Maine’s Lake Vulnerability Index: The Past to the Future

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Maine Lake Vulnerability Index: The Past to the Future

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Introduction

- Maine is a lake-rich state
  - GIS – 33,000 lakes & ponds
  - > 10 acres - ~2,700
  - ~1,900 – managed by IF&W
- Lake Trophic State
  - Oligotrophic – low nutrients, high transparency
  - **Mesotrophic** – moderate nutrients & transparency
  - Eutrophic - high nutrients, low transparency
Lake Succession

- Oligotrophy to Eutrophy
- Thousands of years – geologic time
- Anthropomorphic acceleration
  - Timing depends on many factors including
    - Size
    - Depth
Lake Class GPA

- Suitable for fishing, swimming, etc.
- Stable or decreasing trophic state
- Habitat as naturally occurs
Historical Context

- Mid-1900s – nutrients linked to lake eutrophication
- Maine – Sebasticook ‘tipped’
- Point source & Agriculture
Lake Science - Eutrophication

- Caused by excess nutrients (P)
- Early Model
  - $\text{Phos}_{(\text{lake})} = \text{Phos}_{(\text{input})} - \text{Phos}_{(\text{sed})}$
- Vollenweider and others

\[
P = 0.368 \times \frac{L}{Z_p} \times \frac{1}{1+1/\sqrt{p}}
\]

- $P$ = in-lake total phosphorus concentration (mg/l)
- $L$ = areal phosphorus load (lbs/ac/yr)
- $Z$ = mean depth of lake (feet), and
- $p$ = the flushing rate in times (per year)
Political Scene

- 1970 – DEP established
- 1971 – VMP born
- 1972 - Muskie – Clean Water Act
- 1976 – EPA Clean Lakes Prg
- 1980 – BEP considers P
Maine Lake Protection Born

- Mid-1980s – Jeff Dennis applying the Vollenweider model to Maine Lakes
- Developed method to review development in lake watersheds
- 1997 – Stormwater Law
• Peter Lowell – Long Lake Watershed Study, Handbook for long-term lake protection

• Scott Williams – Watershed Survey method, first used on China Lake
China Lake ‘tipping’

- Non-point sources
- Extensive metaphyton along east shore
- Internal recycling
DEP – Reference Lake Study

- 1996
- ~100 lakes in undeveloped areas
- Deep enough to stratify
- Some with low dissolved oxygen
- A subset of which were not releasing P from sediments
Why?
Geochemistry?

• Dr. Steve Norton
• Dr. Aria Amirbahman
PO₄³⁻ + Fe²⁺ \rightleftharpoons \text{ANOXIA} \rightarrow Fe(OH)_3 \cdot PO₄

The Ferrous Wheel

Lake water/ Hypolimnion

Sediment

Courtesy of G. W. G. Ferris, 1882
Sequential Extraction

1 M NH₄Cl @ pH 7

Sediment

Residue

0.1 M Na₂S₂O₃/NaHCO₃

Residue

0.1 M NaOH 25°C

Digestion

NaOH-TP - NaOH-rP = NaOH-nrP

Al-P

Org./Bact.-P

Labile

Fe-P

Ca-P

0.5 M HCl

Residue

1 M NaOH 85°C

Residue

Refractory-P

Modified after Psenner
Aluminum

- Critical ratios – no P release
  \[ \text{Al:Fe} > 3:1 \]
  \[ \text{Al:P} > 25:1 \]

Based on Fitzgibbon, 2016. Data from DEP, LEA and UM.
Independent parameters: sediment reducible P, Schmidt Stability, Adjacent Ag:LA ratio, $r^2=0.771$.

Source: Fitzgibbon and Amirbahman, 2016
Lake Auburn

Historically oligotrophic – clear with low nutrients
• Extreme weather events
  • 2011 – Hurricane Irene
  • 2012 – late June 8” over 24-36 hrs
  • Severe erosion

• Gloeotrichia echinulata
The goals of surveys and focus groups

- Build a profile of citizen-stewards
- Examine what monitoring/stewardship activities are typically conducted across lakes
- Examine factors that influence residents’ involvement in lake stewardship
- Understand factors contributing to effective stewardship and active lake associations
The surveys & focus groups

• Responses from 28 unique lake/pond associations
  56% of lakes/ponds included in study
  Total: 267 respondents

• Focus Groups
  • Two focus groups sessions

• Analysis
  Qualitative content analysis
  Descriptive analysis
Respondent profile from survey data

Responded: 261

Respondents –
Male: 57%
Female: 43%

Highest Level of Education

- GRADUATE/PROFESSIONAL DEGREE: 49.8%
- BACHELORS DEGREE: 29.5%
- SOME COLLEGE: 14.6%
- HIGH SCHOOL/GED: 4.6%
- SOME HIGH SCHOOL: 0.4%

Average annual income

- > $100,000: 45.1%
- $75,000 – $100,000: 19.4%
- $50,000 – $75,000: 20.9%
- $30,000 – $50,000: 9.2%
- < $30,000: 5.3%

Responded: 206
Respondent profile from survey data

Retired: 45% - Working: 55%
Primary residence along lake: 39% Yes – 61% No

Respondents age range

- 71 OR OLDER: 21.5%
- 61 - 70: 35.0%
- 51 - 60: 28.5%
- 41 - 50: 8.5%
- 31 - 40: 3.5%
- 18 - 30: 3.1%

 Responded: 260
Citizen scientist or citizen steward?

- Other (Please Specify): 20%
- Data Collection: 9%
- Citizen Science: 7%
- Environmental Stewardship: 60%
- Community Service: 33%
- Volunteerism: 44%

Responded: 186
## Lake Association Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Elects officers to different positions</td>
<td>94%</td>
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<tr>
<td>Circulates regular newsletter annually</td>
<td>92%</td>
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<tr>
<td>Engages in regular water quality monitoring of the lake</td>
<td>91%</td>
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<tr>
<td>Holds regular meetings</td>
<td>85%</td>
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<tr>
<td>Engages in environmental monitoring of the lake and proximity</td>
<td>83%</td>
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<tr>
<td>Engages in regular invasive species monitoring around lake</td>
<td>83%</td>
</tr>
<tr>
<td>Coordinates lake monitoring activities with VLMP and other organizations or conservation groups</td>
<td>82%</td>
</tr>
<tr>
<td>Plans/coordinates responses to relevant lake issues</td>
<td>80%</td>
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<tr>
<td>Invites speakers about lake issues to meetings</td>
<td>73%</td>
</tr>
<tr>
<td>Conducts occasional educational sessions or workshops for association members</td>
<td>58%</td>
</tr>
<tr>
<td>Holds community events for members</td>
<td>51%</td>
</tr>
</tbody>
</table>

Responded: 208
Primary concerns for your lake association

- **INVASIVE SPECIES**: 94%
- **WATER QUALITY TRENDS**: 90%
- **SHOREFRONT DEVELOPMENT ACTIVITIES**: 66%
- **LAKE USAGE ACTIVITIES BY NON-RESIDENTS**: 47%
- **LAKE USAGE ACTIVITIES BY RESIDENTS**: 45%
- **INCREASED DEVELOPMENT IN WATERSHED**: 39%
- **CLIMATIC SHIFTS ON LAKE CONDITIONS**: 36%
- **LIMITED FUNDING - LAKE STEWARDSHIP ACTIVITIES**: 22%
- **RESIDENTS UNCONCERNED ABOUT THE LAKE**: 10%
- **TOURISM IMPACTS**: 10%
- **MINIMAL TO NO STEWARDSHIP ACTIVITIES**: 5%

Responded: 205
Motivation to participate

1. I AM CONCERNED ABOUT THE HEALTH OF THE LAKE: 4.74
2. I HAVE A DEEP PERSONAL ATTACHMENT TO THE LAKE: 4.65
3. HELPS MAINTAIN THE CURRENT STATE OF THE LAKE: 4.50
4. IT GIVES ME A DEEP SENSE OF PERSONAL SATISFACTION: 4.21
5. HELPS INDIRECTLY MAINTAIN LAKE FRONT PROPERTY VALUES: 4.08
6. I HELP MONITOR AN IMPORTANT RESOURCE FOR MAINE: 4.08
7. KEEPS ME INVOLVED WITH MY LAKE COMMUNITY: 4.04
8. I CAN CONTRIBUTE TO LAKE MANAGEMENT DECISIONS: 3.95
9. I MEET LIKE-MINDED PEOPLE: 3.93
10. KEEPS ME BUSY AND ACTIVE: 3.57
11. IT HELPS INDIRECTLY MAINTAIN TOURISM REVENUE: 3.45

Likert scale (1-5) weighted mean

Responded: 200
Factors critical to supporting long-term stakeholder involvement in lake stewardship - content analysis themes

- Volunteer Recognition: 5.47%
- Seeing results of actions taken: 7.81%
- More funding for activities: 10.16%
- Strong/present leadership/lake associations: 11.72%
- Continued attention to monitoring & control of invasives: 16.41%
- Role of property owners as stewards: 17.97%
- Maintaining/increasing lake association membership: 17.97%
- Communication/collaboration with members & partners: 21.88%
- Creation of a positive/active volunteer community: 21.88%
- Continued attention to water quality & monitoring: 28.13%
- Education/community outreach: 46.09%
Survey analysis

- Levels of commitment vary
- Education, communication, and outreach
- Building social capital (self organizing; nested relationships/networks)
- Deliberative and collaborative efforts
- Involvement of younger generation
- Role of supporting institutions
Lake Vulnerability is Complex

- Lakes are not static features
- Lakes are on a trajectory
- Point sources are not a big problem in Maine
- Land use contributes to non-point sources
- Morphology, Geochemistry and Extreme Weather control the natural trophic state of lakes
- Land use and associated pollution can modify this
- Local stewardship is key to lake protection
Lake Vulnerability Considerations

- Many factors contribute to ‘tipping’ points
- Most often lots of somewhat unseen changes result in what looks like a ‘tipping point’
- What causes one lake to ‘tip’ is likely very different than what will cause another to ‘tip’
- Lakes must be considered individually
- Monitoring is essential to track the rate of change in lakes
Inherent Factors
Factors we can control

Extreme weather presents our greatest challenge!
Thus,
We expect that the Vulnerability Index 2.0 will have two layers:

- Inherent aspects
  - Morphometric
  - Geochemical
- ‘Social’ qualifiers
  - Checklist of protection activities
  - Other
Thank you…
Questions?