonized nearly all of the littoral zone and more than one-third of the total lake area, to a maximum depth of 13 feet. The 0-5 ft. depth zone supported the most abundant aquatic plant growth.

Twenty-nine (29) aquatic plant species were recorded in Rock Lake. *Ceratophyllum demersum* (coontail) was the dominant species within the plant community, especially in the 1.5-20ft depth zones, occurring at more than three-quarters of the sample sites and exhibiting a dense growth form. *Nymphaea odorata* (white water lily) was sub-dominant, occurring at nearly half of the sites.

The aquatic plant community in Rock Lake is characterized by average quality, very good species diversity, an average tolerance to disturbance and within the 25% of lakes in the state and region closest to an undisturbed condition.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play 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 out-compete sensitive species, thus reducing diversity.

Aquatic plant communities improve water quality in many ways: they trap nutrients, debris, and pollutants entering a water body; absorb and break down some pollutants; reduce erosion by damping wave action and stabilizing shorelines and lake bottoms; remove nutrients that would otherwise be available for algae blooms (Engel 1985).



Aquatic plant communities provide important fishery and wildlife resources. Plants (including 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 9). Plant cover within the littoral zone of Rock Lake is 91% and over the entire lake is 37%. This 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 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. Plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Table 9. Wildlife and Fish Uses of Aquatic Plants in Rock Lake

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
<u>Submergent Plants</u>							
Ceratophyllum demersum	F,I*, C, S	F(Seeds*), I, C			F		
Elodea canadensis	C, F, I	F(Foliage) I					
Myriophyllum heterophyllum	I*, C	I* F(Seeds, Foliage)					
Myriophyllum sibiricum	F*, I*, S	F(Seeds, Foliage)	F(Seeds)		F		
Najas flexilis	F, C	F*(Seeds, Foliage)	F(Seeds)				
Potamogeton amplifolius	F, I, S*,C	F*(Seeds)			F*	F	F
Potamogeton crispus	F, C, S	F(Seeds, Tubers)					
Potamogeton praelongus	F, I, S*,C	F*(All)			F*	F	F
Potamogeton pusillus	F, I, S*,C	F*(All)			F*	F	F
Potamogeton robbinsii	F, I, S*,C	F*			F*	F	F
Potamogeton zosteriformis	F, I, S*,C	F*(Seeds)			F*	F	F
Vallisneria americana	F*, C, I, S	F*, I	F		F		
Zosterella dubia	F, C, S	F(Seeds)					
<u>Floating-leaf Plants</u>							
Lemna minor	F	F*, I	F	F	F	F	
Lemna trisulca	F, I	F*, I					

Aquatic Plants	**Fish**	**Water Fowl**	**Song and Shore Birds**	**Upland Game Birds**	**Muskrat**	**Beaver**	**Deer**
Nuphar variegata	F,C, I, S	F, I	F		F*	F	F*
Nymphaea odorata	F,I, S, C	F(Seeds)	F		F	F	F
Spirodela polyrhiza	F	F		F			
Wolffia columbiana		F			F		
<u>Emergent Plants</u>							
Acorus calamus		F, C, Nests			F, S		
Bidens frondosus		F (Seeds),	F	F	F		
Carex spp.	S*	F*	F* (Roots, Sprouts, Seeds)	F* (Roots, Sprouts, Seeds)	F* (Roots, Sprouts)	F	F
Leersia oryzoides		F			F		
Pontederia cordata	F, I, C	F*(Seeds), C			F		
Sagittaria sp.		F*, C	F(Seeds), C	F, C	F	F	
Scirpus validus	F, C, I	F (Seeds)*, C	F(Seeds, Tubers), C	F (Seeds)	F	F	F
Sparganium spp.	I	F(Seeds), C	F, C		F		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.

After Fassett, N. C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, WI

Nichols, S. A. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Info. Circ. #73

Management Recommendations

1) Lake property owners preserve the natural shoreline cover that is found around Rock Lake. Wooded cover, shrubs and native herbaceous growth protected 94% of the shoreline. Maintaining natural shoreline cover is critical to maintaining water quality and wildlife habitat. Even the limited amount of disturbance (6%) appears to be impacting the lake.
    a) The evidence that disturbance has impacted the aquatic plant community is that the Floristic Quality Index is lower at the disturbed shore transects indicating they are farther from an undisturbed condition. Also the combined frequency of the most sensitive species is lower at disturbed shore community.
    b) Disturbance appears to be impacting the quality of the aquatic plant community. The quality (AMCI) of the aquatic plant community is lower at the disturbed shore community than the natural shore community.
    c) Disturbance appears to be impacting the habitat. A lower percent colonization by vegetation and lower maximum rooting depth at the disturbed shore community results in less habitat. The lower diversity index, lower number of species and lower species richness indicate a less diverse plant community at disturbed shore sites which will support a less diverse wildlife and plant community. Disturbed shore aquatic plant community supports less cover of emergent vegetation which is a very important component of quality habitat for fish spawning and wildlife cover, nesting and feeding.
2) Lakes residents use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake. Abundant filamentous algae suggests nutrient enrichment to the lake. In addition, the majority of floating-leaf and submergent species (this includes the dominant and sub-dominant species) are species that can grow to nuisance conditions with increased nutrients.
3) Lake residents begin monitoring the water quality through the Self-Help Volunteer Lake Monitoring Program to expand knowledge and track changes in water quality in Rock Lake.
4) DNR to designate sensitive areas within Rock Lake. These are areas that are most important for habitat and maintaining water quality.
5) DNR and lake residents maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Rock Lake. One non-native pondweed was recorded in Rock Lake in 2006, but was not commonly occurring or growing at high densities.

LITERATURE CITED

Barko, J. and R. Smart. 1986. Sediment-related mechanisms of growth limitation in submersed macrophytes. Ecology 61:1328-1340.

Dennison, W., R. Orth, K. Moore, J. Stevenson, V. Carter, S.Kollar, P. Bergstrom, and R. Batuik. 1993. Assessing water quality with submersed vegetation. BioScience 43(2):86-94.

Duarte, Carlos M. and Jacob Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submerged macrophyte communities. Limnol. Oceanogr. 31(5):1072-1080.

Dunst, R.C. 1982. Sediment problems and lake restoration in Wisconsin. Environmental International 7:87-92.

Engel, Sandy. 1990. Ecosystem Response to Growth and Control of Submerged Macrophytes: A Literature Review. Technical Bulletin #170. Wisconsin Department of Natural Resources. Madison, WI.

Engel, Sandy. 1985. Aquatic Community Interactions of Submerged Macrophytes. Wisconsin Department of Natural Resources. Technical Bulletin No. 156. Madison, WI

Fassett, Norman C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, WI.

Gleason, H. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada (Second Edition). New York Botanical Gardens, NY.

Jessen, Robert and Richard Lound. 1962. An evaluation of a survey technique for submerged aquatic plants. Minnesota Department of Conservation. Game Investigational Report No. 6.

Lillie, R. and J. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. Wisconsin Department of Natural Resources Tech. Bull. #138. Madison, WI.

Nichols, Stanley, S. Weber, B. Shaw. 2000. A proposed aquatic plant community biotic index for Wisconsin lakes. Environmental Management 26:491-502.

Nichols, Stanley. 1998. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2):133-141.

Nichols, Stanley A. and James G. Vennie. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Information Circular 73.

Shaw, B, C. Mechenich and L. Klessig. 1993. Understanding Lake Data. University of Wisconsin – Extension. Madison, WI