2005

A Watershed Analysis of China Lake [Presentation]

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

Colby Environmental Assessment Team, Colby College

A Watershed Analysis of China Lake

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Waterville, ME

December 8, 2005

Presentation Overview

Introduction
Water Quality Analysis
Geographic Information Systems
Land Use Analysis

Intermission

Development
Phosphorus Budget
Lake Remediation
Summary

Study Objectives

- Water Quality Analysis
- Land Use Analysis
- Development Surveys
- Future Projections
- Remediation Possibilities

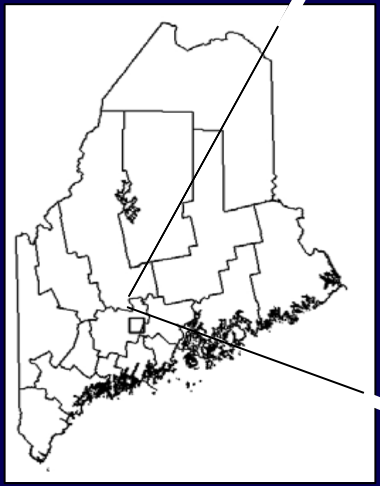
General Lake Background

Spencer Koury

The Value of Maine Lakes

- Intrinsic (Biodiversity, Beauty)
- $6.7 Billion Annual Net Value
- Commercial
- Recreational
- Drinking Water

China Lake



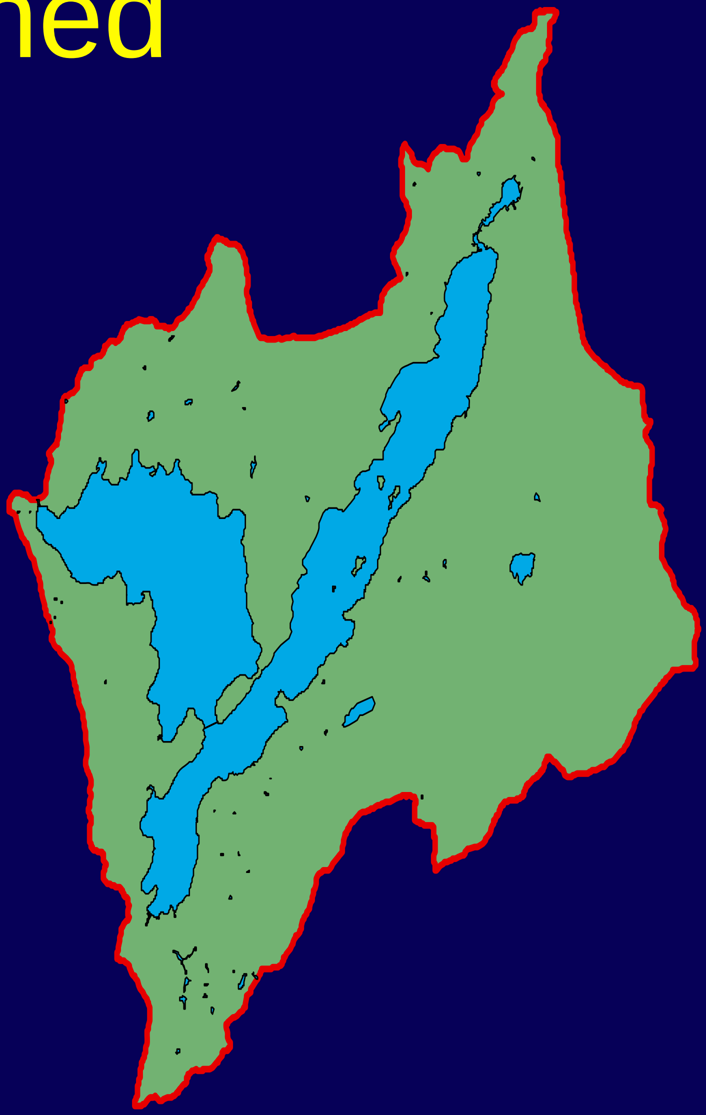
China Lake Formation

Laurentide Ice Sheet

- Receded from Maine 10,000 years ago
- Created southeasterly orientation
- Basin composition
  - Glaciomarine clay-silt
  - Bedrock
  - Glacial till
- Nutrient poor
- Predicts lakes to be oligotrophic

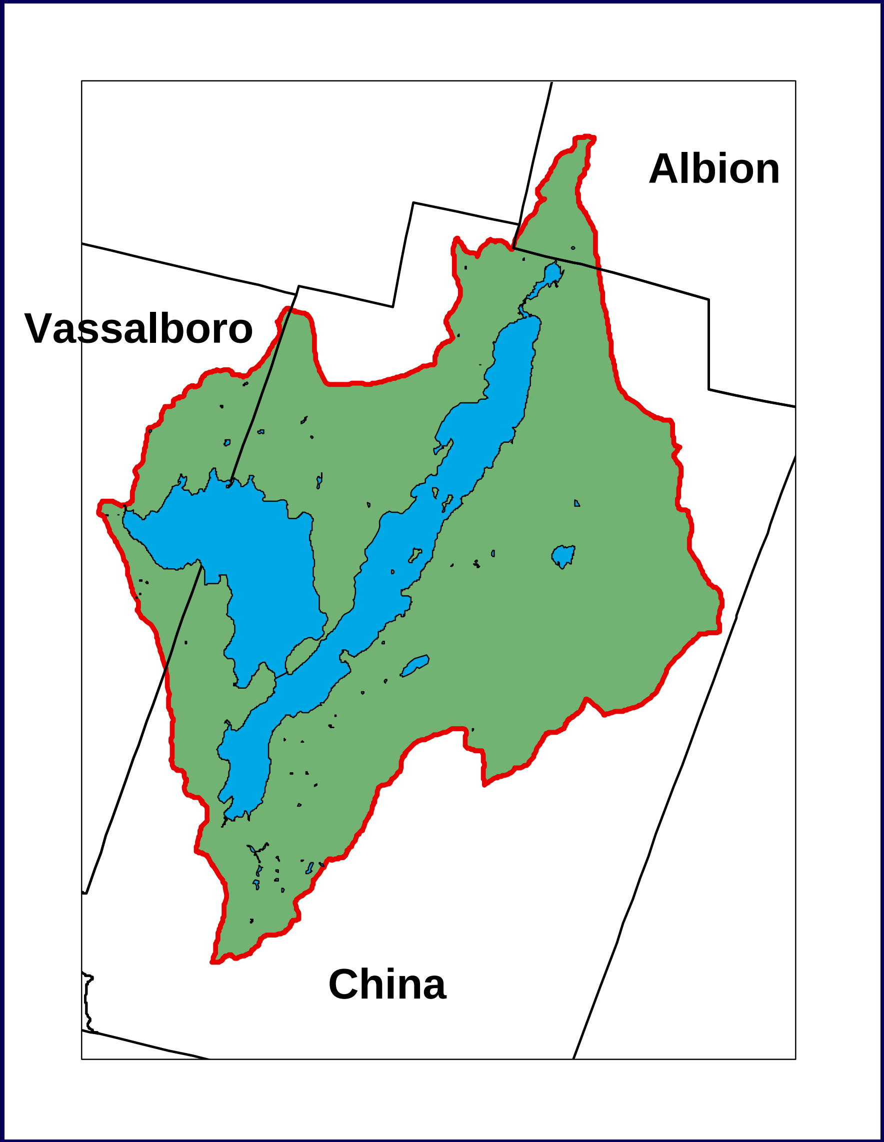
The Watershed

- Watershed
  - A watershed is the total land area that contributes a flow of water to a particular basin
- China Lake Watershed
  - 85.15 km^2
  - Includes sub-watershed of Evans Pond



Municipal Jurisdiction

- China
  - 75.47 km^2
  - Jones Brook
  - Wetlands
- Vassalboro
  - 7.68 km^2
  - Dam
  - Outlet Stream
- Albion
  - 2.00 km^2



Historical Land Use

- Agriculture
- Commercial
- Residential

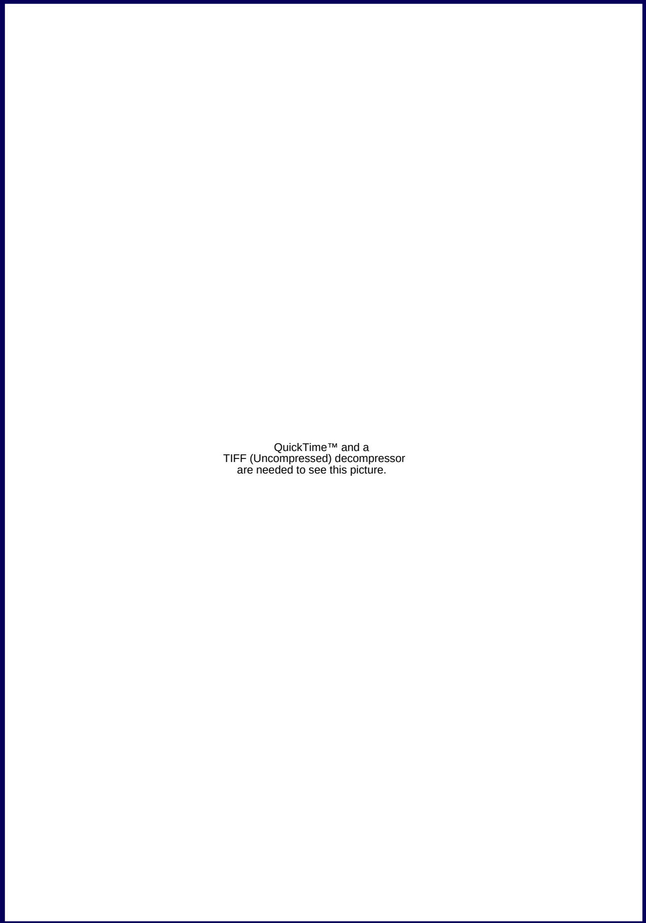
China Lake Dam
Water Level

- Dam is located in the Town of Vassalboro
- Dam was first constructed in 1800’s
- Raised to its current level in 1969
- Elevation of spillway is 171.5 feet

Fish Population of China Lake

Native Species

- Largemouth Bass
- Smallmouth Bass
- Brown Bullhead
- White Perch
- Yellow Perch
- Brown Trout
- Chain Pickerel
- Smelt

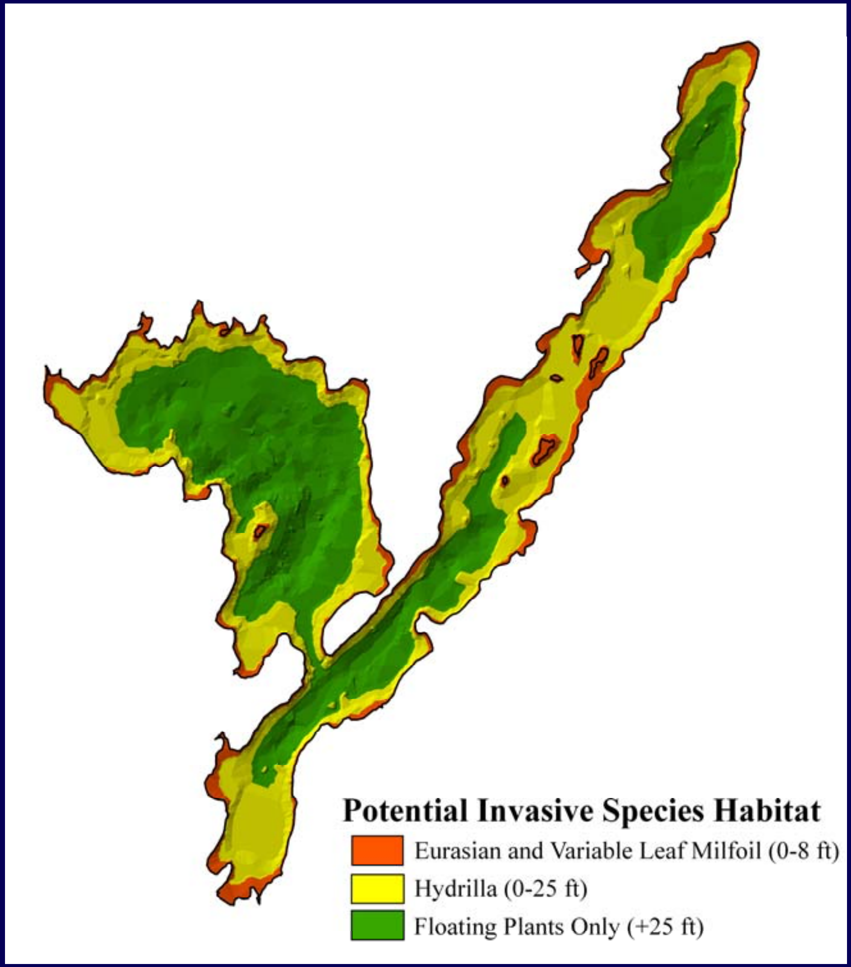


Manipulated Fish Species

- Non Native Species
  - Black Bass
  - Black Crappie
  - Northern Pike
  - Alewife
- Stocked Species
  - Brown Trout
  - Brook Trout

Invasive Species

- Maine Lists Eleven Aquatic Invasive Species
  - Infestations of Five Species
  - None in China Lake
- Boating Activity
- Susceptibility
  - Hydrilla
  - Eurasian Water Milfoil
  - Variable-Leaf Milfoil



Natural Eutrophication

- Eutrophication is the natural aging process of lakes
- Lake Classifications
  - Oligotrophic
  - Mesotrophic
  - Eutrophic

Eutrophic Lakes

EPA classification of an lake as eutrophic requires these relative characteristics

- Lower dissolved oxygen concentrations in hypolimnion
- Higher nutrient content
- Increased suspended matter
- Increased turbidity
- Increased phosphorous concentration in sediment
- Cyanobacteria population

Anthropogenic Influence on Eutrophication

- Development of Watershed
- Point Sources
- Increased Runoff
- Non Point Sources

Stratification and Turnover

- Stratification
  - Epilimnion
  - Thermocline
  - Hypolimnion
- Seasonal Turnover
- Dimictic Lakes

QuickTime™ and a
Photo - JPEG decompressor
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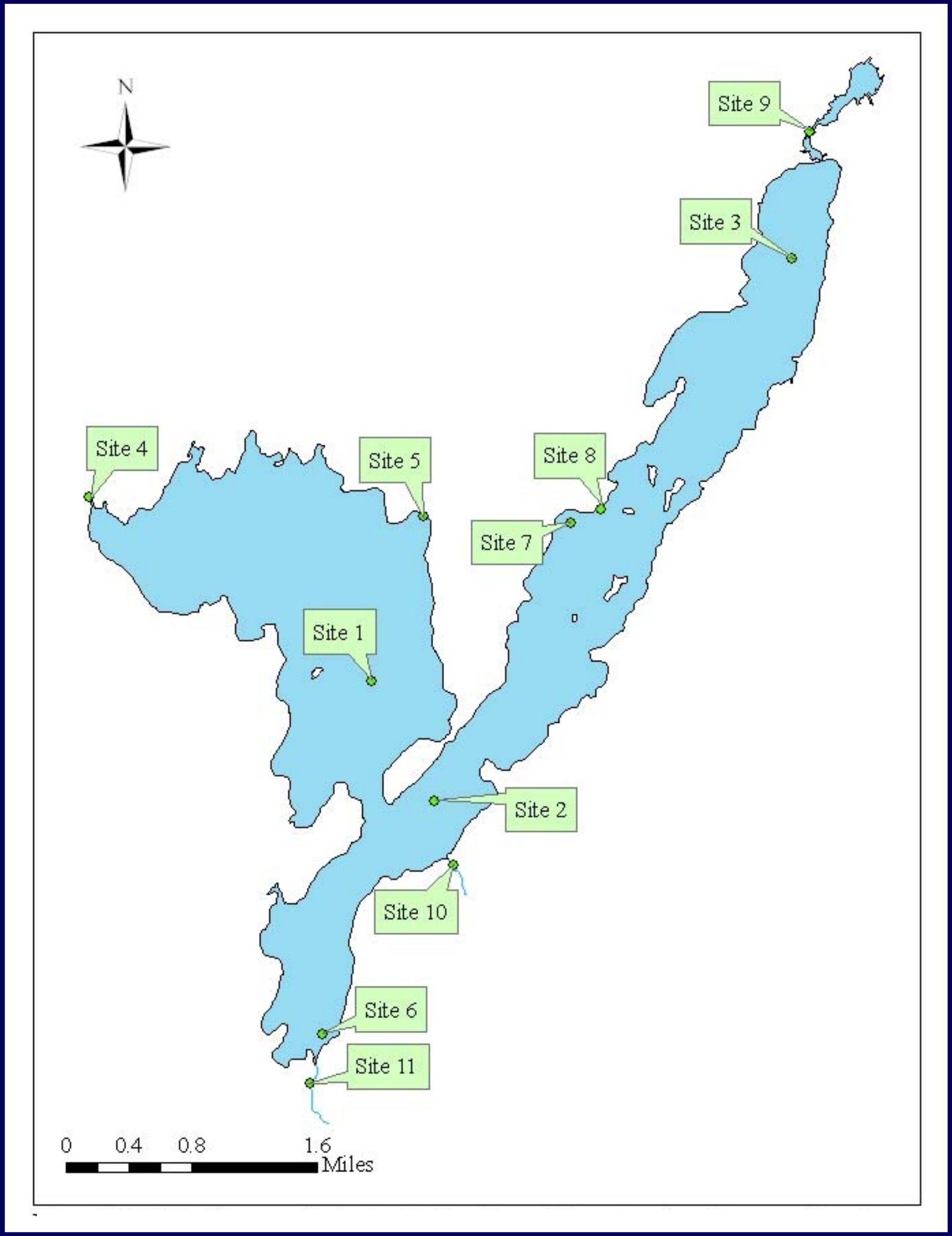
Algal Blooms

- Anthropogenic Influences
- Algal Population
  - 3 cyanobacteria
  - 1 green alga
  - 3 diatoms
- Timing of blooms
- Three distinct blooms
  - Spring
  - Late Summer
  - Fall

Water Quality Overview

Elli Jenkins

Sample Site Locations



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China Lake Bathymetry

Water Quality Measurements

Physical Parameters

- Temperature
- Dissolved Oxygen
- Conductivity
- Transparency
- Turbidity
- Color

Biological Parameter

- Chlorophyll-*a*

Chemical Parameters

- pH
- Alkalinity
- Nitrates
- Total Phosphorus

Physical and Biological Parameters

Physical Parameters

- Temperature
- Dissolved Oxygen
- Conductivity
- Transparency
- Turbidity
- Color

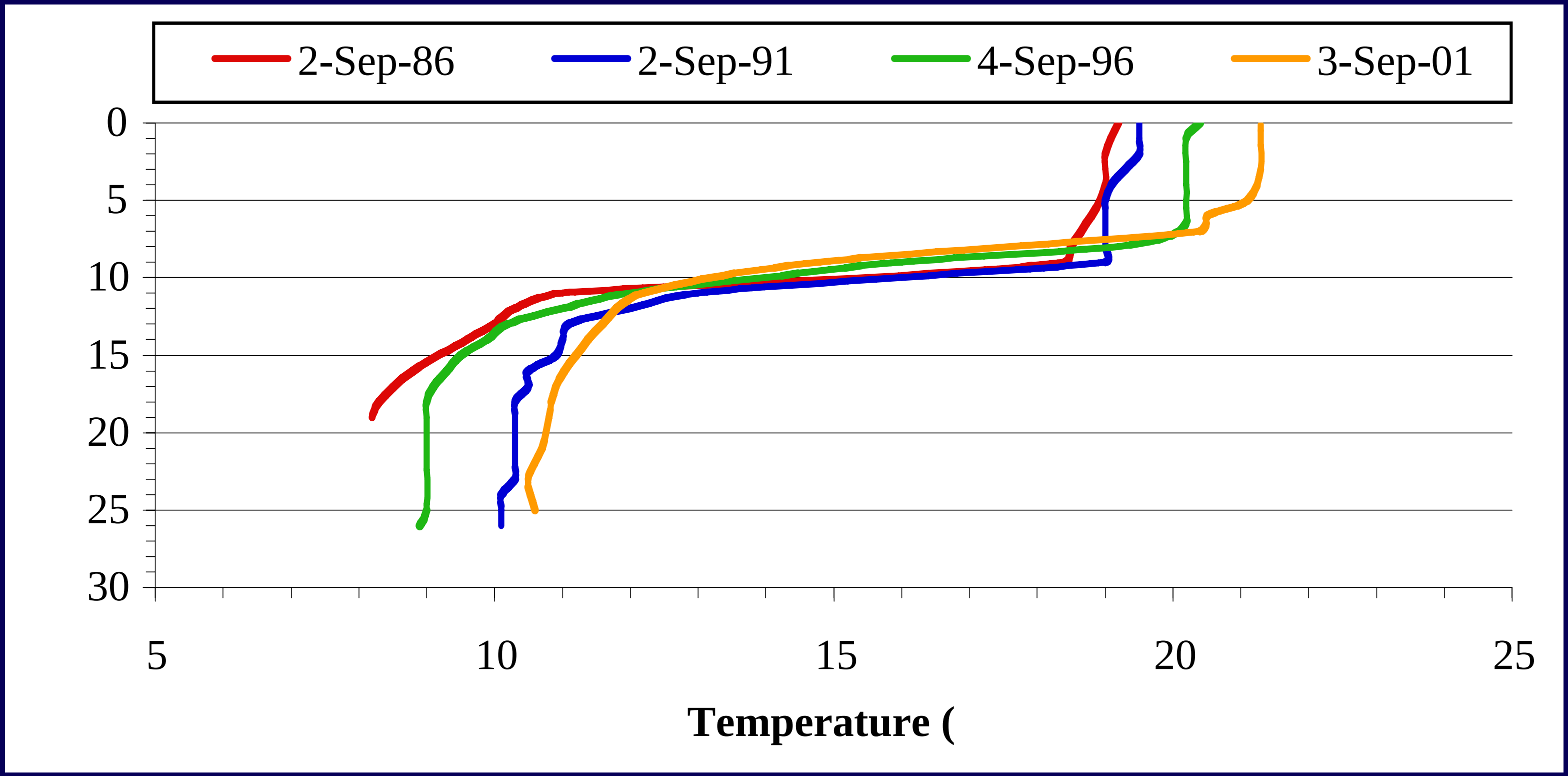
Biological Parameter

- Chlorophyll-*a*

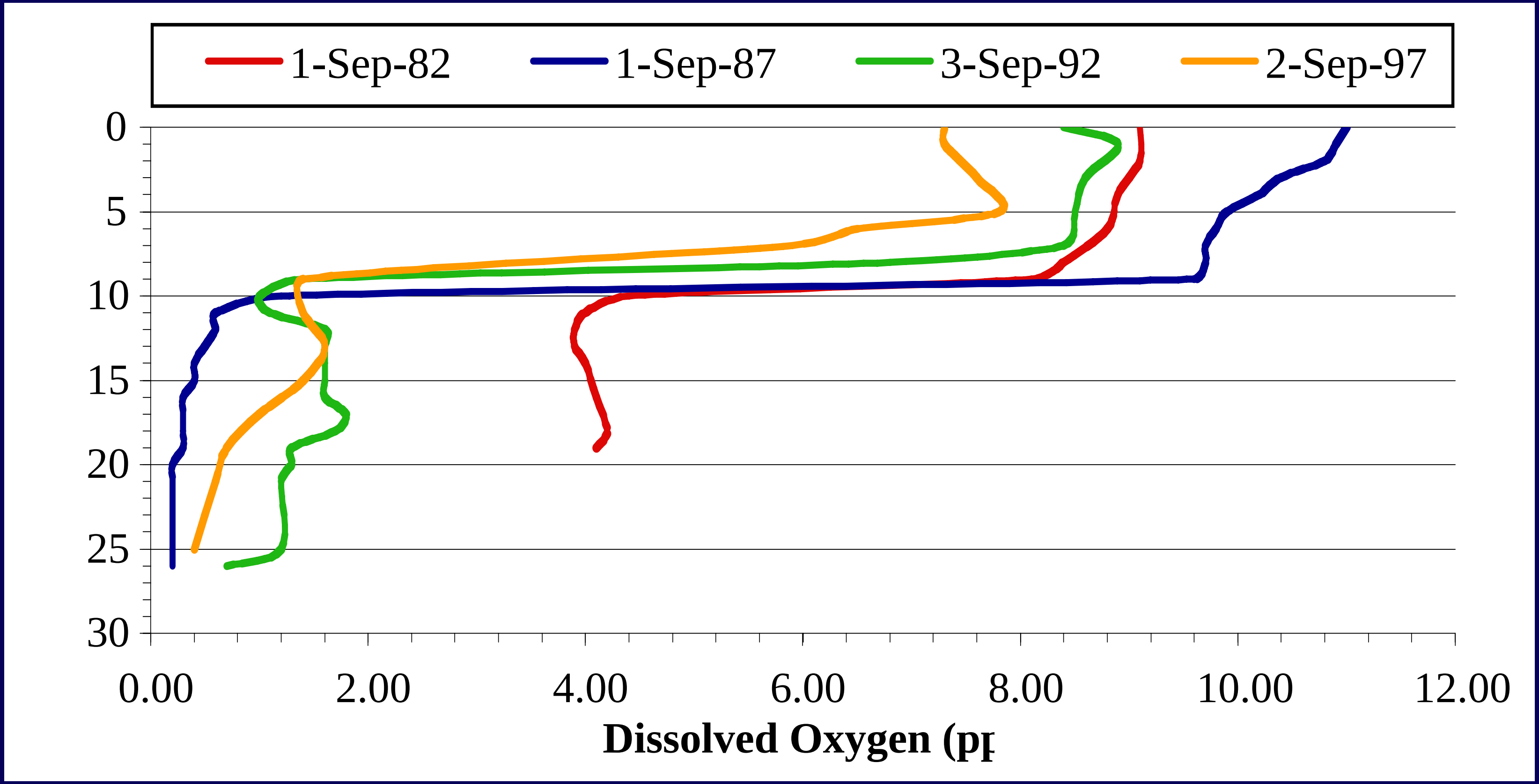
Chemical Parameters

- pH
- Alkalinity
- Nitrates
- Total Phosphorus

Historic Temperature



Dissolved Oxygen Profile



Summary of Bloom Parameters

China Lake	Range	Mean ± SE	Rating
Transparency (m)	1.2 – 6.10	2.9 ± 0.40 (n = 15)	Productive
Turbidity (NTU) (surface)	0.68 – 6.42	2.64 ± 0.38 (n = 50)	N/A
Color (SPU) (surface)	10 - 175	11.88 ± 0.77 (n = 8)	Uncolored
Chlorophyll-*a* (ppm) (0 – 10 m)	0 – 6.5	2.14 ± 0.13 (n = 121)	Moderately Productive

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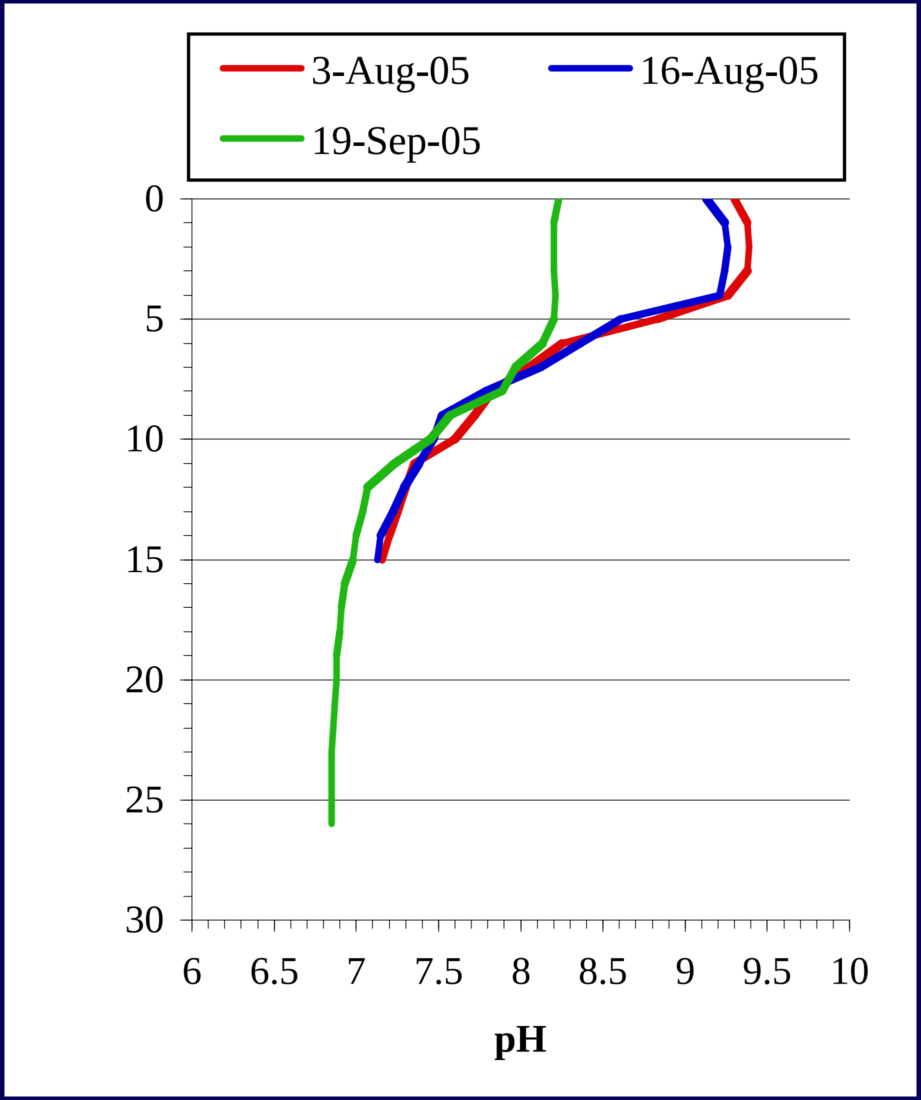
Chemical Parameters

Physical Parameters
- Temperature
- Dissolved Oxygen
- Conductivity
- Transparency
- Turbidity
- Color

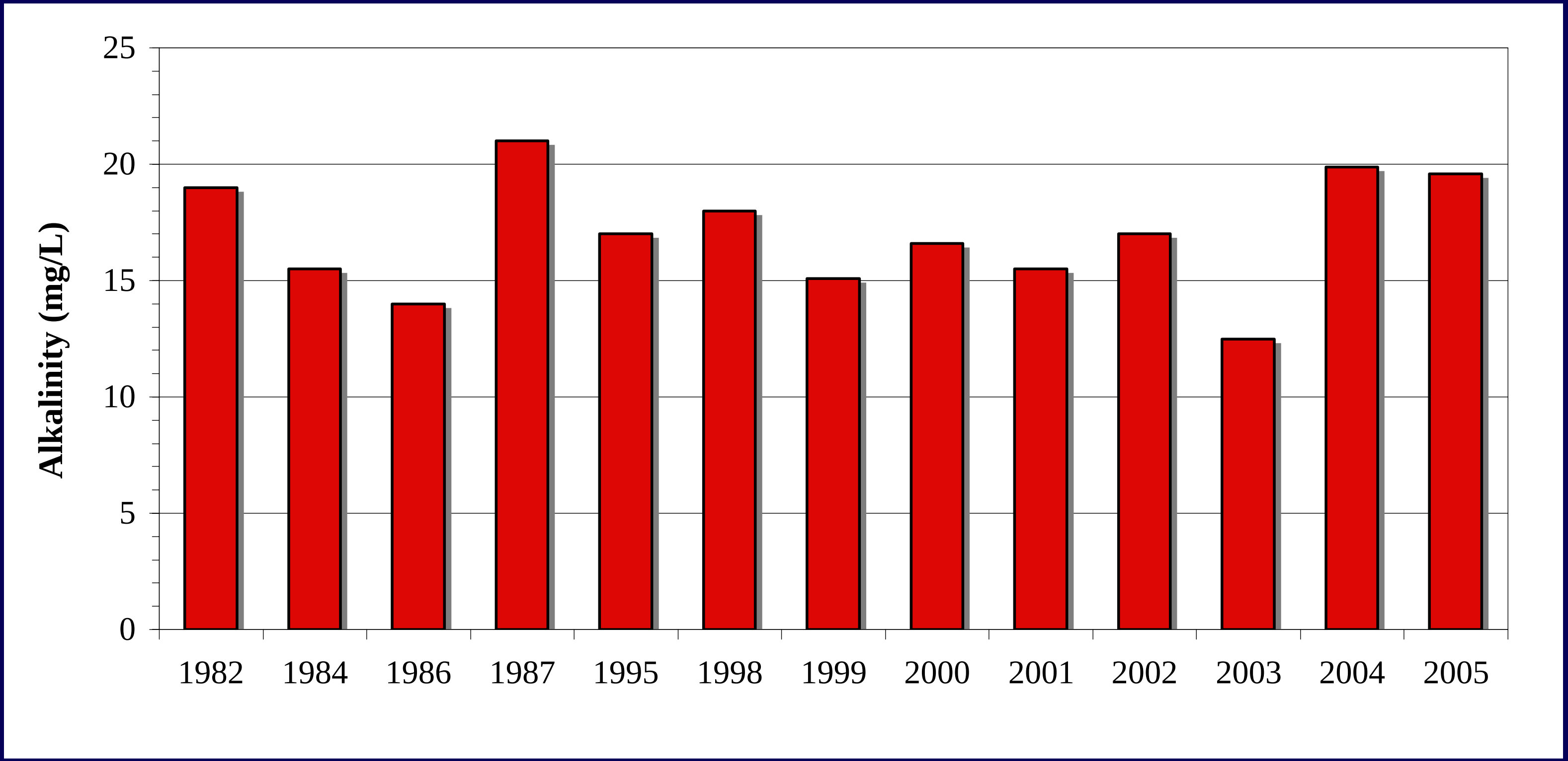
Biological Parameter
- Chlorophyll-*a*

Chemical Parameters
- pH
- Alkalinity
- Nitrates
- Total Phosphorus

pH Profile

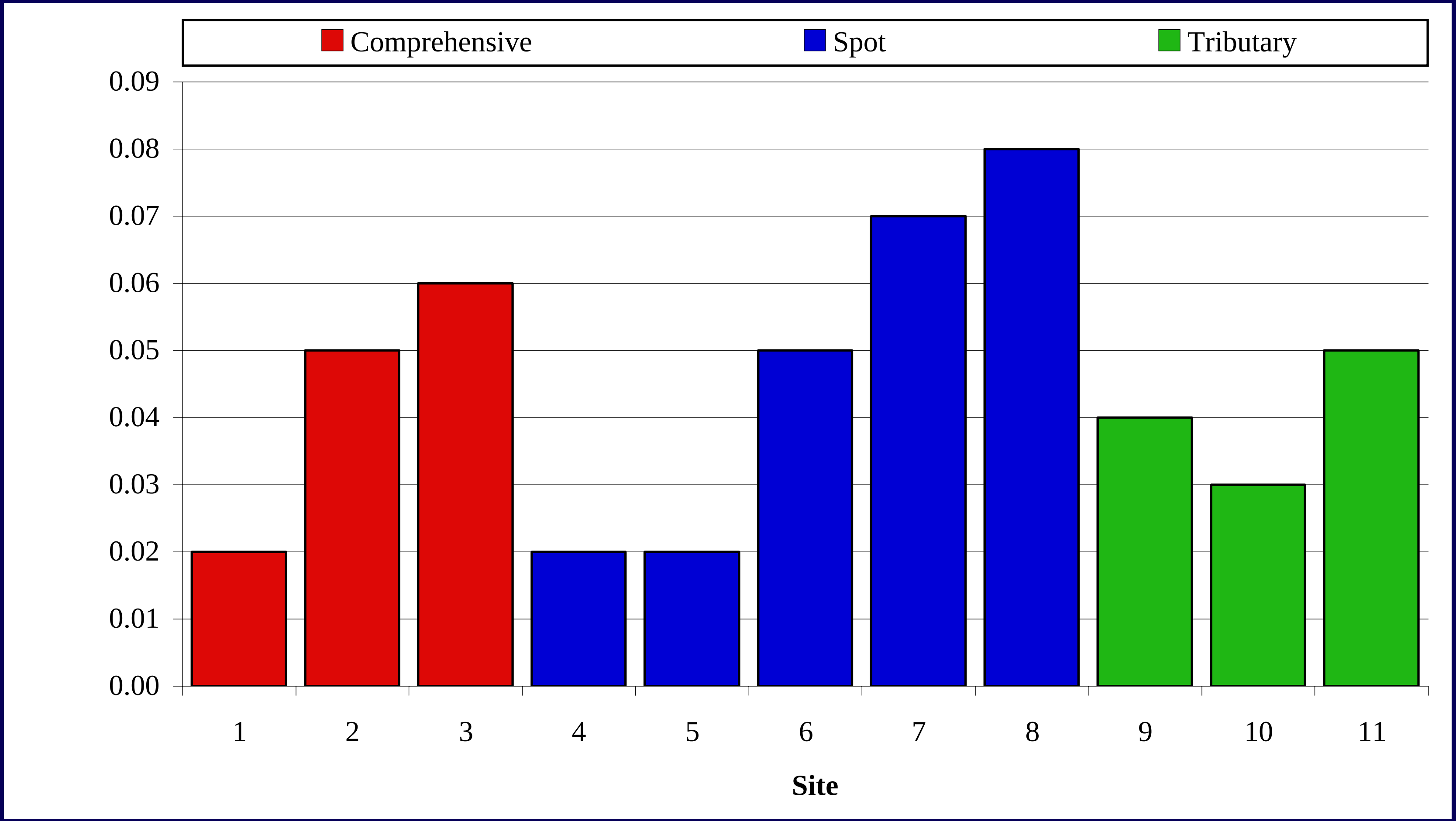


Alkalinity

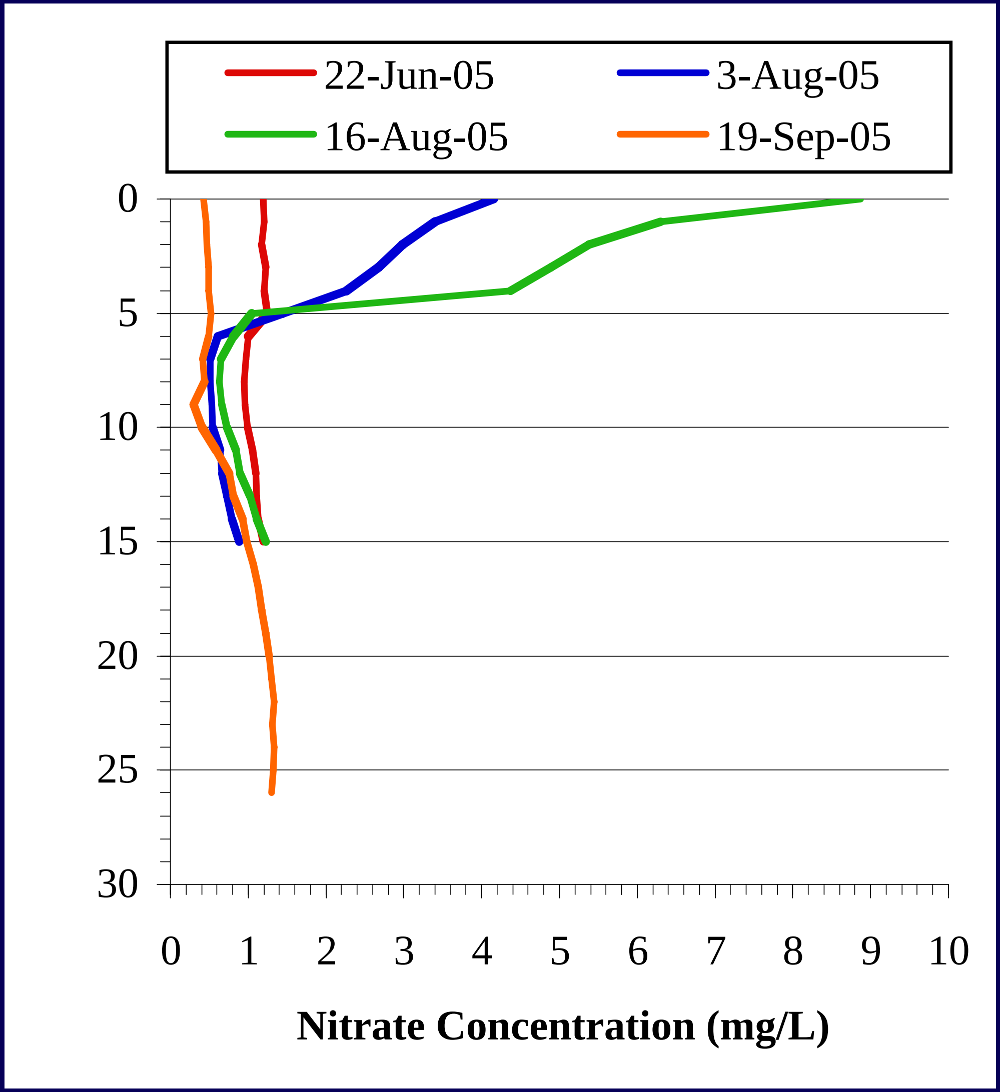


Alkalinity (mg/L)
25
20
15
10
5
0
1982
1984
1986
1987
1995
1998
1999
2000
2001
2002
2003
2004
2005

Surface Nitrates



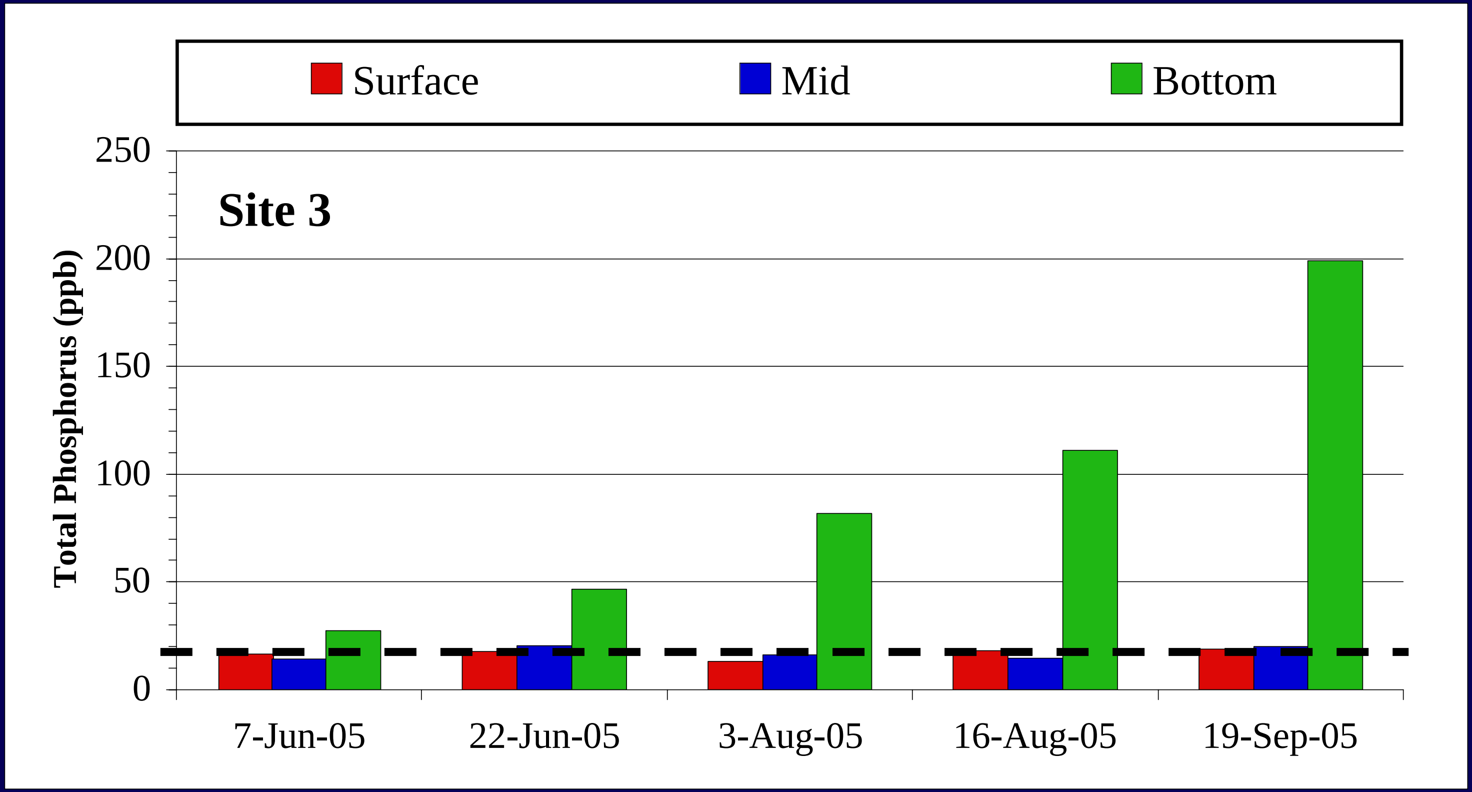
Nitrate Profile

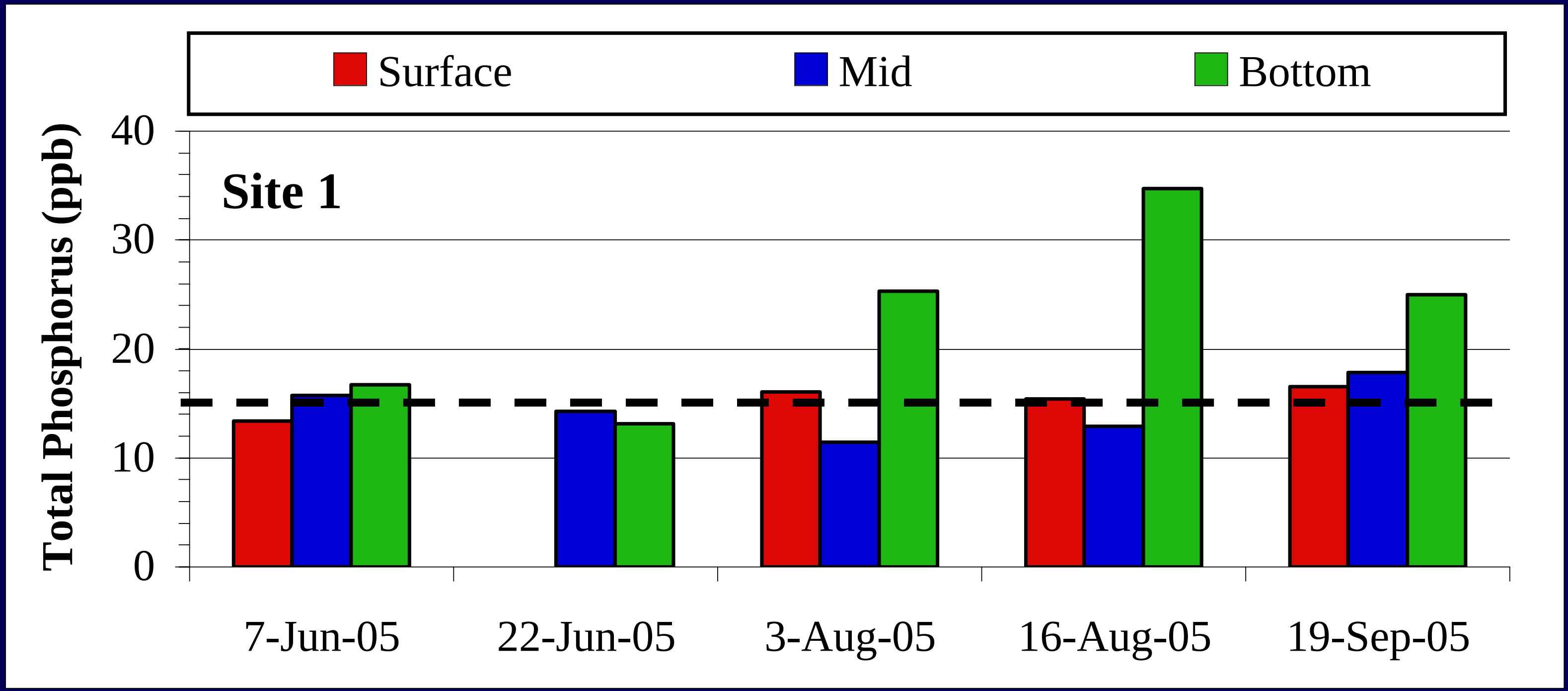


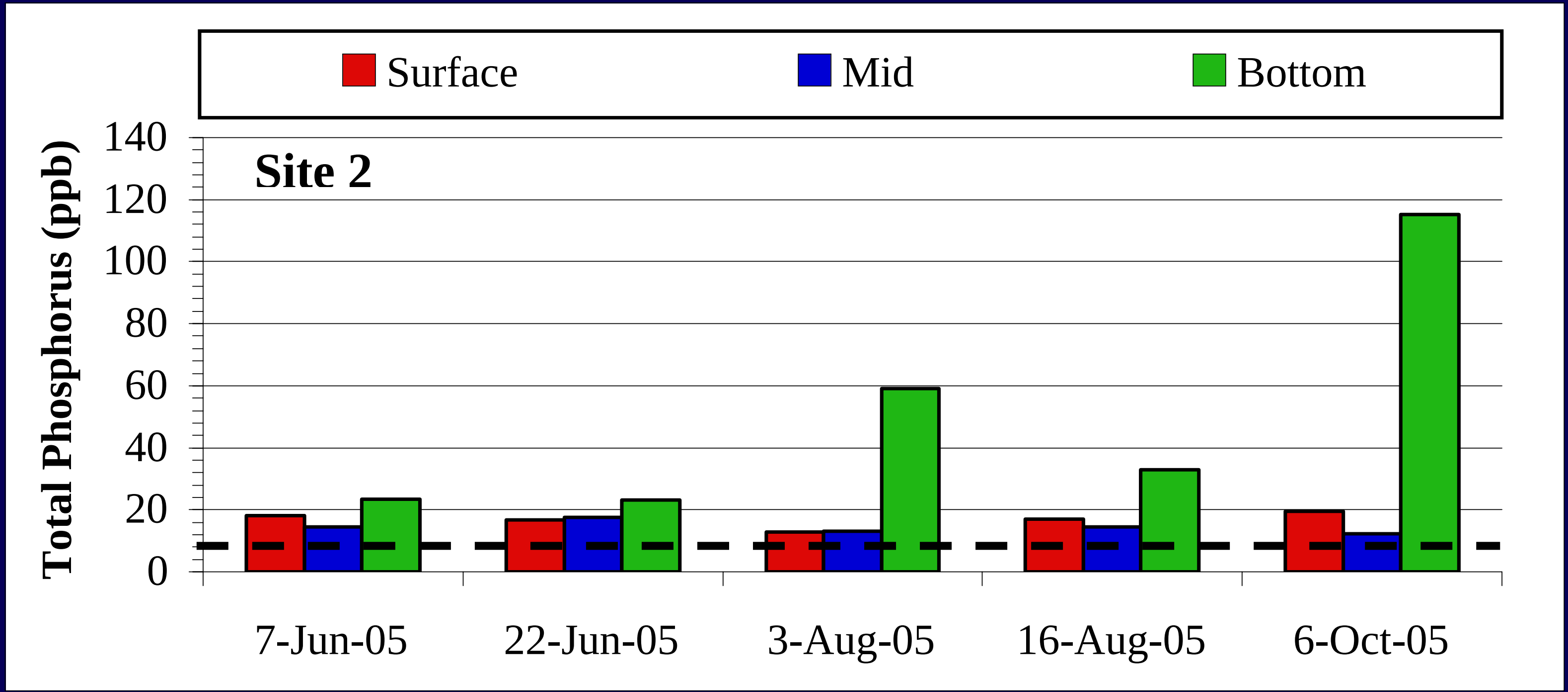
Nitrates in Local Lakes

Lake	Surface Nitrates (mg/L)
China Lakes Region	
China Lake	0.04 ± 0.01 (n = 11)
Threemile Pond	0.15 ± 0.04 (n = 4)
Webber Pond	0.11 ± 0.04 (n = 11)
Belgrade Lakes Region	
East Pond	0.04 (n = 7)
Great Pond	< 0.02
Long Pond North Basin	0.05 ± 0.01 (n = 9)

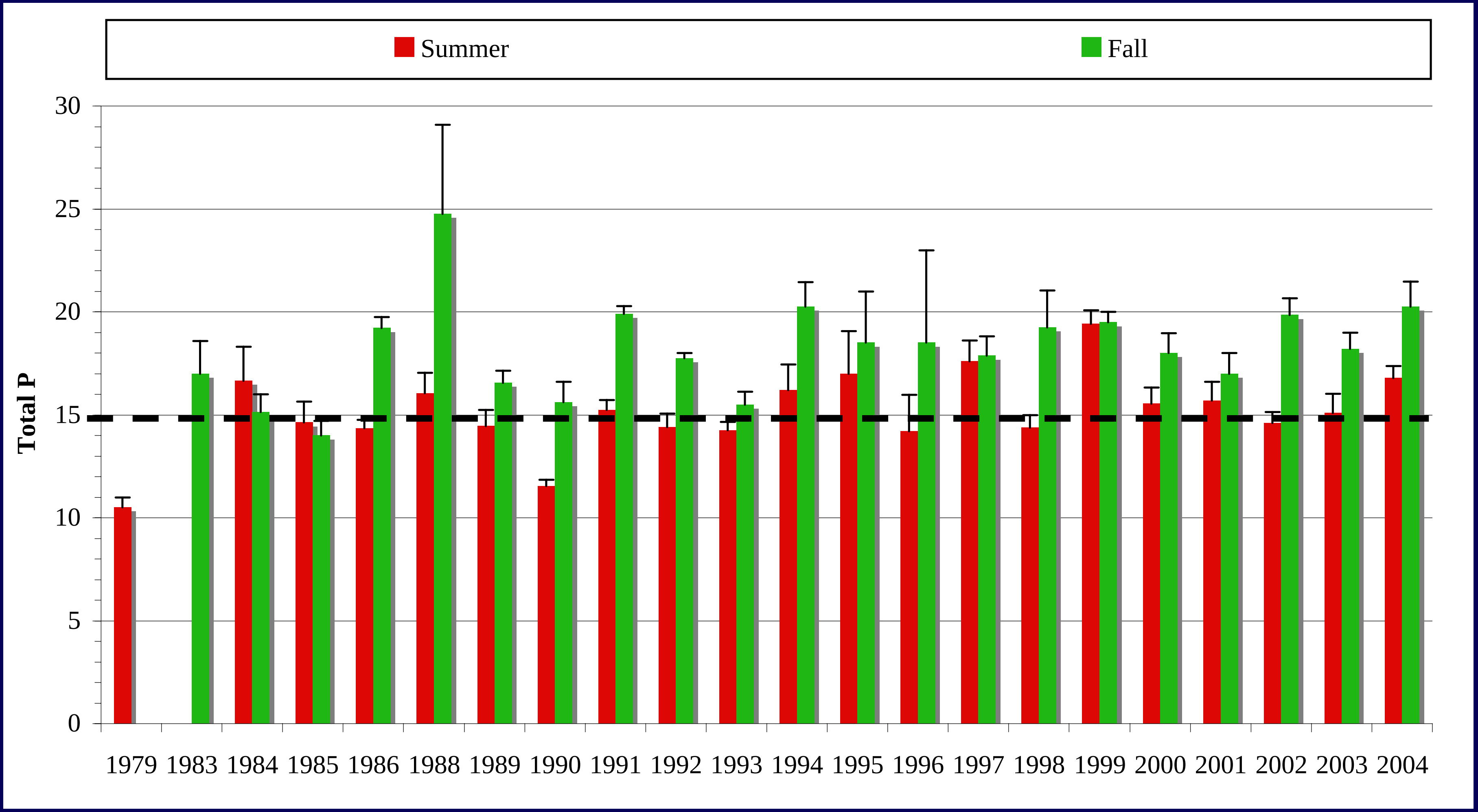
Total Phosphorus




Surface
Mid
Bottom
Site 1
Total Phosphorus (ppb)
0
10
20
30
40
7-Jun-05
22-Jun-05
3-Aug-05
16-Aug-05
19-Sep-05


Surface
Mid
Bottom
Site 2
Total Phosphorus (ppb)
0
20
40
60
80
100
120
140
7-Jun-05
22-Jun-05
3-Aug-05
16-Aug-05
6-Oct-05

Historic Phosphorus



Nutrient Loading

- Addition of nutrients into the lake
- Direct result of the combination of human activities and runoff

Flushing Rate

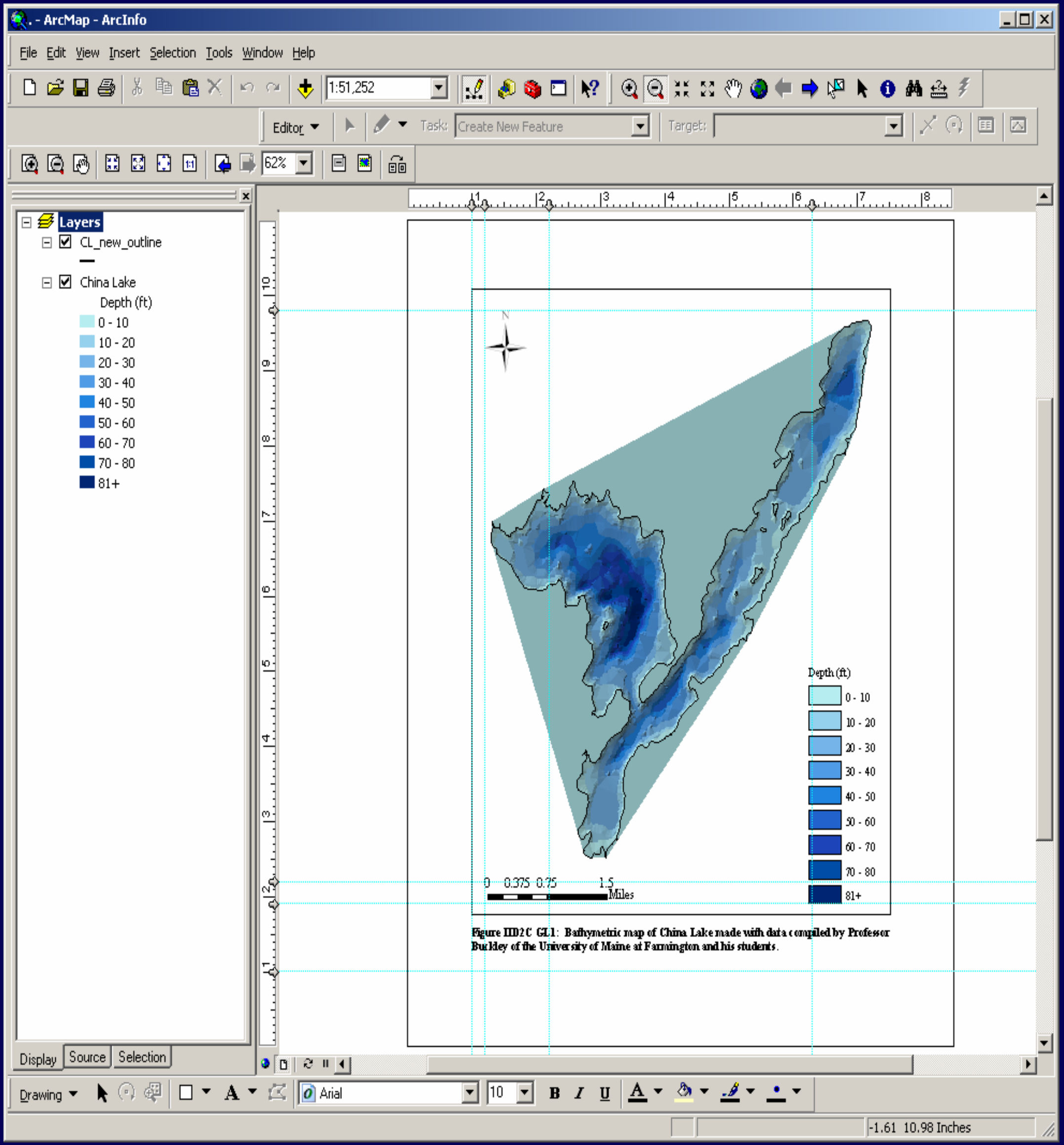
- Create a water budget to estimate flushing rate
- Flushing rate of China Lake is 0.35 flushes per year

Geographic Information Systems and Land Use Analysis

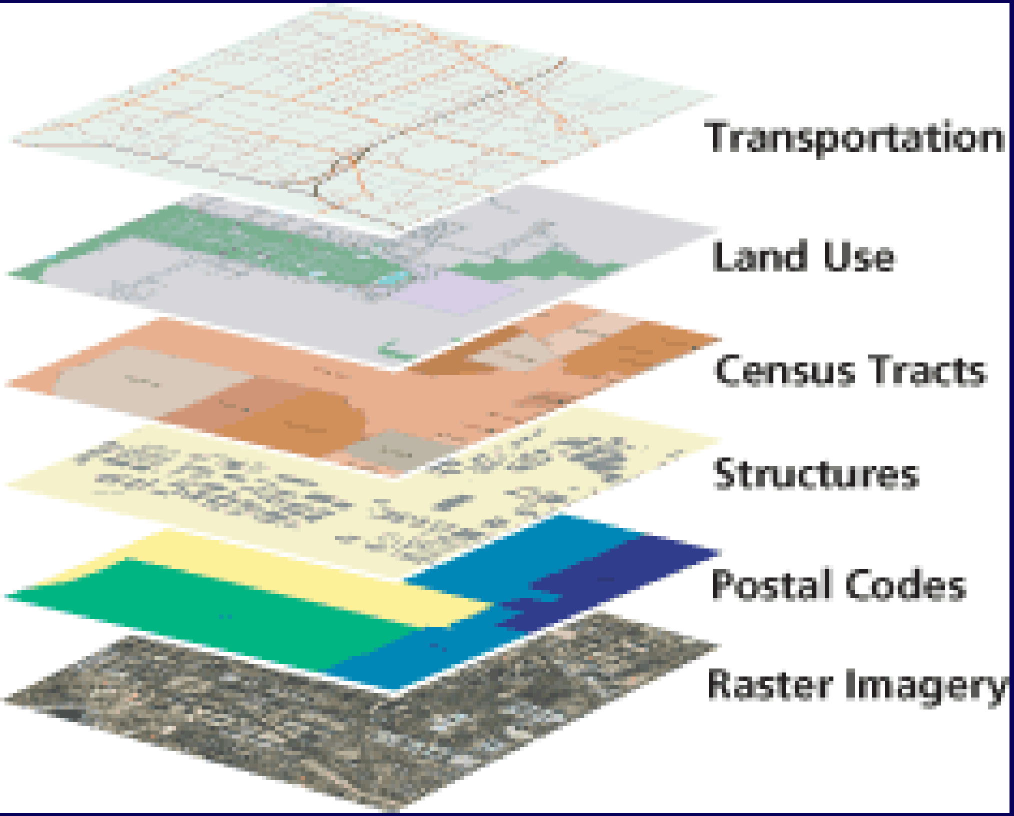
Jakob Moe

Geographic Information System

- Geographic Information System (GIS)
- A computer system based on a common coordinate system designed to display, manipulate, and analyze geographic data



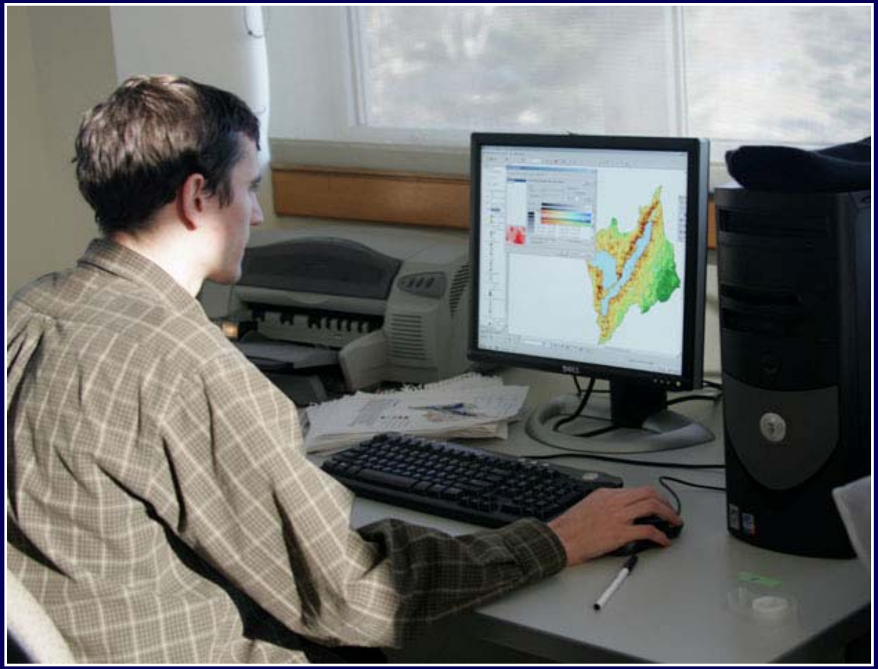
GIS Analysis



- Geographic data displayed as a layer
- Can add, manipulate, or create new data, represented by points, lines, or area (polygons)

Uses of GIS Analysis

- Surveying
  - Land Use Analysis
- Modeling
  - Septic Suitability Model
  - Erosion Potential Model
  - Potential Erosion Impact Model



Land Use Analysis

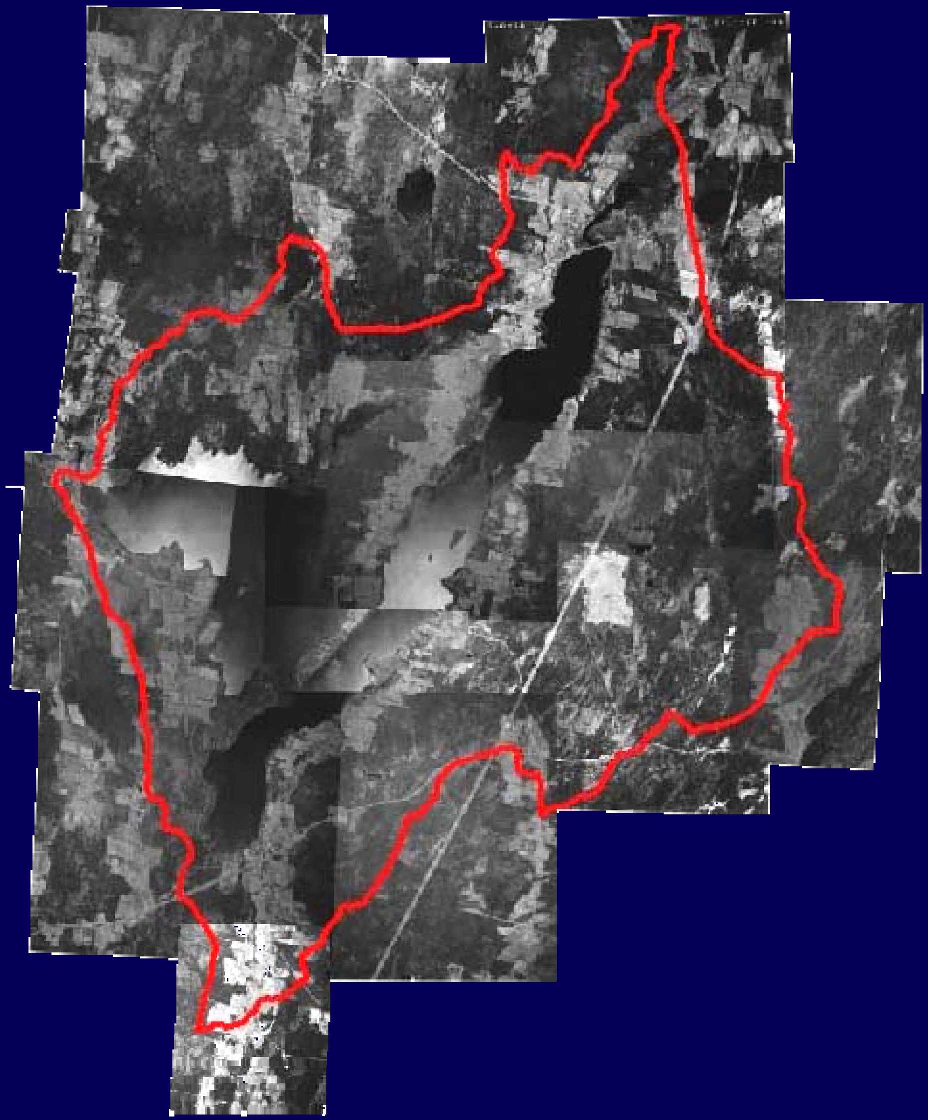
- Can find patterns in land use and development
  - Establishes rate of development for a given period
  - Can be used to predict future development
- Land use patterns reflect changes in:
  - Erosion
  - Sediment Loading
  - Nutrient Loading

Land Use Analysis Methods

- Determine period of study
- Compile and import images of China Lake watershed into GIS
- Determine and identify different land use types
- Following land use identifications, use GIS to designate areas of different land use
- Compute areas of each land use type
- Complete for both 1965 and 2003 surveys

China Lake Watershed 1965

- 18 large format aerial photographs
  - USDA
  - GIS coordinates system not yet incorporated



Georeferencing

Incorporation of the GIS Coordinate System with aerial photographs

China Lake Watershed 2003

- 14 Digital Orthophoto Quadrangles (DOQ)
  - Downloaded from Maine Office of GIS
  - GIS coordinate system incorporated
    - No need to georeference

Land Use Classifications

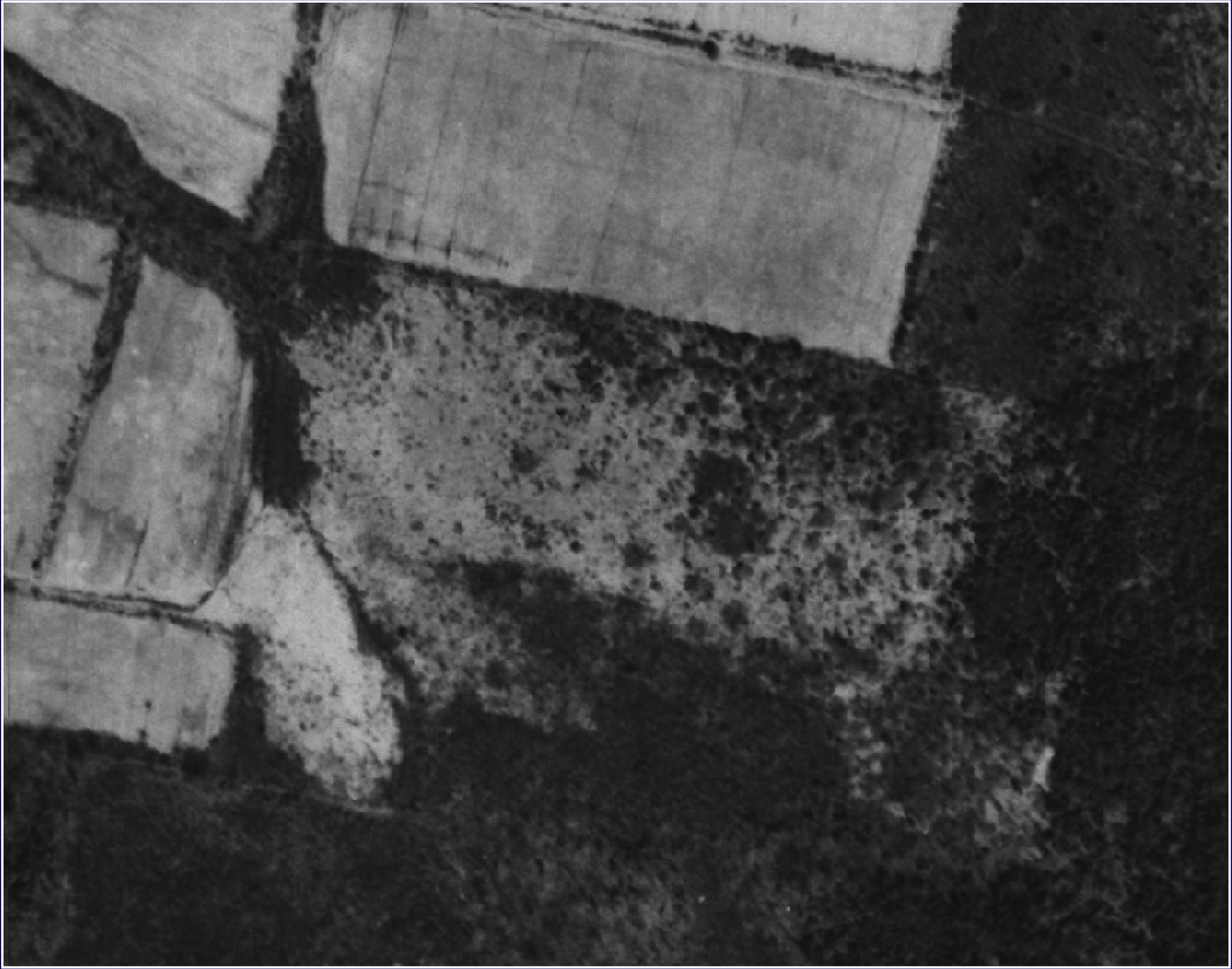
- Agriculture Land
- Commercial/Municipal Land
- Residential Land
- Reverting Land
- Forest
- Wetlands
- Lake/Ponds

Agricultural Land

Residential and Commercial/Municipal

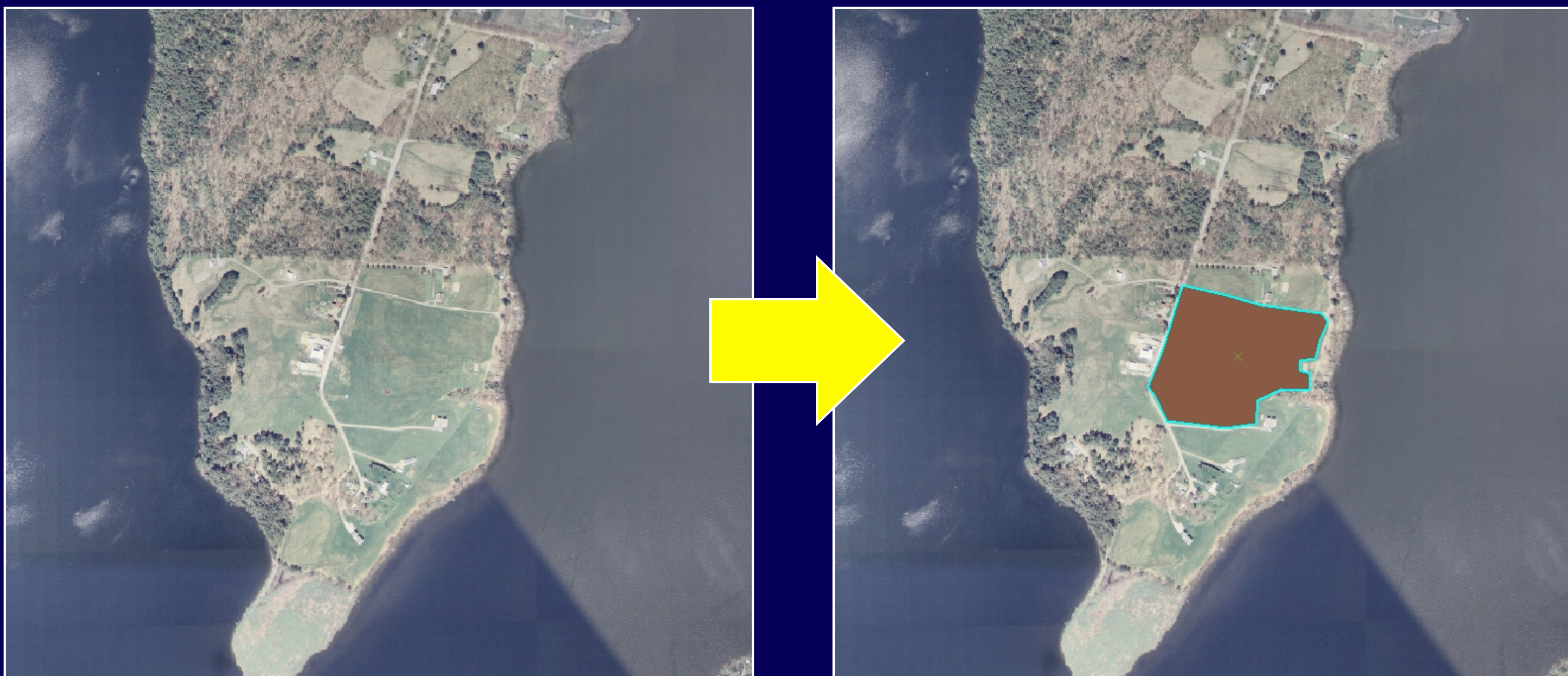
Forest and Wetlands

Reverting Land

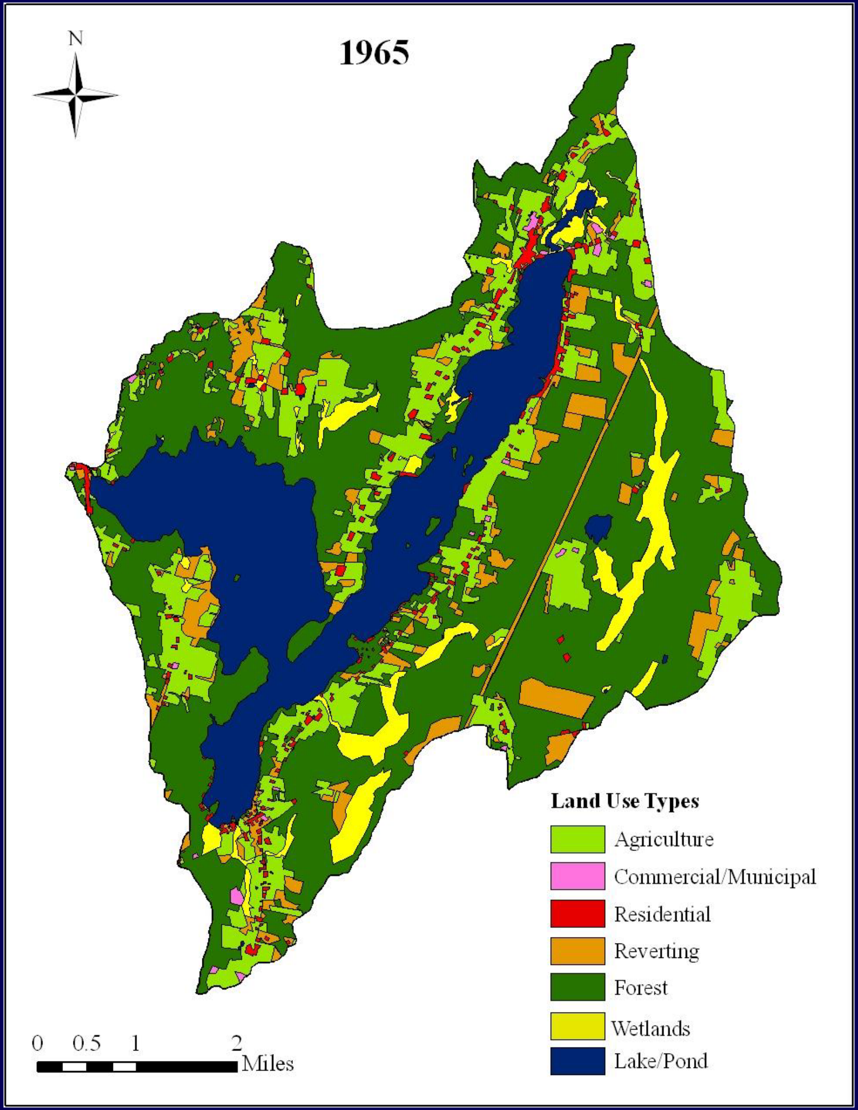


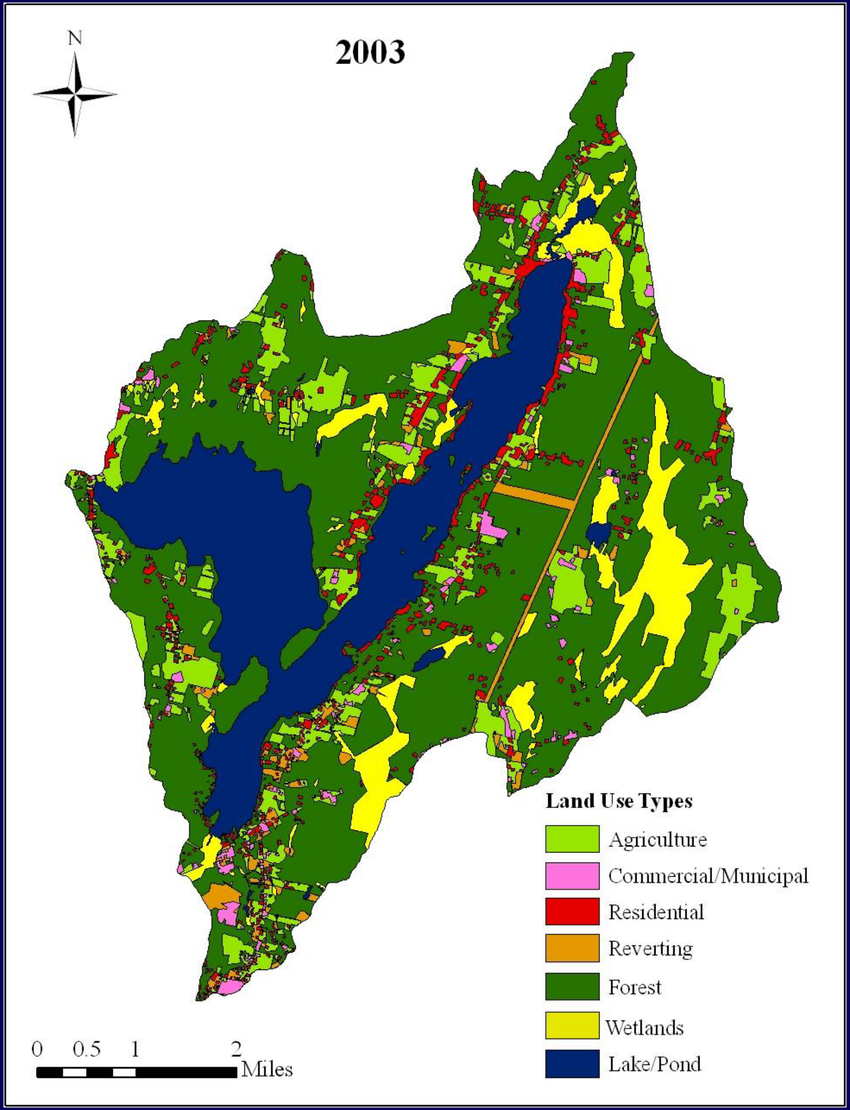
Creating Polygons

Designating land use types within GIS



Land Use Maps





Lake Quality Impacts: Agriculture

- Fertilizers contribute high levels of phosphorus
- High erosion potential
- Increased runoff
- 14.1% of watershed land area in 2003
- Down from 21.3% in 1965

Lake Quality Impacts: Forest

- Low erosion and runoff
- High nutrient absorption

- 61.9% of watershed land area in 2003
- Up from 59.5% in 1965

Lake Quality Impacts: Reverting

- Marginal runoff and erosion control
- Residual phosphorus from previous agricultural land use
- 3.3% of watershed land area in 2003
- Down from 9.3% in 1965

Lake Quality Impacts: Wetlands

- Absorbs nutrients that would otherwise run into the lake
- 9.5% of watershed land area in 2003
- Up from 7.2% in 1965

Lake Quality Impacts: Residential

- High levels of impervious surfaces
- Pollutants from household chemicals and neglected septic systems
- 8.1% of watershed land area in 2003
- Up from 2.3% in 1965

Lake Quality Impacts: Commercial/Municipal

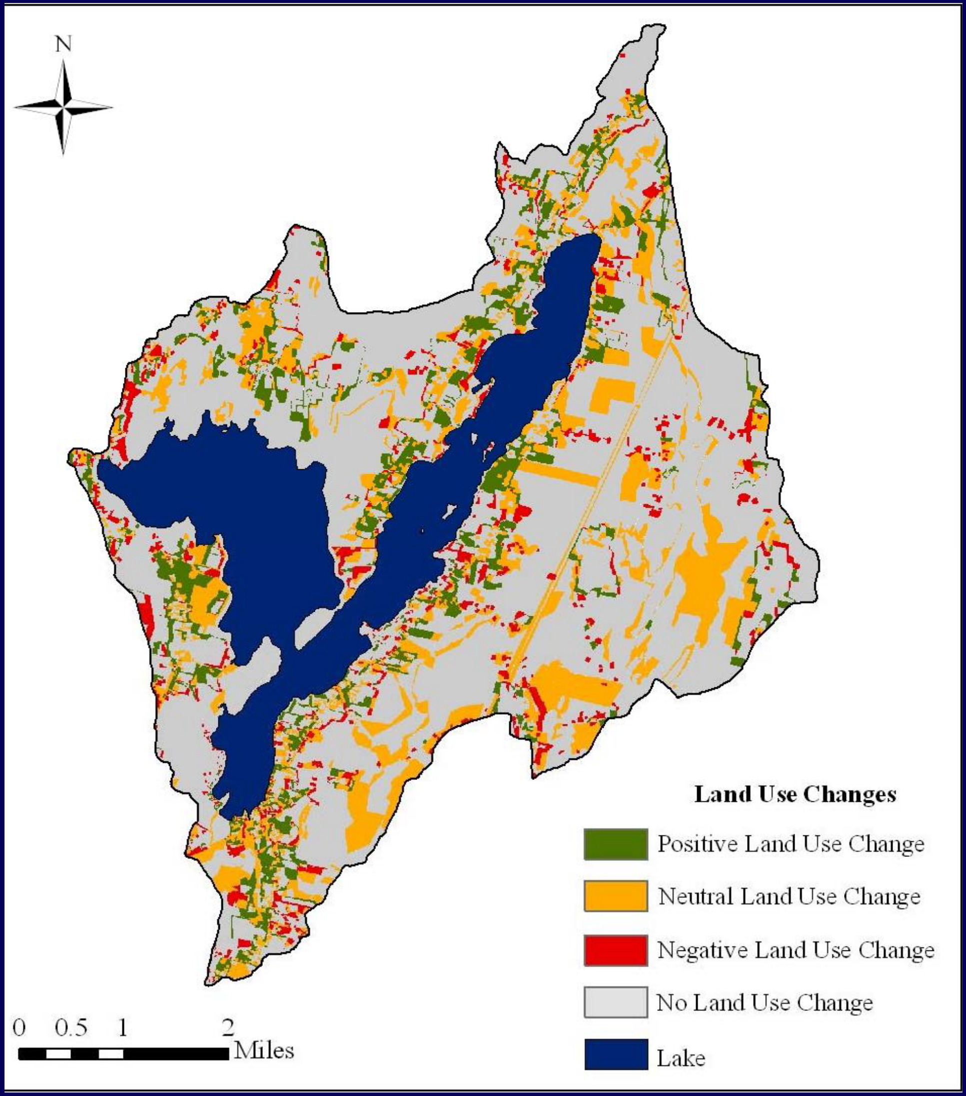
- Large impervious surfaces
- High levels of traffic
- Highly used septic systems
- 1.9% of watershed land area in 2003
- Up from 0.4% in 1965

Lake Quality Impacts: Roads

- Impervious surface can channel water and nutrients into the lake
  - Paved and camp roads
- 1.1% of watershed land area in 2005

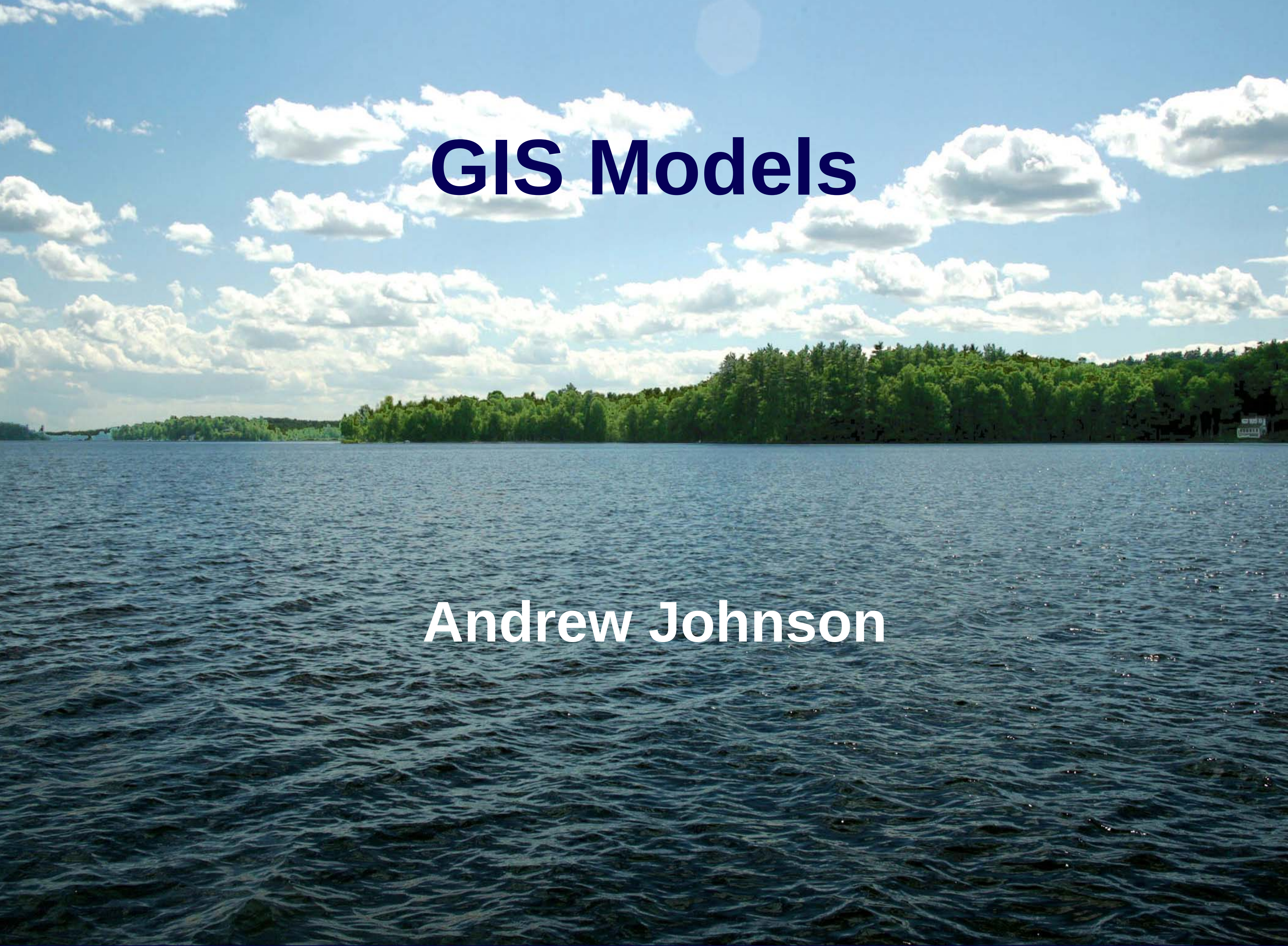
Map of Land Use Change

- 1965-2003
- Based on grouping of land use types
  - Developed
  - Undeveloped



Land Use Summary

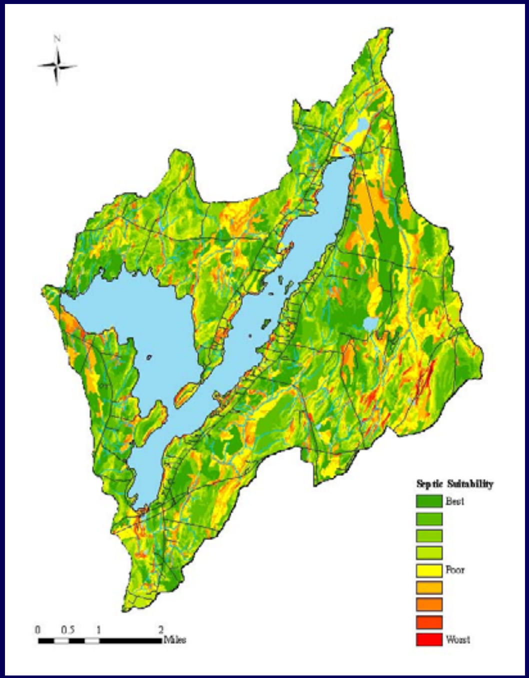
- Land use trends
  - Decreases in agricultural land between 1965 and 2003
  - Increases in residential land
- Land use changes are relevant to nutrient loading
  - GIS modeling
  - Phosphorus budget



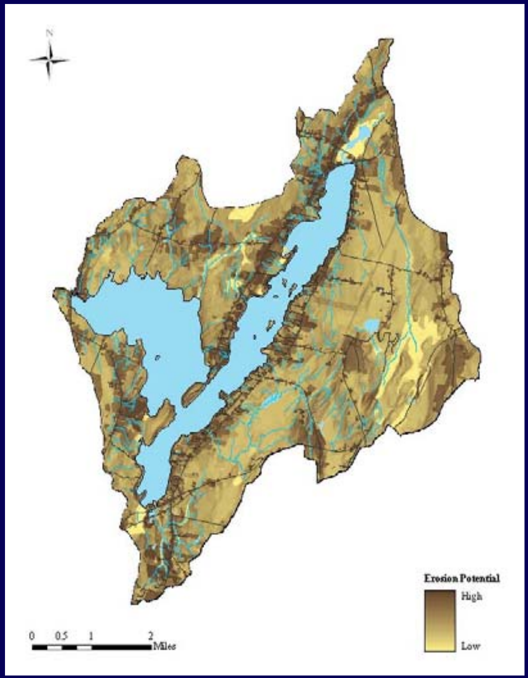
GIS Models

Andrew Johnson

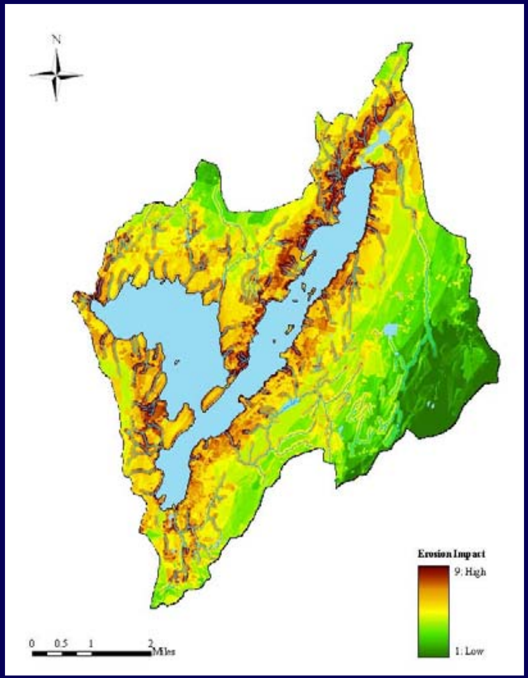
Models Created



Septic Suitability

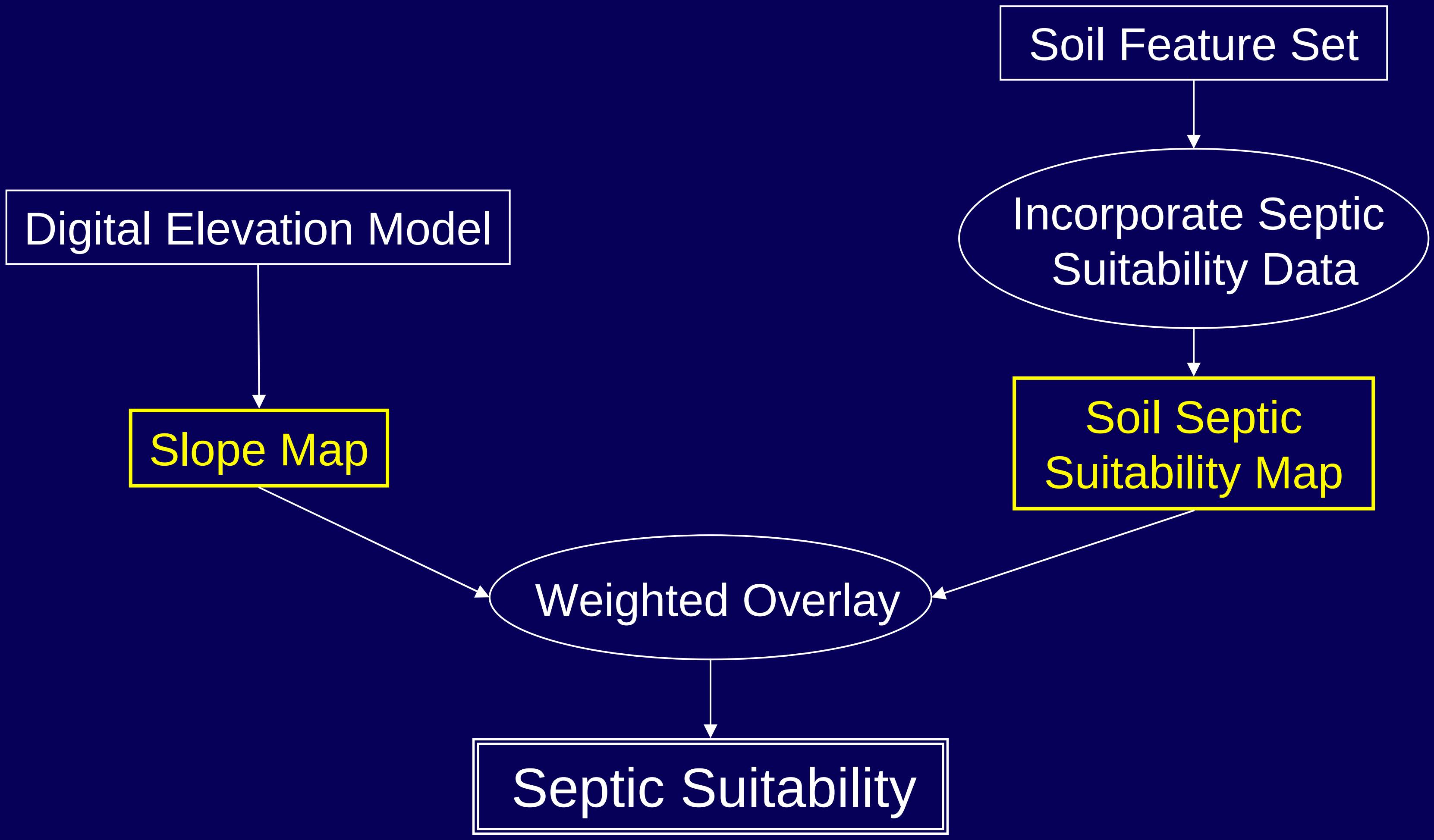


Erosion Potential



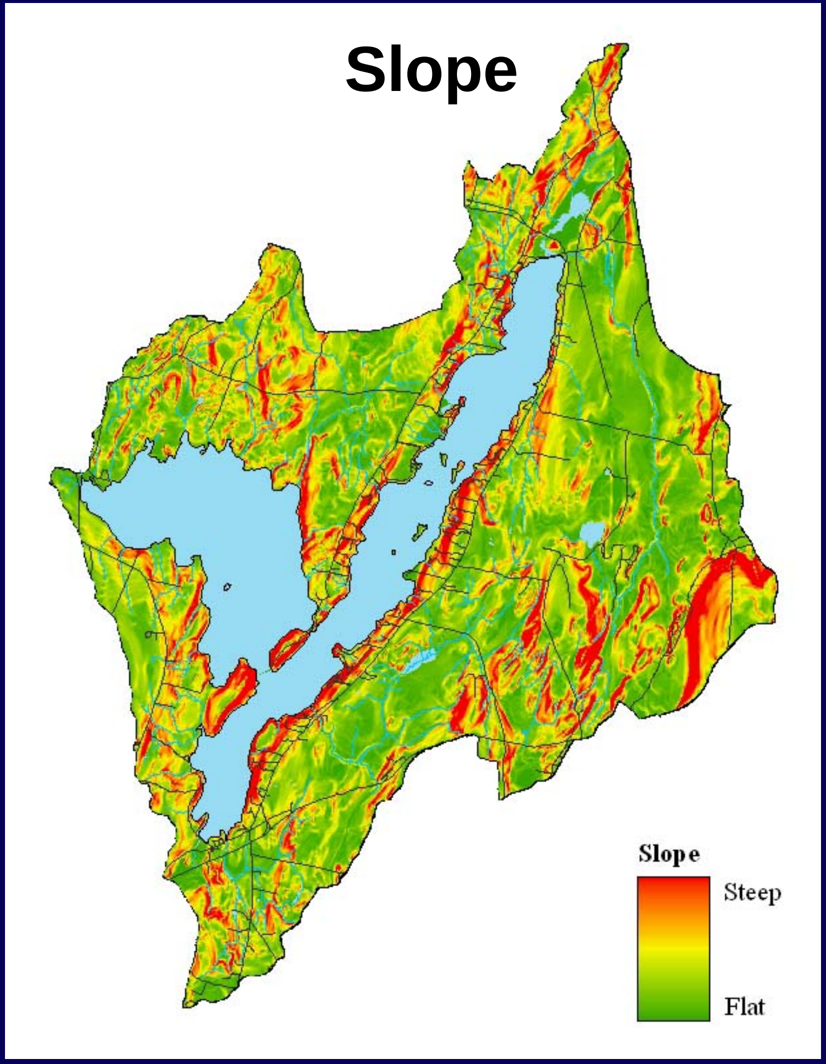
Impact of Erosion

Septic Suitability



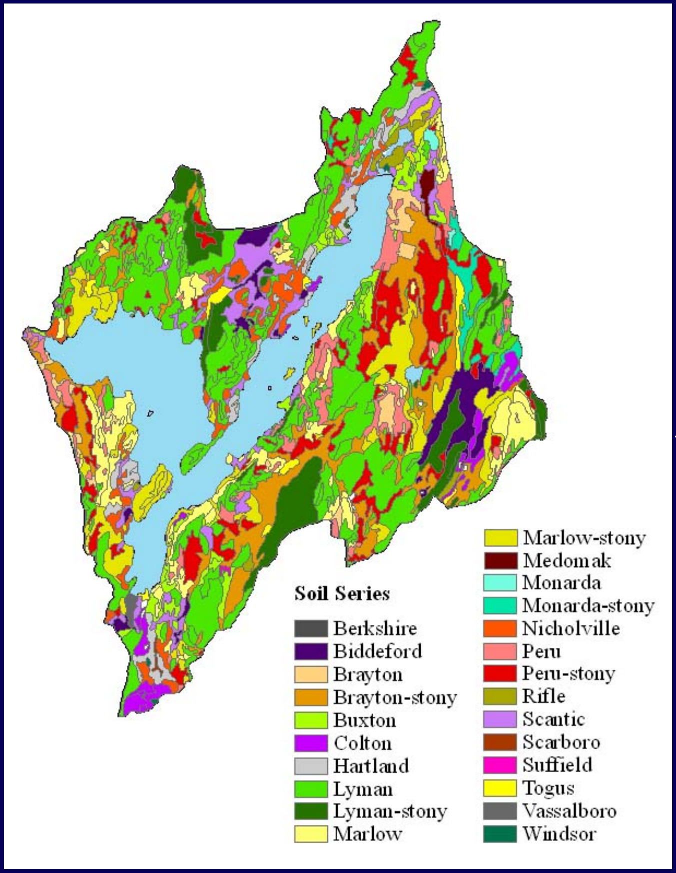
Slope Data

- Slope derived from elevation model
- Slopes range from 0 to 59%
- Slopes scaled to a 1 - 9 range



Soil Septic Suitability

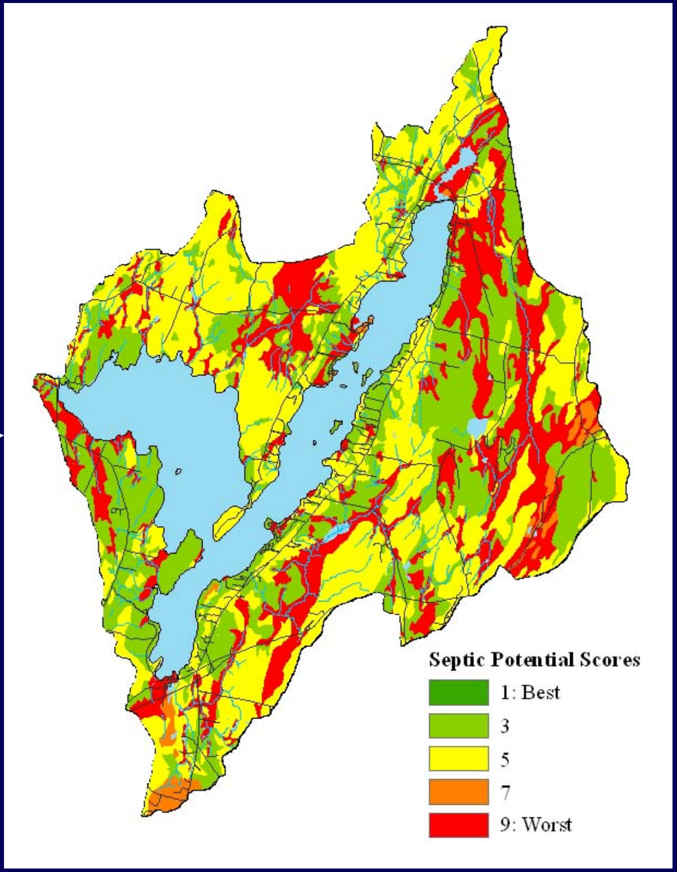
Soil Map



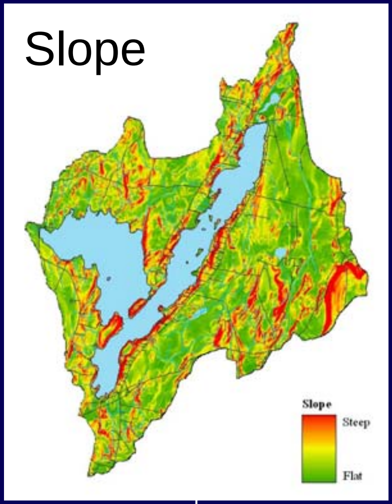
Soils classified by their septic potential

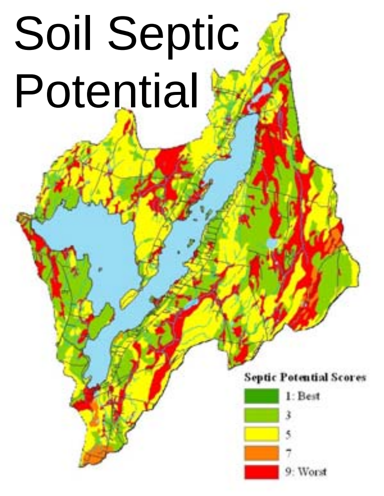
Assigned scores from 1 - 9

Soil Septic Potential

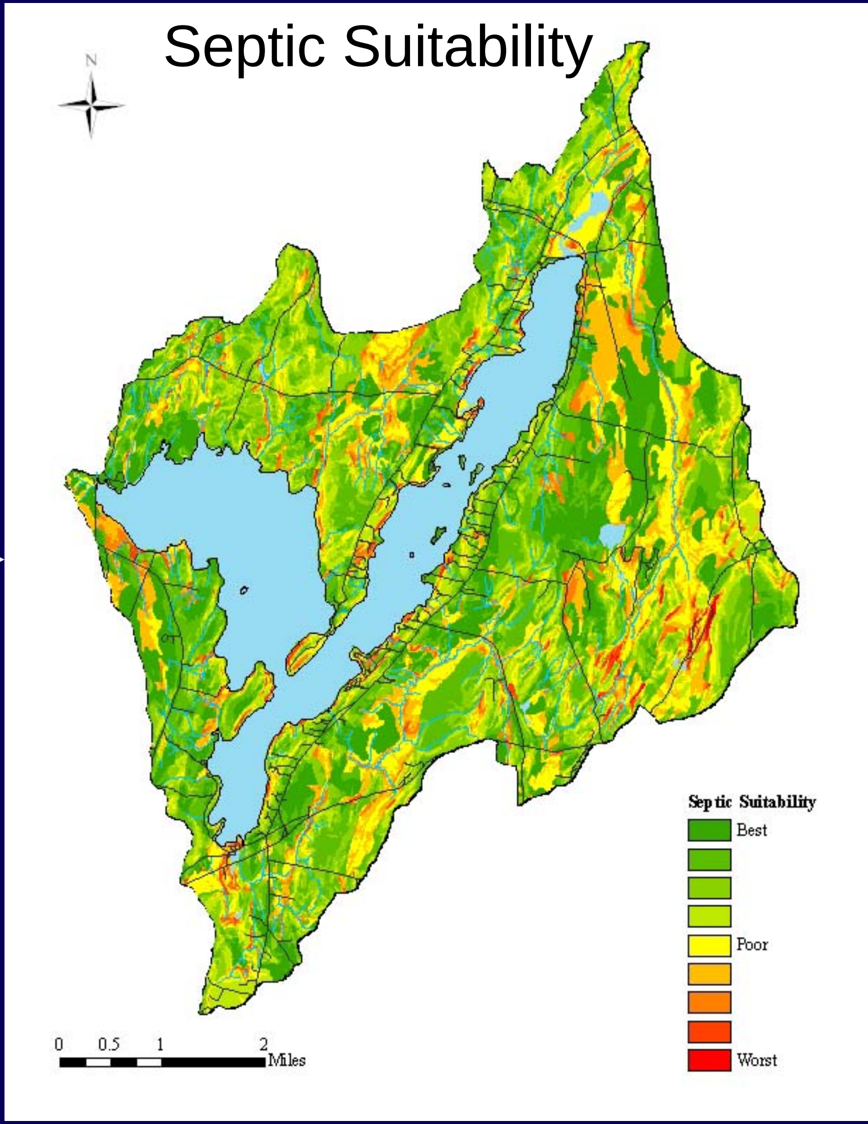


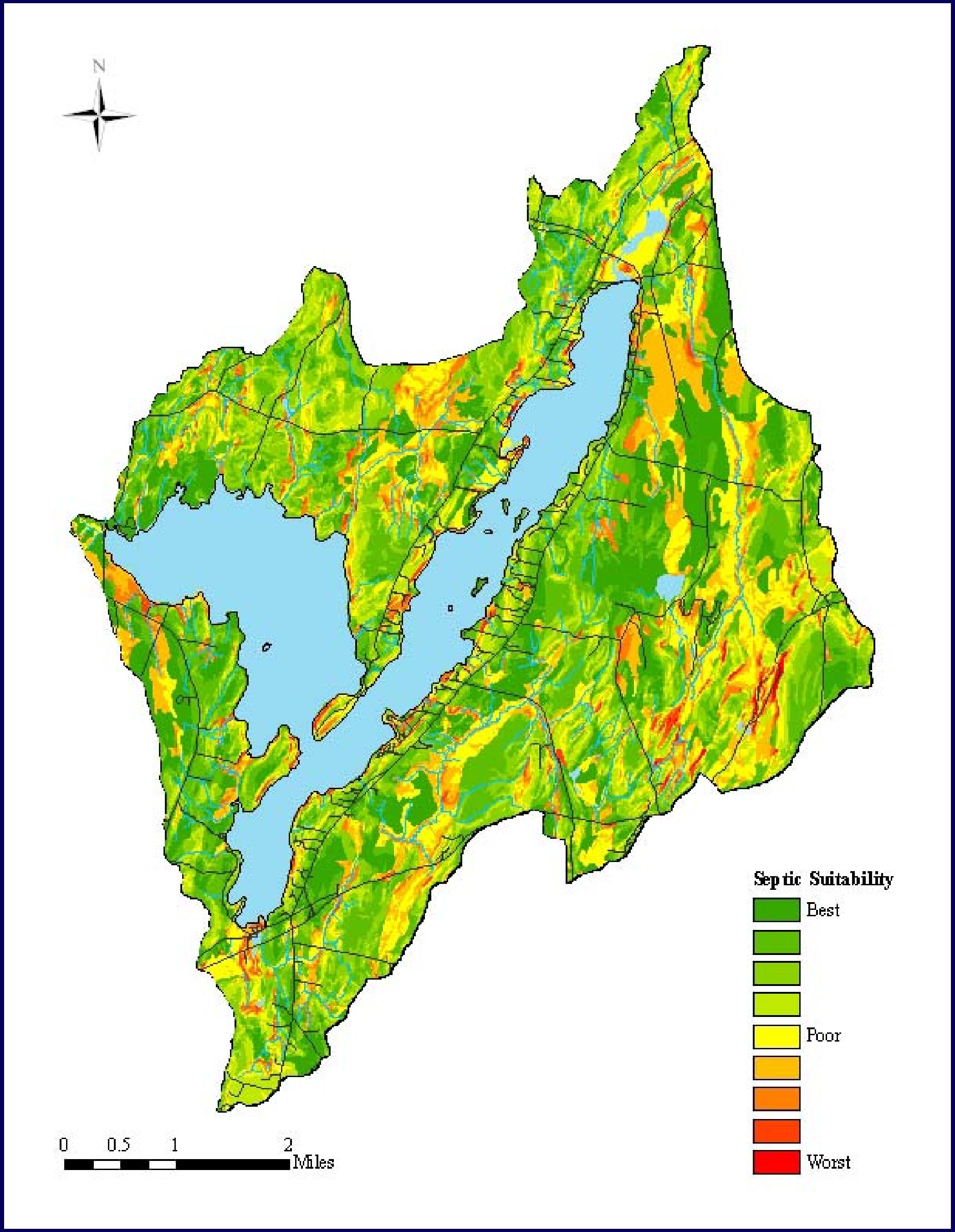
Weighted Overlay





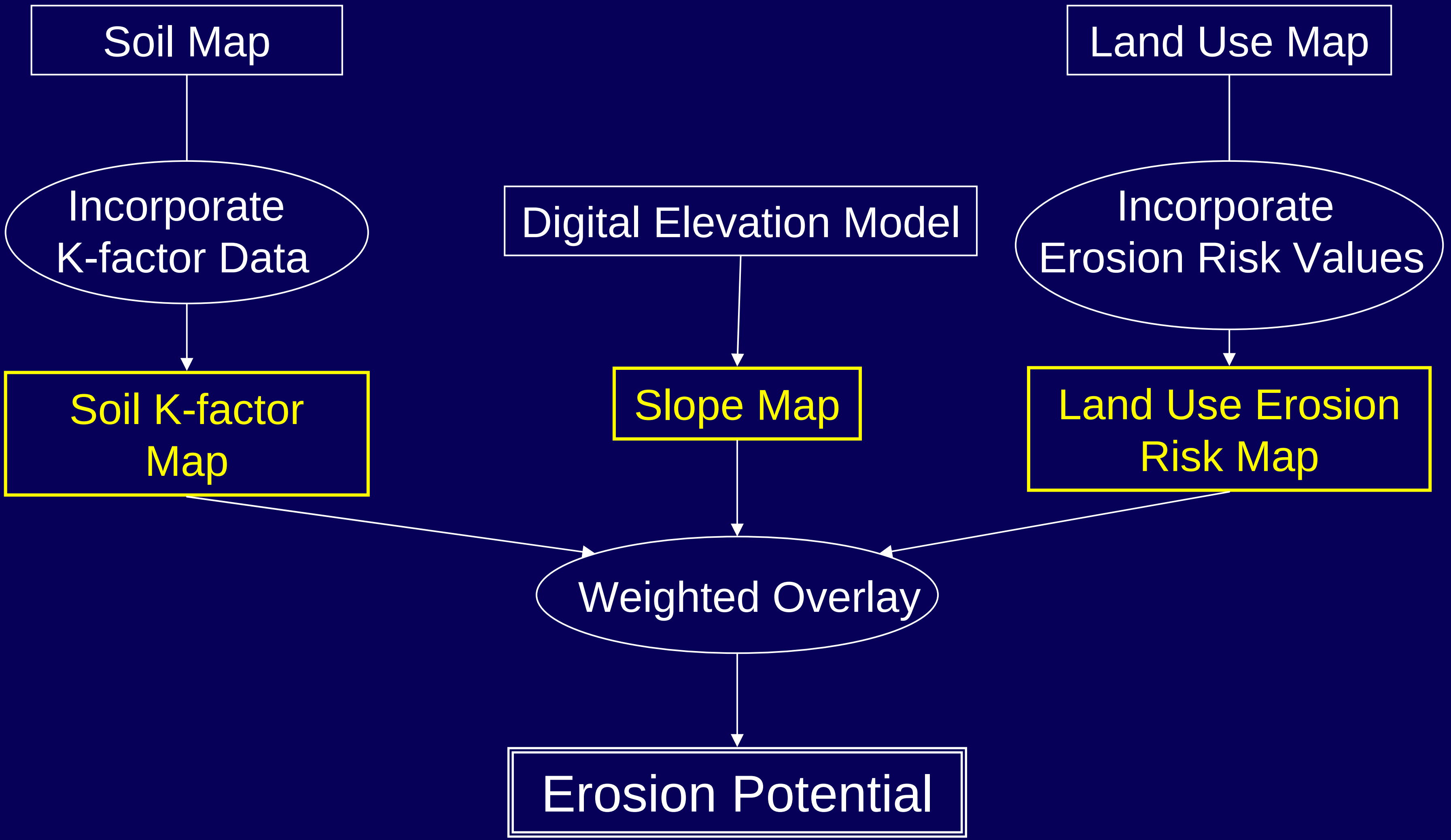
The scores of the two datasets were combined 50/50





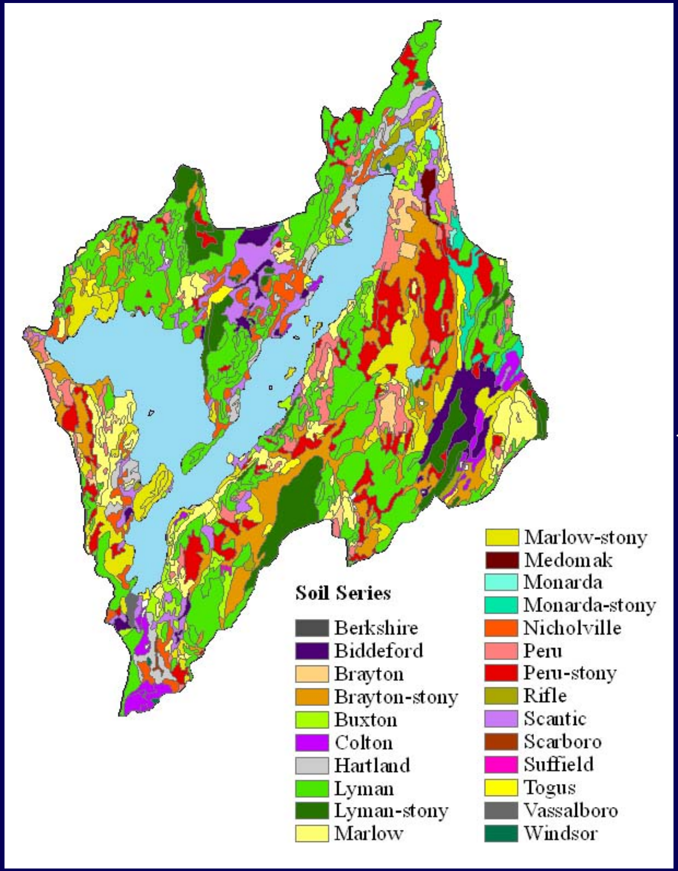
Septic Suitability

Erosion Potential



Soil K-factor Map

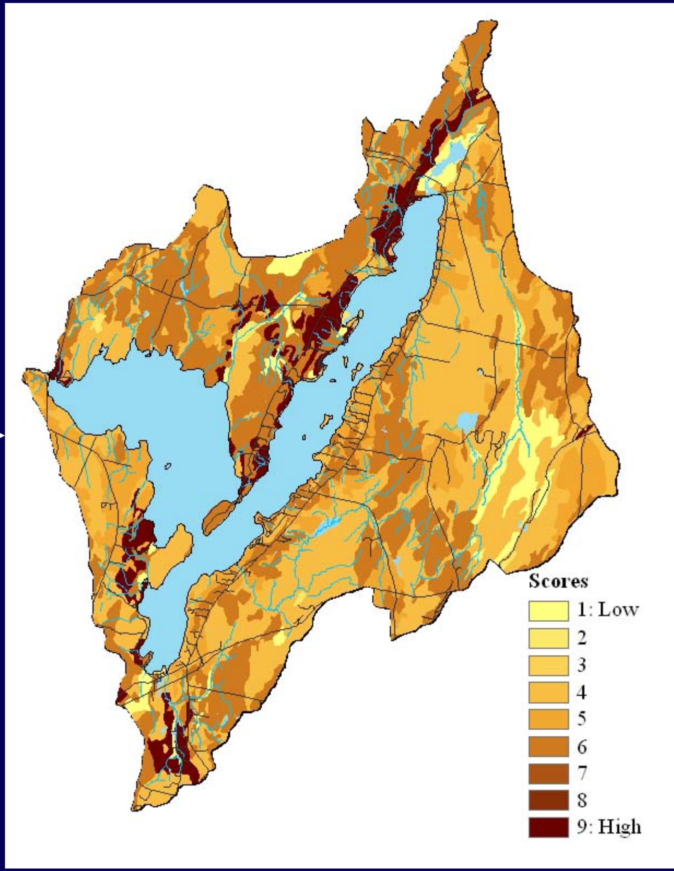
Soil Map



Soils classified by their K-factors

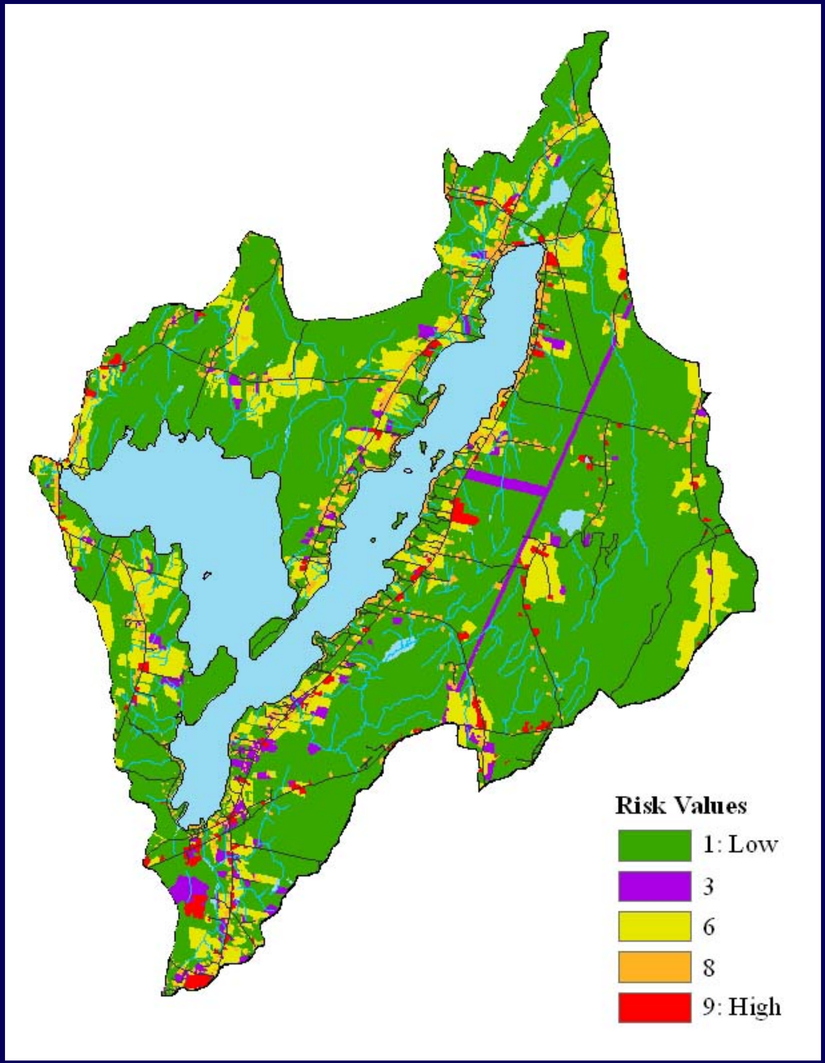
K-factors scaled to a 1 - 9 range

Soil K-factors

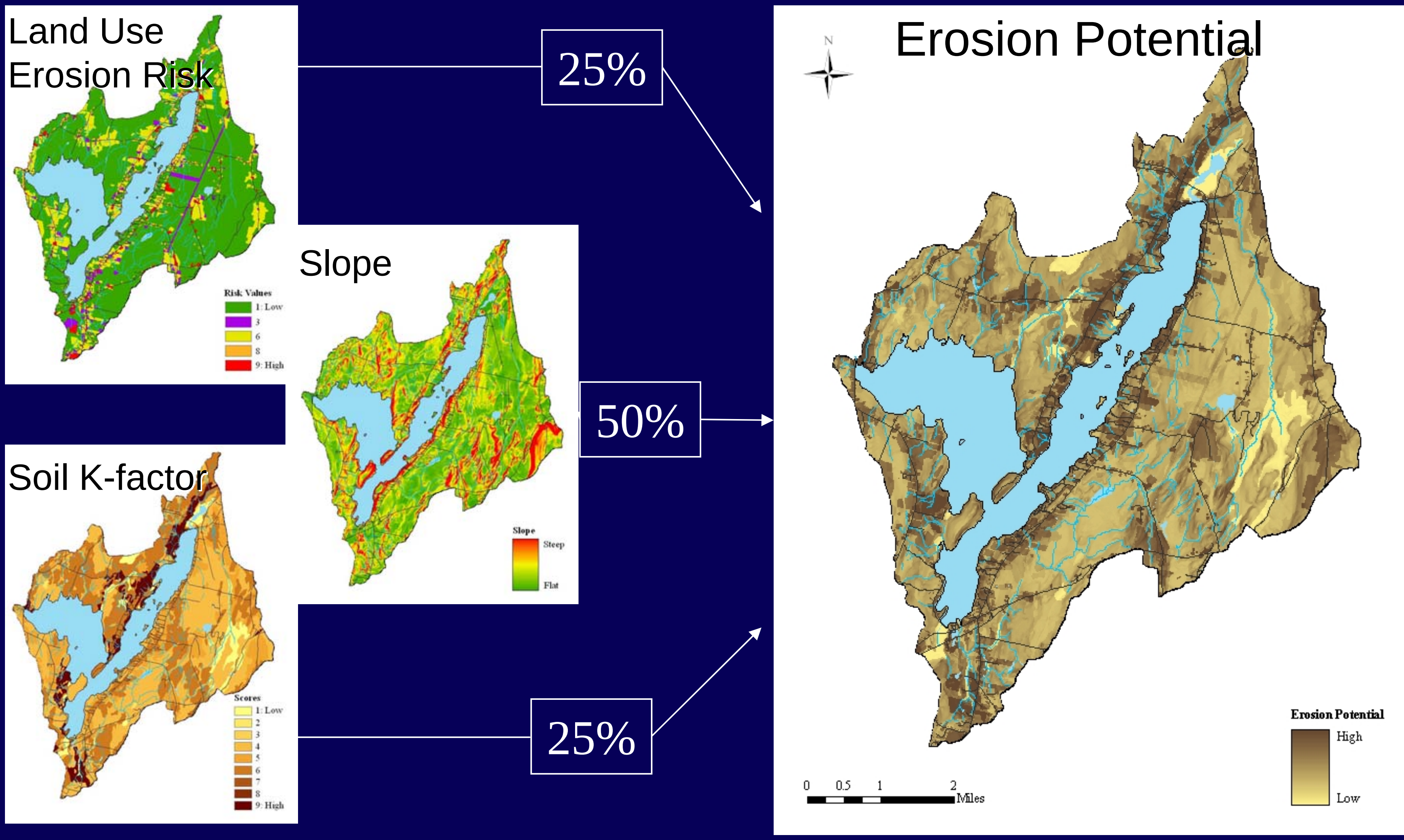


Land Use Erosion Risk Map

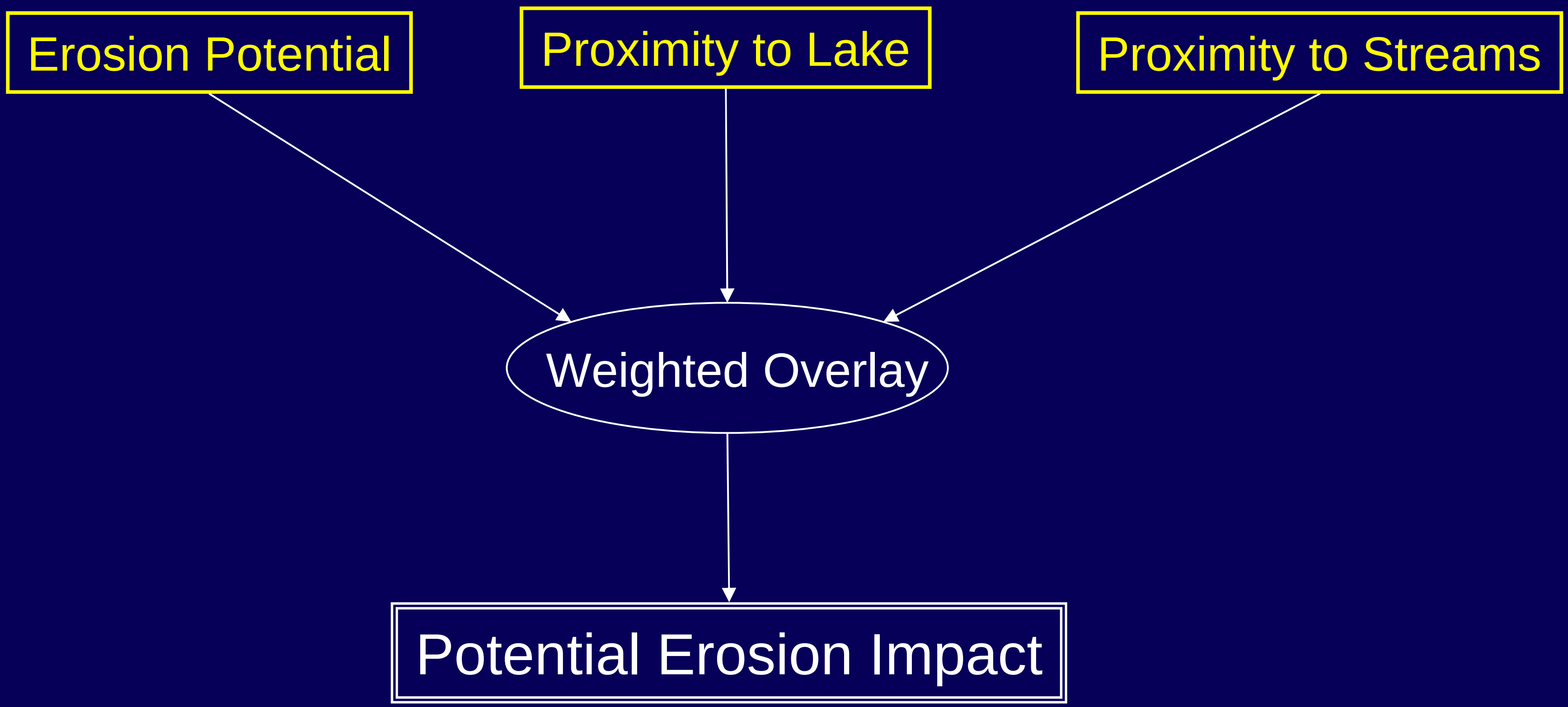
- Erosion risk values were chosen and applied to the different land use types
- Values ranged from 1 to 9



Weighted Overlay

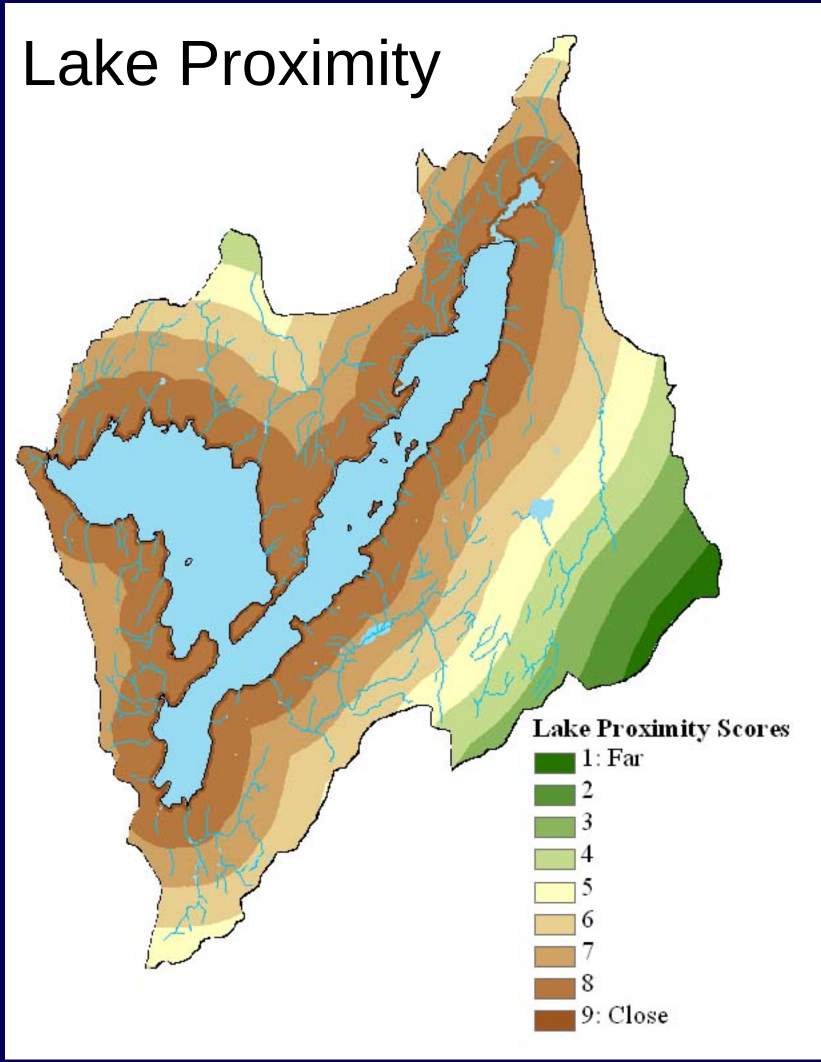


Potential Impact of Erosion



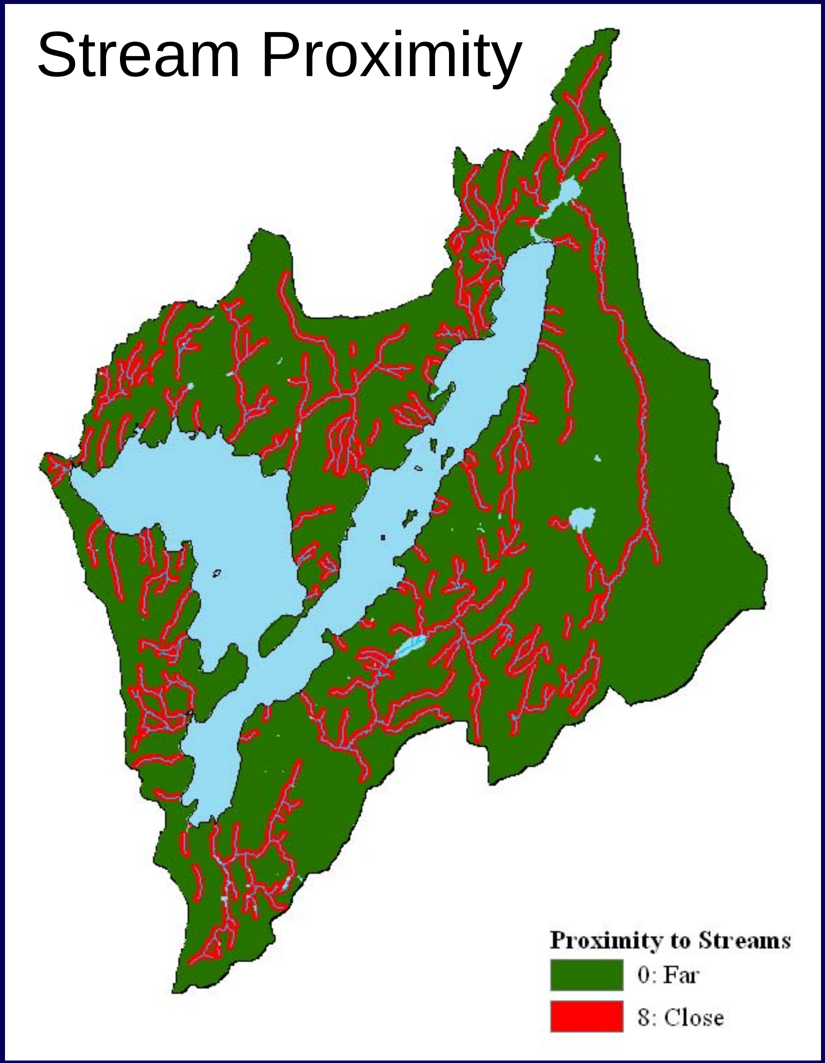
Proximity to Lake

- 9 proximity zones were made around the lake
- 200 ft shoreline zone
- 2000 ft zones for the remaining watershed
- Each buffer was assigned a value 1 - 9 according to proximity

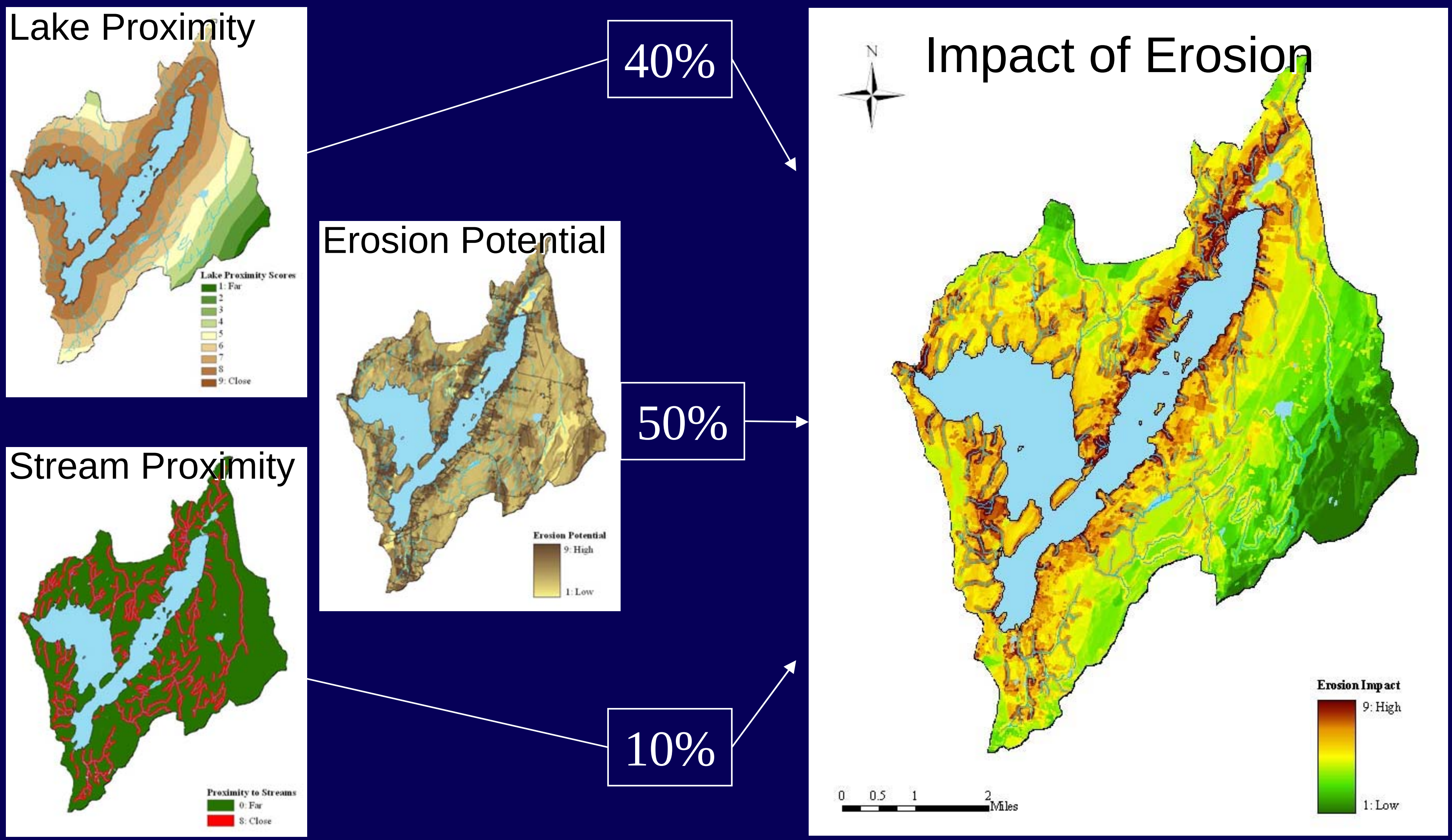


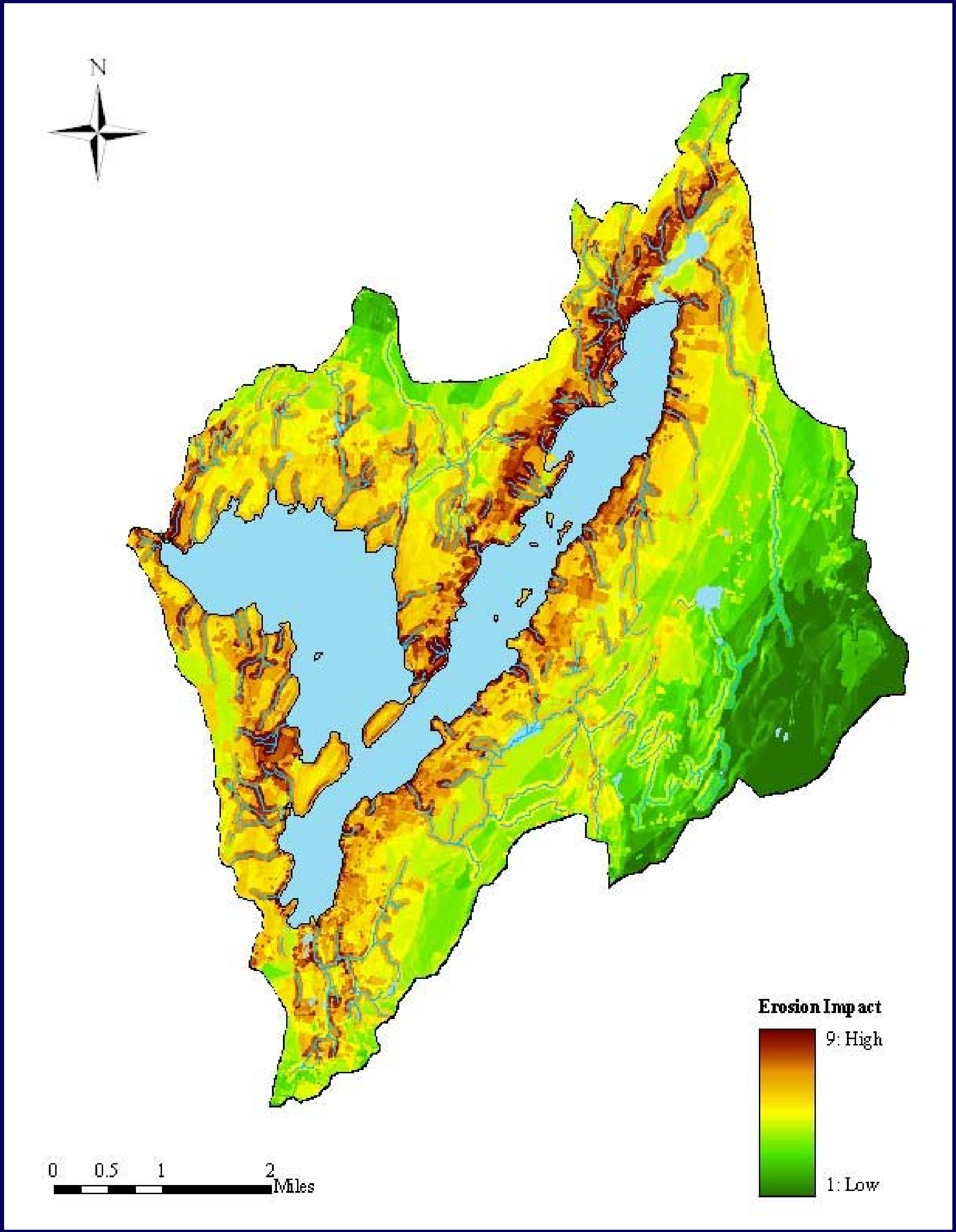
Proximity to Streams

- A single 200 ft proximity zone was made around the streams in the watershed
- Each stream proximity zone was assigned a value of 8
- All other areas were assigned a value of 0



Weighted Overlay





Potential Impact of Erosion

Intermission


Development
Jenna Morrison

Development Objectives

- Maine Residential Shoreline Rules
  - Town regulations
- Impact on the water quality of China Lake
  - Buffer Strip Survey
  - Watershed House Count
  - Septic Systems
  - Commercial Land Use
- Remediation Techniques

Maine Regulations

- Maine Residential Shoreland Zoning Act (1974)
  - 250 ft zone
  - Requirements: lot size, setbacks, buffer strips
  - Resource Protection Districts
    - 5 on China Lake
  - Non-conformance
    - pre-1974 development

- Regulations are enforced by a Code Enforcement Officer

Town Policies

China

- Regulations for septic system construction
- Phosphorus control ordinance

Vassalboro

- Replacement ordinance for pre- 1974 septic systems
- Land around West Basin owned by KWD

Background: Development

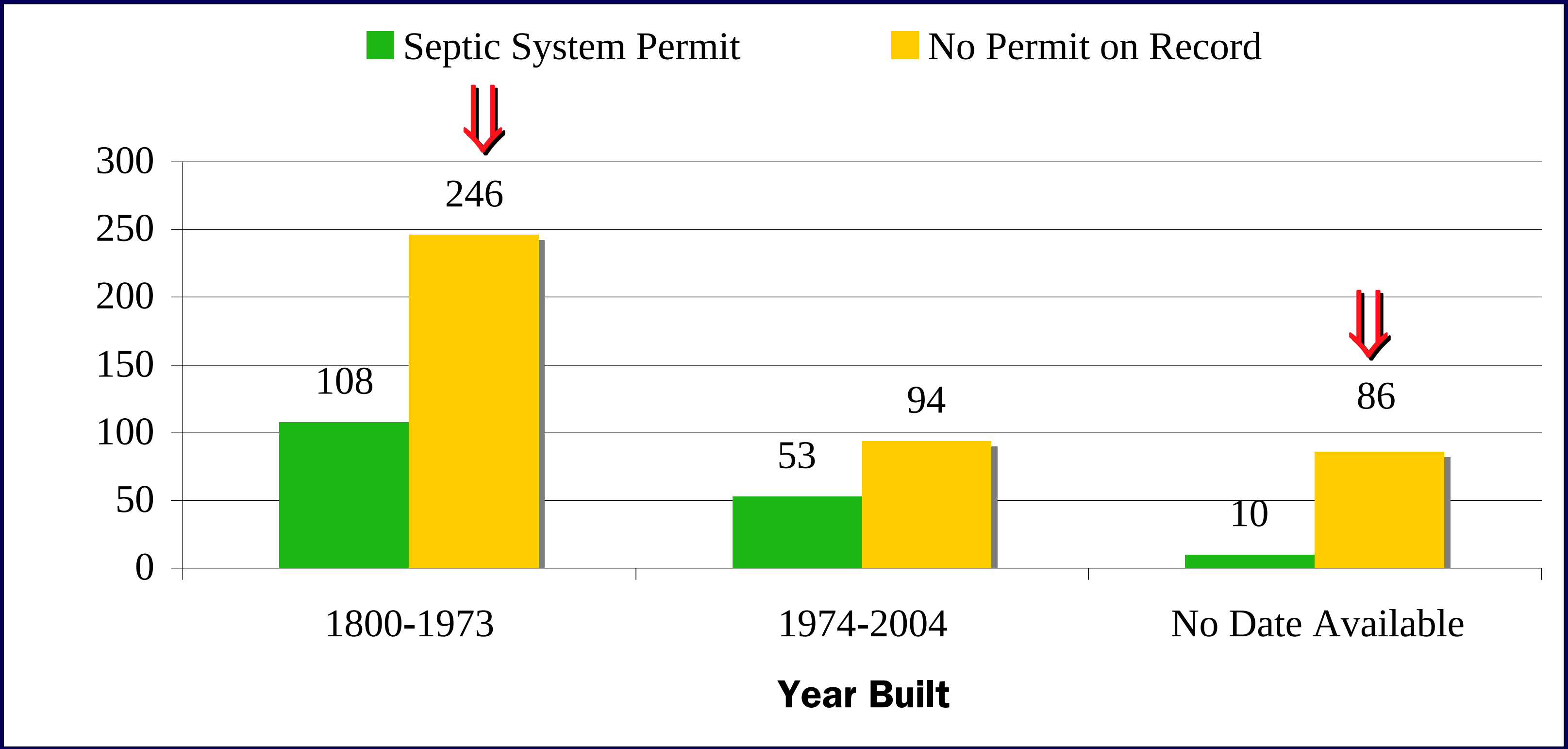
- Shoreline development activities impact water quality
- Buffer strips slow nutrient and sediment runoff
- Septic systems can contribute to nutrient loading
- Commercial land use has the potential to add pollutants

Watershed House Count Survey

Zone and Use	Houses
Shoreline Seasonal	296
Shoreline Year-Round	176
Non-shoreline Seasonal	37
Non-shoreline Year-Round	1109
Watershed Total	1618

- Method: shoreline and road survey
- 63% of shoreline houses are seasonal
  - Concentrated septic system use during summer
- 30.2 houses per shoreline mile

Subsurface Wastewater Disposal Systems



- China Lake Septic Project produced by the Town of China and KWD (2005)
- Pre- 1974 septic systems without permits are potentially contributing to nutrient loading

Buffer Strip Survey

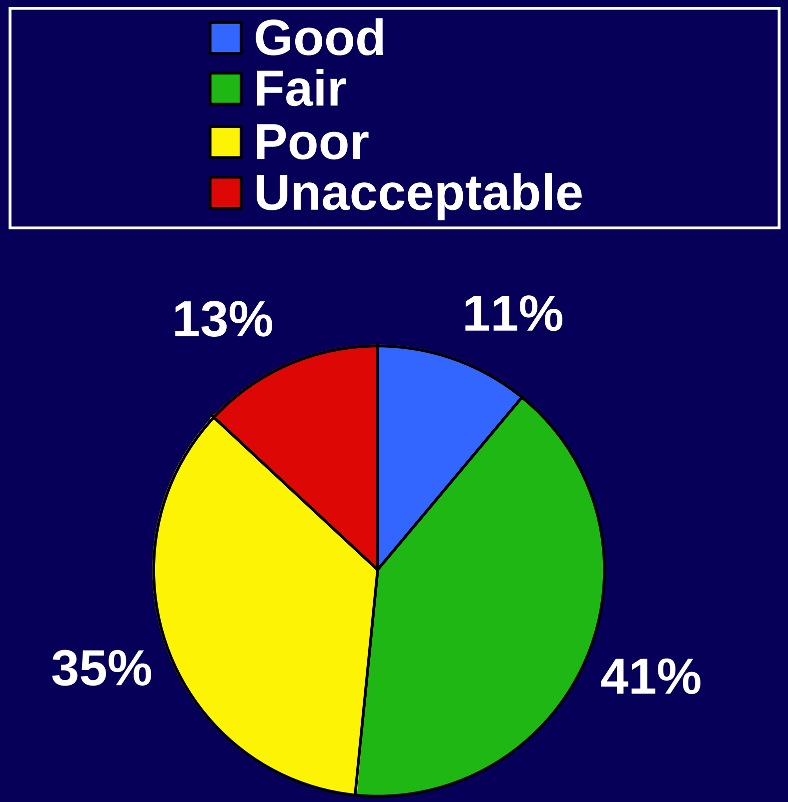
- Methods: evaluate each shoreline property
  - Category rating of effectiveness of buffer strips

Good

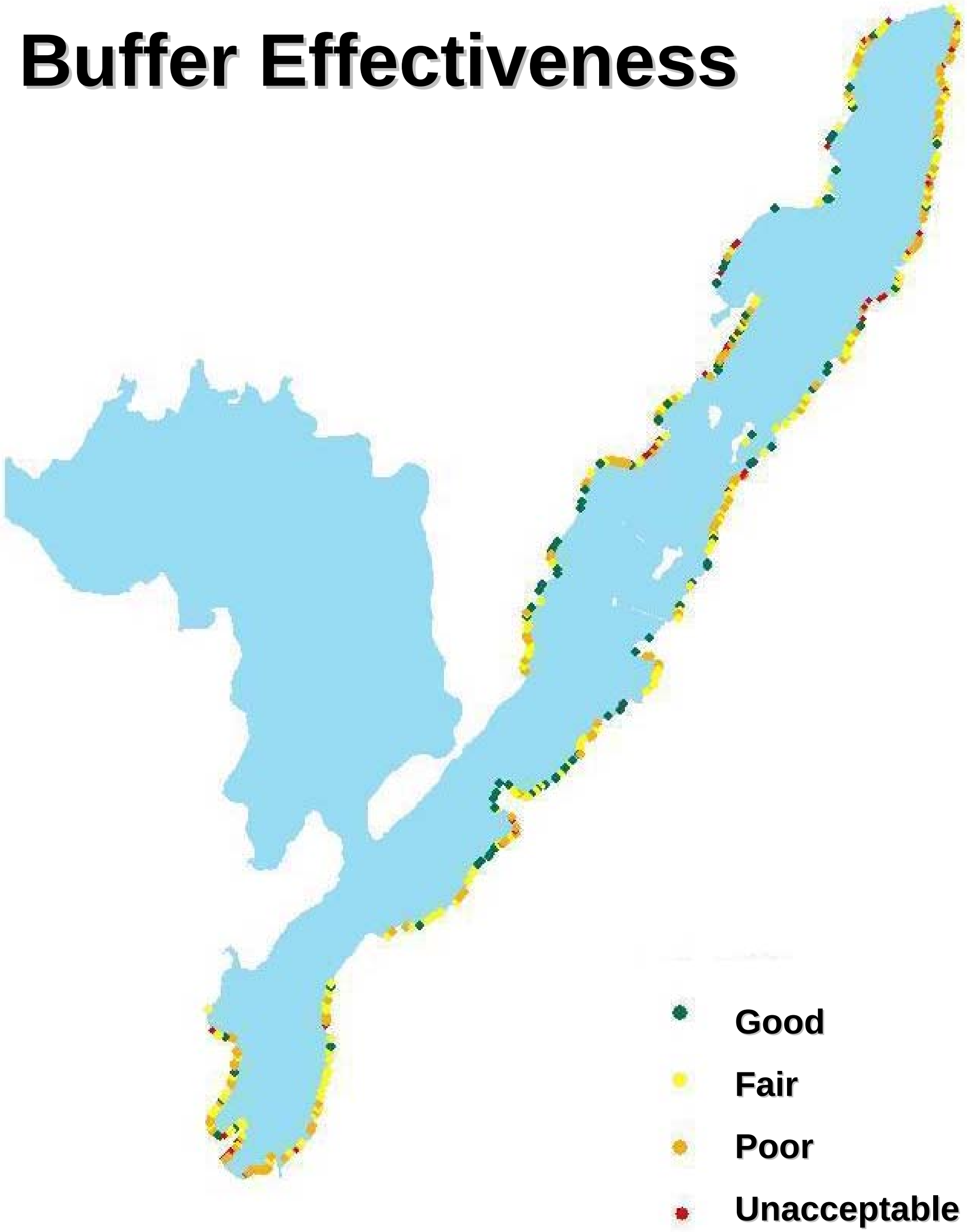
Unacceptable

Buffer Strip Results

- 55% had less than 60 ft of shoreline
- 61% had a 0-10 ft buffer depth
- Heavy shoreline development
  - Few forested areas on East Basin



Buffer Effectiveness



Watershed Commercial Land Use

- Impervious surface
- Farming and forestry
- Three schools
- Gas stations have contaminated soil
  - Garages/ repair shops

- Smaller Issues
  - Salt and sand storage
  - Capped landfill and transfer station
  - Seasonal eateries

Remediation Techniques

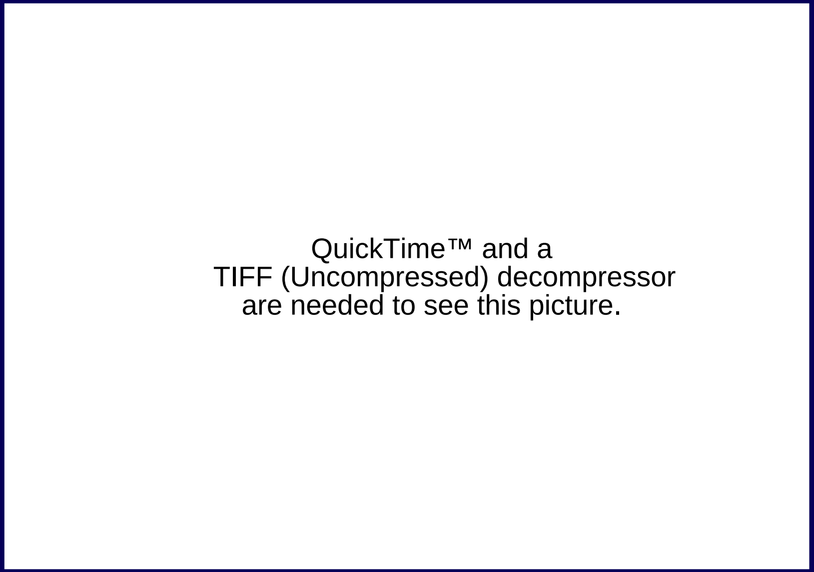
- Maintain vegetated buffer strip
  - Across entire lot and up to 75 foot depth
  - Several layers: trees, shrubs, ground cover
- Maintain and replace septic systems
  - Monitor
  - Update town records of permits
  - Incentives to replace grandfathered systems
  - Low-interest loans available
- Conscious commercial and residential development

Development and Road Survey

Jackie Rolleri

Watershed Development Projections

- Residential Growth
  - Estimate: 250 houses will be built in both China and Vassalboro by 2015
  - Larger house size increases nutrient loading
  - More septic systems, roofs, driveways, roads, etc.
  - China: about 36 of 512 total lots remain undeveloped



Watershed Development Projections

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

- Commercial buildings increase by one per year in both China and Vassalboro
- New bridge linking I-95 to Route 3
- China: plans for a Commercial Site Review Ordinance

Road Survey

Methods

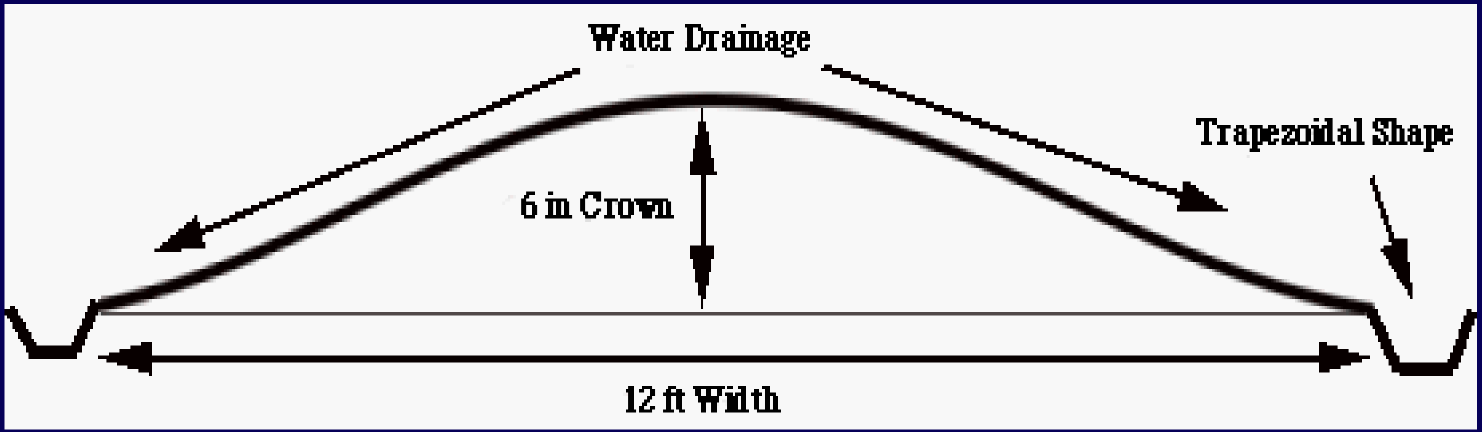
- Measured:
  - Length
  - Width
  - Crown
  - Slope

Recorded

- Problems:
  - Crown
  - Grade
  - Ditch
  - Water Diversion
  - Culvert

Road Survey

- Crown
  - Allows proper drainage
  - Prevents deterioration of road surface
- Grading
  - Process of smoothing and crowning a gravel road
  - Keep road edges smooth so water can flow off side

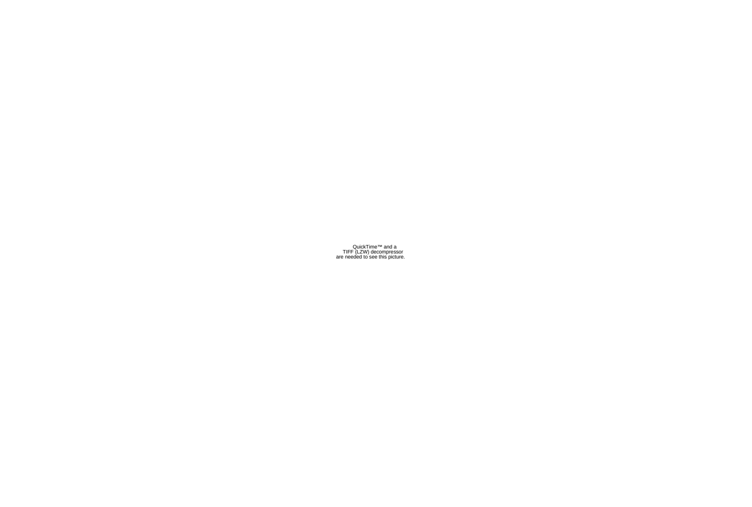


Road Survey

- Ditch
  - Diverts water flow off road and away from body of water
  - U-shape, do not exceed depth:width ratio of 2:1

Road Survey

- Water Diversion
  - Water bar: ridge running diagonally across road
  - Rubber bar: divert water off sloping sections of a road while allowing traffic to drive over it□



Road Survey

- Culvert
  - Hollow pipes installed beneath roads to channel water in proper drainage patterns
  - Size: large enough to handle water at peak flow time

Road Condition Ranking

Good

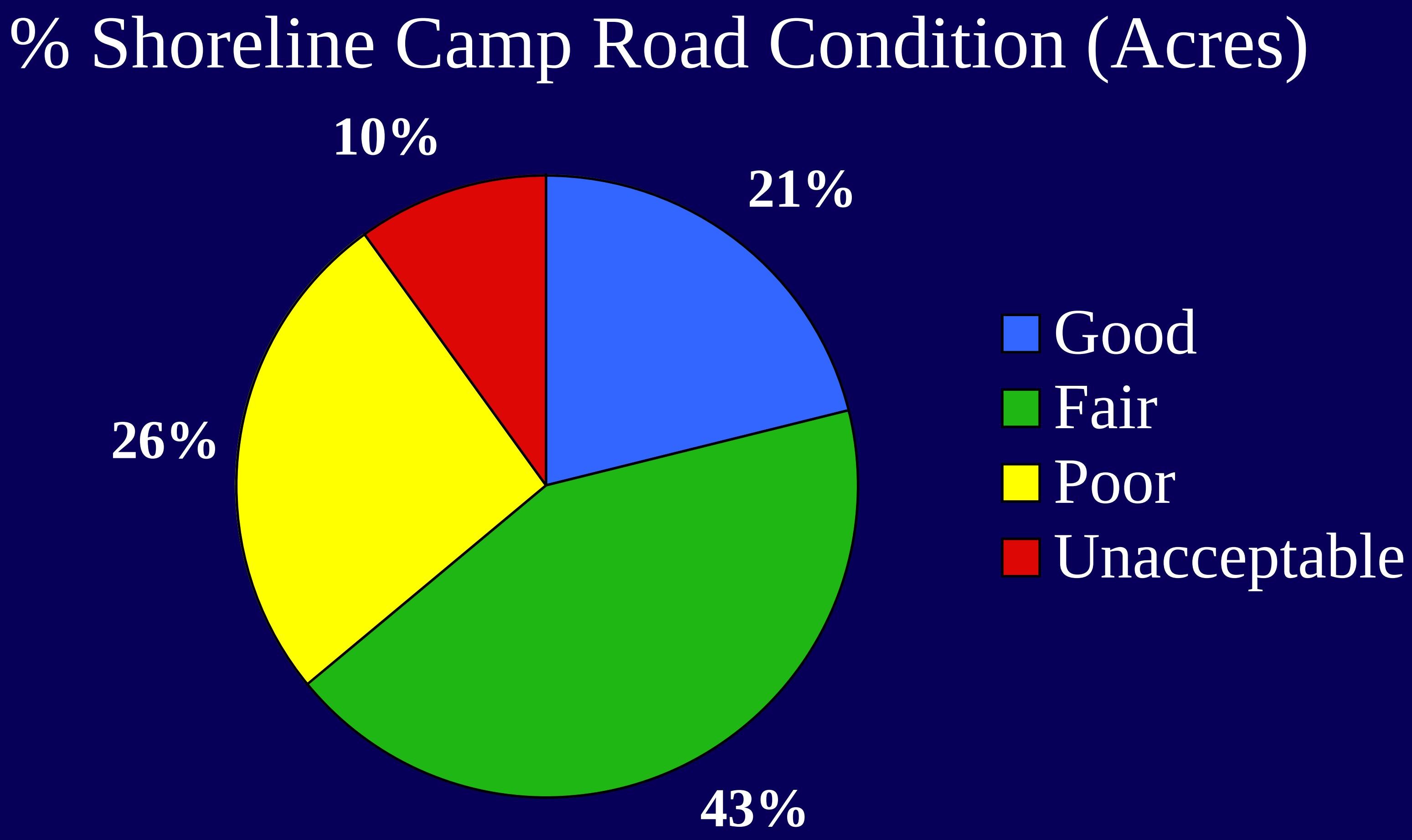
Fair

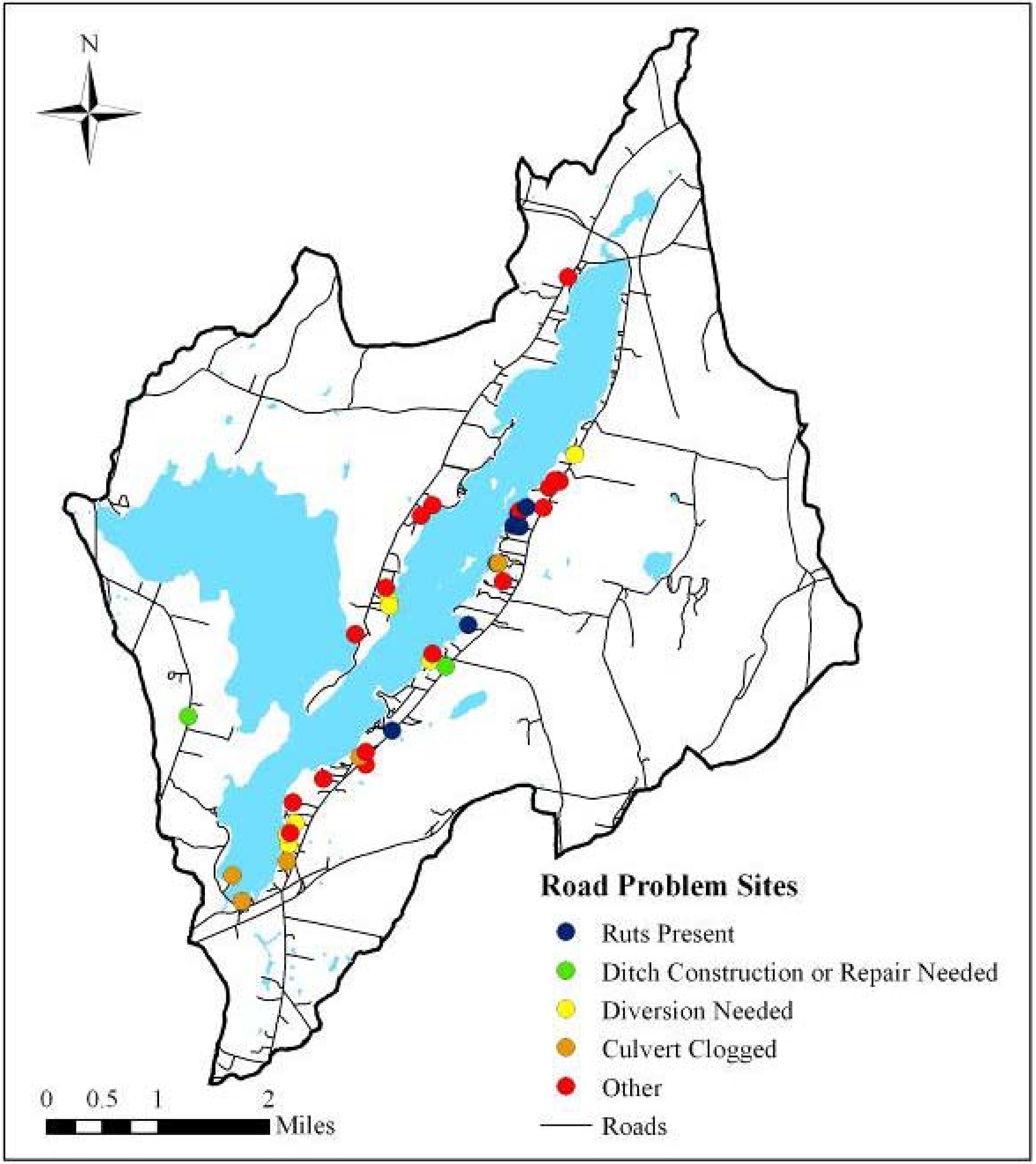
Road Condition Ranking

Poor

Unacceptable

Road Assessment Results

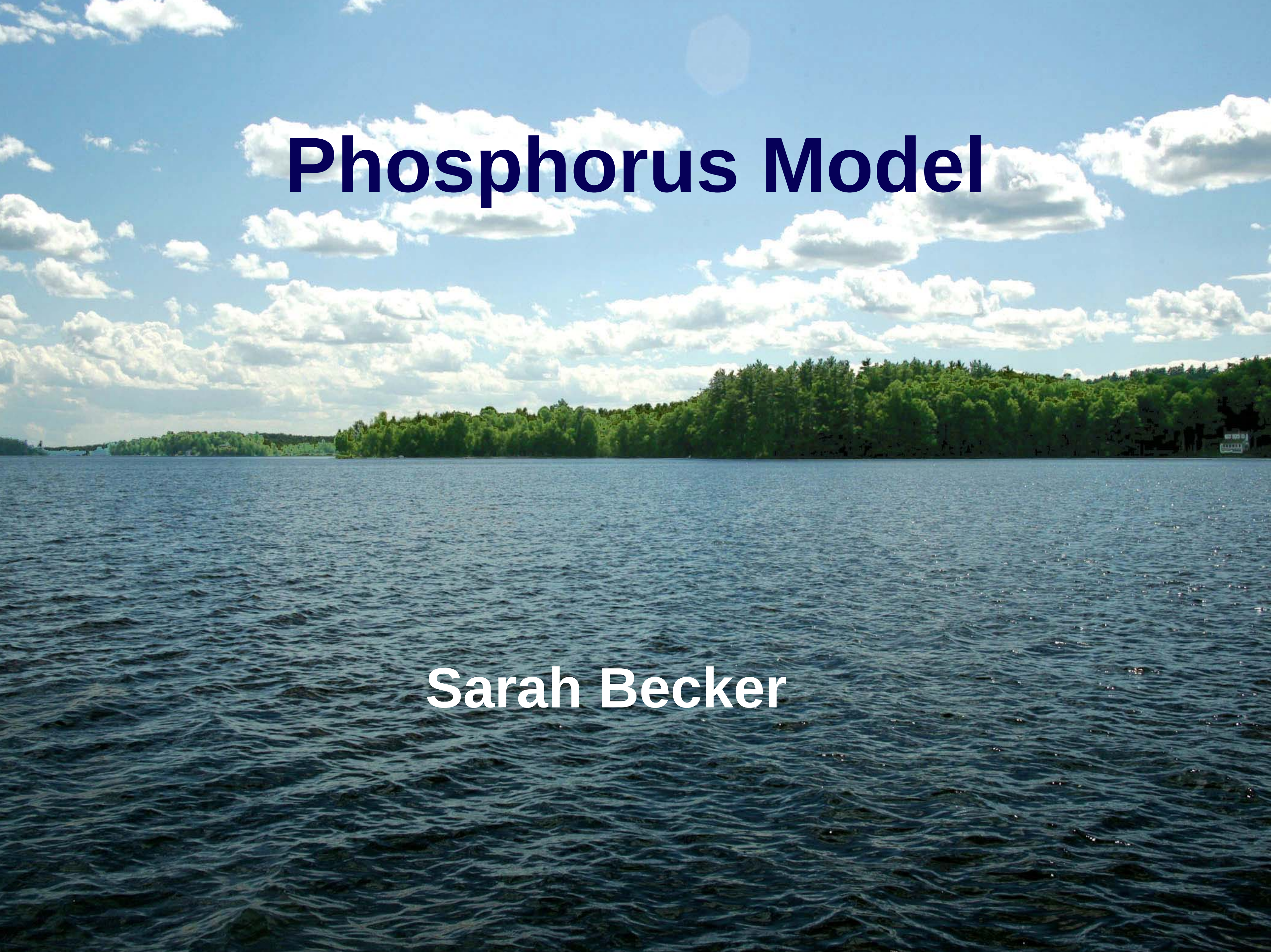



N
Road Problem Sites
Ruts Present
Ditch Construction or Repair Needed
Diversion Needed
Culvert Clogged
Other
Roads
0 0.5 1 2
Miles

Problem Areas

Remediation Techniques

- Roads
  - Maintain proper crown
  - Clear debris from culverts and ditches
  - Eliminate berms
  - Install water diversions where appropriate
  - Road associations



Phosphorus Model

Sarah Becker

Phosphorus Model: What is it?

- Estimation of the total amount of phosphorus (P) entering the lake from:
  - Various external sources
  - Internal source = Sediment release
- Mathematical model used to make:
  - Current estimates
  - Future predictions

Phosphorus Model:
How is it Calculated?

$$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#\text{capita years} \times (1-SR_1)] + [Ec_{ns} \times \#\text{capita years} \times (1-SR_2)] + [I_A \times (1-SR_{3A})] + [I_B \times (1-SR_{3B})] + [I_C \times (1-SR_{3C})] + (Sd \times A_b)$$

Phosphorus Model: How is it Calculated?

$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#capita\ years \times (1-SR_1)] + [Ec_{ns} \times \#capita\ years \times (1-SR_2)] + [I_A \times (1-SR_{3A})] + [I_B \times (1-SR_{3B})] + [I_C \times (1-SR_{3C})] + (Sd \times A_b)$

- W = total amount of P entering the lake in a year (kg/yr)

Phosphorus Model: How is it Calculated?

$$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#\text{capita years} \times (1-SR_1)] + [Ec_{ns} \times \#\text{capita years} \times (1-SR_2)] + [I_A \times (1-SR_{3A})] + [I_B \times (1-SR_{3B})] + [I_C \times (1-SR_{3C})] + (Sd \times A_b)$$

- W = total amount of P entering the lake in a year (kg/yr)
- (Ec x Area) = amount of P from a particular land use type (kg/yr)

Phosphorus Model: How is it Calculated?

$$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#capita\ years \times (1-SR_1)] + [Ec_{ns} \times \#capita\ years \times (1-SR_2)] + [I_A \times (1-SR_{3A})] + [I_B \times (1-SR_{3B})] + [I_C \times (1-SR_{3C})] + (Sd \times A_b)$$

- W = total amount of P entering the lake in a year (kg/yr)
- (Ec x Area) = amount of P from a particular land use type (kg/yr)
- Septic systems

Phosphorus Model: How is it Calculated?

$$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#capita\ years \times (1-SR_1)] + [Ec_{ns} \times \#capita\ years \times (1-SR_2)] + [I_A \times (1-SR_{3A})] + [I_B \times (1-SR_{3B})] + [I_C \times (1-SR_{3C})] + (Sd \times A_b)$$

- W = total amount of P entering the lake in a year (kg/yr)
- (Ec x Area) = amount of P from a particular land use type (kg/yr)
- Septic systems
- Schools and residential summer camps

Phosphorus Model: How is it Calculated?

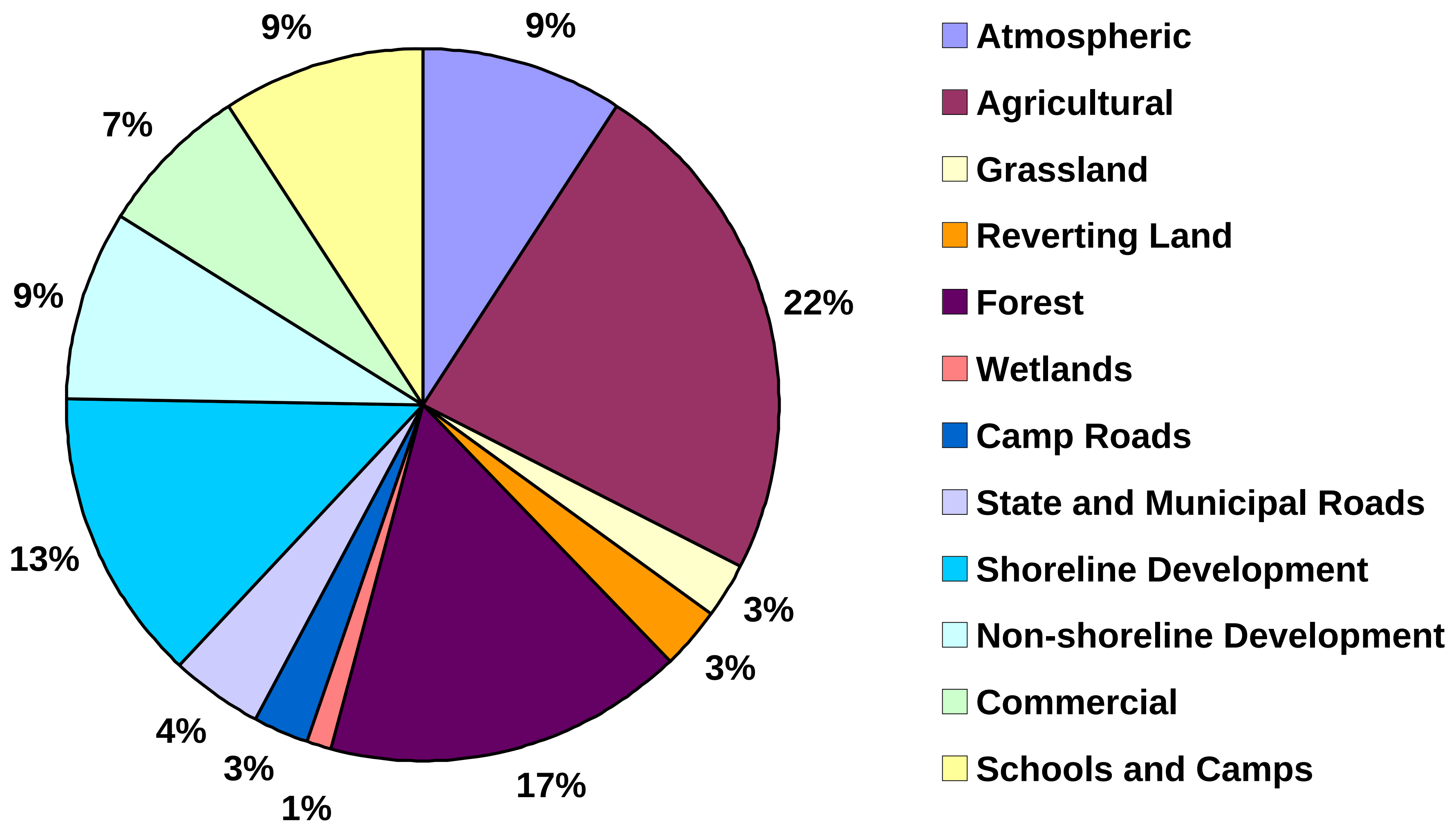
$W = (Ec_a \times A_s) + (Ec_{mf} \times Area_{mf}) + (Ec_{cp} \times Area_{cp}) + (Ec_p \times Area_p) + (Ec_g \times Area_g) + (Ec_w \times Area_w) + (Ec_{rl} \times Area_{rl}) + (Ec_{cm} \times Area_{cm}) + (Ec_{cr} \times Area_{cr}) + (Ec_{sr} \times Area_{sr}) + (Ec_s \times Area_s) + (Ec_n \times Area_n) + [Ec_{ss} \times \#capita\ years \times (1\text{-}SR_1)] + [Ec_{ns} \times \#capita\ years \times (1\text{-}SR_2)] + [I_A \times (1\text{-}SR_{3A})] + [I_B \times (1\text{-}SR_{3B})] + [I_C \times (1\text{-}SR_{3C})] + (Sd \times A_b)$

- W = total amount of P entering the lake in a year (kg/yr)
- (Ec x Area) = amount of P from a particular land use type
- Septic systems
- Schools and residential summer camps
- Sediment release

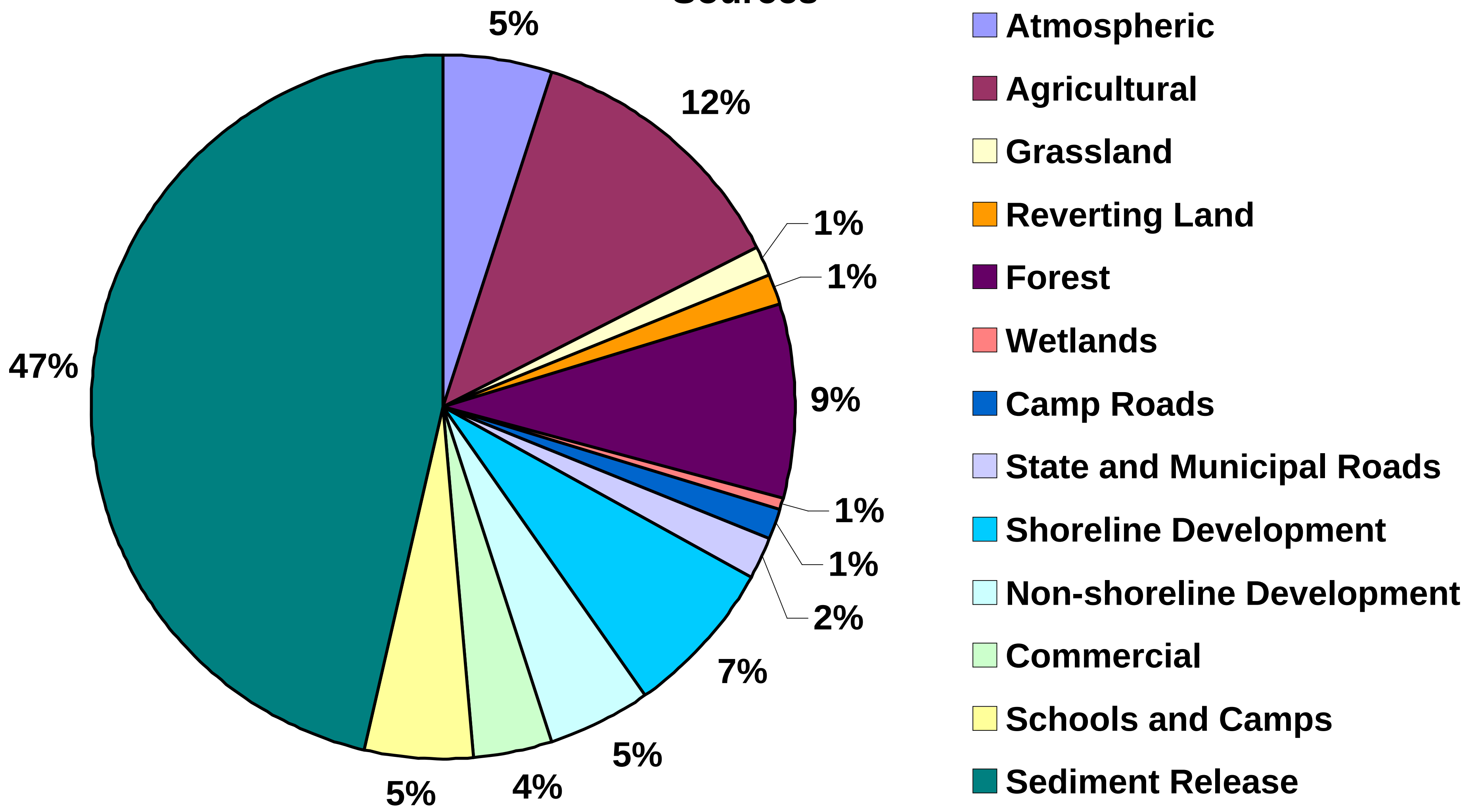
Phosphorus Model: Results

	External Sources Only			External Sources and Sediment Release		
	Low	Best	High	Low	Best	High
W **(kg/yr)**	1210	2447	5716	2814	4843	8283
P **(ppb)**	4.7	10.1	22.2	10.9	18.8	32.2

Percent Contribution of Phosphorus from External Sources



Percent Contribution of Phosphorus from External and Internal Sources



Phosphorus Model: Implications and Conclusions

- Best estimate from external sources and sediments:
  - W = 4843 kg/yr
  - P = 18.8 ppb
- Threshold for algal blooms = 15 ppb
- To lower phosphorus concentrations to 15ppb, W needs to be reduced to **3850 kg/yr**
- How?

Phosphorus Model: Implications and Conclusions

- Taking measures to reduce external loading will help
- Sediments **must** also be addressed
- Example:

Total P from:
- Roads
- Septic
- Residential

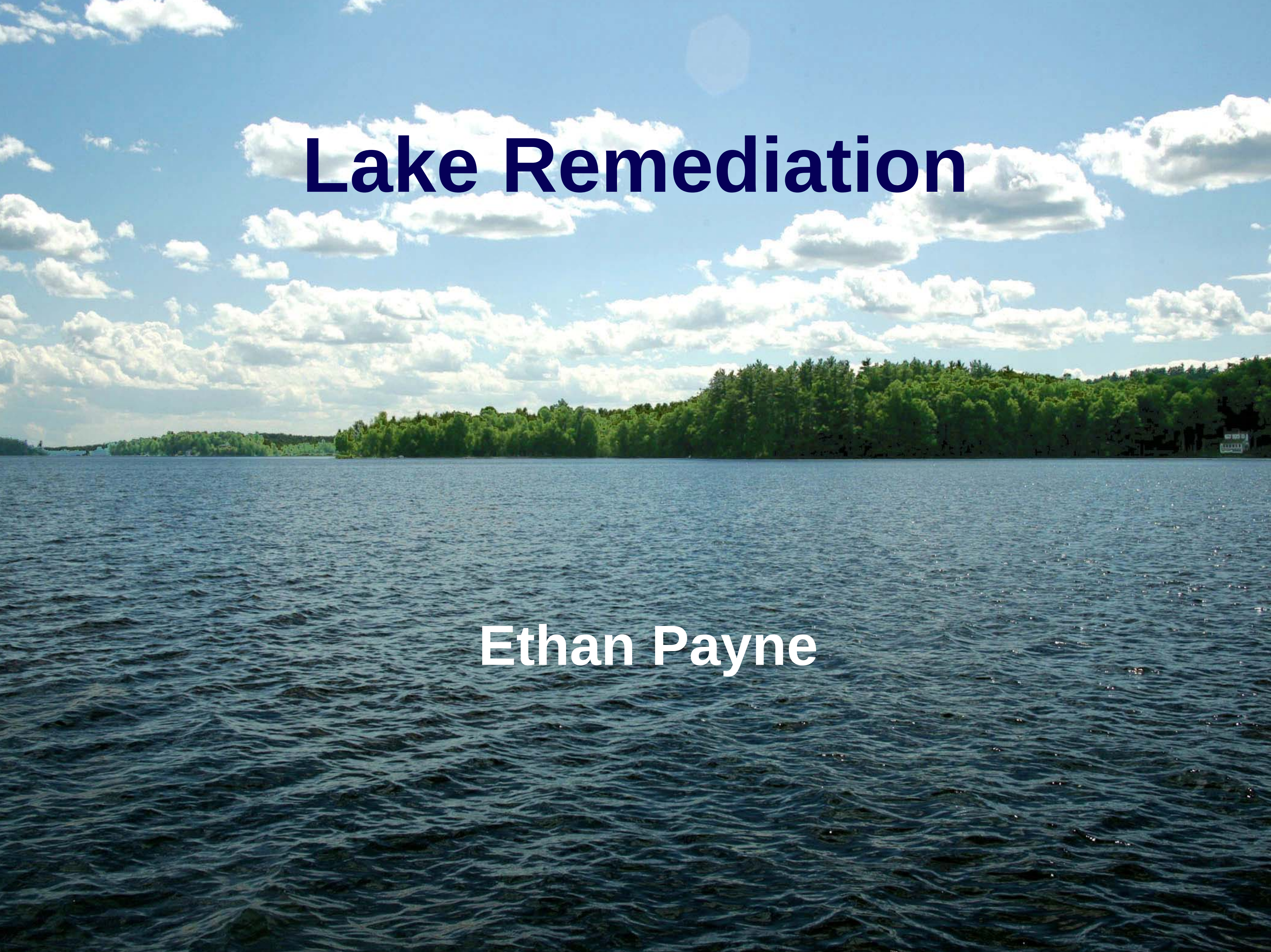
$\downarrow$50% →

W $\downarrow$
374 kg/yr

Phosphorus Model: Implications and Conclusions

- To reach goal of 15 ppb, **both** external and internal sources must be addressed
  - External sources - to reduce the amount of new phosphorus that enters the lake each year
  - Sediment release - to reduce internal phosphorus cycling

Lake Remediation



Ethan Payne

Lake Remediation

- Controlling phosphorus loading in China Lake is not easy
- In-lake remediation attempts to control internal phosphorus loading
- Land use and development trends will determine which techniques may be viable and which will not

Challenges for Remediation

- Both internal and external phosphorus loading must be controlled
- Two townships and two basins
- High costs of in-lake treatments
- No guaranteed in-lake phosphorus management techniques

Physical Remediation Techniques

- Dredging
  - Removal of sediment
  - Takes sediment phosphorus out of the lake
- Hypolimnetic Withdrawal
  - Remove phosphorus-rich water from bottom
- Hypolimnetic Aeration
  - Pump air or oxygen into the hypolimnion

Drawdown

Drawdown

- Seasonal drop in water level every year
- Done at the time of the fall turnover
- Currently done in China Lake

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Chemical Manipulation

- Ferrous treatment
  - Iron complexes can form in presence of oxygen
- Calcium treatment
  - Calcium carbonate salts dissociate and form phosphorus precipitate in basic water (pH > 9)
- Algicides
  - Targets the algal cell growth
  - Doesn’t remove phosphorus
  - Short-term fix

Alum Treatment

- Aluminum sulfate forms phosphate complex
- Creates a layer on the sediment which stops phosphorus release
- Done over deepest parts of the lake
- Can last up to 15 yrs

Alum Treatment (con't)

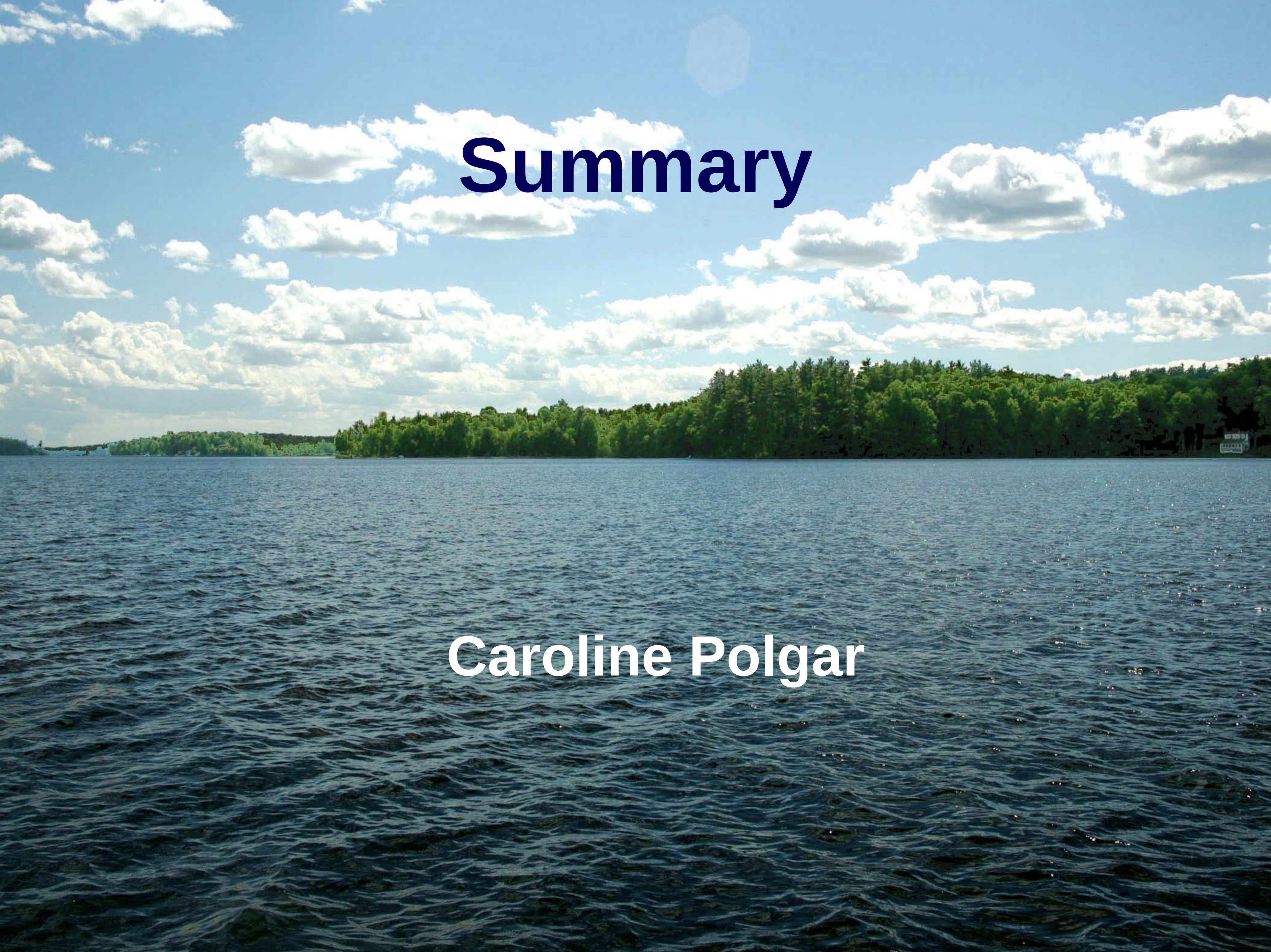
- Threemile Pond treatment was not effective
- Not enough alum applied to the deeper parts of the lake
- Disruption of the sediment from weather
- Using GPS and detailed bathymetry would be more efficient

Biological Manipulation

- Aquatic Plant Harvesting
  - Remove phosphorus from water using vegetation, then remove the vegetation
  - Labor intensive
- Fish stock manipulation
  - Increase populations of algae consumers
  - East Pond study

Suggested Lake Remediation

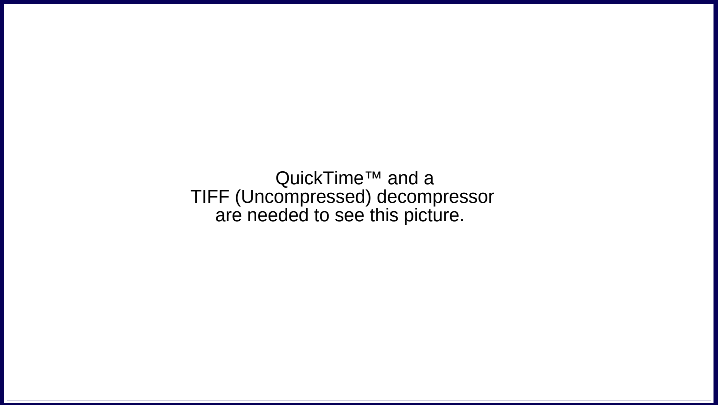
- Alum treatment is the best way to combat internal phosphorus loading
  - Application needs to be carefully planned
  - Initial costs would be high, but a successful treatment could last 10 years


Summary
Caroline Polgar

Project Summary

What Can We Do To Improve China Lake's Water Quality?

- History of algal blooms indicates a water quality problem.
- Phosphorus level high in the water column and sediments.
- Sediment accounts for almost half of phosphorus in lake.
- To effectively improve water quality, internal and external sources must be addressed.

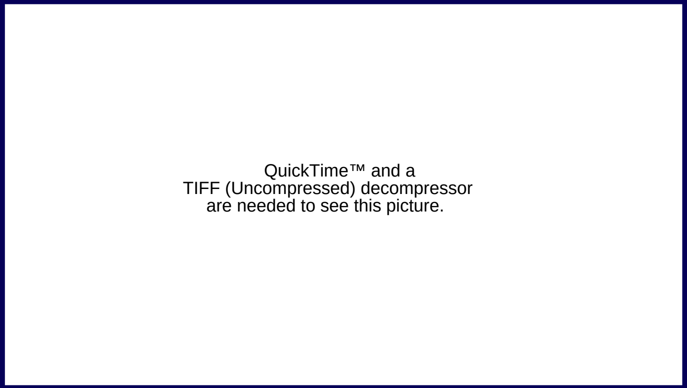


Project Summary

What Can We Do To Improve China Lake's Water Quality?

Suggestions to reduce phosphorus loading from external sources:

- When developing the shoreline, consider lake water quality
- Improve or create buffer strips
- Maintain septic systems and roads
- Use fertilizer responsibly on lawns and agricultural fields



Project Summary:

What can we do to improve China Lake's water quality?

- Internal sources of phosphorus must be reduced
- Possible in-lake treatments include
  - Alum treatment
- Sources of funding are available

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Community Awareness and Education

- What YOU can do to improve the water quality of China Lake
  - Post signs explaining the risks of introduced species
  - Get local students involved
  - Work together
- SPREAD THE WORD!

Acknowledgements

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Kirsten Ness	Department of Biology, Colby College
Philip Nyhus	Environmental Studies Program, Colby College
Scott Pierz	China Township Code Enforcement Officer
Guy Piper	Farm Service Agency Service Center Office, Kennebec County
Jon Van Bourg	Kennebec Water District
Bobby Van Riper	Maine Department of Inland Fisheries and Wildlife

The Staff of:

China Town Office
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
Maine Soil and Water Conservation District, Kennebec County
Vassalboro Town office

Questions?