Lake and Reservoir Dynamics

Dan Obrecht – UMC
obrechtd@missouri.edu
Talk Topics

• Nonpoint source pollution
  – Most common pollutants and how they impact water quality
  – Most common sources

• Variability
  – Regional Trends?
  – Spatial and Temporal variation

• Thermal Patterns (briefly)
Most common pollutants:
Most common pollutants:

- Nutrients
- Metals
- Suspended Sediment
Most common pollutants:
- Nutrients
- Metals
- Suspended Sediment
Proposed 2004/2006
303(d) Impaired Waters
List

Lead – 1 lake

(Mercury?)
Most common pollutants:
- Nutrients
- Metals
- Suspended Sediment
PHOSPHORUS & NITROGEN
Missouri Lakes –
Phosphorus vs Algal Biomass

![Graph showing the relationship between phosphorus and algal biomass in Missouri Lakes.](image)
Missouri Lakes –
Nitrogen vs Algal Biomass

![Graph showing the relationship between Nitrogen concentration (mg/L) and Algal Biomass (Chl ug/L) in Missouri Lakes. The graph is a scatter plot with a logarithmic scale on both axes, indicating a positive correlation between the two variables.]
Algae are the base of the aquatic food web and supply dissolved oxygen to the water.
Excessive algae can:

- Decrease recreational value
- Cause extreme dissolved oxygen fluctuations
- Increase treatment cost
- Reduce water clarity
Most common pollutants:

- Nutrients
- Metals
- Suspended Sediment
Suspended sediment can:

- Fill in lake bottom
- Impact substrate habitat
- Increase cost to treat
- Reduce water clarity
Secchi Disk
Secchi Disk

MO values
Average ~39”
Minimum = 3”
Maximum >360” (30 FEET!)
Leading sources:

- Agriculture
- Municipal point sources
- Urban runoff
Agriculture

Source of both nutrients and sediment
Municipal Point
Source

Source of nutrients
Most lakes in Missouri do not have Sewage Treatment Point Sources in their watershed.
Urban Runoff

Source of both nutrients and sediment
Regional Patterns?
### Average Values
(for physiographic regions)

<table>
<thead>
<tr>
<th>Region</th>
<th>Sediment (mg/L)</th>
<th>Phosphorus (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glacial Plains</td>
<td>6.8</td>
<td>44</td>
</tr>
<tr>
<td>Osage Plains</td>
<td>16.5</td>
<td>73</td>
</tr>
<tr>
<td>Ozark Border</td>
<td>4.5</td>
<td>40</td>
</tr>
<tr>
<td>Ozark Highlands</td>
<td>2.1</td>
<td>17</td>
</tr>
</tbody>
</table>
Long-term average phosphorus for six Glacial Plains lakes

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>TP (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maysville (n=10)</td>
<td>182</td>
</tr>
<tr>
<td>Grindstone (n=5)</td>
<td>147</td>
</tr>
<tr>
<td>Unionville (n=10)</td>
<td>98</td>
</tr>
<tr>
<td>Long Branch (n=20)</td>
<td>48</td>
</tr>
<tr>
<td>Viking (n=16)</td>
<td>26</td>
</tr>
<tr>
<td>Forest (n=19)</td>
<td>23</td>
</tr>
</tbody>
</table>
Missouri Lakes
Forest vs. Phosphorus

Total Phosphorus (µg/L)

Amount of Forest in the Watershed

Low Medium High
Missouri Lakes – Row Crop vs Phosphorus

Total Phosphorus (µg/L)

Amount of Row Crop in the Watershed

Low
Medium
High
<table>
<thead>
<tr>
<th>Reservoir</th>
<th>TP (µg/L)</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maysville (n=10)</td>
<td>182</td>
<td>25%</td>
</tr>
<tr>
<td>Grindstone (n=5)</td>
<td>147</td>
<td>55%</td>
</tr>
<tr>
<td>Unionville (n=10)</td>
<td>98</td>
<td>21%</td>
</tr>
<tr>
<td>Long Branch (n=20)</td>
<td>48</td>
<td>34%</td>
</tr>
<tr>
<td>Viking (n=16)</td>
<td>26</td>
<td>15%</td>
</tr>
<tr>
<td>Forest (n=19)</td>
<td>23</td>
<td>3%</td>
</tr>
</tbody>
</table>
Volume / Inflow = Residence Time (years)

- Outflow 50
- Inflow 50
Volume 100
RT = 2 years

- Outflow 100
- Inflow 100
Volume 100
RT = 1 year

- Outflow 200
- Inflow 200
Volume 100
RT = 0.5 years
<table>
<thead>
<tr>
<th>Reservoir</th>
<th>TP (µg/L)</th>
<th>Crop</th>
<th>Res. Time (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maysville (n=10)</td>
<td>182</td>
<td>25%</td>
<td>2.9</td>
</tr>
<tr>
<td>Grindstone (n=5)</td>
<td>147</td>
<td>55%</td>
<td>6.3</td>
</tr>
<tr>
<td>Unionville (n=10)</td>
<td>98</td>
<td>21%</td>
<td>6.3</td>
</tr>
<tr>
<td>Long Branch (n=20)</td>
<td>48</td>
<td>34%</td>
<td>10.5</td>
</tr>
<tr>
<td>Viking (n=16)</td>
<td>26</td>
<td>15%</td>
<td>70.6</td>
</tr>
<tr>
<td>Forest (n=19)</td>
<td>23</td>
<td>3%</td>
<td>32.4</td>
</tr>
</tbody>
</table>
Temporal Variability
Longview Lake – Seasonal patterns

Phosphorus and Chlorophyll (µg/L) vs Total Nitrogen (µg/L) from May to September.

- Phosphorus
- Chlorophyll
- Nitrogen

May: Phosphorus and Chlorophyll reach their peak.
June: Chlorophyll remains high, while Phosphorus and Nitrogen decrease.
July: Nitrogen decreases further, Chlorophyll starts to decline.
August: Phosphorus and Chlorophyll continue to decrease, Nitrogen stabilizes.
September: Phosphorus and Chlorophyll continue to decrease, Nitrogen remains stable.
Lake Jacomo - Chlorophyll Values

- Hypereutrophic
- Eutrophic
- Mesotrophic
- Oligotrophic


Chlorophyll (µg/L)
Spatial Variability

(Individual Lake)
Lake of the Ozarks – Average phosphorus values ($\mu$g/L)
Table Rock Lake – Average phosphorus values (µg/L)
Longview Lake – Average phosphorus values (ug/L)

930 acres

Approximately 1 mile between the two sites.
### Vertical Variability

<table>
<thead>
<tr>
<th></th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lake Surface</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>$= 10 \mu g/L$</td>
<td>$= 21 \mu g/L$</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>$= 260 \mu g/L$</td>
<td>$= 330 \mu g/L$</td>
</tr>
<tr>
<td><strong>Lake Bottom</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>$= 63 \mu g/L$</td>
<td>$= 94 \mu g/L$</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>$= 420 \mu g/L$</td>
<td>$= 570 \mu g/L$</td>
</tr>
</tbody>
</table>
Stratification and Turnover
Thanks