Littoral Macrophytes

I. General Ecology
II. Contribution to Productivity
III. Nutrient Utilization
IV. Conesus Lake

Contribute significantly to productivity
Important refuge for young fish and invertebrates
Essential source of detrital material
Stabilize sediments, and buffer wave action

Other aspects of macrophyte ecology
- Emergent species use atmospheric CO$_2$-Carbon, whereas submerged species use HCO$_3$-
- 3-50 % of biomass occurs in underground tissues
- Because of strength of plant tissues and chemical deterrents only 0.5 - 8% is lost to herbivores (waterfowl, fish, some invertebrates)

Community Structure
Species Distribution and Biomass
Not uniform; there is much horizontal variation and some vertical zonation

Maximum depth of the community is determined by the availability of light
II. Contribution to Productivity

Percentage Contribution of Various Producers to annual NPP per m² (Mikolaźjko Lake, Poland)

<table>
<thead>
<tr>
<th>Producer Type</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>LITTORAL</td>
<td></td>
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<tr>
<td>Macrophytes</td>
<td>28%</td>
</tr>
<tr>
<td>Planktonic algae</td>
<td>10%</td>
</tr>
<tr>
<td>Attached Algae</td>
<td>61%</td>
</tr>
<tr>
<td>LITTORAL WITH EMERGENT VEGETATION</td>
<td></td>
</tr>
<tr>
<td>Macrophytes</td>
<td>57.2%</td>
</tr>
<tr>
<td>Planktonic algae</td>
<td>19.6%</td>
</tr>
<tr>
<td>Attached Algae</td>
<td>23.2%</td>
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II. Contribution to Productivity

With only 0.5-8% utilized by herbivores, what is the fate of the macrophyte biomass in the lake ecosystem?

Many species are annuals; others overwinter as rhizomes, some remain active throughout.

II. Contribution to Productivity

Appearance of milfoil plants during enclosure experiments

III. Nutrient Utilization

Are roots important to nutrient uptake?

Are the sediments or the water column the primary source of P and N?
The relative importance of water P and hydrosoil P depends on water P concentration.

Conclusions about rooted macrophytes:
- They are abundant and productive in the shallow water of lakes.
- They are not readily eaten by herbivores but contribute to the nutrient budget of lakes as they decay or as detritus.
- Having a vascular system, they absorb nitrogen (NH$_4$ and NO$_3$) as well as PO$_4^{2-}$ from sediments via the root system and from the water column via the foliage.
- When nutrient supplies in the sediment are limiting to growth or when nutrient concentrations are higher in the water column, foliar absorption may be relatively important to growth.
- Possible that management of nutrient loading could reduce biomass.

<table>
<thead>
<tr>
<th>Year</th>
<th>DW/N</th>
<th>N addition</th>
<th>1982</th>
<th>1983</th>
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<tbody>
<tr>
<td>82</td>
<td>120%</td>
<td>100%</td>
<td>110%</td>
<td>120%</td>
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<tr>
<td>83</td>
<td>140%</td>
<td>115%</td>
<td>135%</td>
<td>125%</td>
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</table>

N supplies were limiting to growth and nutrient enhancement increased biomass production.

IV. Interactions of the dominant inshore and offshore plants

Two systems, the nearshore dominated by macrophytes and the offshore dominated by phytoplankton interact through nutrient utilization, light competition, and wave plume. Water turbidity is a function of phytoplankton abundance and limits the depth of macrophyte habitation.
Lakes with larger cover of macrophytes (red) tend to have a higher transparency than lakes with the same nutrient status but in which vegetation is sparse.

Can any single lake shift from one state to another?

Mathematical model by Scheffer et al.

- Front picture represents the stability properties at a different nutrient status.
- Rear picture represents a hypertrophic condition in which just one turbid equilibrium exists.
- Between extremes, the lake can exist in alternate stable states. Nutrient reductions can alter the balance, but a radical change is necessary to bring about a shift.

Is there evidence in support of this model?

Some examples of switching, triggered by:
- Changes in water levels that favor macrophytes
- Biomanipulation (planktivore fish removal)

What are the implications of this model to management?

Review of paper by Bin Zhu et al.

Alteration of Ecosystem Function by Zebra Mussels in Oneida Lake: Impacts on Submerged Macrophytes

B. Zhu, D. C. Fitzgerald, C. M. Meyer, L. G. Redfearn, and E. L. Miller

Department of Biology, Syracuse University, USA; Lake Erie Research, USA; Lake Erie Research, USA; University of Toronto, Canada

Table 1. Submerged Macrophyte Species Diversity and the Frequency of Dominance (%)

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Note: Data collected during the summer months from 1974 to 1981. Percentage values indicate the frequency of each species in the community.
Strategies for Control of Macrophyte Growth: Case study in Conesus Lake

Watershed Includes land from Conesus, Geneseo, Groveland, Livonia, Sparta, and Springwater. Two public water supply systems (Geneseo and Avon) serving about 15,000 people draw water from the Lake.

II. Littoral Macrophytes

List of Characteristics based on reading of Smith and Barko:

- Weed growth
- Algae and loss of clarity
- Pathogen indicators (coliform bacteria)
- Pesticides
- Increasing chloride (salt) concentrations

Conesus Lake Watershed Management Process

Lake Characterization Report: Lake Issues

- Weed growth
- Algae and loss of clarity
- Pathogen indicators (coliform bacteria)
- Pesticides
- Increasing chloride (salt) concentrations

Priority Waterbodies Listing for Conesus Lake

<table>
<thead>
<tr>
<th>Affected Use</th>
<th>Severity</th>
<th>Pollutant Type</th>
<th>Pollutant Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swimming and Boating</td>
<td>Impaired</td>
<td>Excess macrophyte</td>
<td>Nutrients and sediment</td>
</tr>
<tr>
<td>Water Supply</td>
<td>Threatened</td>
<td>Turbidity</td>
<td>Nutrients and sediment</td>
</tr>
<tr>
<td>Fishing and Aesthetics</td>
<td>Discouraged</td>
<td>Turbidity</td>
<td>Freshwater changes</td>
</tr>
</tbody>
</table>

NYSDEC Scale of Increasing Severity

- Threatened
- Stressed
- Impaired
- Healthy

On USEPA 303d list of impaired lakes; could some day impose TDML Restrictions

D. Interactions of the dominant inshore and offshore plants

Two systems, the nearshore dominated by macrophytes and the offshore dominated by phytoplankton

Interact through nutrient utilization, light competition

Maximum Density of Macrophytes Has Shifted to Shallower Water

Source: Bosch et al. 2000
Community Diversity in 1999

Community Diversity 1976

Chemical Control
Only six chemicals approved in New York State

Fluridone (Sonar) - slow acting systemic herbicide; milfoil more susceptible; dose dependent effect

Glyphosate (Rodeo Roundup) - contact and systemic; low toxicity, non-selective; must be sprayed

Endothall (Aquathol) - faster contact herbicide, mildly toxic at low concentrations; non-selective

2,4 D - systemic herbicide for leafed plants toxic on aquatic fauna

Copper Sulfate - copper toxicity

Diquat Dibromide - fast acting, nonselective contact herbicide

Fatal if swallowed, toxic at contact

Introduction of Herbivores

Triploid grass carp

(Hypophthalmichthys nobilis)

Herbivore Control: Weevil

Acentra ephemerella

Milfoil moth
Experimental Manipulation of Entire Watersheds through BMPs: Nutrient Fluxes, Fate and Transport and Biotic Responses

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Livingston County Planning Department
Livingston County Farm Service
Example of reduced nutrient loading achieved by watershed-level agricultural management

Agricultural Management
- Strip Cropping
- Nutrient Management
- Diversion Ditches
- Terrace Systems
- Buffer Strips
- Sub-Surface Drainage
- Manure Storage Facility

Anticipated Reductions
1 - 2 years
- Soil/nutrient loss
- Microbial contaminants
2 - 3 years
- Algal mats
> 3 yrs
- Weed beds

Total milfoil biomass in the 2-3 m depth zone of maximum growth before and after implementation of agricultural BMPs upstream.