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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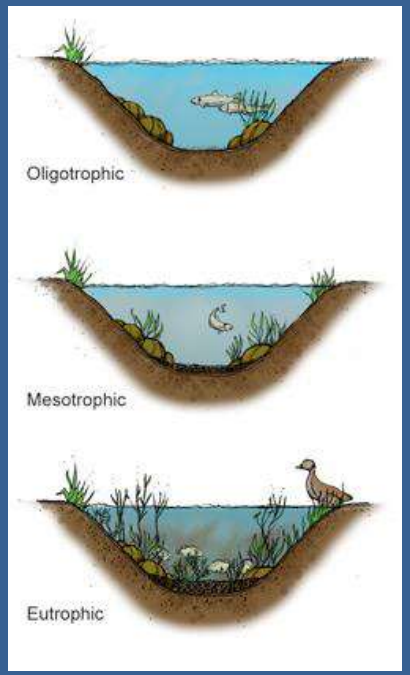
Maine Volunteer Lake Monitoring Program

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
  - Phos $_{(lake)}$ = Phos $_{(input)}$ – Phos $_{(sed)}$
- Vollenweider and others

$$P = 0.368 \times \frac{L}{Zp} \times \frac{1}{1+1/\sqrt{p}}$$

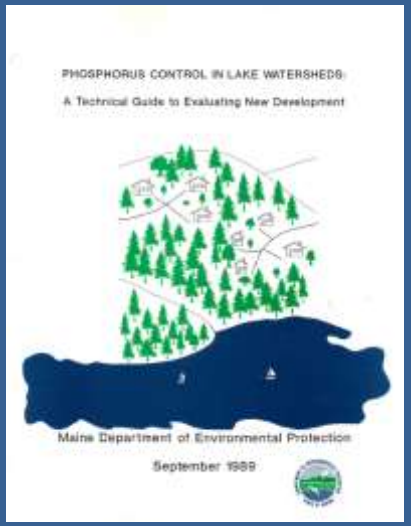
0.368 = conversion factor
P = in-lake total phosphorus concentration (mg/l)
L = areal phosphorus load (lbs/ac/yr)
Z = mean depth of lake (feet), and
p = the flushing rate in times (per year)

Political Scene

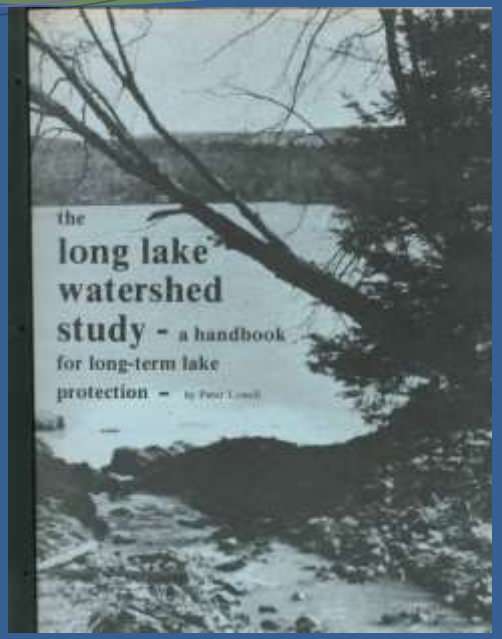
- 1970 – DEP established
- 1971 – VMP born
- 1972 - Muskie – Clean Water Act
- 1976 – EPA Clean Lakes Prg
- 1980 – BEP considers P

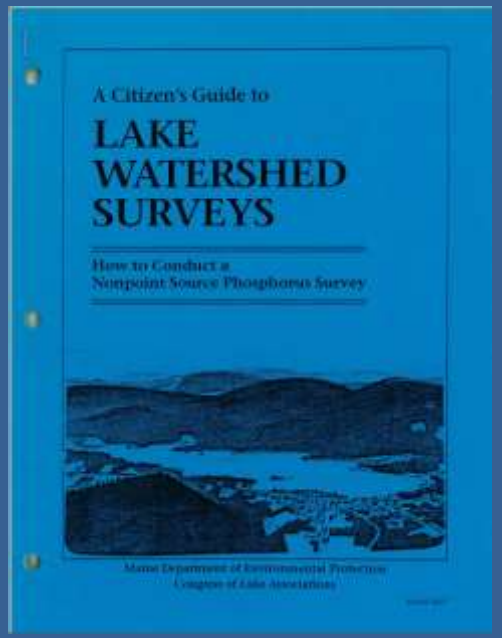
Maine Lake Protection Born

- 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’

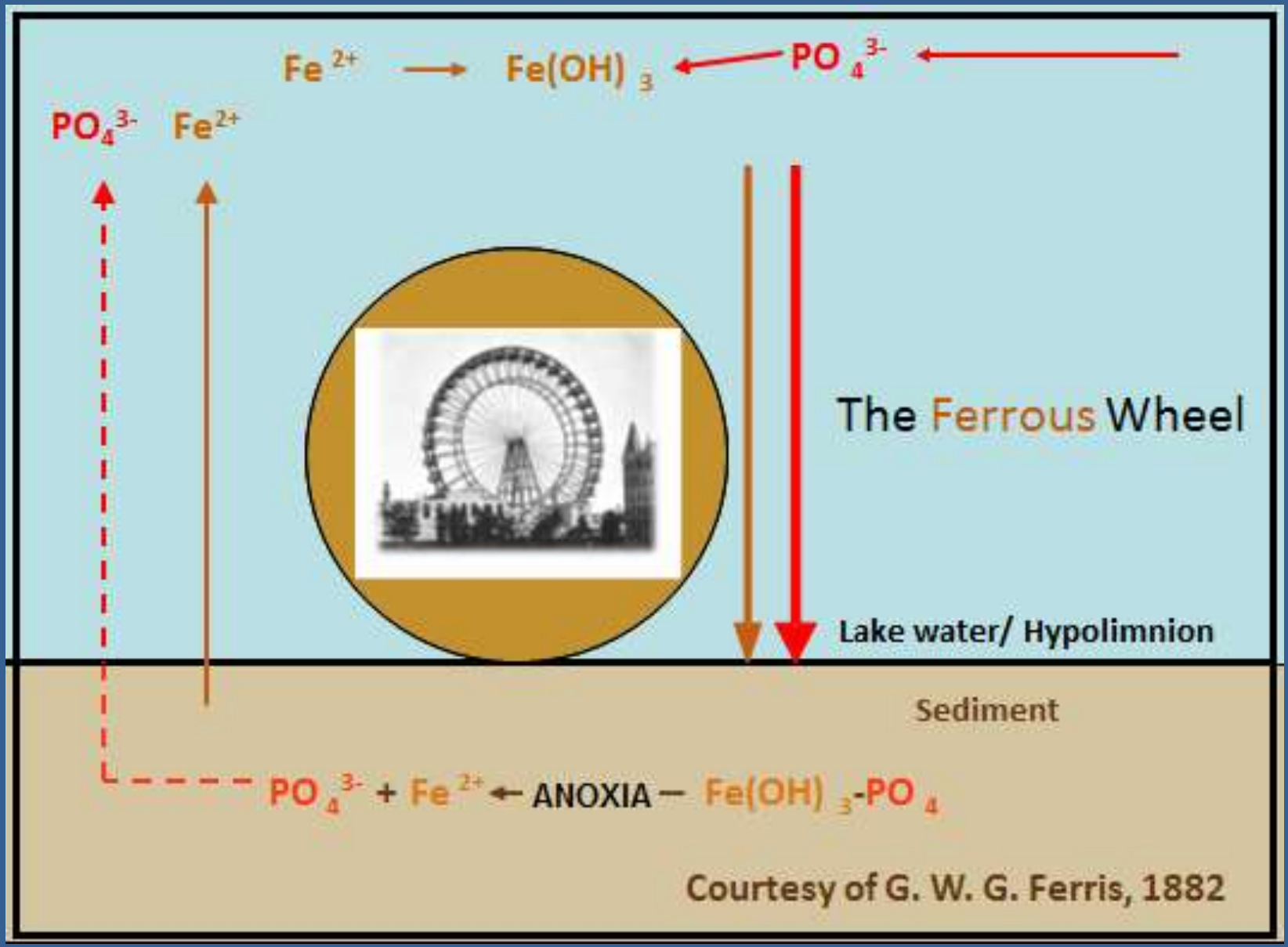
- Non-point sources
- Extensive metaphyton along east shore
- Internal recycling

DEP – Reference Lake Study

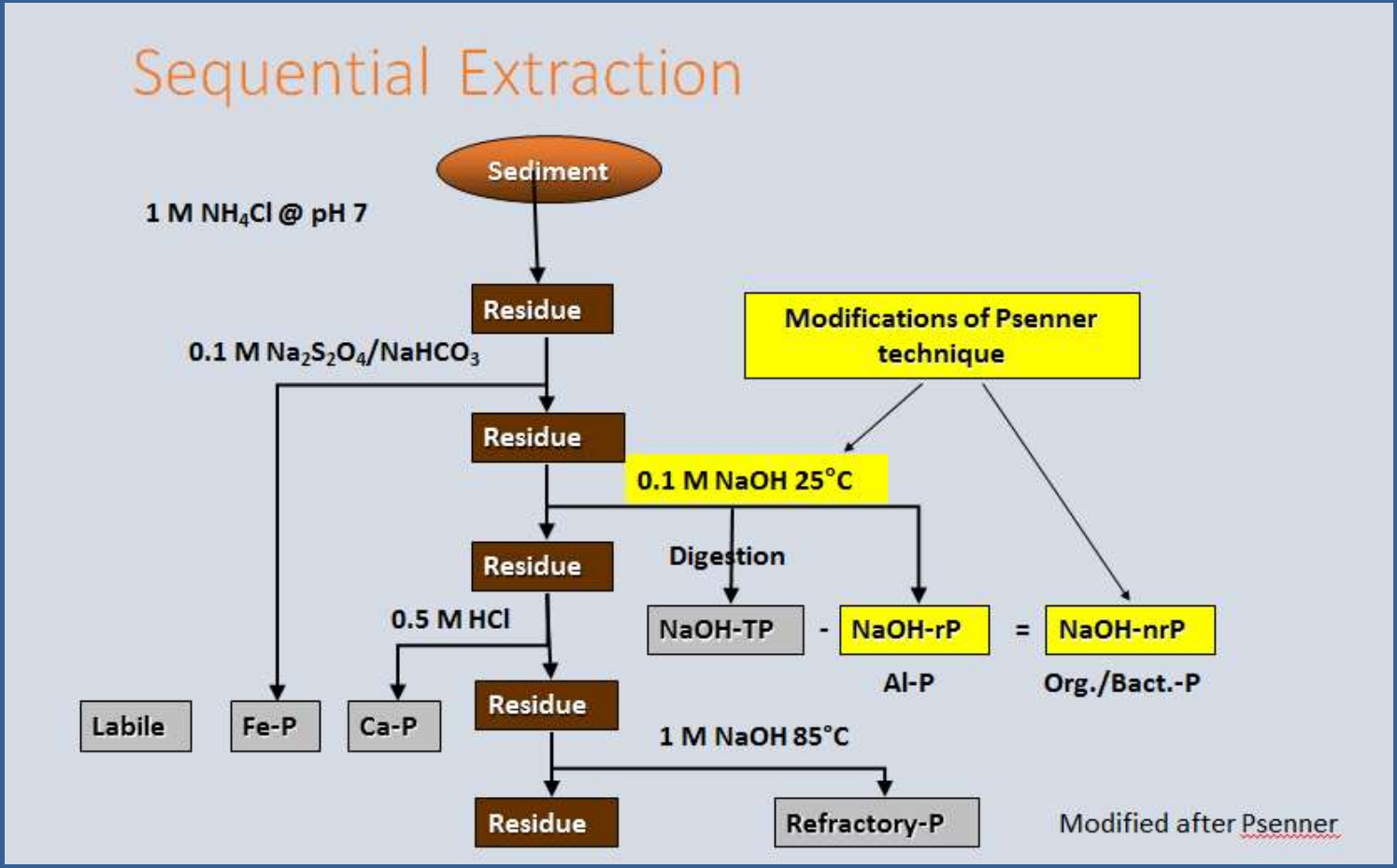
- 1996
- ~100 lakes in undeveloped areas
- Deep enough to stratify
- Some with low dissolved oxygen
- A subset of which were not releasing P from sediments

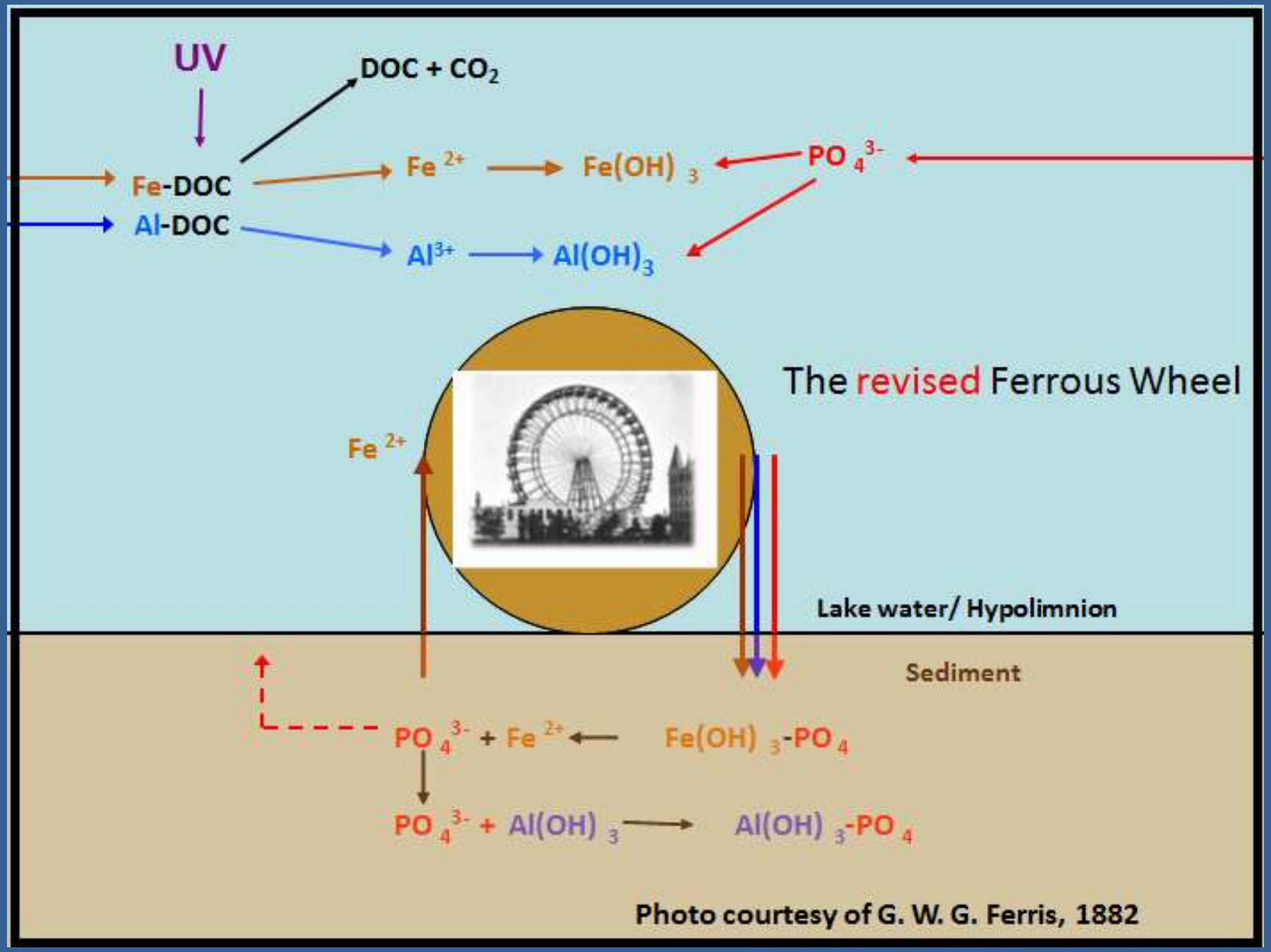
Why? Geochemistry?

- Dr. Steve Norton
- Dr. Aria Amirbahman


Fe 2+
Fe(OH) 3
PO 4 3-
PO4 3-
Fe2+
The Ferrous Wheel
Lake water/ Hypolimnion
Sediment
PO 4 3- + Fe 2+ ANOXIA Fe(OH) 3-PO 4
Courtesy of G. W. G. Ferris, 1882

Sequential Extraction

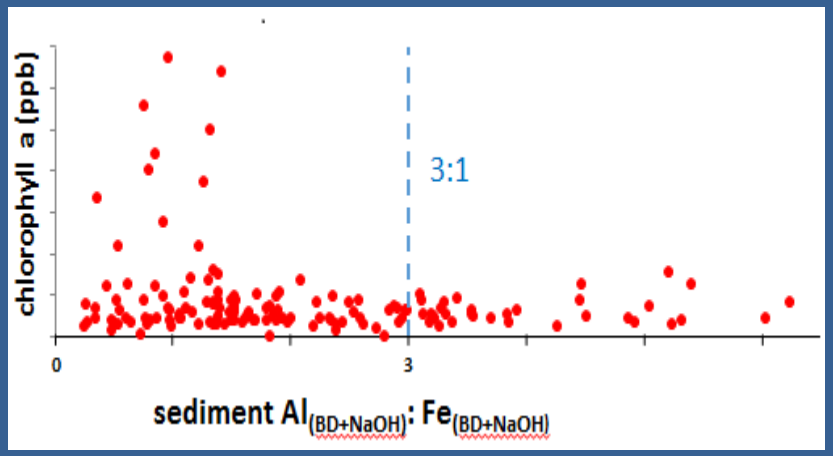



UV
DOC + CO_2
Fe-DOC
Al-DOC
Fe^{2+}
$Fe(OH)_3$
PO_4^{3-}
Al^{3+}
$Al(OH)_3$
The revised Ferrous Wheel
Fe^{2+}
Lake water/ Hypolimnion
Sediment
PO_4^{3-} + Fe^{2+}
$Fe(OH)_3$-PO_4
PO_4^{3-} + $Al(OH)_3$
$Al(OH)_3$-PO_4
Photo courtesy of G. W. G. Ferris, 1882

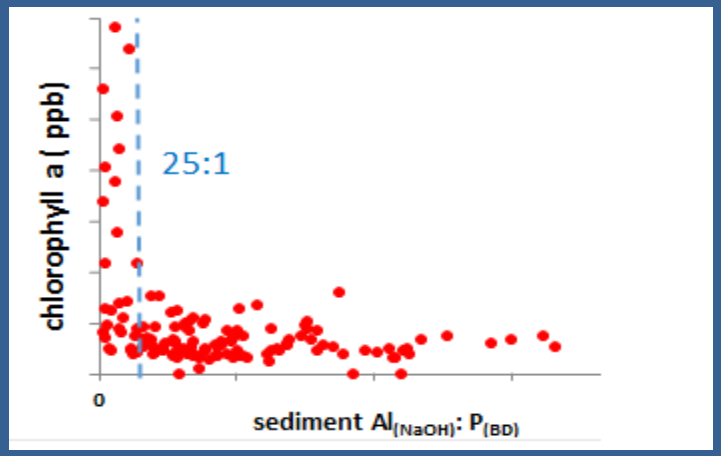
Aluminum

- Critical ratios – no P release

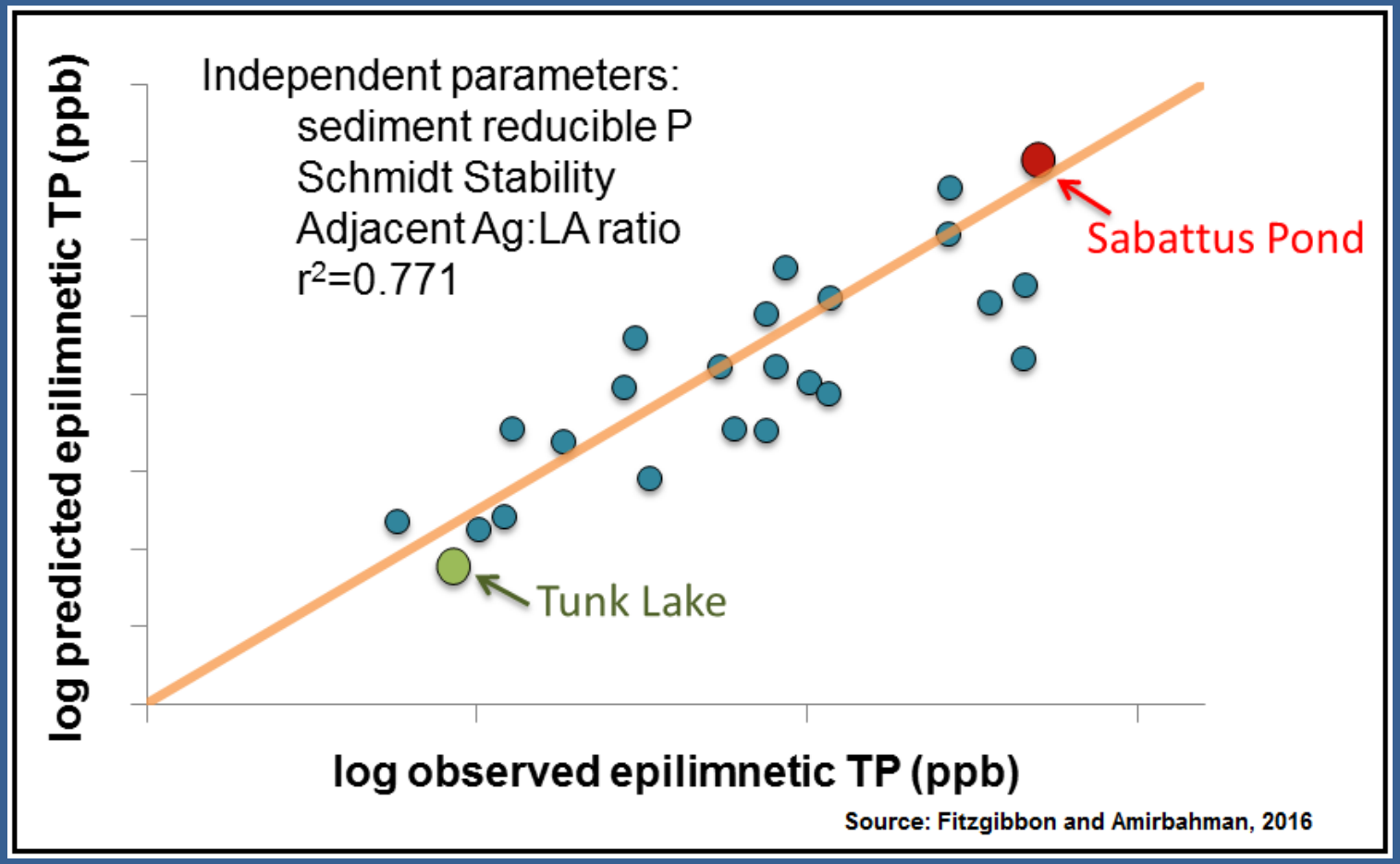
Al:Fe>3:1



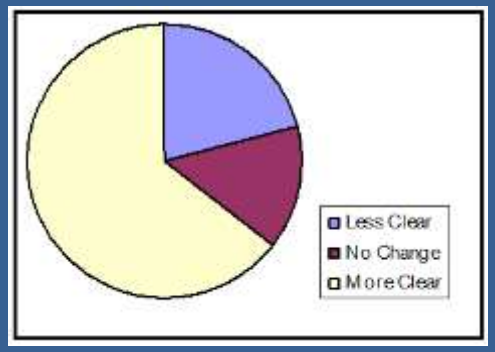
Al:P>25:1

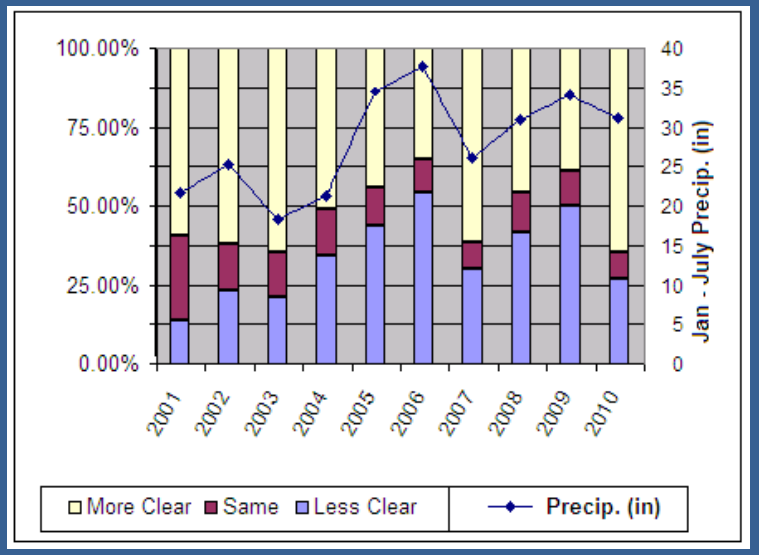


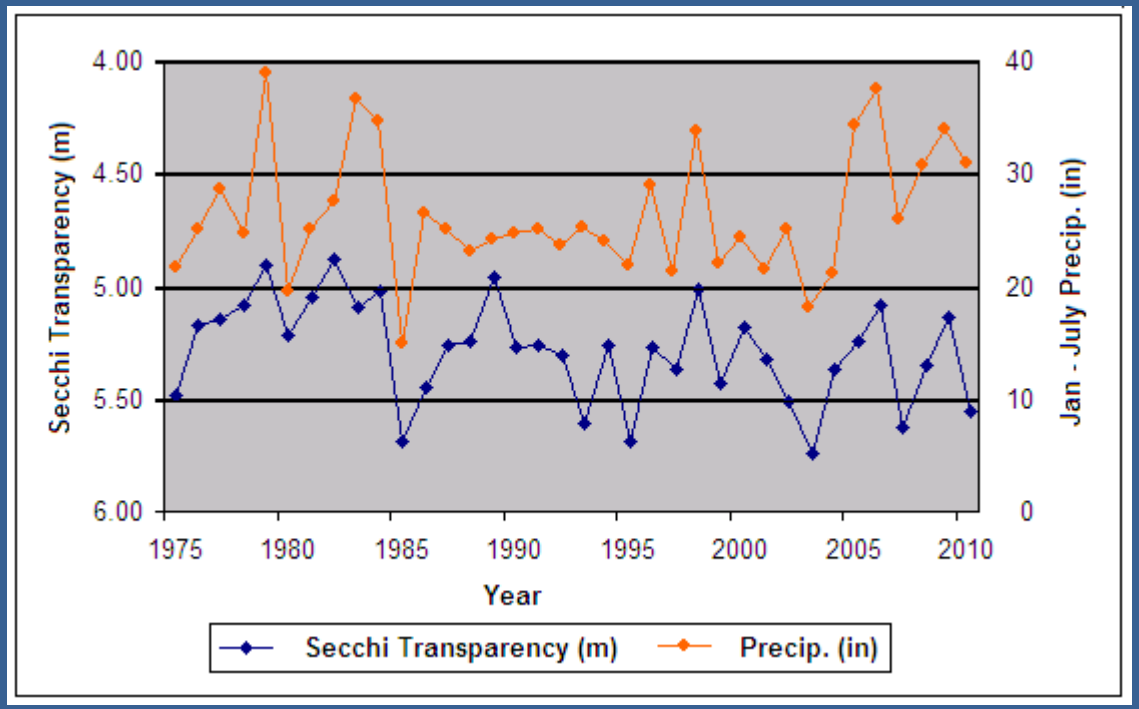
Based on Fitzgibon, 2016. Data from DEP, LEA and UM.


Independent parameters:
sediment reducible P
Schmidt Stability
Adjacent Ag:LA ratio
r²=0.771
Sabattus Pond
Tunk Lake
log predicted epilimnetic TP (ppb)
log observed epilimnetic TP (ppb)
Source: Fitzgibbon and Amirbahman, 2016

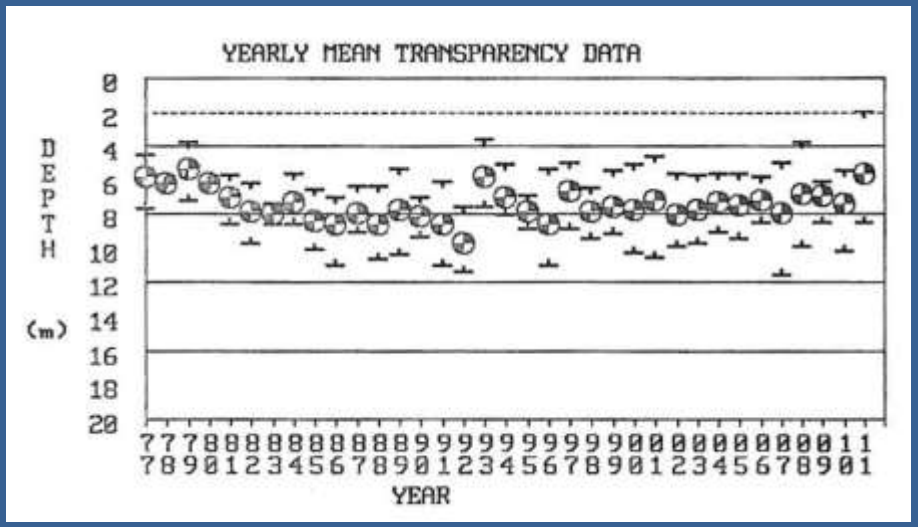
Precipitation





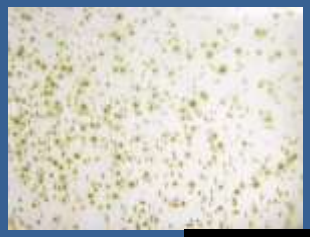


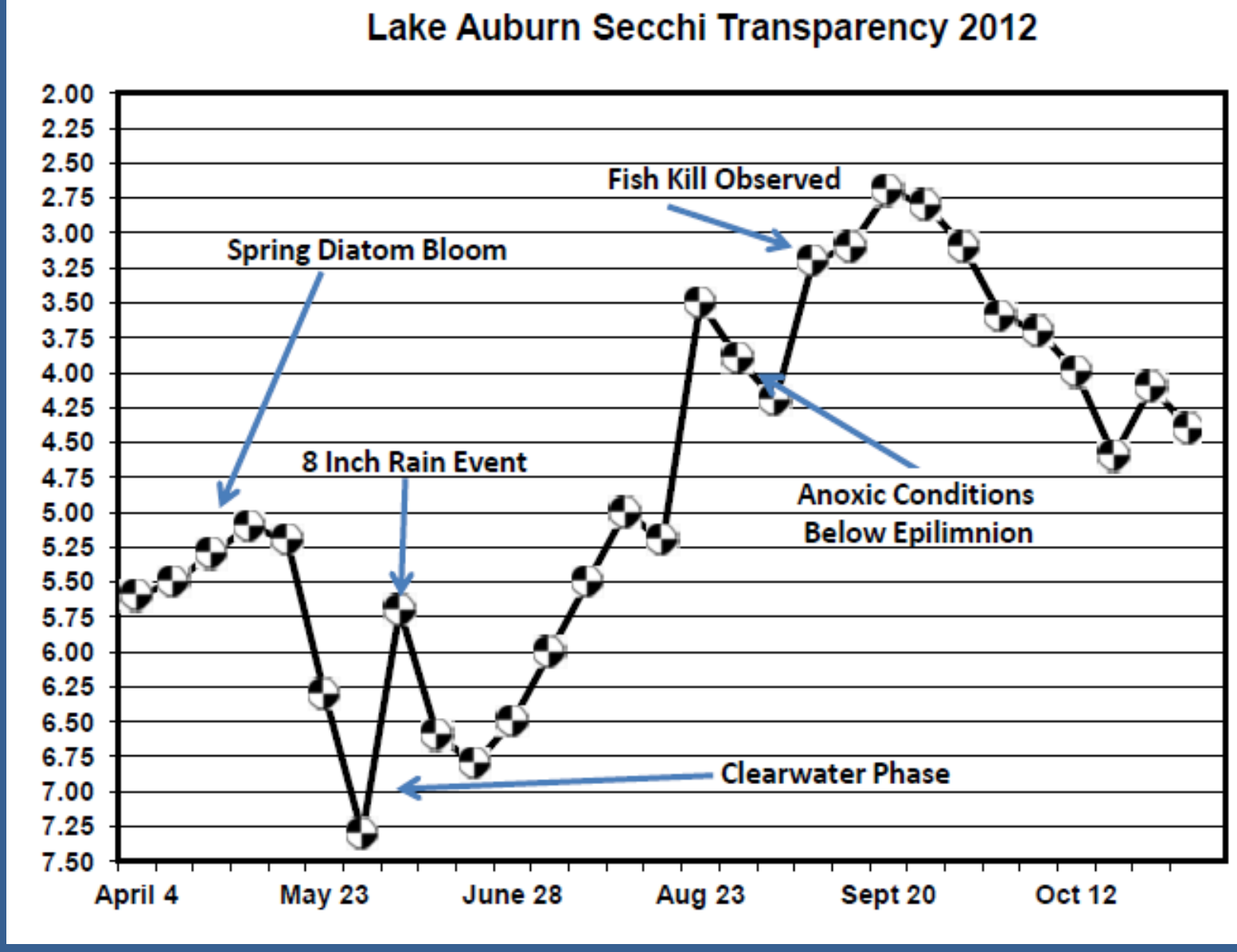
Lake Auburn



Historically oligotrophic – clear with low nutrients

- Extreme weather events
  - 2011 – Hurricane Irene
  - 2012 – late June 8” over 24-36 hrs
  - Severe erosion
- *Gloeotrichia echinulata*




Lake Auburn Secchi Transparency 2012
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
5.00
5.25
5.50
5.75
6.00
6.25
6.50
6.75
7.00
7.25
7.50
April 4
May 23
June 28
Aug 23
Sept 20
Oct 12
Fish Kill Observed
Spring Diatom Bloom
8 Inch Rain Event
Anoxic Conditions
Below Epilimnion
Clearwater Phase

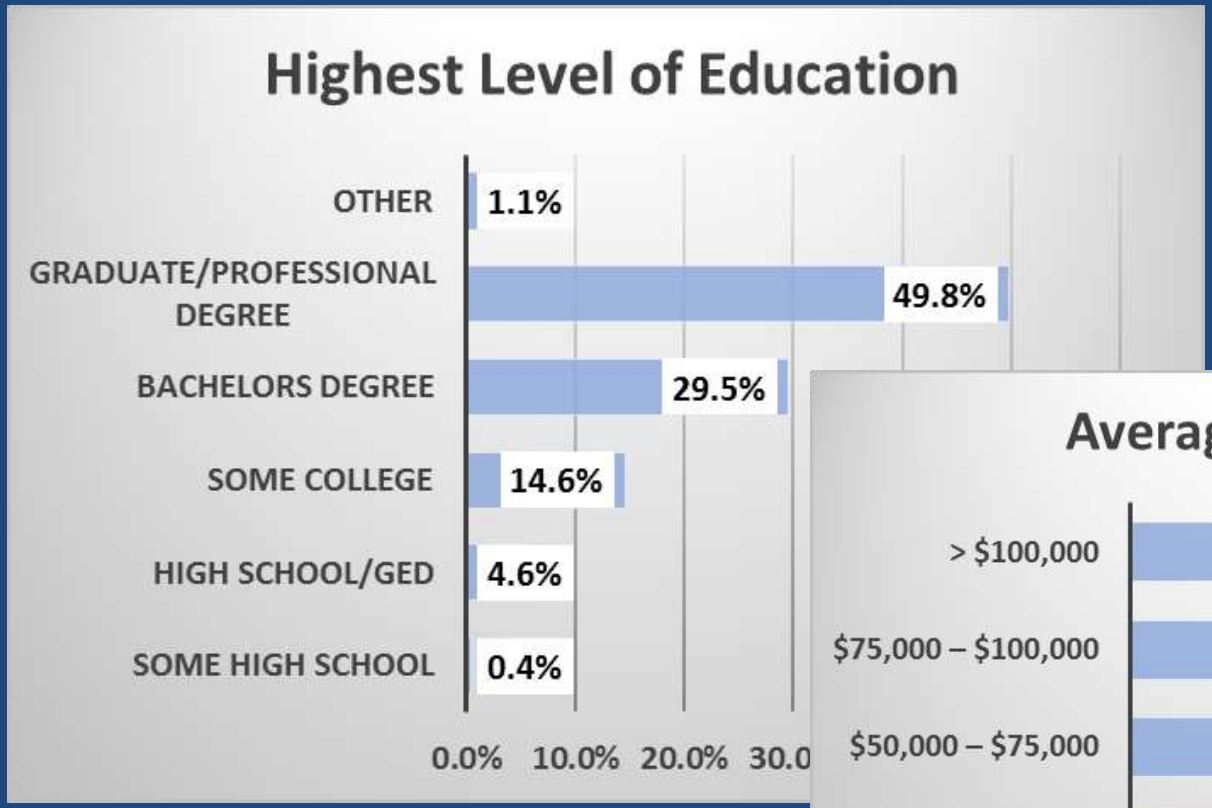
The goals of surveys and focus groups

- 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

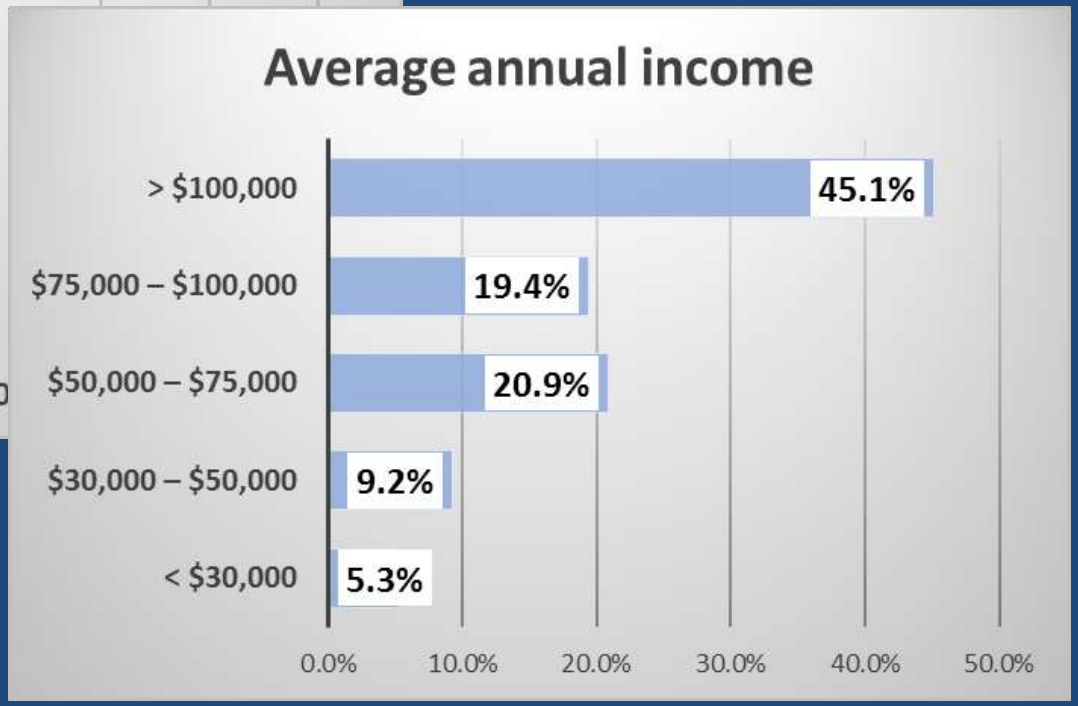
- Responses from 28 unique lake/pond associations
  56% of lakes/ponds included in study
  Total: 267 respondents
- Focus Groups
  - Two focus groups sessions
- Analysis
  Qualitative content analysis
  Descriptive analysis

Respondent profile from survey data



Responded: 261

Respondents –
Male: 57%
Female: 43%

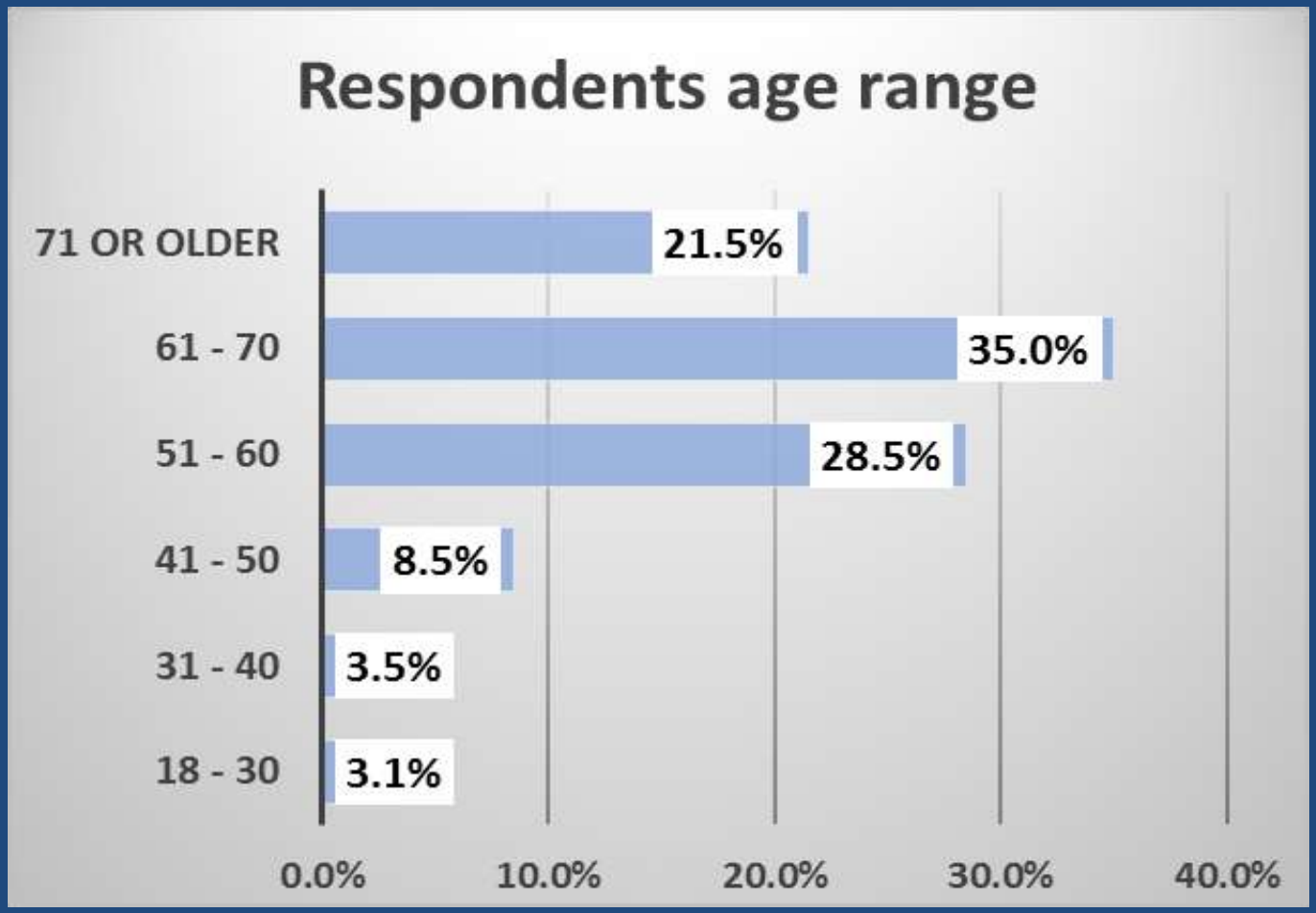


Responded: 206

Respondent profile from survey data

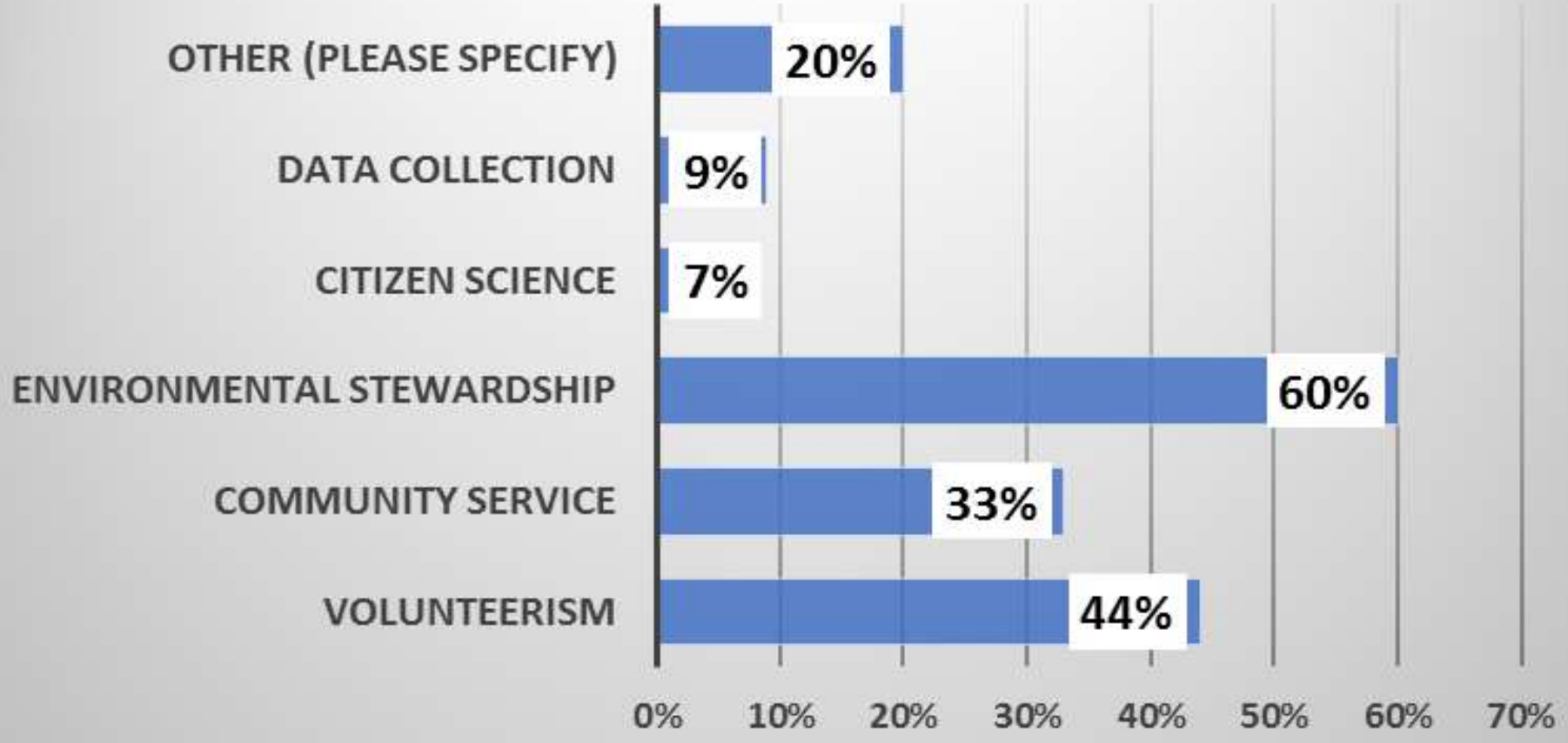
Retired: 45% - Working: 55%

Primary residence along lake: 39% Yes – 61% No

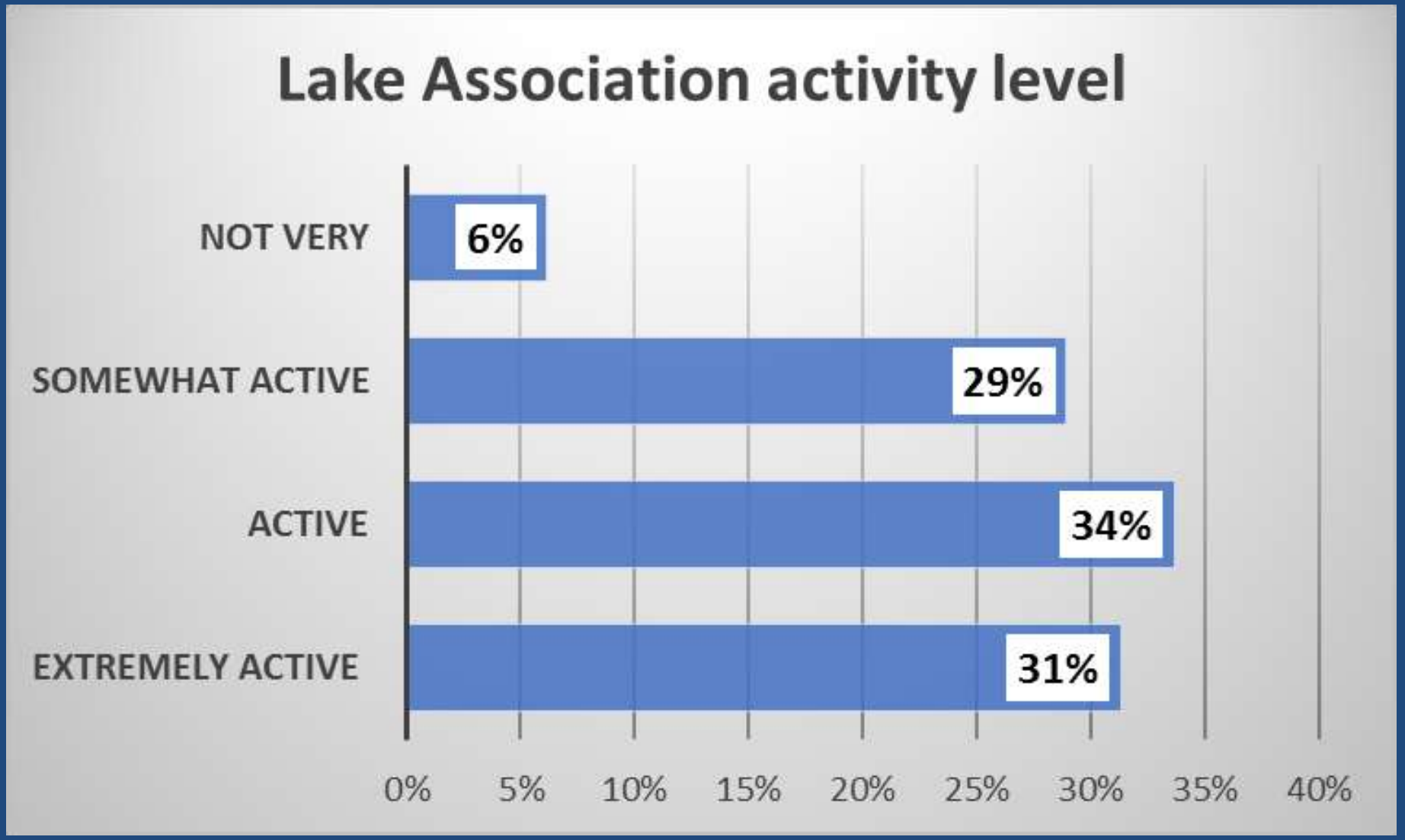


Responded: 260

Citizen scientist or citizen steward?



Responded: 186



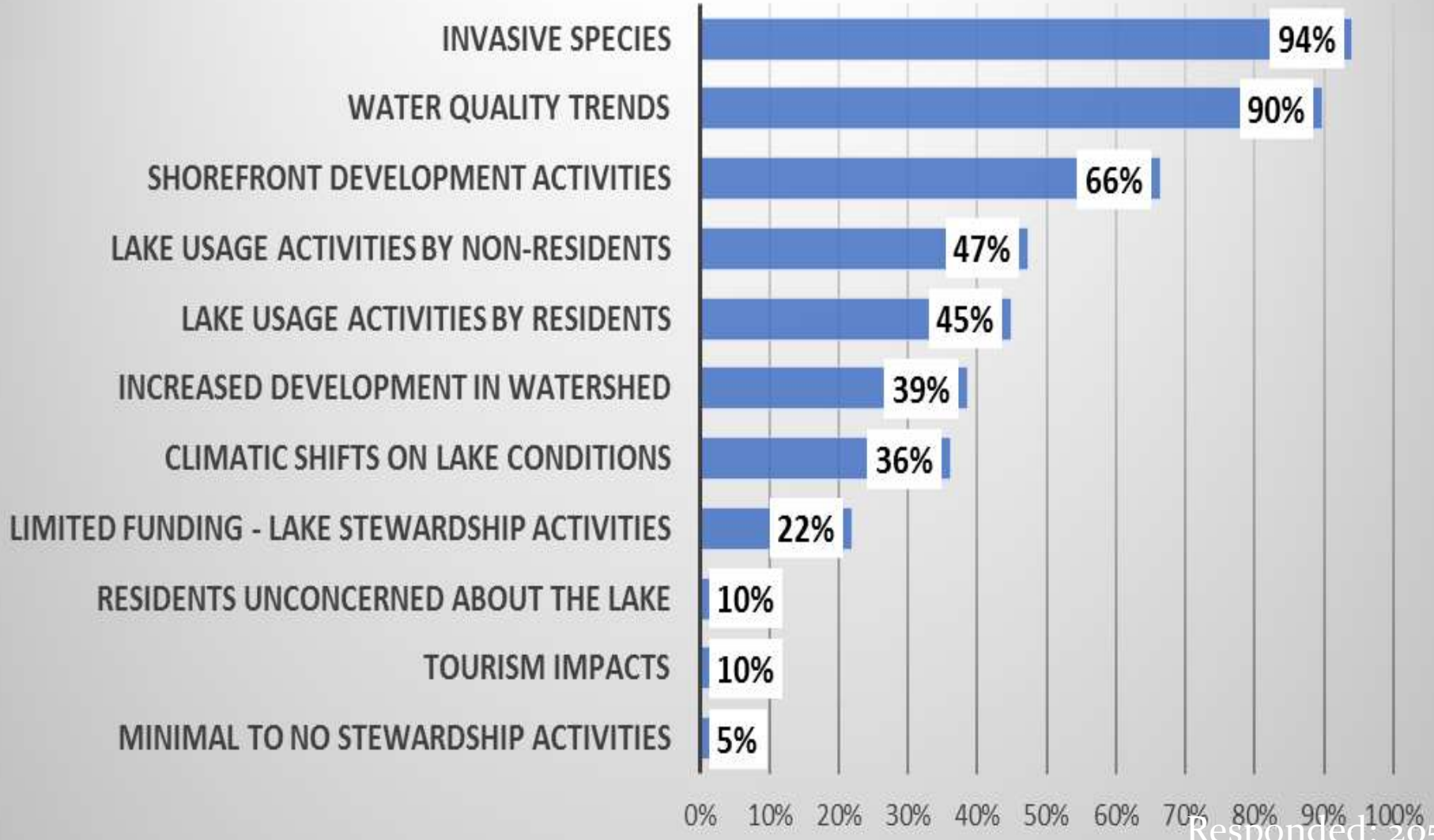
Responded: 211

Lake Association Activities

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

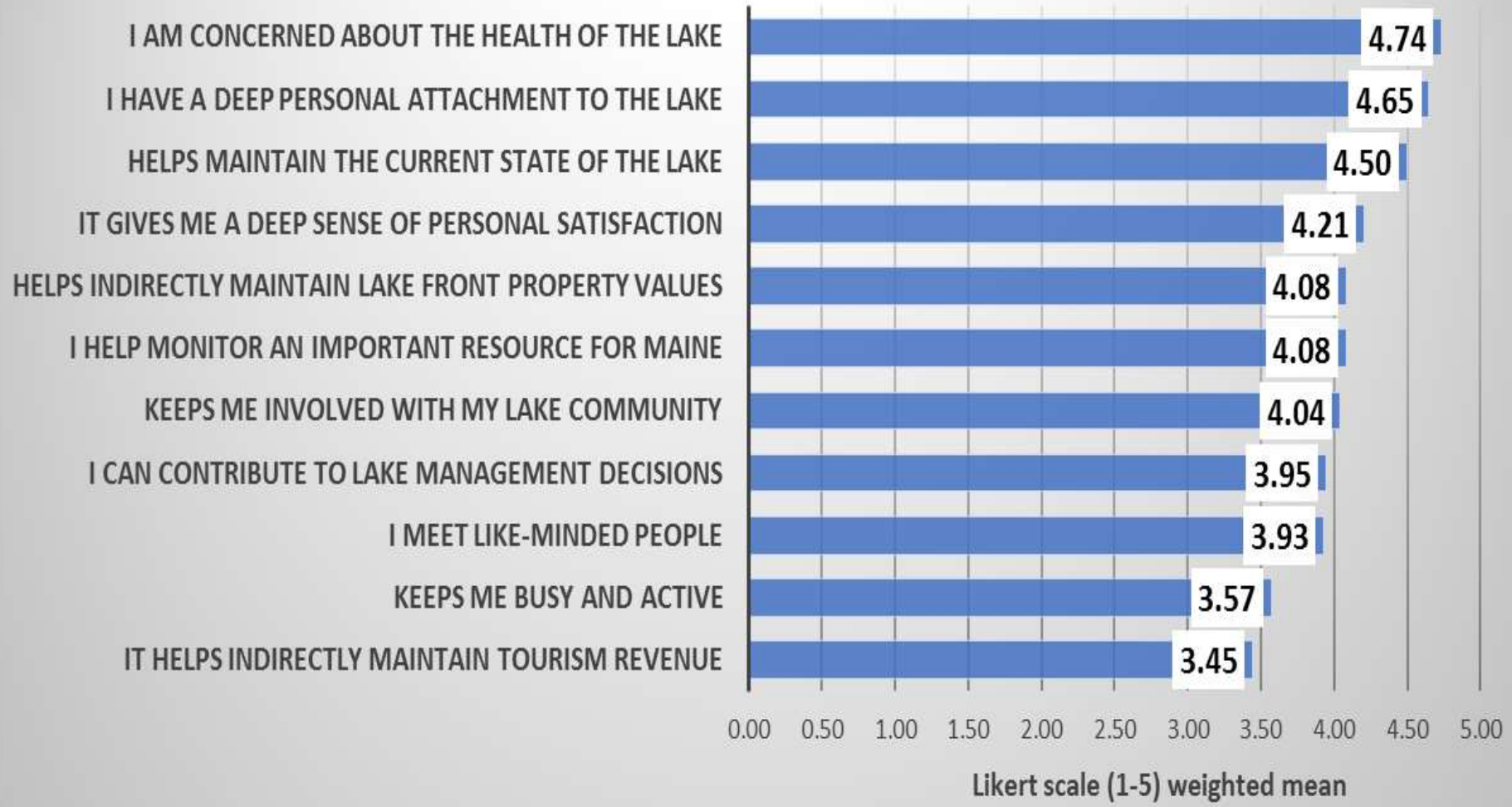
Responded: 208

Primary concerns for your lake association

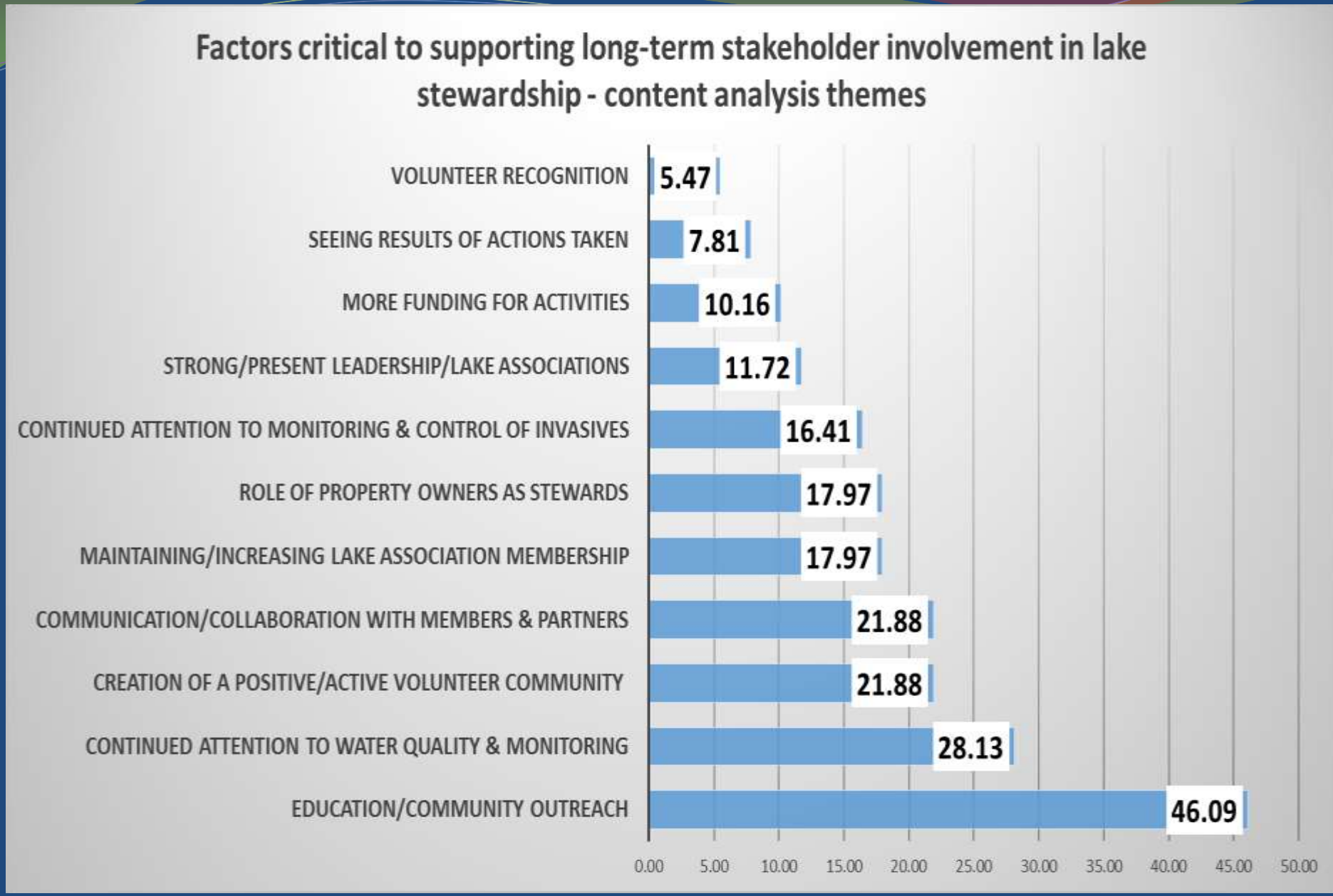


Responded: 205

Motivation to participate



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
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00

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

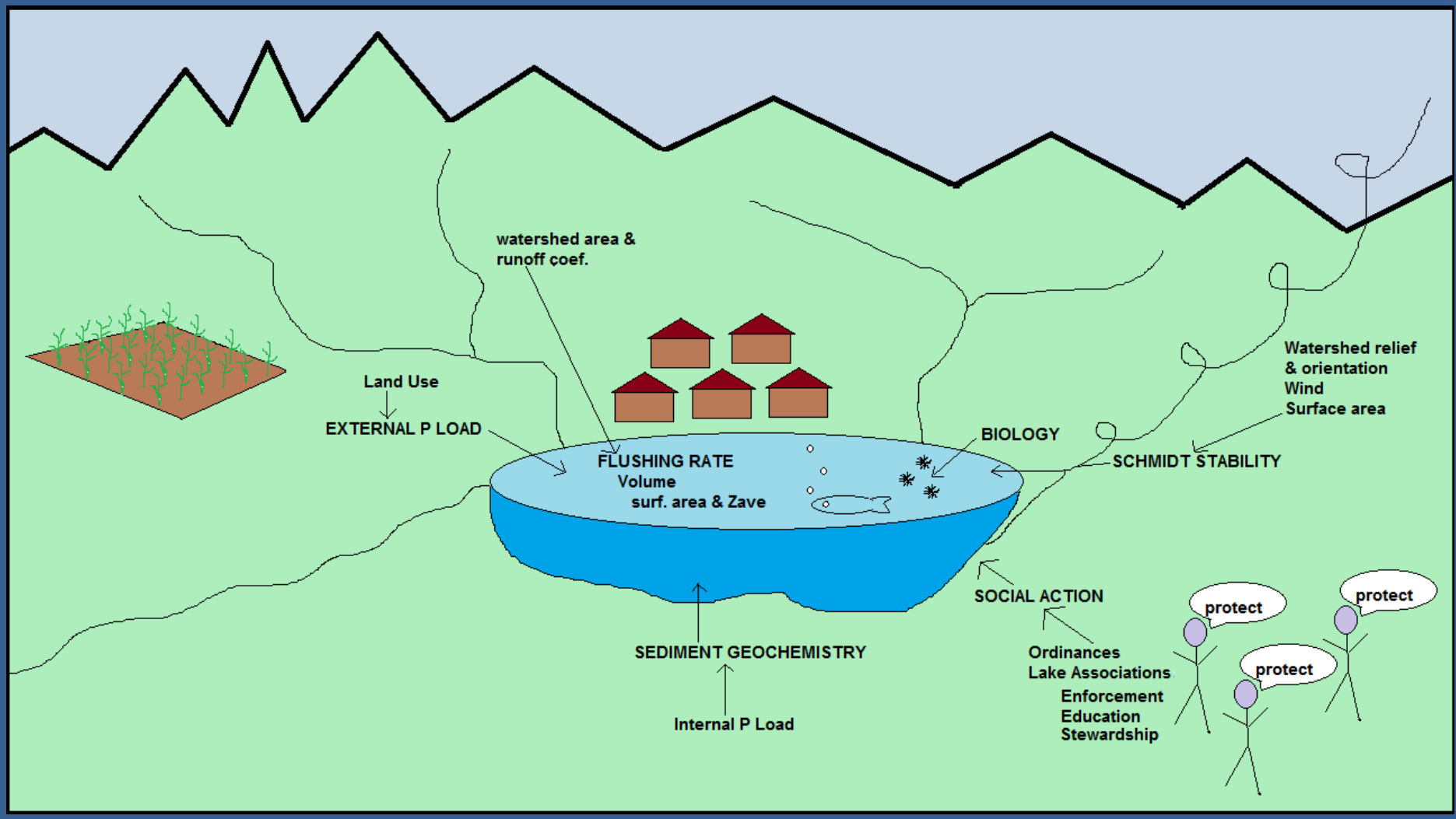
Lake Vulnerability is Complex

- 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

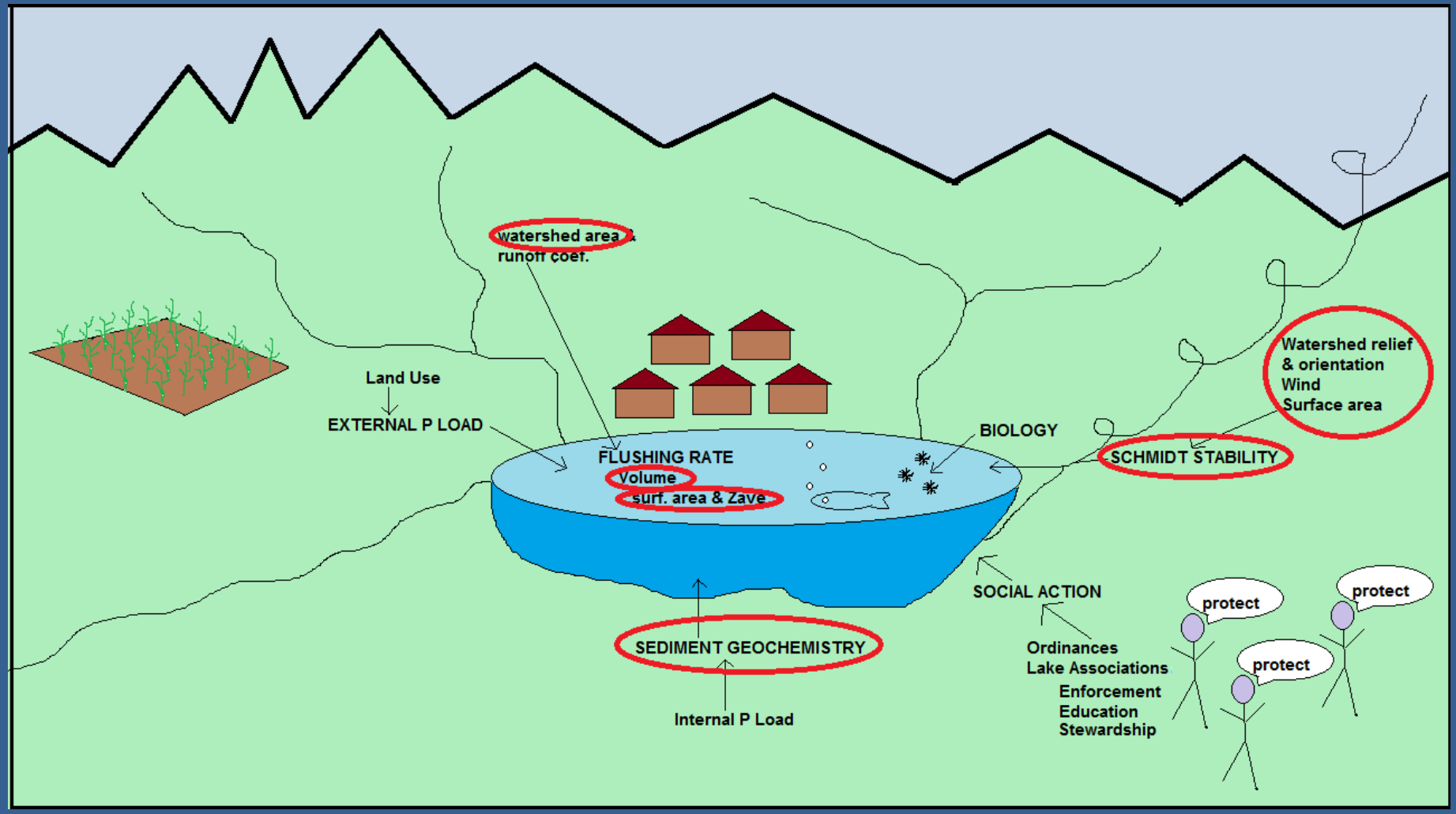
Lake Vulnerability Considerations

- 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 that what will cause another to ‘tip’
- Lakes must be considered individually
- Monitoring is essential to track the rate of change in lakes

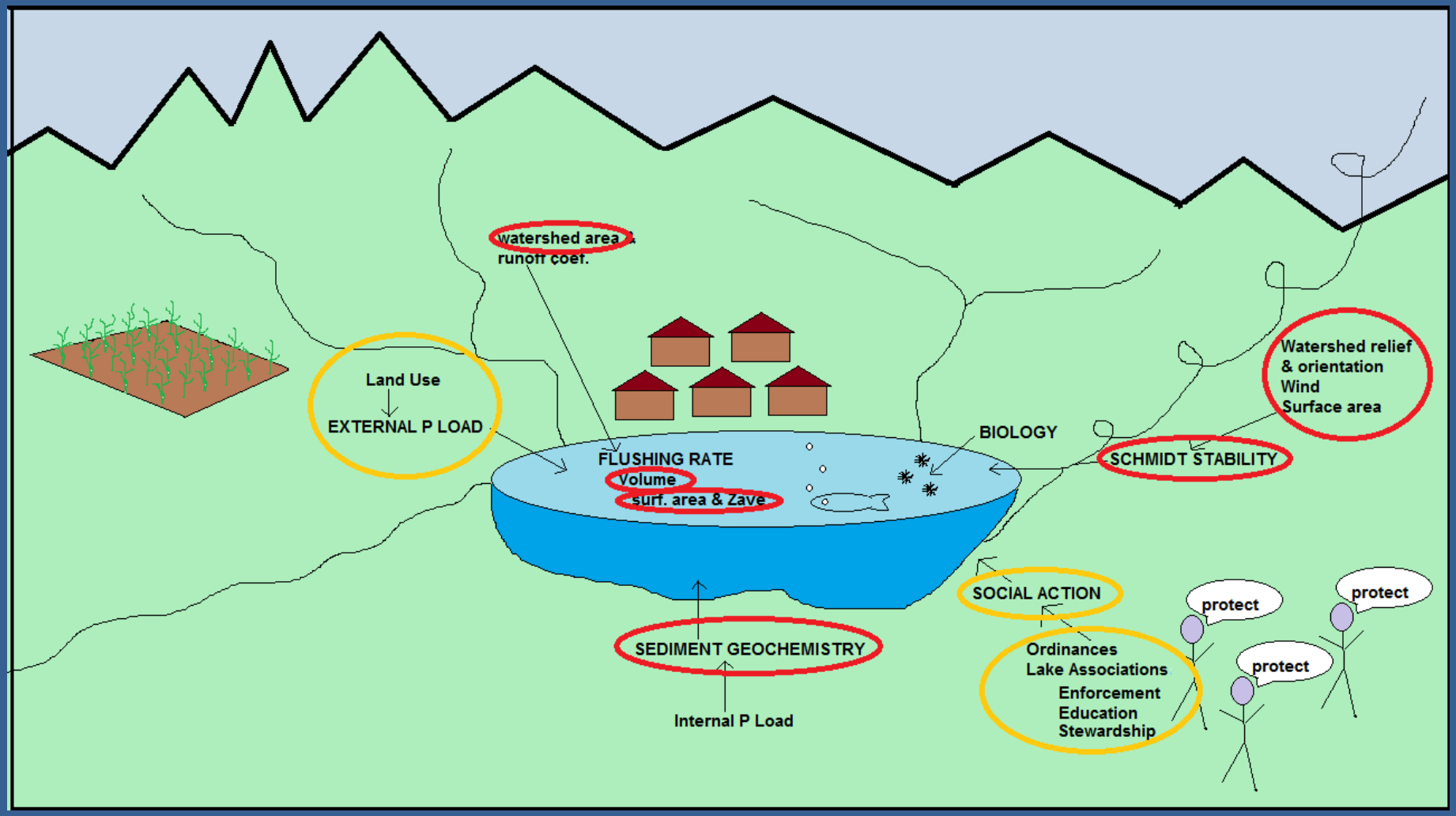
Watershed Attributes



Inherent Factors



Factors we can control

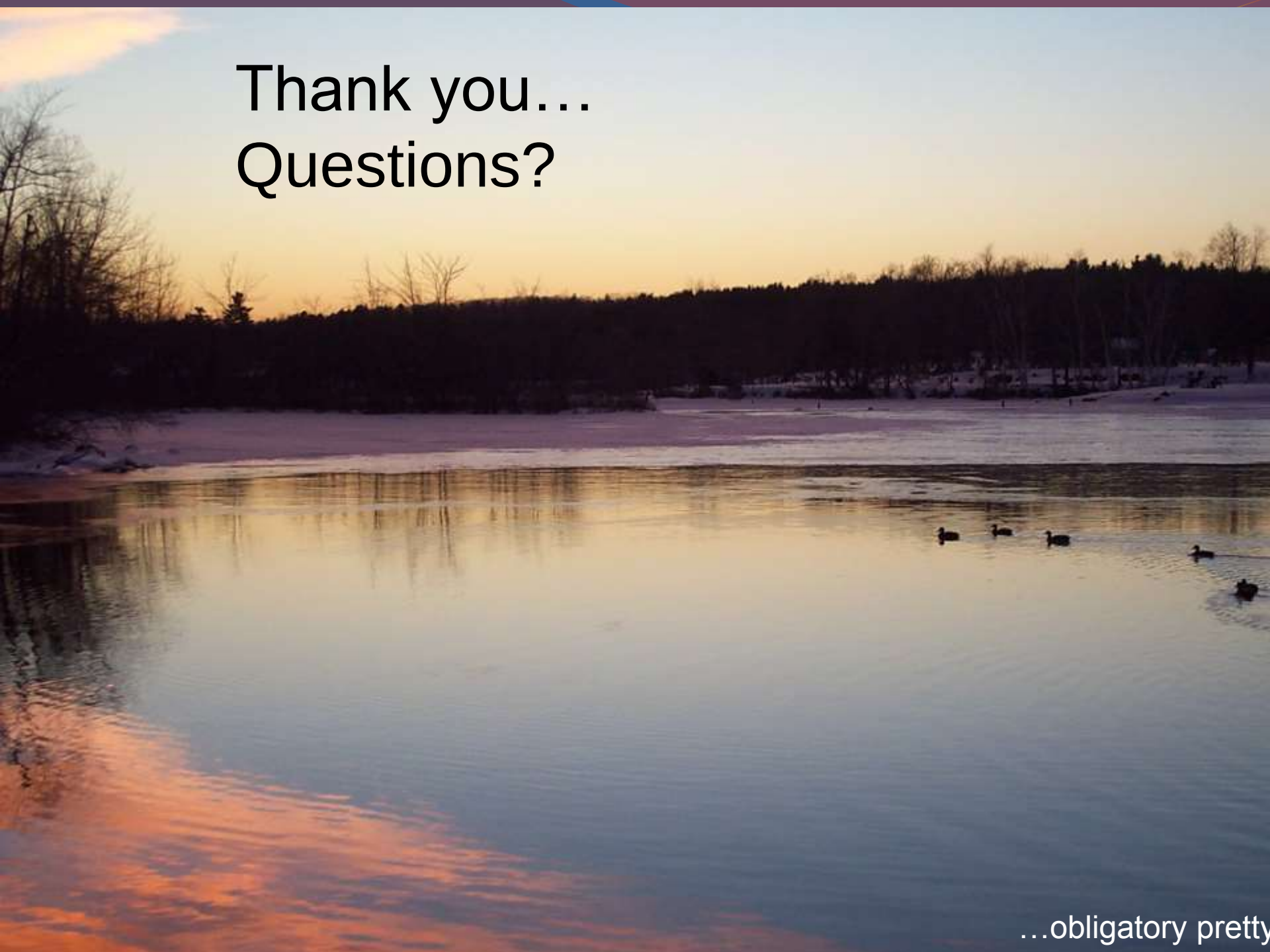


Extreme weather presents our greatest challenge!

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?
…obligatory pretty