

**Changes in the Aquatic Plant Community and  
The Long-term Impact of Winter Drawdown on  
Eurasian Watermilfoil and the Native Plant Community  
Lake Mallalieu, St. Croix County  
1991-2005**

**I. INTRODUCTION**

Studies of the aquatic macrophytes (plants) in Lake Mallalieu were conducted during July 1998, July 1999, June 2001 and August 2005 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR).

A plant survey had been conducted in August 1991 by Barr Engineering of Minneapolis (Barr 1992), but only sites up to a maximum depth of 4-feet were sampled.

The present study was conducted to assess the long-term impacts to the native plant community and the Eurasian milfoil of a recent 3-foot winter drawdown (2004-05) and to compare with the impacts of a more severe 6-foot winter drawdown during 1998-99. The present study will also provide information for fish habitat improvement, protection of sensitive wildlife areas, aquatic plant management, and water resource regulations.

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 larger animals and fish. 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 nutrients (Dennison et. al. 1993).

**Background and History**

Lake Mallalieu is a 270-acre impoundment on the Willow River in St. Croix County, Wisconsin. Its maximum depth is 17 feet at the dam and the mean depth is 5 feet. The first dam that formed Lake Mallalieu was built for a sawmill operation in 1848.

The first recorded complaints of algae blooms in Lake Mallalieu were in 1946; the first recorded complaints concerning excess plant growth were in 1949, when letters were sent to the DNR requesting help in “destroying” the weeds. The first permit approved for chemical control of aquatic plants in Lake Mallalieu was issued in 1961. This led to a series of arsenic treatments (Table 1).

**Table 1. Chemical Treatments for Aquatic Plant Control.**

	Arsenic	Endothall	Diquat	2,4 -D	Silvex
1961	2860#				
1962	660#				
No Treatment Recorded					
1964	1800#				
1965	1200#				
1966	720#	3.6 #	12 gal.		5 #
1998		4 gal.	2 gal.	73 oz.	
2000				22 oz.	
Totals	7240#		14 gal.	95 oz.	5 #

The total of pounds of arsenic applied to Lake Mallalieu during the 1960's was 7240 pounds, mostly in the littoral zone and the shallow northeast end of the lake. Arsenic does not break down and will remain in the sediment; a 1979 sediment study in Lake Mallalieu recorded arsenic in the sediments. Arsenic, along with Silvex (2,4,5-TP), was later found to be toxic, so are no longer approved for aquatic application. Arsenic and Silvex are broad-spectrum herbicides, therefore, they are not selective and would kill any plant to which they were applied. Other broad-spectrum chemicals have been used in Lake Mallalieu: endothall and diquat (Table 1).

There is no record of chemical treatments between 1966 and 1998, but some property owners admitted to using unpermitted herbicides. The types and amounts are unknown and so cannot be included in the table.

In 1974, long-time residents of the Hudson area expressed concern about the lack of plant growth in Lake Mallalieu. DNR investigations confirmed that aquatic plant growth was sparse. Frequent drawdowns, past chemical treatments and carp were thought to be the reason for the lack of plant growth. The condition of sparse plant growth likely facilitated the invasion and colonization of the exotic plant species in Lake Mallalieu.

There have been numerous drawdowns on Lake Mallalieu, including a 7-foot drawdown in 1983 for dam repairs and two recent winter drawdowns that were conducted for Eurasian watermilfoil control:

- a 6-foot drawdown in 1998-99
- a 3-foot drawdown in 2004-05.

The lake was drawn down six feet in the fall of 1998 to repair the dam. The water was

left down over the winter in an attempt to control the Eurasian watermilfoil that had densely colonized the shallow east basin. The intention had been to bring the lake up to 3 feet below normal level after the repairs were finished and leave the lake down 3 feet over the winter. However, there was a problem with the gates freezing, so the lake was left down 6 feet over the winter. When Eurasian watermilfoil recolonized and started to spread throughout the east end of the lake again in 2003, another winter drawdown was planned. The lake was drawdown 3 feet in fall 2004 and left down for the winter.

The Lake Mallalieu Association received a grant in 1997 to develop a lake management plan. The Lake Management Plan was completed in 2001 and made many recommendations to manage aquatic plants and to enhance and protect water quality.

- 1) Educate lake users and residents on the value of aquatic plants, woody debris, natural shoreline and the elimination of lawn fertilizers.
- 2) Encourage homeowners to leave woody debris and provide examples and assistance in maintaining natural shoreline.
- 3) Work with lake residents on decreasing stormwater run-off.
- 4) Use newsletter as an education medium and put together "Homeowner Packets" to present to new residents on the lake about these issues.
- 5) Review and evaluate development in the watershed to decrease erosion and non-native species introductions.
- 6) Seek DNR permit for winter drawdown when needed for Eurasian watermilfoil control.
- 7) Form a Water Quality Committee to, among other things, review town ordinances as to adequacy to protect water quality and prevent erosion and partner with Willow River watershed residents to protect water quality.
- 8) Form a Plant Watch Committee
  - a) Report plant problems and recommend appropriate actions
  - b) Watch for reoccurrence of purple loosestrife
  - c) Watch for reoccurrence of Eurasian watermilfoil
  - d) Encourage low-tech plant control
  - e) Educate lake users and residents on the benefits of aquatic plants

## II. METHODS

### Field Methods

The 1998, 1999, 2001 and 2005 study design was based on the rake-sampling method developed by Jessen and Lound (1962). Twenty-three transects were placed along the shoreline, perpendicular to the shoreline (Appendix XIV). The transects were placed in the same location that Barr Engineering had sampled in their 1991 study and mapped for use in all subsequent surveys.

One sampling site was randomly located in each depth zone (0-1.5ft., 1.5-5ft., 5-10ft., and 10-17ft.) along each transect. Using a long-handled, steel thatching-rake, four rake samples were taken at each sampling site. The four samples were taken from each quarter of a 6-foot diameter quadrat. The aquatic plant species that were present on each rake sample were recorded. The species recorded included macrophytes (vascular plants), and macrophytic algae, such as *Nitella* and *Chara* that have a plant-like growth form. Each species was given a density rating (0-5), 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 1 rake sample at that site;
- A rating of 2 indicates that a species was present on 2 rake samples;
- A rating of 3 indicates that a species was present on 3 rake samples;
- A rating of 4 indicates that a species was present on 4 rake samples at that site;
- A rating of 5 indicates that it was abundantly present on all rake samples at that sampling site.

The sediment type at each sampling site was recorded. Occurrence of filamentous algae was recorded. Visual inspection and periodic samples were taken between transect lines 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).

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 visually estimated.

### Data Analysis

Data from each survey year was analyzed separately and compared. The percent frequency of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendix I-IV). Relative frequency was calculated (the number of occurrences of a species/sum of all species occurrences) (Appendix I-IV). The mean density was calculated (sum of a species' density ratings/number of sampling sites) (Appendix V-VIII). Relative density was calculated (sum of a species density/sum of all plant densities). 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 V-VIII). The relative frequency and relative density of each species was summed to obtain a Dominance Value for each species (Appendix IX-XII). Simpson's Diversity Index was calculated (Appendix I-IV).

Each sampling year was compared with the Coefficient of Community Similarity (Table 9).

The Aquatic Macrophyte Community Index (AMCI) developed by Nichols, et. al (2000) was applied to Lake Mallalieu. Measures for each of seven categories that characterize a plant community are converted to values between 0 and 10 and summed to quantify the quality of the aquatic plant community.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated, as outlined by Nichols (1998), to measure 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 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 (nutrient concentration, algal concentration, water clarity, water hardness) can influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shore land 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 concentration, and water clarity data are collected to determine the trophic state.

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

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

**Mesotrophic lakes** have intermediate levels of nutrients and biomass.

#### Nutrients

Phosphorus is a limiting nutrient in many Wisconsin lakes and is measured as an indication of the nutrient enrichment in a lake. Increases in phosphorus in a lake can feed algae blooms and excess plant growth.

**2003 Mean Summer phosphorus in Lake Mallalieu was 50.2ug/l., indicating a eutrophic status** (Table 2).

**Table 2. Trophic Status**

	Quality Index	Phosphorus ug/l	Chlorophyll 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	<b>50-150</b>	<b>15-30</b>	<b>3-4</b>
Hypereutrophic	Very Poor	>150	>30	>3
Lake Mallalieu - 2003	Poor	50.2	20.7	4.3

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

Although phosphorus is a limiting nutrient in most Wisconsin lakes, about 10% of Wisconsin lakes are considered nitrogen limited. Nitrogen limitation results when the ratio of nitrogen:phosphorus is less than 10:1 (Shaw et. al. 1993). The 2001

nitrogen:phosphorus ratio in Lake Mallalieu is 8:1, which means that nitrogen can be limiting and inputs of nitrogen can feed algae and plant growth.

### **Algae**

Measuring the concentration of chlorophyll in lake water gives an indication of algae concentrations. Algae are natural and essential in lakes, but high algae levels can increase the turbidity, reducing the light available for plant growth.

**2003 Mean Summer chlorophyll in Lake Mallalieu was 20.7ug/l., indicating a eutrophic status** (Table 2).

### **Water Clarity**

Water clarity is a critical factor for aquatic plants. When plants receive less than 1 - 2% of the surface illumination, they can not survive. In addition, different species of aquatic plants have varying tolerances to water clarity, so that clarity will also impact which species colonize a lake and how deep. Water clarity is reduced by turbidity (suspended materials such as algae cells and silt) and dissolved organic chemicals that color the water. Water clarity is measured with a Secchi disc that measures the combined effect of turbidity and color.

**2003 Mean Summer Secchi disc clarity was 4.3 ft., indicating a eutrophic status and poor water clarity** (Table 2).

The combination of nutrient and algae concentration and water clarity indicates that Lake Mallalieu is a eutrophic lake with poor water quality. This trophic state would support abundant plant growth and frequent algae blooms.

### **Hardness**

The alkalinity as measured by mg of  $\text{CaCO}_3/\text{l}$  indicates the hardness of the water.

**The 2001 hardness in Lake Mallalieu was 144 mg  $\text{CaCO}_3/\text{l}$ .**

Hardness values between 121 and 180 mg  $\text{CaCO}_3/\text{l}$  indicate hard water; hard water favors plant growth in lakes.

### **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).

Lake Mallalieu has an irregular-shaped basin. The littoral zone is gradually-sloped in most of the lake, except for the basin west of the Highway 35 bridge and a small area on the south shore, east of the boat landing where a rock wall drops vertically into the water. The broad east basin is shallow and very gradually-sloped, favoring plant growth.

## SEDIMENT COMPOSITION

Sand, a hard, high-density sediment, was the overall dominant sediment in Lake Mallalieu (Table 3), more common at depths greater than 1.5 feet. Sand mixed with gravel, also a hard, high-density sediment, dominated the shallow 0-1.5ft depth zone.

Silt, a soft, intermediate-density sediment, dominated the 5-17ft depth zone, but did not occur in the shallowest depth zone. Silt mixed with sand was common in the 1.5-10ft depth zone (Table 3).

**Table 3. Sediment Composition, 2005**

		0-1.5ft.	1.5-5ft.	5-10ft.	10-17 ft.	Overall
<b>Hard Sediments</b>	Sand	18%	27%	22%	25%	23%
	Rock	18%	14%		12%	11%
	Sand/Gravel	41%	9%	6%	12%	19%
	Sand/Rock	4%		6%		3%
	Gravel		9%			3%
	Gravel/Rock		4%			1%
<b>Mixed Sediments</b>	Sand/Silt		23%	28%	12%	16%
	Rock/silt	4%	4%			3%
<b>Soft Sediments</b>	Silt		4%	39%	38%	16%
	Muck	9%	4%			4%
	Silt/Muck	4%				1%

## SEDIMENT INFLUENCE

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

The availability of mineral nutrients for plant growth is highest in sediments of intermediate density, such as silt (Barko and Smart 1986). Highly organic muck sediments are low-density sediments; sand, gravel and rock are high-density sediments. Sand sediments occurred commonly in Lake Mallalieu and supported vegetation at 50% of the sand sediment sites (Table 4).

Silt, a favorable sediment for aquatic plant growth, supported vegetation at only slightly

more than one-third of the silt sites. The low colonization of aquatic plants on silt sediment is likely due to the occurrence of silt more commonly at the deeper sites (Table 3) where light availability may have been the limiting factor. Silt combined with sand supported vegetation at nearly two-thirds of the sites; combined with rock or organic muck, at all of the sites.

**Table 4. Sediment Influence**

		Percent Occurrence	Percent Vegetated
<b>Hard</b>	Sand	23%	50%
	<b>Sediments</b>		
	Rock	11%	38%
	Sand/Gravel	19%	38%
	Sand/Rock	3%	0%
	Gravel	3%	0%
	Gravel/Rock	1%	100%
<b>Mixed Sediments</b>	Sand/Silt	16%	64%
	Rock/silt	3%	100%
<b>Soft Sediments</b>	Silt	16%	36%
	Muck	4%	100%
	Silt/Muck	1%	100%

### **SHORELINE LAND USE**

Land use can 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 nutrients from fertilizer run-off and soil erosion and increased toxics from farmland and urban run-off.

Shrub growth was the most frequently encountered shoreline cover at the transects and wooded cover had the highest mean coverage in 2005 (Table 5). Lawn occurred at half the sites and covered more than 1/4 of the shoreline. Wooded cover, shrubs, native herbaceous growth, rip-rap and hard structures were also commonly encountered in 2005 (Table 5).

**Table 5. Shoreline Land Use**

Cover Type		Frequency of Occurrence at Transects		% Coverage at Shore	
		1998	2005	1998	2005
Natural Shoreline	Wooded	70%	64%	40%	31%
	Native Herbaceous	35%	60%	8%	15%
	Shrub	61%	68%	18%	14%
	Rock		9%		3%
	<b>Total</b>			<b>66%</b>	<b>63%</b>
Disturbed Shoreline	Cultivated Lawn	52%	50%	27%	22%
	Paved Surface	13%	14%	5%	4%
	Gravel Road		9%		4%
	Rip-Rap	13%	27%	1%	3%
	Hard Structures	4%	27%	1%	2%
	Eroded Soil		14%		2%
	<b>Total</b>			<b>34%</b>	<b>37%</b>

Native herbaceous plant cover was the only natural cover type that increased from 1998 to 2005, however, the area of the shoreline covered by natural shoreline decreased from 66% in 1998 to 63% in 2005 (Table 5).

The occurrence of disturbed shoreline (cultivated lawn, paved surfaces, erosion, rip-rap and hard structures) increased from 61% of the sites in 1998 to 77% in 2005. The area of the shoreline covered by disturbed shoreline increased from 34% in 1998 to 37% in 2005.

The coverage of wooded shoreline has decreased the most at the expense of increases in eroded areas, road surface, rip-rap and hard structures (Table 5).

## **MACROPHYTE DATA**

### **SPECIES PRESENT**

Twenty-nine species were found in Lake Mallalieu during the 1991-2005 aquatic plant surveys. Of the 29 species, 8 were emergent species, 4 were a floating-leaf species and 17 were submergent species (Table 6).

No endangered or threatened species were found.

Three non-native species were found:

*Lythrum salicaria* - purple loosestife

*Myriophyllum spicatum* - Eurasian watermilfoil

*Potamogeton crispus* – curly-leaf pondweed

**Table 6. Lake Mallalieu Aquatic Plant Species, 1992-2005**

<b>Scientific Name</b>	<b>Common Name</b>	<b>I. D. Code</b>
<b><u>Emergent Species</u></b>		
1) <i>Asclepias incarnata</i> L.	swamp milkweed	ascin
2) <i>Calamagrostis canadensis</i> (Michx.)	bluejoint	calca
3) <i>Carex</i> sp.	sedge	carsp
4) <i>Impatiens capensis</i> Meerb.	orange jewelweed	impca
5) <i>Iris versicolor</i> L.	northern blue flag	irive
6) <i>Lycopus virginicus</i> L.	water-horehound	lycvi
7) <i>Lythrum salicaria</i> L.	purple loosestrife	lytsa
8) <i>Typha latifolia</i> L.	common cattail	typla
<b><u>Floating-leaf Species</u></b>		
9) <i>Lemna minor</i> L.	small duckweed	lemmi
10) <i>Nymphaea odorata</i> Aiton.	white water lily	nymod
11) <i>Spirodela polyrhiza</i> (L.) Schleiden.	greater duckweed	spipo
12) <i>Wolffia columbiana</i> Karsten.	common watermeal	wolco
<b><u>Submergent Species</u></b>		
13) <i>Ceratophyllum demersum</i> L.	coontail	cerde
14) <i>Elodea canadensis</i> Michx.	common waterweed	eloca
15) <i>Myriophyllum sibiricum</i> Komarov.	common watermilfoil	myrsi
16) <i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	myrsp
17) <i>Najas flexilis</i> (Willd.) R. & S.	northern water-nymph	najfl
18) <i>Potamogeton crispus</i> L.	curly-leaf pondweed	potcr
19) <i>Potamogeton foliosus</i> Raf.	leafy pondweed	potfo
20) <i>Potamogeton illinoensis</i> Morong.	Illinois pondweed	potil
21) <i>Potamogeton natans</i> L.	floating-leaf pondweed	potna
22) <i>Potamogeton nodosus</i> Poiret.	long-leaf pondweed	potno
23) <i>Potamogeton pectinatus</i> L.	sago pondweed	potpe
24) <i>Potamogeton pusillus</i> L.	slender pondweed	potpu
25) <i>Potamogeton zosteriformis</i> Fern.	flat-stem pondweed	potzo
26) <i>Ranunculus longirostris</i> Godron.	white water crowfoot	ranlo
27) <i>Vallisneria americana</i> L.	water celery	valam
28) <i>Zannichellia palustris</i> L.	horned pondweed	zanpa

29) *Zosterella dubia* (Jacq.) Small.

water stargrass

zosdu

## FREQUENCY OF OCCURRENCE

The species with the highest frequency of occurrence in 1998 was *Ceratophyllum demersum* (30%) (Table 7), but it disappeared in 1999. The most frequent species in 1999 and 2001 was *Nymphaea odorata*, even though its occurrence declined dramatically in 1999 (Table 7). The frequency of *N. odorata* recovered in 2001, but declined again in 2005, not as dramatically as in 1999. In 2005, *Potamogeton pectinatus* became the most frequently occurring aquatic plant species after occurring at low frequencies in 1999 (Table 7)

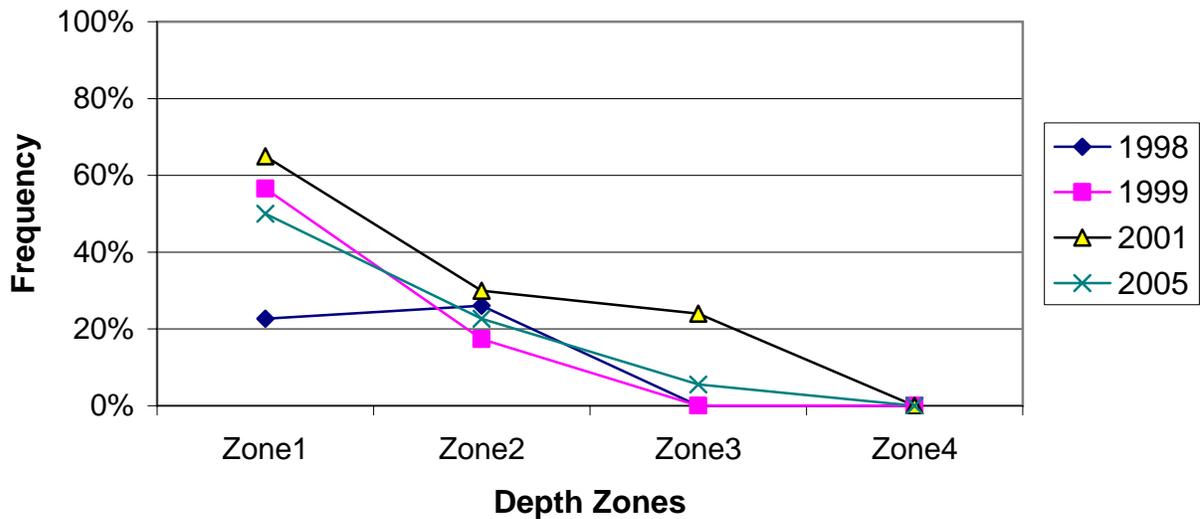
**Table 7. Frequency of Aquatic Plant Species in Lake Mallalieu, 1998-2005.**

<b>Species</b>	<b>1998</b>	<b>1999</b>	<b>2001</b>	<b>2005</b>
<i>Ceratophyllum demersum</i>	<b>30%</b>		7%	13%
<i>Elodea canadensis</i>	20%	1%		1%
<i>Myriophyllum spicatum</i>	17%			6%
<i>Najas flexilis</i>	2%	4%		11%
<i>Nymphaea odorata</i>	23%	<b>10%</b>	<b>21%</b>	14%
<i>Potamogeton pectinatus</i>	14%	6%	10%	<b>16%</b>
<i>Zosterella dubia</i>	25%			13%

The overall occurrence of filamentous algae in Lake Mallalieu was 11%:

- 17% of the sample sites in 1998
- 24% of the sample sites in 1999
- 36% of the sample sites in 2001
- 24% of the sample sites in 2005

The overall increase in filamentous algae was the result of a nearly three-fold increase in filamentous algae in the shallow zone in 1999 and an increase in the 5-10 ft. depth zone in 2001 (Figure 1). Filamentous algae has occurred more frequently in the shallower depth zones since the 1998/99 winter drawdown (Figure 1).



**Figure 1. Occurrence of filamentous algae in Lake Mallalieu, 1998-2005.**

#### **DENSITY**

*Ceratophyllum demersum* was the species with the highest mean density (0.66 on a scale of 4) in 1998 (Table 8), but was not found at the sample sites in 1999. *Nymphaea odorata* was the species with the highest mean density in 1999 and 2001, although its mean density was very low in 1999 (Table 8). *Najas flexilis* increased in density and became the species with the highest mean density in 2005. *N. flexilis* had an above average “density where present” (Appendices V-VIII), indicating that it exhibited an aggregated or dense growth form in Lake Mallalieu.

**Table 8. Mean Density of Aquatic Plant Species in Lake Mallalieu, 1998-2005.**

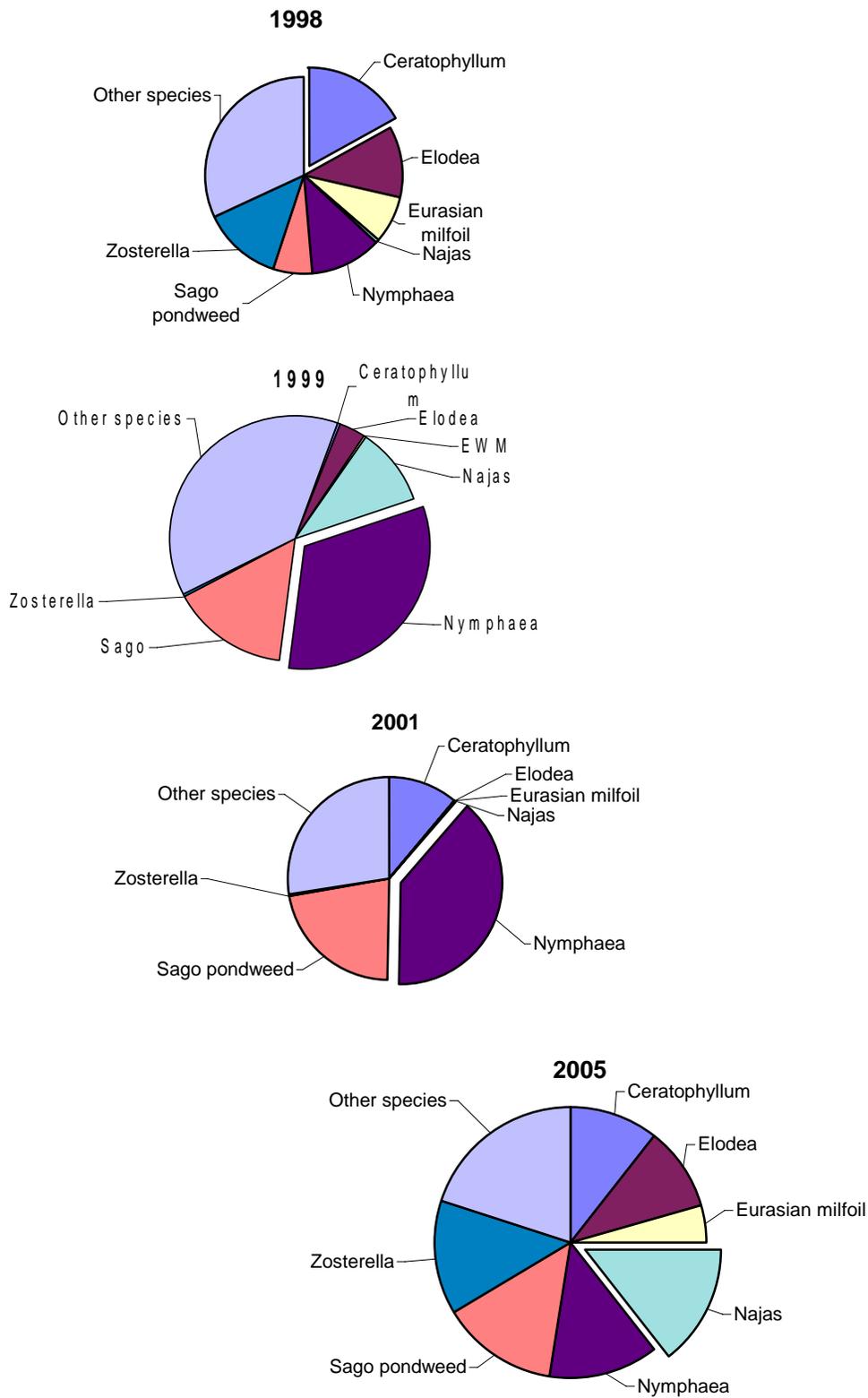
<b>Species</b>	<b>1998</b>	<b>1999</b>	<b>2001</b>	<b>2005</b>
<i>Ceratophyllum demersum</i>	<b>0.66</b>		0.07	0.14
<i>Elodea canadensis</i>	0.44	0.01		0.01
<i>Myriophyllum spicatum</i>	0.25			0.06
<i>Najas flexilis</i>	0.02	0.04		<b>0.30</b>
<i>Nymphaea odorata</i>	0.39	<b>0.17</b>	<b>0.30</b>	0.20
<i>Potamogeton pectinatus</i>	0.22	0.07	0.20	0.21
<i>Zosterella dubia</i>	0.47			0.24

## **DOMINANCE**

Combining relative frequency and relative density into a Dominance Value illustrates how dominant each species is within the aquatic plant community (Appendix IX-XII). Based on the Dominance Value, *Ceratophyllum demersum* was the dominant species in 1998, with *Elodea canadensis*, *Nymphaea odorata* and *Zosterella dubia* as sub-dominants (Figure 2).

*Ceratophyllum demersum* disappeared in 1999. *Nymphaea odorata* became the dominant species in 1999 and 2001 with *Potamogeton pectinatus* as the sub-dominant species (Figure 2).

In 2005, *Najas flexilis* became the dominant species, with *Potamogeton pectinatus* still the sub-dominant species (Figure 2).



**Figure 2. Dominance within the aquatic plant community, of the most prevalent species, 1998-2005.**

## DISTRIBUTION

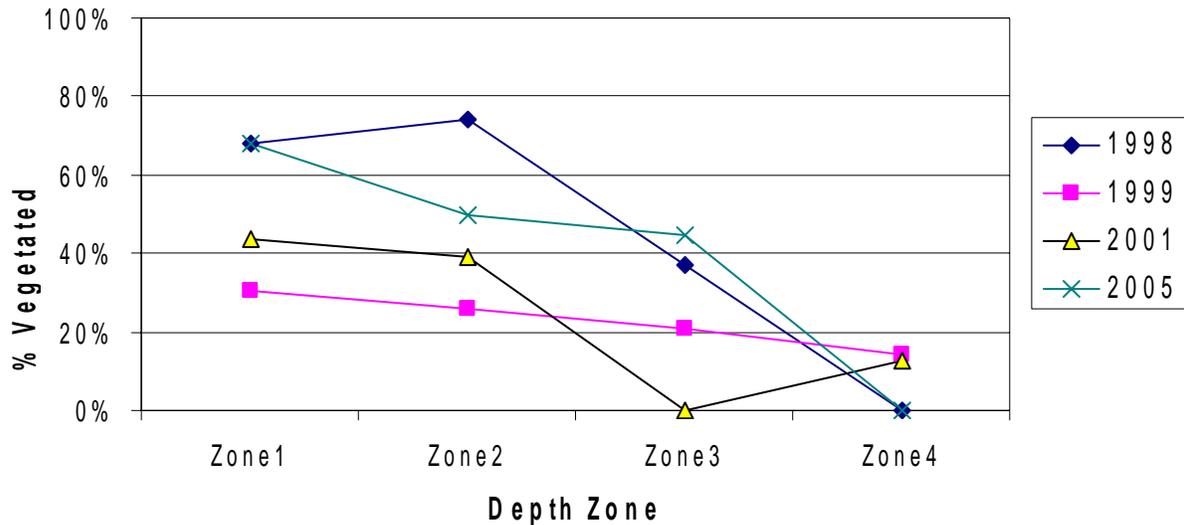
Aquatic plants covered 49% of the littoral zone to a maximum rooting depth of 8 feet, scattered throughout the east end of the lake and very sparse in the west end. *Najas flexilis* occurred at the maximum rooting depth.

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

**Based on the 2003 Secchi disc water clarity, the predicted maximum rooting depth in Lake Mallalieu would be 10.9 ft.**

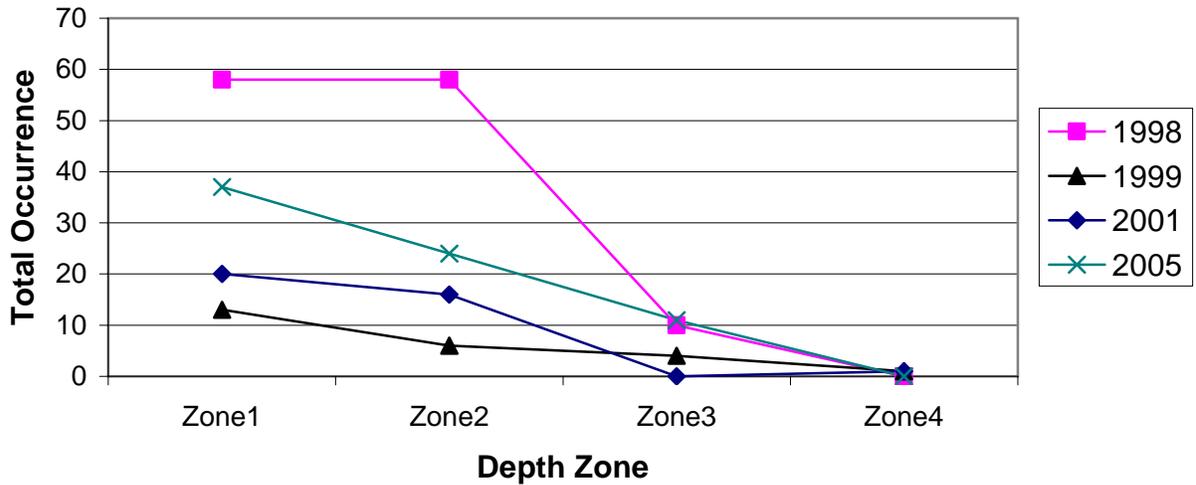
The actual maximum rooting depth is less than predicted.

The highest percent of vegetated sites has shifted from the 1.5-5 ft. depth zone in 1998 to the 0-1.5ft depth zone in 1999-2005. The year with the highest percent of vegetated sites was 1998 (Figure 3). The percent of vegetated sites decreased in 1999 and has since been increasing (Figure 3).

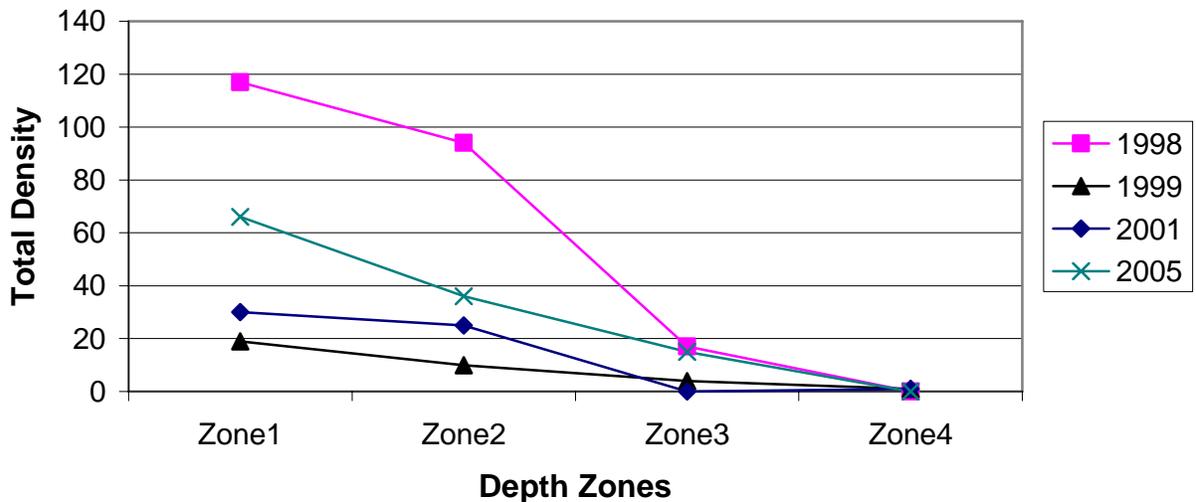


**Figure 3. Percent of sites with rooted vegetation, by depth zone and year, 1998-2005.**

The 0-1.5ft depth zone supported the greatest total occurrence and total density of aquatic plants (Figure 4, 5). The highest total occurrence and total density of aquatic plants was in 1998. The total occurrence and density of plant growth decreased dramatically in 1999 and has been recovering slightly during 2001 - 2005 (Figure 4, 5).

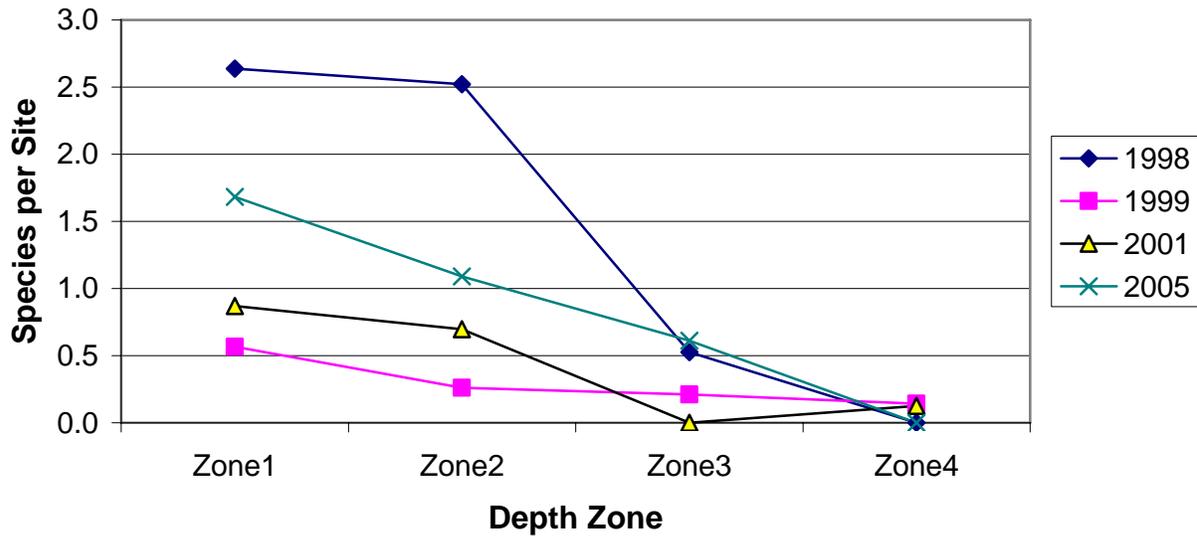


**Figure 4. Total occurrence of aquatic plants by depth zone, 1998-2005.**



**Figure 5. Total density of aquatic plants by depth zone, 1998-2005.**

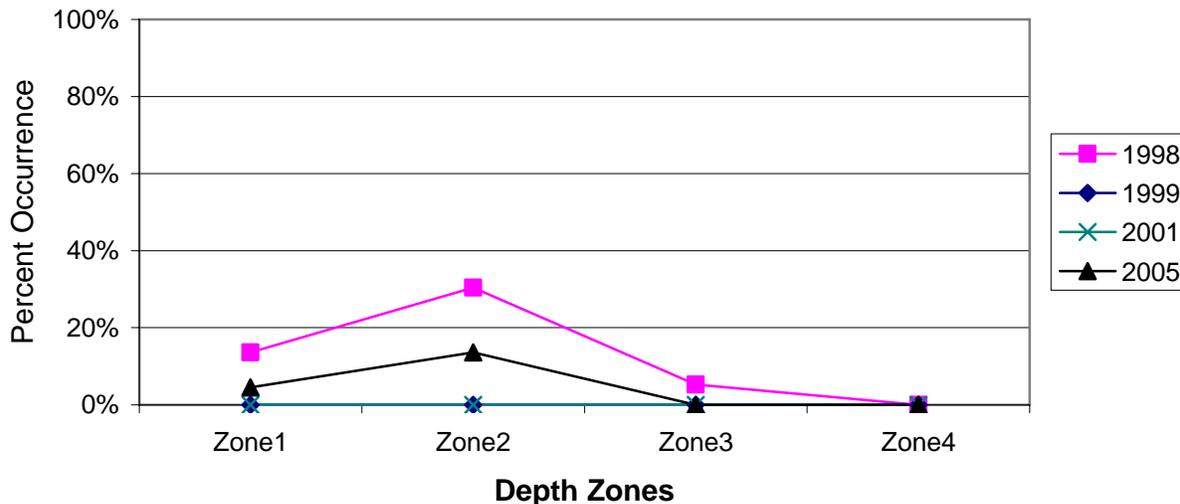
The greatest Species Richness (mean number of species per site) has been in the 0-1.5ft depth zone (Figure 6). The greatest number of species per sample site was recorded in 1998, followed by a dramatic decrease in 1999 and slight recoveries in 2001 and 2005 (Figure 6). Species Richness in 2005 was 1.03.



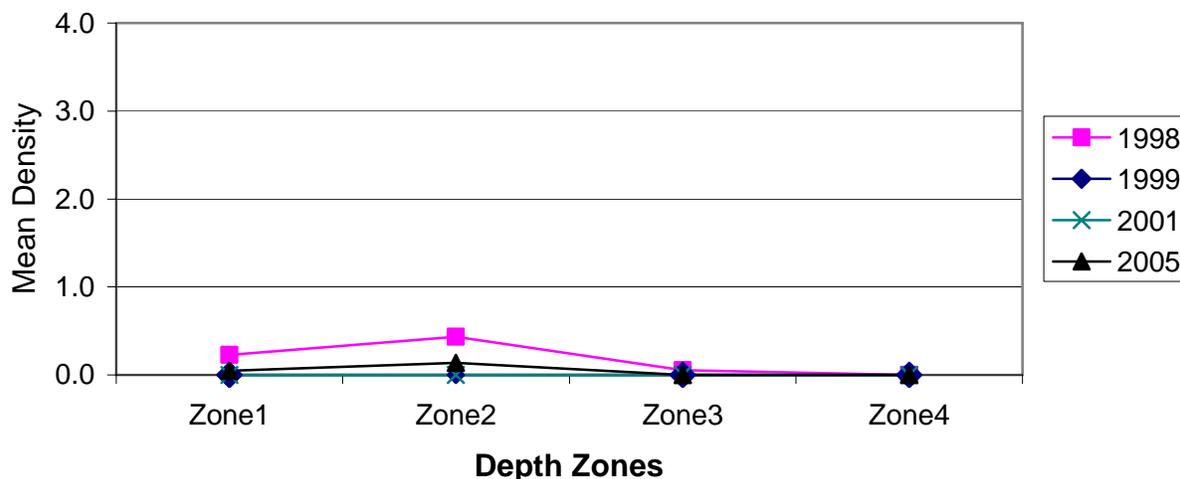
**Figure 6. Species Richness, by depth zone, 1998-2005.**

In 2005, *Zosterella dubia* was the dominant species in the 0-1.5ft depth zone (as it had been in 1998); *Najas flexilis*, the dominant species overall, was the dominant species in the 1.5-5ft depth zone; *Nymphaea odorata* was the dominant species in the 5-10ft depth zone. *N. odorata*, had been dominant in the 1.5-5ft depth zone in 1998, in the 1.5-10ft depth zones in 1999 and in the 0-10ft depth zones in 2001.

*Myriophyllum spicatum* was recorded at its highest frequency and density in 1998 before the first winter drawdown of 6 feet (Figure 7, 8). *M. spicatum* disappeared in 1999 and did not occur at the transects in 2001. However, *M. spicatum* was found at two other sites in 2001; a few plants were found in the shallow bay west of transect #23 and a plant was found in the northeast end where the Willow River enters the impoundment. Both areas were pulled. *M. spicatum* recolonized and spread after 2001. The 2004-05, 3-foot winter drawdown did not eliminate *M. spicatum*, but reduced it to a very low frequency and density (Figure 7, 8,). When *M. spicatum* has been found in Lake Mallalieu, its highest frequency and density has been in the 1.5-5ft depth zone.



**Figure 7. Frequency of *Myriophyllum spicatum* by depth zone, 1998-2005.**



**Figure 8. Density of *Myriophyllum spicatum* by depth zone 1998-2005.**

*Nymphaea odorata* is a valuable species for wildlife and fish habitat, but since it is sensitive to winter drawdown, there was concern as to how the drawdown would impact this species and therefore the habitat in Lake Mallalieu. *N. odorata* was at its highest frequency and density in Lake Mallalieu in 1998, but declined dramatically in 1999 after the 6-foot winter drawdown. It rebounded in 2001 and declined slightly after the 3 foot drawdown (Figure 9, 10). The depth zone of *N. odorata*'s highest frequency and density has shifted from the 1.5-5 ft. depth zone to the 5-10ft depth zone in 2005 (Figure 9, 10). This is likely due to freeze damage in the exposed shallow zone.

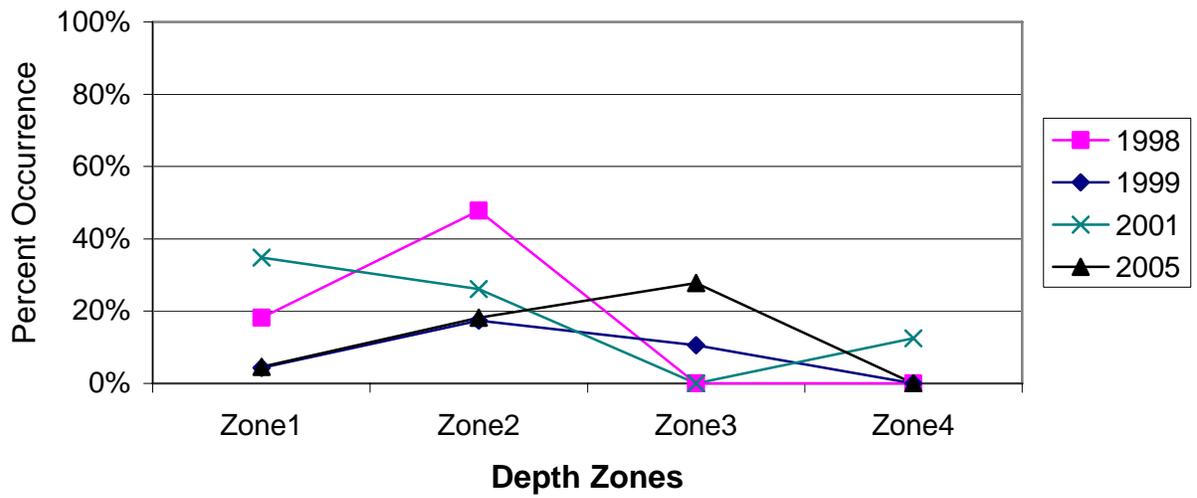


Figure 9. Frequency of *Nymphaea odorata* by depth zone, 1998-2005.

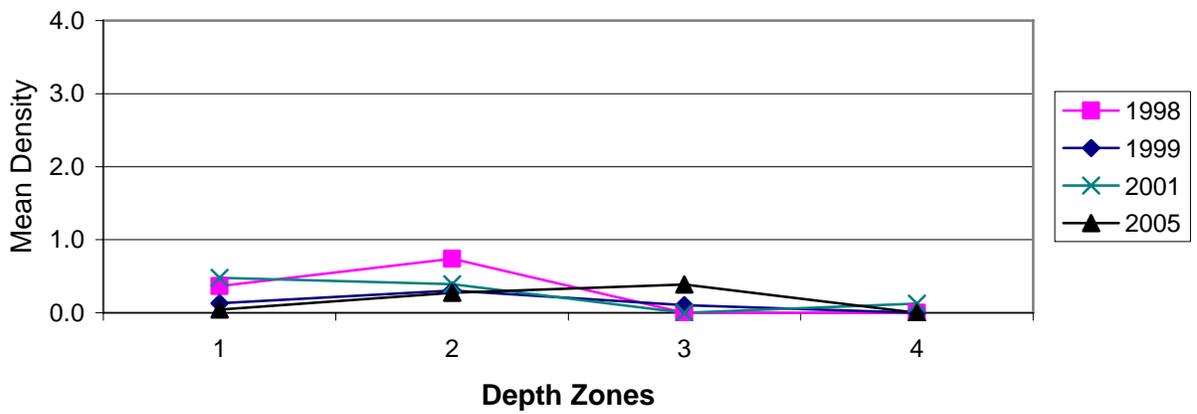


Figure 10. Density of *Nymphaea odorata* by depth zone, 1998-2005.

## THE AQUATIC PLANT COMMUNITY

The Coefficient of Community Similarity is a measure of the percent similarity between two communities. Coefficients less than 0.75 indicate that the two communities are considered significantly different, in that they are less than 75% similar.

The coefficients for Lake Mallalieu indicate that the 1998 and 1999 aquatic plant communities were significantly different (Table 9), only 36% similar. The 1999 and 2001 communities were also significantly different, but more similar than the 1998-99. The 2001 and 2005 plant communities were also significantly different, only 54% similar.

Some of the change between 1998 and 2005, however, may be changes related to recovery of the plant community. The coefficient for the 1998 and 2005 communities suggest this. The 1998 and 2005 communities are significantly different, but being 64% similar, are more similar than any two consecutive surveys and therefore may indicate that the plant community is returning somewhat to the 1998 community (Table 9).

**Table 9. Coefficients of Community Similarity: Lake Mallalieu, 1998-2005**

Coefficient of Similarity		Percent Similar
1998-99	0.356	35.6%
1999-01	0.61	61%
2001-05	0.545	54.5%
1998-05	0.637	63.7%

Many measures and indices can be used to characterize a plant community and determine what specific changes have occurred in the plant community.

Some measures decreased from 1998 through 1999 and 2001 and partially recovered in 2005 (Table 10).

- 1) The number of species at the sampling sites
- 2) The diversity index
- 3) The quality of the plant community (as measured by AMCI discussed later)
- 4) Floristic Quality (discussed later)

Some measures decreased after the 1998-99 drawdown and have been increasing since, through 1999, 2001 and 2005 (Table 10).

- 1) The percent of the littoral zone vegetated
- 2) the percent occurrence of free-floating species
- 3) the percent occurrence of submergent species
- 4) Species Richness (number of species per site)

Some measures changed after each drawdown year (Table 10).

- 1) Cover of floating-leaf (lily pad) species decreased after each winter drawdown, but the 3-foot 2004/05 drawdown did not impact the lily beds as much as the 1998/99 6-foot drawdown.
- 2) Tolerance to disturbance increased after each drawdown (Average Coefficient of Conservatism – discussed later), likely from the disturbance created by the drawdown.

The greatest decrease has been in Species Richness and the cover of free-floating species (Table 10).

The only measures that have increased since 1998 are:

- 1) Maximum rooting depth, possibly from a consolidation of sediments.
- 2) Percent coverage of emergent species. Drawdown favors emergent species due to better germination of their seeds on mudflats as opposed to shallow water.

**Table 10. Changes in the Lake Mallalieu Aquatic Plant Community**

	1998	1999	2001	2005	Max. Change	%Change 1998-05
<b>Number of Species</b>	23	11	7	15	16.0	-34.8%
<b>Maximum Rooting Depth</b>	7.0	11.0	10.0	8.0	4.0	14.3%
<b>% Littoral Zone Vegetated</b>	61%	25%	28%	49%	0.4	-19.7%
<b>%Sites/Emergents</b>	2%	1%		4%	3%	100.0%
<b>%Sites/Free-floating</b>	33%		7%	17%	26%	-48.5%
<b>%Sites/Submergents</b>	50%	15%	18%	36%	35%	-28.0%
<b>%Sites/Floating-leaf</b>	22%	10%	21%	14%	12%	-36.4%
<b>Simpson's Diversity Index</b>	0.91	0.85	0.76	0.79	0.2	-13.2%
<b>Species Richness</b>	1.97	0.32	0.52	1.03	1.7	-47.7%
<b>AMCI</b>	44	34	28	32	16.0	-27.3%
<b>Average Coefficient Conservatism</b>	4.57	4.00	4.57	4.50	0.6	-1.5%
<b>Floristic Quality</b>	21.89	13.27	12.09	16.84	9.8	-23.1%

Simpson's Diversity Index decreased from 0.91 (very good species diversity) in 1998, to 0.79 (very poor species diversity) in 2001 and 2005. An index 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) developed by Nichols et. al. (2000) was applied to Lake Mallalieu (Table 11). The highest value for this index is 70. Lake

Mallalieu has been in the lowest quartile of lakes in Wisconsin and the North Central Hardwoods Region of Wisconsin in all years. This indicates that Lake Mallalieu is among the group of lakes in the state and region with the lowest quality aquatic plant community. The quality of the aquatic plant community, as measured by the AMCI, in Lake Mallalieu has been declining since 1998, but rebounded slightly in 2005 (Table 11).

**Table 11. Lake Mallalieu Aquatic Macrophyte Community Index, 1998-2005**

Category	Category Values			
	1998	1999	2001	2005
Maximum Rooting Depth	3	6	5	3
% Littoral Zone Vegetated	10	3	3	9
Simpson's Diversity	9	6	4	4
# of Species	9	5	3	7
% Submersed Species	4	4	2	4
% Sensitive Species	5	5	5	0
% Exotic Species	4	5	6	5
Totals	44	34	28	32

The decline in the quality as measured by AMCI had been due to decreased colonization of the littoral zone by aquatic plants, decreased colonization of submerged plant growth and declining numbers of species and species diversity.

The Average Coefficient of Conservatism for the Lake Mallalieu aquatic plant community has been in the lowest quartile for all Wisconsin lakes and lakes in the North Central Hardwood Region (Table 12). This suggests that the plant community in Lake Mallalieu is among the 25% of lakes most tolerant of disturbance, probably the result of being subjected to disturbance.

**Table 12. Floristic Quality and Coefficient of Conservatism of Lake Mallalieu, Compared to Wisconsin Lakes and Region Lakes, 1998-2005.**

	Average Coefficient of Conservatism†	Floristic Quality‡	Based on Relative Frequency	Based on Dominance Value
Wisconsin Lakes	5.5, 6.0, 6.9*	16.9, 22.2, 27.5*		
NCHF	5.2, 5.6, 5.8*	17.0, 20.9, 24.4*		
1998	4.57	21.89	20.02	19.90
1999	4.00	13.27	14.79	15.39
2001	4.57	12.09	13.30	13.38
2005	4.50	16.84	17.41	18.01

\* Values indicate the highest value of the lowest quartile, the mean, the lowest value of the upper quartile

†Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (most tolerant of disturbance) 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 of the plant community in Lake Mallalieu was below the mean of Wisconsin lakes and Northern Central Hardwood lakes in 1998 (Table 12). In 1999 and 2001 the Floristic Quality decreased to within the lowest quartile of both Wisconsin lakes and Northern Lakes (Table 12). This indicates that the plant community in Lake Mallalieu was below average in its closeness to an undisturbed condition in 1998, but in 1999 and 2001 was within the 25% of lakes farthest from an undisturbed condition.

These values were based only on the occurrence of disturbance tolerant or intolerant species and did not take into consideration the frequency or dominance of these tolerant or intolerant species in the community. The Floristic Quality was recalculated, weighting each species coefficient with its relative frequency and dominance value. The resulting values indicated a slightly different change. The values suggest the aquatic plant community in Lake Mallalieu was farther from an undisturbed condition than the average lake in 1998 after the 6-foot drawdown; decreased into the group of lakes farthest from an undisturbed condition in 1999 and 2001; rebounded slightly to below average in 2005.

Disturbances can be of many types:

- 1) Direct disturbances to the plant beds result from boat traffic, plant harvesting, chemical treatments, water level manipulations and the placement of docks and other structures, etc.
- 2) Indirect disturbances can be the result of factors that impact water clarity and thus stress species that are more sensitive: resuspension of sediments, sedimentation from erosion, 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, destruction of plant beds by the fish population, etc.

Major disturbances in Lake Mallalieu likely include past broad-spectrum chemical treatments, winter drawdowns, shoreline development, poor water clarity and the introduction of non-native plant species.

Aquatic plant communities change because the frequency and density of the plant species in the community change (Appendix XIII). Many species disappeared between 1998 and 2005: 7 of these species were recorded at only one or two sites and possibly were not recorded in subsequent surveys because of slight shifts in transect locations.

Besides these 7 species, 12 other species disappeared or declined. Six of these are known to be intolerant of winter drawdown, six prefer soft sediments and 7 are tolerant of high turbidity. *Myriophyllum sibiricum*, *Ranunculus longirostris*, *Spirodela polyrhiza* and *Vallisneria americana* disappeared after the 1998-99 drawdown and have not been found in subsequent surveys. Four of these species decreased dramatically after the 1998-99 drawdown and have remained sparse. Three of these species decreased after the 1998-99 drawdown and appear to be coming back. *Nymphaea odorata* decreased after each drawdown, recovering in between. The species that decreased the most, besides the species that disappeared, were *Elodea canadensis* (91-98% decrease in freq., dens., dominance) and *Potamogeton crispus* (80-95%). These species have been known to decrease with drawdown, prefer soft sediments and are turbidity tolerant.

Between 1998 and 2005, 4 species increased in frequency and dominance. Three of these species are known to be tolerant of winter drawdown, these three started increasing after the first drawdown in 1998/99. The largest increase was seen in *Najas flexilis*, a drawdown tolerant – turbidity intolerant species that prefers hard substrate. *N. flexilis* increased seven-fold in frequency, with increases in density and dominance.

The decline of species with a preference for soft substrate and increase to dominant of a species with a preference for hard substrate may also be tied to the winter drawdown. Drawdowns can result in the refocusing of soft sediments to deeper water.

#### IV. DISCUSSION

Based on nutrient and algae concentrations and water clarity, Lake Mallalieu is a eutrophic lake with poor water clarity and quality. Data from 2001 suggest that the lake is nitrogen limited. Filamentous algae occurred at 11% of the sites, abundant in the 0-1.5ft depth zone and common in the 1.5-5ft depth zone.

Abundant nutrients, hard water, large areas of shallow water and the gradually-sloped littoral zone would favor plant growth in Lake Mallalieu. Conversely, plant growth in Lake Mallalieu would be limited where the littoral zone is steeply-sloped, by the poor water clarity and the dominance of hard, high-density sediments (especially within the photic zone). The sediment types favorable to plant growth occur at lower frequencies in Lake Mallalieu and are more dominant in the deeper zones, where light is limiting.

The 2005 Lake Mallalieu aquatic plant community was composed of 15 aquatic plant species and was characterized by low quality, very poor species diversity and a high tolerance to disturbance. The community was farther from an undisturbed condition than the average lake in the state or region. This suggests an above average amount of disturbance has occurred in Lake Mallalieu. Species Richness was 1.03, meaning, on average, there was only slightly more than one species per site.

Aquatic plant growth colonized 49% of the littoral zone, mainly in the east basin, to a maximum rooting depth of 8 feet, less than the predicted maximum rooting depth based on water clarity. The most abundant plant growth occurred in the 0-1.5ft-depth zone. *Najas flexilis*, a drawdown tolerant-turbidity tolerant species with a preference for hard substrate, was the dominant species, especially in the 1.5-5ft depth zone. *N. flexilis* exhibited a growth form of above average density in Lake Mallalieu. *Potamogeton pectinatus* was sub-dominant.

## Changes 1998-2005

There has been a significant change in the aquatic plant community as measured by the Coefficients of Community Similarity. Each study year was significantly different than the previous study, being only 36-61% similar between any two consecutive studies. The 2005 quantitative survey is also significantly different from the first in 1998, but more similar (64%) than any two years, so this may suggest the aquatic plant community is in the process of returning to the 1998 community.

The dominant species changed from coontail, *Ceratophyllum demersum* in 1998, to a species that provides more habitat value (white water lily, *Nymphaea odorata*) in 1999-2001, to *Najas flexilis* (a disturbance tolerant, pioneer species) in 2005. *N. flexilis* is also intolerant of turbidity and an indicator of hard sediment.

Positive changes after the drawdowns:

- 1) Since 1998, the two non-native species have been impacted; *Myriophyllum spicatum* has declined 67-76% in frequency and density and *Potamogeton crispus* has declined 80-95%.
- 2) Emergent vegetation has doubled in its occurrence.

Negative changes after the drawdowns:

These negative impacts were more dramatic after the 6-foot drawdown and currently appearing to be recovering.

- 1) The number of aquatic plant species occurring in Lake Mallalieu has decreased 35%. Twelve species have disappeared, including the 1998 dominant species. This loss of species has resulted in a decrease in the diversity index from very good to very poor and a reduction in Species Richness. These measure have only partially recovered since 1999.
- 2) The percent of the littoral zone that is vegetated decreased dramatically in 1999 but has nearly recovered in 2005.
- 3) The percent of sites that supported submergent vegetation decreased as did the percent of sites that supported free-floating vegetation and floating-leaf vegetation.
- 4) Total occurrence and density of plant growth dropped dramatically in 1999 and has since been gradually recovering.
- 5) The occurrence of filamentous algae increased, especially in the shallowest zone. This may be due to the reduced plant growth, making more nutrients available for algae growth.
- 6) The Floristic Quality Index (FQI) decreased 23%, placing Lake Mallalieu farther from an undisturbed condition than the average lake in Wisconsin and the North Central Hardwood Region.
- 7) The quality of aquatic plant community, as measured by the AMCI decreased.
- 8) *Nymphaea odorata* had decreased after the 6-foot drawdown, had nearly rebounded by 2001 and decreased again, but less dramatically, after the 3-foot drawdown. *N. odorata* has shifted its most abundant growth from the

1.5-5ft depth zone to the 5-10ft depth zone, likely due to freeze damage in the shallow area.

As these measures are all recovering since 1999, this suggests that the 3-foot drawdown either did not have as severe an impact on the plant community or had little impact on the plant community and the community is still recovering from 1999. The community's tolerance to disturbance and the coverage of floating-leaf vegetation (lily pads) are the only measures that decreased after both drawdowns (although less dramatically after the 3-foot drawdown).

The aquatic community in Lake Mallalieu appears to be losing its protecting shoreline buffer zone. Since 1998, the mean coverage of natural shoreline (wooded, shrub and native herbaceous growth) on Lake Mallalieu has decreased and the occurrence and coverage of disturbed shoreline has increased. In 2005, some form of disturbed shoreline occurred at 77% of the sites and covered 37% of the shoreline. One type of disturbed shoreline, cultivated lawn was found at nearly half the sites and covered nearly one-quarter of the shoreline. Wooded cover on Lake Mallalieu decreased.

There are several reasons for concerns about non-natural shorelines. Cultivated lawn increases the run-off of fertilizers and pesticides into the lake. Reducing lawn fertilizers is important because it appears that nitrogen is limited in Lake Mallalieu and the addition of either nitrogen or phosphorus can feed algae blooms. Rip-rap and hard structures also increase run-off to the lake and do not filter the run-off as well as natural buffers.

## V. CONCLUSIONS

Lake Mallalieu is a eutrophic lake with poor water quality and clarity. Filamentous algae has increased since 1998 and is abundant in the shallow depth zones.

The aquatic plant community in Lake Mallalieu is characterized by low quality, very poor species diversity and a high tolerance to disturbance. The plant community indicates that Lake Mallalieu is farther from an undisturbed condition than the average lake in Wisconsin or the North Central Hardwoods Region of the state. Less than half of the littoral zone is vegetated, to the maximum rooting depth of 8 feet. Vegetation is most abundant in the 0-1.5ft depth zone.

*Najas flexilis*, a drawdown tolerant-turbidity tolerant species with a preference for hard substrate, is the dominant plant species in the community, especially in the 1.5-5ft depth zone, exhibiting a growth form of above average density. *Potamogeton pectinatus* is the sub-dominant.

There has been a significant change in the aquatic plant community during 1998-2005. There are indications that the winter drawdowns may be a major factor in the change. These indications are:

- 1) Three of the 4 species that increased in frequency and dominance between 1998 and 2005 are known to be tolerant of winter drawdown. These species started increasing after the first drawdown in 1998/99.
- 2) Of the 12 species disappeared or declined, half of these are known to be intolerant of drawdown. Four of these species disappeared after the 1998-99 drawdown and have not been found in subsequent surveys.
- 3) The two species that decreased the most, besides those that disappeared, have been known to decrease with drawdown, prefer soft sediments and are turbidity tolerant. The most dramatic decreases occurred after the 1998-99 drawdown.
- 4) The dominance has shifted to *Najas flexilis*, a drawdown tolerant species that prefers hard substrate. *N. flexilis* increased seven-fold in frequency, with increases in density and dominance.
- 5) *Nymphaea odorata*, a drawdown intolerant species decreased after each drawdown, recovering in between. Its highest zone has shifted into the deeper waters where a 3-foot drawdown would not impact it.

The positive aspect of the two winter drawdowns are that there was a substantial decrease of the two exotic invasive plant species: *Myriophyllum spicatum* (67-76%) and *Potamogeton crispus* (80-95%).

The changes in the plant community were more dramatic after the 1998-99, 6-foot winter drawdown than the 2004-05, 3-foot winter drawdown. Even though winter drawdown impacts the aquatic plant community, this impact can be lessened by limiting the extent of the drawdown.

## **Benefits of Aquatic Plants**

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 resources for fish and wildlife
- 3) resisting invasions of non-native species
- 4) checking excessive growth of tolerant species that could crowd out more sensitive species and therefore reduce diversity.

### **Improving Water Quality**

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

### **Providing Resources for Fish and Wildlife**

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 13).

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). Mixed stands of plants support 3-8 times as many invertebrates and fish as monocultural stands because diversity in the plant community creates more microhabitats for the preferences of more species (Engel 1990).

Plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990). Cover within the littoral zone should be about 25-85% to support a healthy fishery. The plant growth in Lake Mallalieu in 2001 provided 49% cover within the littoral zone. This amount of plant growth is at the low end of the ideal range.

## **MANAGEMENT RECOMMENDATIONS**

- A. Department to designate Sensitive Areas on Lake Mallalieu to provide additional protection for those areas most important to preserving fish and wildlife habitat and water quality.
- B. Department to conduct an aquatic plant survey in the future to determine long-term impacts of the less severe 3-foot winter drawdown and compare impacts with the 6-foot winter drawdown.
- C. Lake residents encourage the colonization of emergent vegetation. The amount of emergent vegetation in Lake Mallalieu is very low and this lack of emergents could limit fish populations that depend on them for spawning and wildlife that depend on them as food, cover and nesting. Emergent vegetation protects the shorelines from erosion much better than rip-rap. The occurrence of rip-rap has increased since 1999. Emergent species should be planted and any emergents

currently colonizing the lake should be protected.

D. Lake Association to continue with action items outlined in the 2001 management plan. This plan included action items to:

- 1) Improve the water quality in Lake Mallalieu through efforts in the lake and in the watershed.
  - a) Encourage preservation of the natural buffer zones of native vegetation around the lake to protect water quality and wildlife habitat.
  - b) Encourage and provide examples for restoring “disturbed” shoreline around the lake to natural vegetation, which slows nutrient run-off to the lake and more effectively filters the run-off. Currently, more than one-third of the shoreline on Lake Mallalieu is disturbed and natural shoreline has decreased since 1998. Restoration can be as simple as discontinuing mowing the first 30-50 feet of shore or as involved as replacing rip-rap and hard structures with native plantings.
  - c) Educate lake shore owners on eliminating the use of lawn fertilizers on lake shore property around the lake. Data indicates that Lake Mallalieu may be nitrogen limited. This means that inputs of nitrogen via either natural, organic or chemical fertilizers will increase algae and plant growth in the lake.
  - d) Protect wetlands around the lake and in the watershed to preserve habitat and maintain the wetland functions that help maintain water levels and water quality in Lake Mallalieu.
  - e) Cooperate with educational programs in the community regarding nutrient and pesticide management.
  - f) Cooperate with efforts to reduce erosion and run-off in the watershed.
- 2) Protect native submergent vegetation in the lake.
  - a) Educate lake residents and lake users as to the importance of the aquatic plant community to Lake Mallalieu.
  - b) Ensure that the aquatic vegetation is truly causing a nuisance before attempting control.
  - c) Non-selective control of aquatic plants will only make it easier for non-native invasive species to spread throughout the lake.
  - d) If aquatic plant control is needed use chemical treatments as a last resort.
    - 1) Chemical treatments other than selective methods merely knock down plant growth but do not truly kill the plants.
    - 2) Chemical treatments leave the plant material in the lake to decompose. This decomposition has two major impacts. It releases nutrients that feed algae blooms and the bacteria use dissolved oxygen needed by fish.
    - 3) Chemical treatments may result in concerns in the future about ecological side effects of herbicide. This is illustrated by the previous use of Silvex and arsenic. At the time these were applied, these compounds were not considered toxic.
- 3) Eurasian Watermilfoil Monitoring.
  - a) Plant Watch Committee and all residents look for colonies of Eurasian

water milfoil and remove them as soon as possible.

b) Eurasian watermilfoil disappeared after the 1998-99 winter drawdown, but was not completely eliminated in the 2004-05 drawdown. Eurasian watermilfoil will spread and additional colonies can be introduced into the lake via boat trailers or from upstream.

c) The Eurasian watermilfoil will be easier to keep in check if the scattered colonies are pulled as they are found instead of simply waiting until it becomes dense again.

d) If Eurasian milfoil becomes widespread again, Lake Mallalieu Association should plan for a 3-foot winter drawdown.

e) Plan the winter drawdown so that the lake is down by the end of September at the latest to reduce impact to turtles and amphibians.

## **Executive Summary**

Lake Mallalieu is a eutrophic lake with poor water quality and clarity. Filamentous algae is abundant in the shallow depth zones and has increased since 1998.

The aquatic plant community in Lake Mallalieu is characterized by low quality, very poor species diversity and a high tolerance to disturbance. The plant community indicates that Lake Mallalieu is farther from an undisturbed condition than the average lake in Wisconsin or the North Central Hardwoods Region of the state. Less than half of the littoral zone is vegetated, to the maximum rooting depth of 8 feet. Vegetation is most abundant in the 0-1.5ft depth zone.

*Najas flexilis*, a drawdown tolerant-turbidity tolerant species with a preference for hard substrate, is the dominant plant species in the community, especially in the 1.5-5ft depth zone, exhibiting a growth form of above average density. *Potamogeton pectinatus* is the sub-dominant.

There has been a significant change in the aquatic plant community during 1998-2005. There are indications that the winter drawdowns may be a major factor in the change.

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

### **Management Recommendations:**

- 1) Department to designate Sensitive Areas on Lake Mallalieu to provide additional protection for those areas most important to preserving habitat and water quality.
- 2) Department to conduct an aquatic plant survey in the future to determine long-term impacts of the less severe 3-foot winter drawdown and compare impacts with the 6-foot winter drawdown.
- 3) Lake residents protect emergent vegetation, encourage the spread of emergents and plant additional emergent plants.
- 4) Aquatic plant control conducted only if the vegetation is truly at a nuisance level and chemical control used as a last resort.
- 5) Lake Association to continue with action items outlined in the 2001 management plan. This plan included action items to:
  - a) Improve the water quality in Lake Mallalieu through efforts in the lake and in the watershed.
  - b) Preserve the natural buffer zones of native vegetation around the lake to protect water quality and wildlife habitat.
  - c) Restoring "disturbed" shoreline around the lake to natural vegetation
  - d) Educate lake shore owners on eliminating the use of lawn fertilizers on lake shore property around the lake.
  - e) Become involved with efforts in the watershed to protect wetlands around

the lake and in the watershed, educational programs in the community regarding nutrient and pesticide management and efforts to reduce erosion and run-off in the watershed.

- f) Educate lake residents and lake users as to the importance of the aquatic plant community to Lake Mallalieu.
- g) Plant Watch Committee and all residents look for colonies of Eurasian water milfoil and remove them as soon as possible.
- h) If Eurasian milfoil becomes widespread again, Lake Mallalieu Association should plan for a 3-foot winter drawdown.
- i) Plan the winter drawdown so that the lake is down by the end of September at the latest to reduce impact to turtles and amphibians.