2006

Watershed Assessment of Long Pond North [Presentation]

Colby Environmental Assessment Team, Colby College

Problems in Environmental Science course (Biology 493), Colby College

A Watershed Analysis of Long Pond North

Implications for Water Quality and Land-Use Management

Colby Environmental Assessment Team

December 7th, 2006

Presentation Outline

- Long Pond North Watershed Dylan Harrison-Atlas
- Historic Trends and Study Objectives Ryan Scott
- Water Chemistry Testing Nicole Wong
- Land Use Andrew Adelfio

Intermission

- Development Patterns K.T. Weber
- Water and Phosphorus Budgets Kelly Bakulski
- Summary and Recommendations Alex McPherson

Long Pond North Watershed

Dylan Harrison-Atlas

Long Pond

- Economic, recreational, ecological, and aesthetic value
- Boating, swimming, fishing

Biological Perspective

- Native Aquatic Flora
  - Oxygenate water column
  - Provide food and shelter for aquatic organisms
  - Sequester phosphorus

Biological Perspective

- Invasive Plants
  - Have a competitive advantage over native flora
  - Pose a serious threat to lake health and can dominate entire ecosystems
  - Introduced primarily through boating

Eurasian watermilfoil

http://images.harc.edu/Sites/GalvBayInvasives/Species/Photos/MYSP2_1624031.jpg

Biological Perspective

Invasive Aquatic Plants Threatening Maine's Inland Waters

Common Name	Scientific Name
Eurasian watermilfoil	*Myriophyllum spicatum*
Variable-leaf watermilfoil	*Myriophyllum heterophyllum*
Parrot feather	*Myriophyllum aquaticum*
Water chestnut	*Trapa natans*
Hydrilla	*Hydrilla verticillata*
Fanwort	*Cabomba caroliniana*
Curly-leaf pondweed	*Potamogeton crispus*
European naiad	*Najas minor*
Brazilian elodea	*Egeria densa*
Frogbit	*Hydrocharis morsus-ranae*
Yellow floating heart	*Nymphoides peltata*

Biological Perspective

- Fish stocking
  - Administered by Maine Department of Inland Fisheries and Wildlife (MDIFW)
  - MDIFW stocks brook trout and landlocked salmon into Long Pond
  - Low dissolved oxygen levels threaten salmonids

Brook trout

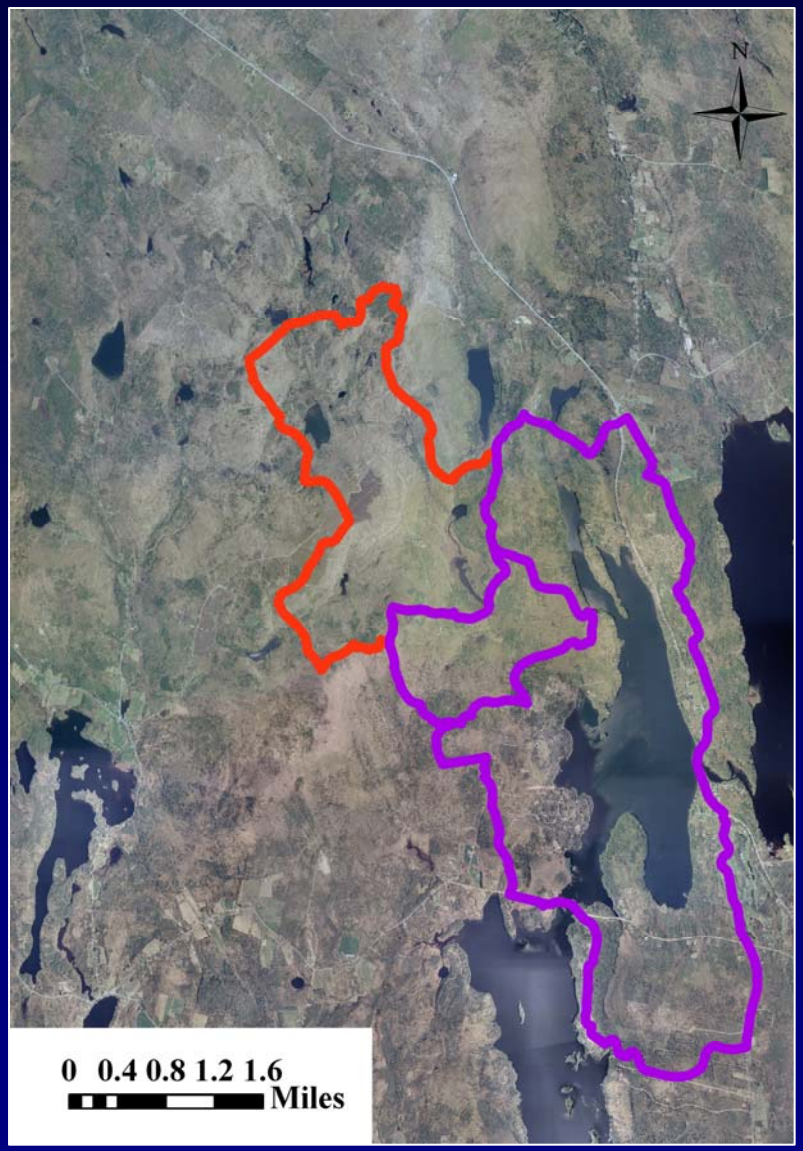
www.stvrainangler.com

Watershed Description

- Watershed: total land area that contributes a flow of water to a particular basin

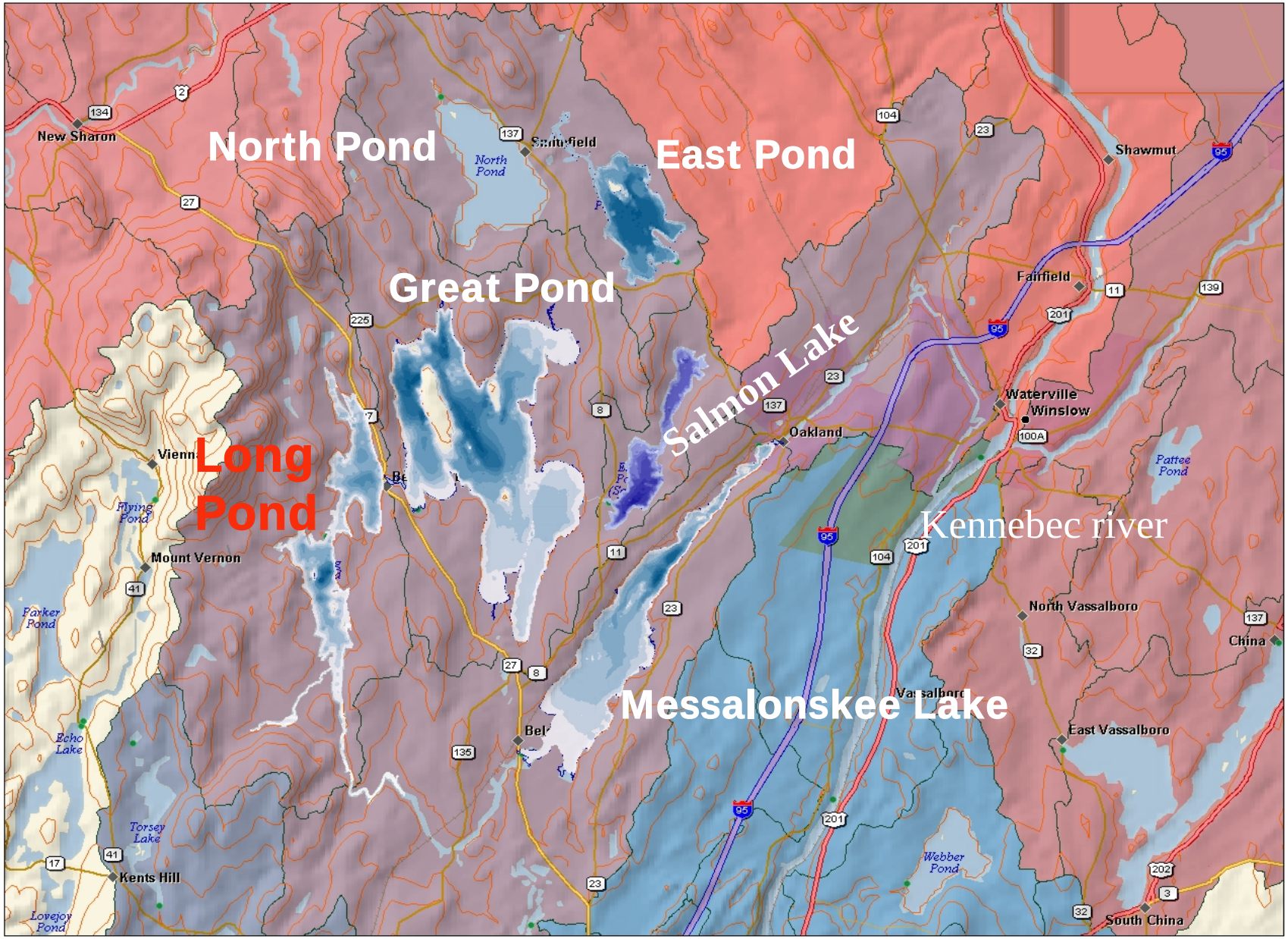
- Watershed boundary defined by highest points of land that surround a lake and its tributaries

Watershed Description



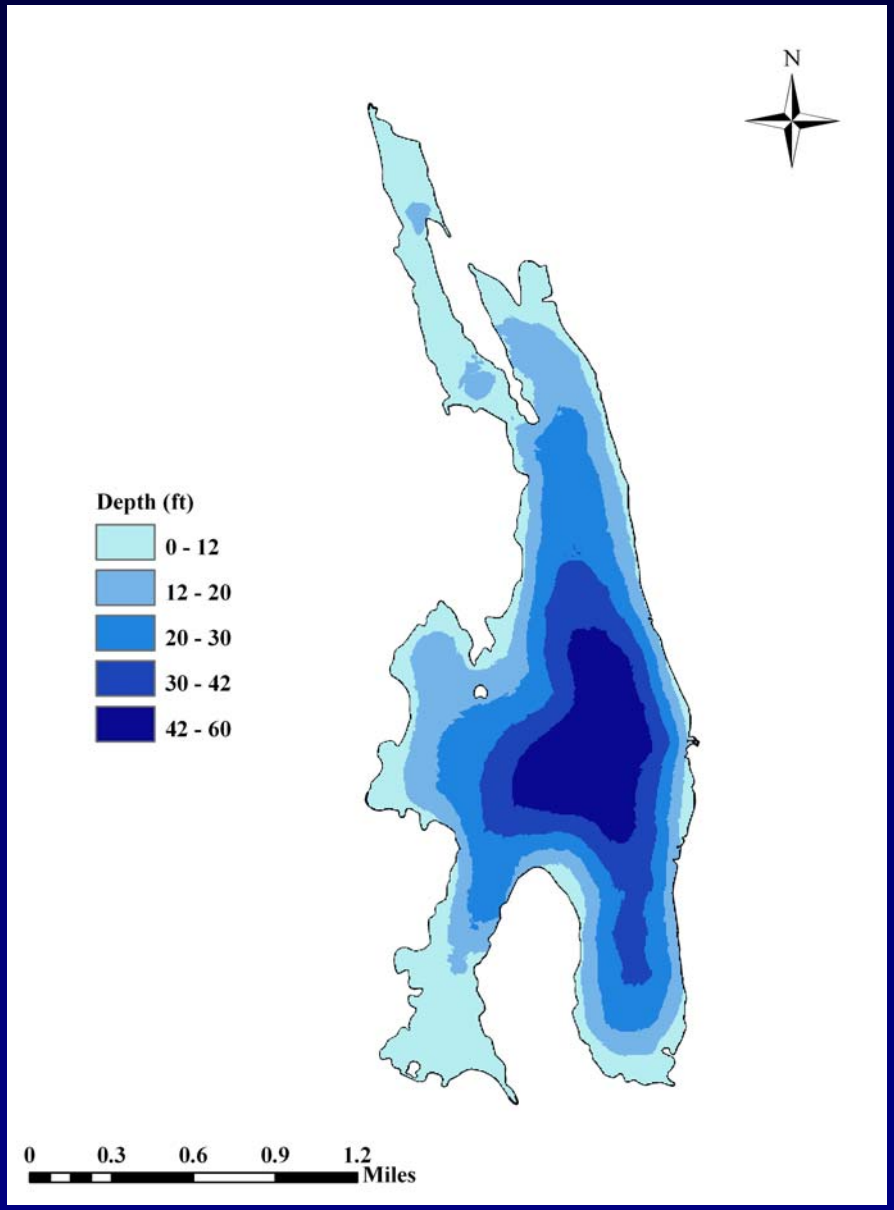
Watershed Description

- Covers more than 6600 acres
- Includes wetlands, coniferous and deciduous forests, small ponds, and riparian habitat


DeLORME
XMap®/GIS Editor
North Pond
East Pond
Great Pond
Salmon Lake
Long Pond
Kennebec river
Messalonskee Lake
New Sharon
Shawmut
Fairfield
Waterville
Winslow
Oakland
Mount Vernon
North Vassalboro
East Vassalboro
China
South China
Kents Hill
North Pond
Flying Pond
Parker Pond
Echo Lake
Torsey Lake
Lovejoy Pond
Webber Pond
Pattee Pond
Data use subject to license.
© 2004 DeLorme. XMap®/GIS Editor.
www.delorme.com
MN (17.1° W)
km
0 1 2 3 4 5 6 7 8
Data Zoom 10-2

Bathymetry

- Surface area = 1275 acres
- Mean depth = 10 meters
- Maximum depth = 20 meters



Long Pond North and Study Objectives

Ryan Scott

Overview

- Current and Historical Trends
- Project Objectives

Long Pond: Present State

- Relatively healthy lake
- There are issues threatening its stability
  - DO, Transparency, *Gloeotrichia*

Transparency

- Secchi Disk
- Indication of lake water quality

http://dipin.kent.edu/images/Secchi%20Disk.jpg

Trophic State Index

- Lakes are characterized as oligotrophic, mesotrophic or eutrophic
- Most Maine lakes are mesotrophic

Trophic State Index

- Determined using transparency
  - Oligotrophic: 0-40
  - Mesotrophic: 40-49
  - Eutrophic: >50
- In 1978 TSI = 33

$TSI_{SD} = 10[6-(\ln SD/\ln 2)]$

Mean SD = 4.65 m

Long Pond TSI = 38

Dissolved Oxygen (DO)

- Measured using YSI DataSonde

- Implications:
  - Deep water fisheries
  - Algal blooms


http://lakeaccess.org/russ/YSIprobes.jpg


http://www.pointsebago.com/images/fish.jpg

Gloeotrichia

- Cyanobacteria

(Blue Green Algae)

  - Becoming abundant in Great Pond
  - Long Pond experiencing increased abundance

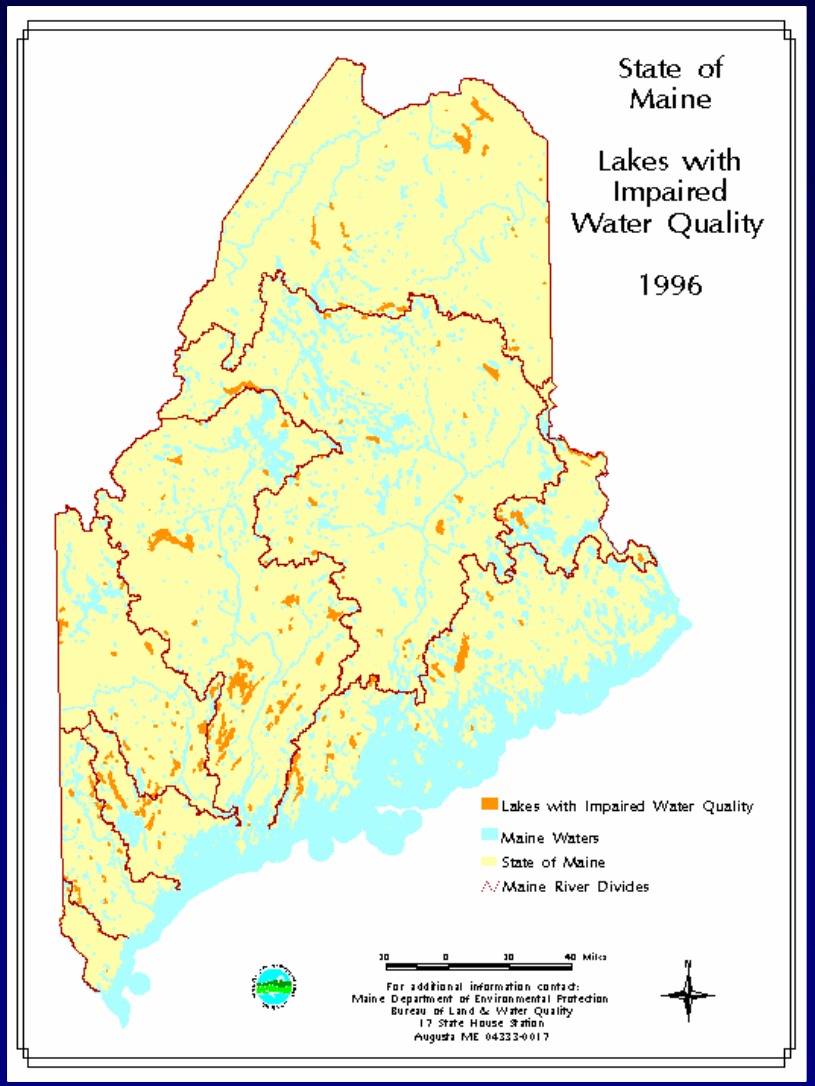
Gloeotrichia

http://www.colby.edu/chemistry/Gloeotrichia/Gloeotichia%20web/Research%20Photos.html

- Current Research
- Implications
  - Health
  - Recreational

Impaired Lakes

- Placement by Maine DEP
  - Combination of factors

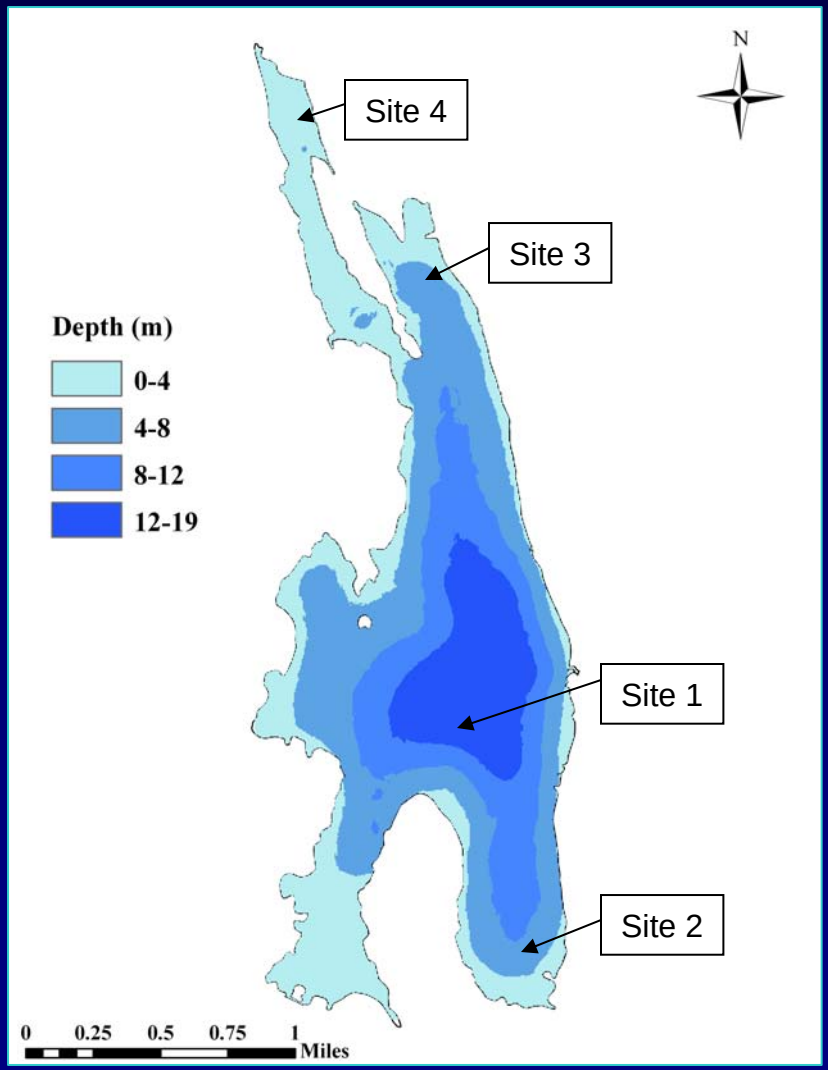


Study Objectives

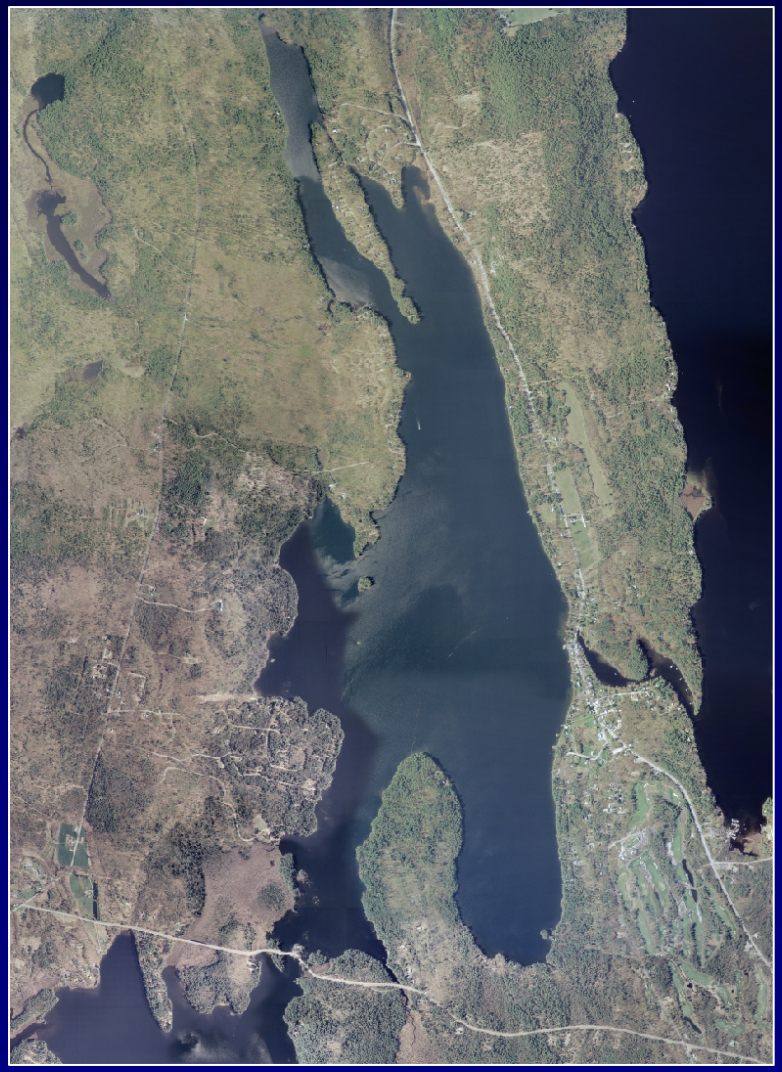
- Water Quality
- Land Use
- Models
- Future Trends

Study Objectives

- Water Quality
  - Multitude of tests
- Varied sample sites
  - Location
  - Sampling techniques

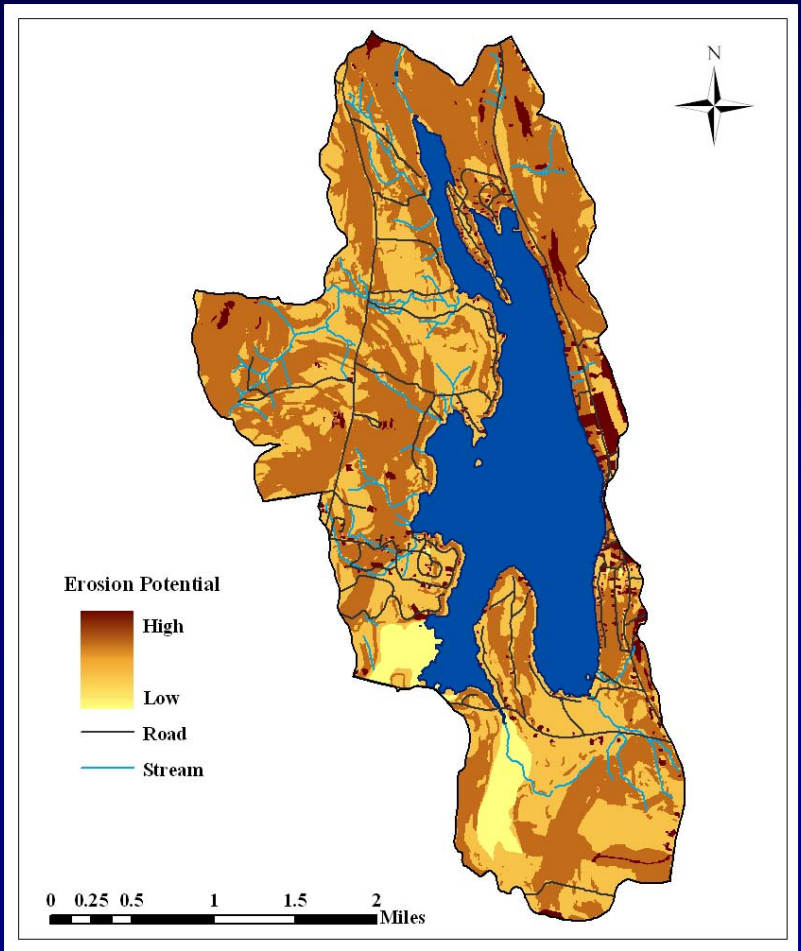


Study Objectives



- Land Use
  - DOQs to determine land use
  - Used for projections, phosphorus budget

Study Objectives



- Models
  - Used to understand and estimate impact of land
  - Septic suitability, erosion potential, phosphorus and water budgets

Study Objectives

- Future Trends
  - Combination of models and information from town officials
  - Crucial in maintaining health of Long Pond

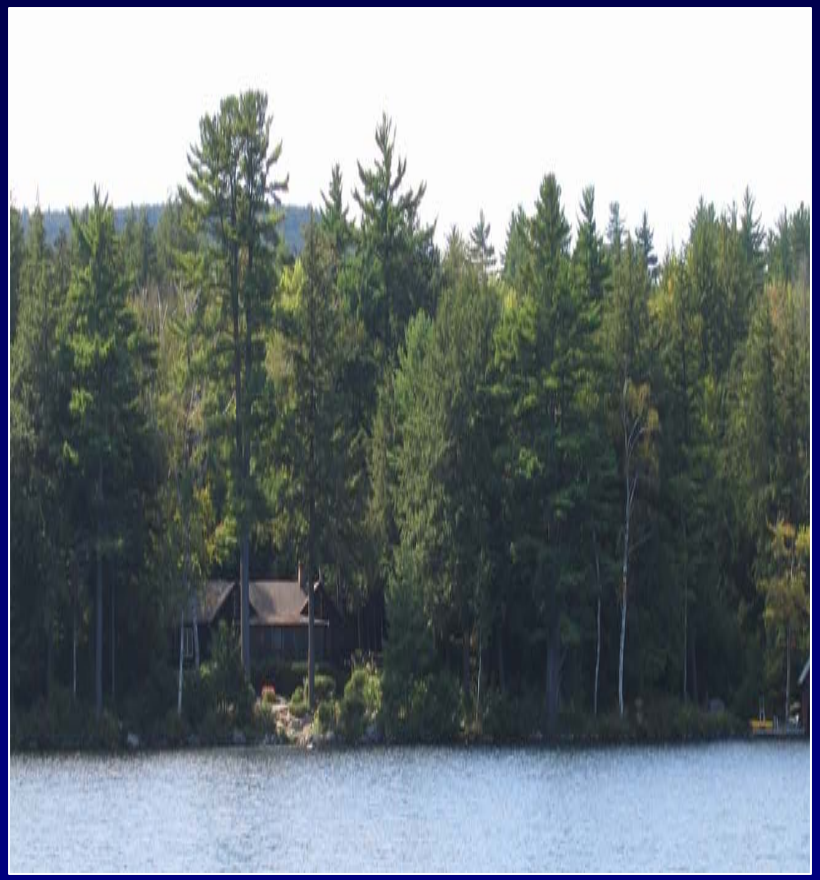
Water Chemistry Testing

Nicole Wong

Overview

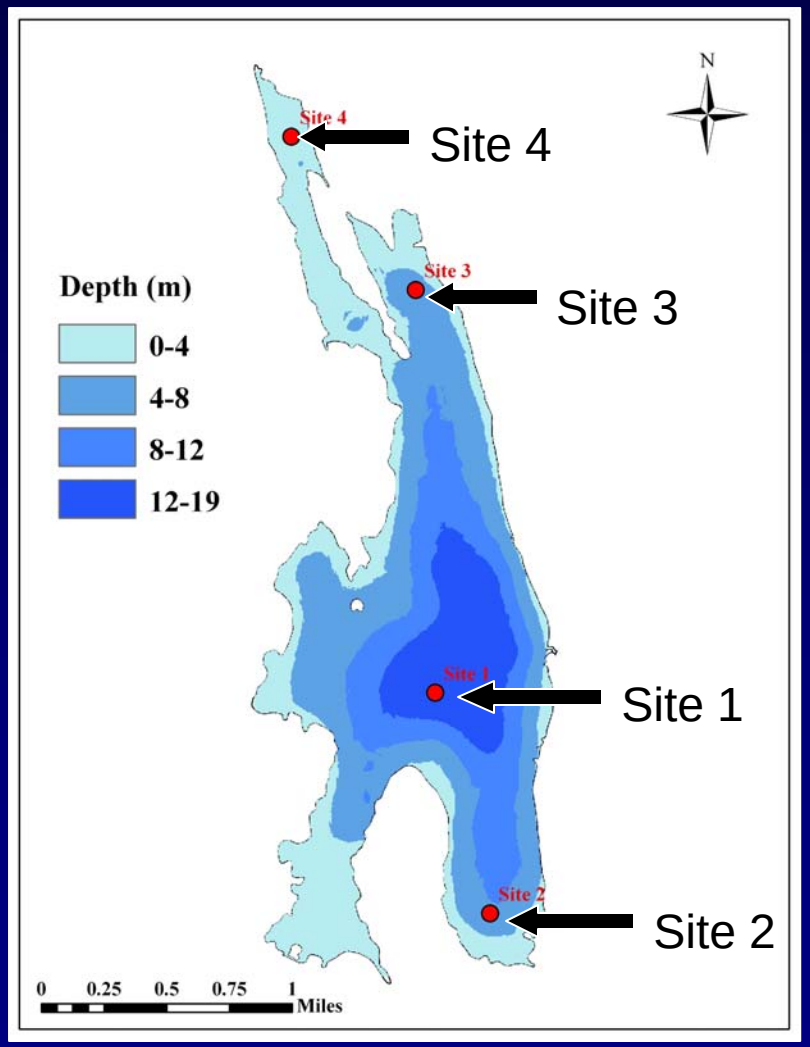
- Introduction
  - What did we measure?
  - Our results
  - Conclusions

Introduction



- Historically high water quality until recently
- 2006 - “Impaired” lake status

Sampling Site Locations



Parameters

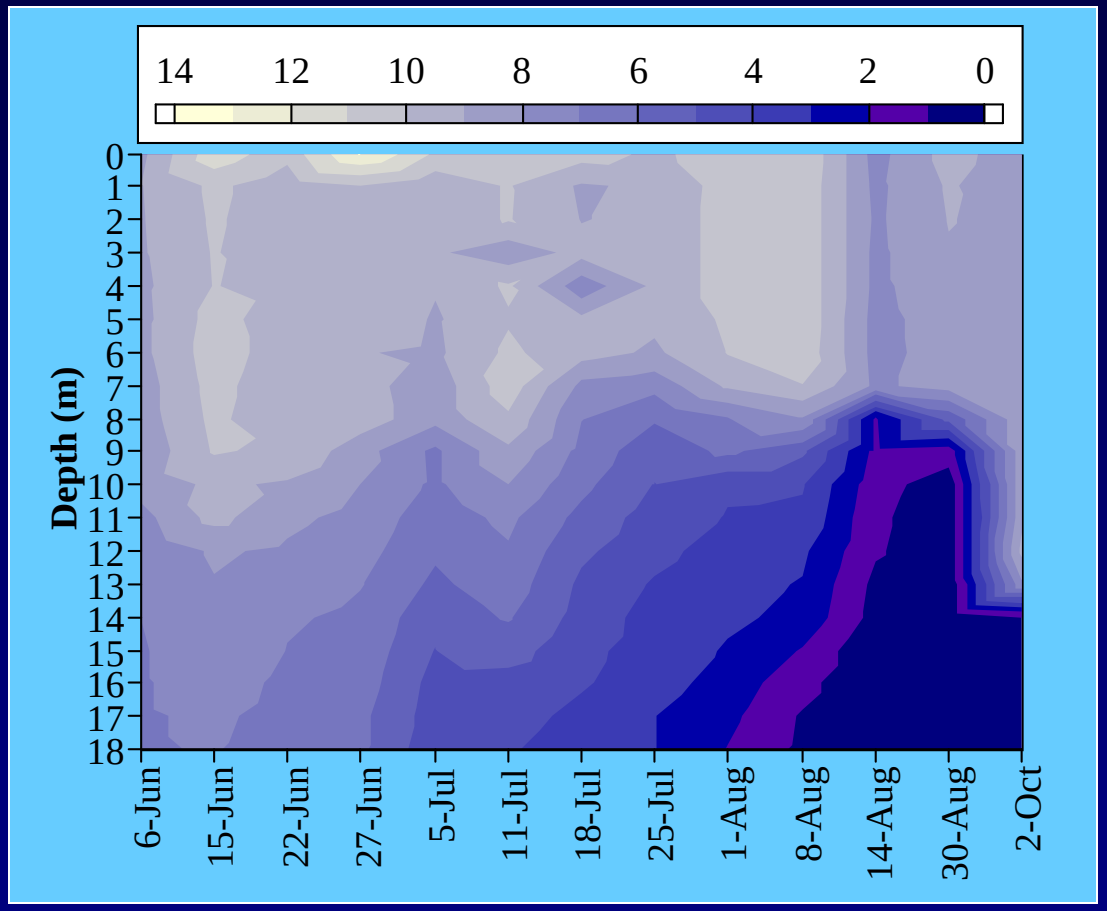
- Dissolved oxygen (DO)
- Phosphorus
- Chlorophyll-a
- Temperature
- pH
- Transparency

Dissolved Oxygen (DO)

www.mrcirl.org

- Measurement of the amount of O_2 dissolved in water
- DO < 5 ppm: dangerous for cold water fish
- DO < 1 ppm: anoxic
- Factors affecting DO:
  - decomposition, microbial activity, respiration, turbulence, wind, salinity, temperature

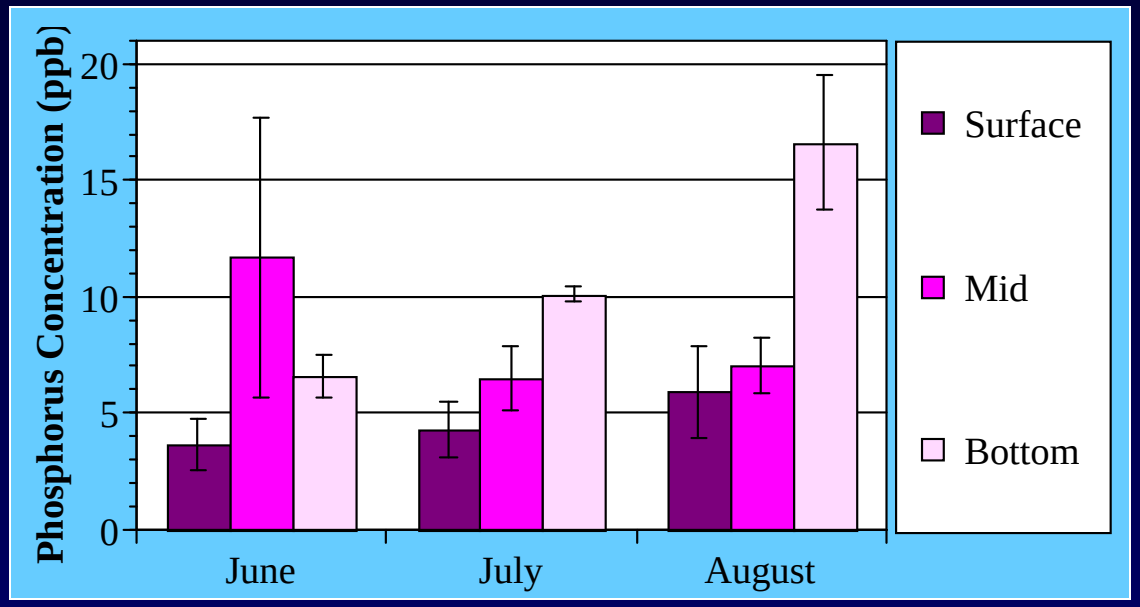
Dissolved Oxygen (DO)



Dissolved oxygen (ppm) profile in 2006 for Long Pond North at site 1.

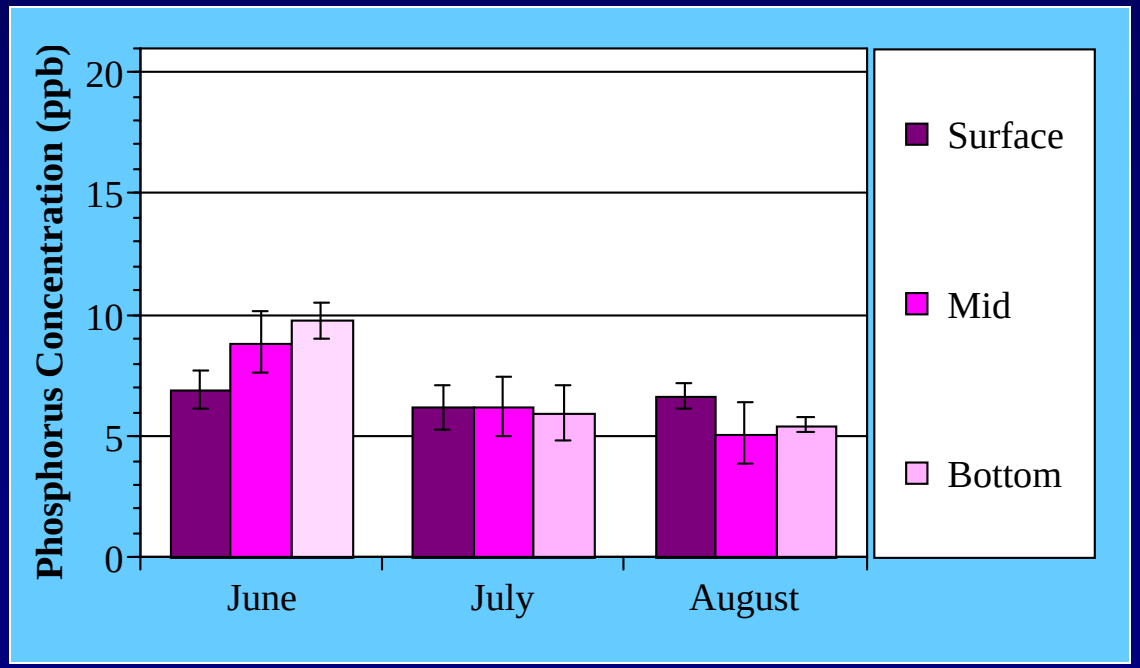
Phosphorus (P)

www.ymparisto.fi



SITE 1

Mean (± SE) surface, mid, and bottom phosphorus concentrations (ppb)



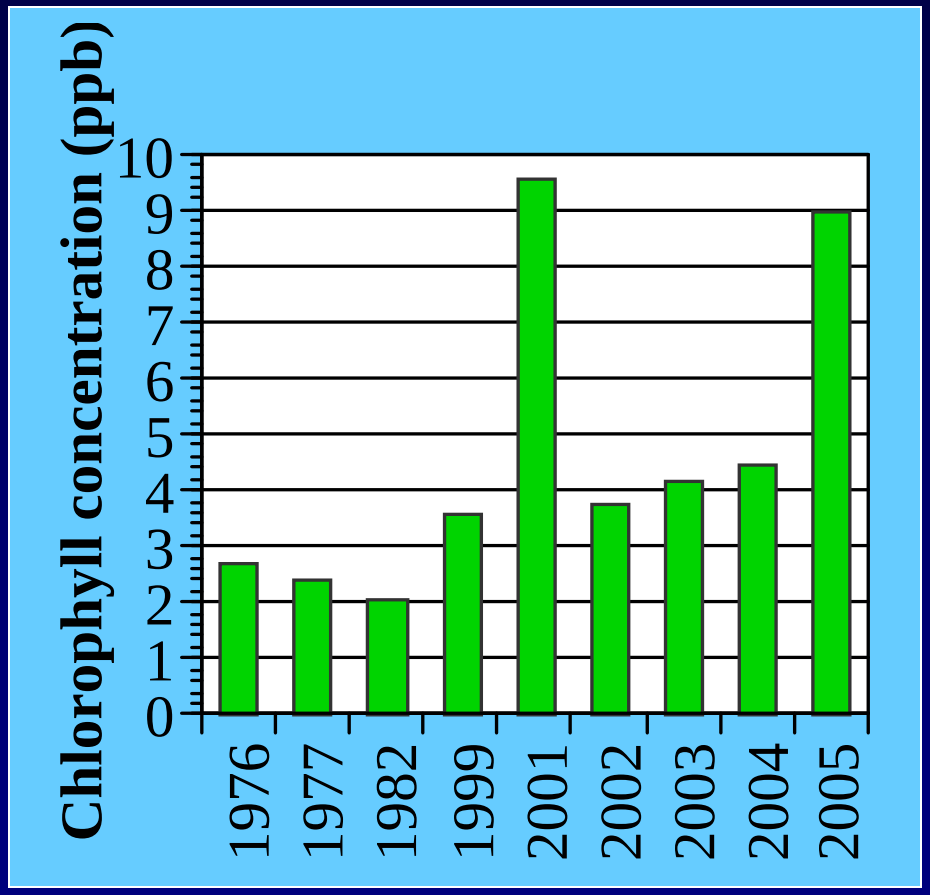
SITE 3

Chlorophyll-a

www.aslo.org

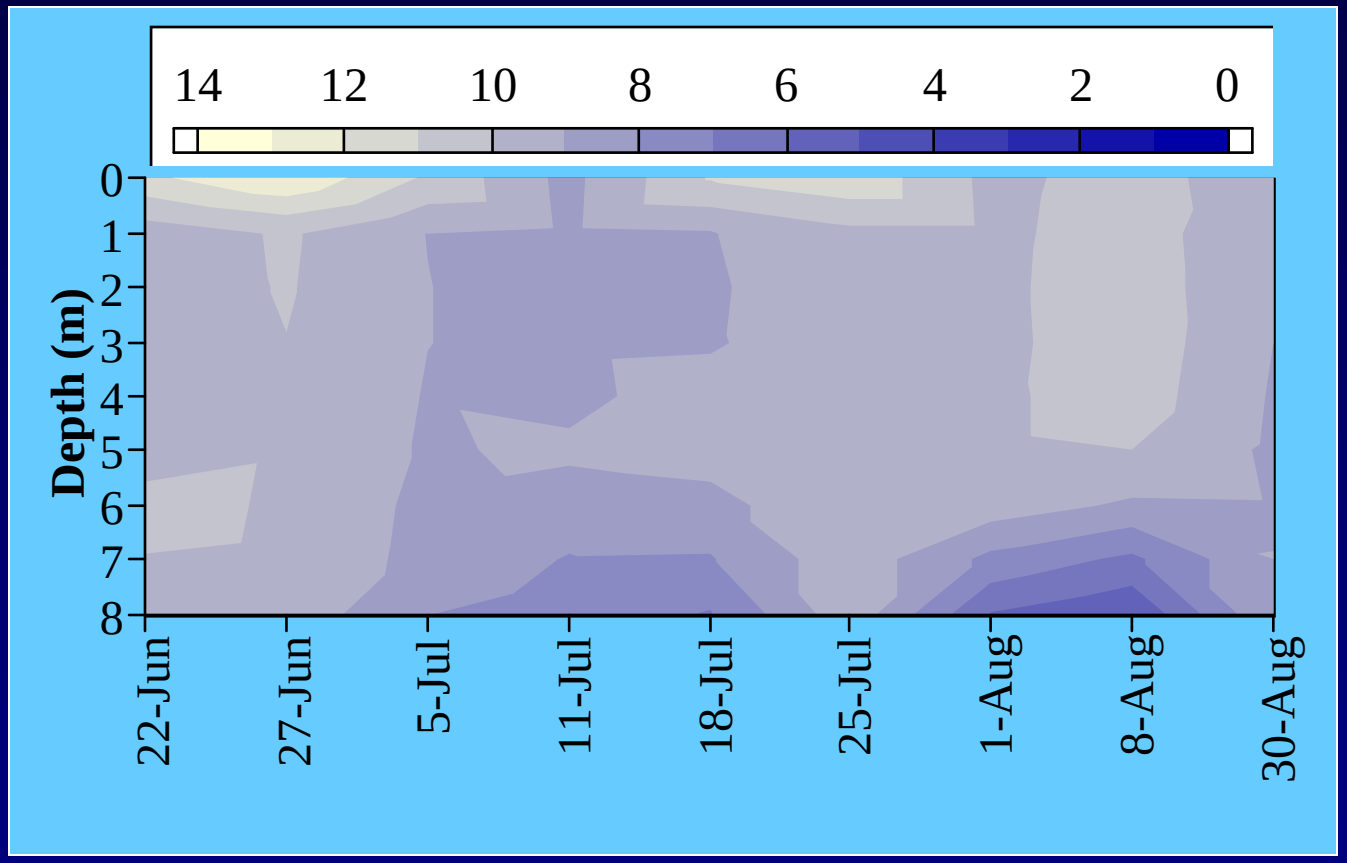
- Photosynthetic pigment
- Estimate of relative phytoplankton biomass
- Factors affecting chlorophyll-a concentrations:
  - temperature, light, nutrient levels, weather conditions

Chlorophyll-a

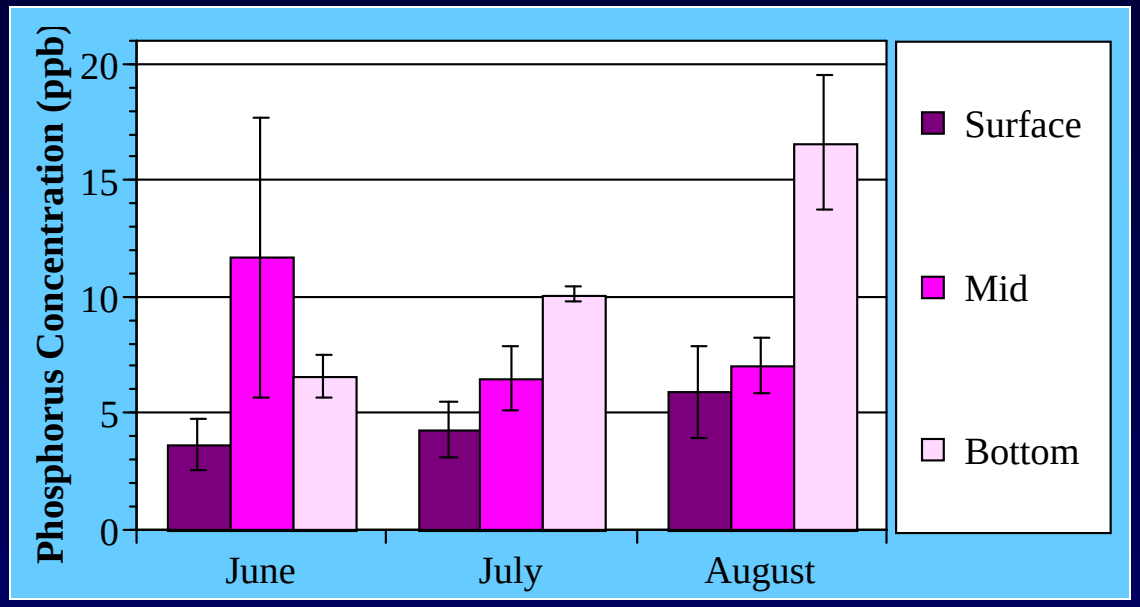


Mean annual chlorophyll concentrations (ppb) at mid-depths in all available years for Long Pond North at site 1

Dissolved Oxygen (DO)

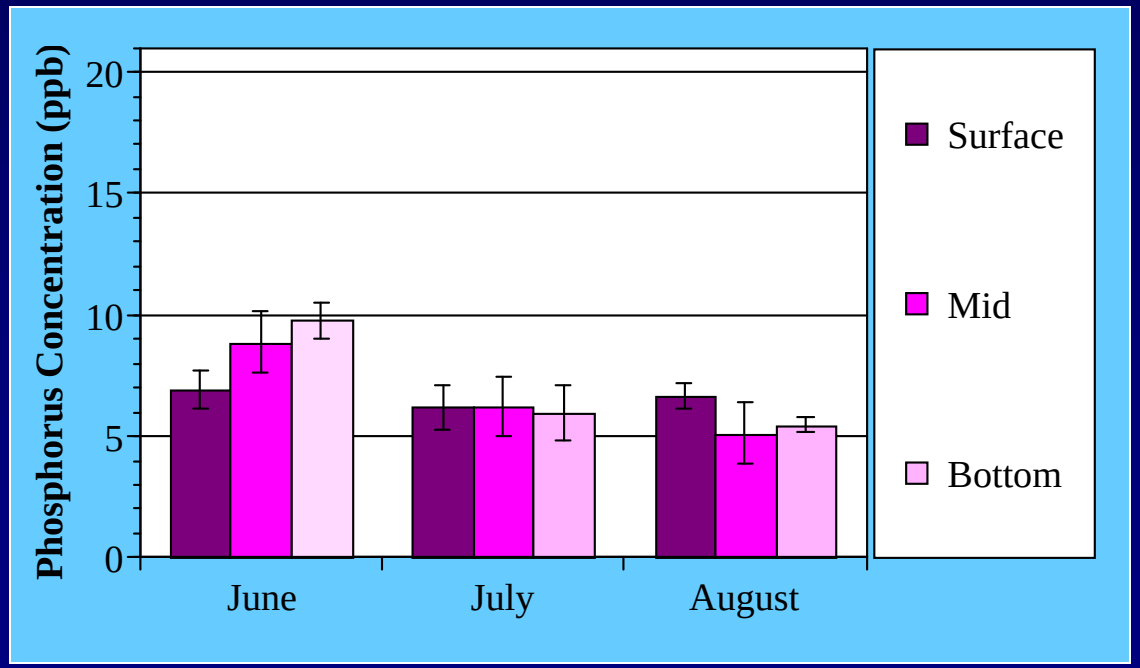


Dissolved oxygen (ppm) profile in 2006 for Lond Pond North at site 3.



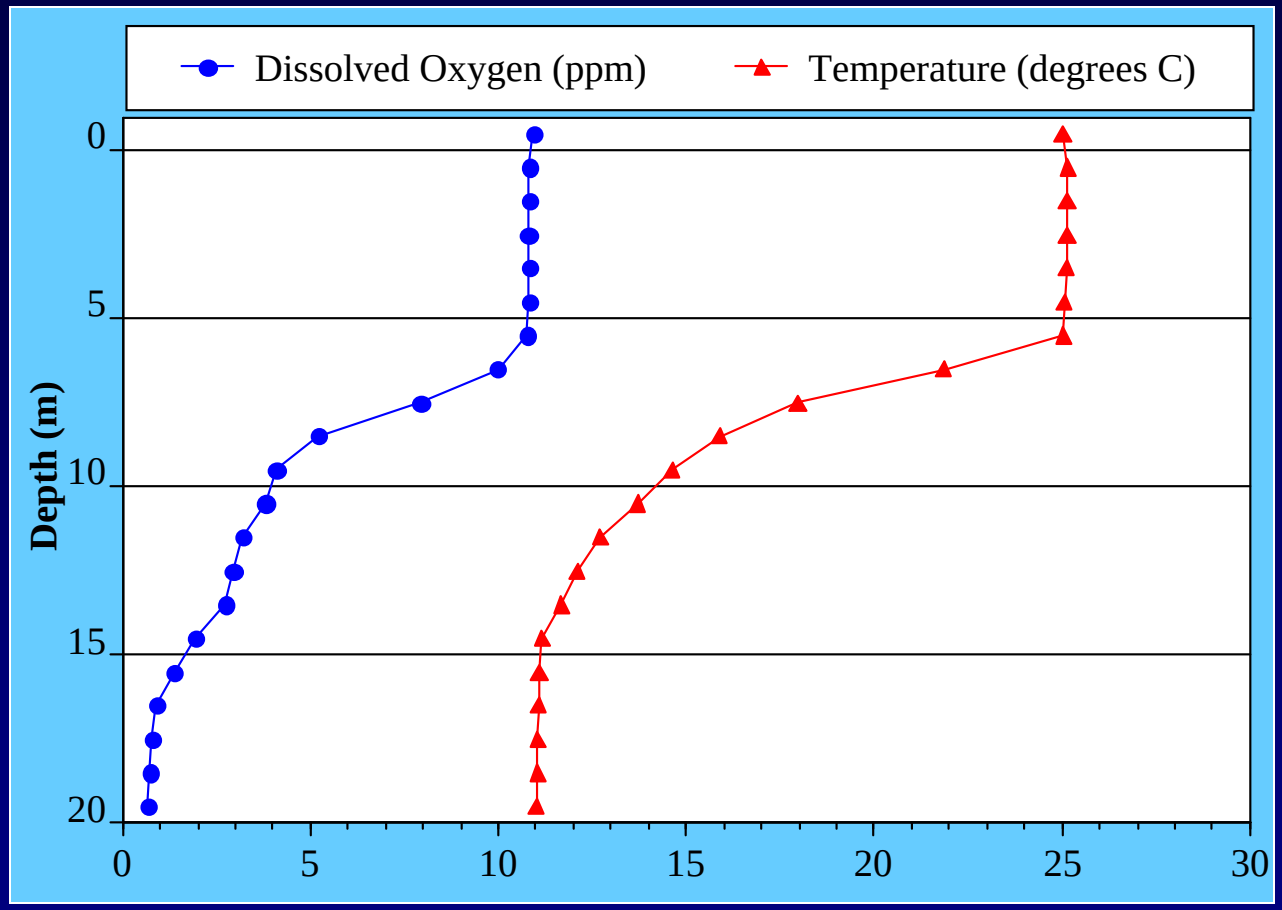
SITE 1

Mean (± SE) surface, mid, and bottom phosphorus concentrations (ppb)



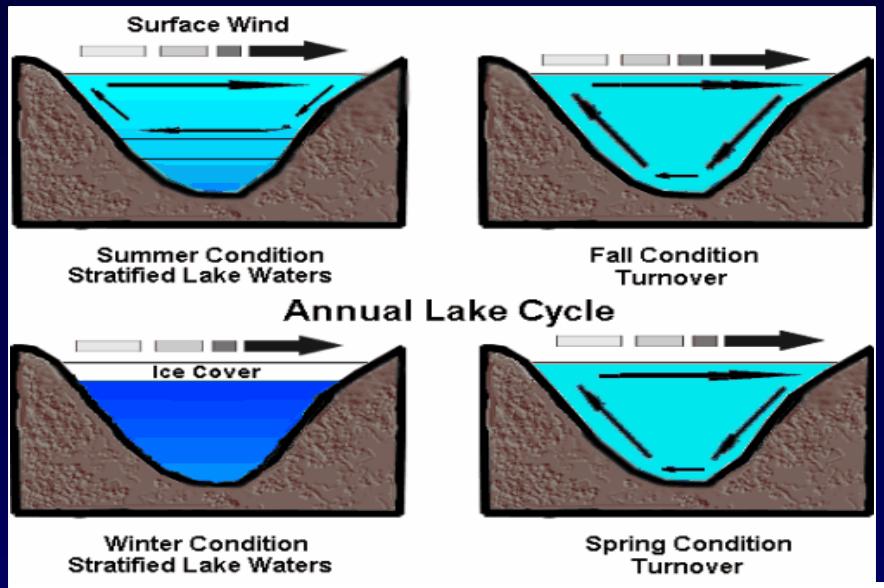
SITE 3

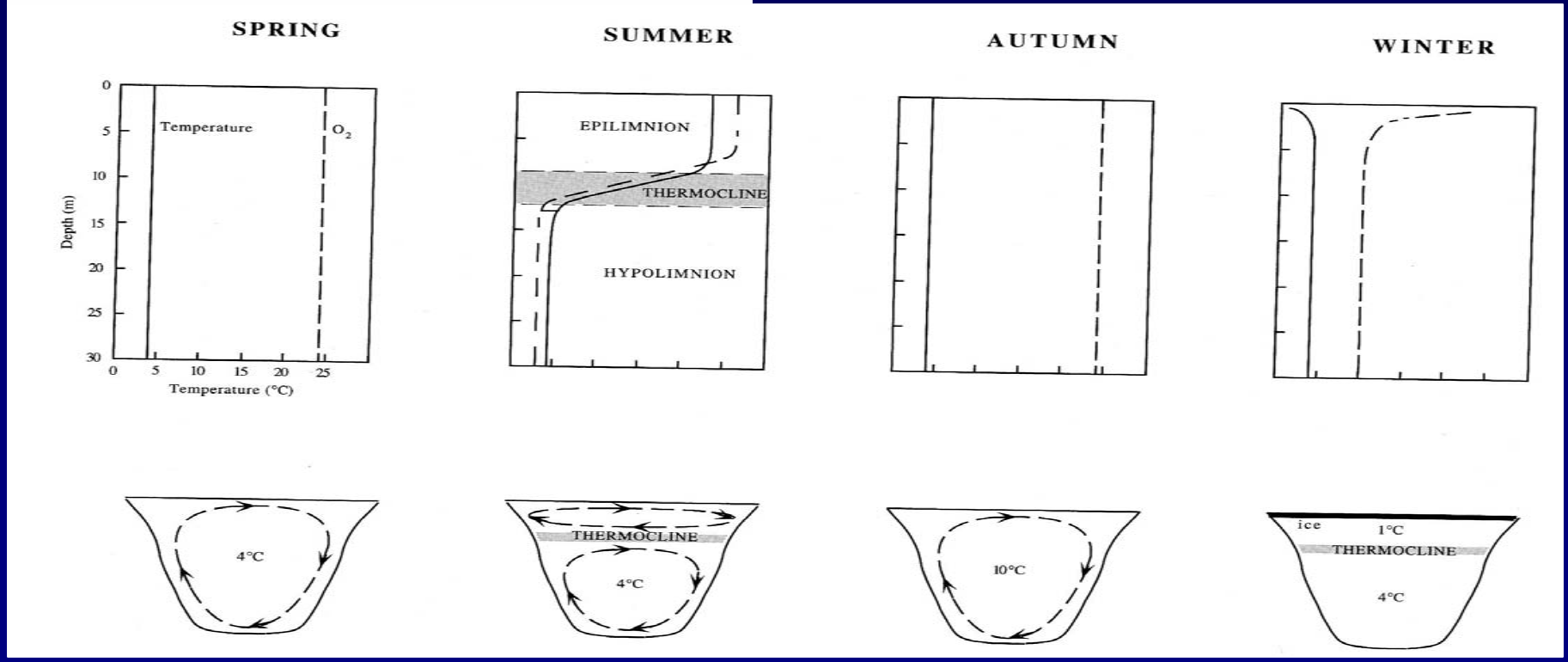
Temperature



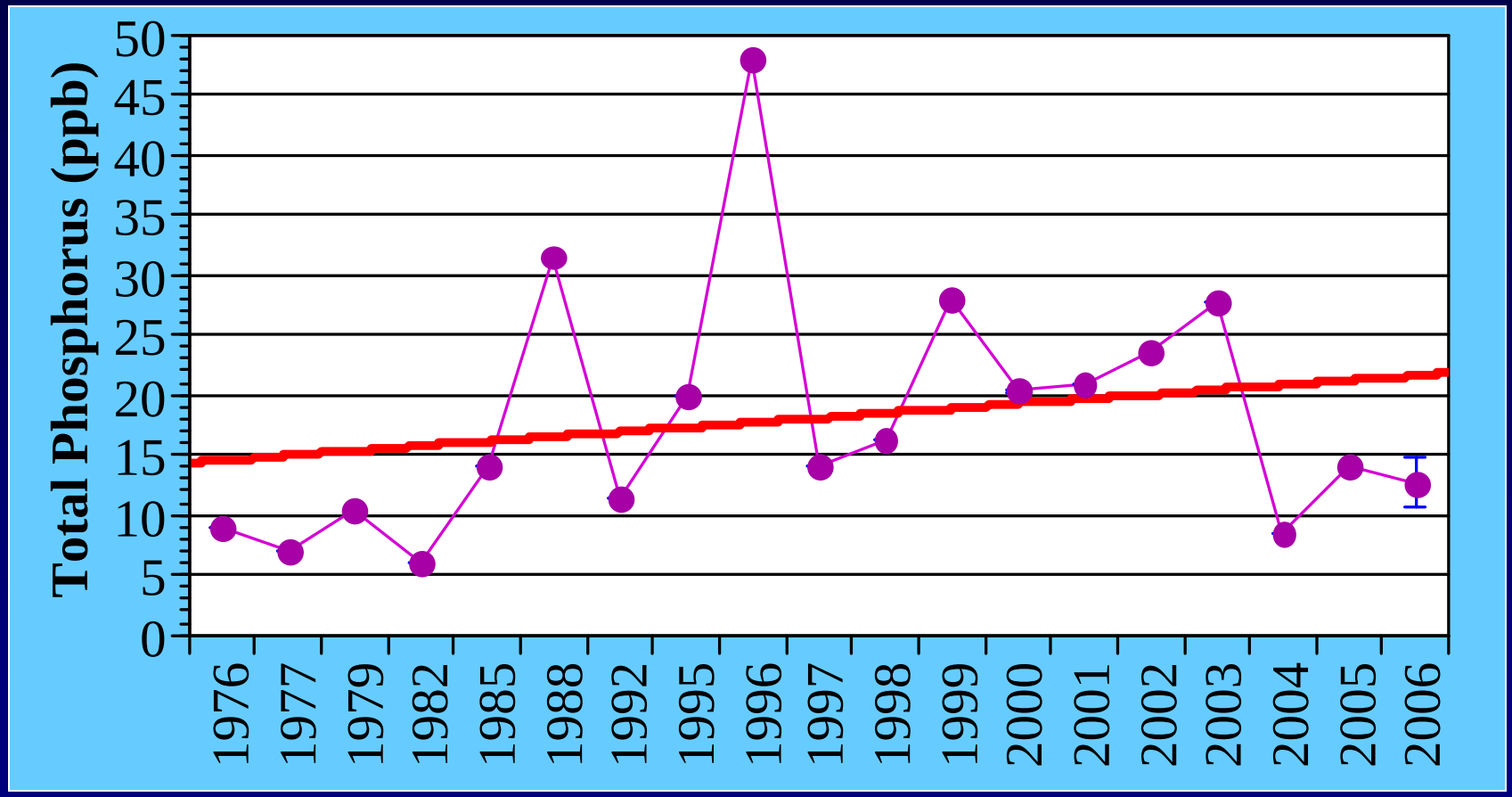
Temperature (˚C) and DO (ppm) profiles in 2006 for Long Pond North at site 1 on 8-Aug-06

Stratification and Turnover



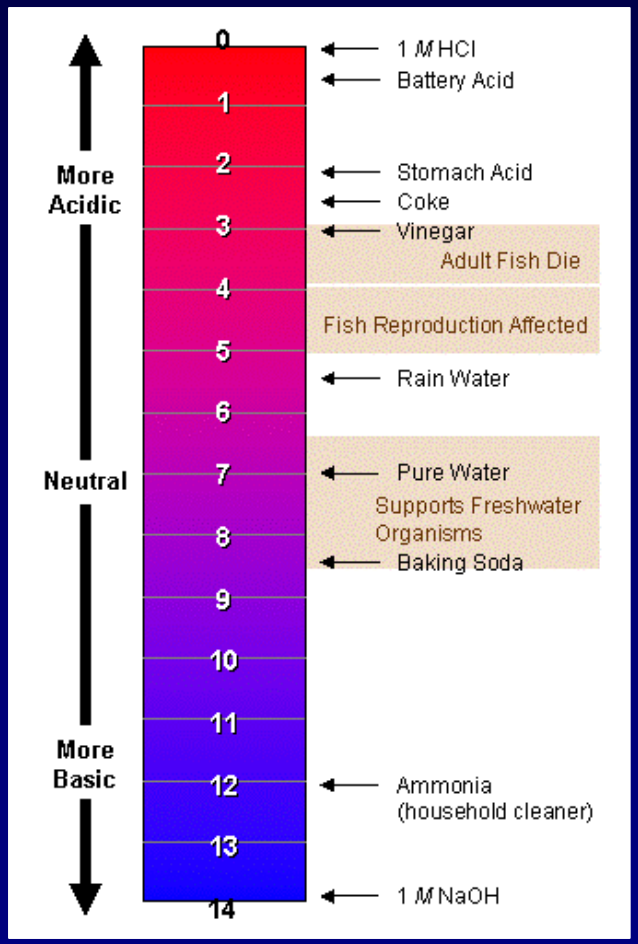


Phosphorus (P)



Mean (± SE) bottom total phosphorus concentrations (ppb) and linear trendline from 1976 to 2006 for Long Pond North at site 1

pH

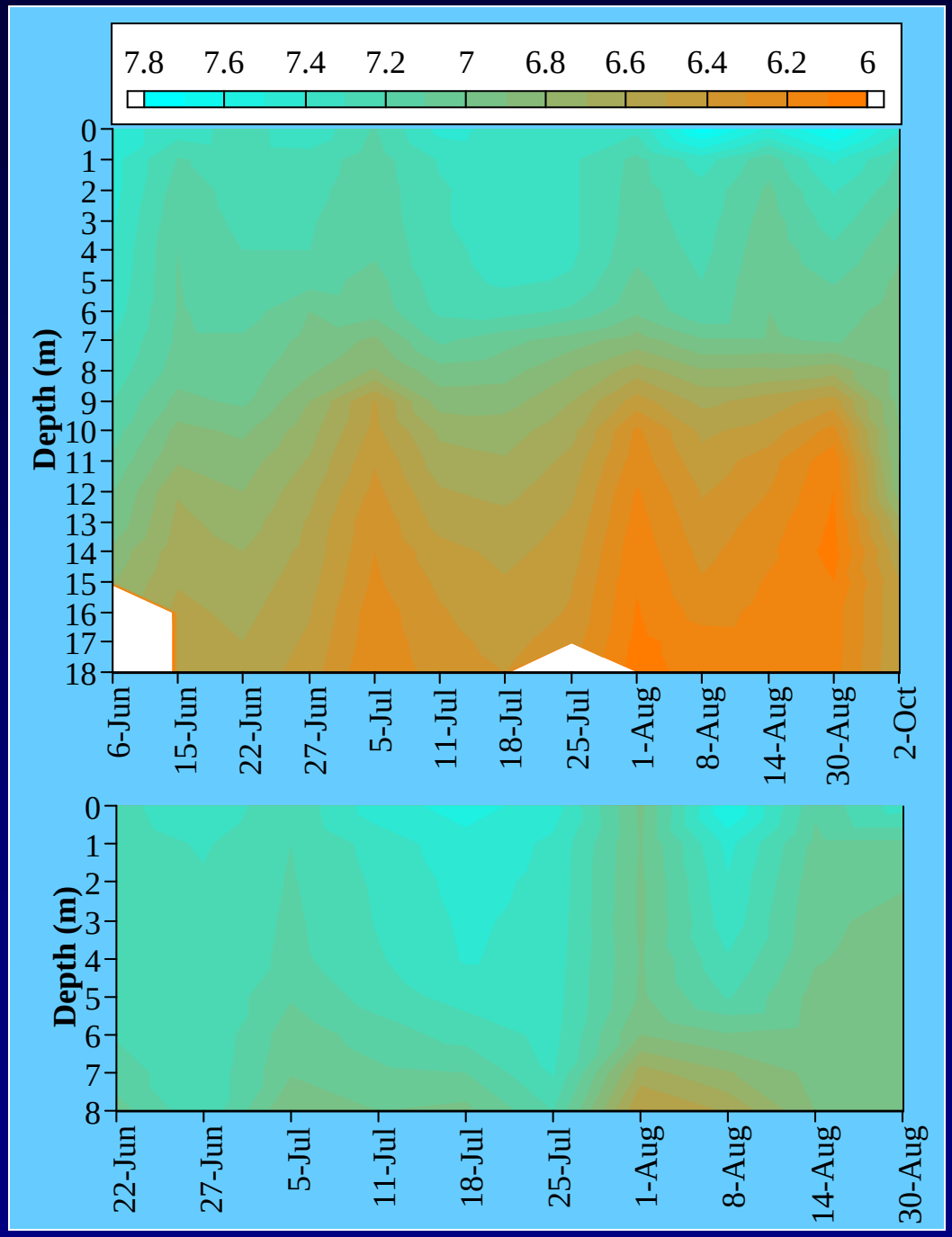


www.jacksonbottom.org

- Measurement of H^+ ions
- Typical lakes: 4 to 9
- Factors that affect pH:
  - Decomposition
  - Acid Rain
  - Primary Production

pH

2006 pH profiles



SITE 1

SITE 3

Transparency

dipin.kent.edu

www.mainevolunteerlakemonitors.org

- Measure of visibility in the water column
- Secchi disk and aquascope
- Secchi depth < 2 m: algae bloom

i.e. Visibility

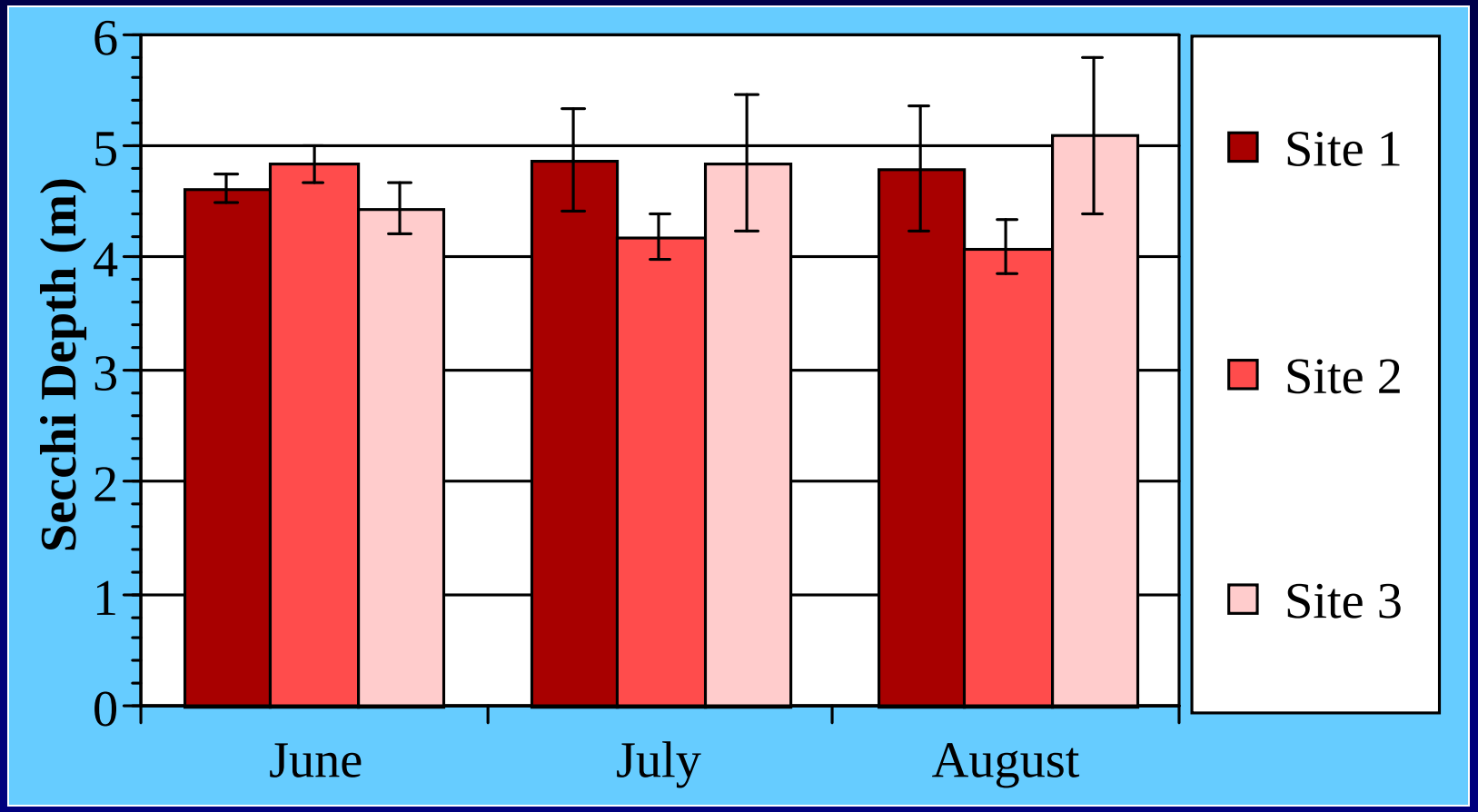
www.baddevelopers.green.net.au

www.friendsofgreenlake.org

www.svid.org

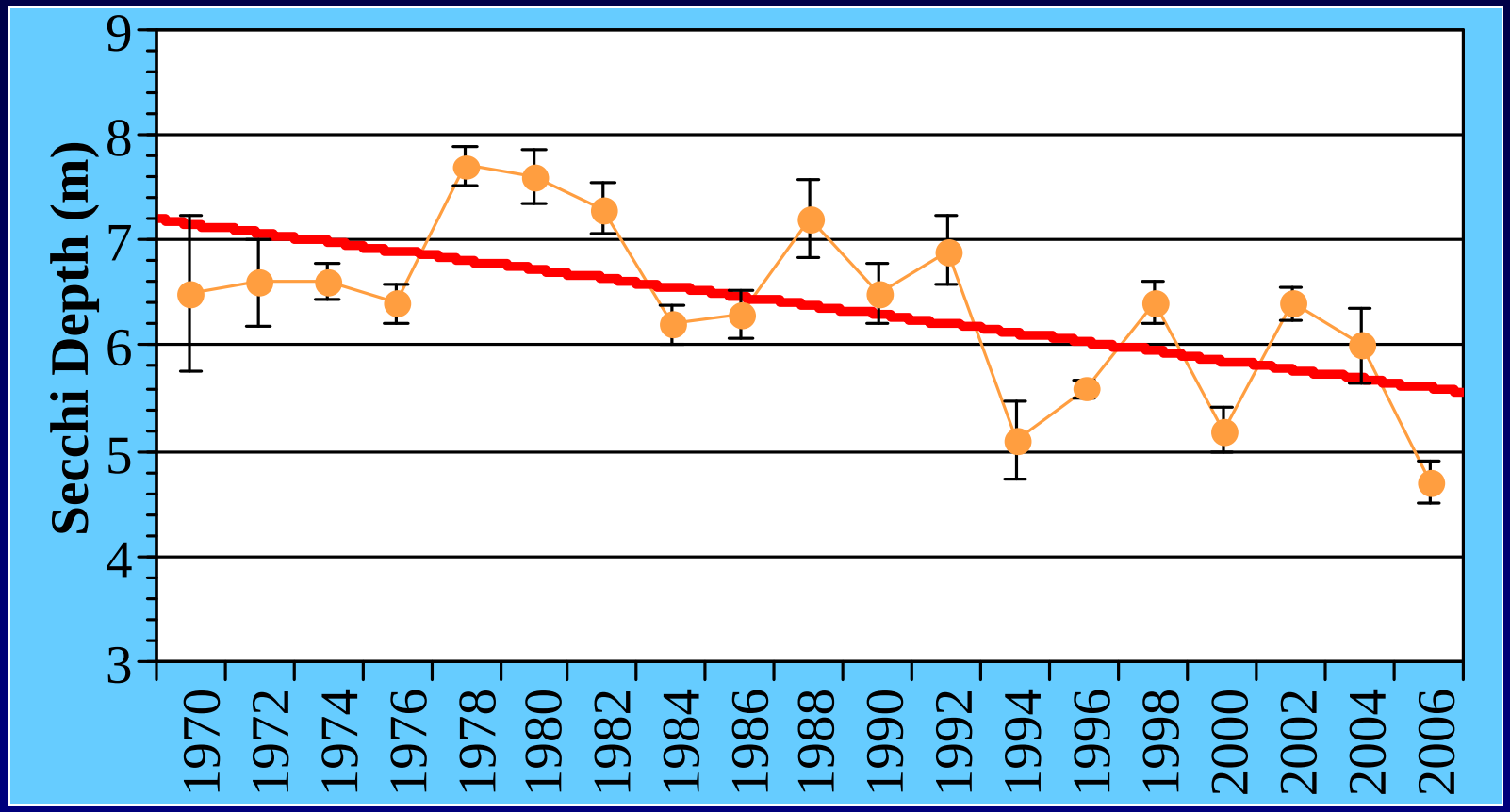
High visibility → Low Visibility

Transparency



Mean (± SE) Secchi depth (m) in 2006 for Long Pond North at sites 1 - 3

Transparency



Water clarity as represented by mean (± SE) Secchi depth (m) and linear trendline from 1970 to 2006 for Long Pond North at site 1

Water Chemistry Conclusions

- The overall water quality of Long Pond North is good
  - PREVENTION IS KEY
- Current concerns:
  - trends in decreasing Secchi depth
  - increasing anoxia

Land Use

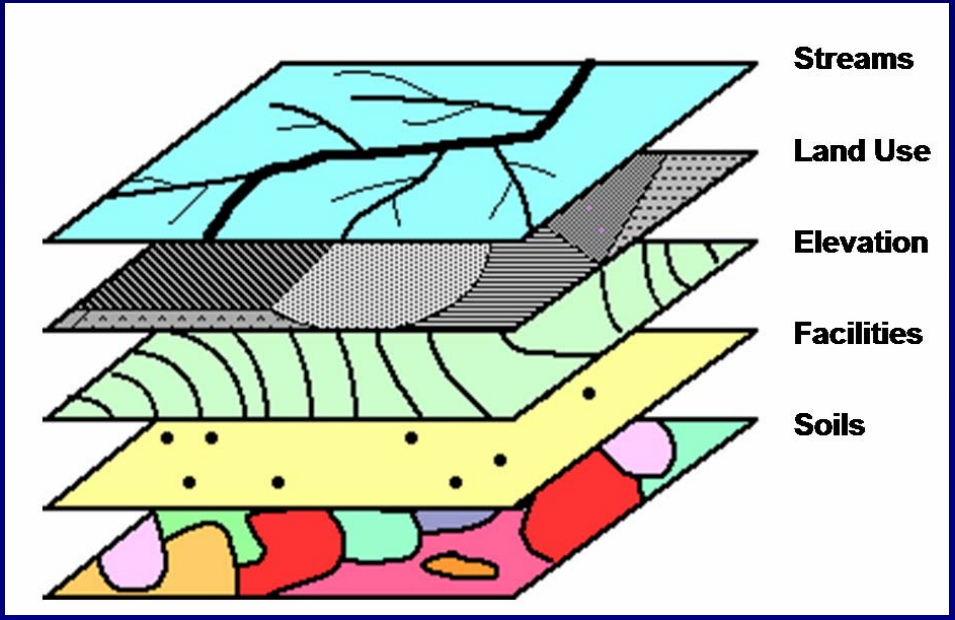
Andrew Adelfio

Land Use

- Importance for our study

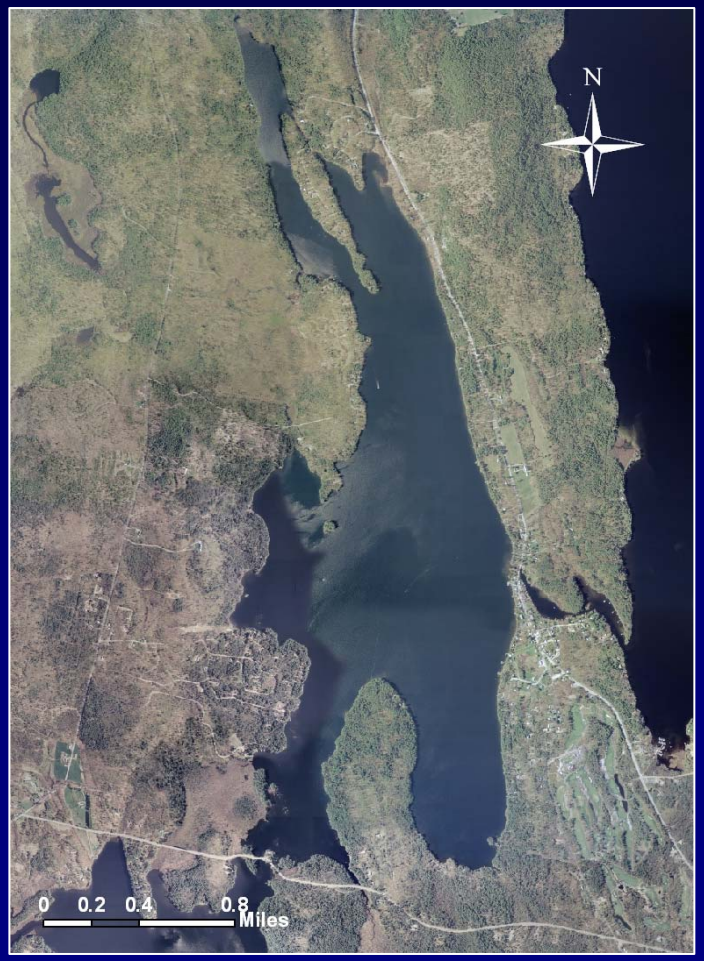
Geographic Information System

- ArcGIS 9.1®
- A computer system that is capable of doing the following to geographically-referenced information:
  - Integrating
  - Editing
  - Analyzing
  - Displaying



Methods for Designating Land-Use Categories

- Digital Orthophoto-Quadrangles (DOQs)
  - Obtained from Maine Office of GIS
  - Aerial photographs taken between 1-Mar-03 and 19-May-03



Land-Use Types

- Water Body
- Wetland
- Coniferous Forest
- Mixed Forest
- Deciduous Forest
- Park
- Regenerating Land
- Golf Course
- Commercial Land
- Cleared Land
- Agricultural Land
- Residential
- Roads
- Shoreline Residential

Example of DOQ Interpretation

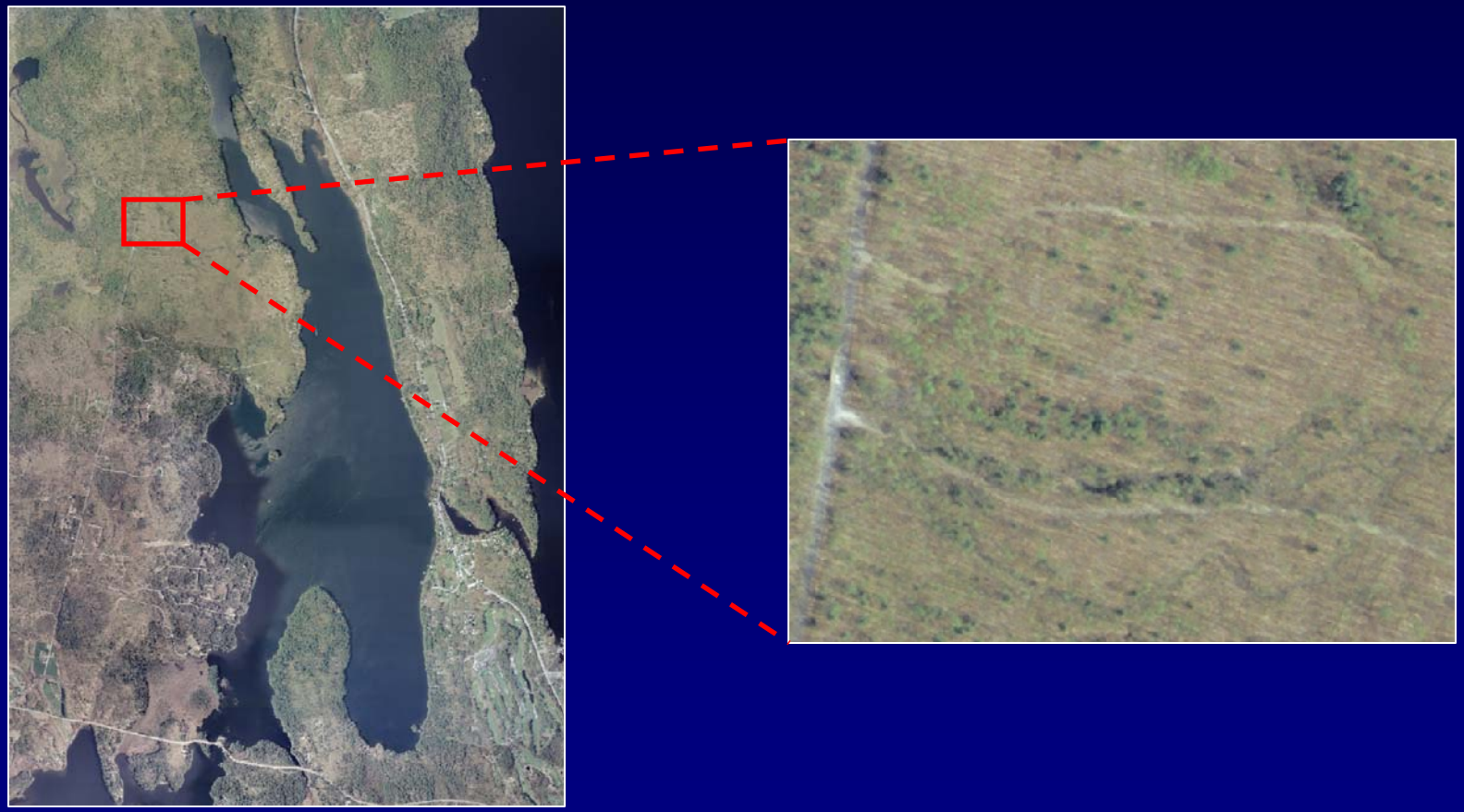
- Shoreline Residential

Ground-Truthing

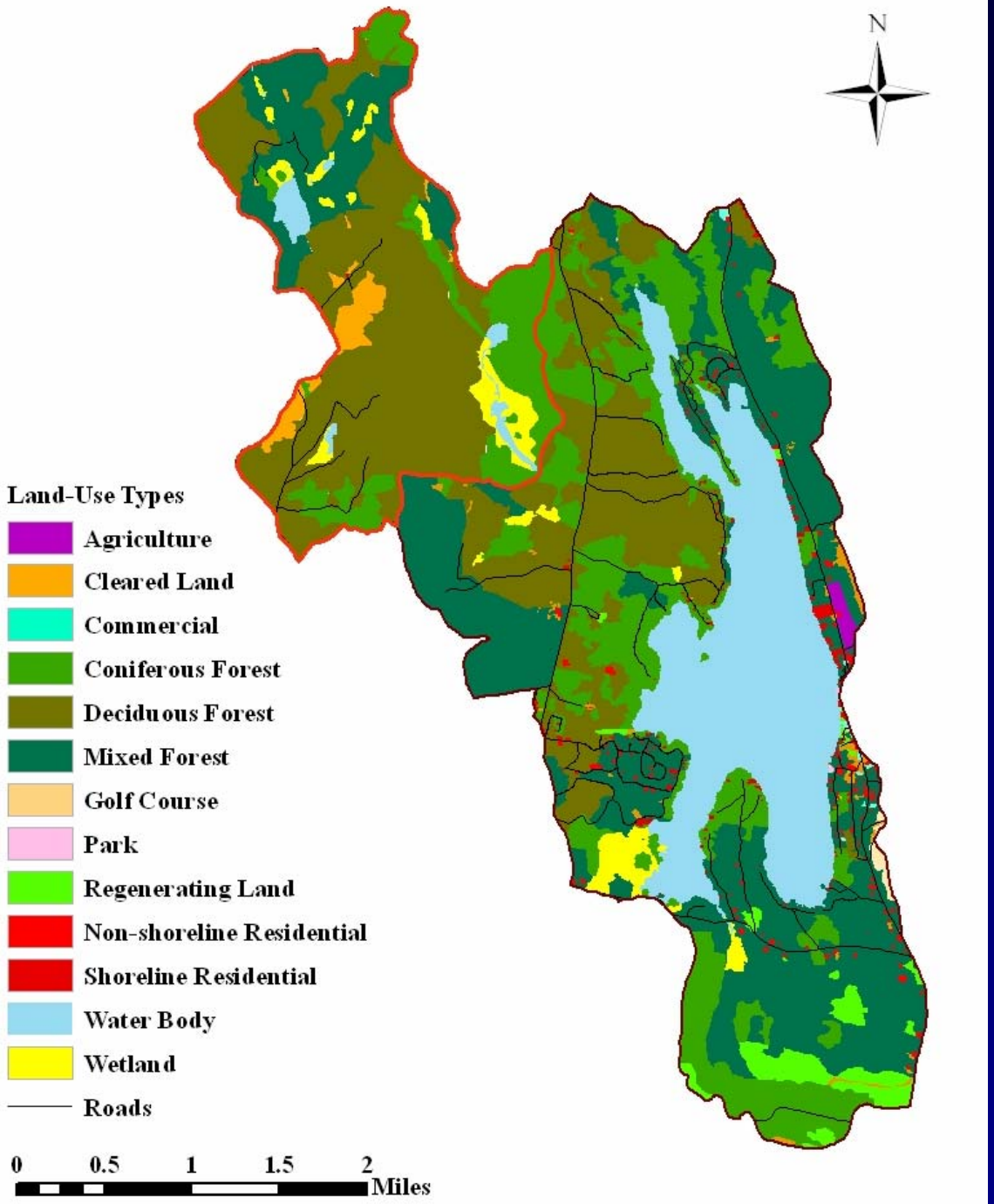
- The use of a ground survey to confirm the findings of an aerial survey

- Learn about areas with:
  - Poor resolution
  - Confusing texture or color

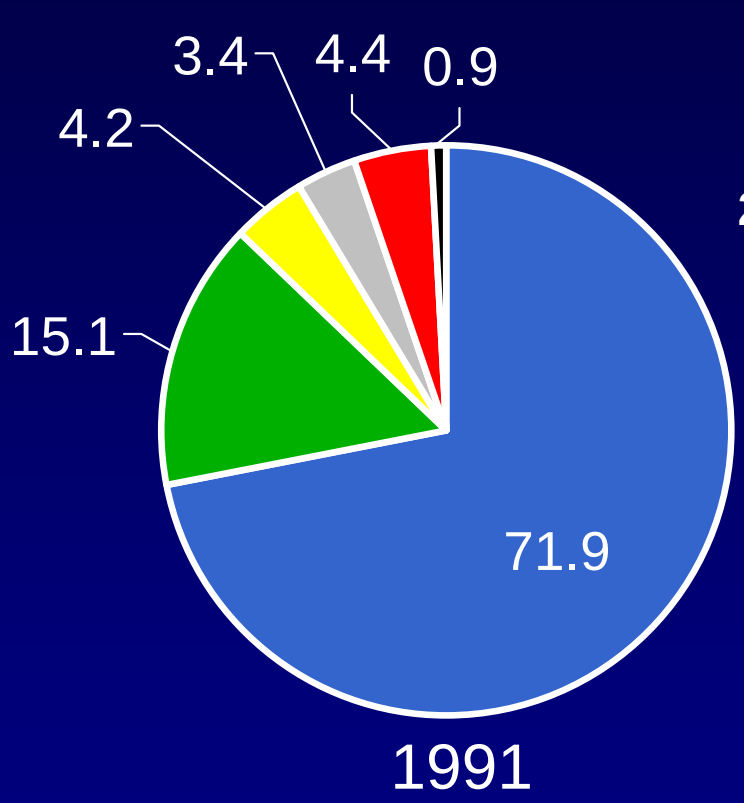
Deciduous Forest Ground-Truthing

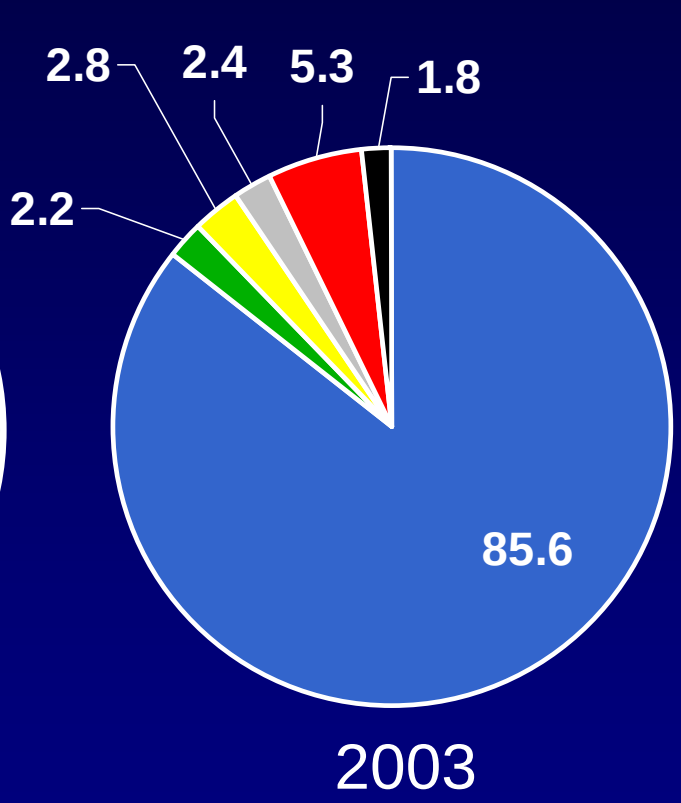


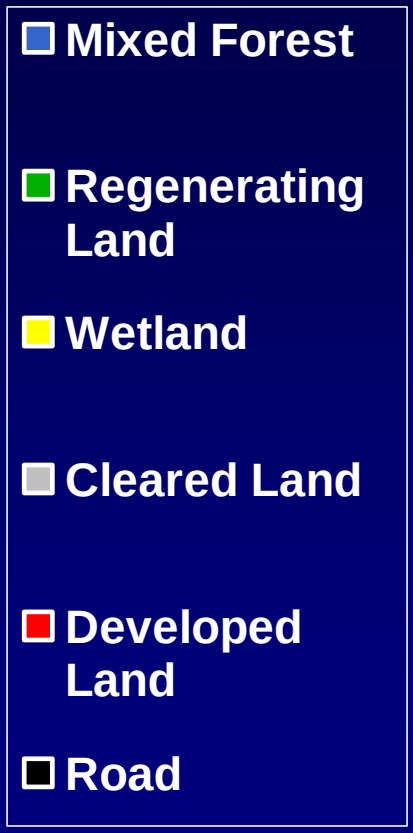
Polygon Creation


N
Land-Use Types
Agriculture
Cleared Land
Commercial
Coniferous Forest
Deciduous Forest
Mixed Forest
Golf Course
Park
Regenerating Land
Non-shoreline Residential
Shoreline Residential
Water Body
Wetland
Roads
0
0.5
1
1.5
2
Miles

Current vs. Past Land Use







Intermission

A Watershed Analysis of Long Pond North, Part II

Implications for Water Quality and Land-Use Management

Colby Environmental Assessment Team

December 7th, 2006

Presentation Outline

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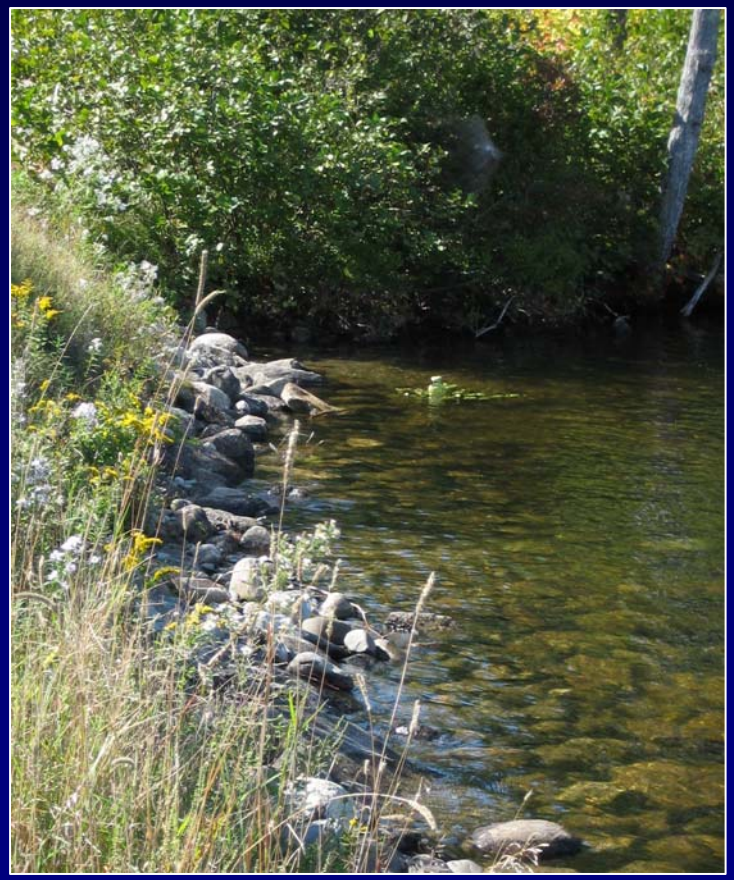
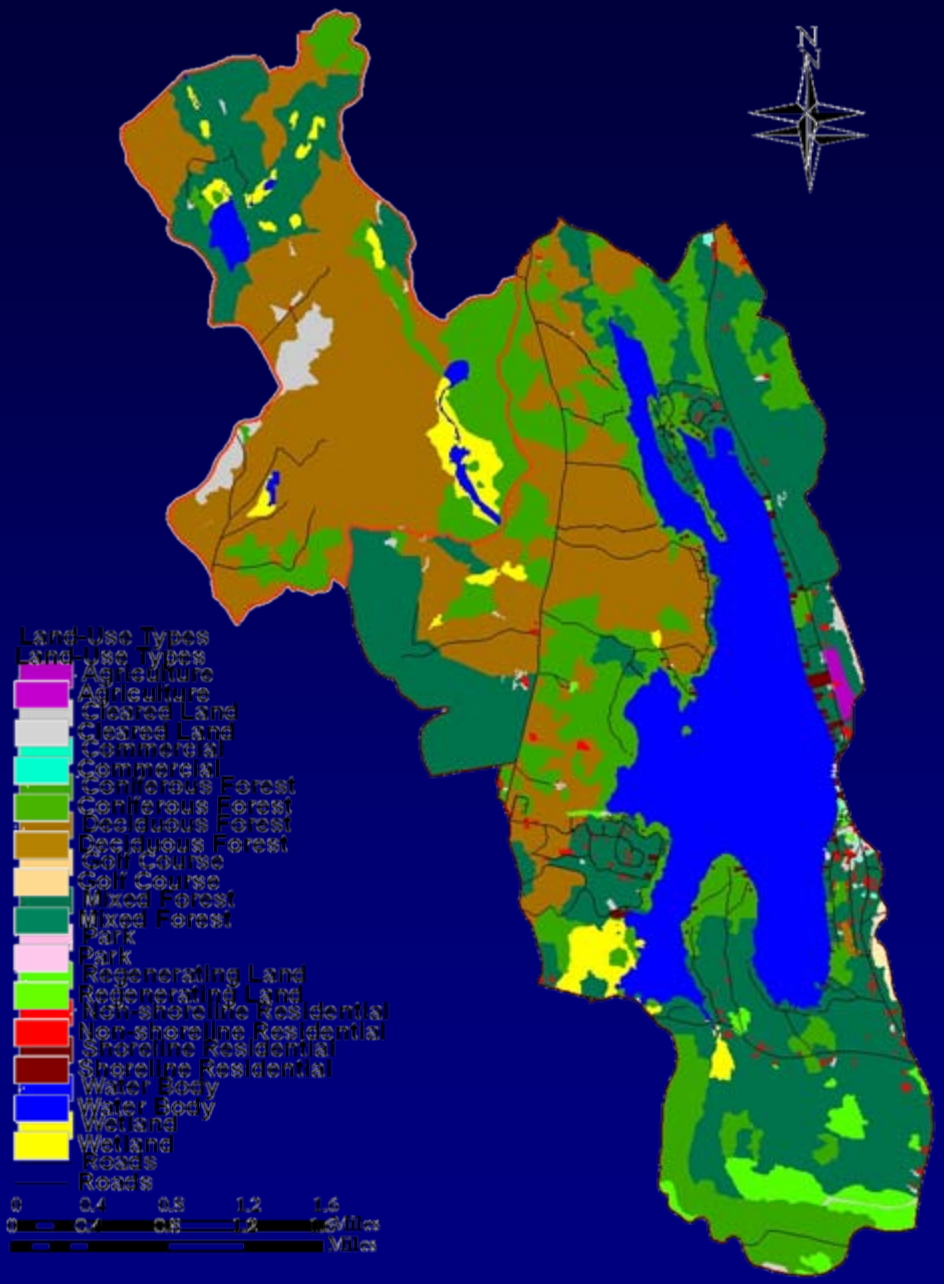
- Water and Phosphorus Budgets Kelly Bakulski
- Summary and Recommendations Alex McPherson

Time for Questions

Ground Surveys



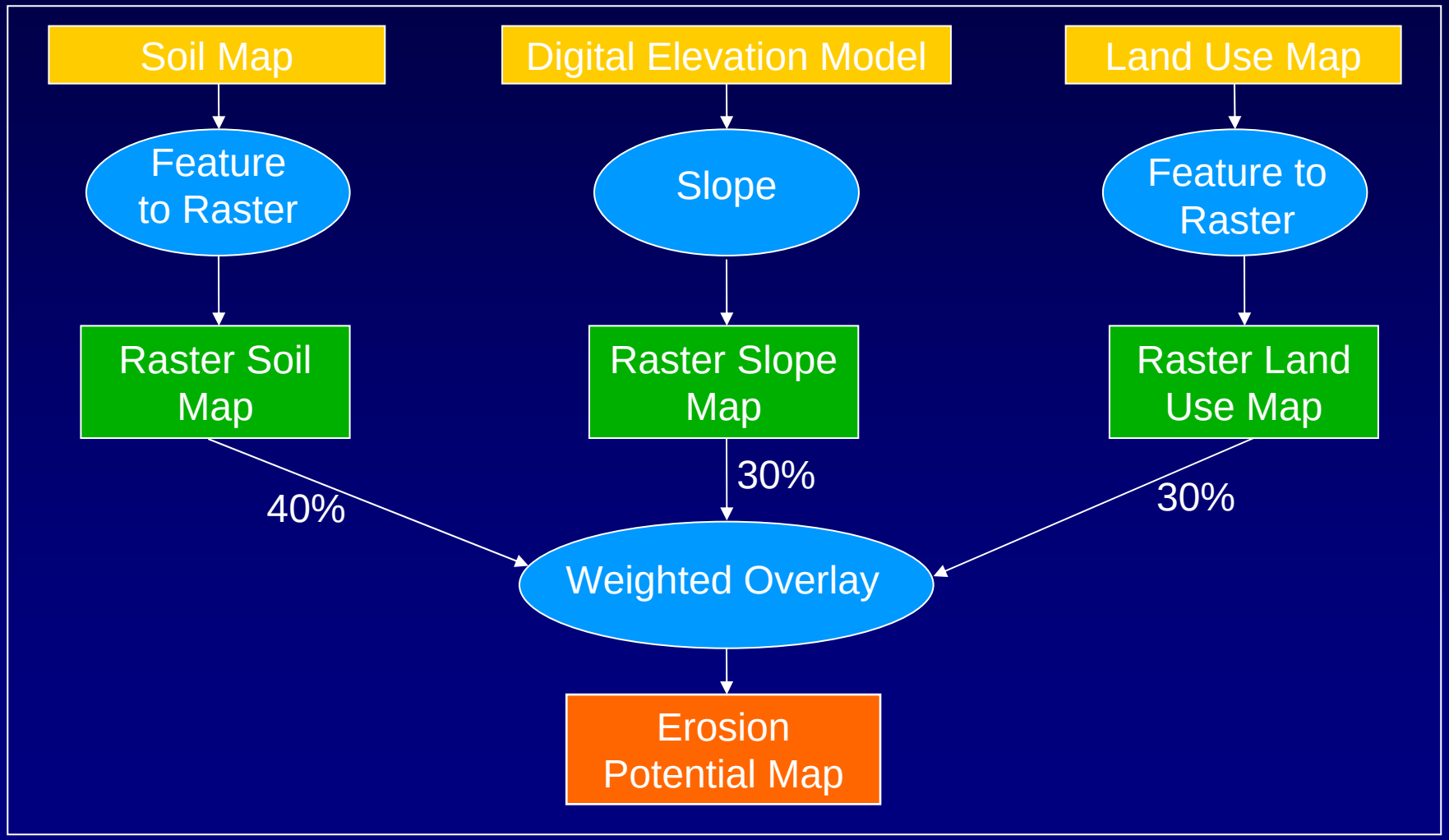
- Roads
  - Area and Condition
- Buffer Strips
  - Coverage
- Residence Count
  - Seasonal or Year-round
  - Shoreline proximity



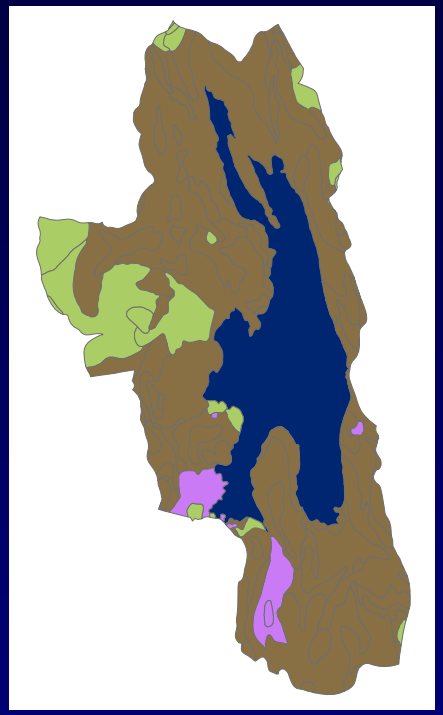
GIS Modeling

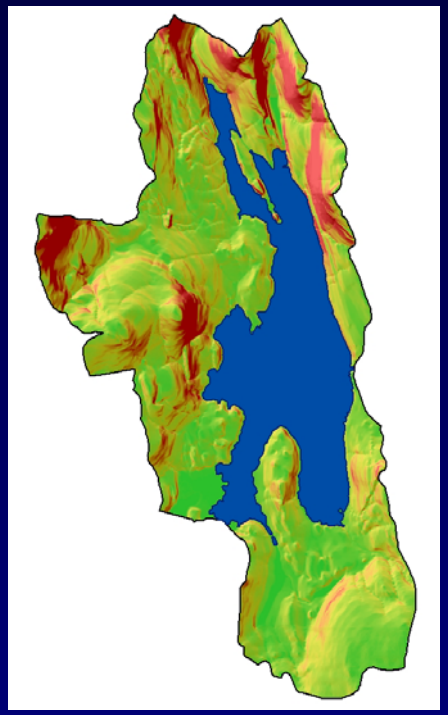
- Maps
  - Bathymetry
  - Slope
- Models
  - Erosion
  - Development

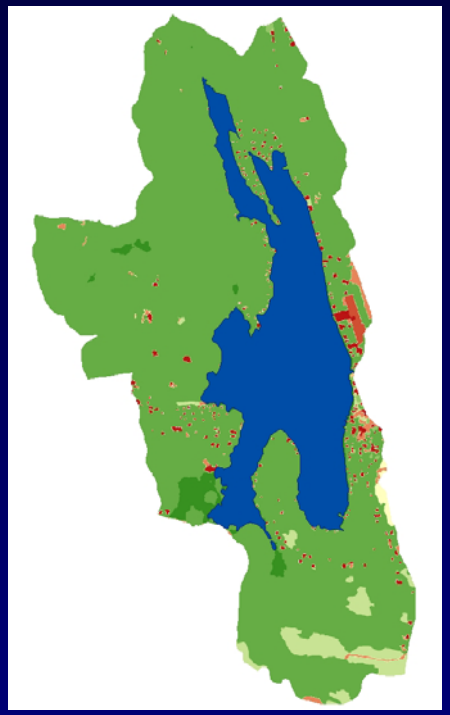
Using Layers



Erosion Potential







Soil Type

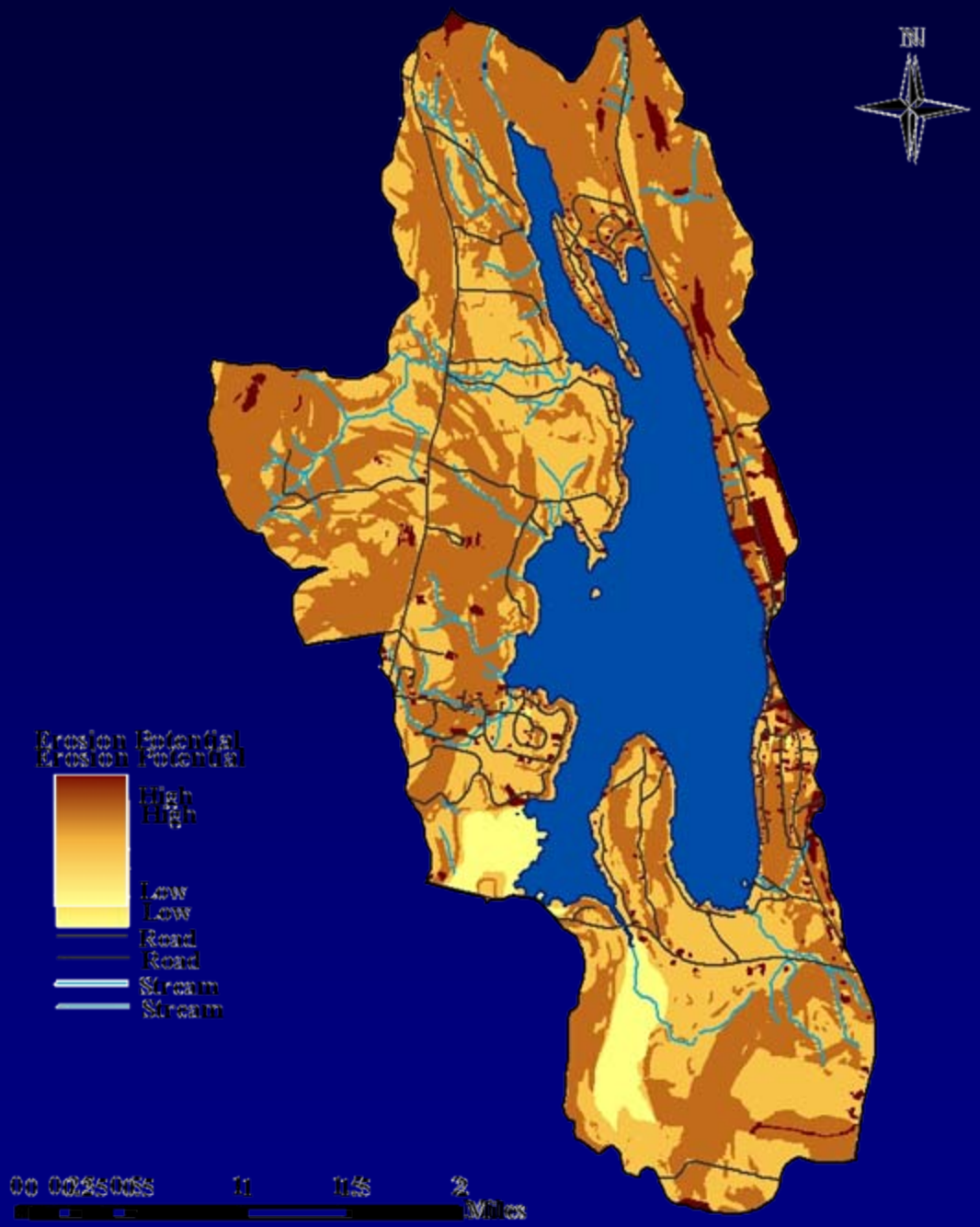
40%

Slope

30%

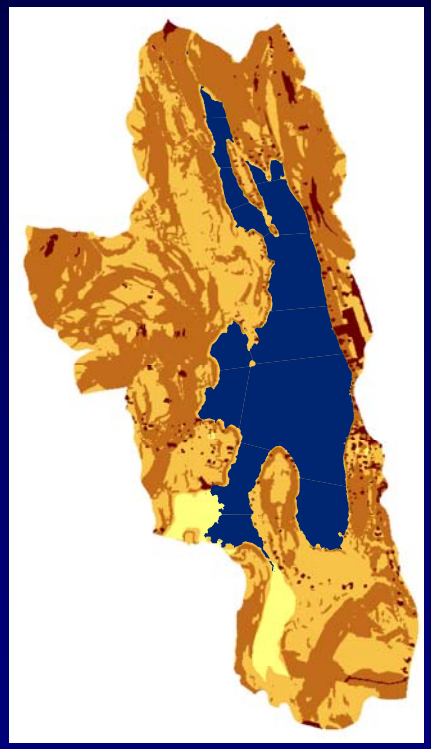
Land Use

30%



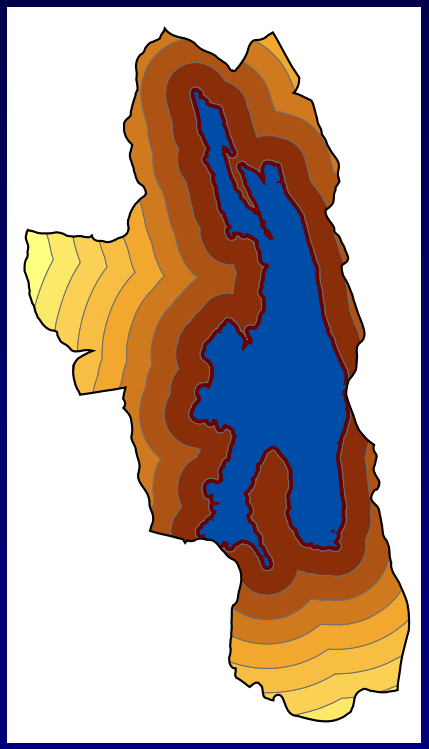
Erosion Potential Model

Erosion Impact



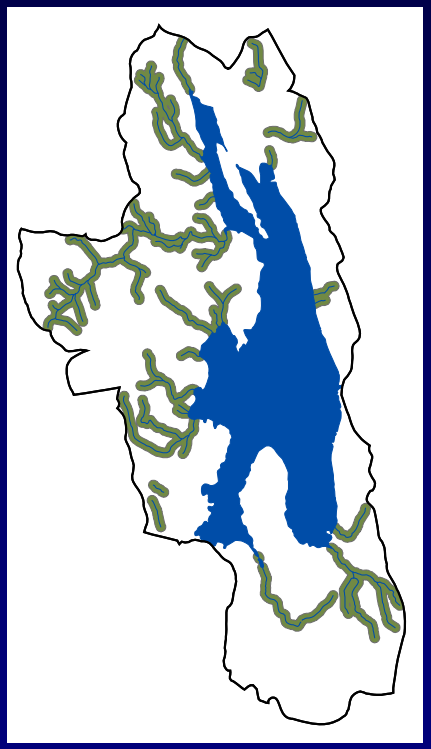
Erosion Potential

50%



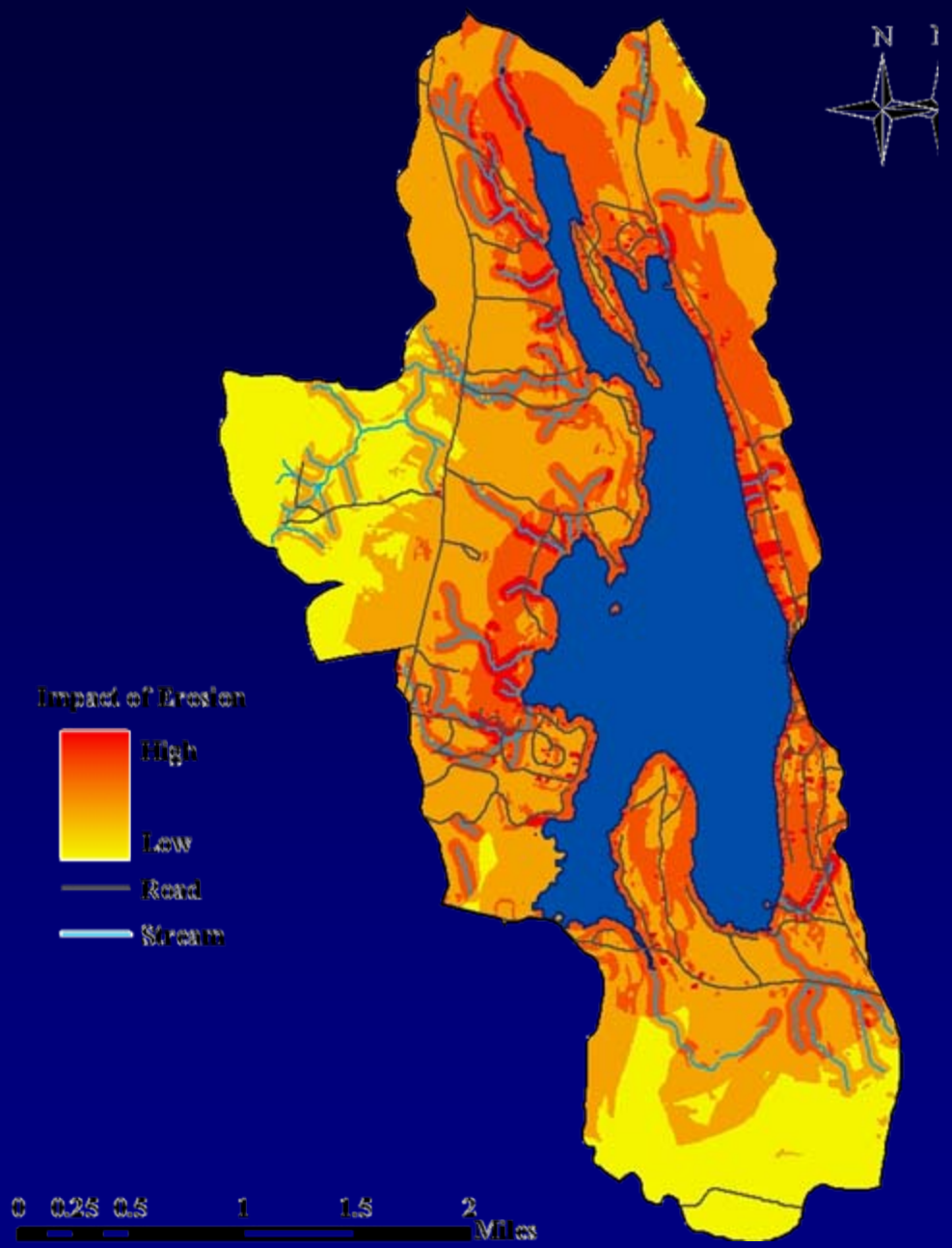
Lake Proximity

40%



Stream Proximity

10%

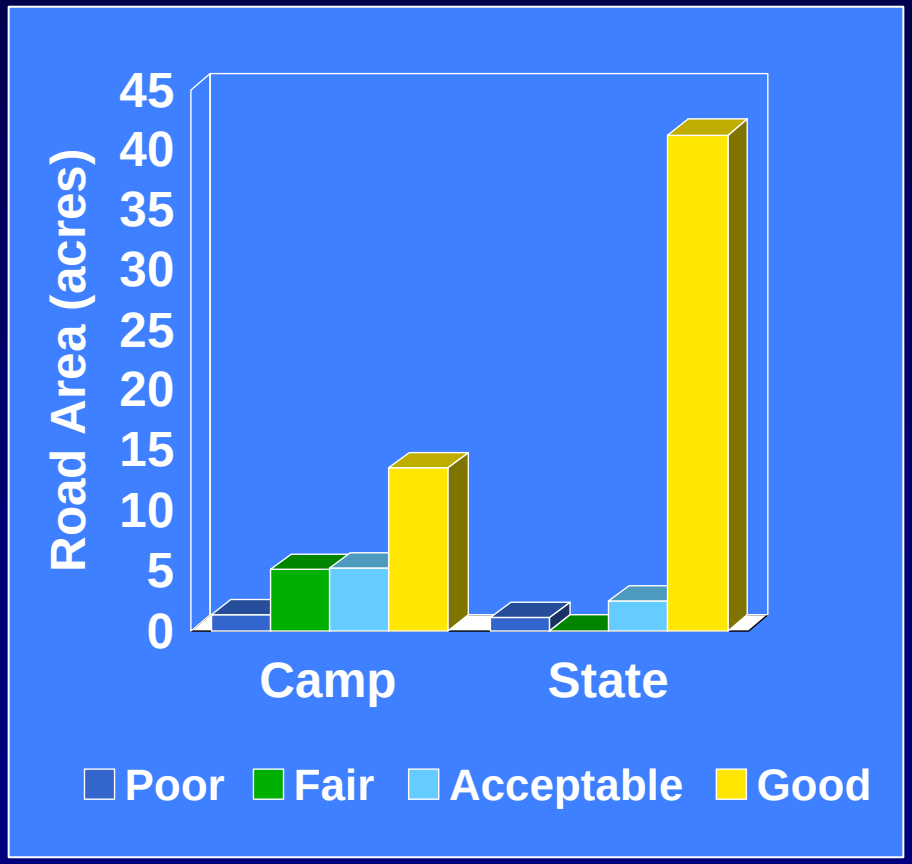


Erosion Impact Model

Road Survey

- Road Concerns
  - Erosion and Sedimentation
  - Drainage
- Maintenance Tools
  - Crowning
  - Ditches
  - Culverts
  - Diversions

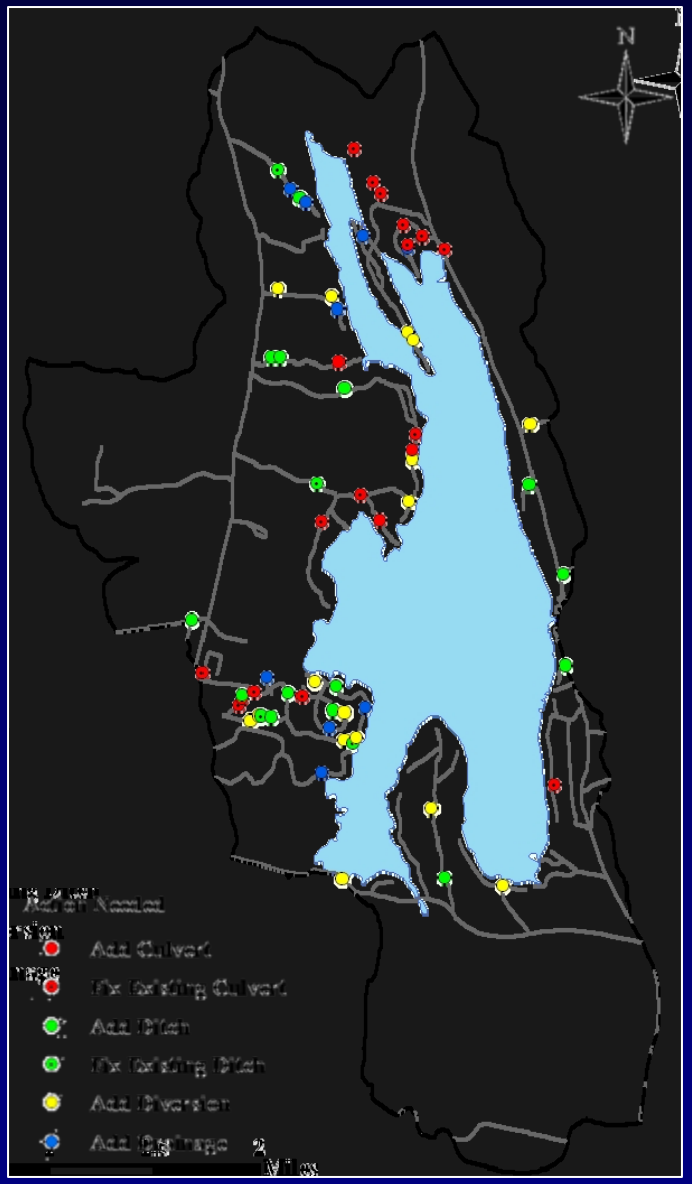
Road Survey Results



- Camp roads
  - Worse condition
  - More Fair and Acceptable
- Targeted Problems
  - Culverts: 32%
  - Ditches: 26%
  - Crowning, diversions, etc.

Road Maps

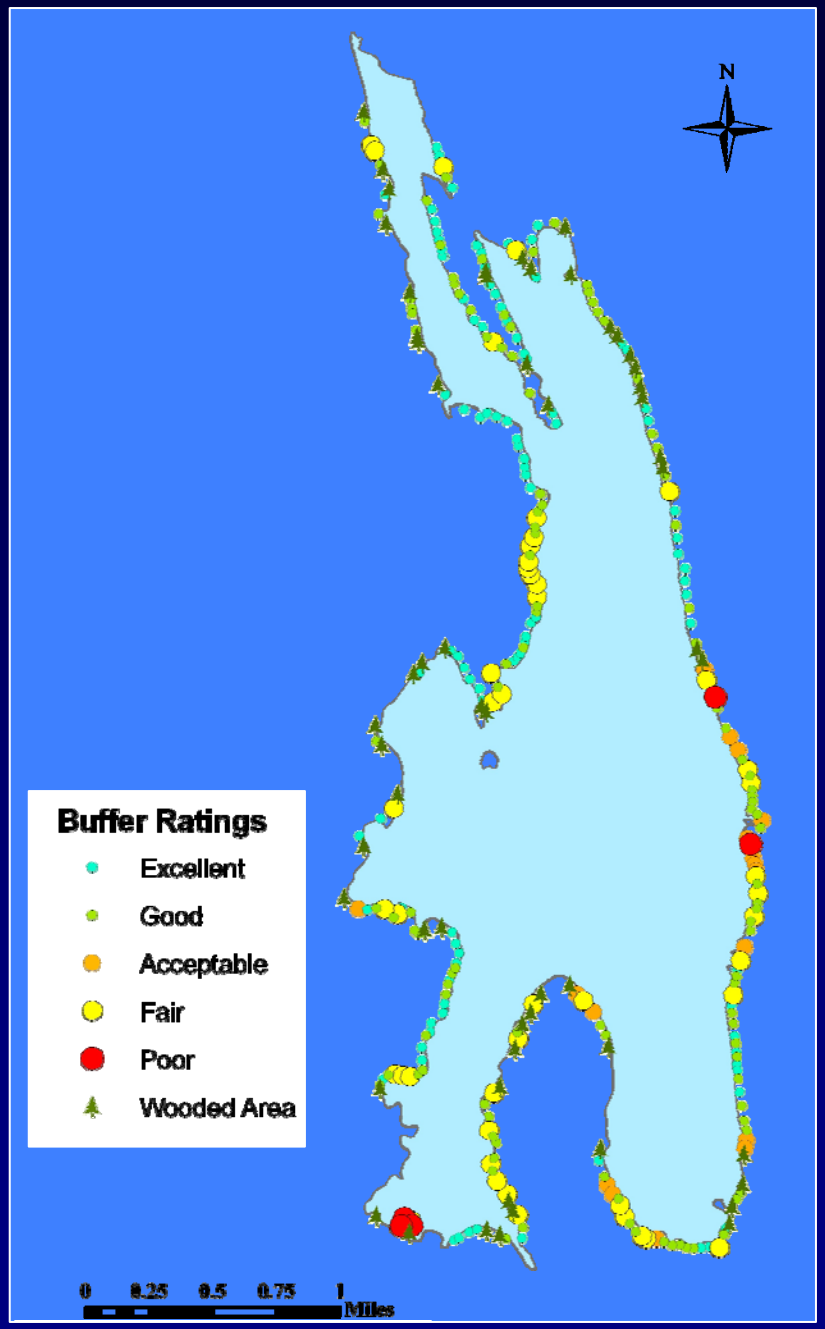

N
Quality of Roads
in Watershed
Good
Acceptable
Fair
Direct Watershed

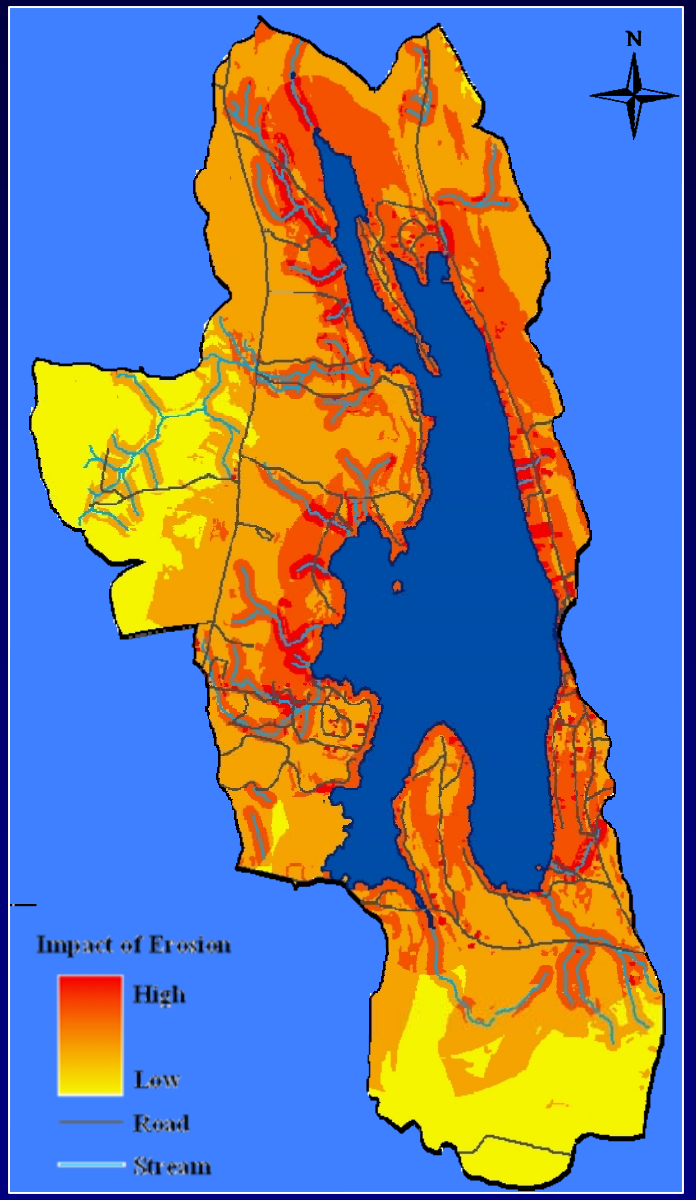

N
Add Culvert
Fix Existing Culvert
Add Ditch
Fix Existing Ditch
Add Diverter

Buffer Strip Survey

- Buffer functions
  - Protect soil
  - Remove nutrients and trap sediment
  - Maintain natural habitat
- Evaluation Parameters

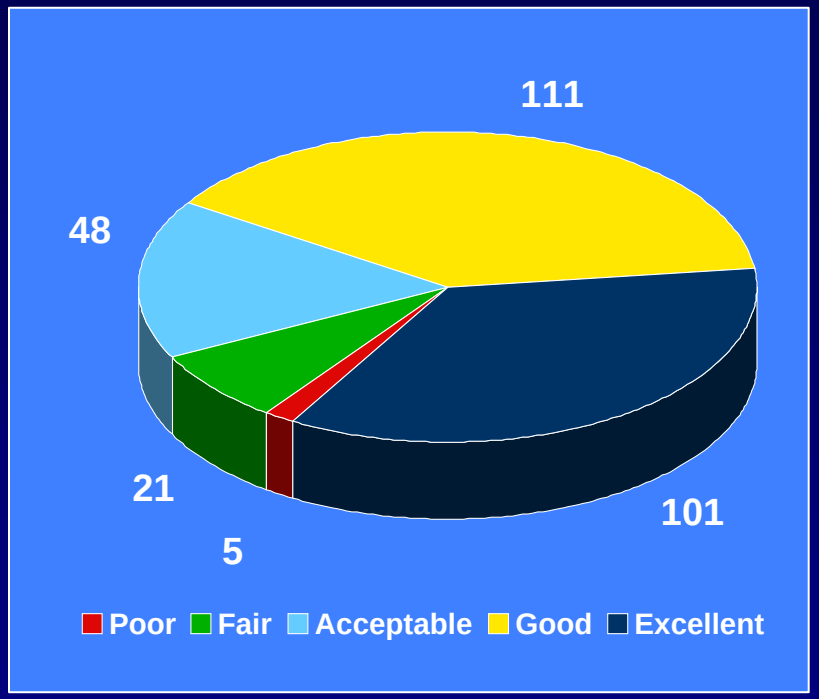
Buffers


N
Buffer Ratings
Excellent
Good
Acceptable
Fair
Poor
Wooded Area
0 0.25 0.5 0.75 1
Miles


N
Impact of Erosion
High
Low
Road
Stream

Buffer Strip Survey

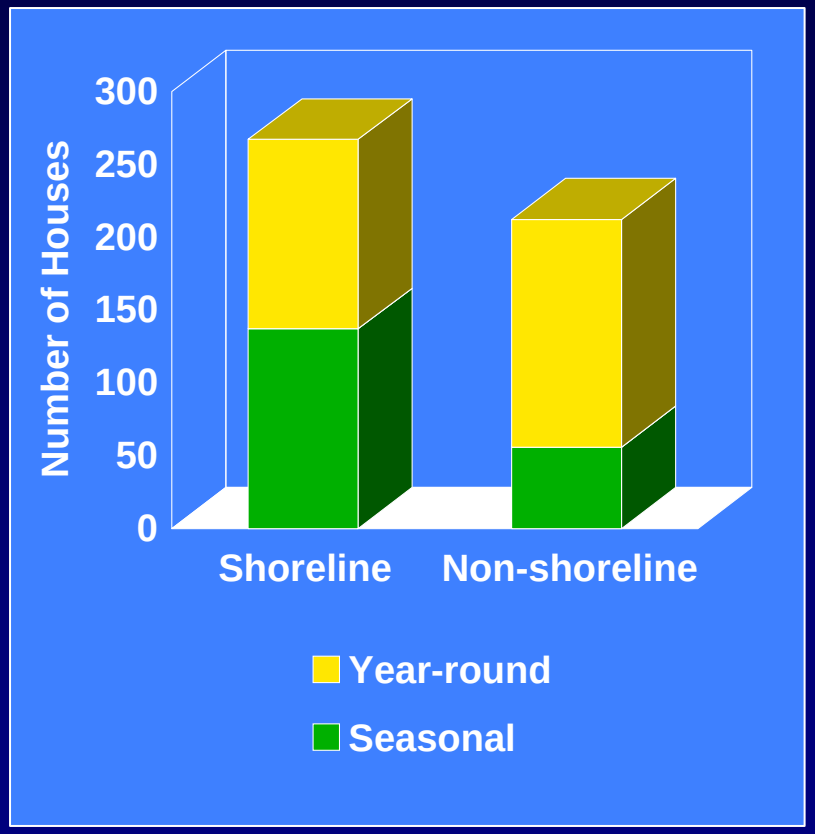
- Overall good buffers
- Weaknesses
  - Depth
  - Canopy trees
  - Commercially developed areas



Residence Count

- Measure human impact
  - Wastewater
  - Recreational use
- Shoreline Houses
  - Within 250 ft

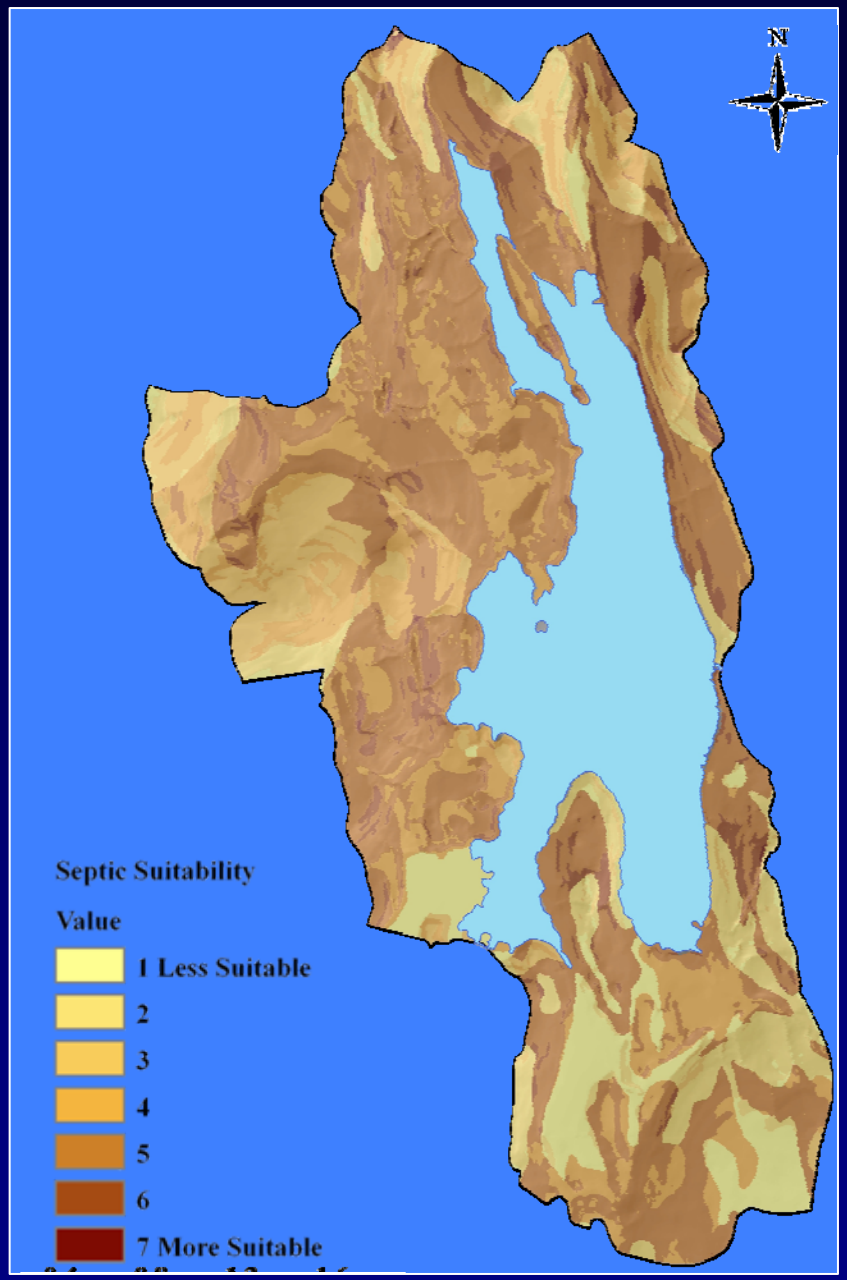
Residences



- 479 Houses
  - Year-round
  - Shoreline
- Residential Density
  - High in developed areas
  - Lowered by tracts of undeveloped land

Undeveloped Areas

- Significant portion of shoreline
  - Some development options
- Protects water quality
  - Less human impact
  - Ecosystem buffer

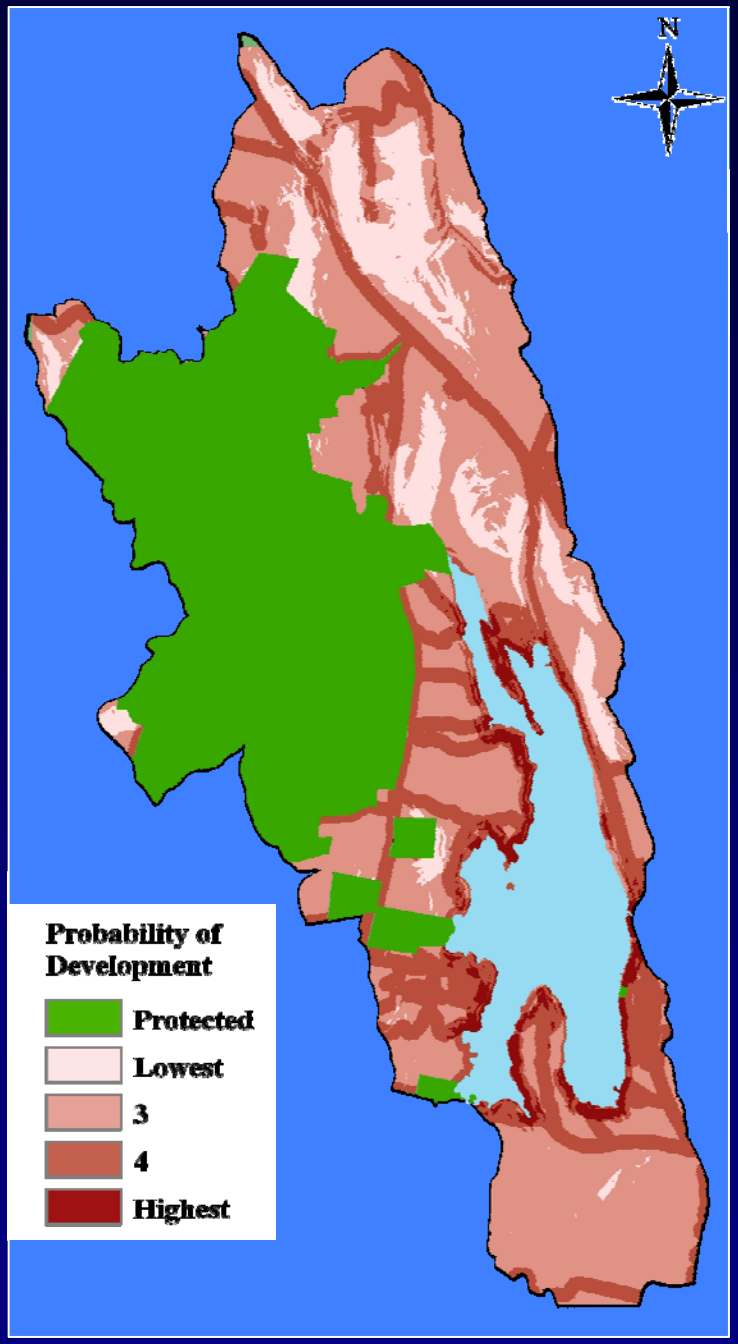


Septic Suitability

- GIS Map
  - Soil type
  - Porosity
  - Slope
- Many Sites Suitable
- Few Areas of Concern
  - Leveling, import soil

Residential Density

Lake	Density
Webber Pond	16.6
Threemile Pond	20.5
China Lake, East Basin	30.2
Long Pond North	17.5
Without undeveloped areas	26.6



Development Potential

- Proximity to lake
- Proximity to existing infrastructure
- Ease of construction
  - Slope
  - Soil type

Future Considerations

- Roads
  - Poor general condition
  - Easy remedies
- Buffers
  - Good general condition
  - Maintain depth
- Residential Count
  - Relatively low
  - Many development opportunities

Water and Phosphorus Budgets

Kelly Bakulski

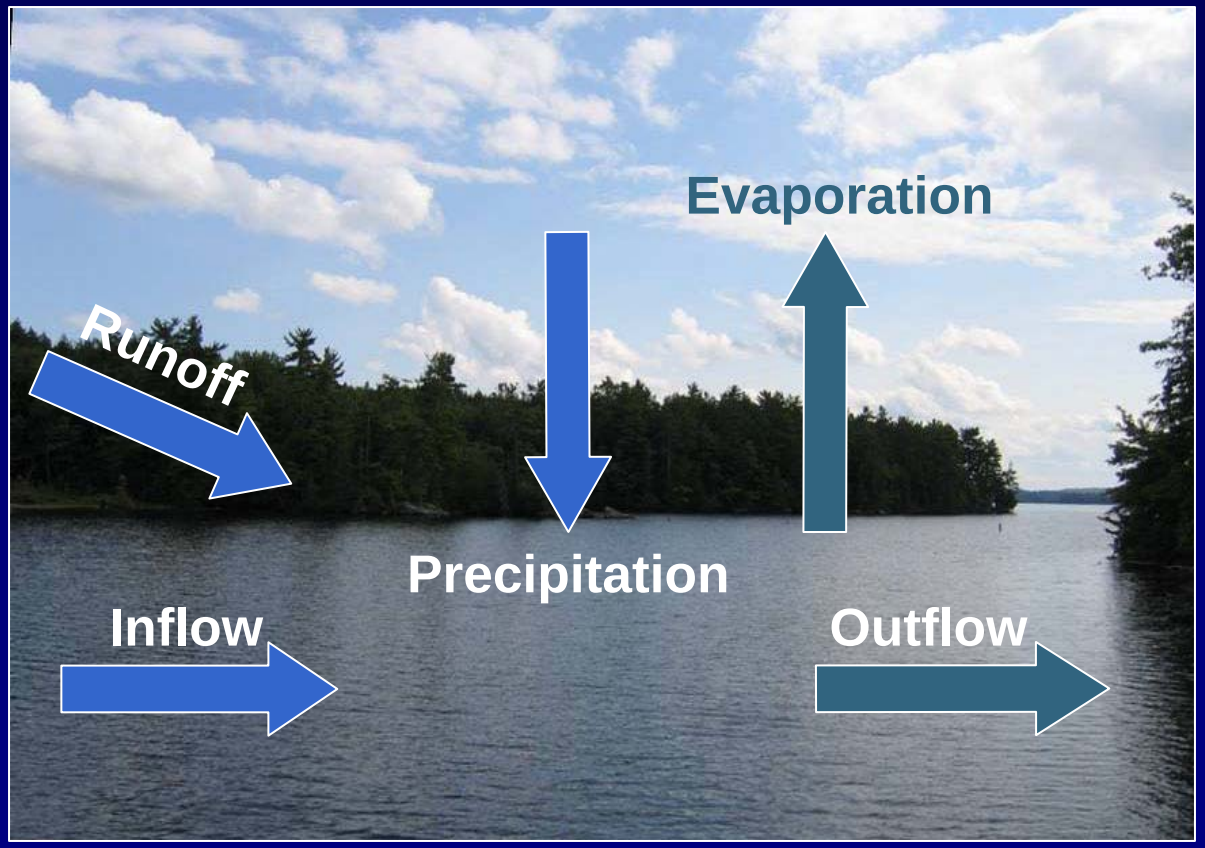
Water Budget Significance

- Flushing Rate

Water Budget Methods

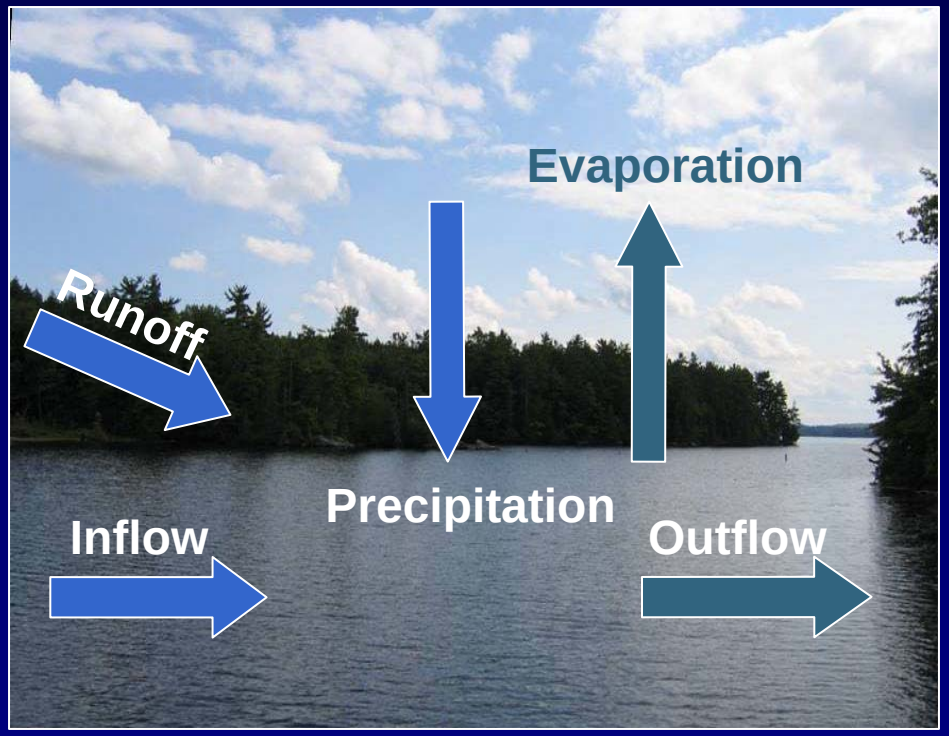
- Basic relationship: (assuming no change in water level)

  runoff + direct inflow + precipitation = evaporation + outflow



Physical Parameters

Physical Parameter	Value
Runoff Coefficient	0.622 meters/year
Evaporation Coefficient	0.560 meters/year
Mean Annual Rainfall	1.057 meters/year
Lake Surface Area	5.044×10^6 meters^2
Watershed Area	2.316×10^7 meters^2
Lake Volume	3.492×10^7 meters^3



Calculating the Net Input

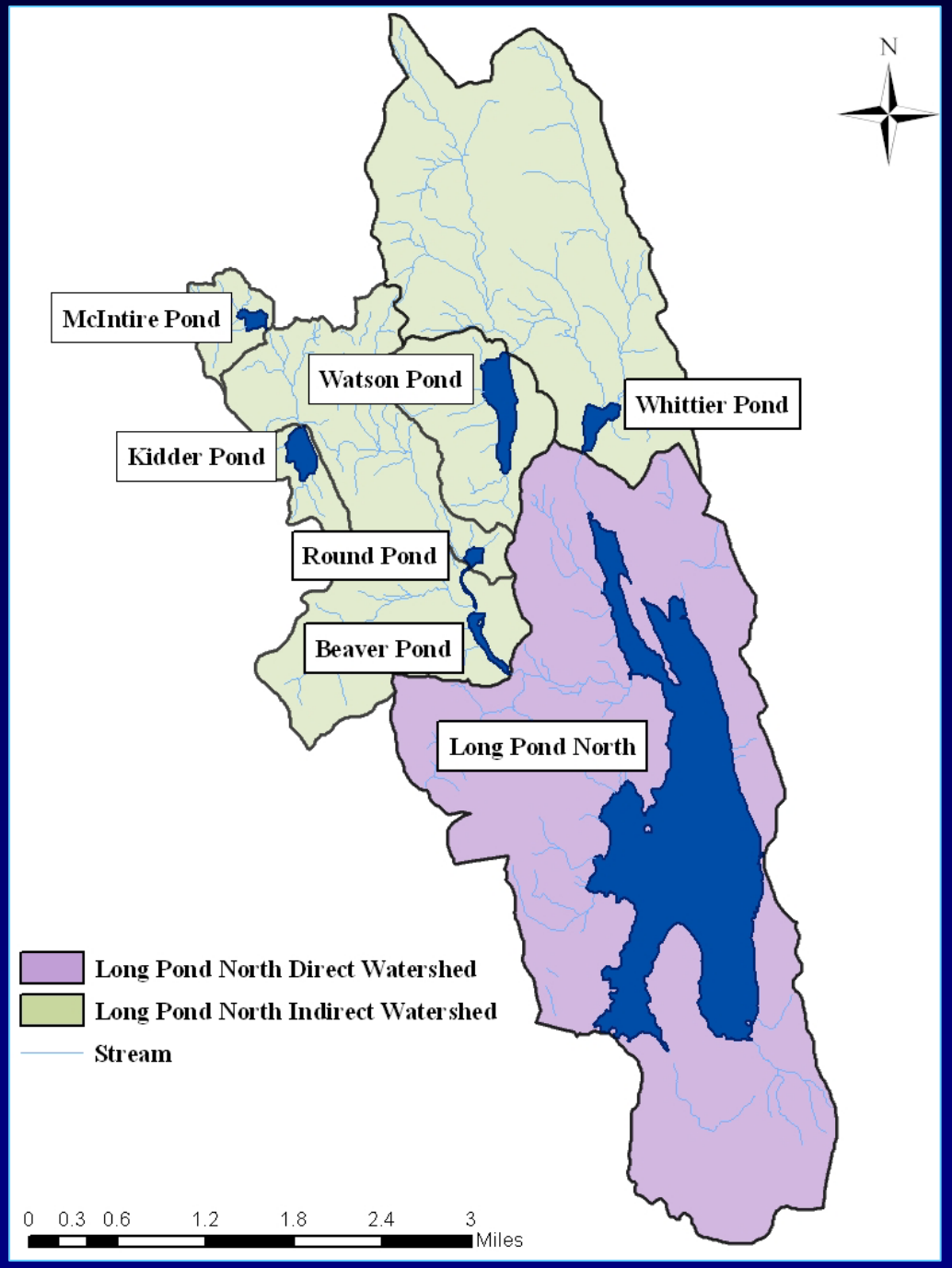
I_{net} = (runoff * watershed area) + (precipitation * lake area) – (evaporation * lake area)

$I_{net} = (0.622 * 2.316 \times 10^7) + (1.057 * 5.160 \times 10^6) – (0.560 * 5.160 \times 10^6)$

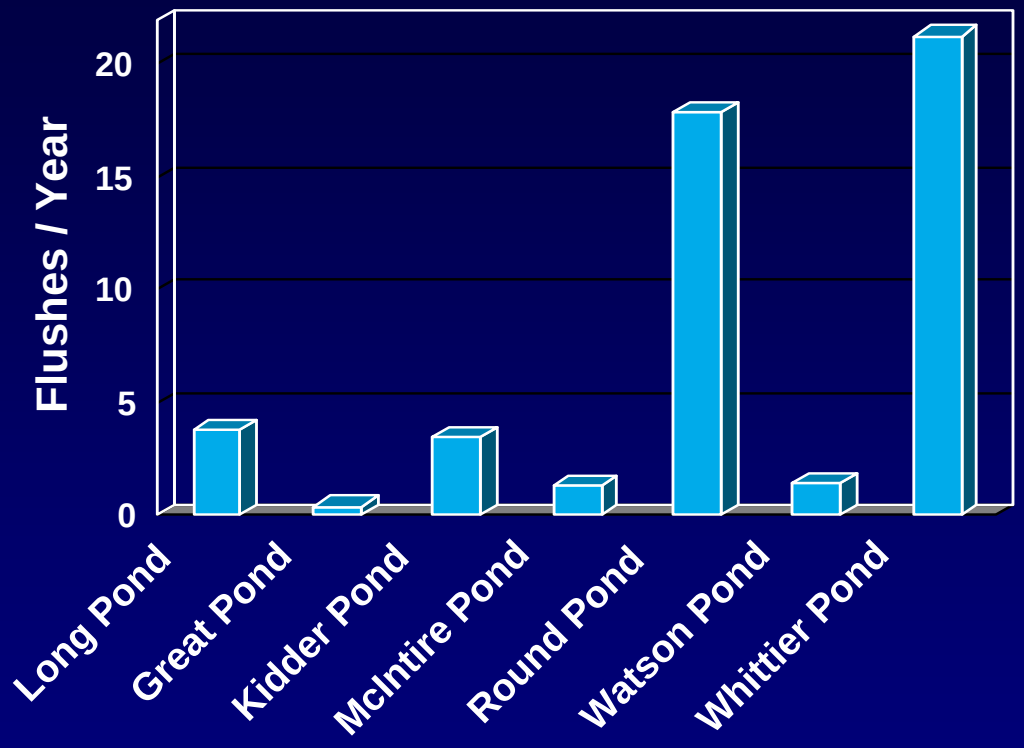
I_{net} Long Pond North = 1.697×10^7 m^3/year

Input From Other Lakes

Lake	% Net Input
Beaver Pond	1.8 %
Great Pond	76.5 %
Kidder and McIntire Ponds	0.7 %
Round Pond	1.8 %
Watson and Whittier Ponds	4.6 %



Flushing Rate



Flushing Rate = [(I_{net} Long Pond) + (I_{net} $Input_1$) + … (I_{net} $Input_n$)] / (Volume of Lake)

Flushing Rate = $(1.324 \times 10^8)/(3.492 \times 10^7)$

Flushing rate of Long Pond North is 3.79 flushes per year.

Phosphorus Budget

- Total amount of P entering a lake from specific sources
- Why?
  - Problem sources
  - Future projections

Phosphorus Budget

Dependent on:

- Land Use
- Population (Septic Use)
- Soil Retention
- Point-Source Inputs

Amount of Phosphorus Entering Long Pond North (W)

$$\mathbf{W} = (Ec_{\text{land-use type}} \times Area_{\text{land-use type}}) + (Ec_a \times Area_s) + (Sd_{cs} \times Area_{cs}) + [Ec_{ss} \times \text{\# capita years} \times (1\text{-}SR_1)] + [Ec_{ns} \times \text{\# capita years} \times (1\text{-}SR_2)] + PSI_{gp} + PSI_{bp} + PSI_{wp}$$

Agriculture
Coniferous Forest
Deciduous Forest
Golf Course
Wetland
Cleared Land
Commercial
Reverting Land

Mixed Forest
Park
Camp Roads
State Roads
Shoreline Development
Non-shoreline Development

Land Use (L) and Lake Concentration (P) Phosphorus Loading

- $L = W / A_s$
- $P = L / (11.6 + 1.2q_s)$

Results

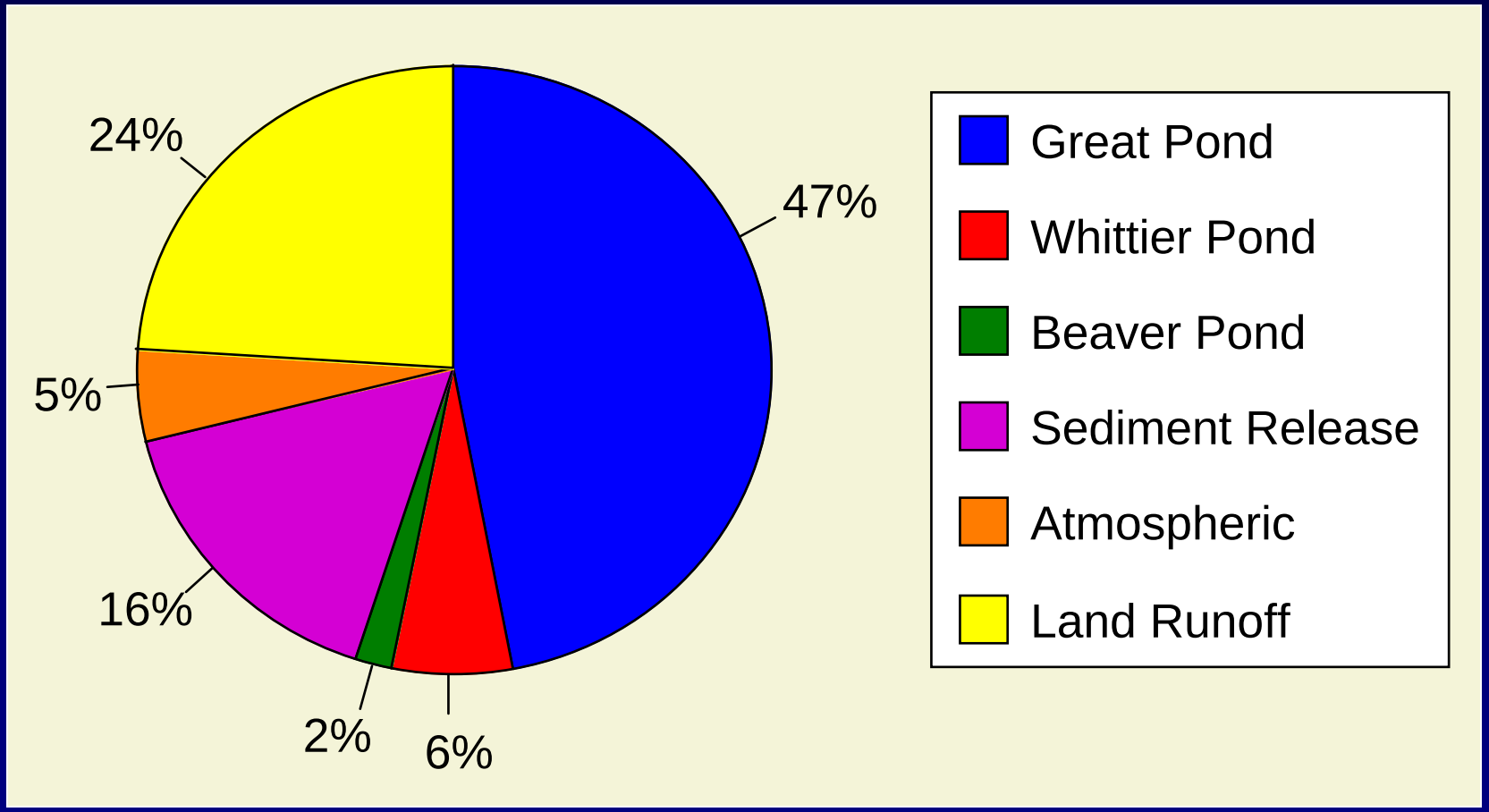
With Sediment Release

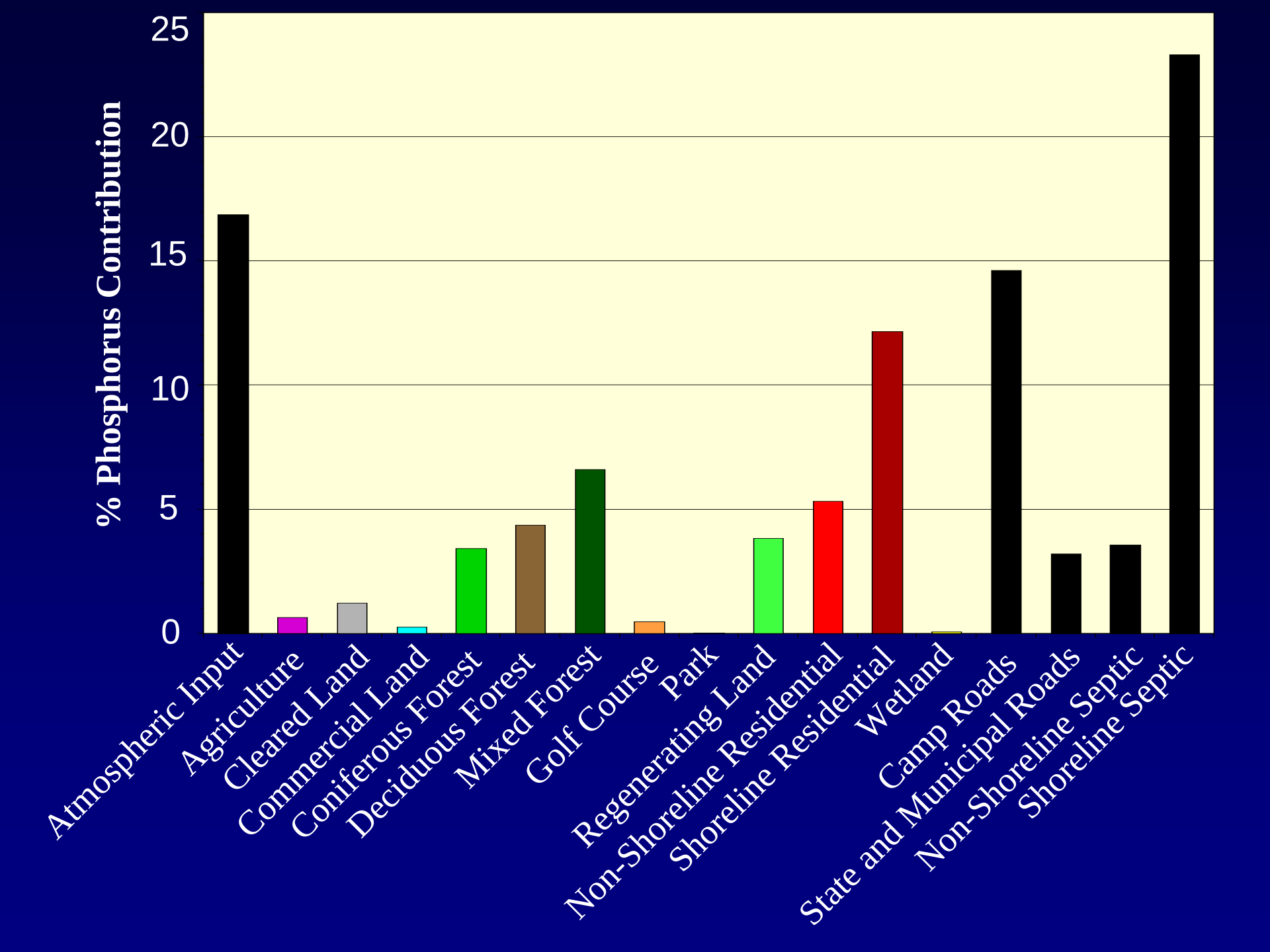
- Range: 6.2 - 12.7 ppb
- Best Estimate: 8.7 ppb

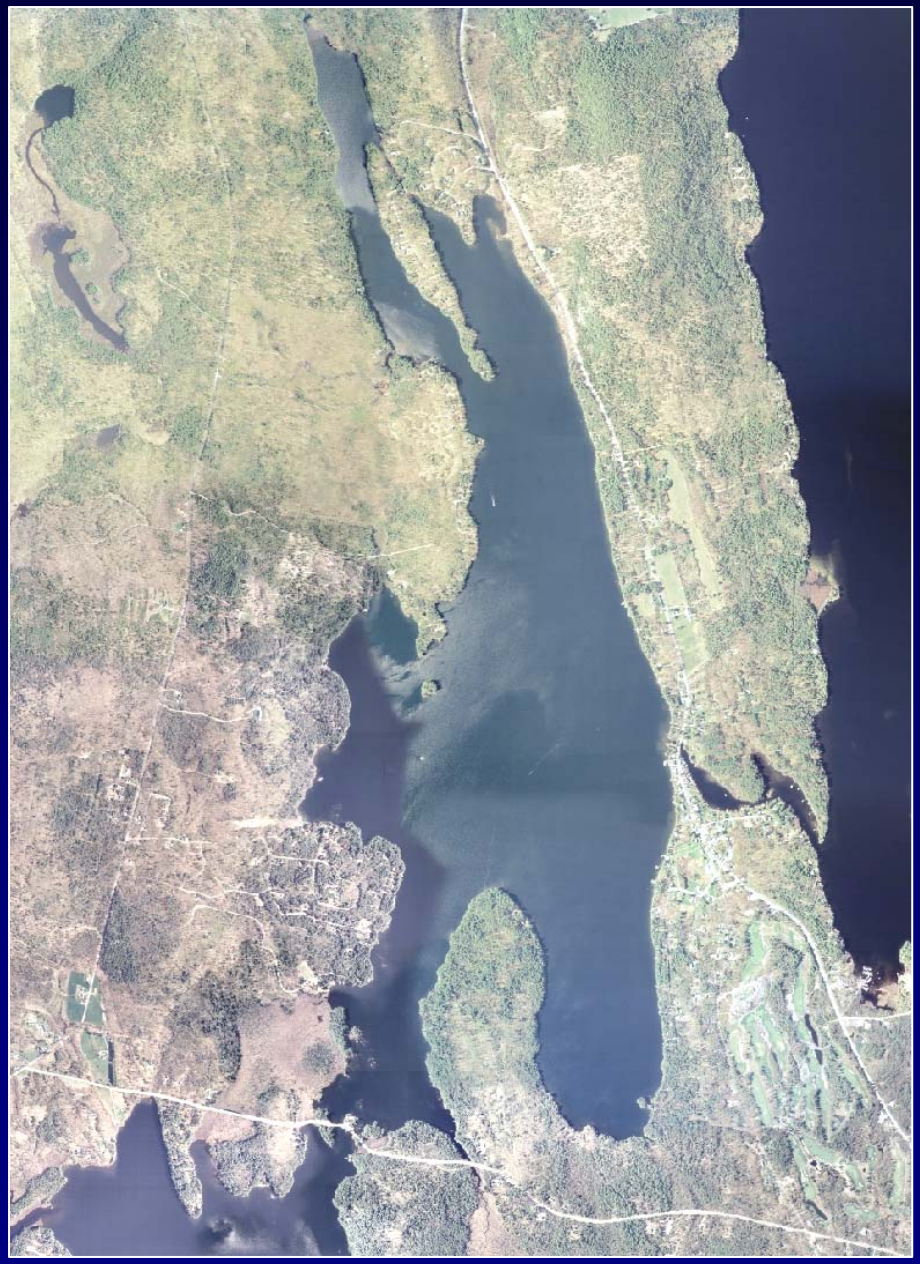
Sampled Site 1

- Mean Epicore: 7.6 ppb

Percent Contribution of Phosphorus




% Phosphorus Contribution
25
20
15
10
5
0
Atmospheric Input
Agriculture
Cleared Land
Commercial Land
Coniferous Forest
Deciduous Forest
Mixed Forest
Golf Course
Park
Regenerating Land
Non-Shoreline Residential
Shoreline Residential
Wetland
Camp Roads
State and Municipal Roads
Non-Shoreline Septic
Shoreline Septic



Future Projections of Phosphorus Budget

- Flow patterns

Summary and Recommendations

Alex McPherson

Long Pond Value

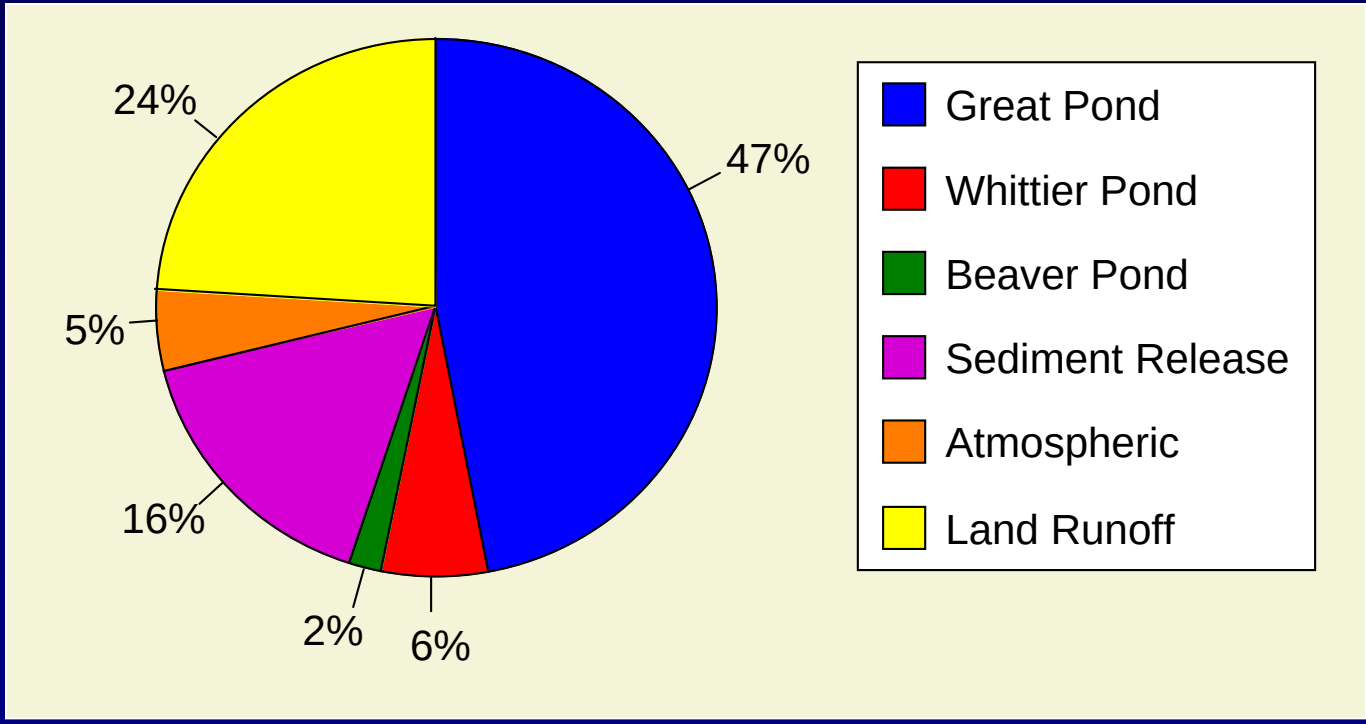
- Aesthetic
- Economic
  - Land values
- Ecological
  - Belgrades
  - Kennebec

Threats

- Phosphorous loading
- *Gloeotrichia*
- Invasive species

Phosphorous Loading

- Sediment Release
- Runoff
- Inflow



Recommendations

- Land use
  - Maintain trends
  - Undeveloped Lots
- Septic systems
  - Maintenance
  - Remediation
- Camp Roads
  - Maintenance programs

Gloeotrichia

- Blue green algae or cyanobacteria
- Seen on the surface
- Currently being studied at Colby

Invasive plants

- Introduced by boats
- “Clog up” the lake
- Are found in neighboring lakes

Recommendations

- Continue to be vigilant!

Main Message

- Long Pond is in good shape
- With continued community support, it can stay that way

Acknowledgments

- Earl Bacon
- Bernadette Bibber
- Curtis Bohlen
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Questions?