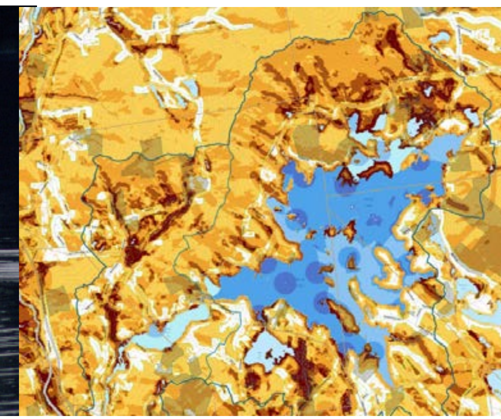
Participatory Citizen Science Delivers the Data for Informed Local Decision-making and Watershed Stewardship





Jeffrey A. Schloss

UNH Cooperative Extension

UNH Center for Freshwater Biology

University of New Hampshire, Durham, NH

Building Bridges: Citizen Science and Policy Workshop, Banff Canada

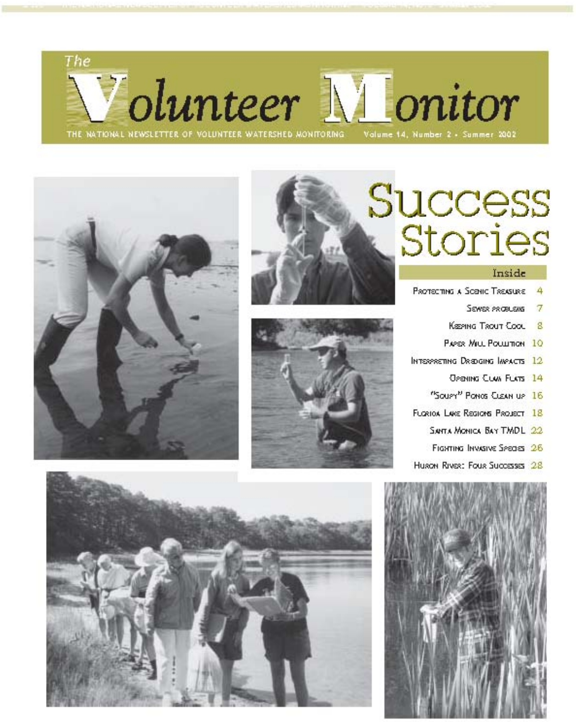
NH Lakes Lay Monitoring Program

Approaching Four Decades of Collaboration between UNH and NH Communities

A Model of "Participatory Research" and Community Empowerment

Model Program

- Helped establish similar programs in 25 states and 7 countries.
- Highlighed often in Volunteer Monitor
- Received technical achievement award from the North American Lake Management Society
- Cited in agency publications
- Contributor to the USDA-NIFA Coop. Ext. Volunteer Monitoring Facilitation Project: www.usawaterquality.org/volunteer/





NH Lakes Lay Monitoring Program

- **Baseline monitoring for long-term trend detection.**
- **Locate problem areas and “hotspots”.**
- **Provide unbiased data for informed watershed management decisions.**
- **Perform cost-effective watershed assessments.**
- **Develop improved protocols for citizen monitoring.**
- **Conduct participatory research that addresses concerns of participants.**
- **Provide sufficient data to utilize high tech analysis tools**

Low Tech Data Gathering Approach (Initially)

Program Outcomes

- Poorly designed development projects rejected
- Sewer bonds past
- No rafting zones approved
- Sensitive lake and wetland areas protected
- Highway road drainages mitigated
- Landscaping practices improved
- Data used to justify qualification for state/ federal assistance

Communities Better Informed on Local Issues

Participatory Research

- Involves community members in the design and implementation of research projects.
- Research processes and outcomes should benefit the community.
- Community members should be part of the analysis and interpretation of data and should have input into how the results are distributed.
- Productive partnerships between researchers and community members should be encouraged to last beyond the life of the project.

Citizen Science Models

	Traditional Science Research Model	Community Science				
		Scientific Consulting Research Model*	Citizen Science Research Model	Adaptive Citizen Science Research Model	Adaptive Co-Management Research Model	Participatory Action Research Model
Question	√		√	√	√	
Study Design	√	√	√	√	√	√
Data Collection	√	√				
Data Analysis and Interpretation	√	√	√	√	√	√
Understanding results	√	√	√	√	√	√
Management Action	Managers	Community Groups	Managers	Individuals	All	Community Groups
Geographic scope of project	Variable	Narrow	Broad	Broad	Narrow	Narrow
Research priority	Highest	Medium	High	High	High	Medium
Education priority	Low	Medium	High	High	High	High

*often called Science Shops

Modified from Wilderman 2007 and Cooper et al 2007

BOW LAKE

2014 SAMPLING HIGHLIGHTS

Station 1 Ledges

Barrington and Northwood, NH

University of New Hampshire
Cooperative Extension

Water quality data displayed in Tables 1 and 2 are surface water measurements with the exception of the dissolve oxygen data that were collected near the lake bottom. Refer to the 2014 Bow Lake Annual Report for additional information.

Blue = Excellent = Oligotrophic

Yellow = Fair = Mesotrophic

Red = Poor = Eutrophic

Gray = No Data

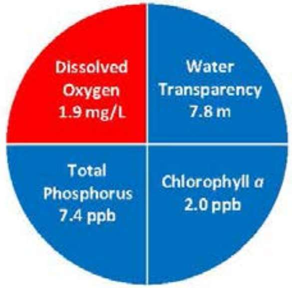


Figure 1. Bow Lake Water Quality (2014)

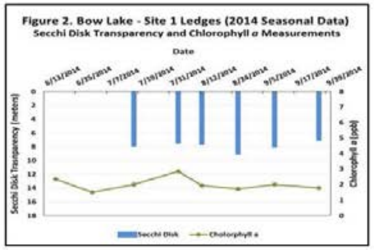
Table 1. 2014 Bow Lake Seasonal Averages and NH DES Aquatic Life Nutrient Criteria

Parameter	Oligotrophic "Excellent"	Mesotrophic "Fair"	Eutrophic "Poor"	Bow Lake – 1 Ledges Average (range)	Bow Lake – 1 Ledges Classification
Water Clarity (meters)	4.0 – 7.0	2.5 - 4.0	< 2.5	7.8 meters (7.0 – 9.1)	Oligotrophic
Chlorophyll *a* (ppb)	< 3.3	> 3.3 – 5.0	> 5.0 – 11.0	2.0 ppb (1.5 – 2.9)	Oligotrophic
Total Phosphorus (ppb)	< 8.0	> 8.0 – 12.0	> 12.0 – 28.0	7.4 ppb (5.2 – 10.8)	Oligotrophic
Dissolved Oxygen (mg/L)	5.0 – 7.0	2.0 – 5.0	<2.0	1.9 mg/L (1.0 – 2.6)	Eutrophic

* Dissolved oxygen concentrations were measured on August 26, 2014 between 10.5 and 18.5 meters, in the bottom water layer.

Table 2. 2014 Bow Lake Seasonal Average Accessory Water Quality Measurements

Parameter	Assessment Criteria					Bow Lake – 1 Ledges Average (range)	Bow Lake – 1 Ledges Classification
Color (color units)	< 10 uncolored	10 – 20 slightly colored	20 – 40 lightly tea colored	40 – 80 tea colored	> 80 highly colored	16.3 color units (14.3 – 18.4)	Slightly colored
Alkalinity (mg/L)	< 0.0 acidified	0.1 – 2.0 extremely vulnerable	2.1 – 10 moderately vulnerable	10.1 – 25.0 low vulnerability	> 25.0 not vulnerable	4.3 mg/L (4.1 – 4.6)	Moderately vulnerable
pH (std units)	< 5.5 suboptimal for successful growth and reproduction		6.5 – 9.0 optimal range for fish growth and reproduction			6.9 standard units (6.7 – 7.0)	Tolerable range for fish growth and reproduction
Specific Conductivity (uS/cm)	< 50 uS/cm Characteristic of minimally impacted NH lakes		50-100 uS/cm Lakes with some human influence	> 100 uS/cm Characteristic of lakes experiencing human disturbances		52.0 uS/cm (52.0– 52.0)	Lakes with some human influences



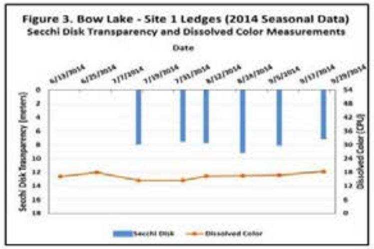


Figure 2 and 3. Seasonal Secchi disk transparency, chlorophyll *a* changes and dissolved color concentrations. Figures 2 and 3 illustrate the interplay among Secchi Disk transparency, chlorophyll *a* and dissolved color. Shallower water transparency measurements oftentimes correspond to increases in chlorophyll *a* and/or color concentrations.

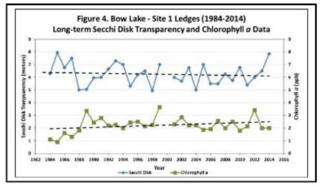
LONG-TERM TRENDS

WATER CLARITY: The Bow Lake water clarity measurements, measured as Secchi Disk transparency, display a trend of decreasing water clarity over thirty years of water quality monitoring conducted between 1984 and 2014 (Figure 4).

CHLOROPHYLL: The Bow Lake chlorophyll *a* concentrations, a measure of microscopic plant life within the lake, display a trend of increasing concentrations over thirty years of water quality monitoring conducted between 1984 and 2014 (Figure 4).

TOTAL PHOSPHORUS: Phosphorus is the nutrient most responsible for microscopic plant growth. The Bow Lake total phosphorus concentrations display a trend of decreasing concentrations over twenty-five years of water quality monitoring conducted between 1984 and 2014 (Figure 5).

COLOR: The Bow Lake color data, the result of naturally occurring "tea" color substances from the breakdown of soils and plant materials, display a trend of increasing concentrations over twenty-six years of water quality monitoring conducted between 1984 and 2014 (Figure 5).



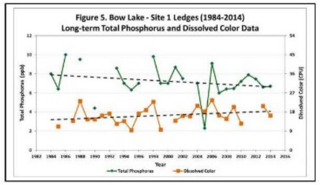


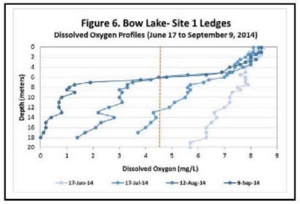
Table 3. Bow Lake Seasonal Average Water Quality Inter-site Comparison (2014)

Site	Average Secchi Disk Transparency (meters)	Average Chlorophyll *a* (ppb)	Average Total Phosphorus (ppb)	Average Dissolved Oxygen (ppm)
1 Ledges	7.8	2.0	7.4	1.9
3 Bennett	7.4	2.2	8.0	1.6

- Dissolved oxygen data were measured on August 26, 2014 in the bottom water layer (hypolimnion).

Figures 4 and 5. Changes in the Bow Lake water clarity (Secchi Disk depth), chlorophyll *a*, dissolved color and total phosphorus concentrations measured between 1984 and 2014. **These data illustrate the relationship among plant growth, water color and water clarity. Total phopshorus data are also displayed and are oftentimes correlated with the amount of plant growth.**

Figure 6. Bow Lake dissolved oxygen concentrations collected between June 17 through September 9, 2014. The vertical red line indicates the oxygen concentration commonly considered the threshold for successful growth and reproduction of cold water fish. *Notice the decreasing dissolved oxygen concentations near the lake bottom between June and September.*

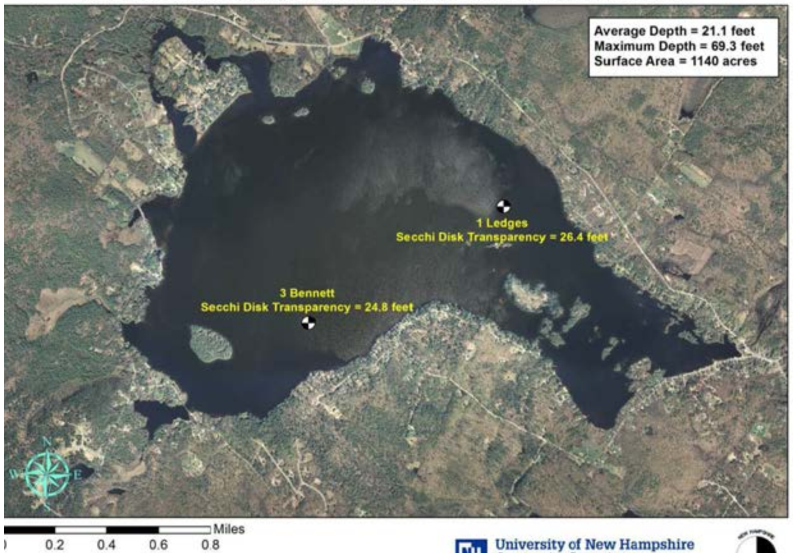


Recommendations

Implement Best Management Practices within the Bow Lake watershed to minimize the adverse impacts of polluted runoff and erosion into Bow Lake. Refer to 'Landscaping at the Water's Edge: An Ecological Approach' and 'New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home' for more information on how to reduce nutrient loading caused by overland run-off.

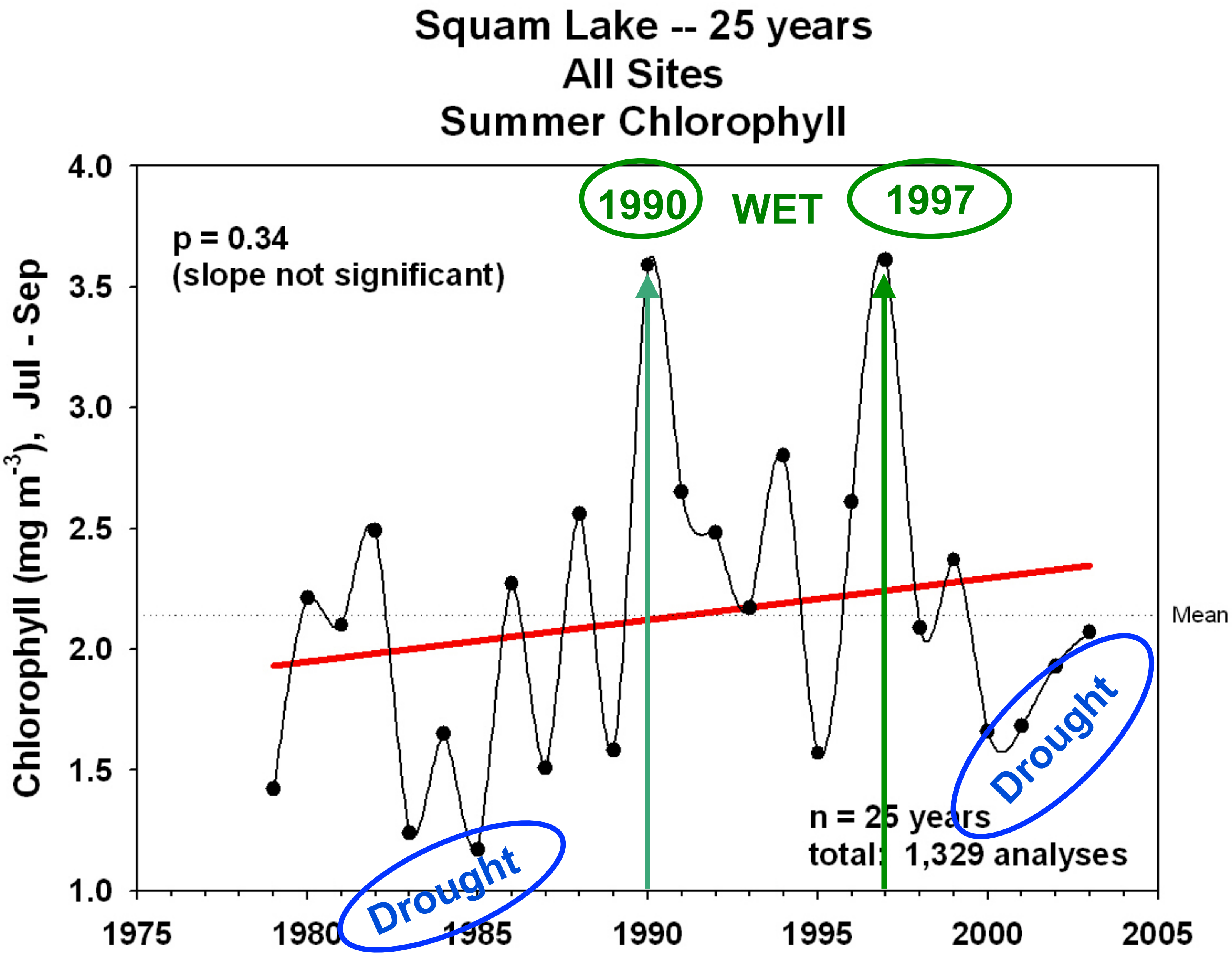
- http://extension.unh.edu/resources/files/Resource004159_Rep5940.pdf
- http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-11-11.pdf

2014 Deep water sampling site locations with seasonal average water clarity



University of New Hampshire
Cooperative Extension

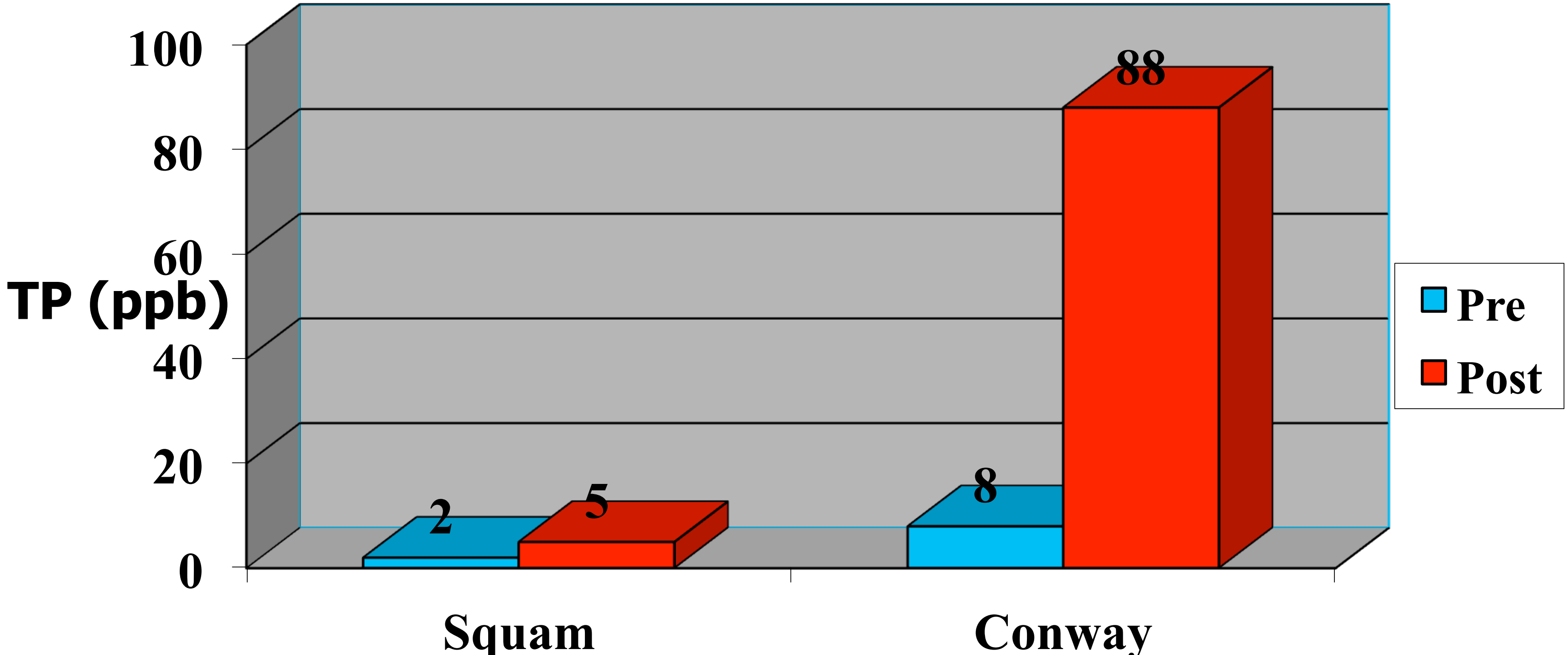
al Orthophoto Source: NH GRANIT
locations GPS coordinates collected by the UNH Center of Freshwater Biology


Squam Lake -- 25 years
All Sites
Summer Chlorophyll
Chlorophyll (mg m-3), Jul - Sep
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1975
1980
1985
1990
1995
2000
2005
p = 0.34
(slope not significant)
1990
WET
1997
Mean
Drought
Drought
n = 25 years
total: 1,329 analyses

UNH Motorboat Studies

Conway Lake 1987/ Squam Lake 1990 – Nutrients

Total Phosphorus



Fish Condition Study

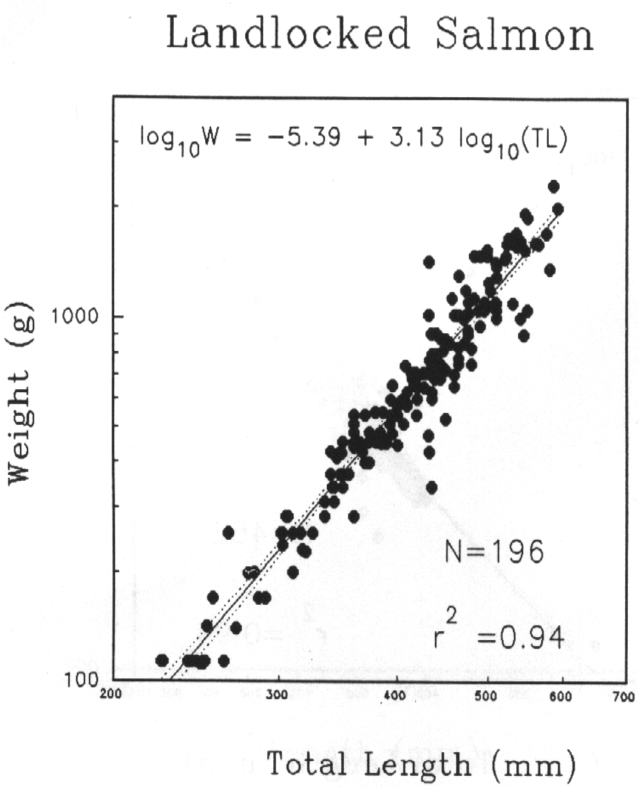
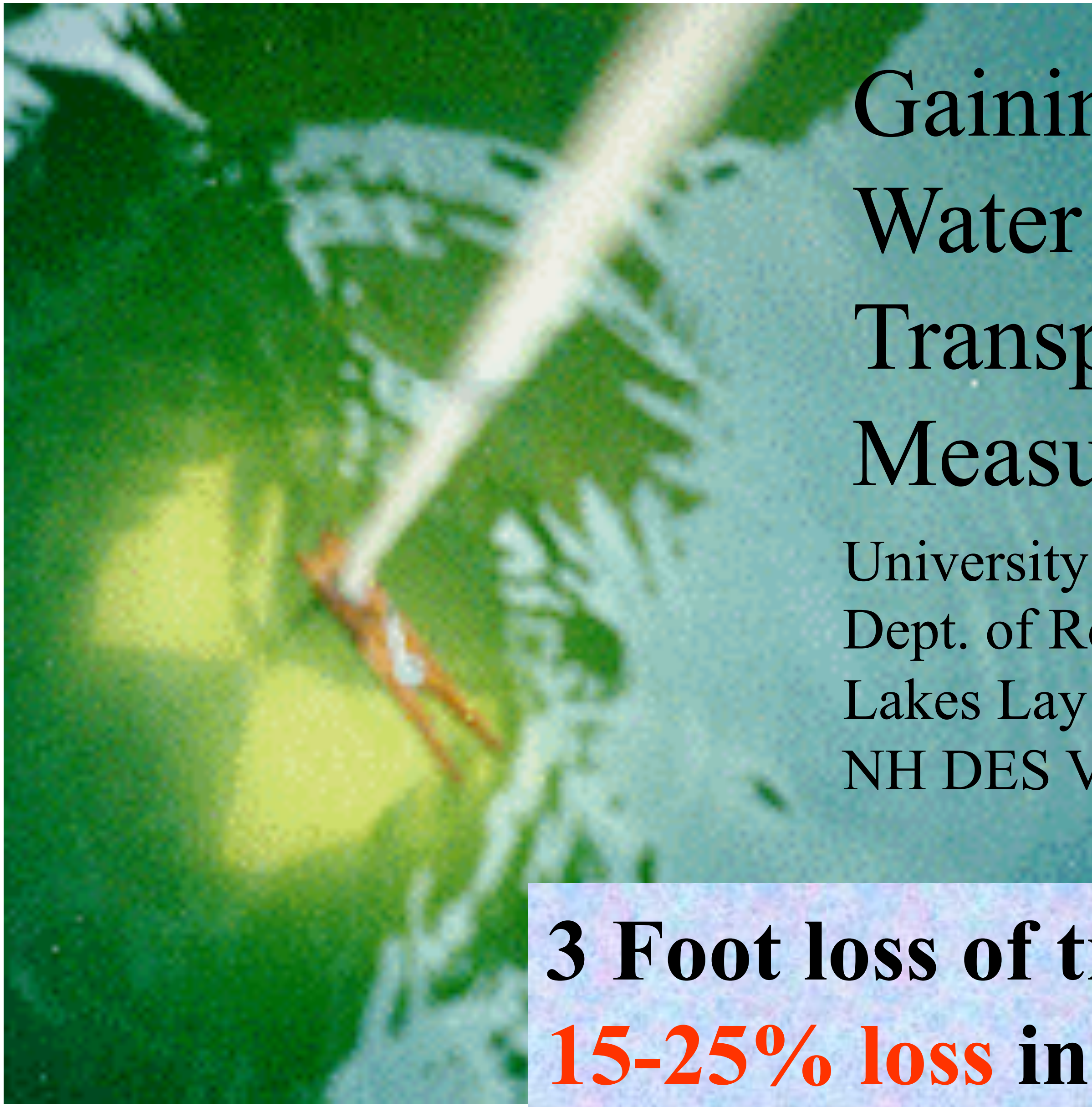


Figure 20. Length–weight relationship of landlocked salmon in New Hampshire lakes. Dotted lines are 95% confidence intervals of the regression line.

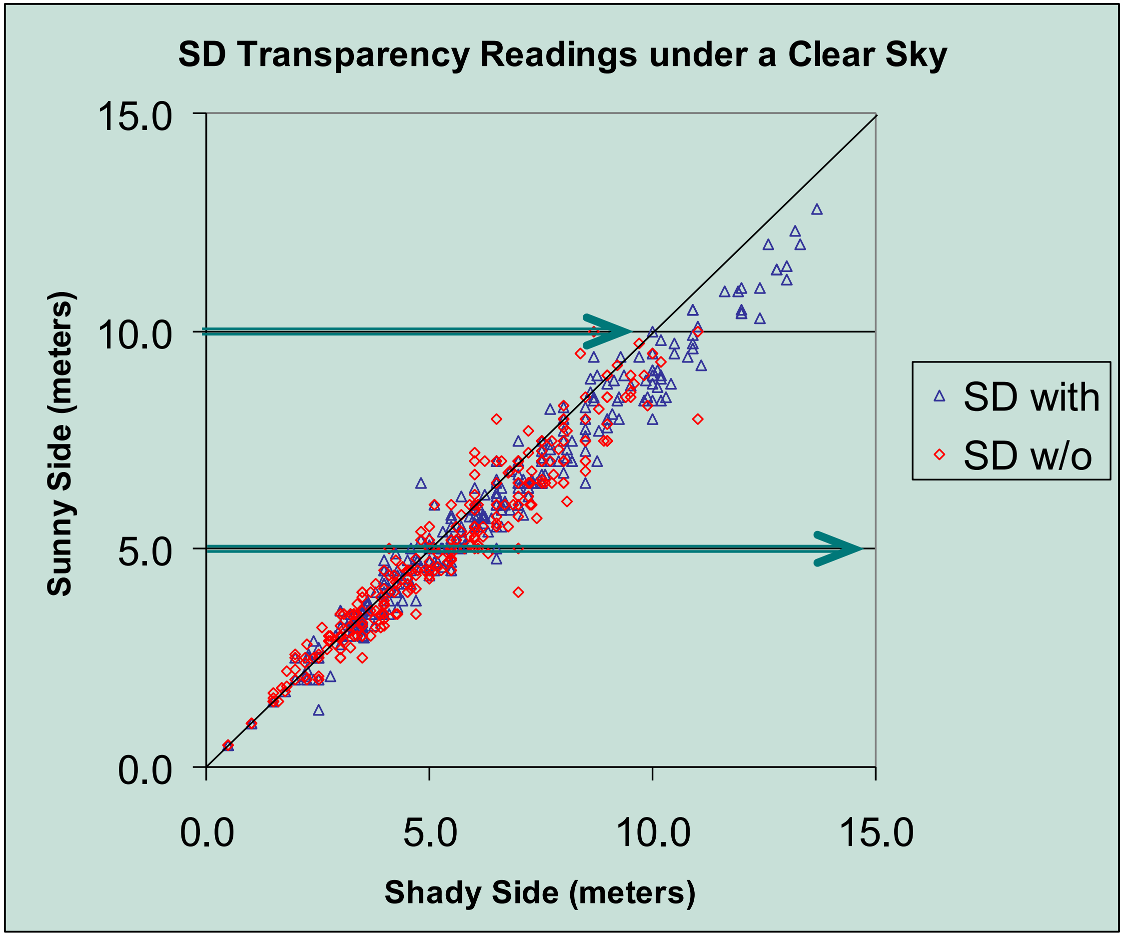


Gaining Clarity on Water Transparency Measurements

University of New Hampshire
Dept. of Resources Economics
Lakes Lay Monitoring Program
NH DES VLAP Program

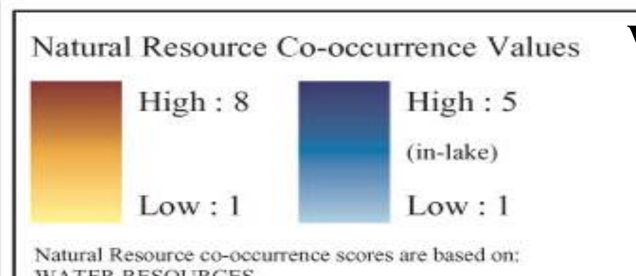
3 Foot loss of transparency = 15-25% loss in property value!

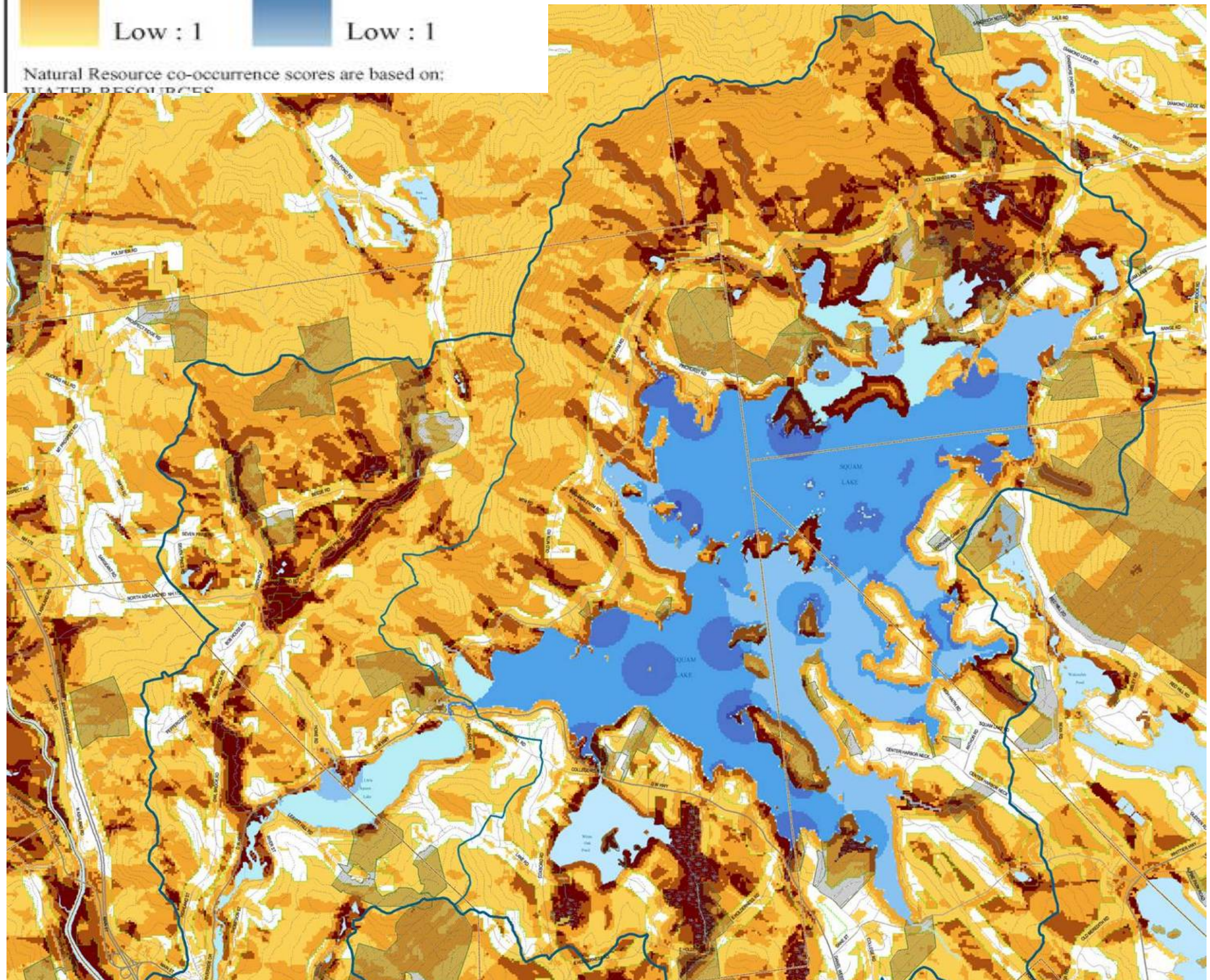
Without View Scope:
Lose deep Secchi sensitivity and precision



BMPs: Are they working?

Watershed and In-Lake Natural Resources Inventories



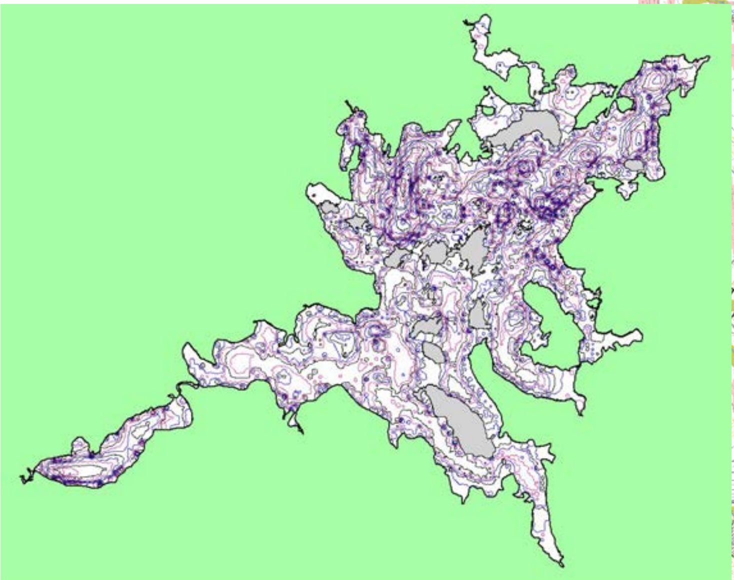


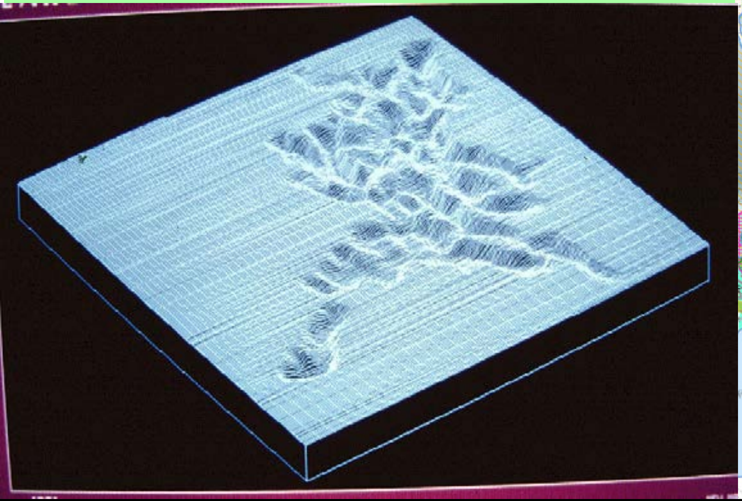
Bottom-up Approach

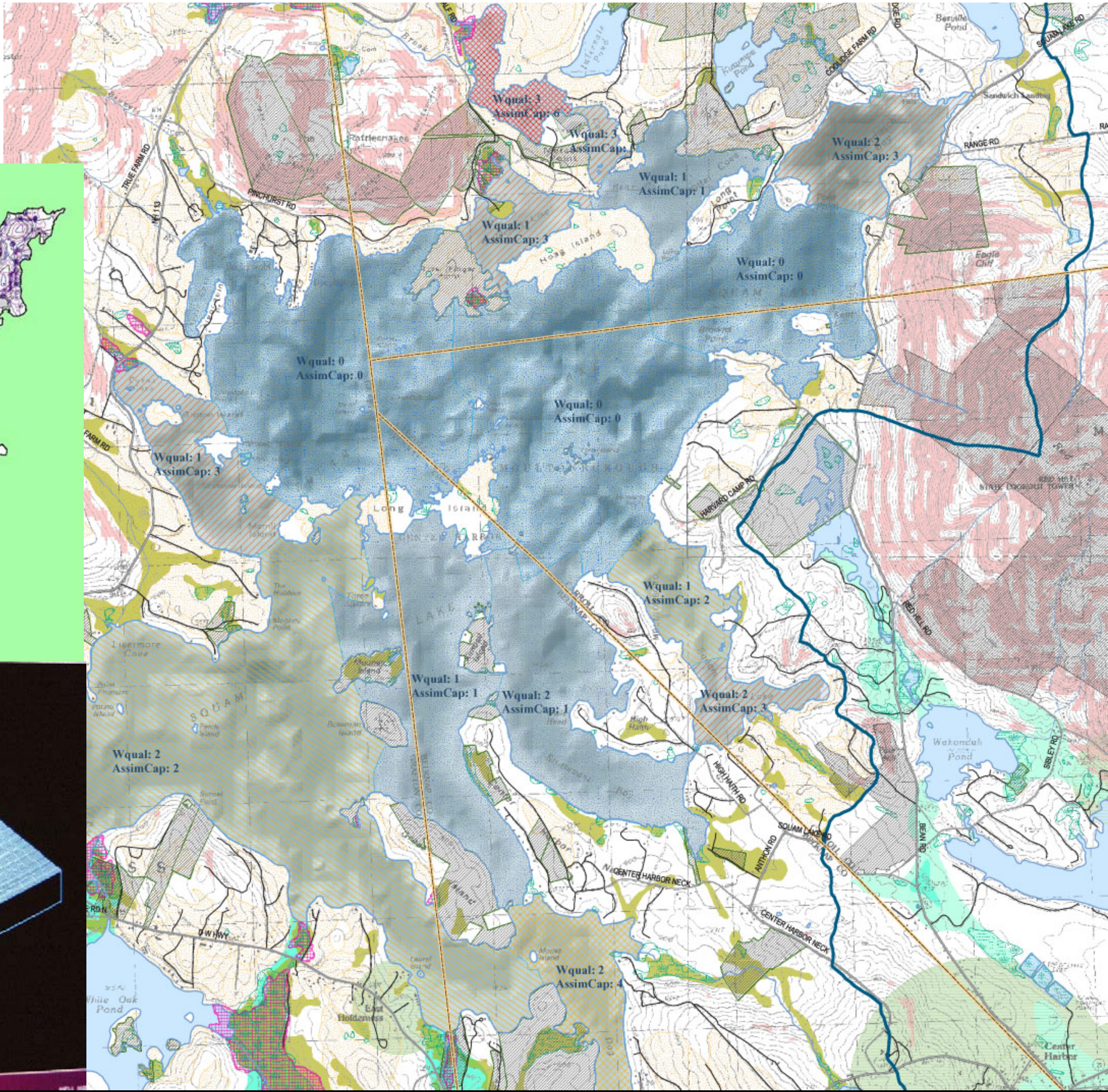
First multijurisdictional management plan to incorporate in-lake and shoreline resources of local concern, current water quality and assimilative capacity.

Provided to local decision-makers for use when reviewing development proposals.

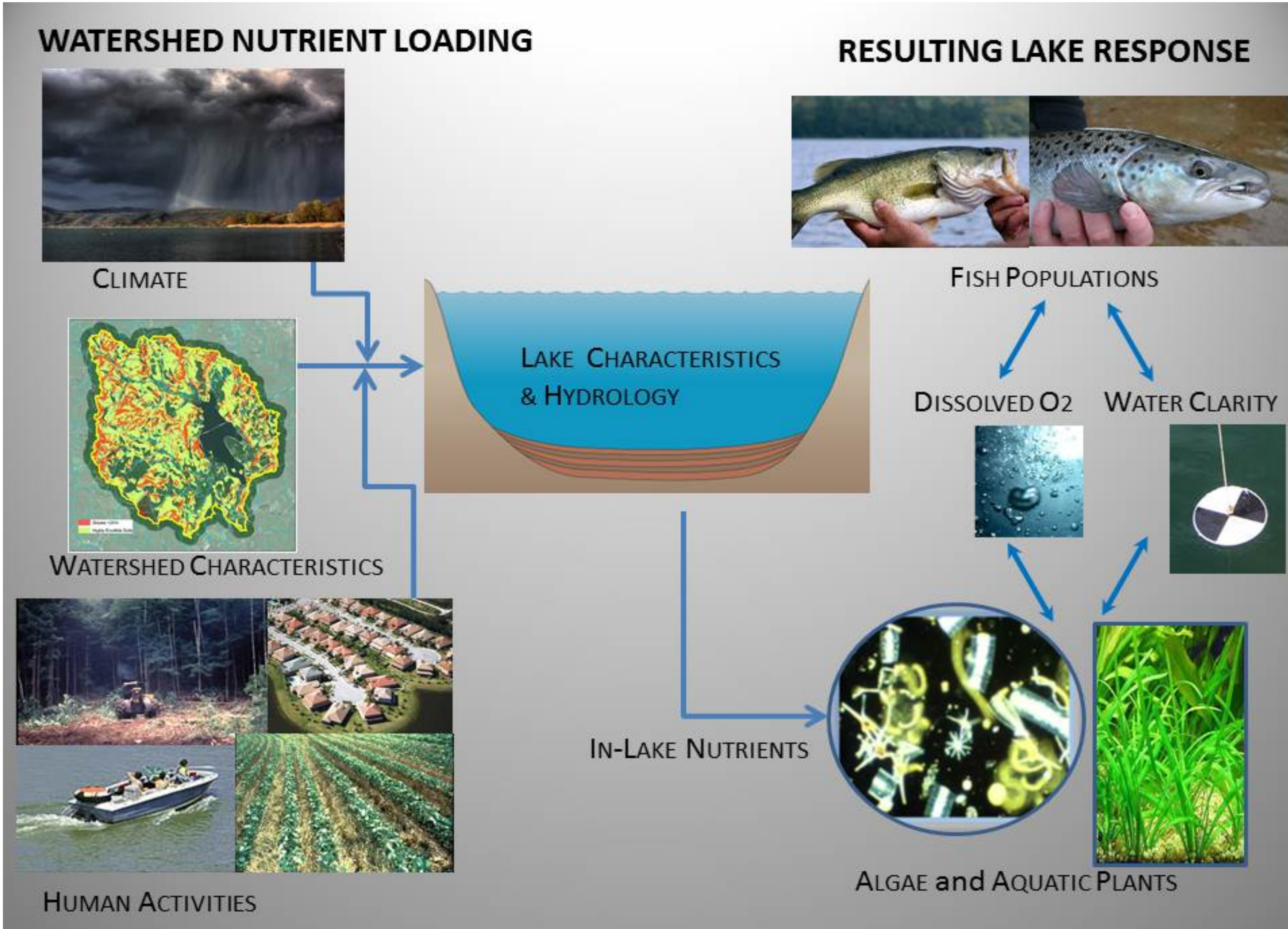
Squam Lake: Complicated Bathymetry Creates 18 Sub-basins



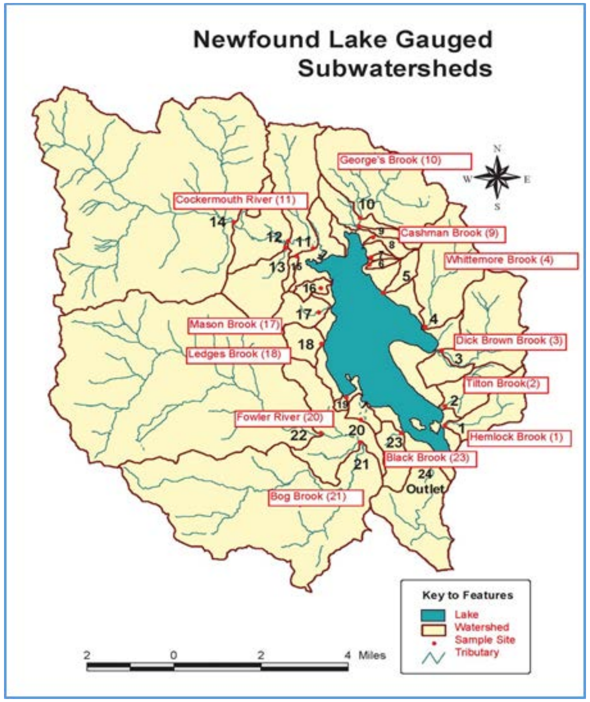




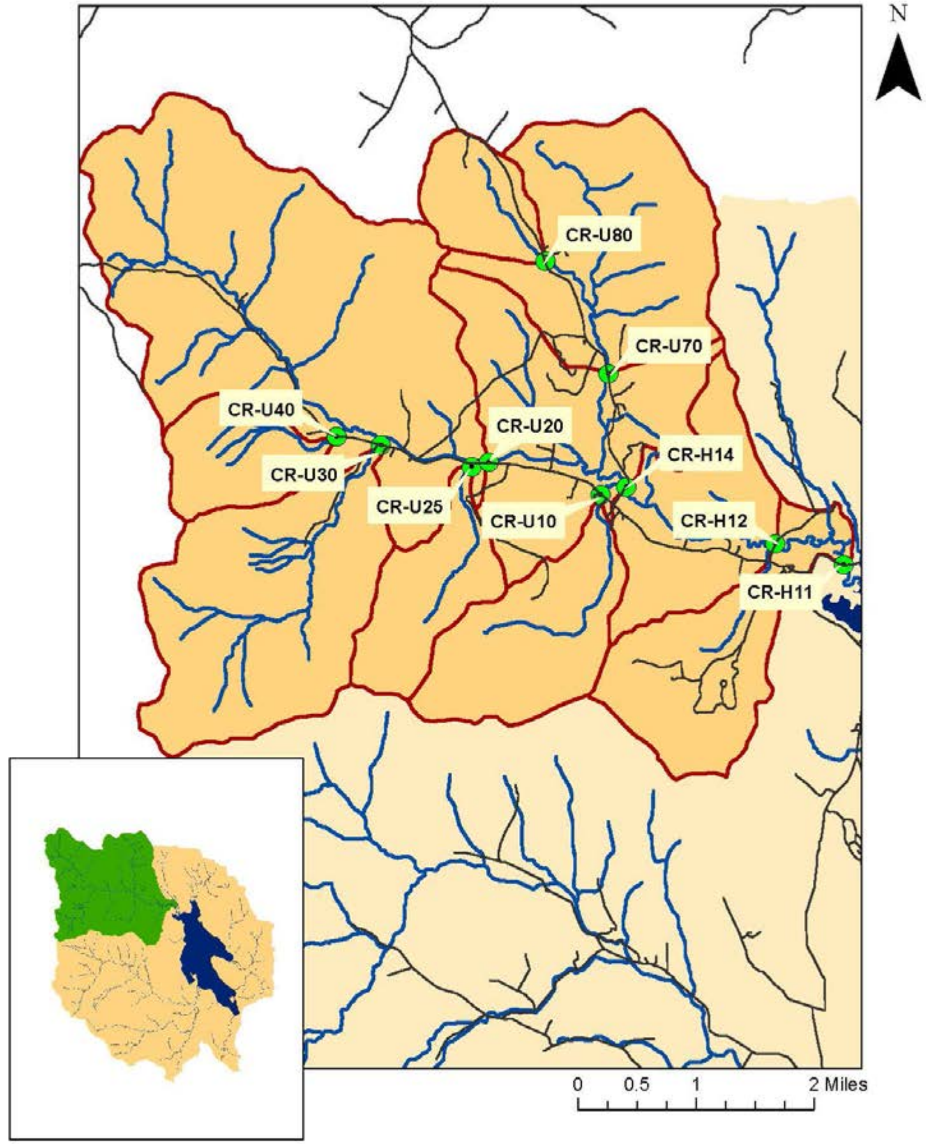
TributarySampling / Nutrient Budgets



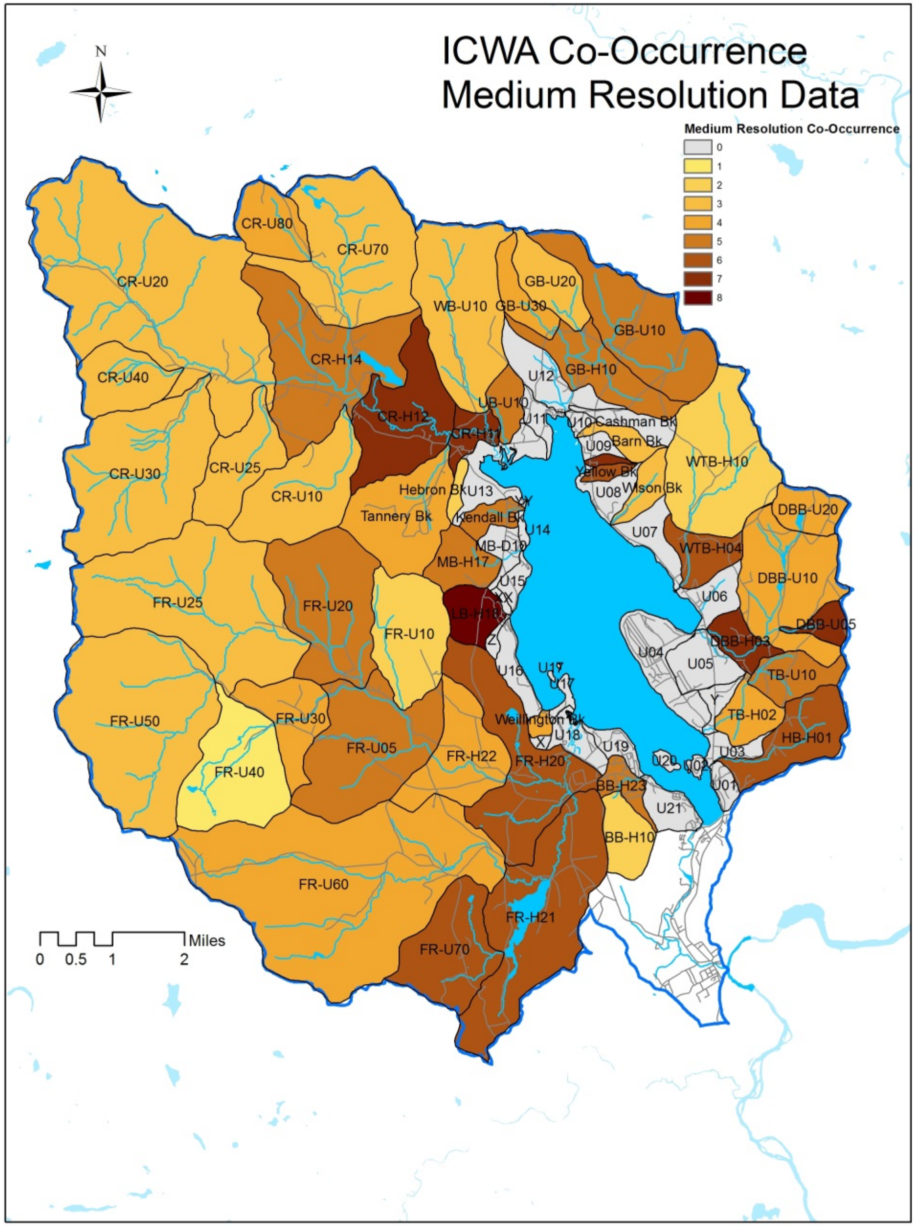
Source: **Schloss and Craycraft 2013 modified and expanded from Reckow et al 1980**



Cockermouth River Subwatershed



Integrated Critical Watershed Analysis



Low Resolution Attributes:

Existing Water Quality Concerns- Tributary

Existing Lake Water Quality or In-Lake Concerns

Medium Resolution Attributes:

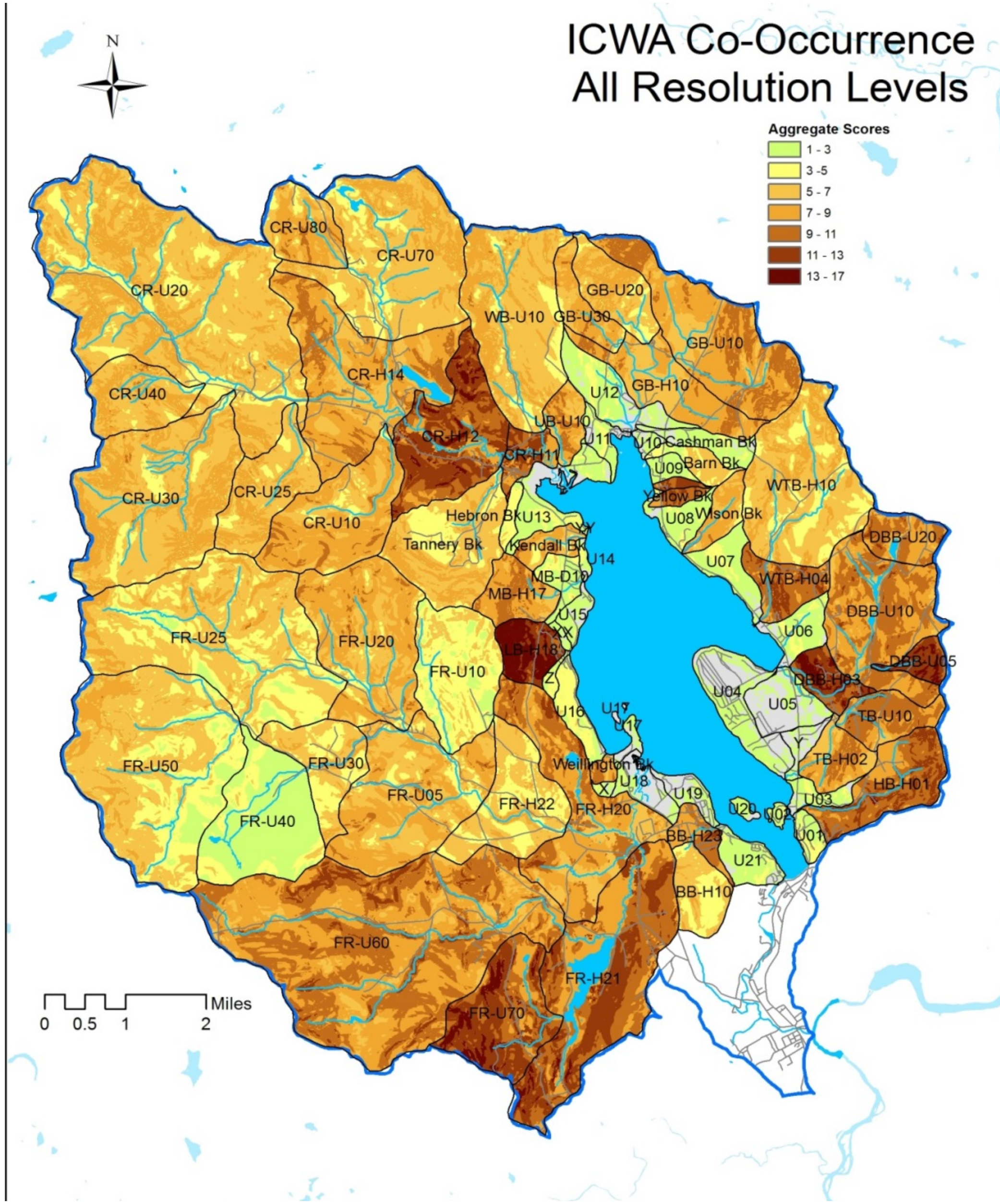
Road and Stream Density

Variable Width Riparian Zone Extent

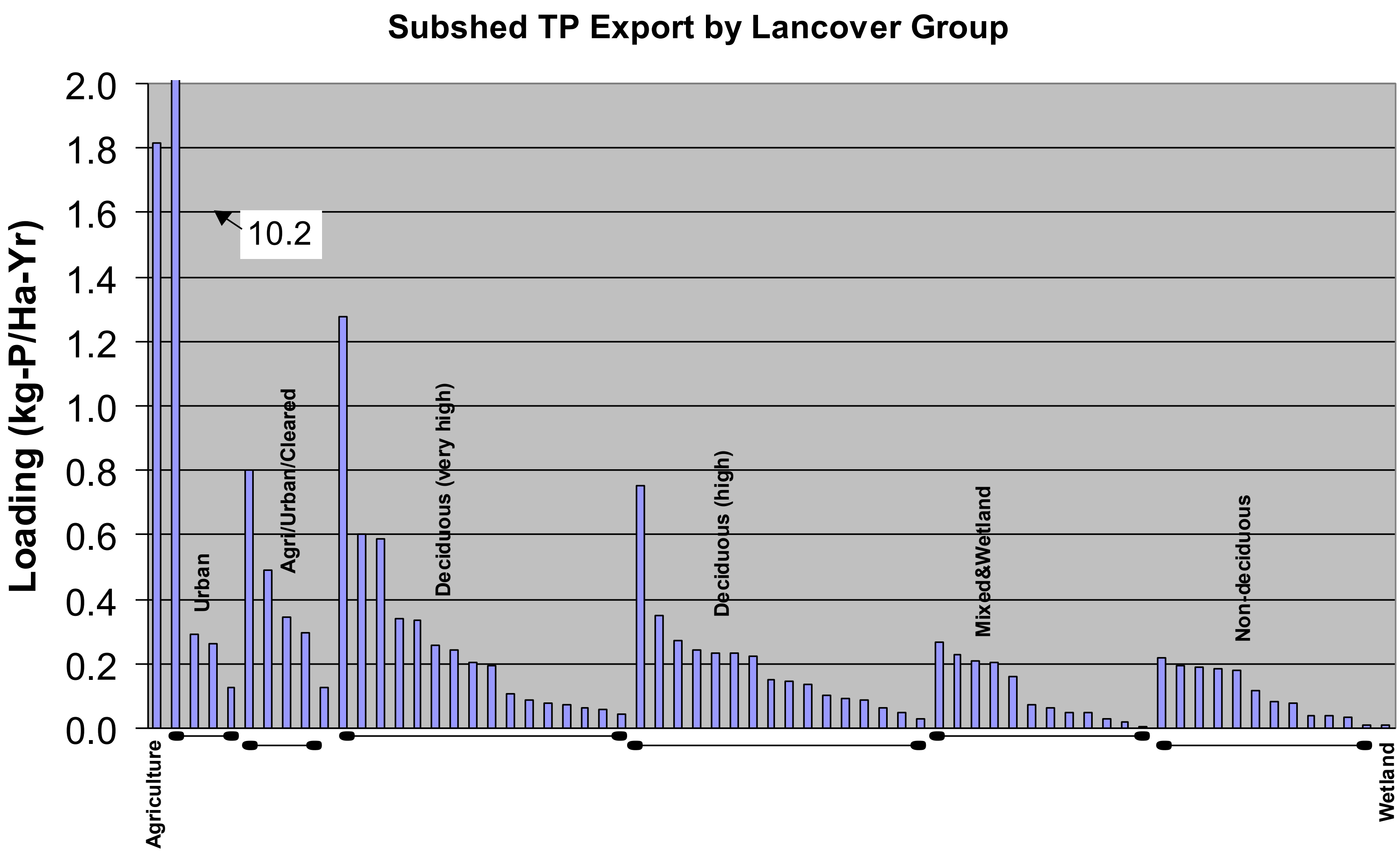
Average Subwatershed Slope

<u>High Resolution Attributes</u>:

- Steep Slopes
- Highly Erodible and Constrained (poor for septic/development) Soils
- Development Intensity
- Agricultural Activity



Subshed TP Export by Landcover



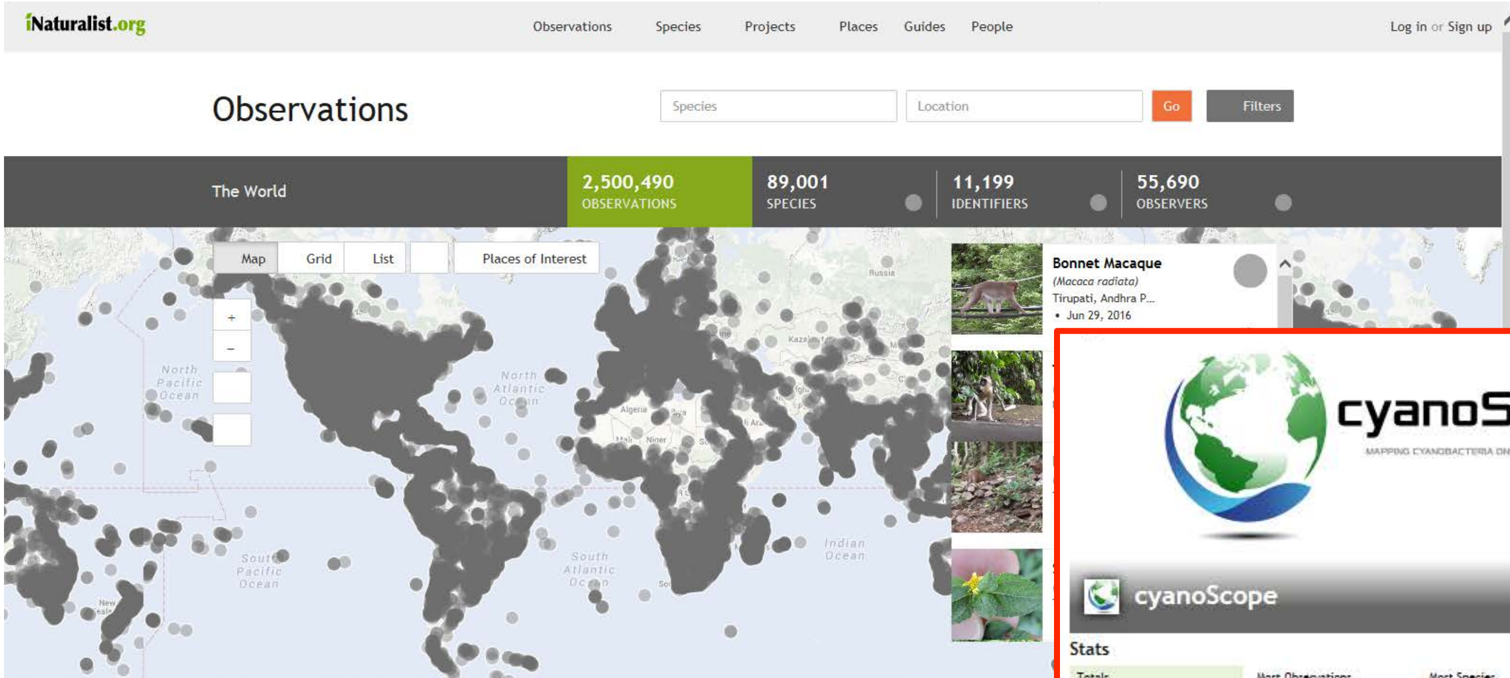

CYANOS OVERVIEW
BLOOMWATCH APP
CYANOSCOPE
CYANOMONITORING
PROGRAM OVERVIEW
OUR PROJECTS
GET INVOLVED
NORTHEAST CYANOBACTERIA MONITORING PROGRAM
THREE COORDINATED MONITORING PROJECTS TO LOCATE AND UNDERSTAND HARMFUL CYANOBACTERIA IN NORTHEAST STATES

Volunteer Cyano Monitoring Participatory Science

- Option to subsample CHL filters and collect whole water samples for microcystin toxin analysis
- Will continue to profile for cyanobacteria during UNH CFB trips and report to NH DES
- GIS mapping of cyanobacteria (CB) distributions
- Core sampling to discover if CBs/toxins occurred historically


WATER

Participatory Citizen Science for Informed Decision-making and Stewardship

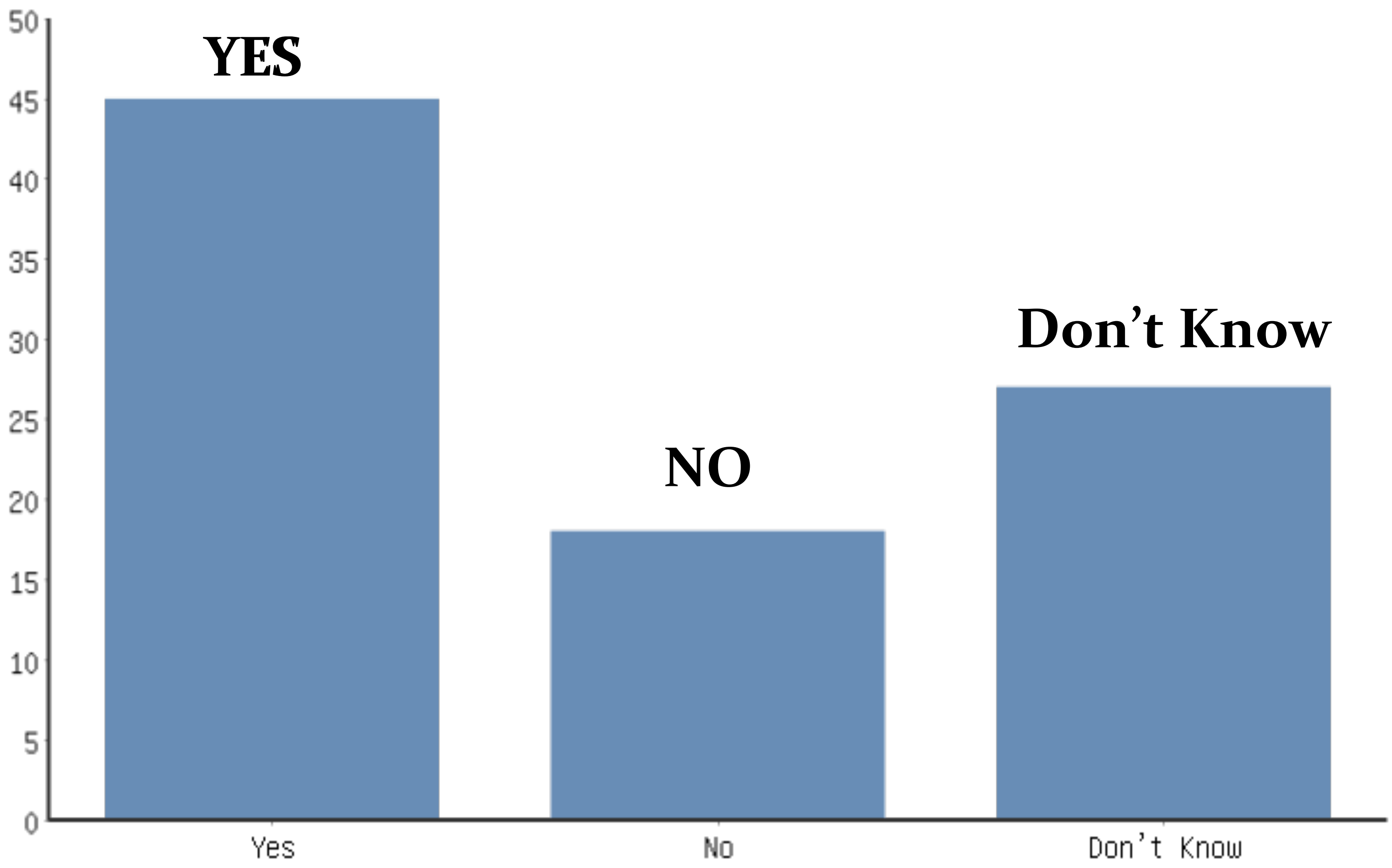

iNaturalist.org
Observations
Species
Projects
Places
Guides
People
Log in or Sign up
Observations
Species
Location
Go
Filters
The World
2,500,490
OBSERVATIONS
89,001
SPECIES
11,199
IDENTIFIERS
55,690
OBSERVERS
Map
Grid
List
Places of Interest
North Pacific Ocean
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Bonnet Macaque
(Macaca radiata)
Tirupati, Andhra P...
Jun 29, 2016


cyanoScope
MAPPING CYANOBACTERIA ONE SLIDE AT A TIME
ADD
OBSERVATIONS
cyanoScope
Stats
Totals
102
Observations »
17
Species »
19
People »
Most Observations
Most Species
Most Observed Species
Members
Export observations
About
What is cyanoScope?
cyanoScope uses modern technologies and social media platforms to learn more about cyanobacteria.
By participating you will be helping scientists and water resource managers gain information on the occurrence and timing of cyanobacteria in lakes, ponds, and reservoirs.
The Process:
Collect
• Collect a water sample from your favorite lake or pond as ...more ↓

Major Survey Objectives

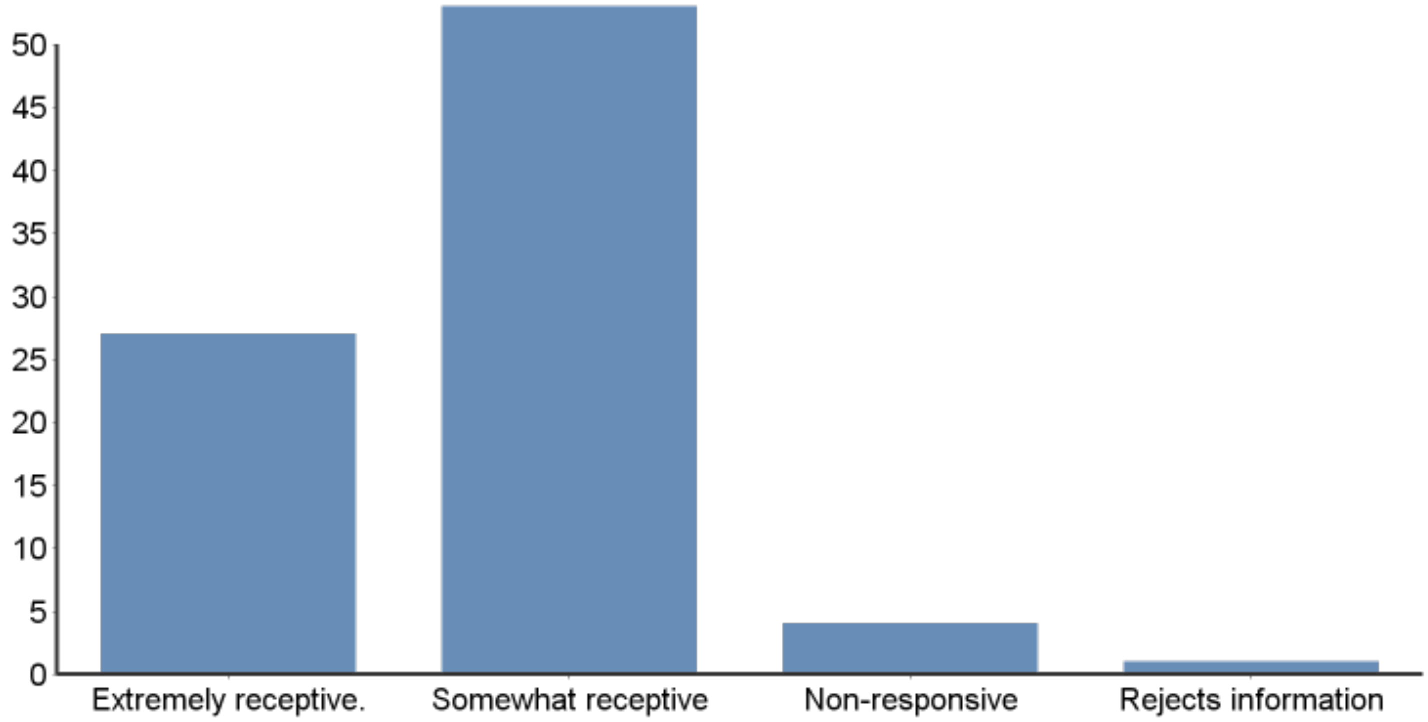
Is lake monitoring information reaching local decision-makers and citizens?

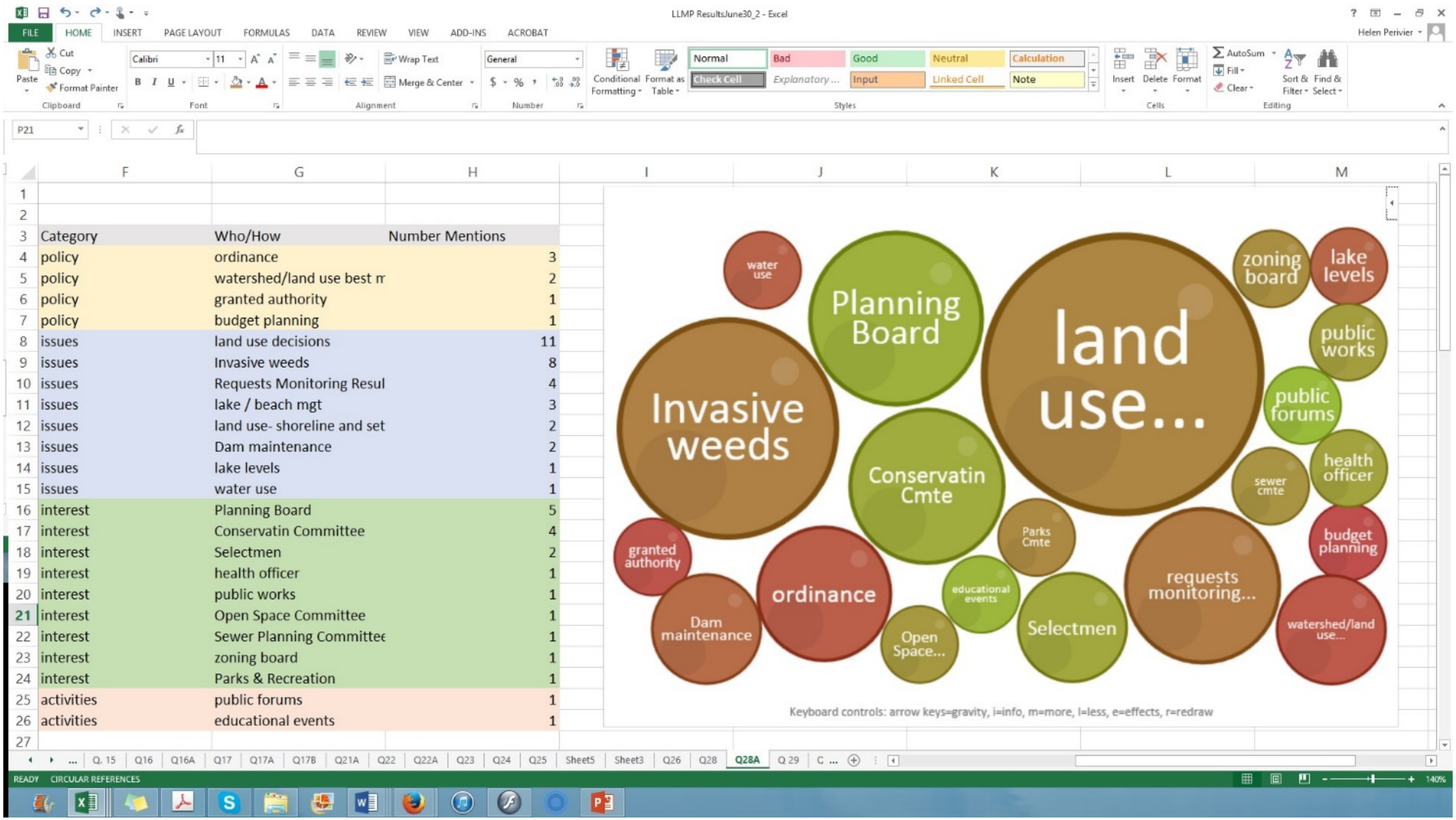
Do monitoring programs influence policies and stewardship in lake communities?



Do any of the local decision makers listed above actively request your or your lake association's input in the decisions that affect your lake? **(90 respondents)**

Are you satisfied with how your decision makers respond to water quality and lake conservation issues? (93 respondents)





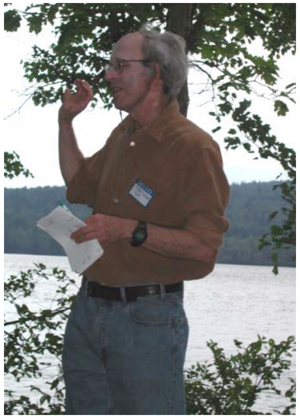
Category	Who/How	Number Mentions
policy	ordinance	3
policy	watershed/land use best m	2
policy	granted authority	1
policy	budget planning	1
issues	land use decisions	11
issues	Invasive weeds	8
issues	Requests Monitoring Resul	4
issues	lake / beach mgt	3
issues	land use- shoreline and set	2
issues	Dam maintenance	2
issues	lake levels	1
issues	water use	1
interest	Planning Board	5
interest	Conservatin Committee	4
interest	Selectmen	2
interest	health officer	1
interest	public works	1
interest	Open Space Committee	1
interest	Sewer Planning Committee	1
interest	zoning board	1
interest	Parks & Recreation	1
activities	public forums	1
activities	educational events	1

Screenshot of analysis of open-ended question, asking for examples of when decision makers had actively requested lake monitoring data and information

Results: Community Capacity

- More than half of respondents monitored with other programs
- More than half said they mentored their lake communities in some way
- About half said their involvement with lake and conservation issues increased as a result of their participation in the monitoring programs.
- Responses indicated that lake monitoring data instilled confidence when approaching decision makers by giving credibility
- About one-third of respondents said they first became active on issues with local government during or after their monitoring experience.

Communication is key to maintaining volunteers



- Timely Feedback
  - How are they doing?
  - What have we learned?
  - What stories do the data tell?
- How they are making a difference
- Offer opportunities for monitors to network
- Provide support so they can report out results
- Recognize long-term commitments

Lessons Learned

Key Elements

- Know the realities and motivations driving your participants
- Quality assured methods –lab <u>and</u> field
- Capture the 'local' knowledge
- Citizen engagement in all aspects of the research process
- Participants present results of efforts
- Provide feedback and keep them challenged

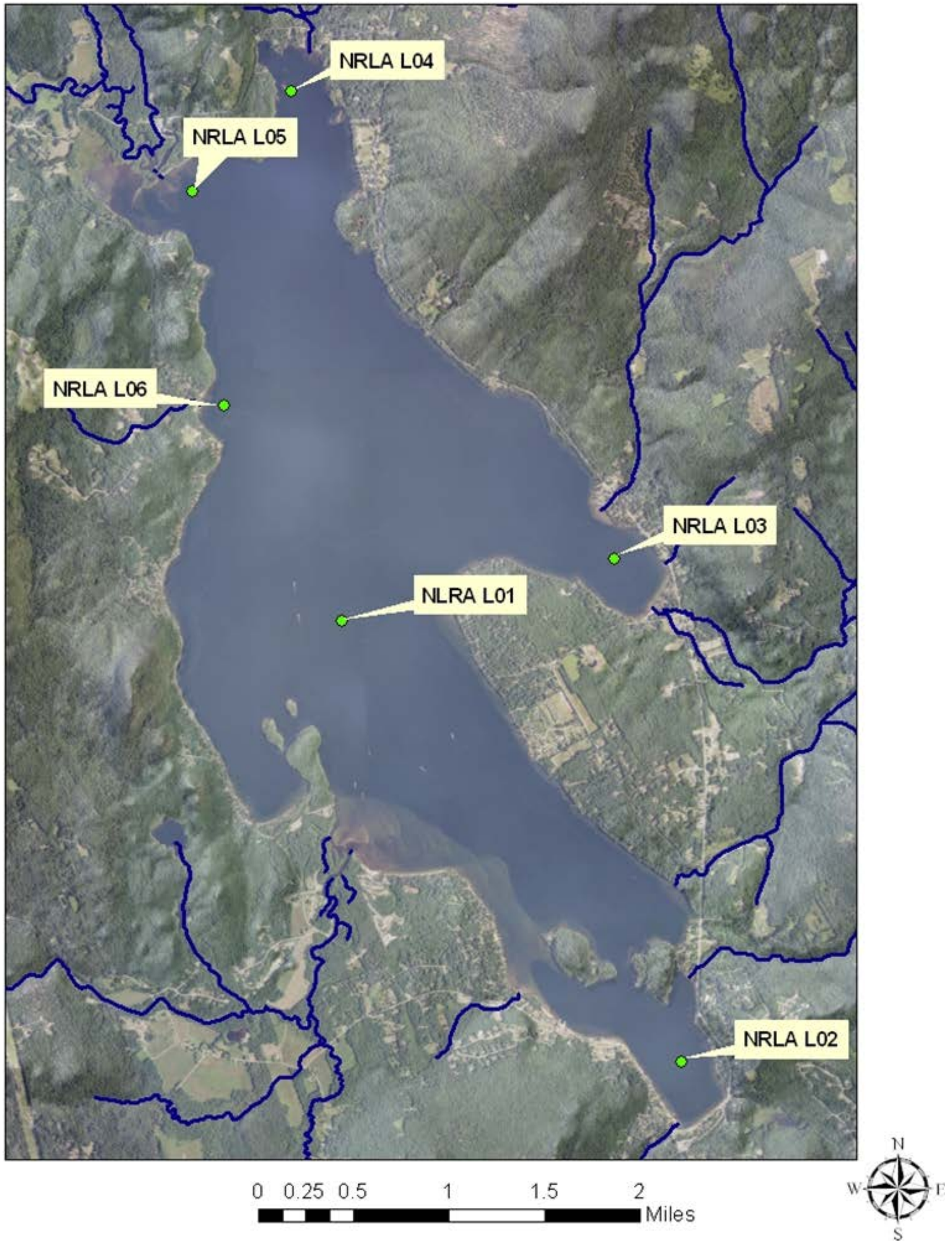
Outcomes

- Increased Spatial and Temporal Data Collection
- Cost effective research partnerships
- Participant empowerment
- Community capacity building
- Informed local decision-making
- Proactive resource protection/advocacy

Invite <u>everyone</u> to the table from the start of the collaboration to insure buy-in

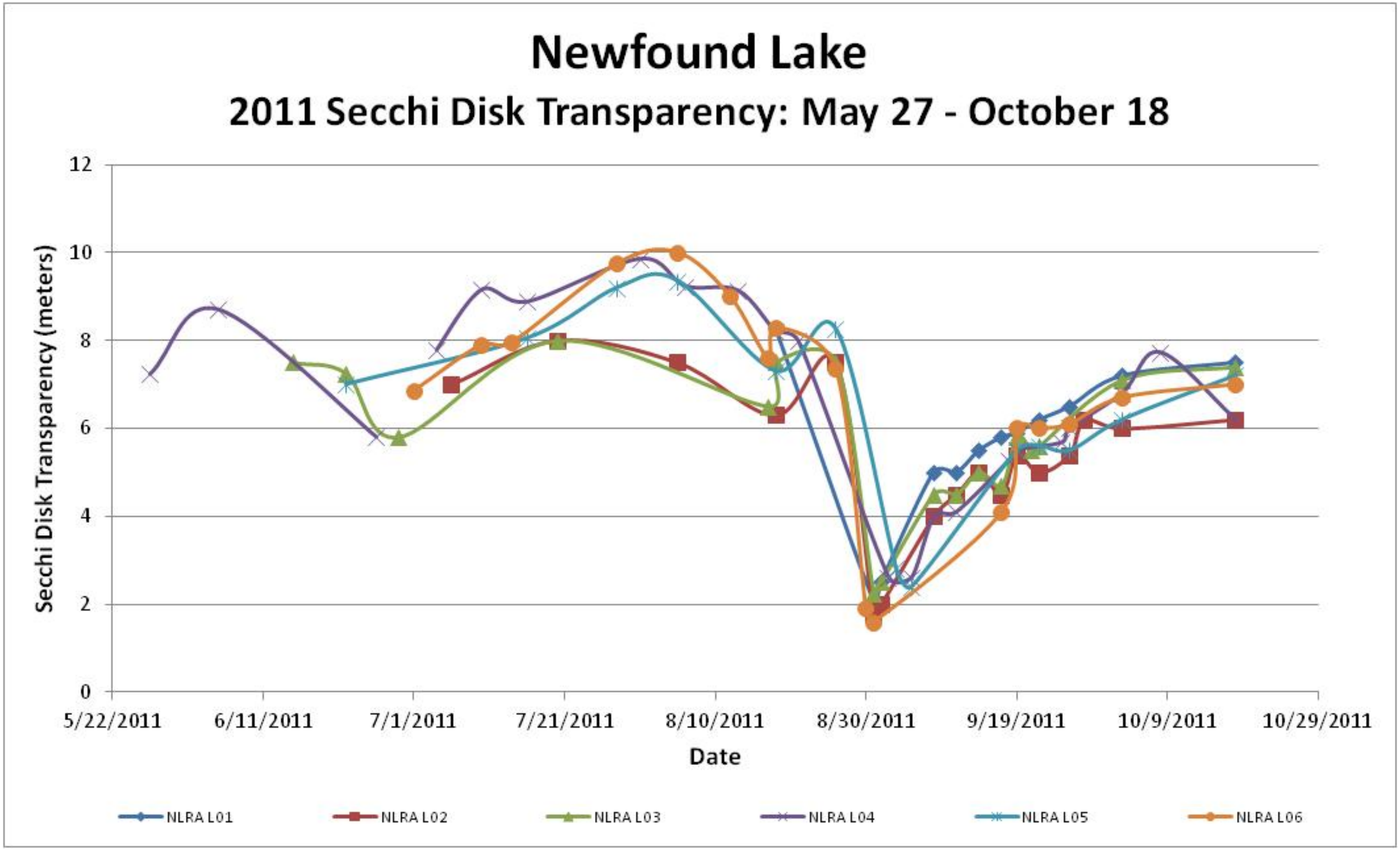
Even the perceived “Bad Dogs”

Newfound Lake (4106 acres)



Hurricane Irene Hits NH on 8/28/2011

Pre and Post Hurricane Irene Water Clarity



the WHITE HOUSE PRESIDENT BARACK OBAMA

Accelerating Citizen Science and Crowdsourcing to Address Societal and Scientific Challenges

SEPTEMBER 30, 2015 AT 6:00 AM ET BY TOM KALIL AND DAVE WILKINSON

Summary: Today, the White House is hosting a forum on citizen science and crowdsourcing.

While only a fraction of Americans are formally trained as professional scientists and engineers, everyone can contribute to science, engineering, and technology through open science and innovation approaches, such as citizen science and crowdsourcing projects.

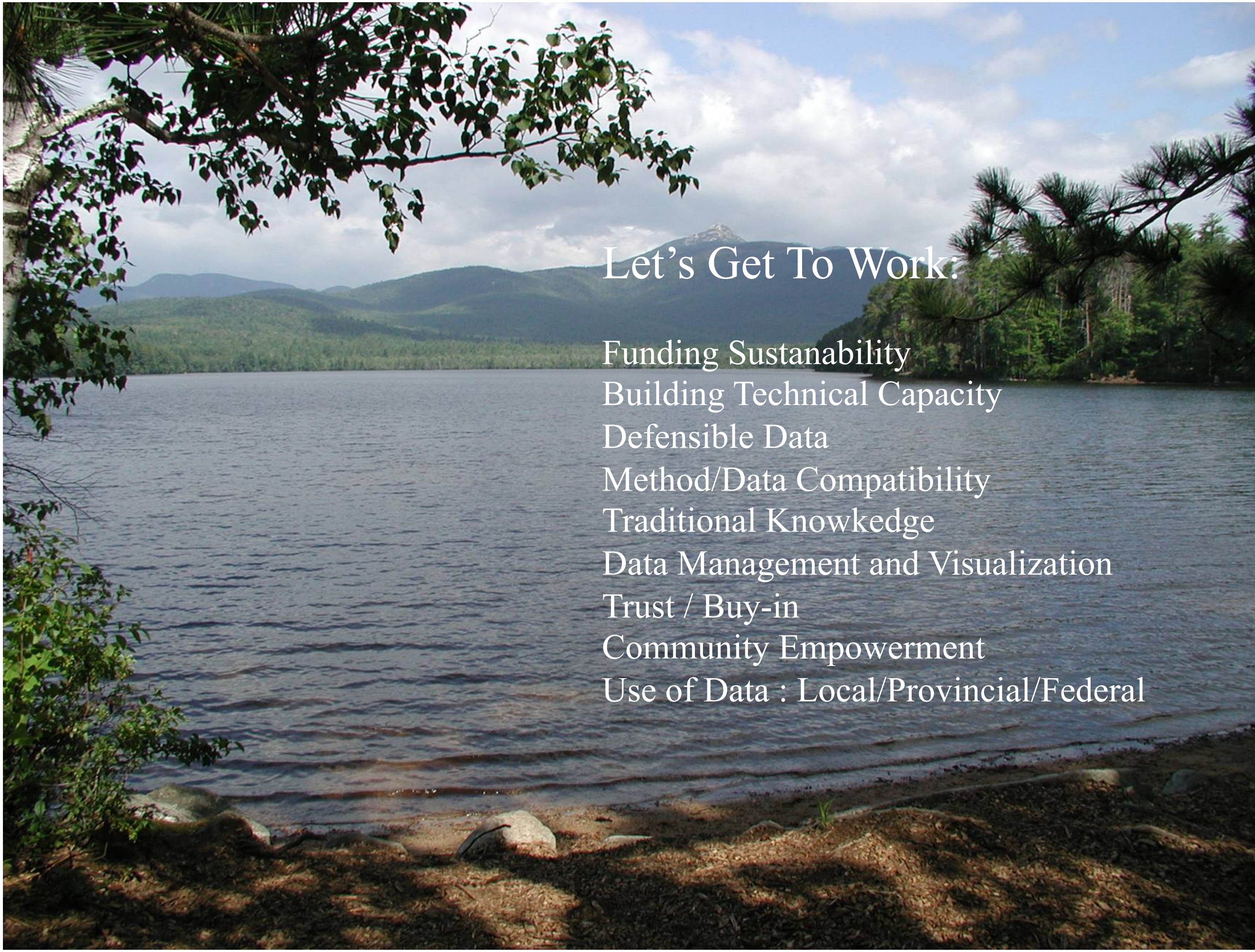
Citizen science encourages members of the public to voluntarily participate in the scientific process. Whether by asking questions, making observations, conducting experiments, collecting data, or developing low-cost technologies and open-source code, members of the public can help advance scientific knowledge and benefit society.

Through **crowdsourcing** – an open call for voluntary assistance from a large group of individuals – Americans can study and tackle complex challenges by conducting research at large geographic scales and over long periods of time in ways that professional scientists working alone cannot easily duplicate. These challenges include understanding the structure of proteins related viruses in order to support development of new medications, or preparing for, responding to, and recovering from disasters.

Projects that adopt these innovative approaches also help the individuals participating in them by creating opportunities for learning outside the classroom; providing people with hands-on, engaging experiences in science, technology, engineering, and mathematics; and creating a sense of connectivity, community, and ownership in the solutions. Low-

Executive Level Support:

Climate Change
Water Sustainability
Citizen Science/Crowd Sourcing
Open Source Data


Let’s Get To Work:
Funding Sustanability
Building Technical Capacity
Defensible Data
Method/Data Compatibility
Traditional Knowkedge
Data Management and Visualization
Trust / Buy-in
Community Empowerment
Use of Data : Local/Provincial/Federal