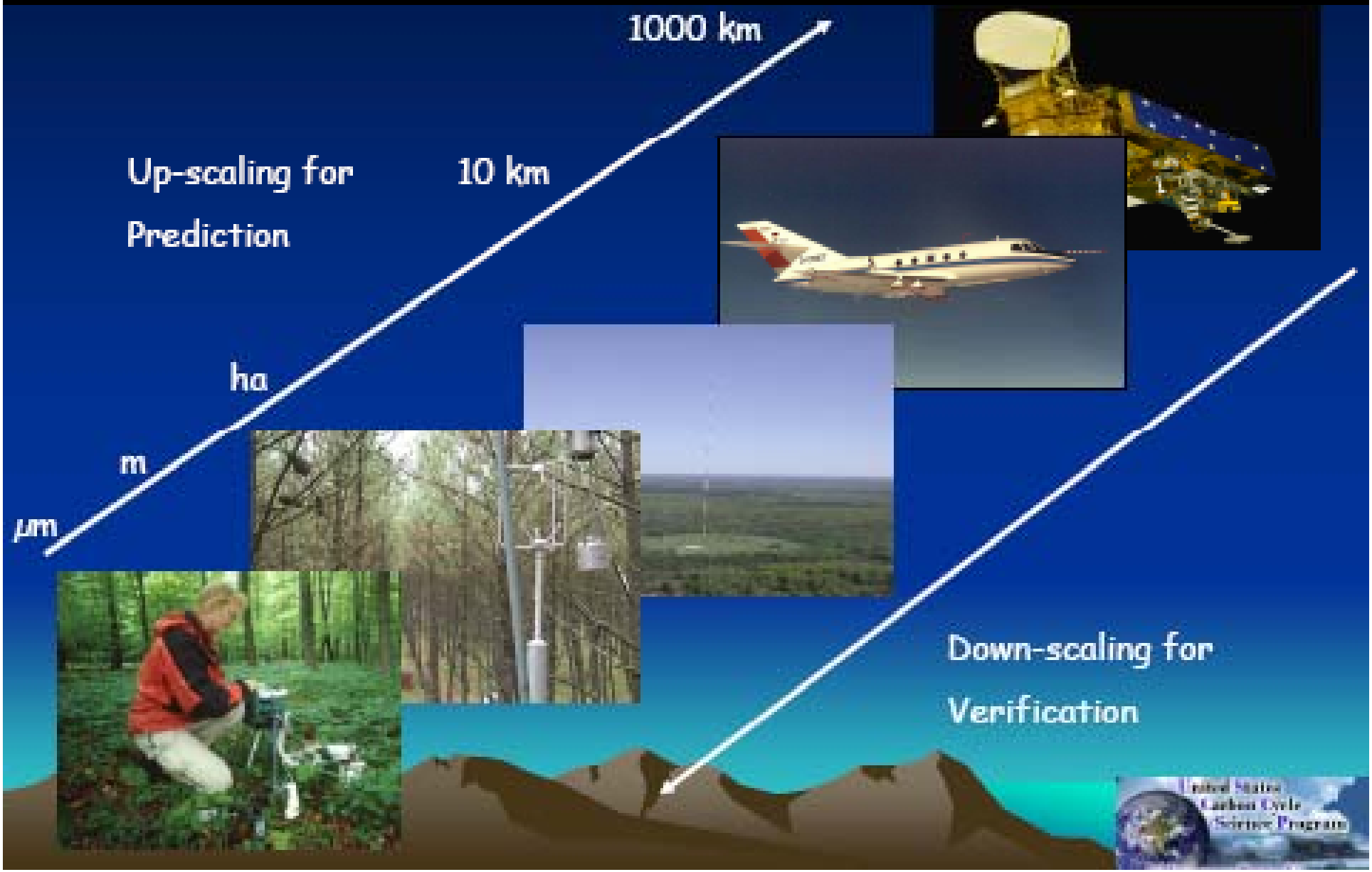
Mission of the Delaware Basin Collaborative Environmental Monitoring and Research Initiative (CEMRI)

"To address regional and watershed-scale issues through testing of potential national-scale collaborative strategies among existing biological, terrestrial, aquatic, and atmospheric monitoring and research programs."

Assessing Regional N-Saturation and Soil Calcium Depletion Through The Collaborative Environmental Monitoring and Research Initiative (CEMRI)

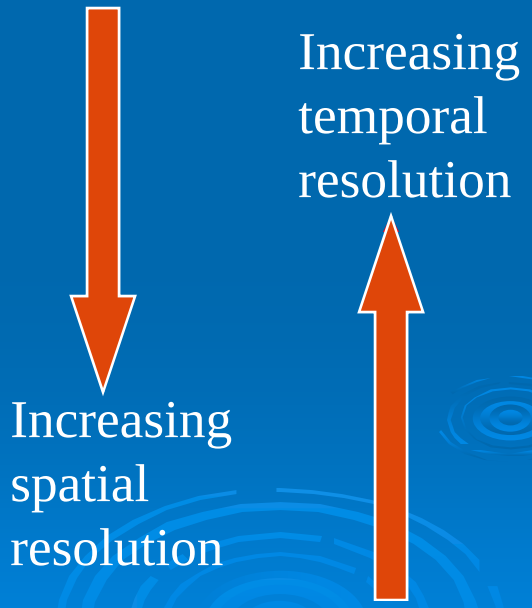
Multi-component –Multi scale Observations For a Common Frame of Reference



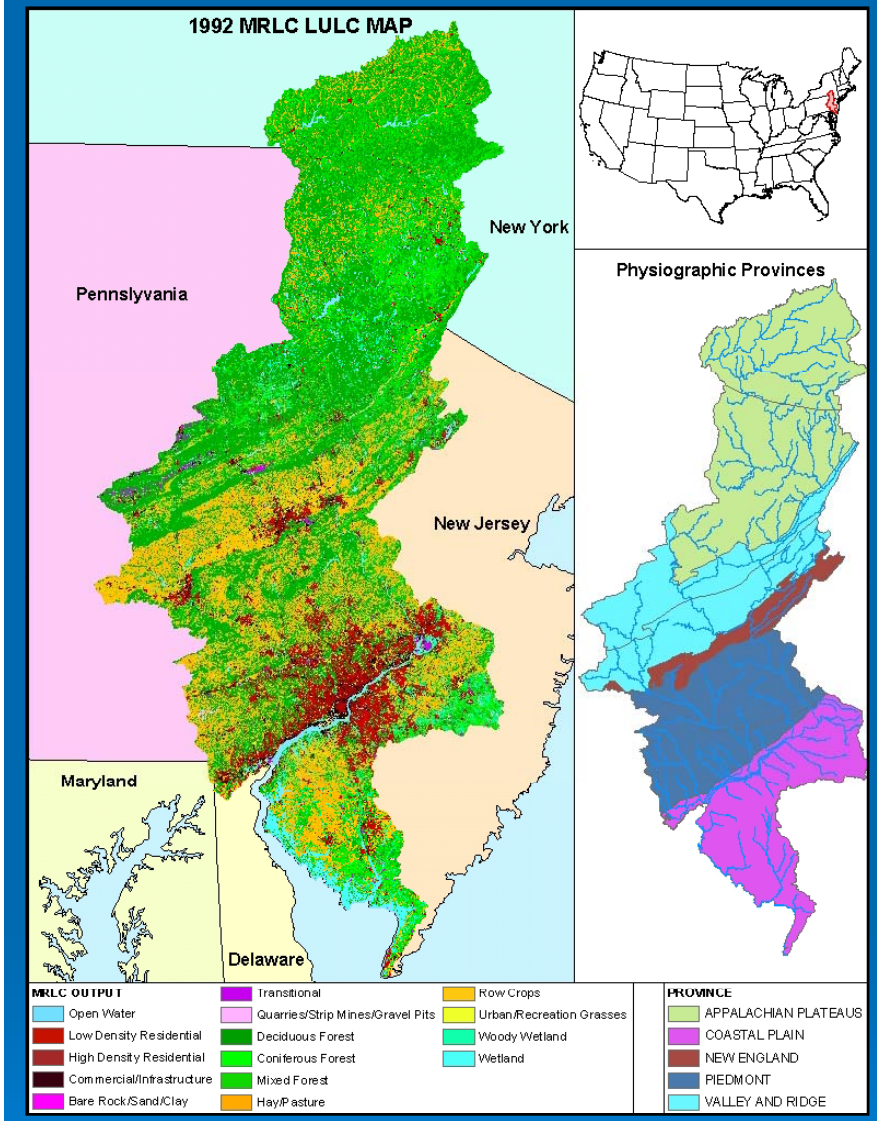
Proposed Monitoring Design

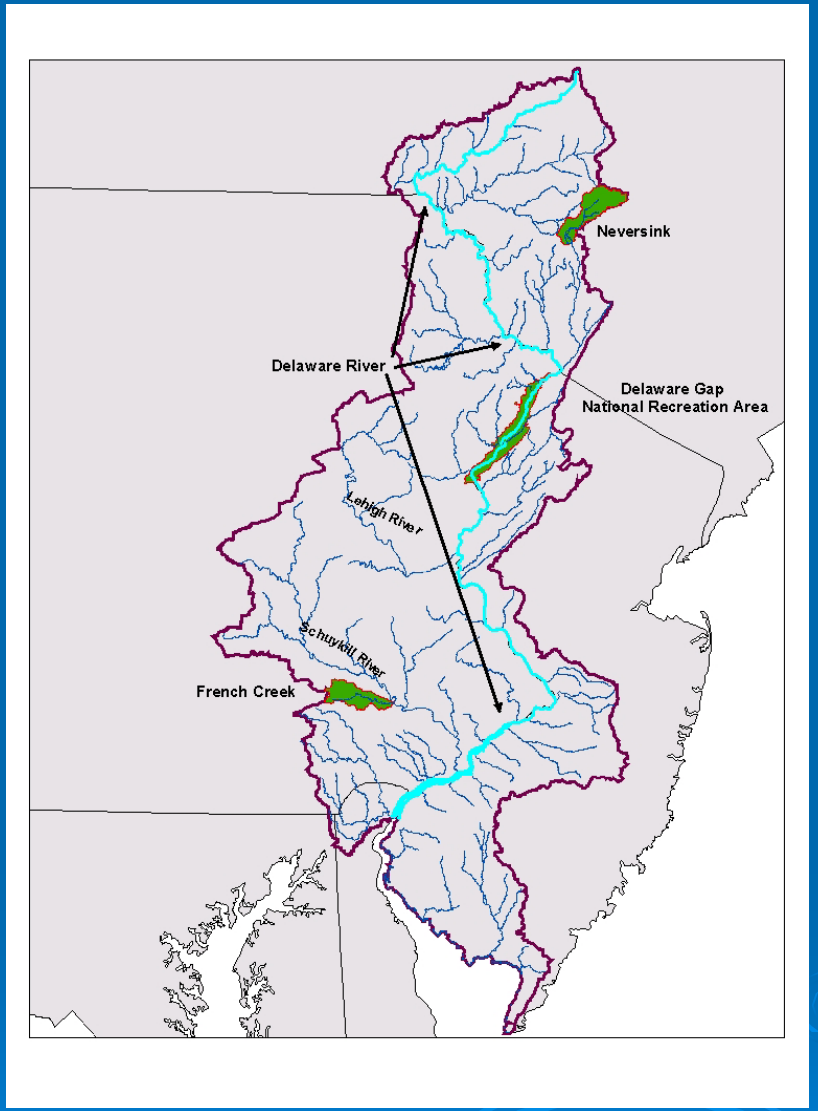
Scale-appropriate monitoring linked through common indicators

- **Tier One** – Intensive Research Areas
  - Relatively small number of specific sites representing important processes
- **Tier Two** – Gradient-based surveys
  - Mapping of condition using sites representative of a specific condition class and indicator coverages.
- **Tier Three –** Extensive Inventories and Surveys
  - Statistical representation of the population
- **Tier Four** –Remote Sensing and Mapping
  - Wall-to-wall coverage



USGS

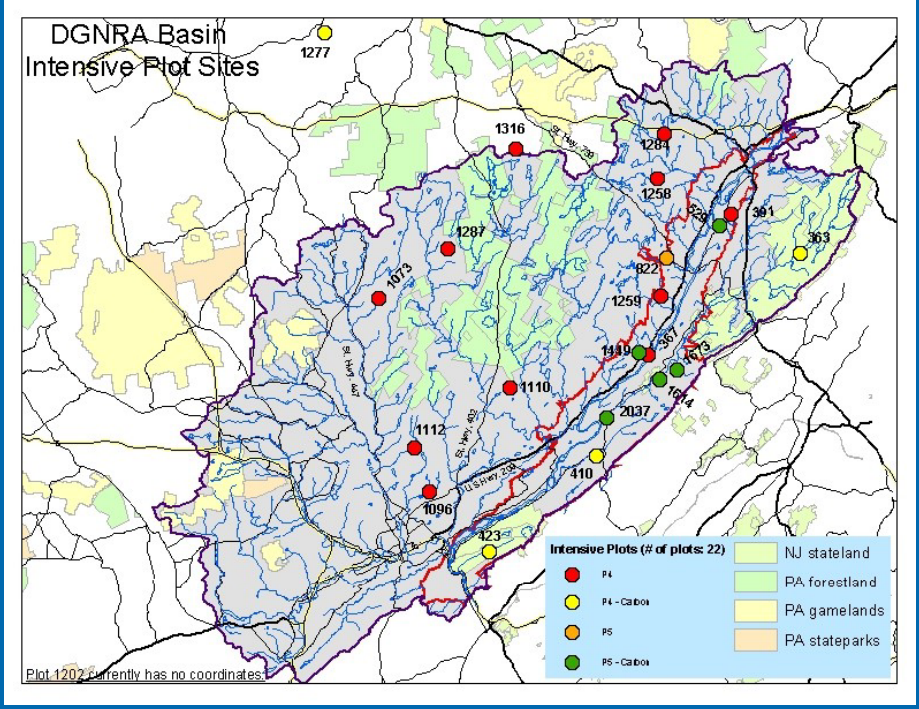


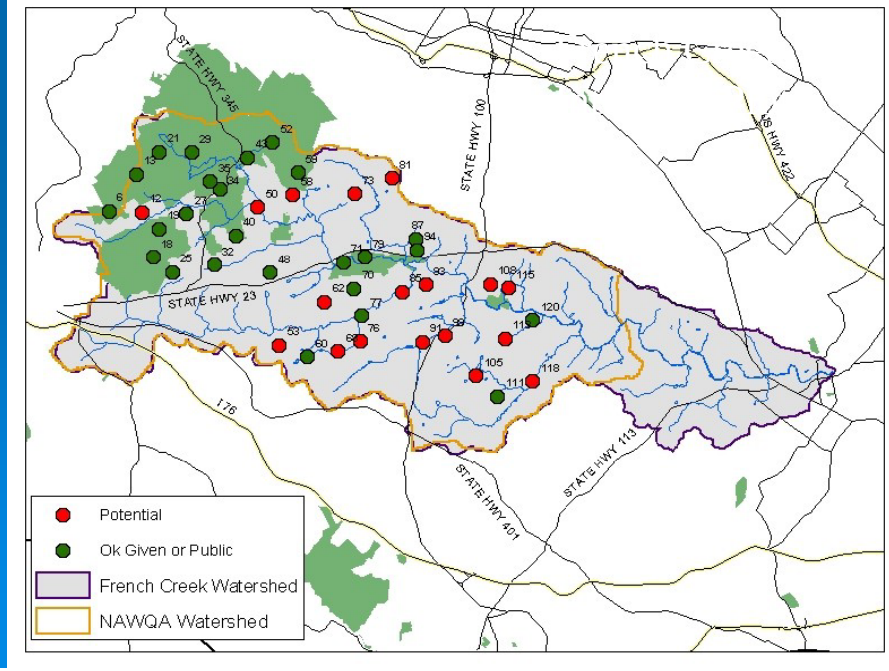


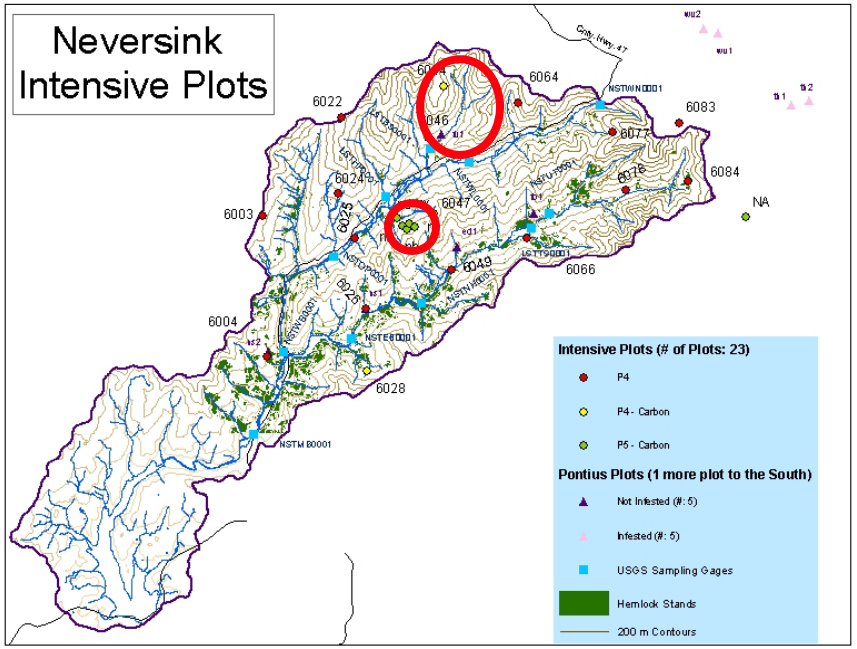
Delaware Basin ISM Watersheds

Built on NAWQA, District, and Park Service infrastructure and program

Sample Intensification (Tier 3 in Tier 1) at 3 Watersheds in the Delaware River Basin

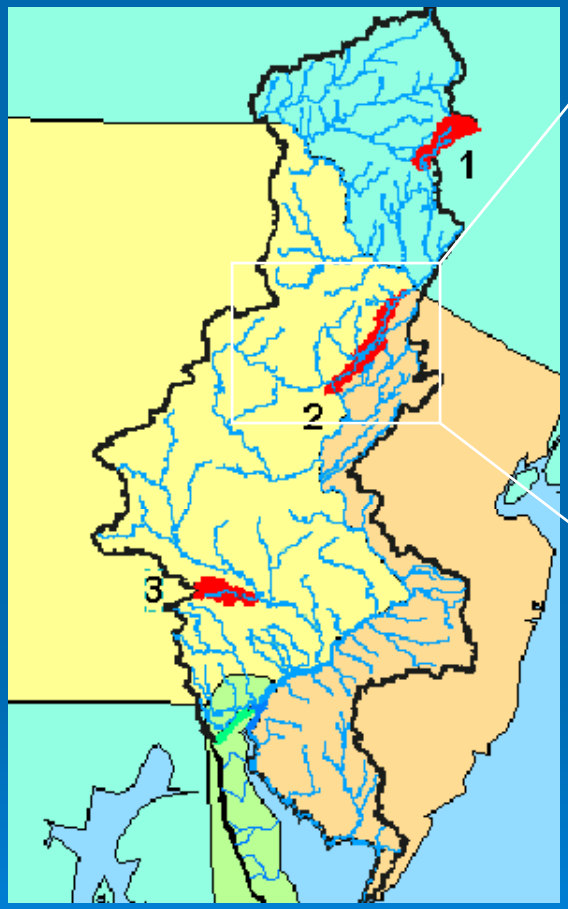




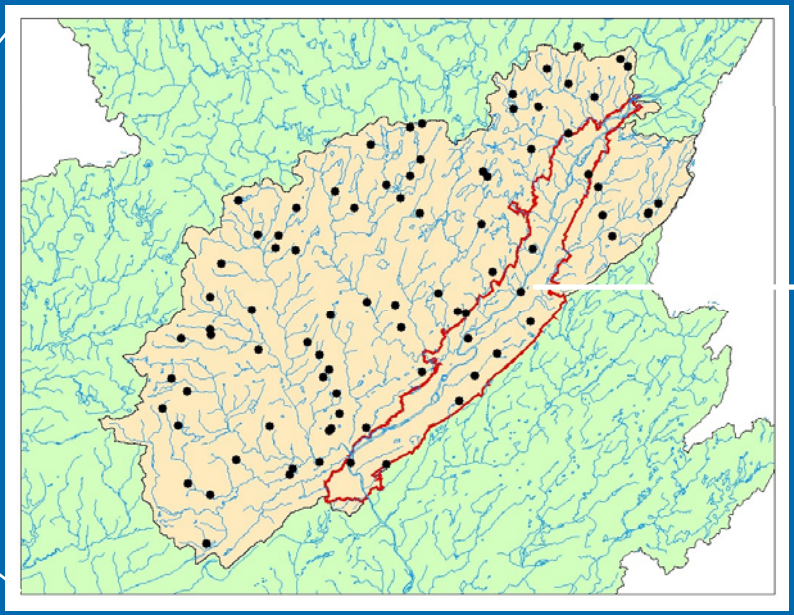


Tier 2 – Condition Sample: Design for Soil CO_2 Flux

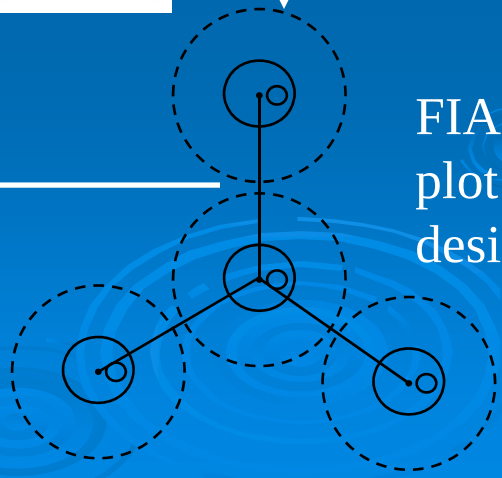
Delaware River Basin



Delaware Water Gap
Intensive Site

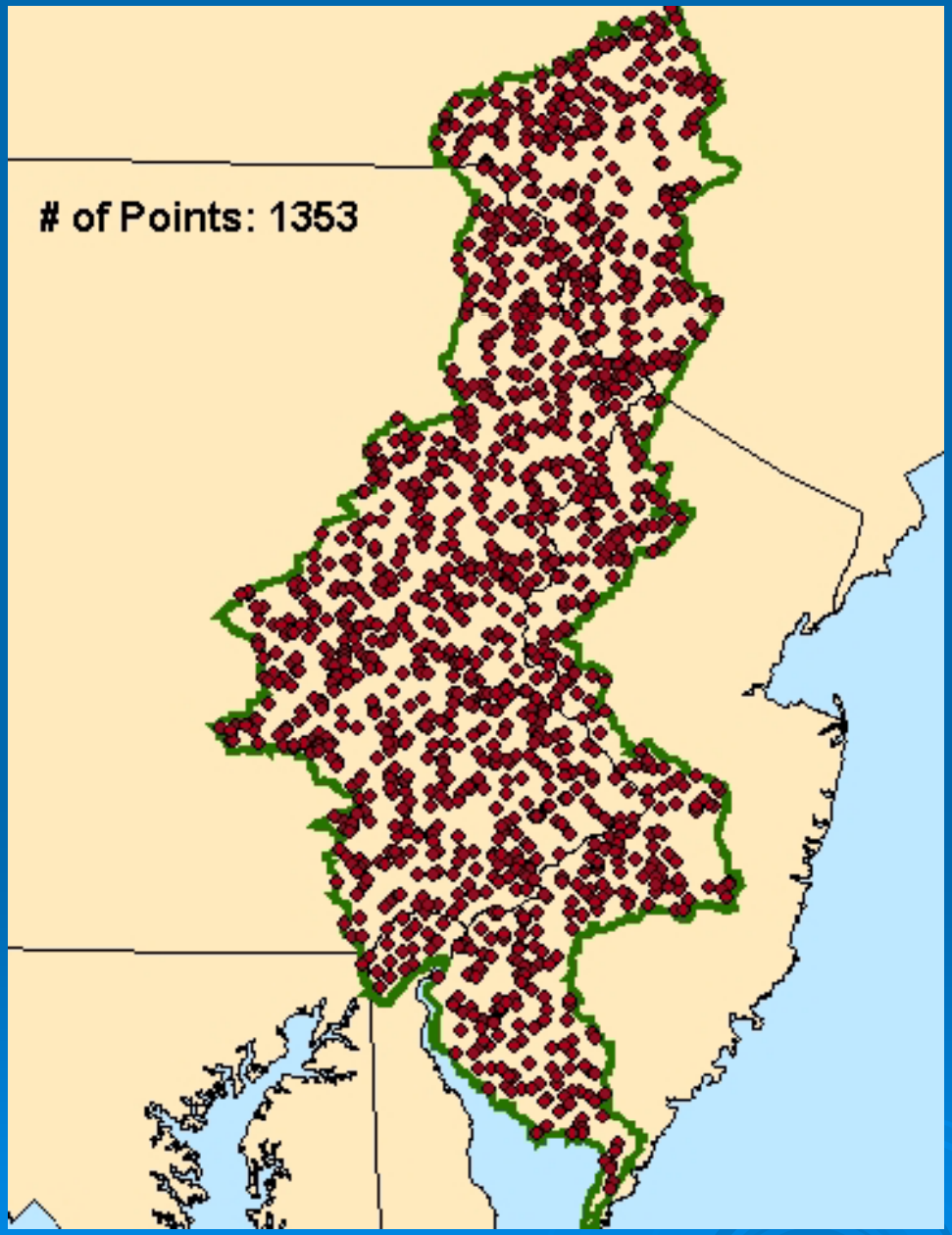


Select new sample sites by forest type and moisture class



FIA plot design

Establish 12 sample locations on lines between sub-plots



Tier 3 – USFS FIA and FHM

Plots measured with a 5-year panel system to characterize forests of the Delaware River Basin.

Added 3 soil samples at 3 depths to each forested plot, + stream survey.

Some of the Intensive Forestry Measurements Added to Forest Inventory Plots

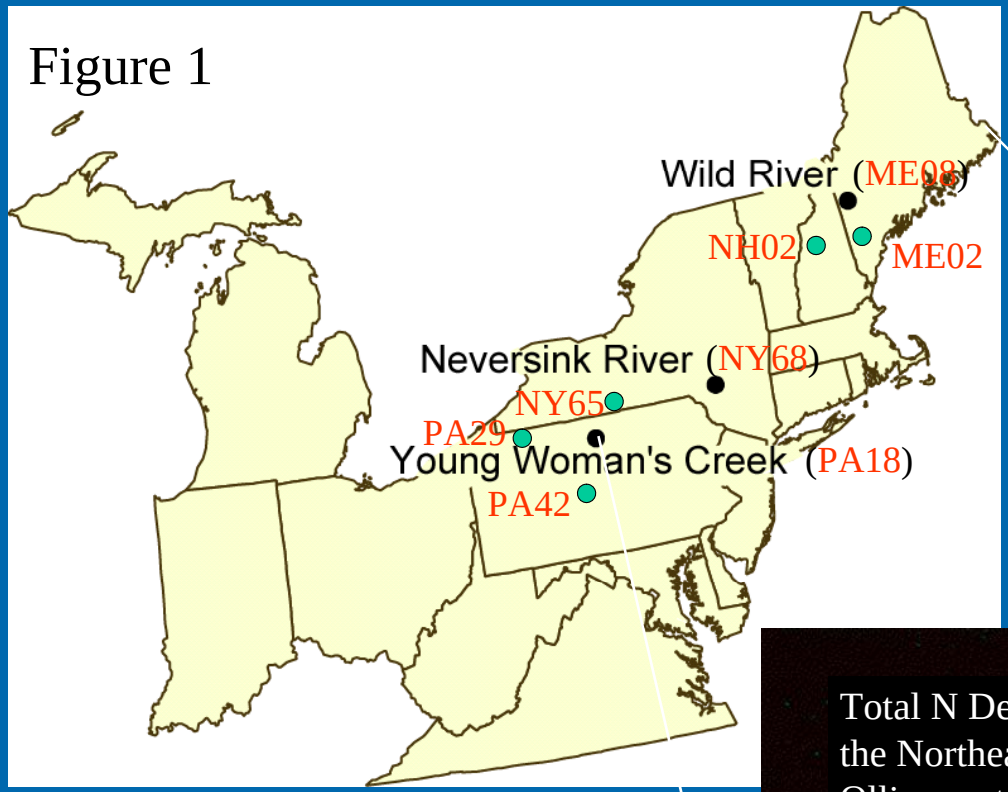
Foliar sampling

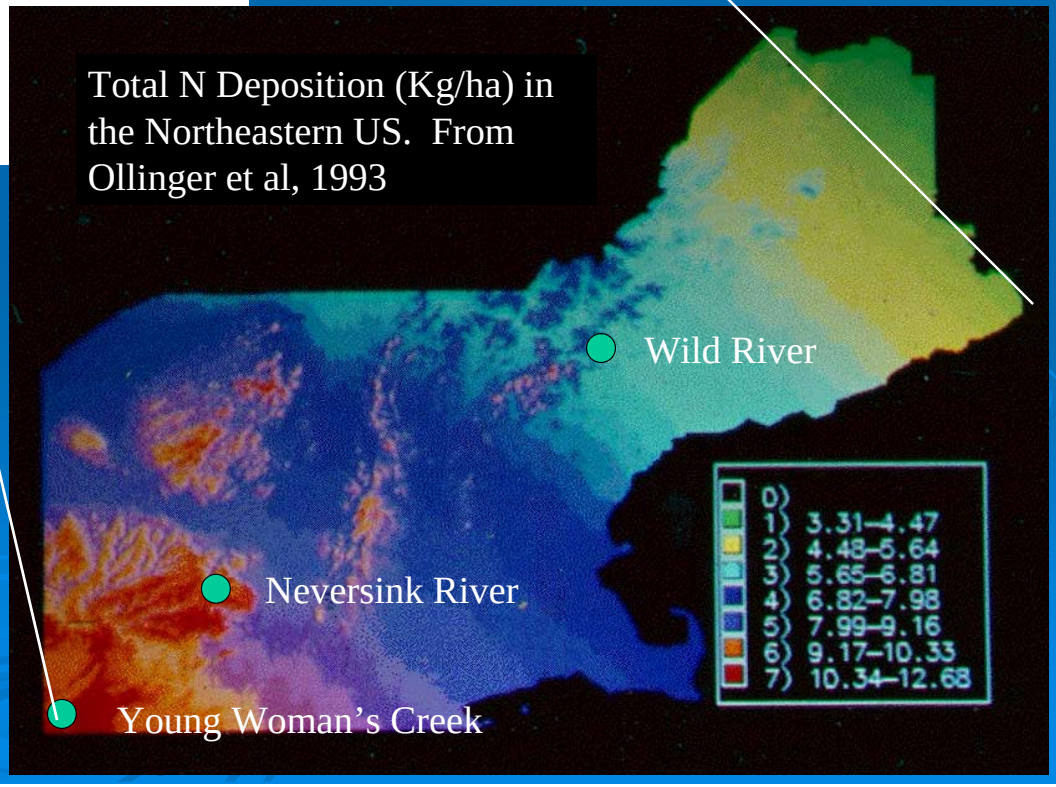
Litterfall collector

Soil temperature logger

Dendrometer band

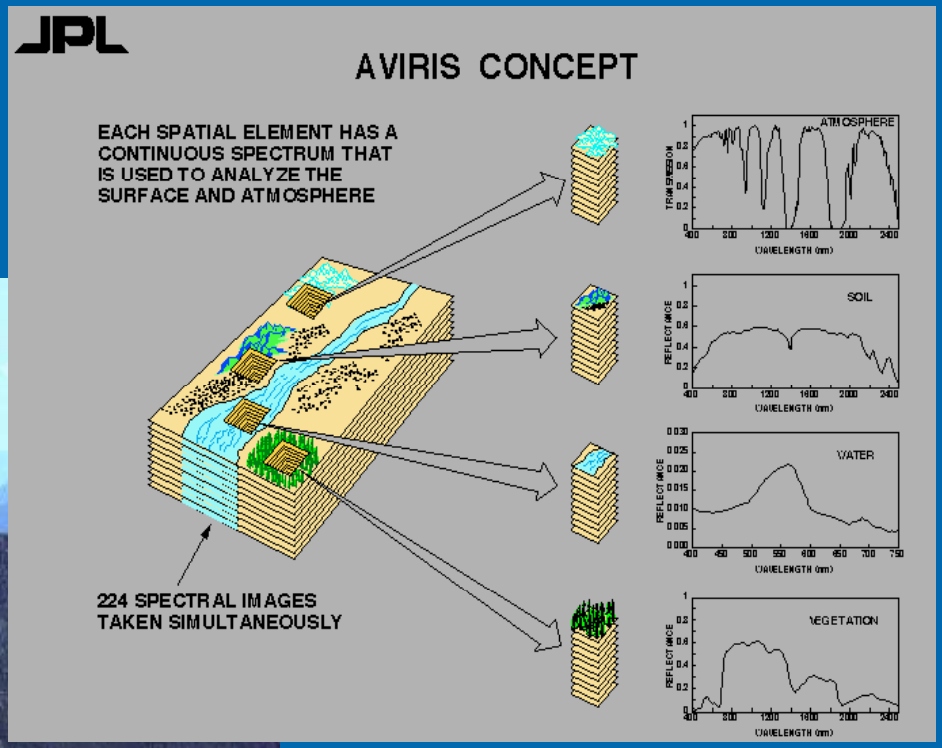
Gradient Example: HBN Study in the Northeast



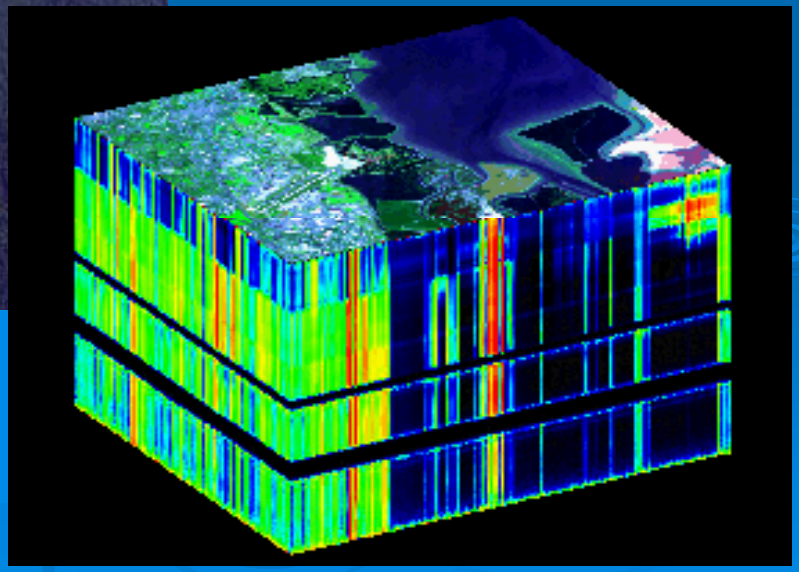


- Deposition monitoring station
- River monitoring station

Remote Sensing: Building new tools through an integrated ground-truthing network



AVIRIS
Airborne **V**isible/**I**nfra**R**ed
Imaging **S**pectrometer

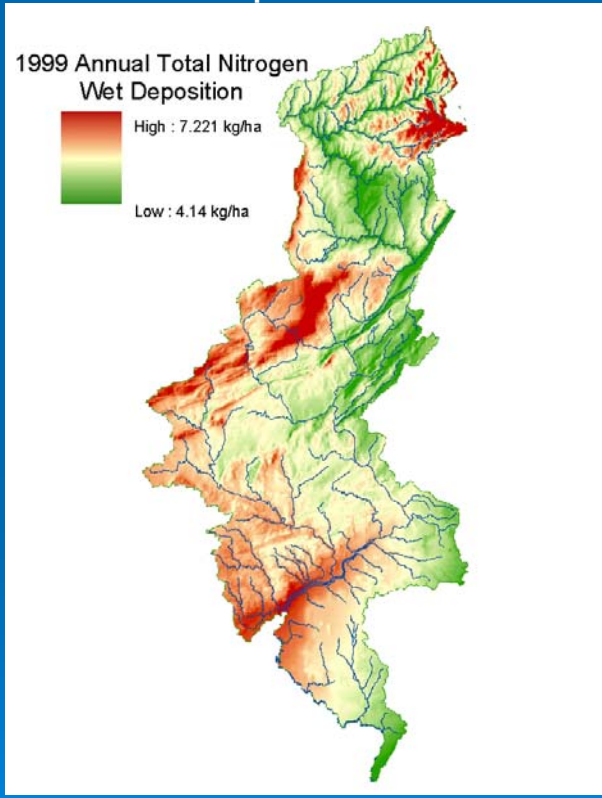


The resulting 224 band layer image is known as an “image cube”. When the data from each band is plotted on a graph, it yields a spectrum.

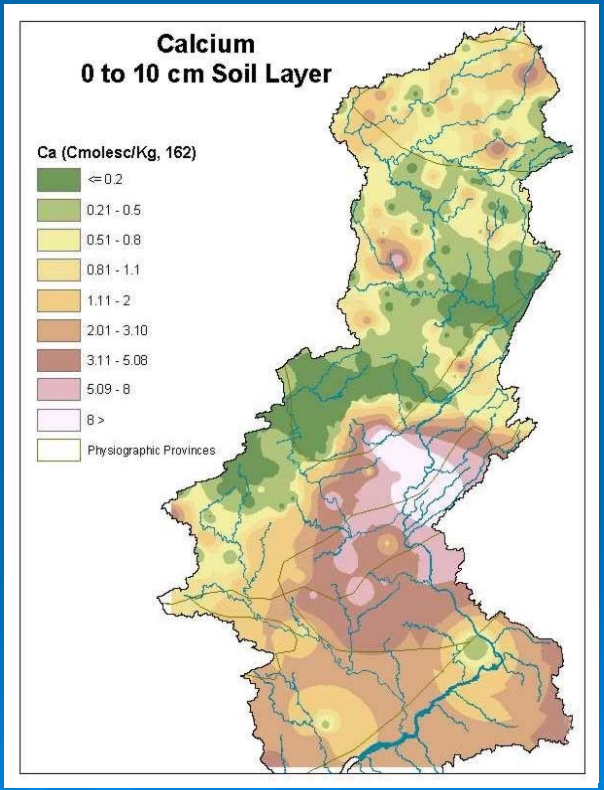
Hallet, USFS

Regional relation of deposition chemistry to soil and stream chemistry

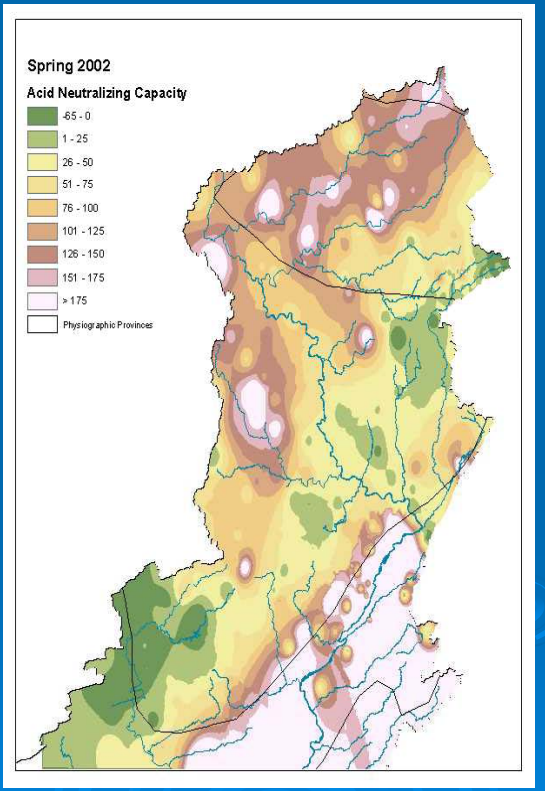
Annual Nitrogen deposition

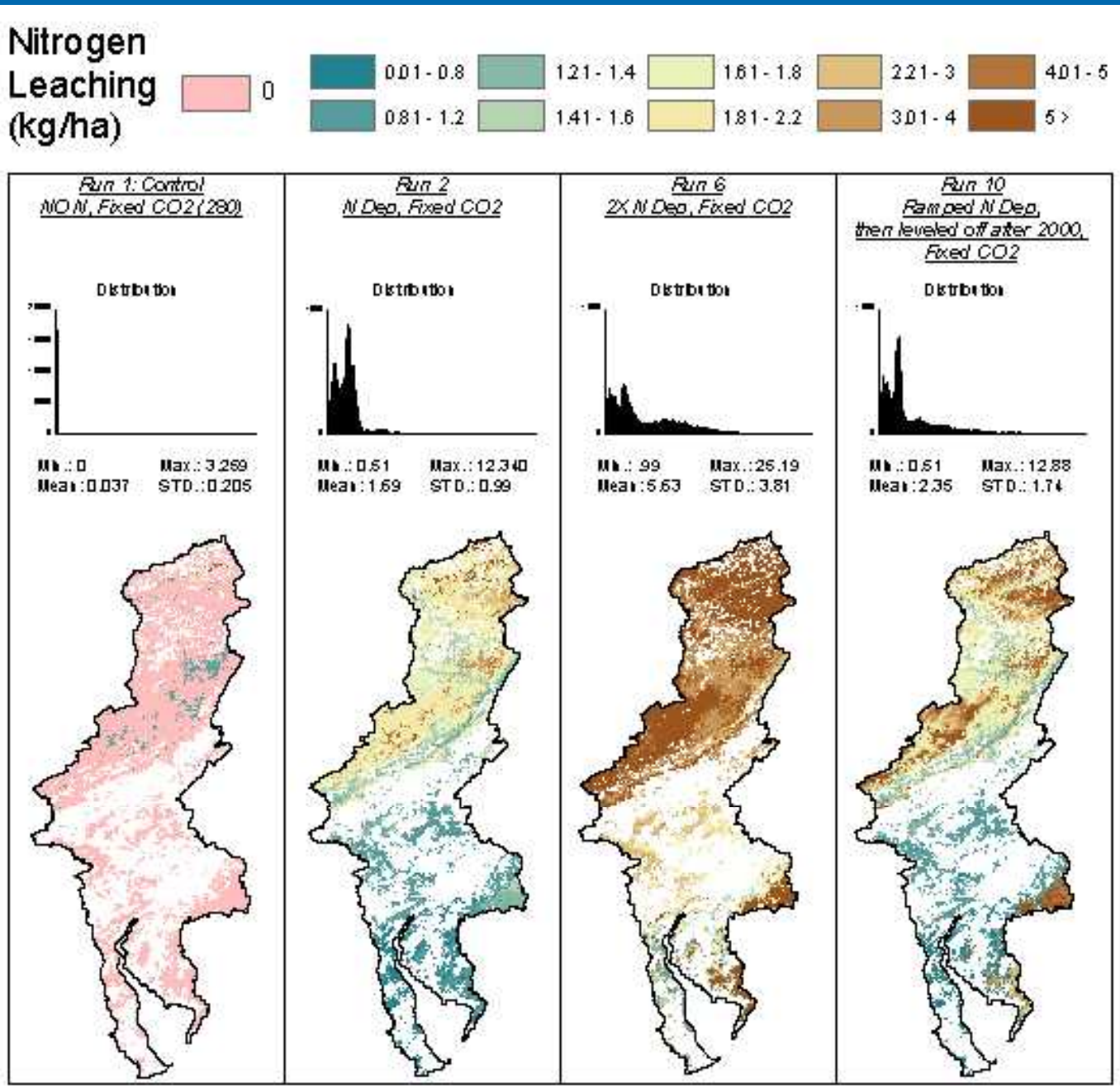


Soil Calcium



Stream acid neutralizing capacity (ANC)



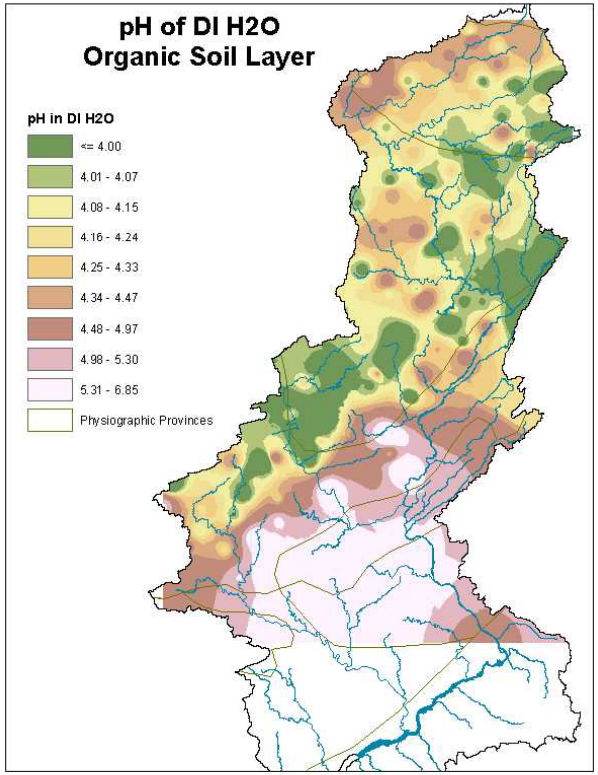


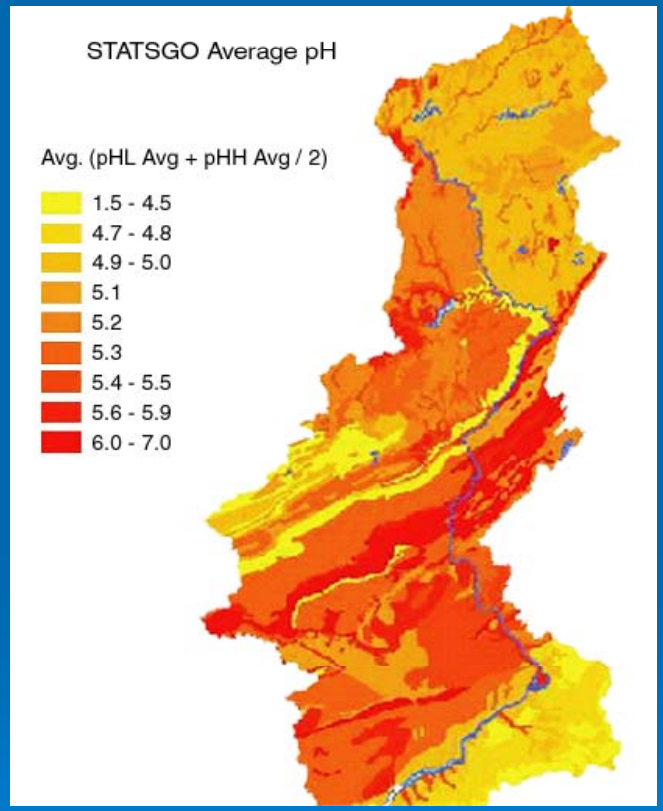
Leveled N-dep model matches current soil Ca and stream pH map for Del basin.

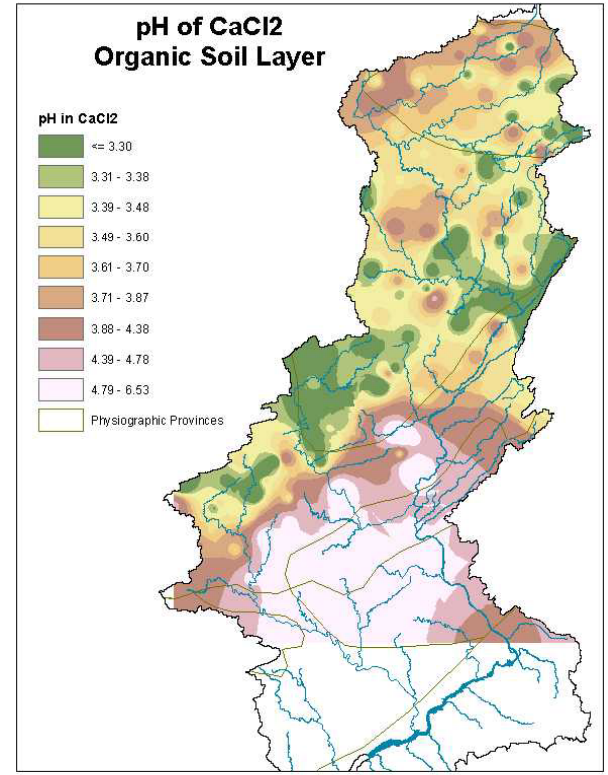
NRCS Soil Geochemistry Plots

Only 2 samples in Delaware for STATSGO map

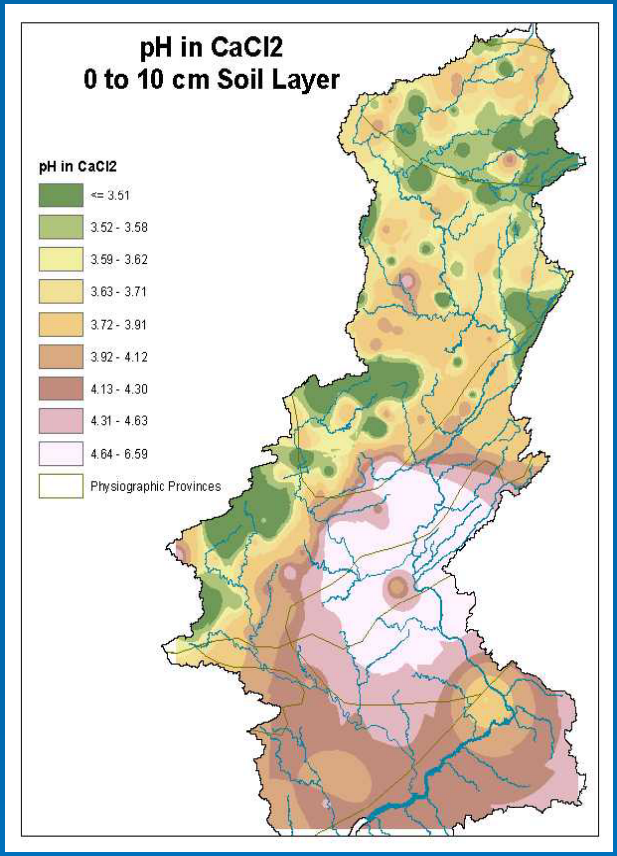
Soil pH, Organic Horizon

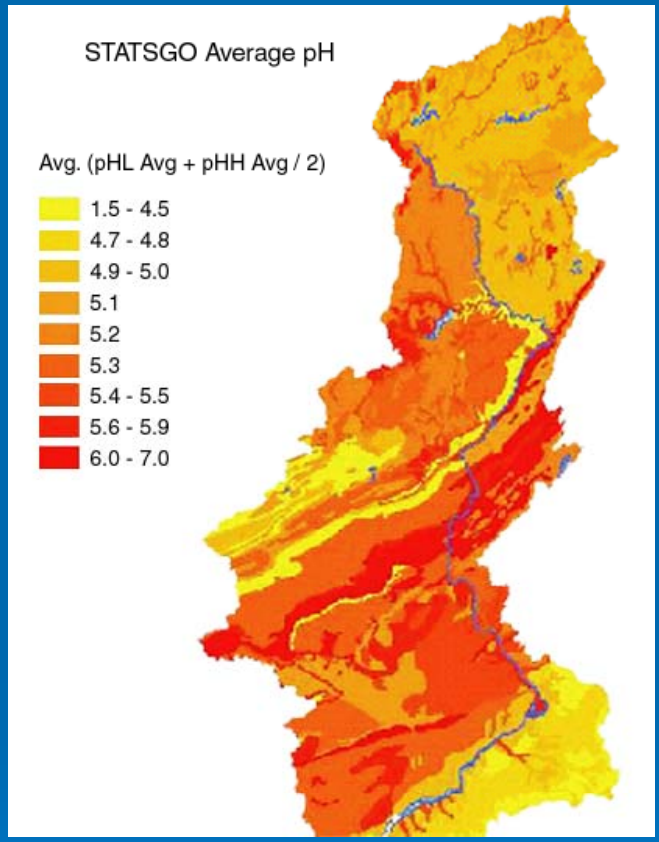


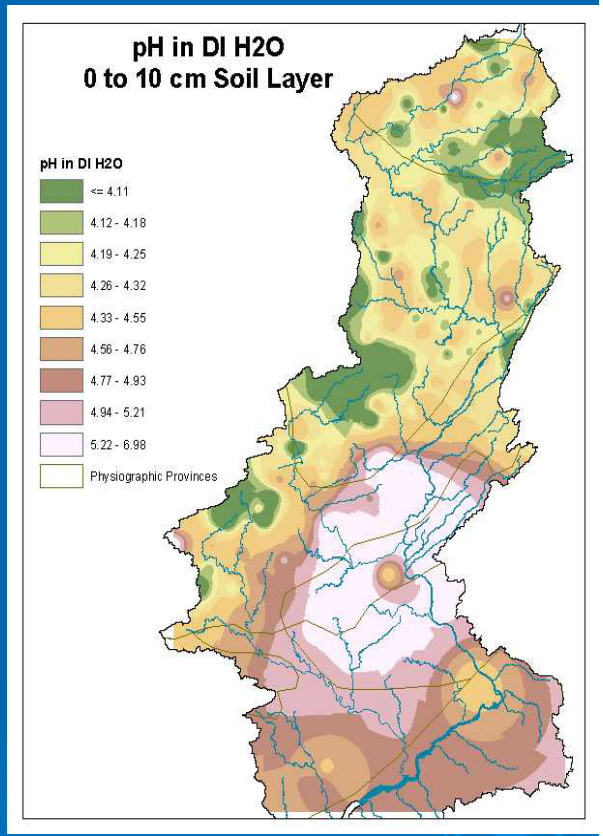




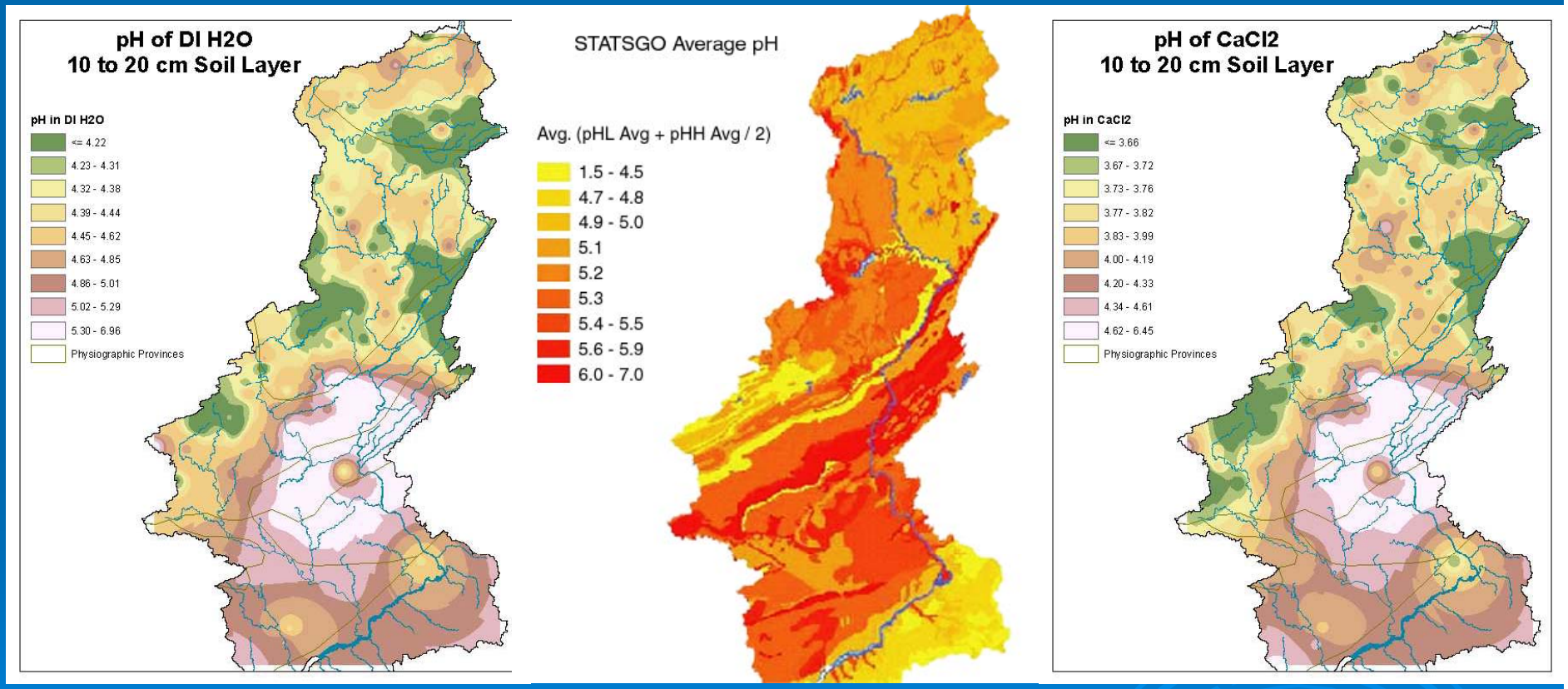
Soil pH, 0-10 cm depth



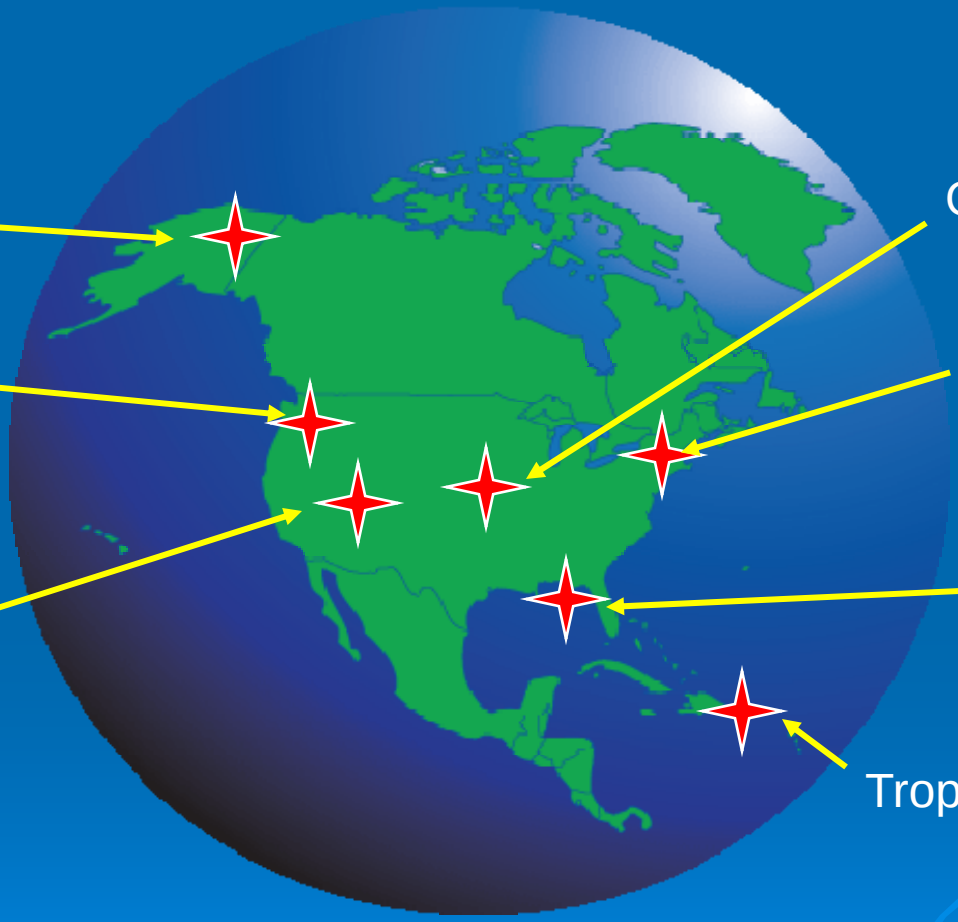




Soil pH, 10-20 cm depth



Possible Collaborative Observation and Research (CORE) Ecoregions



Yukon River Basin and North Slope

Pacific Northwest Rainforest

Southwest Mountains and Desert

Grasslands

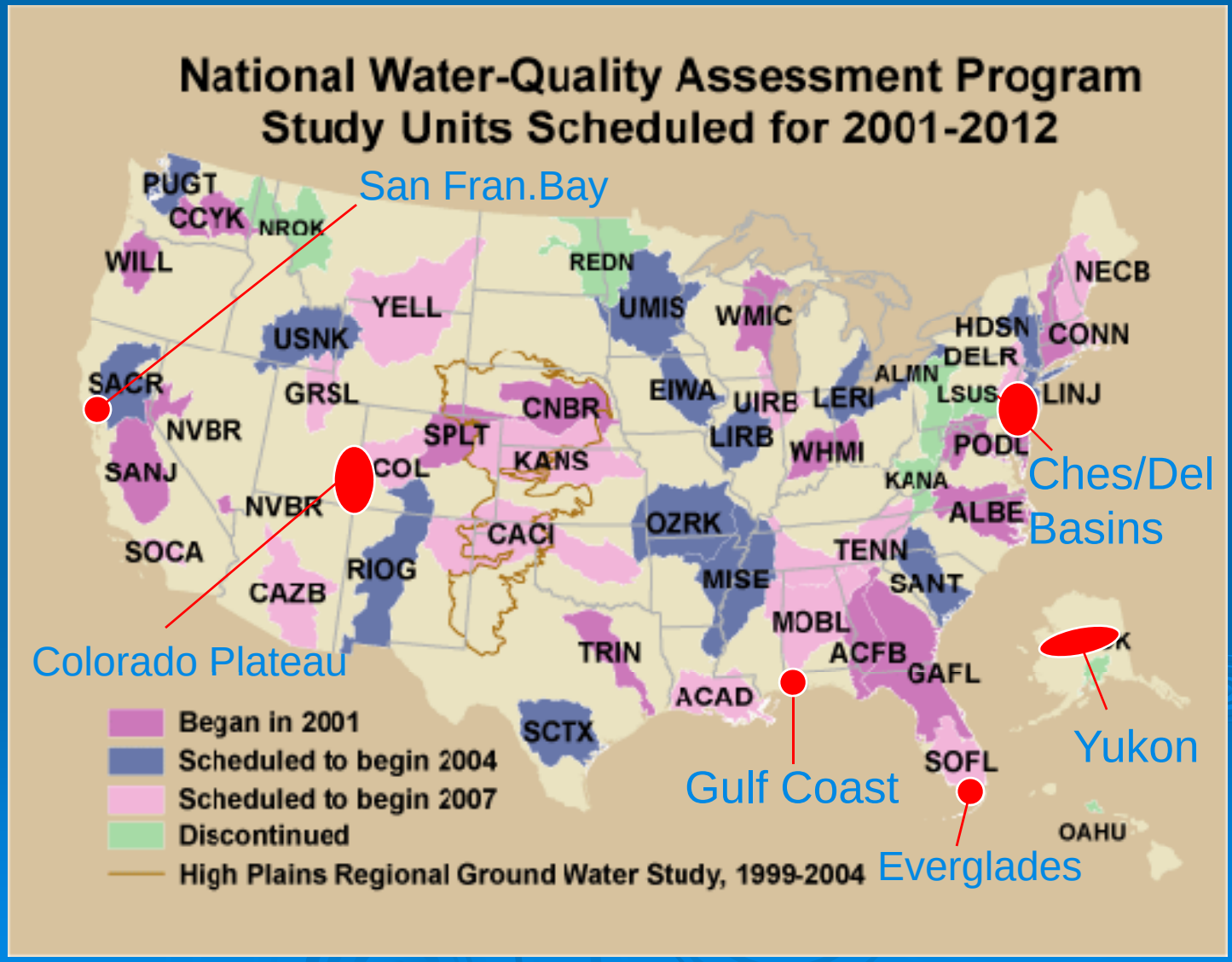
Northeast Temperate Forest

Gulf Coast/ Florida Wetlands

Tropical Forest

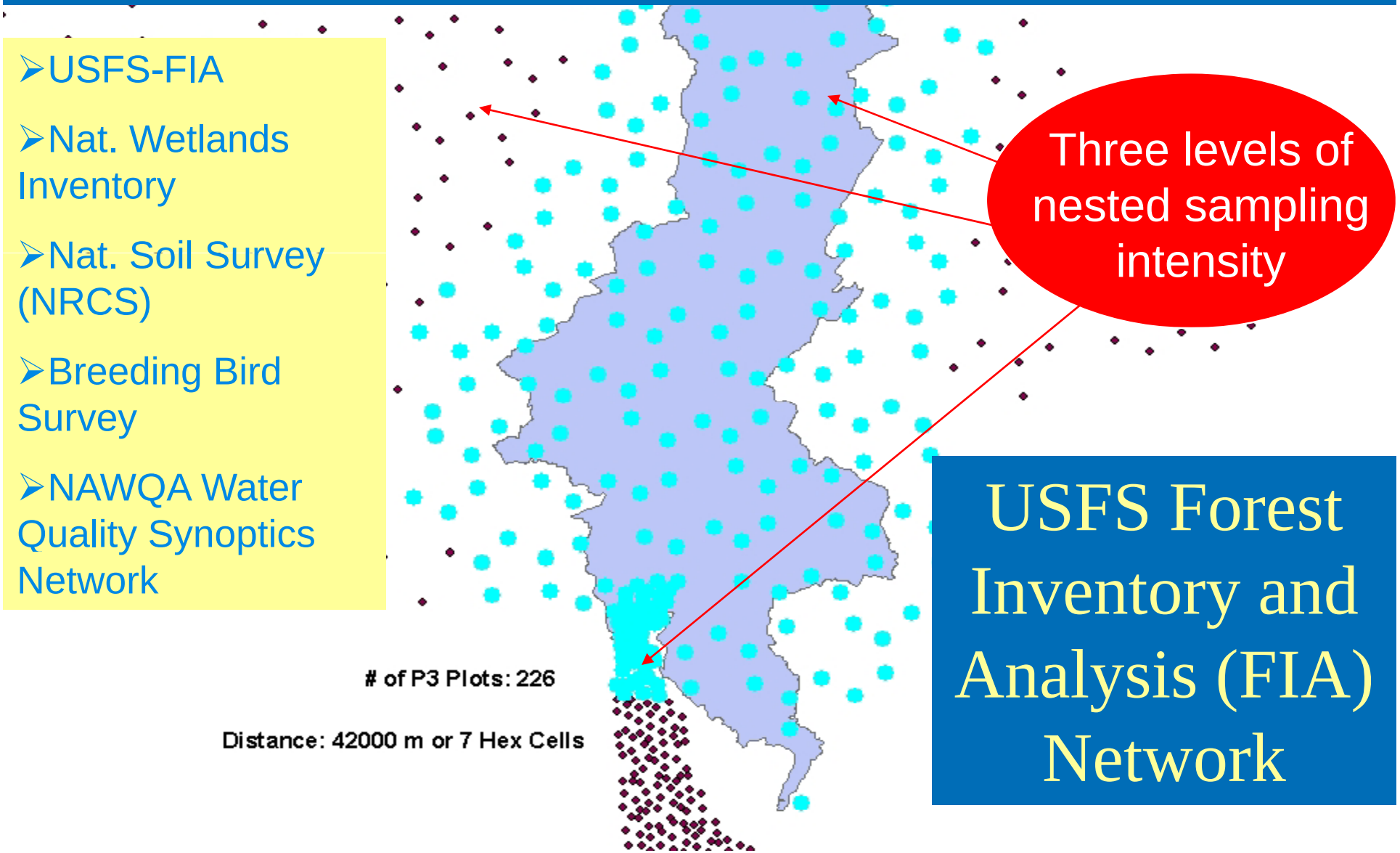
Potential CORE or Gradient Watersheds

- PES
- NAWQA
- WEBB
- ESD Watersheds
- LTER
- USFS Experimental Forests



Regional Extrapolation: Nesting CORE Watersheds within Surveys

- USFS-FIA
- Nat. Wetlands Inventory
- Nat. Soil Survey (NRCS)
- Breeding Bird Survey
- NAWQA Water Quality Synoptics Network

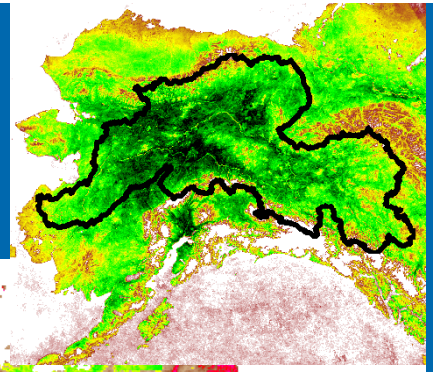


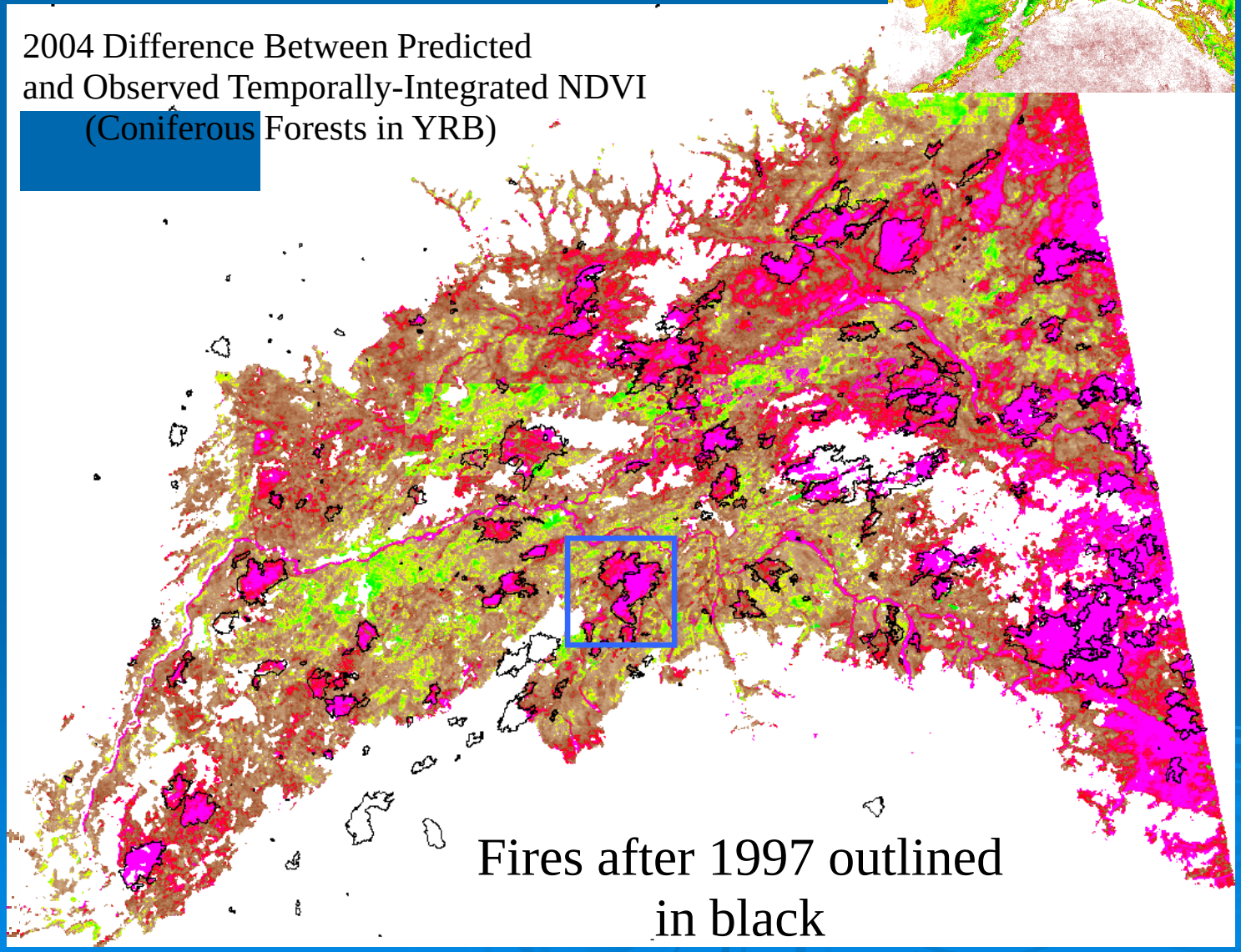
Three levels of nested sampling intensity

USFS Forest Inventory and Analysis (FIA) Network

USGS

2004 Difference Between Predicted
and Observed Temporally-Integrated NDVI
(Coniferous Forests in YRB)





253

positive anomalies

113

-112

negative anomalies

-283

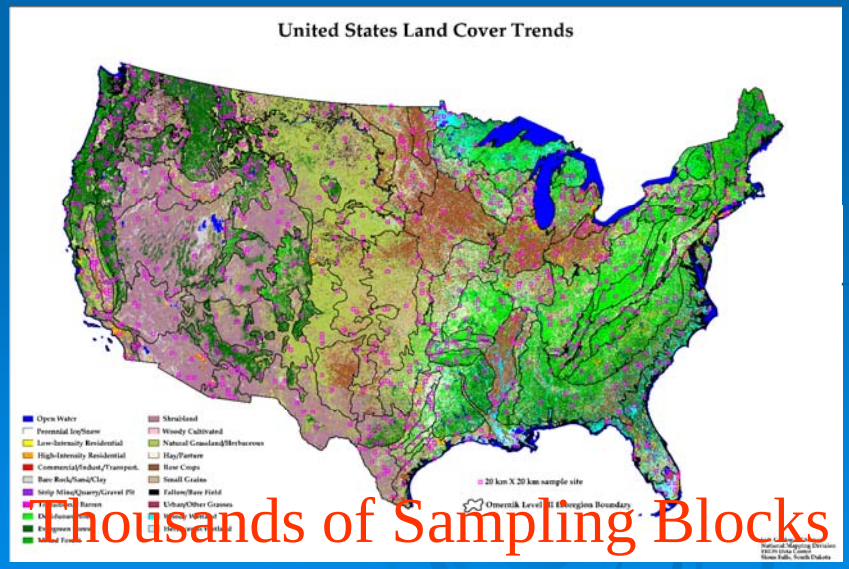
Fires after 1997 outlined in black

Ecosystem Modeling

GEMS (General Ensemble Biogeochemical Modeling System)

Requires modeling staff, data management, computing infrastructure

Land Cover: USGS Land Cover Trends
Soil: STATSGO
Climate: CRTUS2.0 (1900 – 2000)
N Deposition: National Atmospheric Deposition Program
Crop Information: USDA Agricultural Census Data
FIA: Forest biomass, NPP, Age Distribution



Thousands of Sampling Blocks

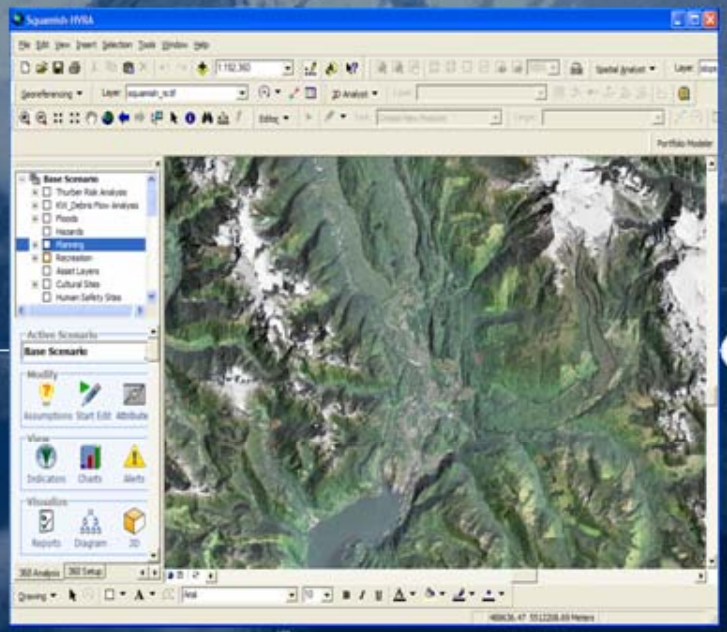
GEMS

Carbon dynamics simulated at 60 m x 60 m spatial resolution within 20 km x 20 km or 10-km by 10-km sampling blocks

Decision Support Systems

EmerGeo

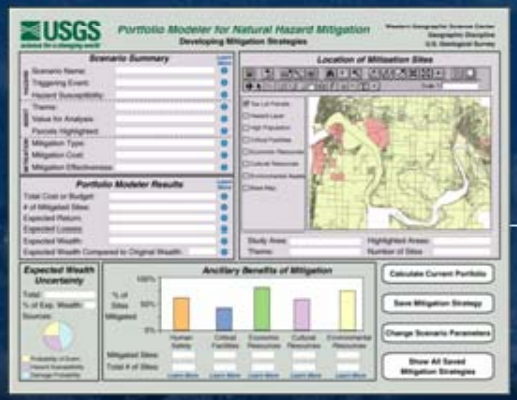
CommunityViz
Scenario 360



Federal/Provincial

Regional

USGS Portfolio



Local

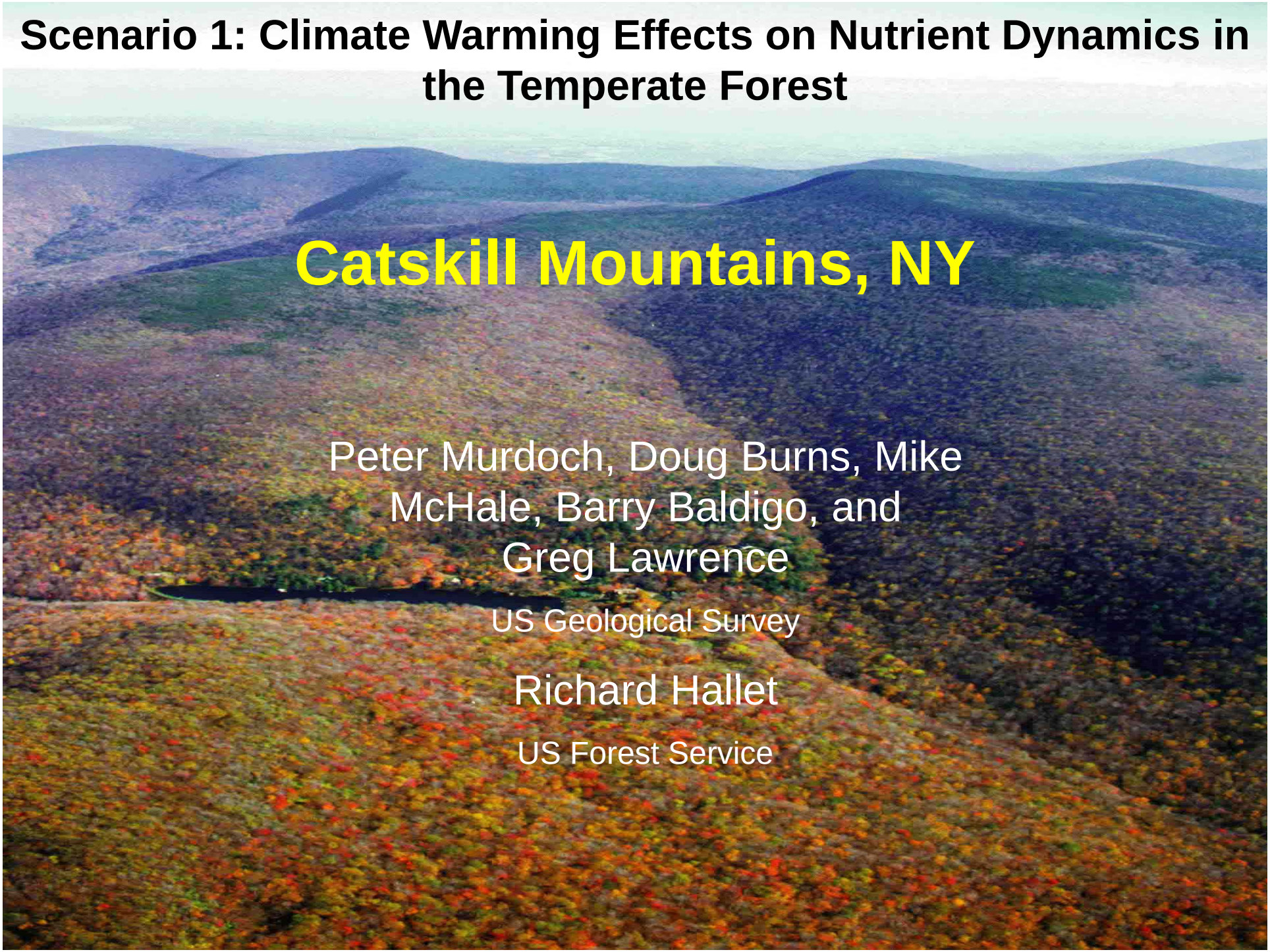
Take home messages

- Regional soil surveys are badly needed
- National soil surveys are starting to emerge
- Method standardization would greatly improve our ability to develop collaborative regional soils maps
- Archiving the soils already collected will provide a significant baseline for assessing temporal changes.

Scenario 1: Enhanced soil calcium depletion from warming and acid rain

- Possible Management Adaptations: Liming of sugar maple stands, partial harvest logging practices, reduced nitrogen emissions.
- Possible Negative Effects: Decline of maple sugar industry, reduced forest value, loss of trout habitat in streams, amphibian decline, enhanced pest and invasive plant infestation, reduction in foliar display in Fall (tourism decline).

Scenario 1: Climate Warming Effects on Nutrient Dynamics in the Temperate Forest



Catskill Mountains, NY

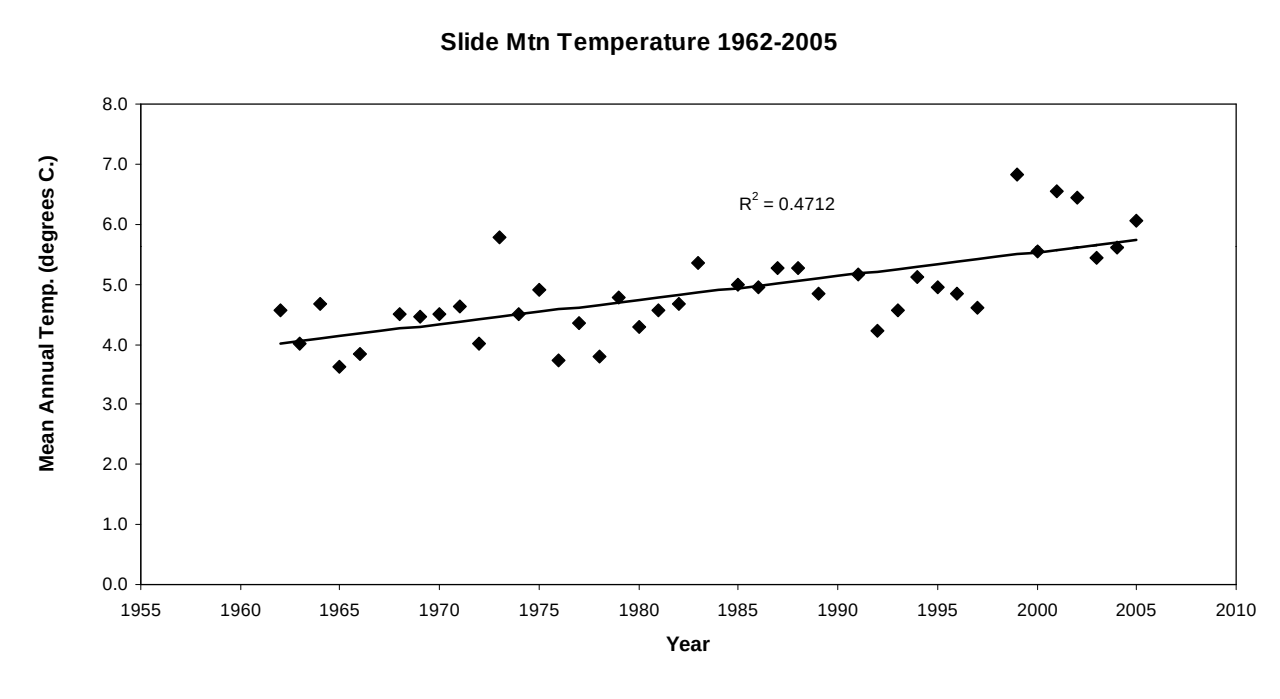
Peter Murdoch, Doug Burns, Mike McHale, Barry Baldigo, and Greg Lawrence

US Geological Survey

Richard Hallet

US Forest Service

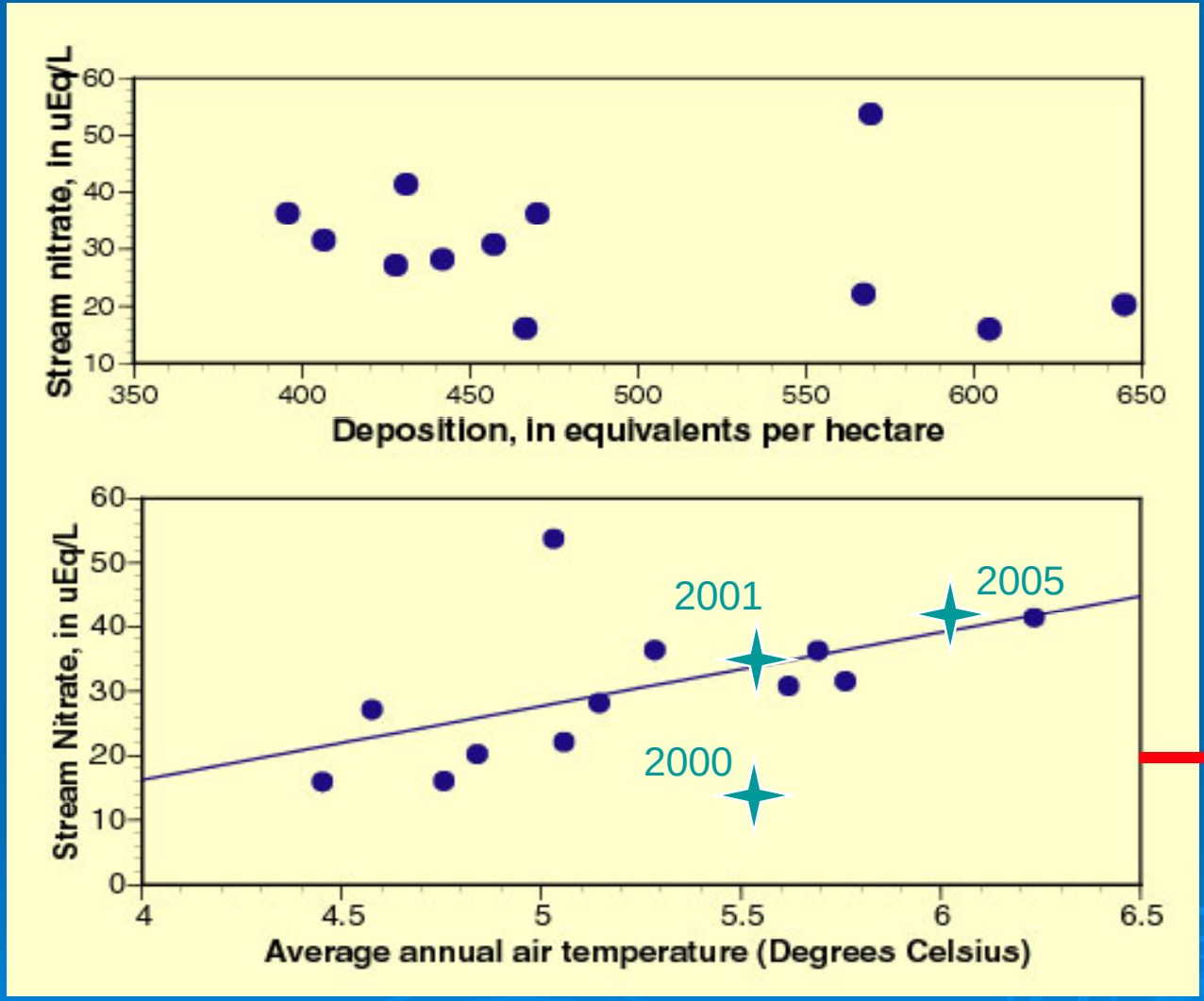
Will a warming climate mitigate of exacerbate existing stressors in forested watersheds of the Northeastern United States?



Annual Air Temperature at Slide Mountain, New York

D.A. Burns, written comm.

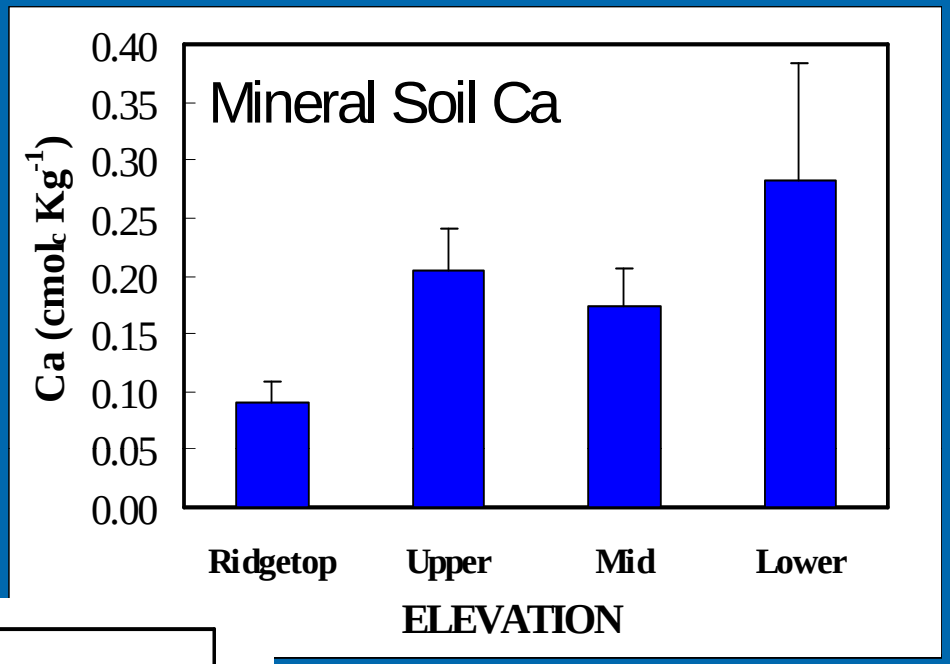
Potential Climate Effect on Nutrient Flux:

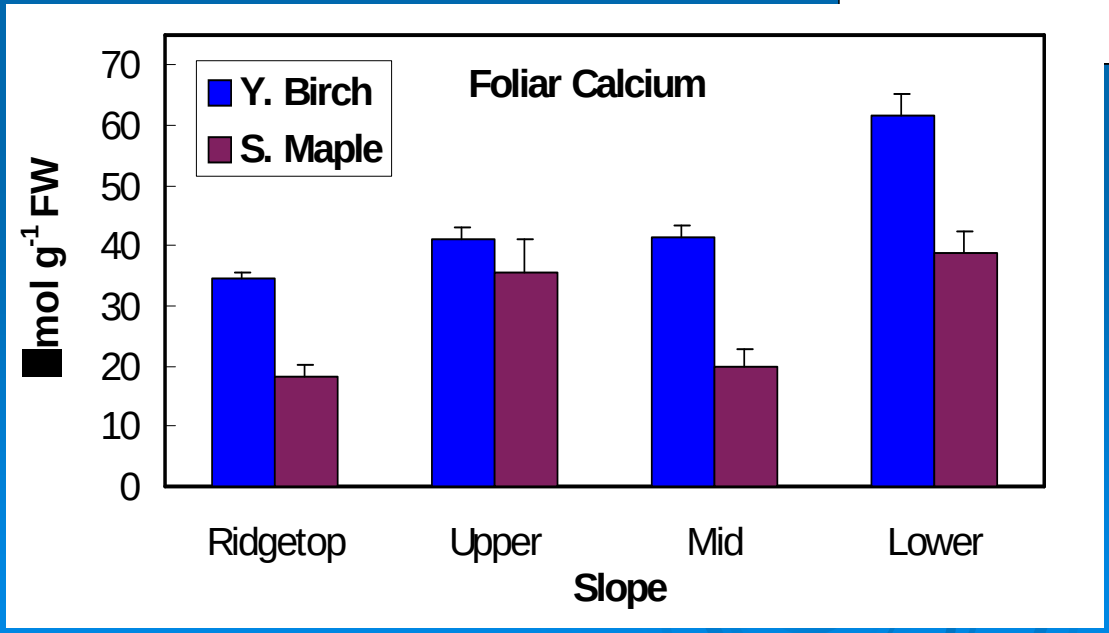


Stream nitrate concentrations are influenced by average annual air temperature

Delaware River Basin: Frost Valley, NY 2000

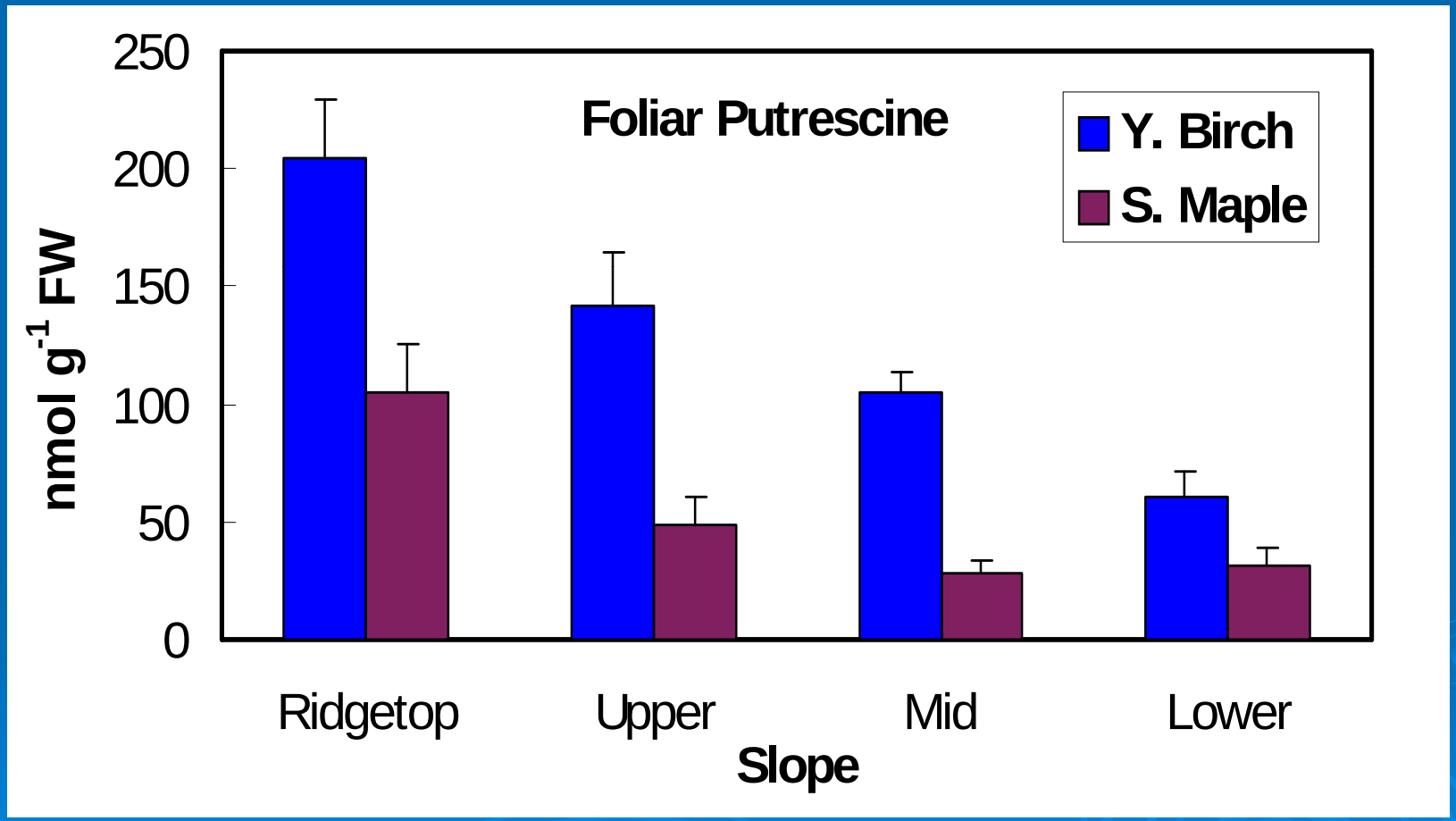
Research plot results: soil and foliar calcium decreased from valley to ridge



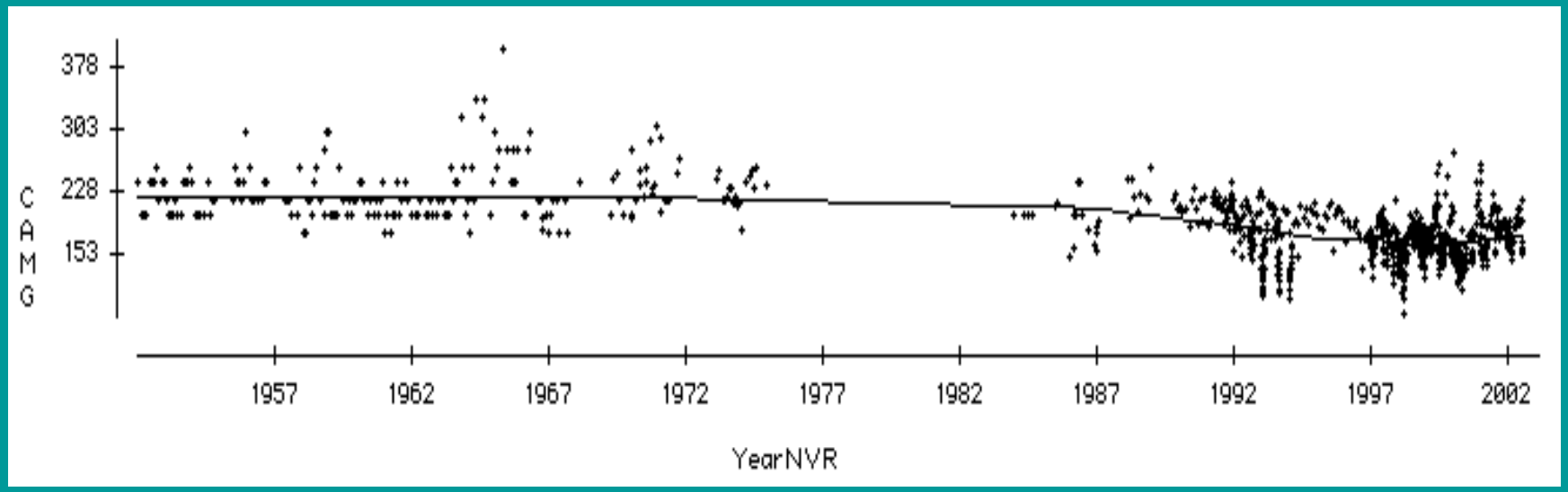


Minocha, USFS

Tree Stress Indicator Increases as Soil Ca Decreases



Minocha, USFS, unpublished data



Intensive Stream Monitoring: Decline in calcium + magnesium concentrations (in microequivalents per liter) in streamwater of the Neversink River, 1952-2002

USGS
science for a changing world

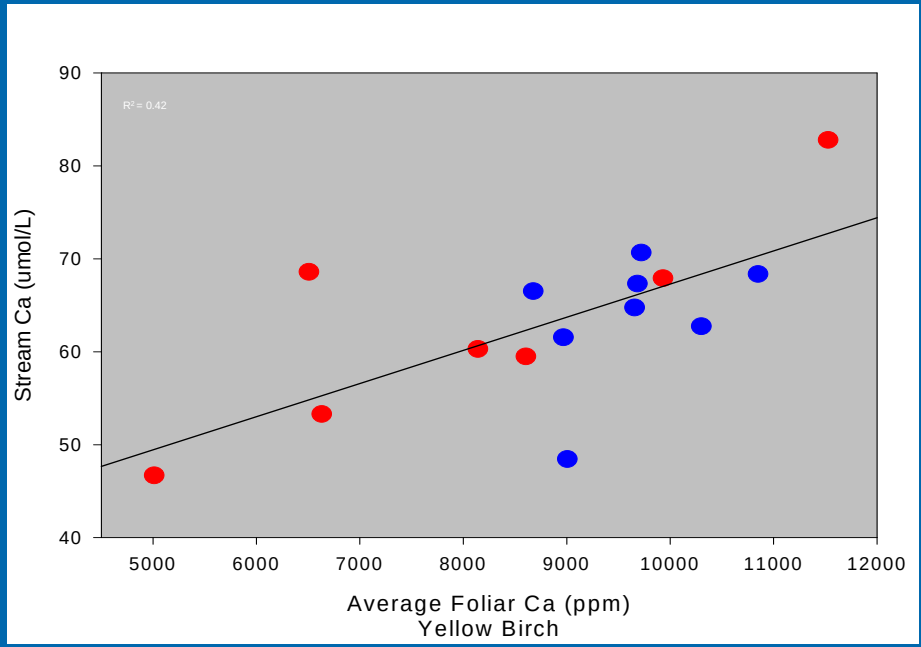
Tier 2: Regional gradient studies

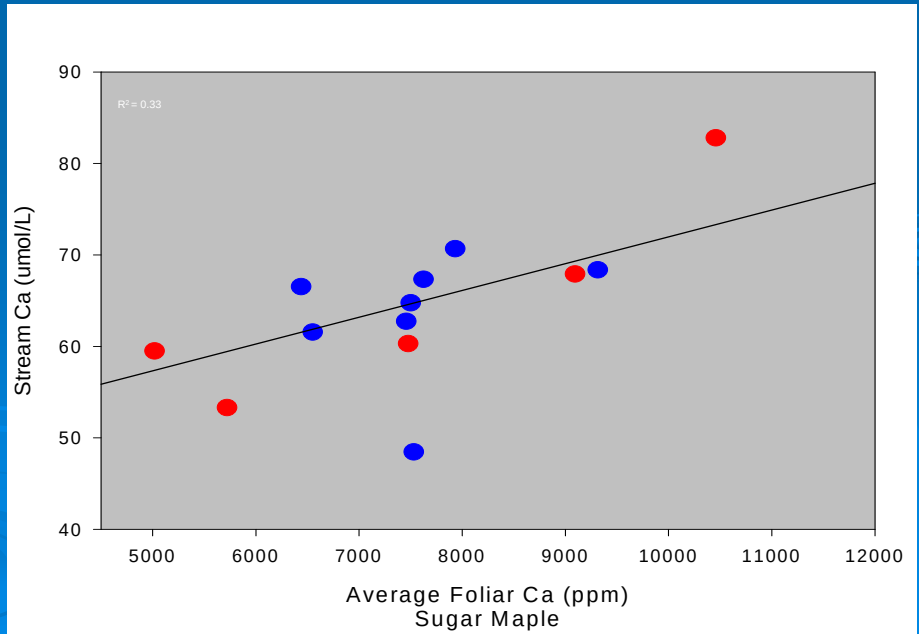
Is regional foliar or soil chemistry correlated with stream chemistry?

NY Watersheds
NH Watersheds

Hallet, USFS

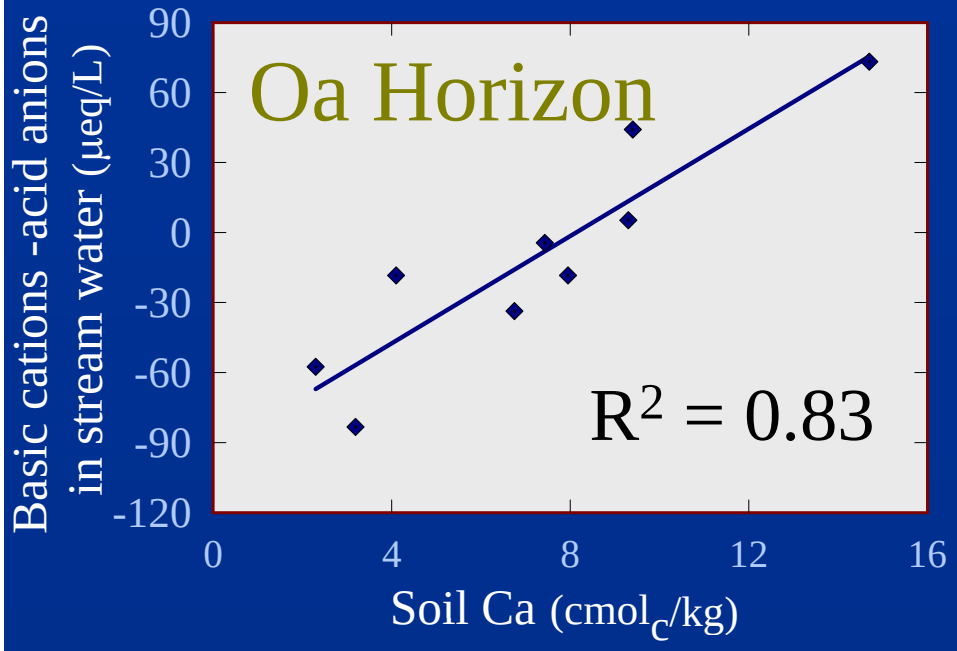
Regional gradient study of stream and foliar Calcium concentration





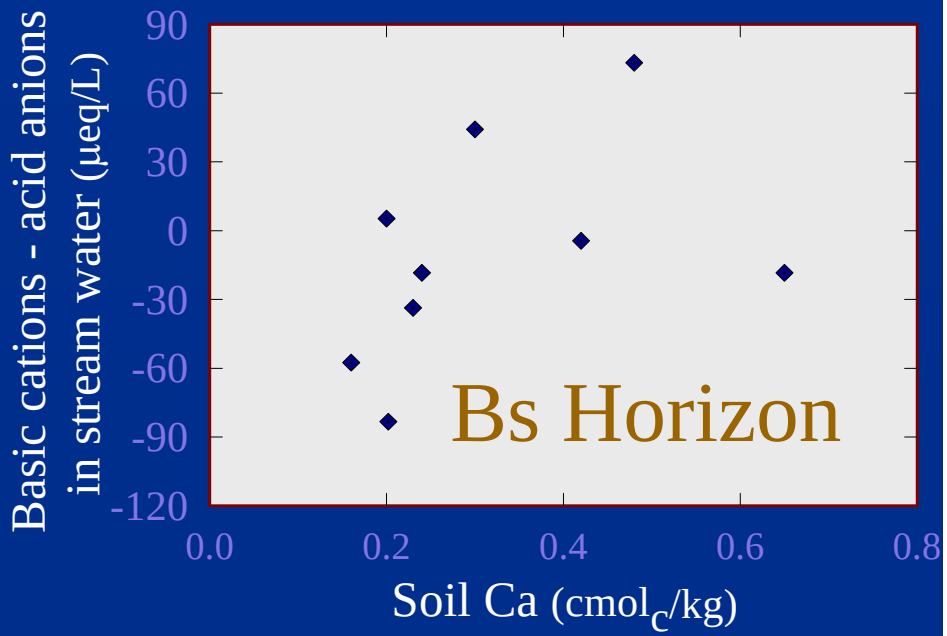
Tier 2: Stream and soil sampling at watersheds representing a gradient of stream and soil condition.

Northeastern Watersheds



Are regional foliar or soil chemistry correlated with stream chemistry? Yes

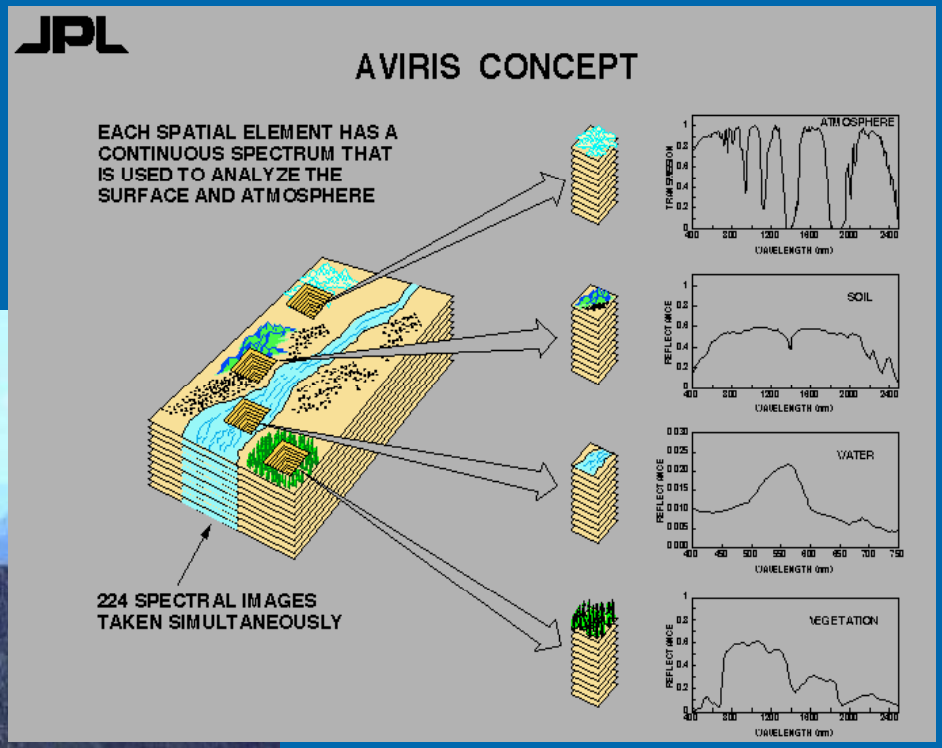
Northeastern Watersheds



Lawrence, USGS

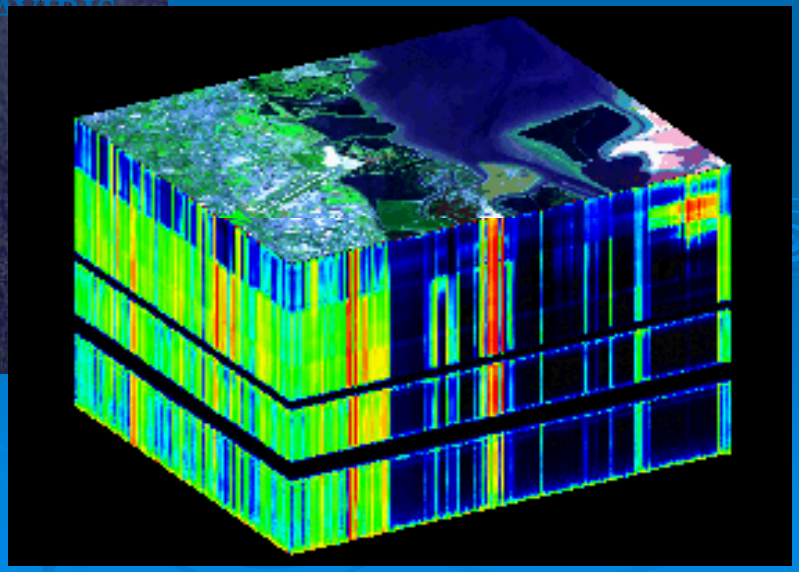
Tier 4: AVIRIS

Airborne Visible/InfraRed Imaging Spectrometer



The NASA Airborne Visible-Infrared Imaging Spectrometer (AVIRIS)

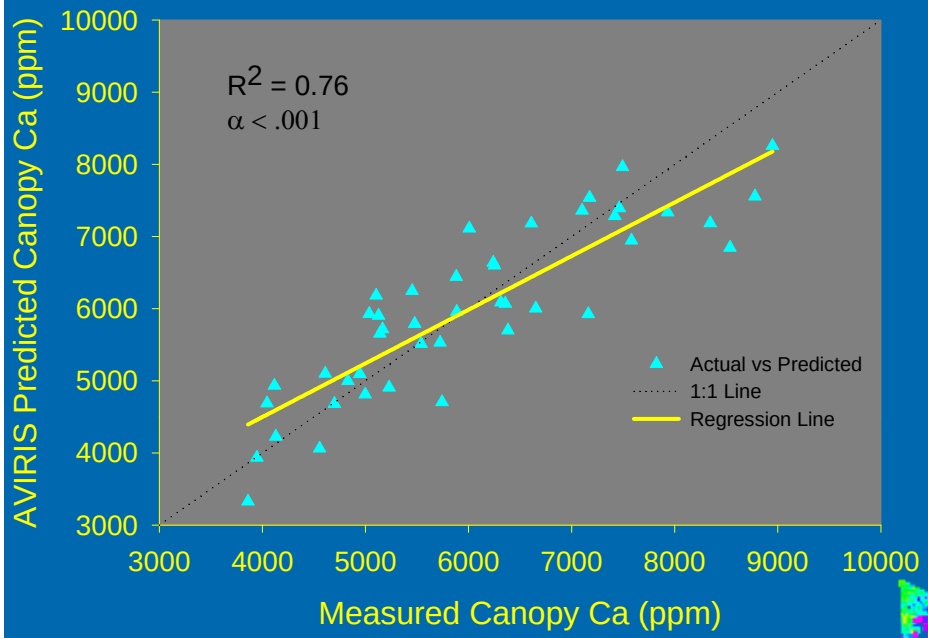
- Flown on a NASA ER-2 aircraft at an altitude of 20km
- Measures 224 contiguous spectral bands from 400-2400nm
- Spectral Resolution = 10nm
- Spatial Resolution = 20m

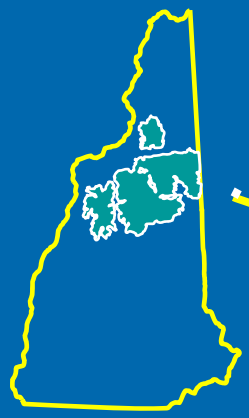


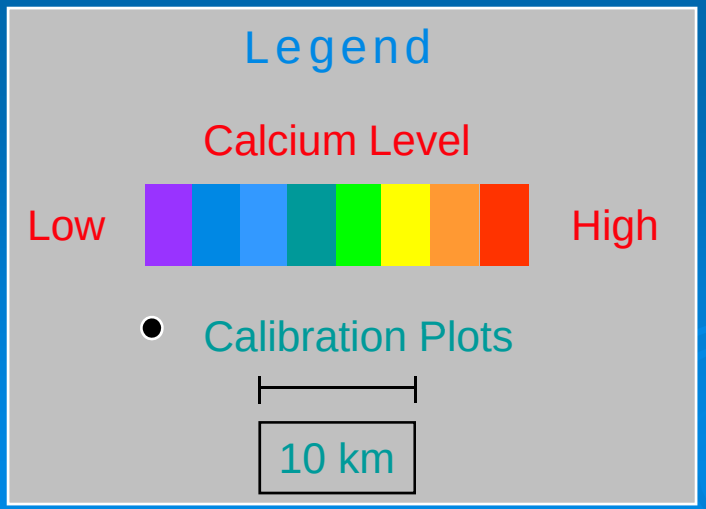
The resulting 224 band layer image is known as an “image cube”. When the data from each band is plotted on a graph, it yields a spectrum.

Hallet, USFS

Predicted Foliar Ca for the WMNF

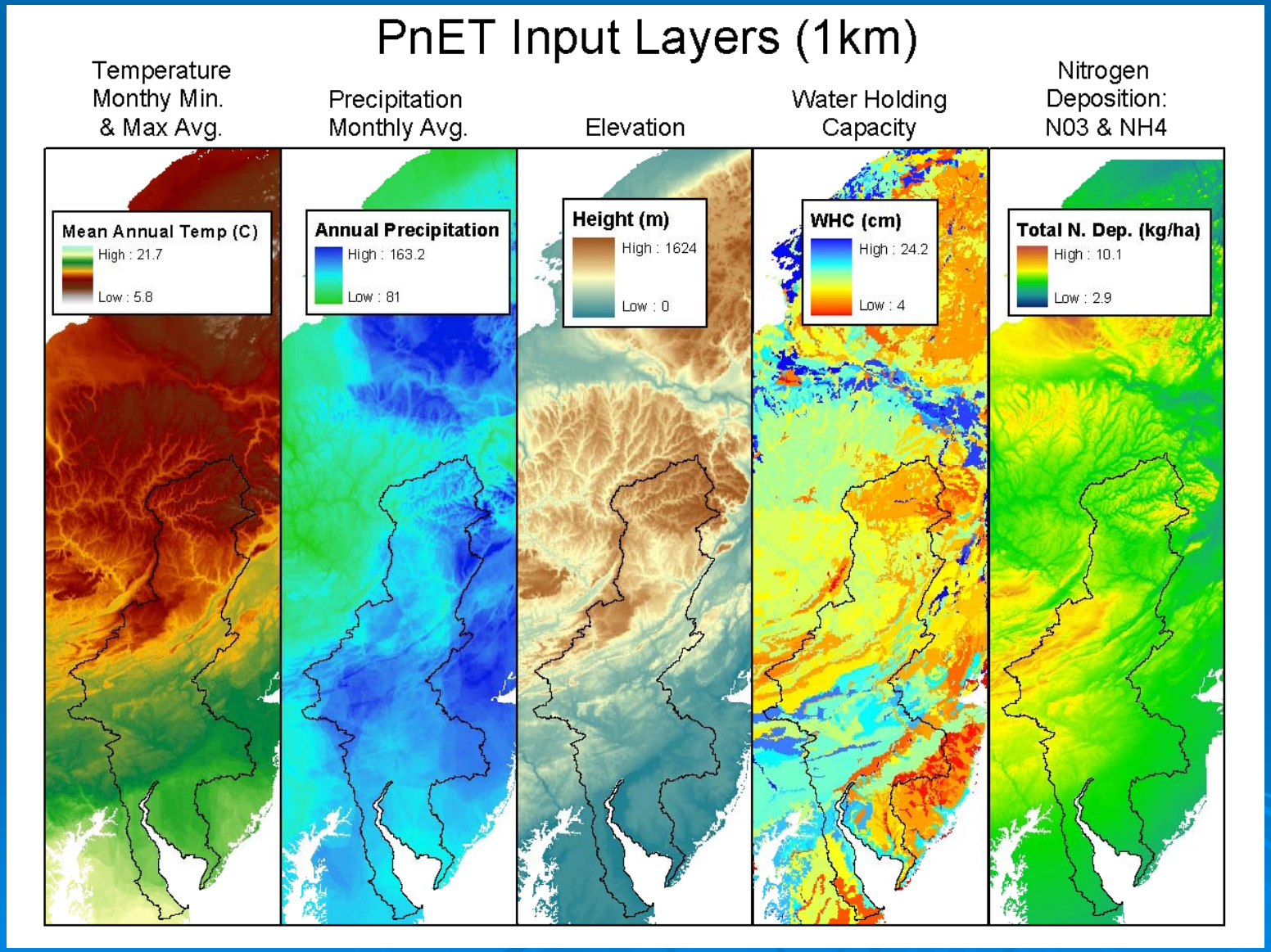






Hallet, USFS

Data integration through modeling

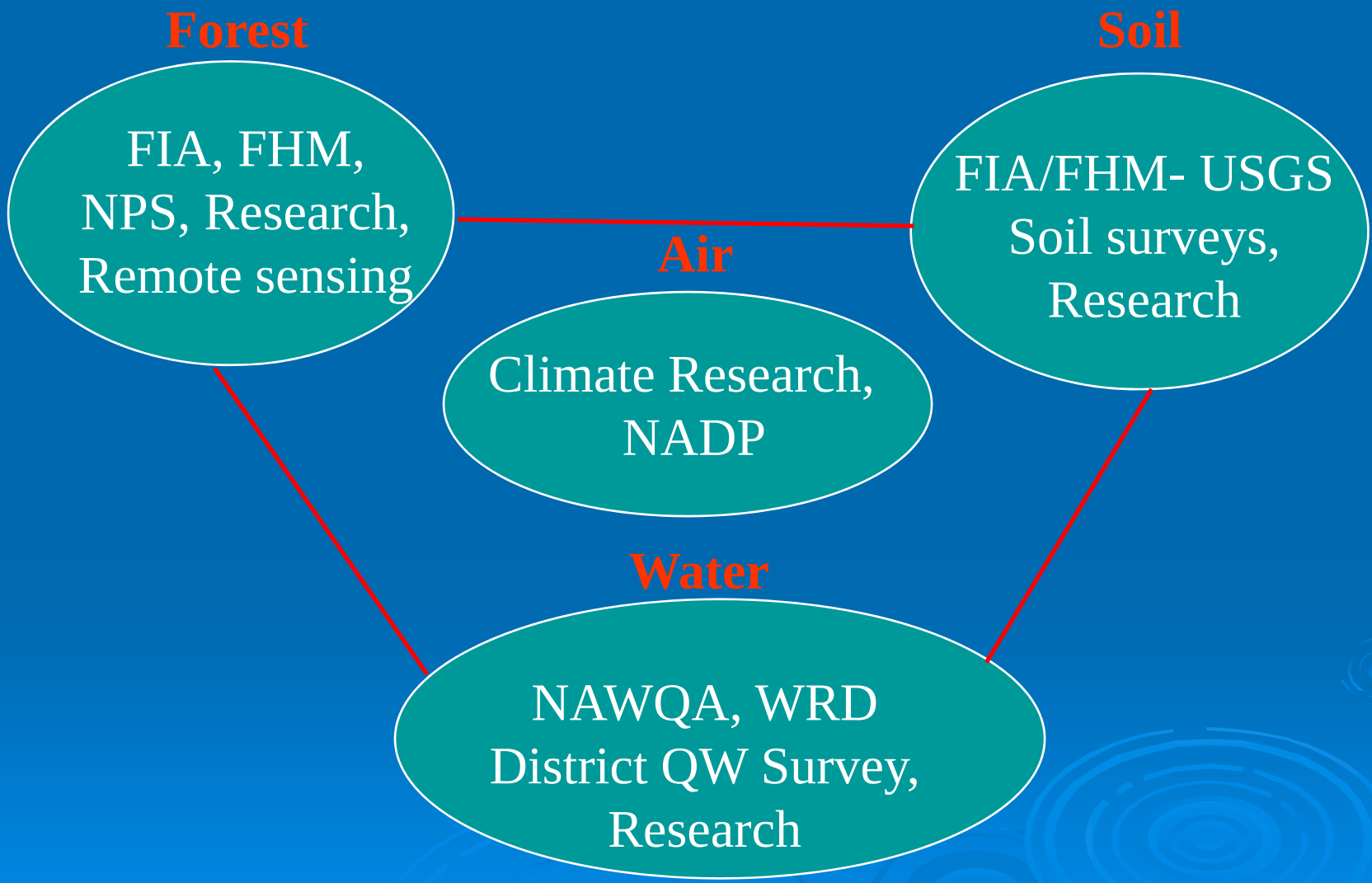


Pan and others, in process

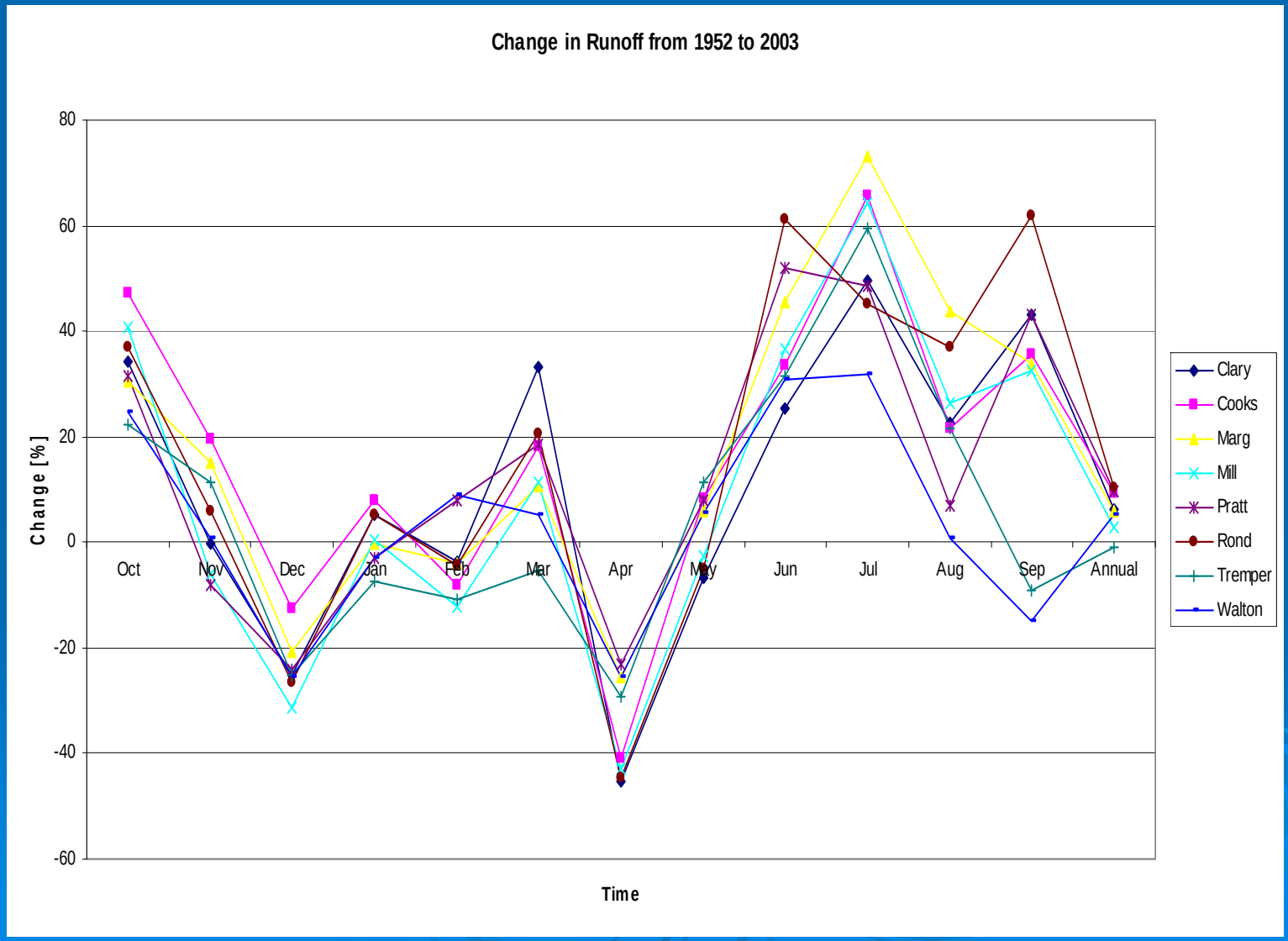
Management Scenarios:

- Nitrogen emissions from cars and factories are reduced to compensate for the increased release from soils due to warming.
- Sugar maple stands with low calcium are detected through the network and are limed to retain the sugaring industry in southeastern New York.
- Invasive pest and plant management uses soil chemistry maps to determine regions of focused mitigation.
- Logging is limited to selective harvest in areas of soil and tree stress.

Integrated Regional Assessment of Disturbance Effects on Vegetation, Soil, and Water in Forested Landscapes



Change in Runoff 1952-2003

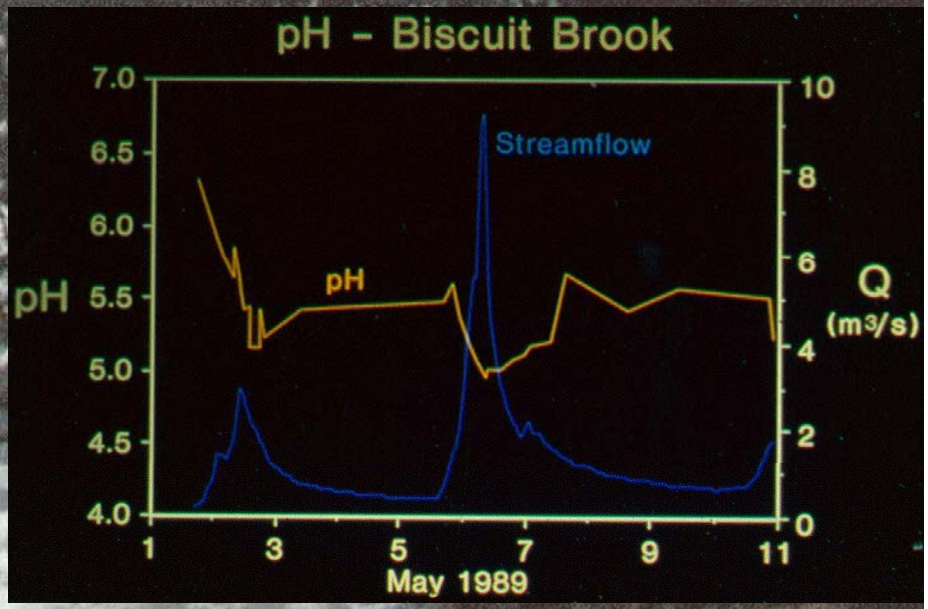


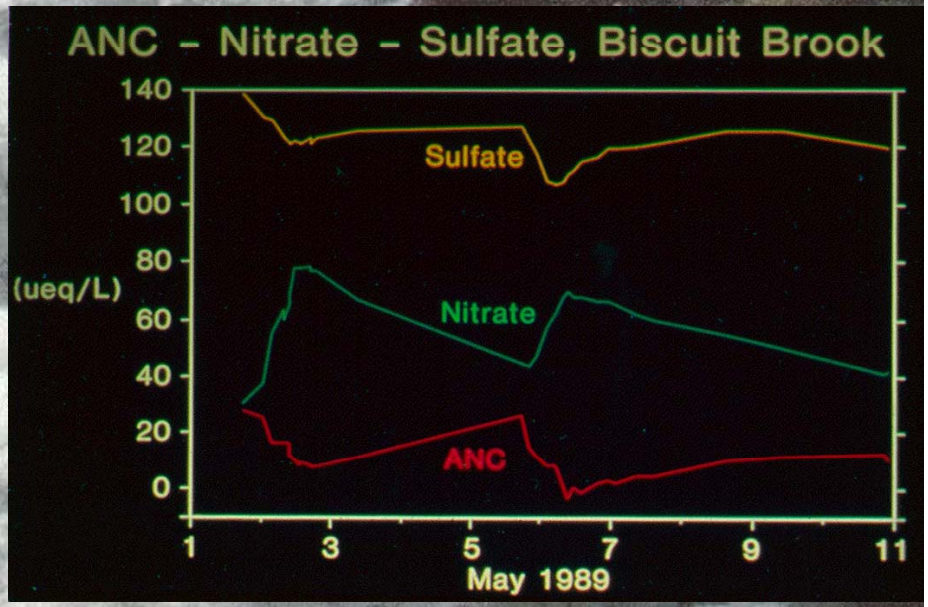
Episodic Acidification

Biscuit Brook, NY

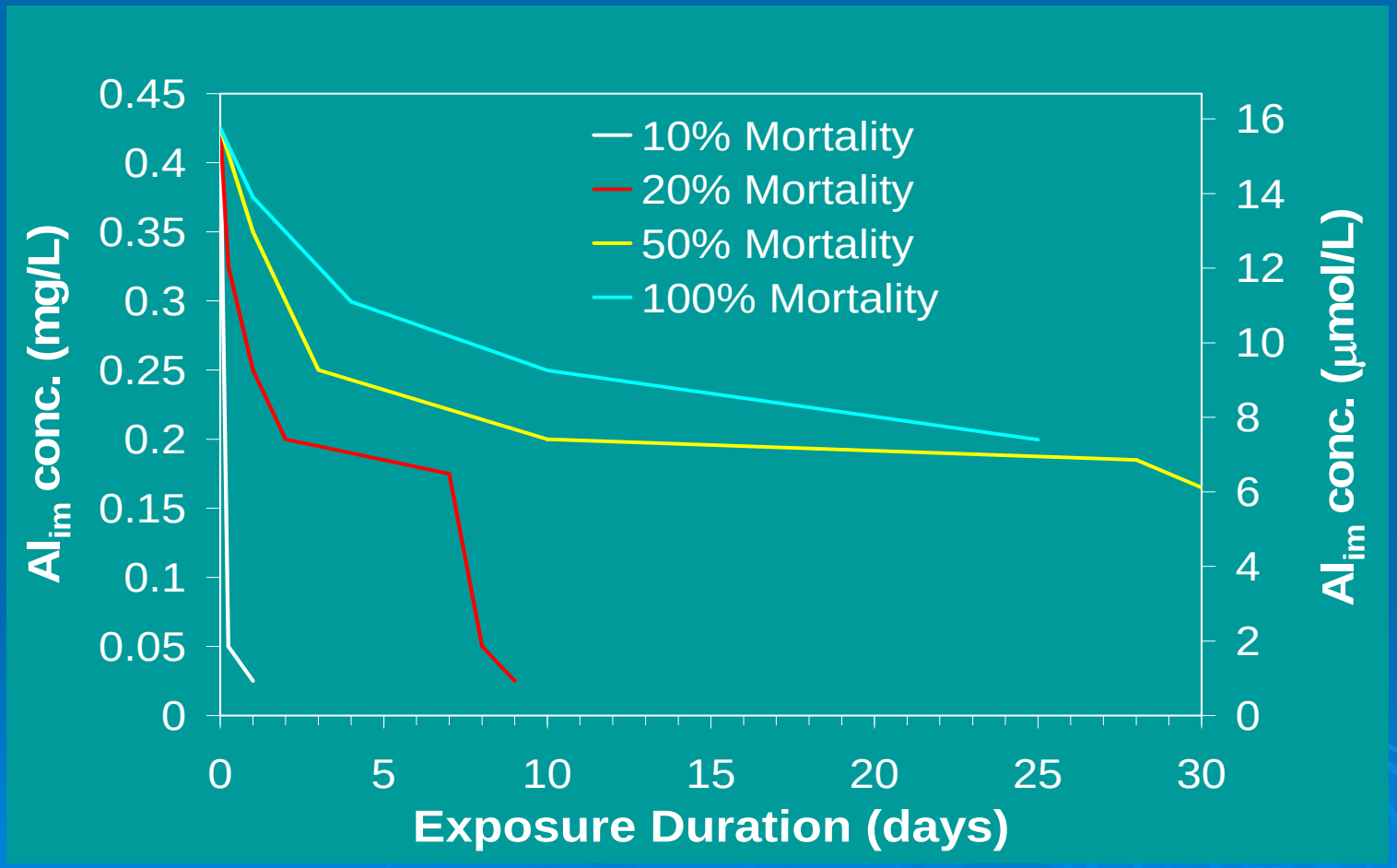
Evidence in the Catskills showed::

- Large pH and ANC decline associated with increased nitrate and decreased sulfate concentrations
- Increases in inorganic aluminum and associated fish mortality.



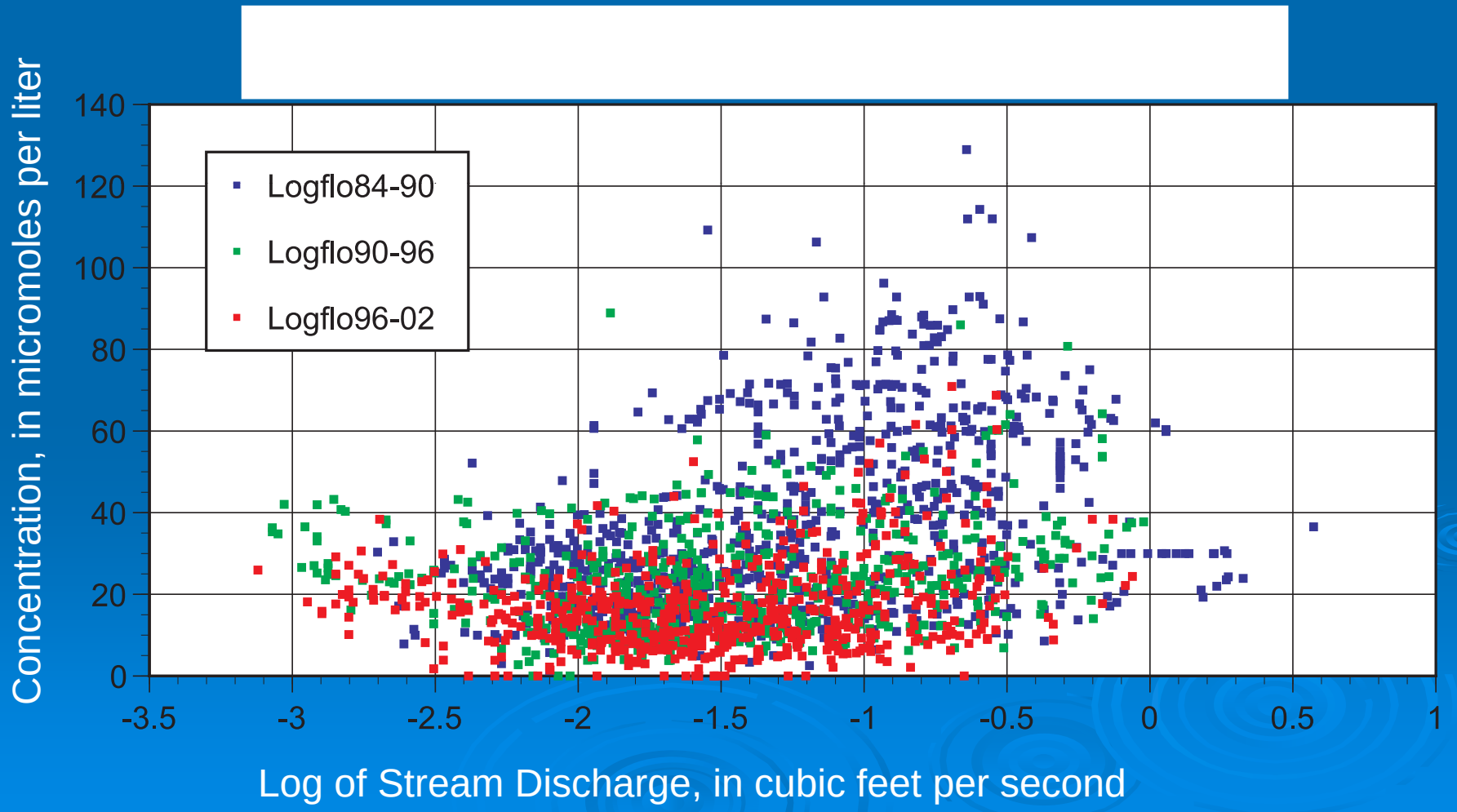


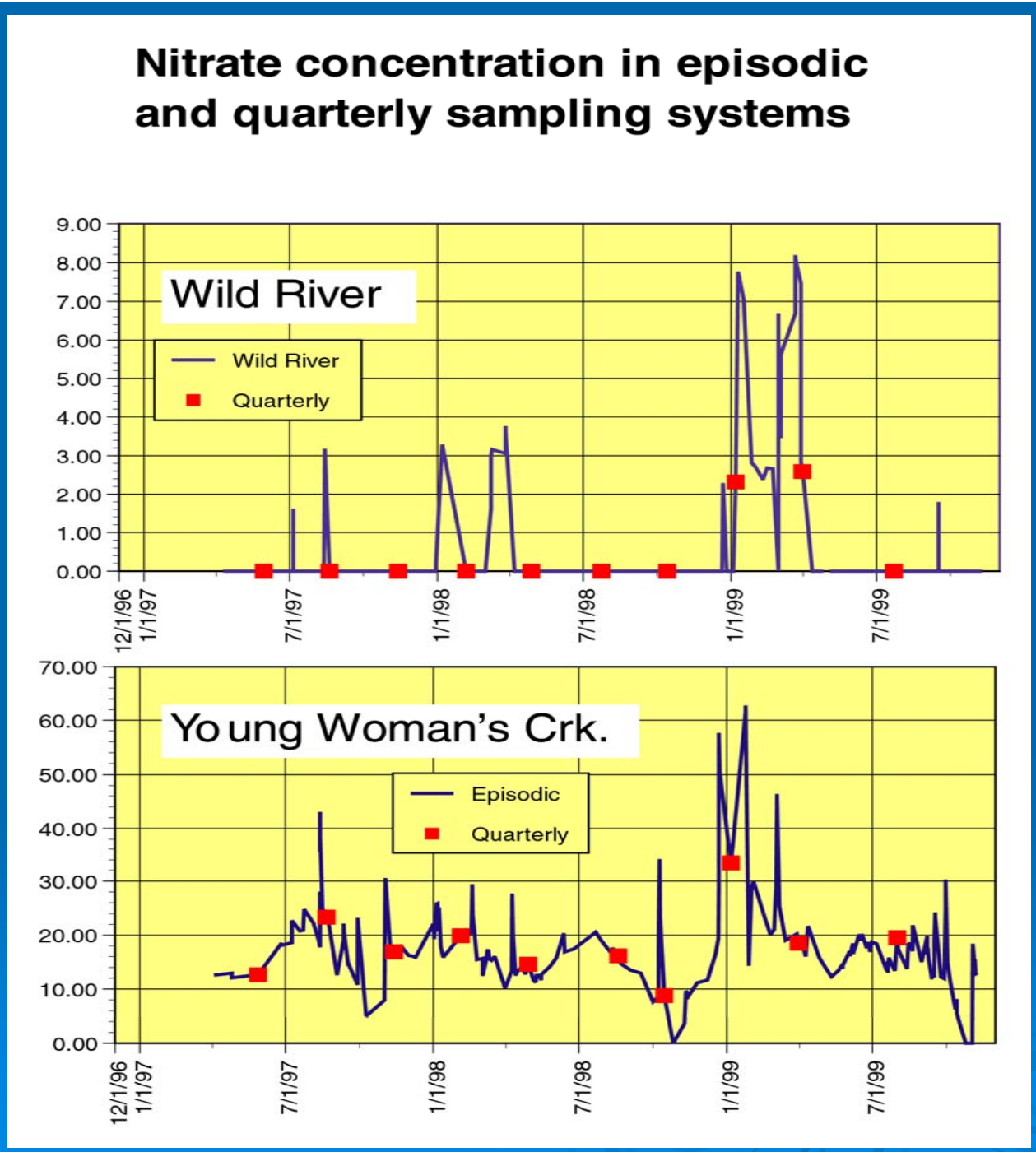
Brook Trout Mortality in Bioassays: Thresholds



Baldigo, 2002

Nitrate Concentration-Discharge Relation

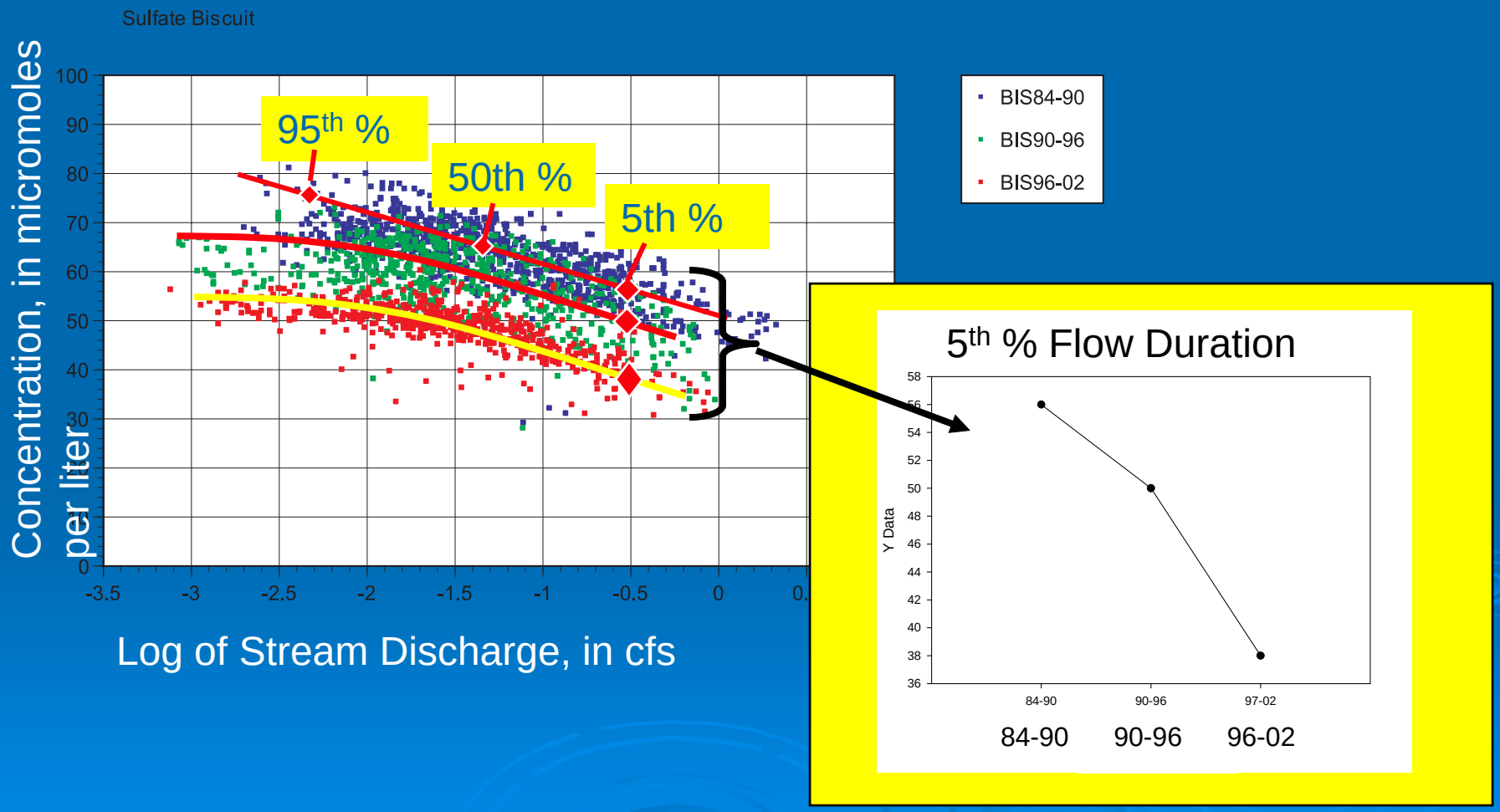


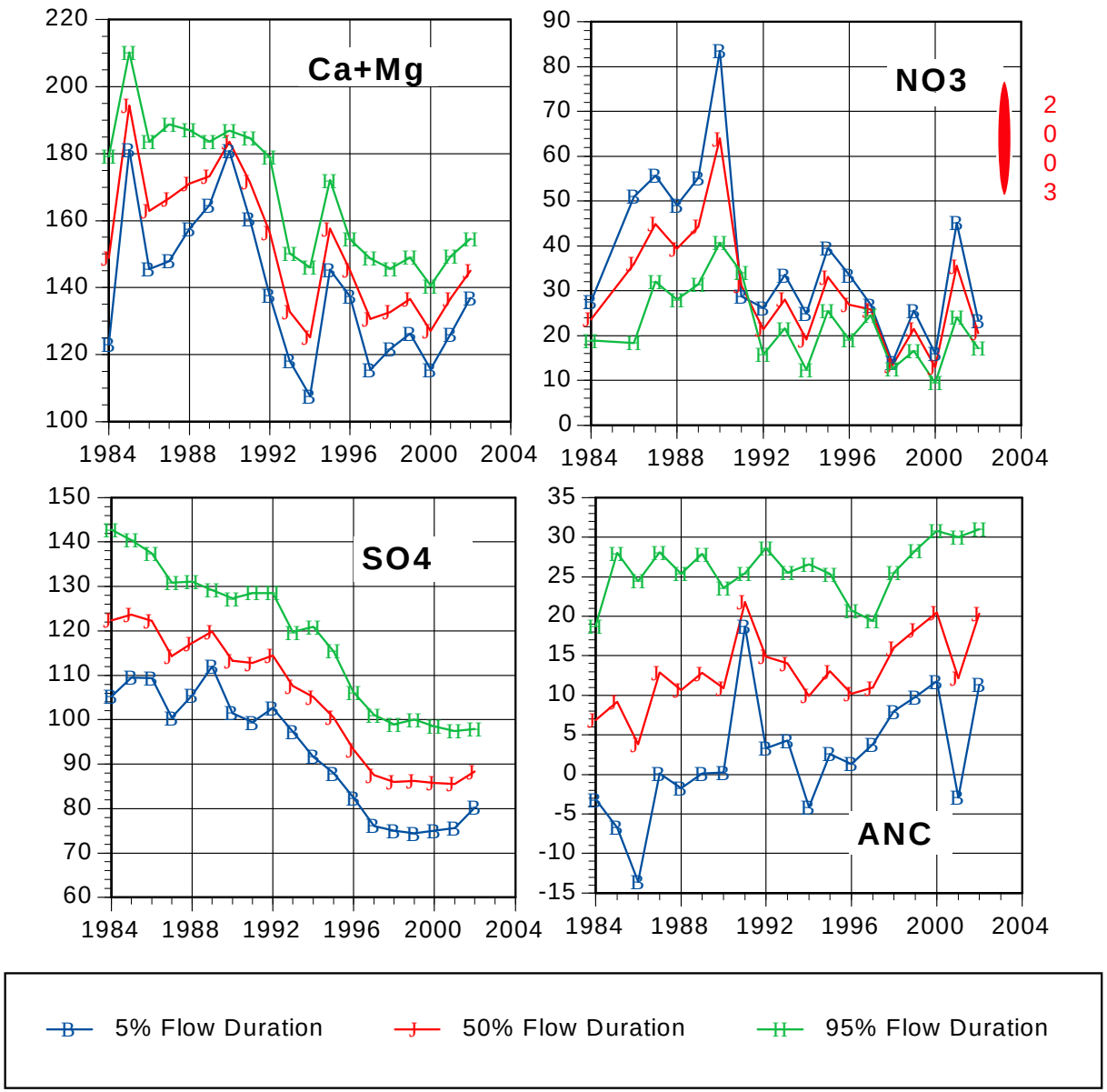


How do we sample to capture trends in high flow?

Quarterly sampling misses the peak concentrations

Developing a flow-specific trend

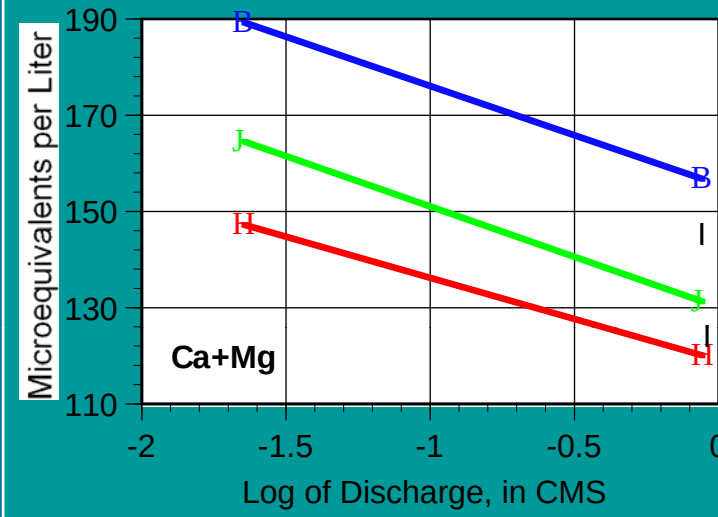


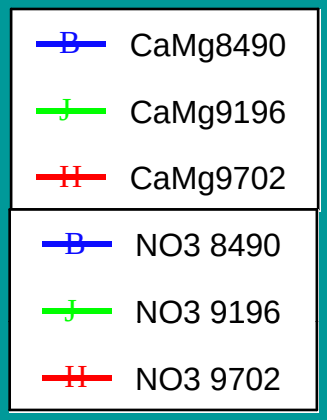


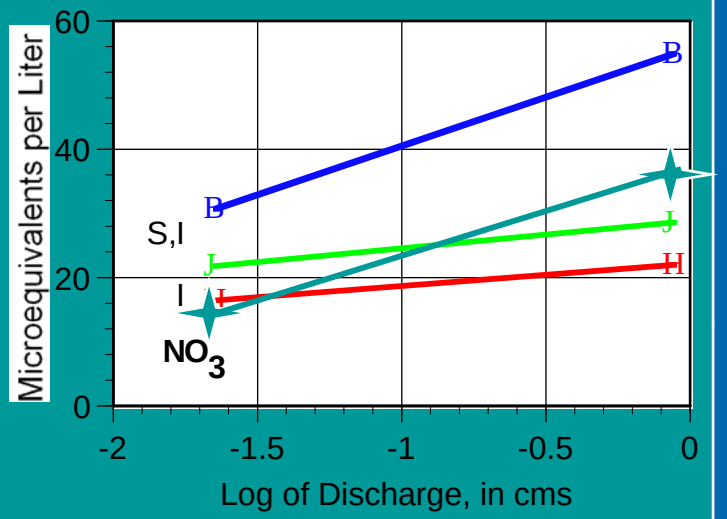
Annual estimated concentrations at high, medium and low flow based on C-Q relations

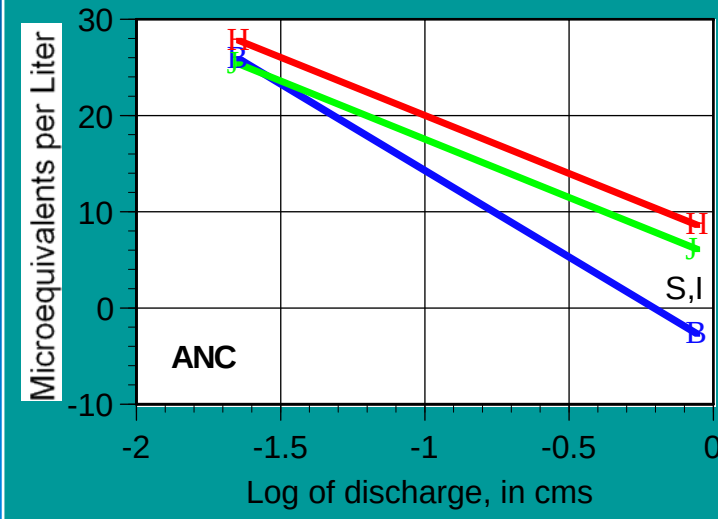
- ANC increases to flat
- SO4 decreases to flat, increasing at high Q
- Ca-Mg decreases to flat, increases at all Q
- Nitrate crashes in ’91
- CaMg and NO3 convergence

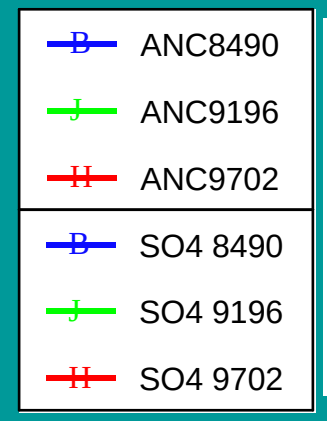
Analysis of Variance for 6-year intervals at Biscuit Brook (S=sig. difference in slope; I= sig. difference in intercept)

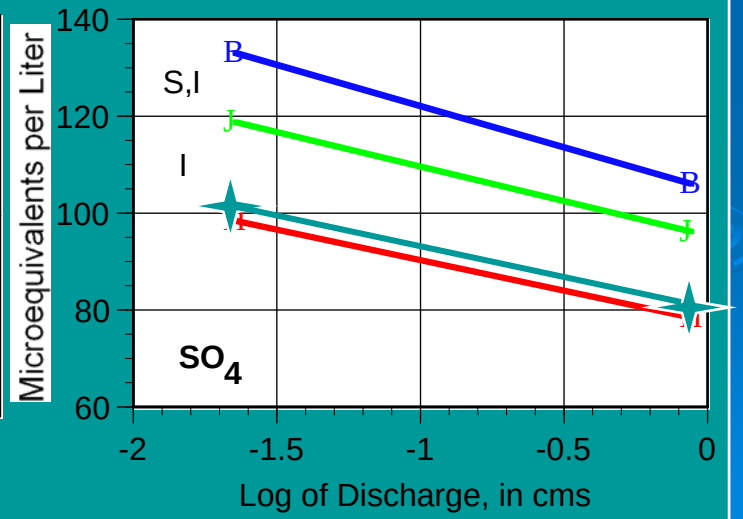




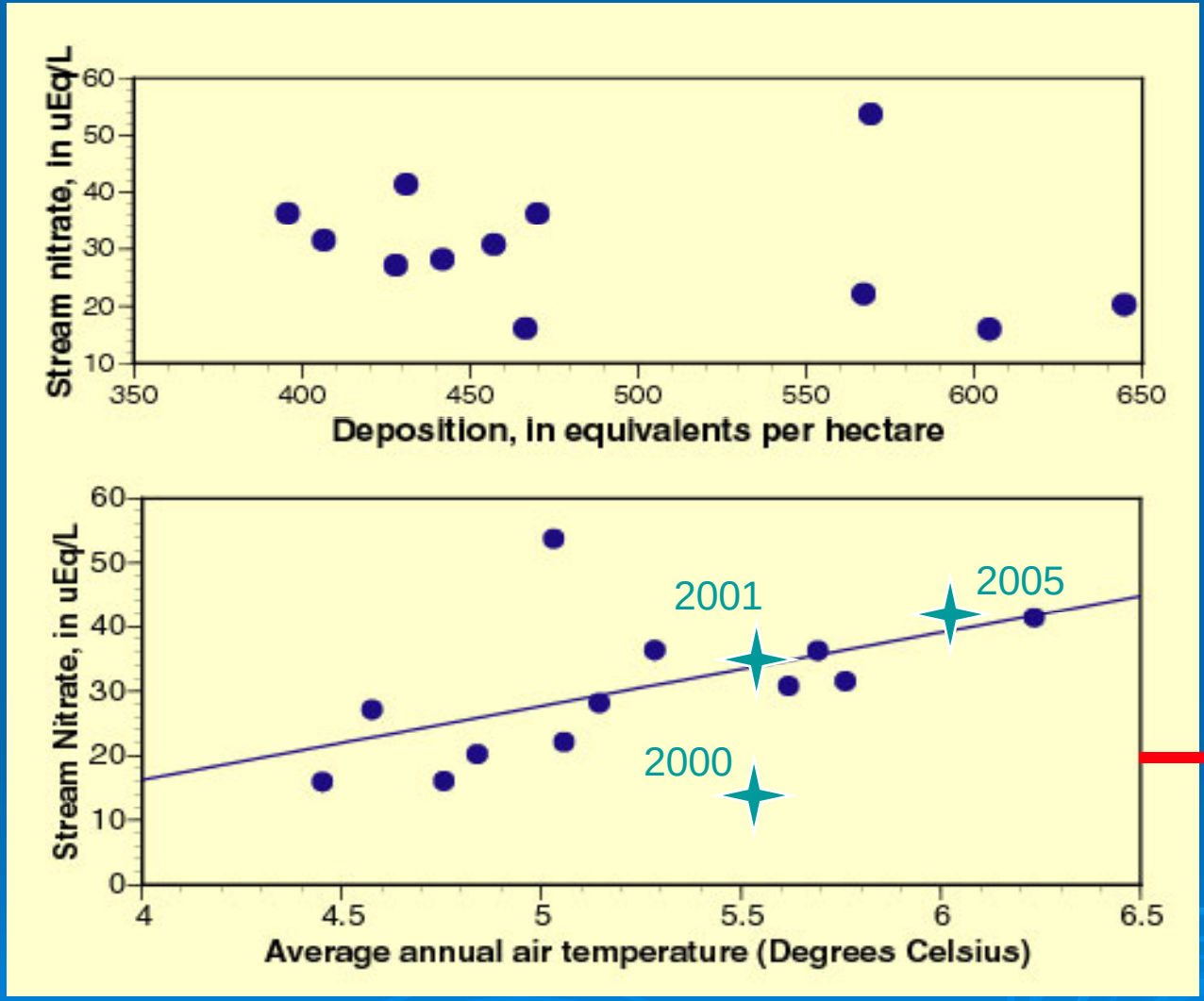




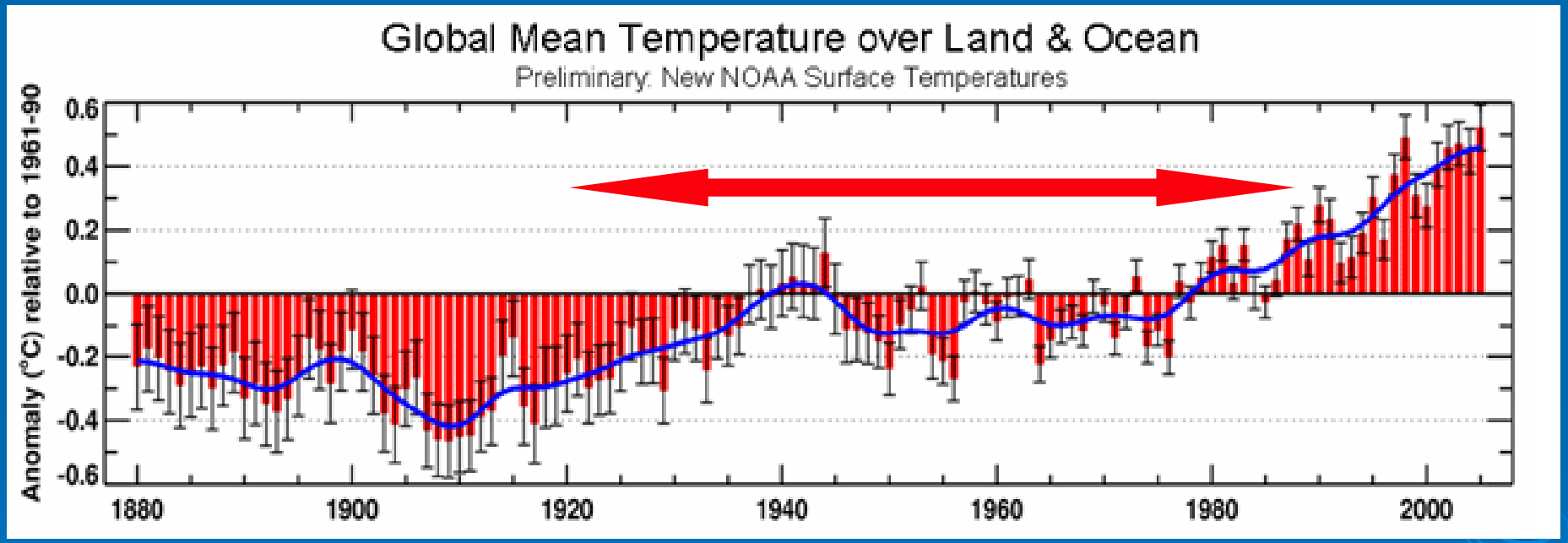




Potential Climate Effect on Nutrient Flux:



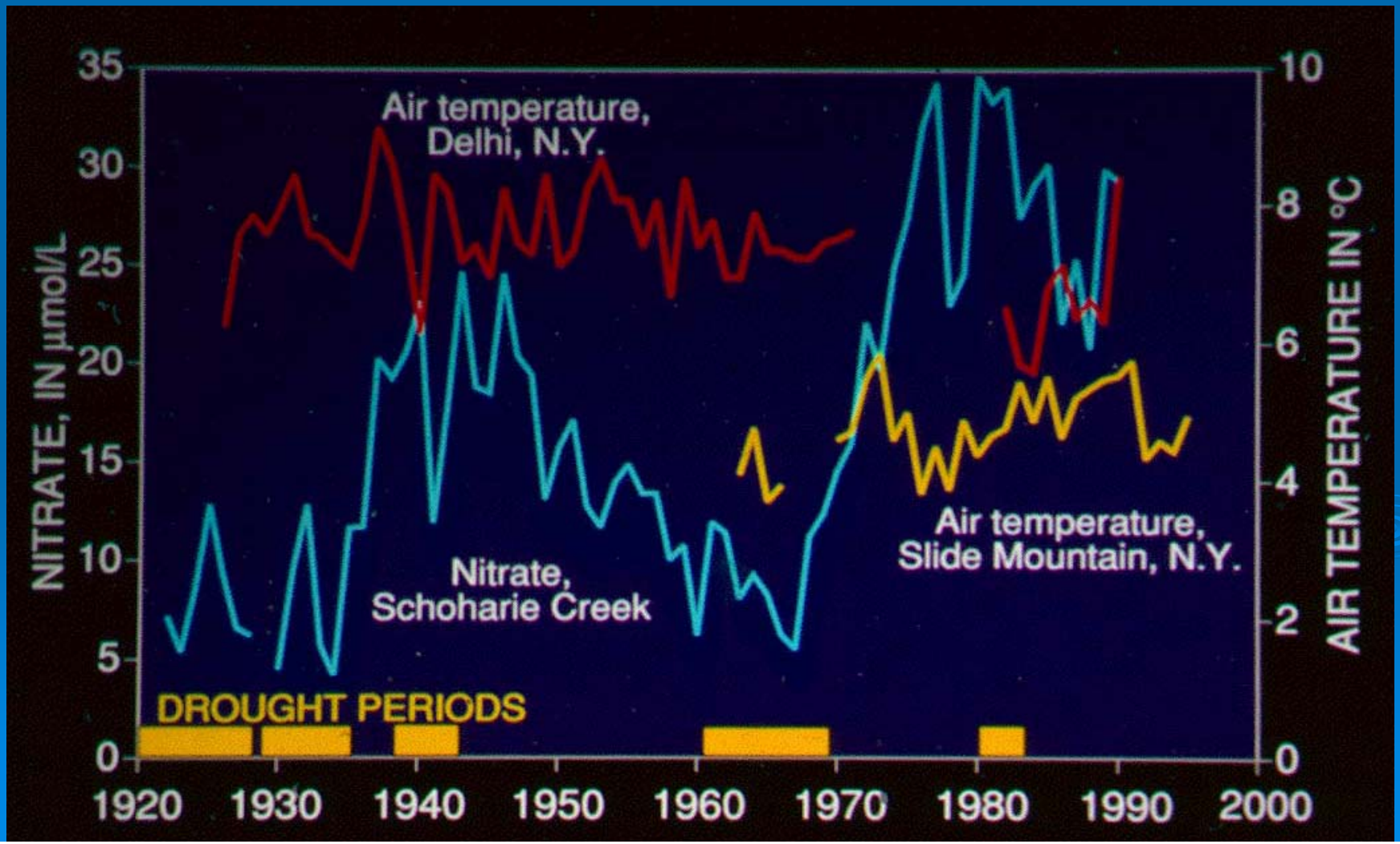
Stream nitrate concentrations are influenced by average annual air temperature


Global Mean Temperature over Land & Ocean
Preliminary: New NOAA Surface Temperatures
Anomaly (°C) relative to 1961-90
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1880
1900
1920
1940
1960
1980
2000

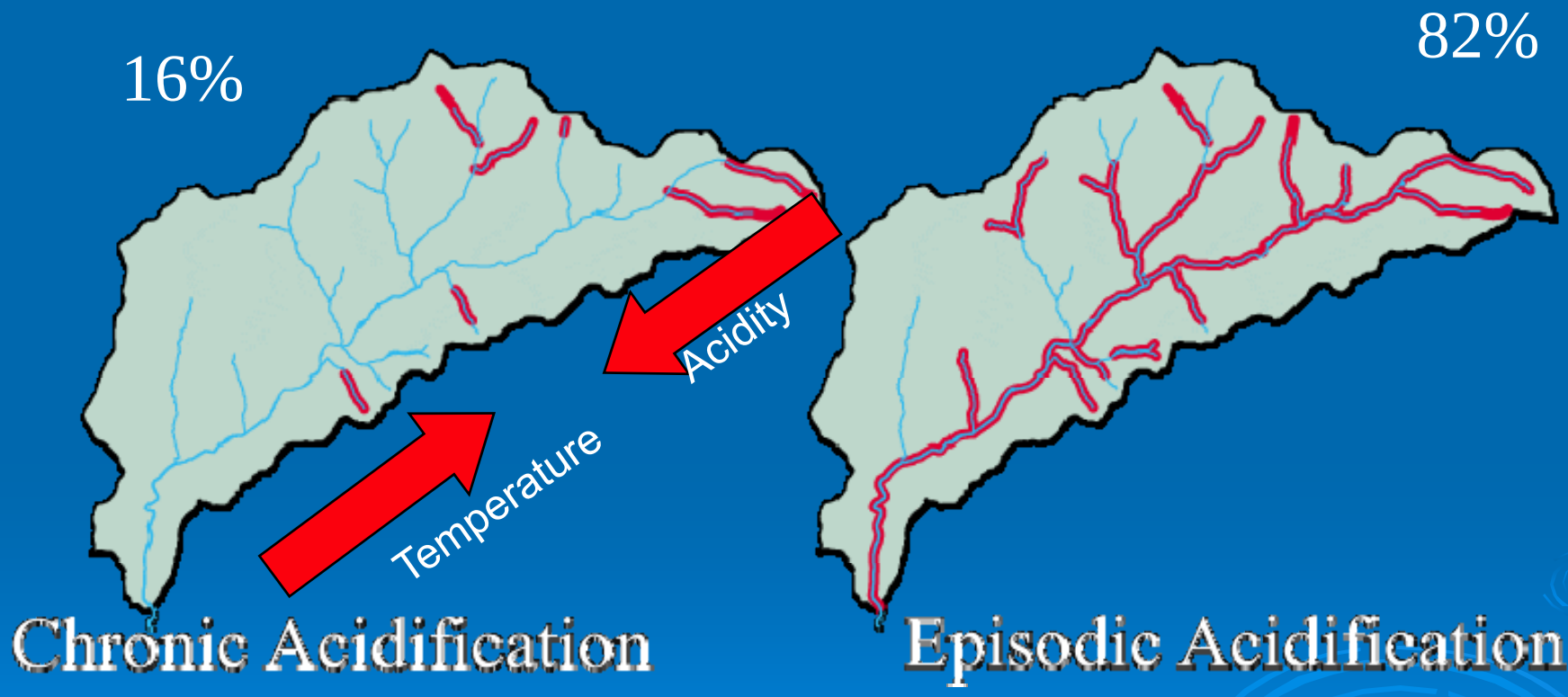
1880-2005

NE Forests thought to be “Nitrogen-Limited”

First indications of change in the stream



Neversink Watershed
A “Thermal-Acid” Squeeze?



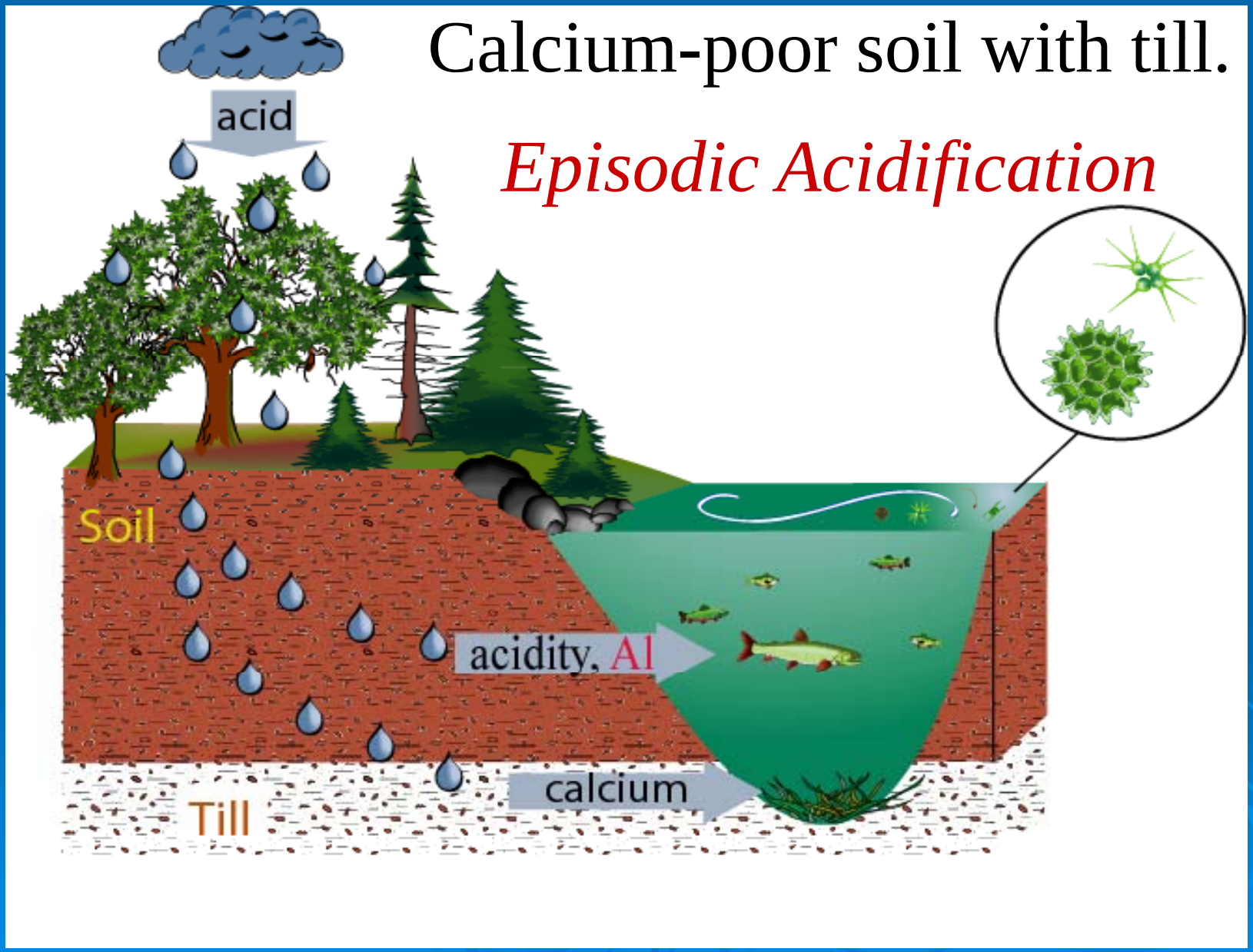
Lawrence, 2003

Increasing temperature forces fish upstream, pH will force them down

Complication:

Calcium-poor soil with till.

Episodic Acidification



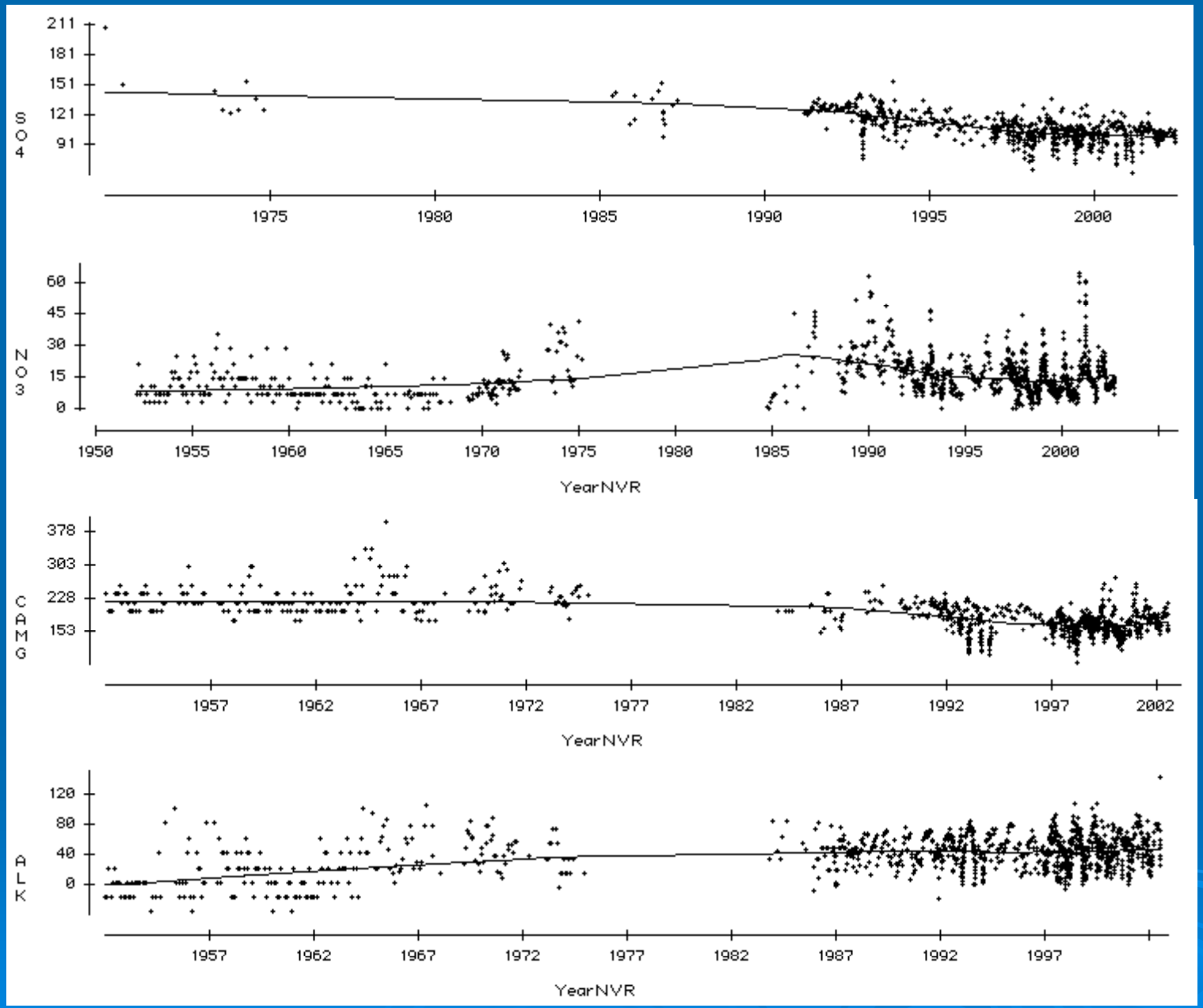
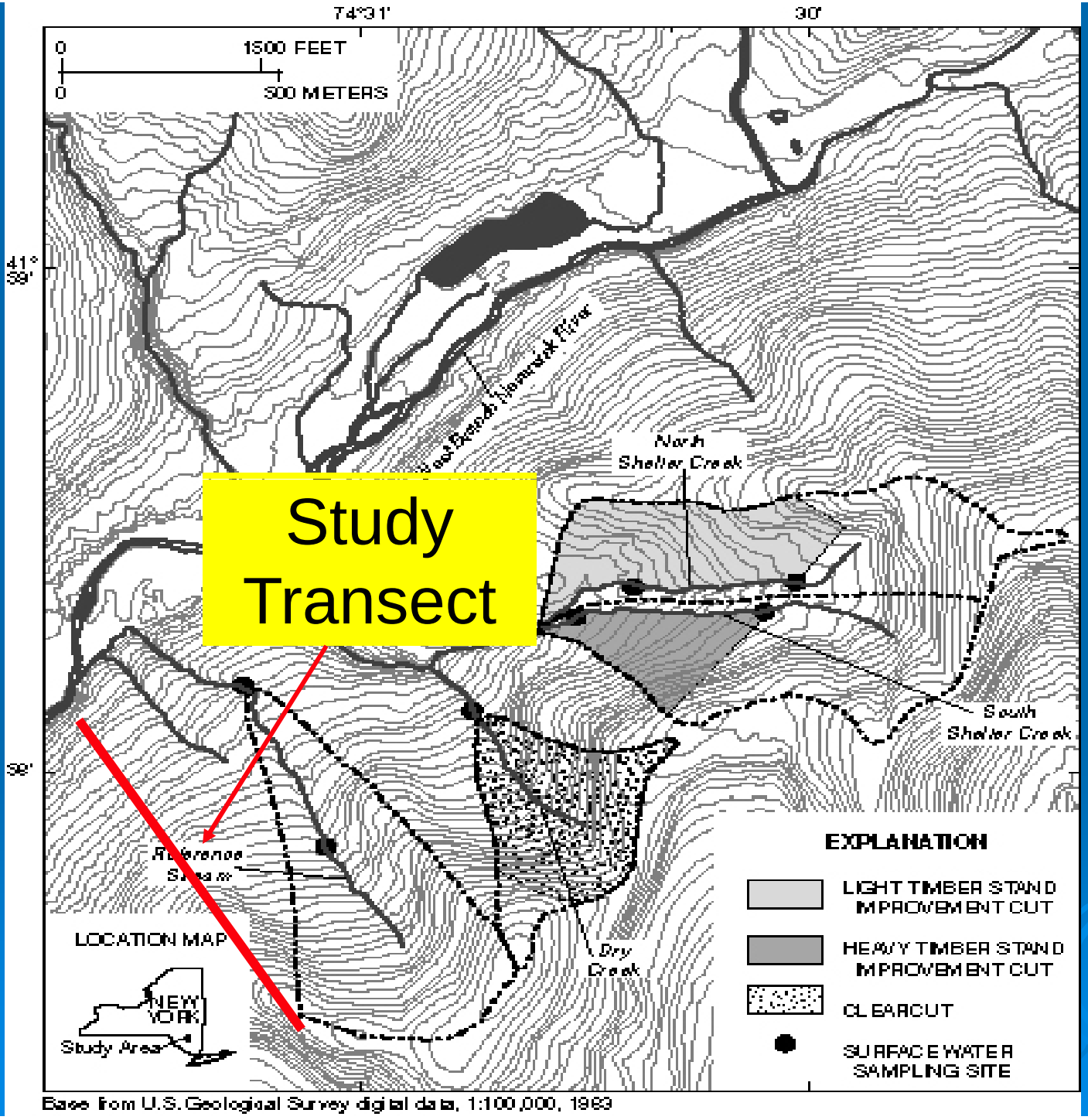
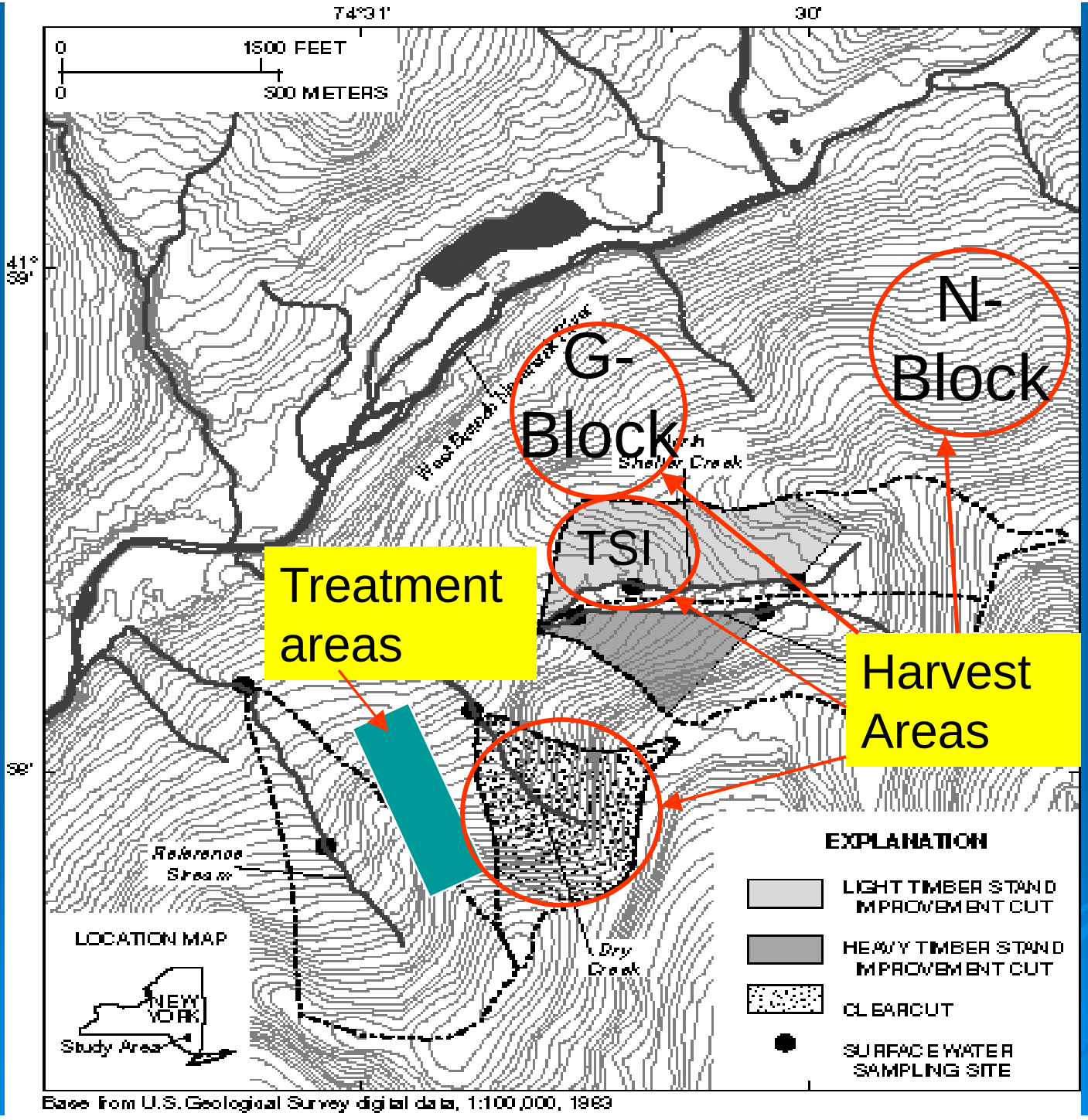


Figure 3b. Concentrations of SO4, NO3, Ca+Mg, and Alkainity in river water at Neversink River, 1952-2002. Concentrations in uEq/L.



Strategy:

Sample soils and foliage at 4 elevations



Strategy:

Nutrient addition and partial harvest plots

Project is integrated with the Model Forest and USGS Phase-I research area

Harvest Block Pre-cut Condition

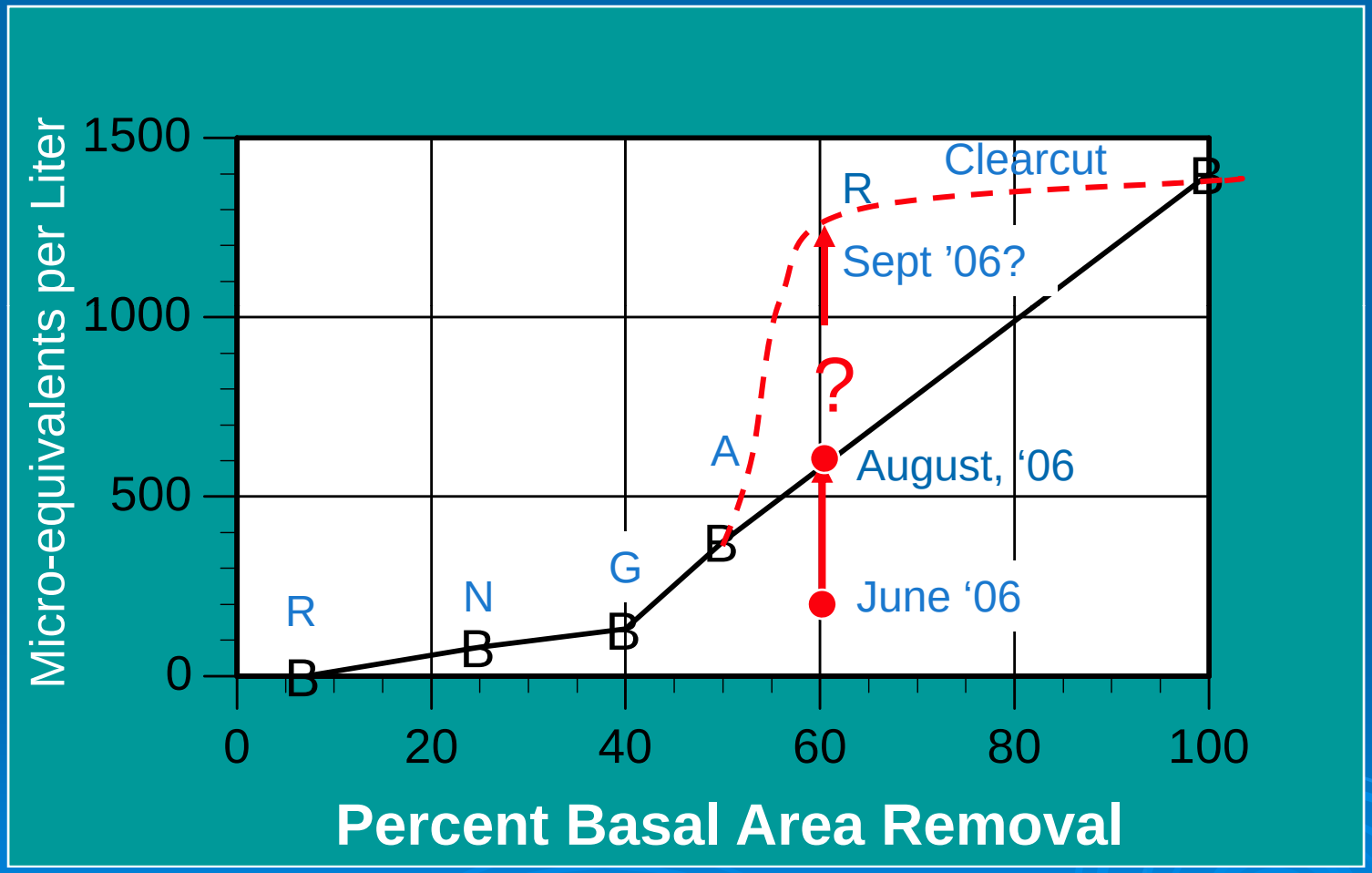
- Block N: 130 sq ft./acre
- Block G: 126 sq ft/acre
- Block A: 130.9 sq ft/acre

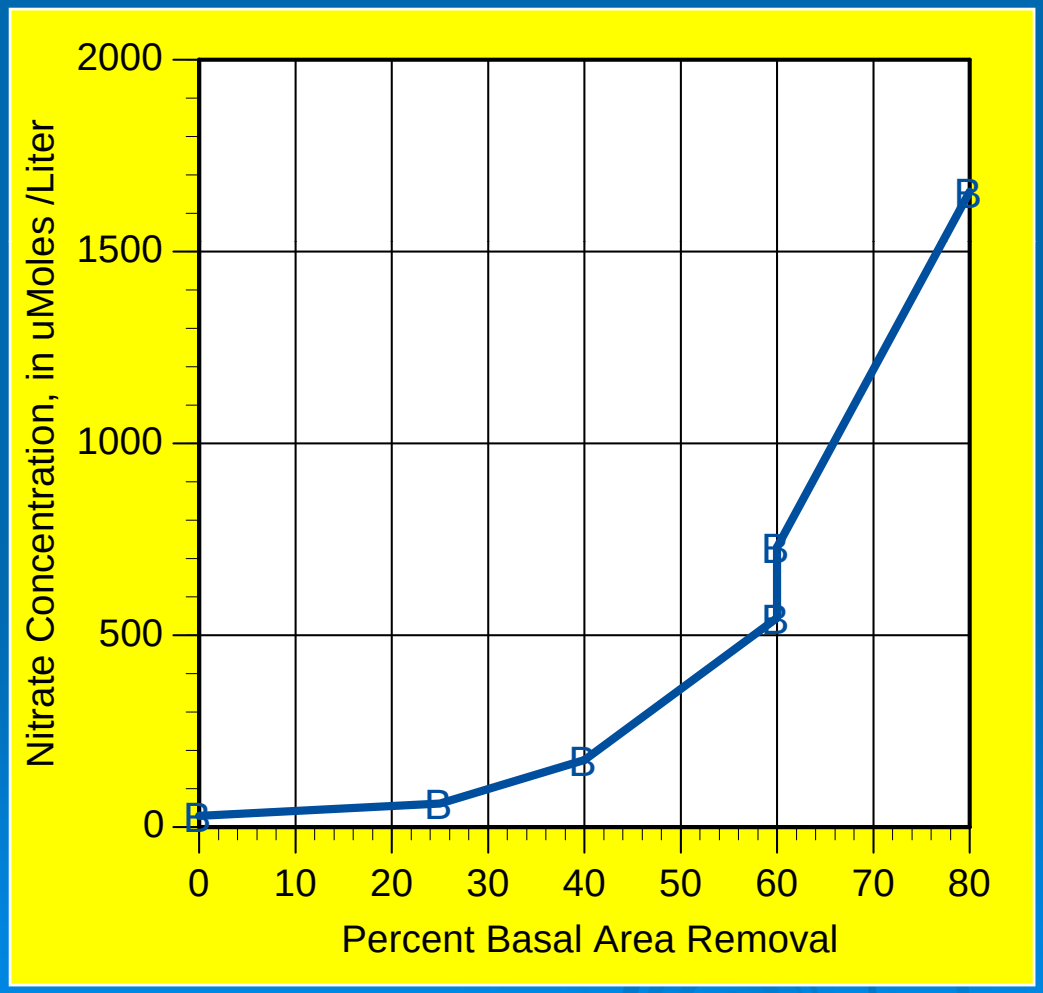
Basal Area Removal

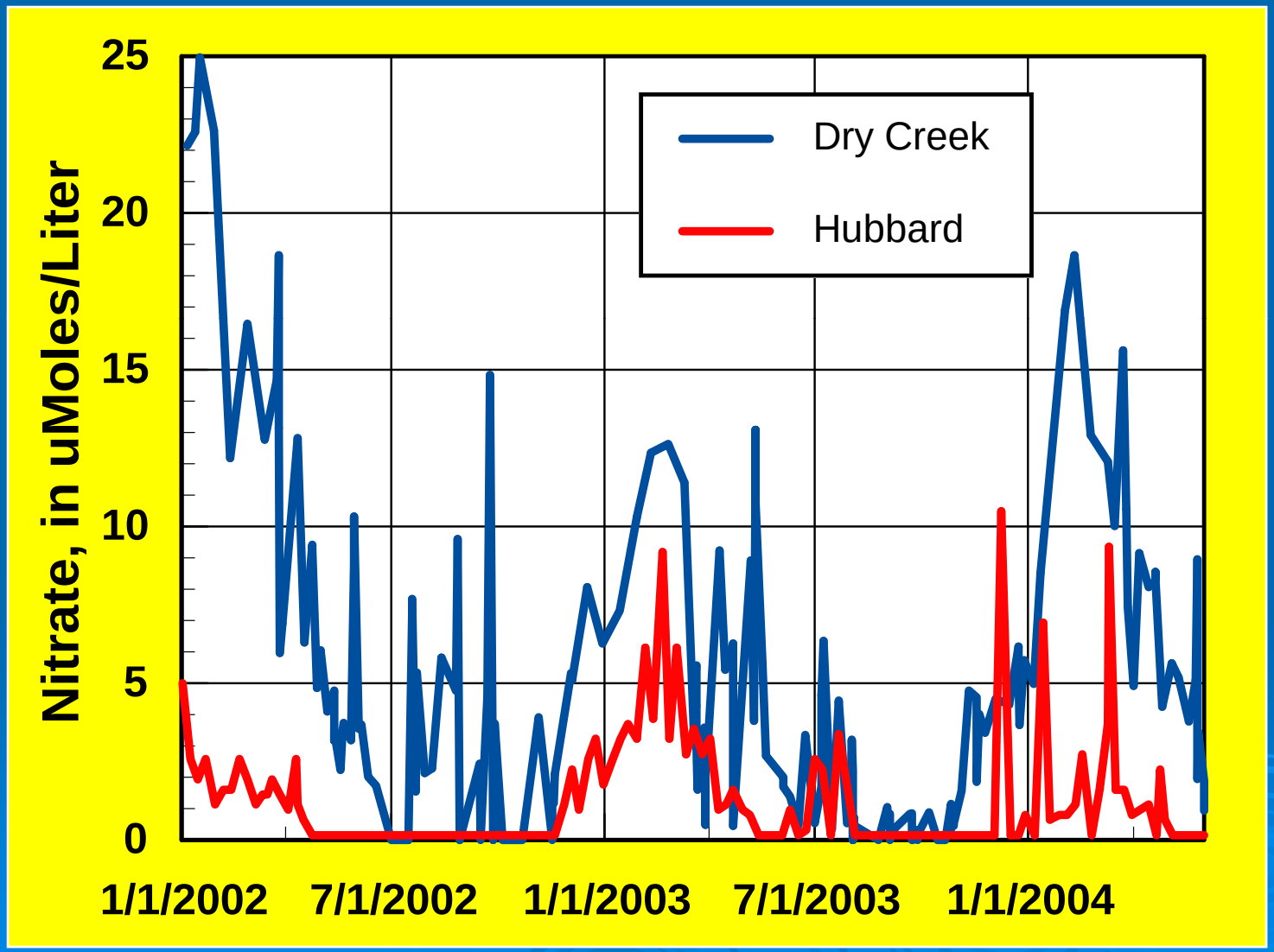
- Block N: 30%
- Block G: 40%
- Block A: 50%
- Butch Creek (Block R): 70%

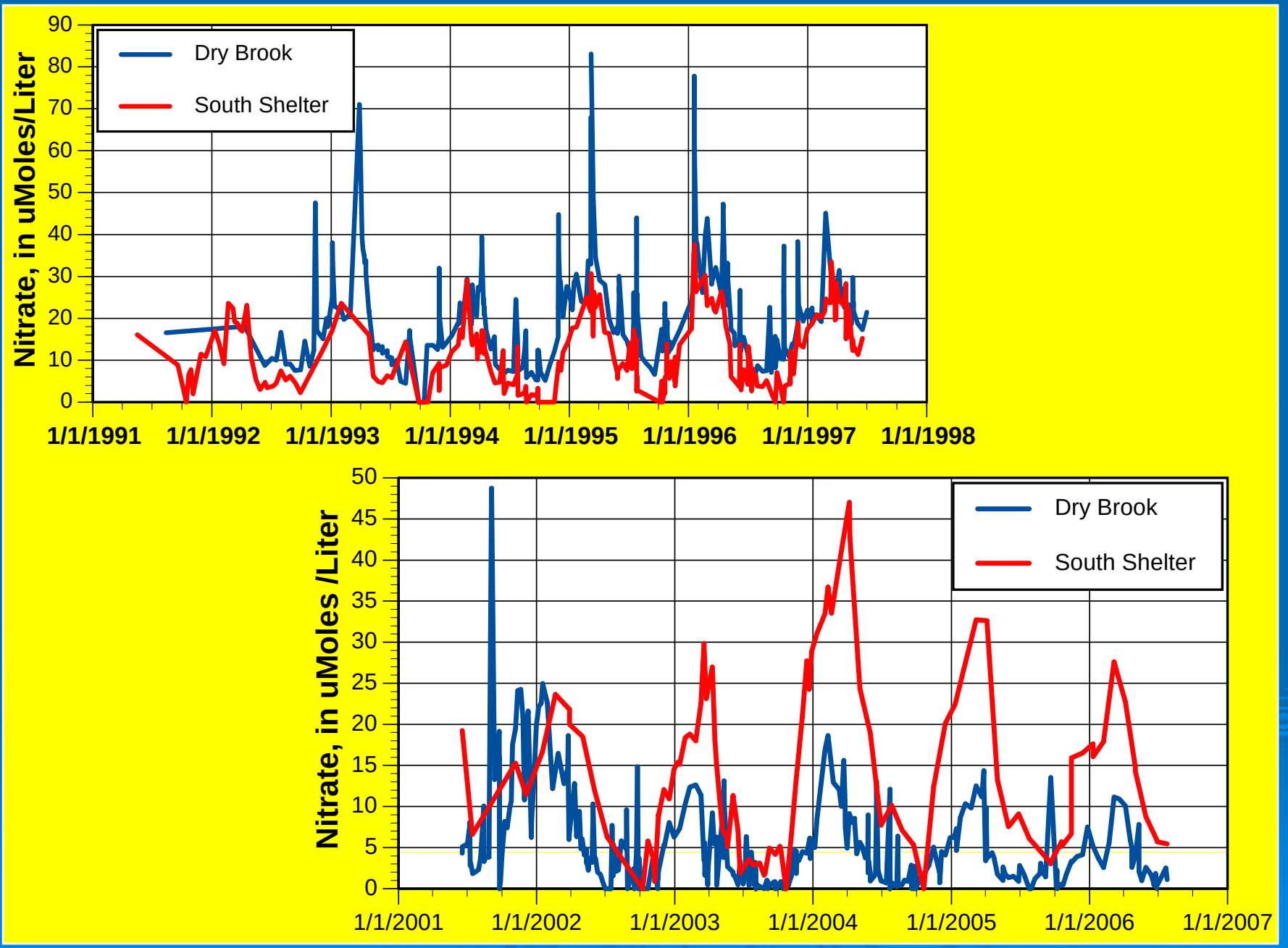
Peak Nitrate Concentration in Episodic Runoff

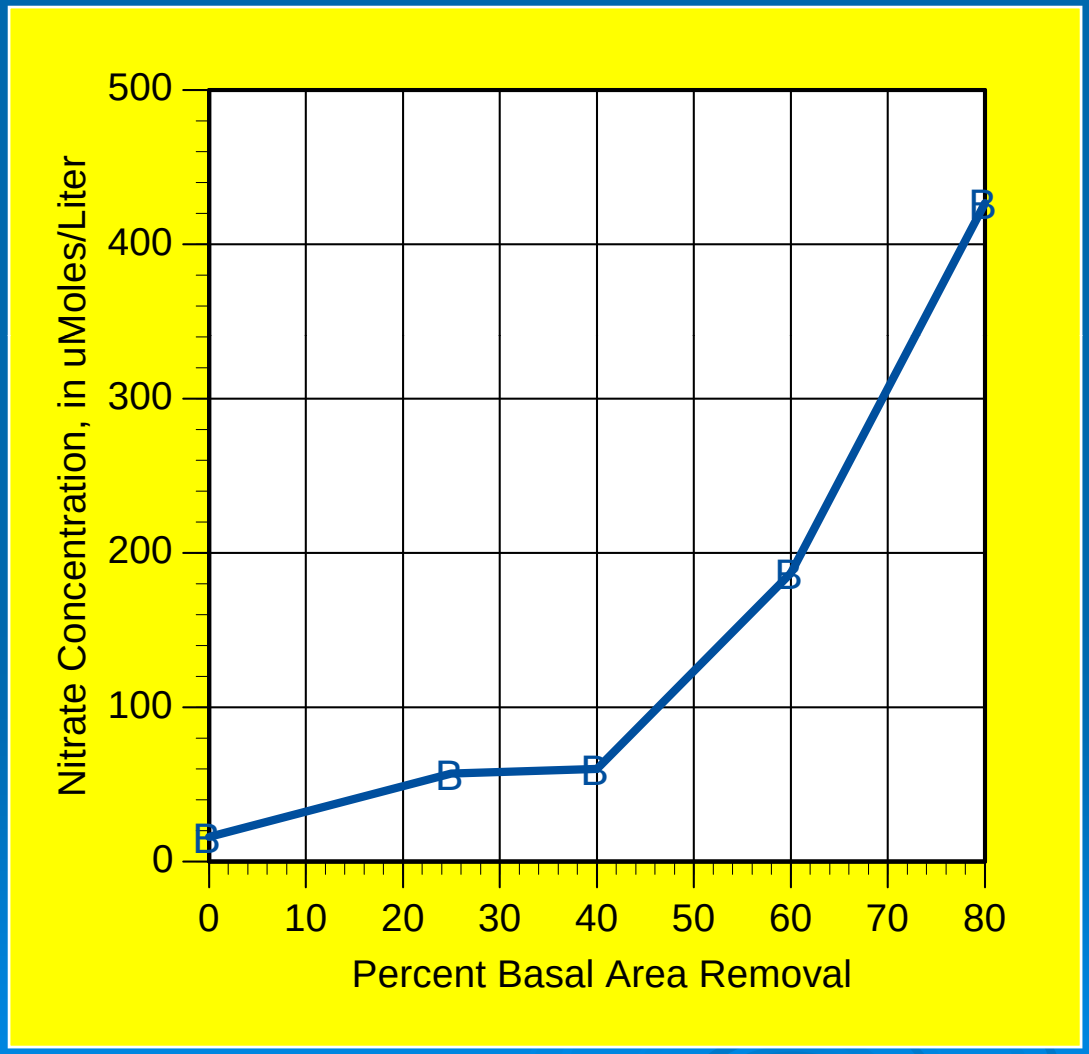
Early Fall following the logging

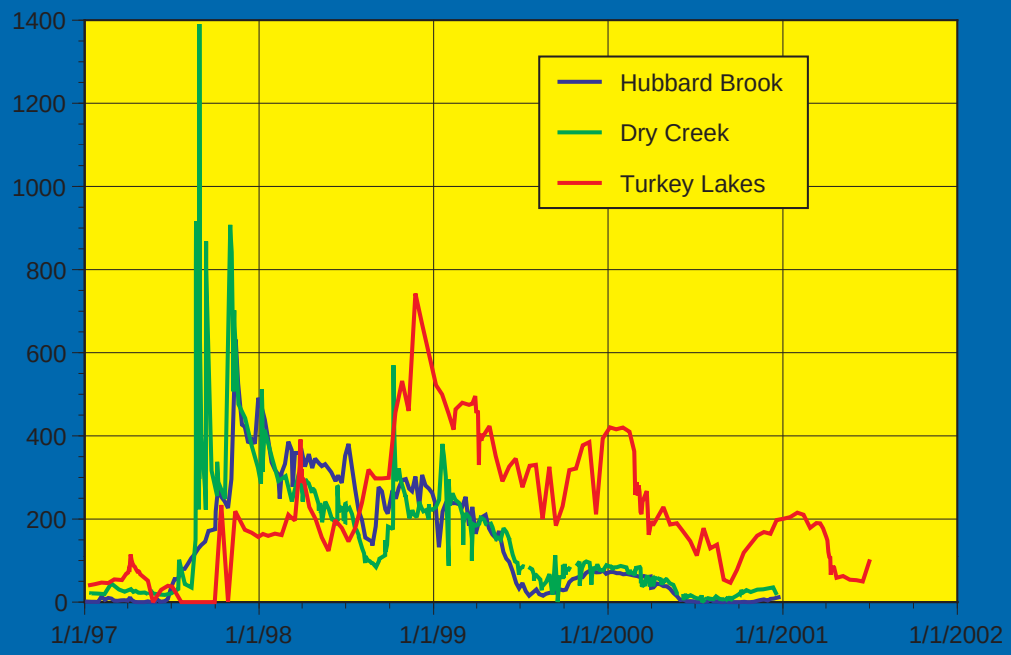



2000
1500
1000
500
0
Nitrate Concentration, in uMoles /Liter
0
10
20
30
40
50
60
70
80
Percent Basal Area Removal

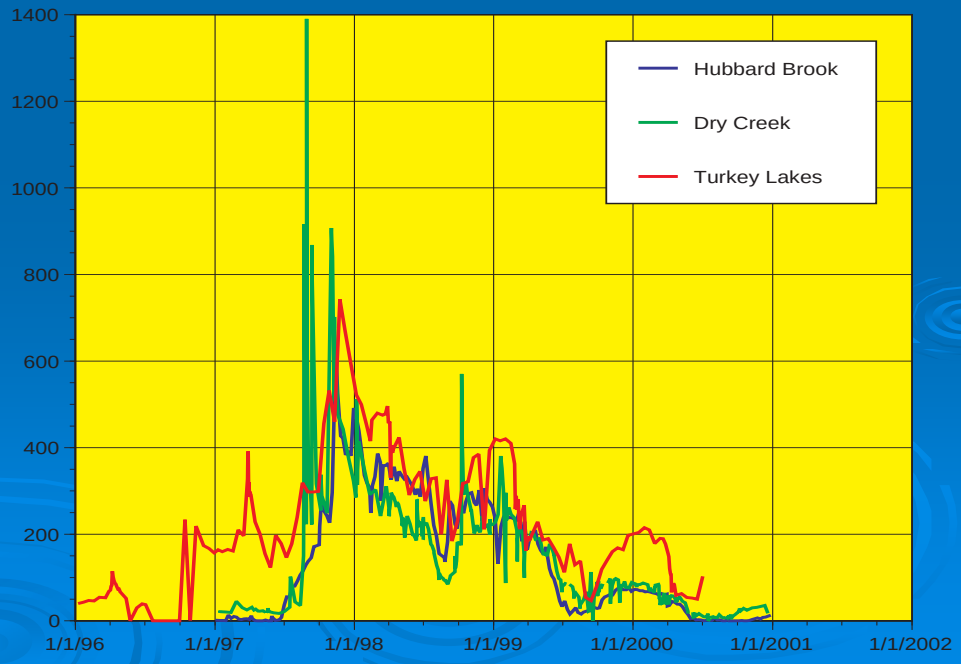

Nitrate, in uMoles/Liter
25
20
15
10
5
0
1/1/2002
7/1/2002
1/1/2003
7/1/2003
1/1/2004
Dry Creek
Hubbard


Nitrate, in uMoles/Liter
90
80
70
60
50
40
30
20
10
0
Dry Brook
South Shelter
1/1/1991
1/1/1992
1/1/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
Nitrate, in uMoles /Liter
50
45
40
35
30
25
20
15
10
5
0
Dry Brook
South Shelter
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007


Nitrate Concentration, in uMoles/Liter
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
Percent Basal Area Removal
B
B
B
B
B



Summer clearcut extends the period of N-release



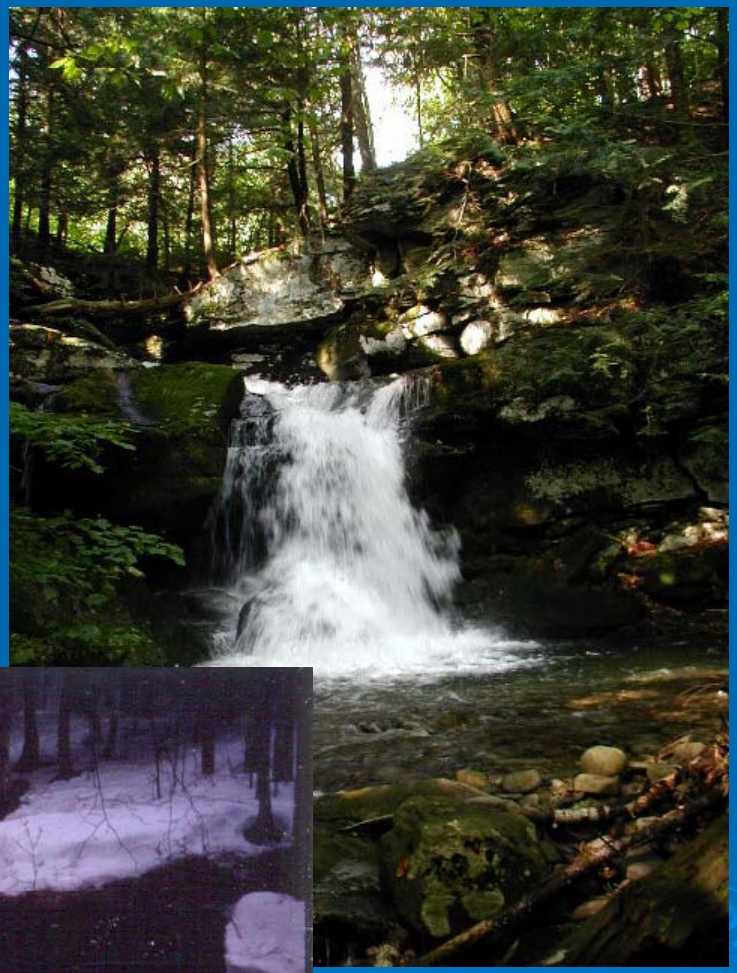
Conclusions

- Climate changes can either enhance or diminish existing forest and water quality disturbances in the Northeast.
- Whether those climatic changes affect ecosystem function or structure will depend on how close each ecosystem is to the “tipping point” or threshold of change.
- Determining those thresholds is a “best-management practice” for resource management, including fish.

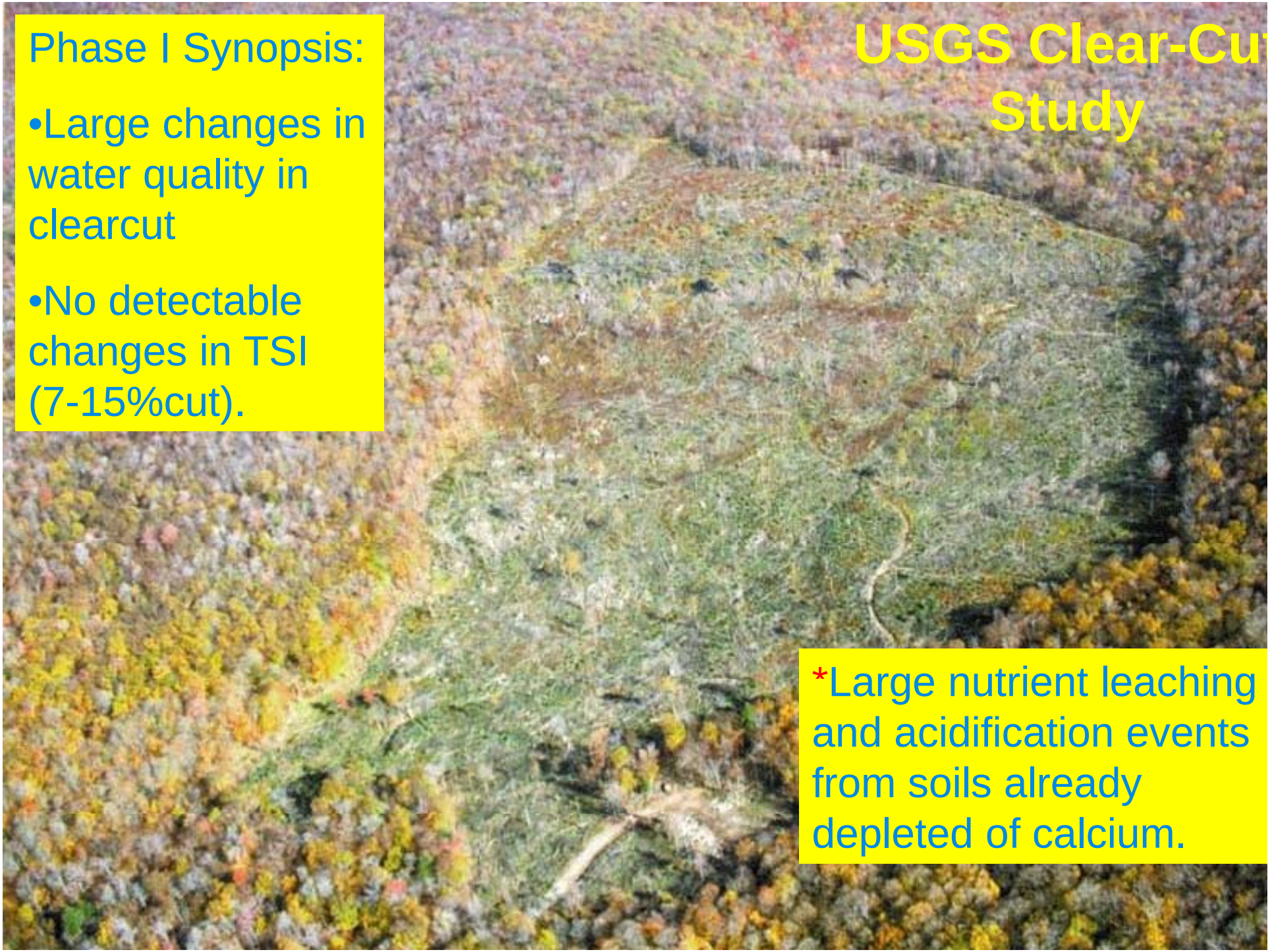
Sponsors

- NYCDEP
- NYSERDA
- USGS
- USDA-FS

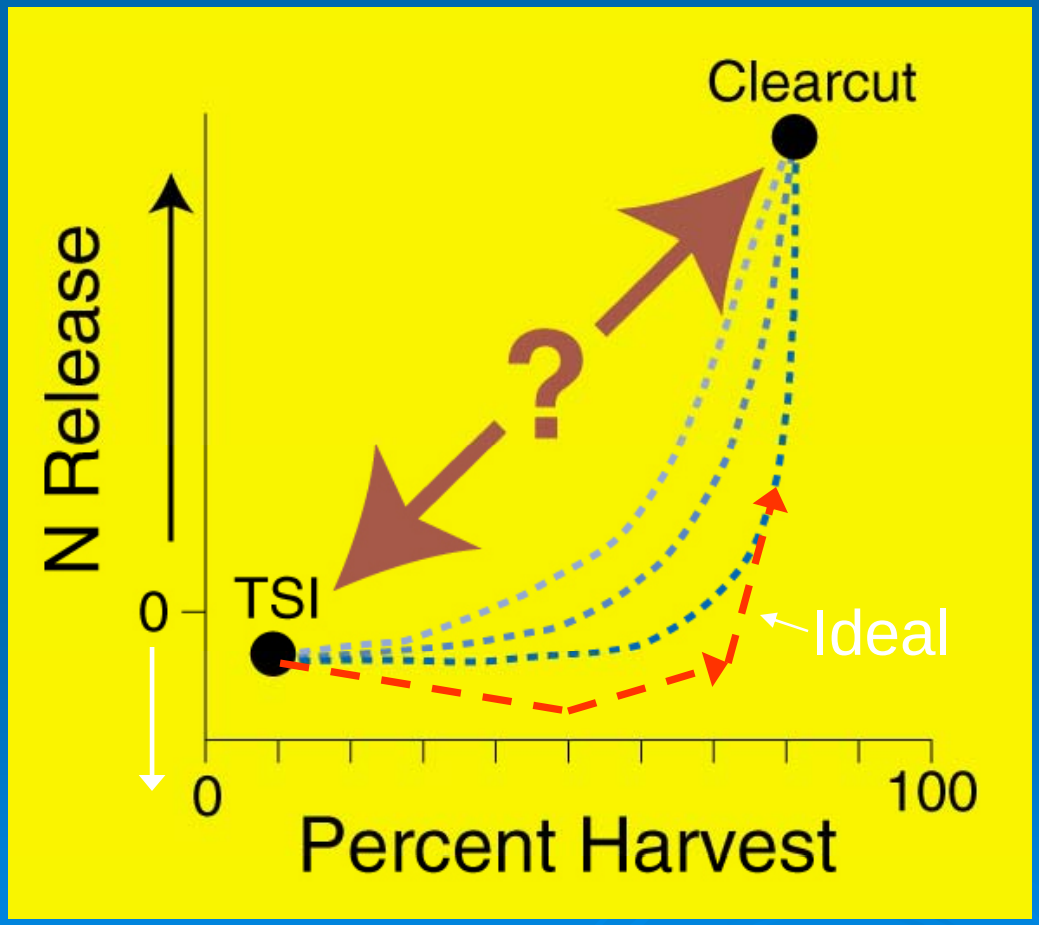
Catskill Mountains



Effects of logging disturbance on stream acidification

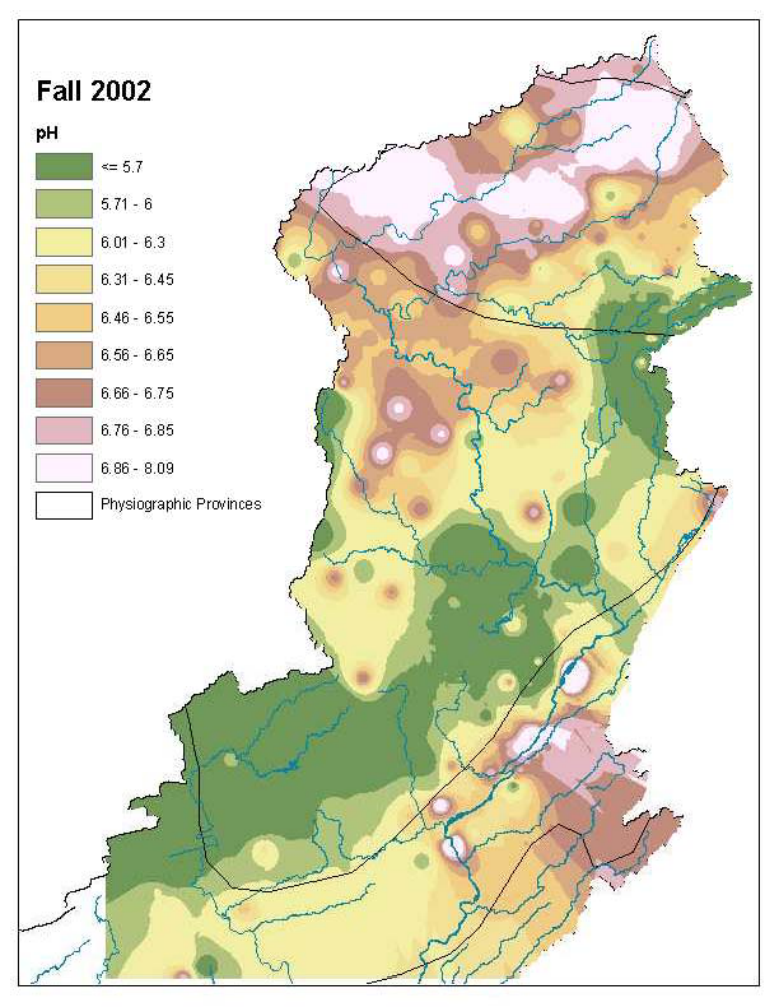

USGS Clear-Cu
Study
Phase I Synopsis:
•Large changes in water quality in clearcut
•No detectable changes in TSI (7-15%cut).
*Large nutrient leaching and acidification events from soils already depleted of calcium.

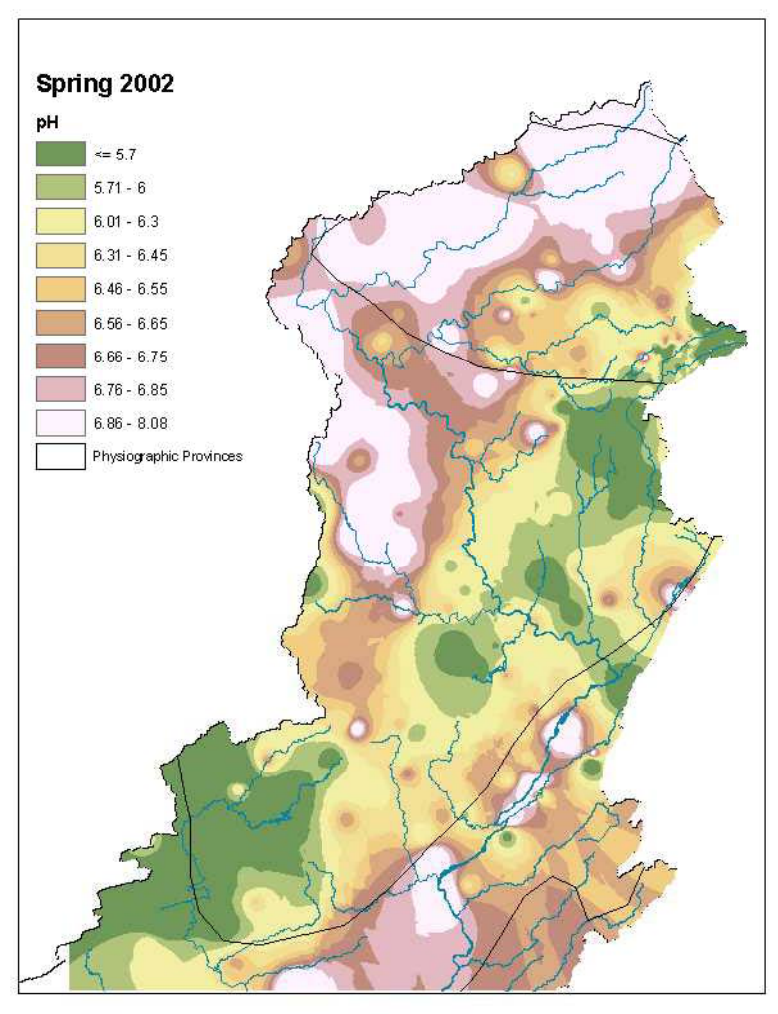
Forest Health/Nutrient Controls Study Phase II- Objectives



- Fill in the gap on the logging-effects curve for different harvest intensities.
- Determine the factors controlling short- and long-term water-quality response to logging.
- Determine the regional patterns in soil chemistry and forest health in the West-of-Hudson

Stream pH


Fall 2002
pH
<= 5.7
5.71 - 6
6.01 - 6.3
6.31 - 6.45
6.46 - 6.55
6.56 - 6.65
6.66 - 6.75
6.76 - 6.85
6.86 - 8.09
Physiographic Provinces

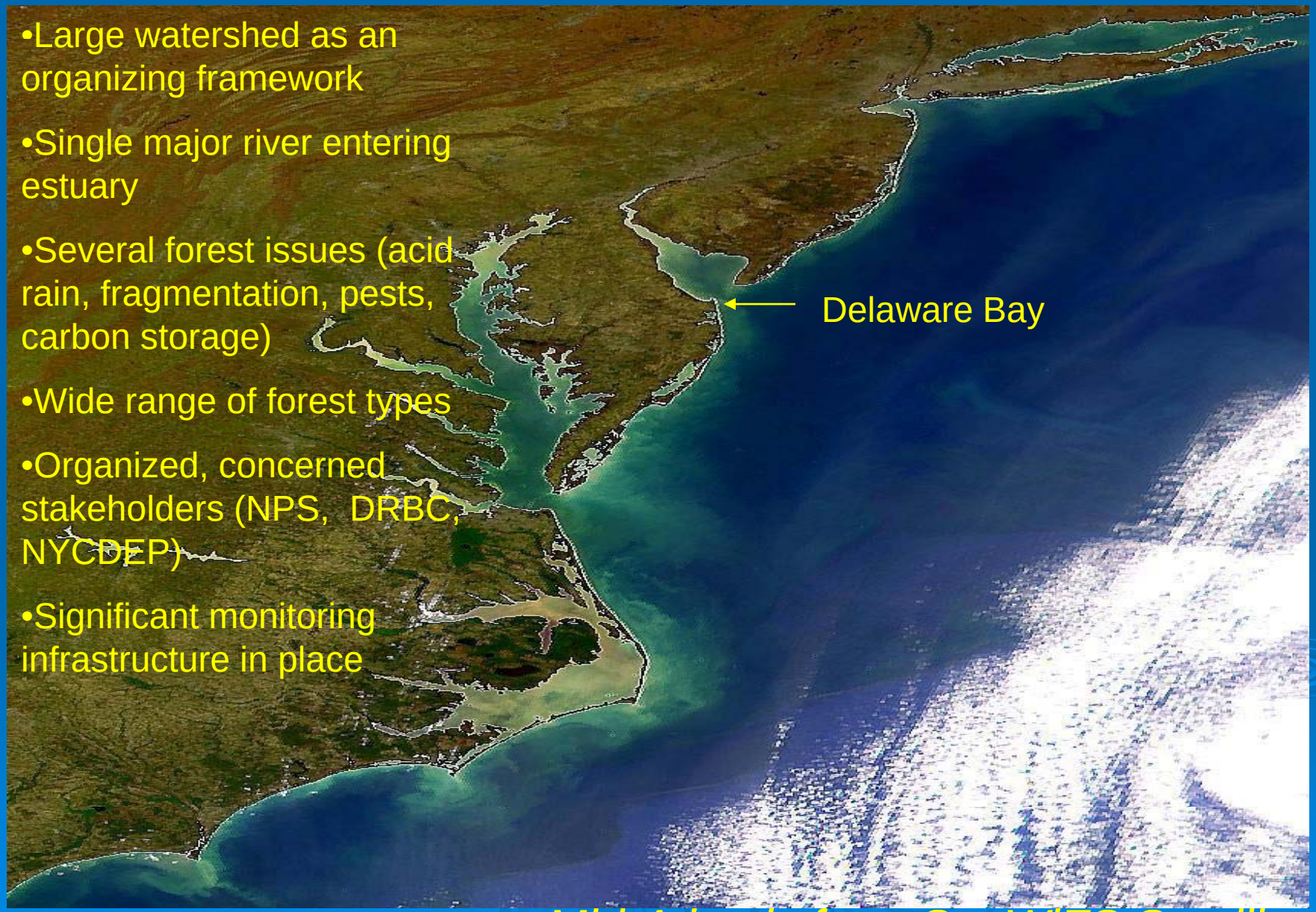

Spring 2002
pH
<= 5.7
5.71 - 6
6.01 - 6.3
6.31 - 6.45
6.46 - 6.55
6.56 - 6.65
6.66 - 6.75
6.76 - 6.85
6.86 - 8.08
Physiographic Provinces

Foundation Programs

- USFS Techn. Devel. Group and Research Lab (Hyperspectral/Aerial Photo Interp.) *Tier 4*
- USFS Forest Inventory & Analysis Prog (FIA) *Tier 3*
- EPA-EMAP and USGS designed stream surveys *Tier 3*
- USGS/New York City Department Of Environmental Protection QW Monitoring *Tier 2*
- USGS- NAWQA *Tier 2*
- USGS District COOP/Basic Data Programs (Research and gaging) *Tier 1 (also 2,3)*
- Forest Service Research Lab- Durham, NH *Tier 1*
- Pennsylvania State University(NTN Research) *Tier 4*
- USGS Hydrologic Benchmark Network *Tier 2*

Why the Delaware Basin?

- Large watershed as an organizing framework
- Single major river entering estuary
- Several forest issues (acid rain, fragmentation, pests, carbon storage)
- Wide range of forest types
- Organized, concerned stakeholders (NPS, DRBC, NYCDEP)
- Significant monitoring infrastructure in place



Mid-Atlantic from SeaWiFS Satellite

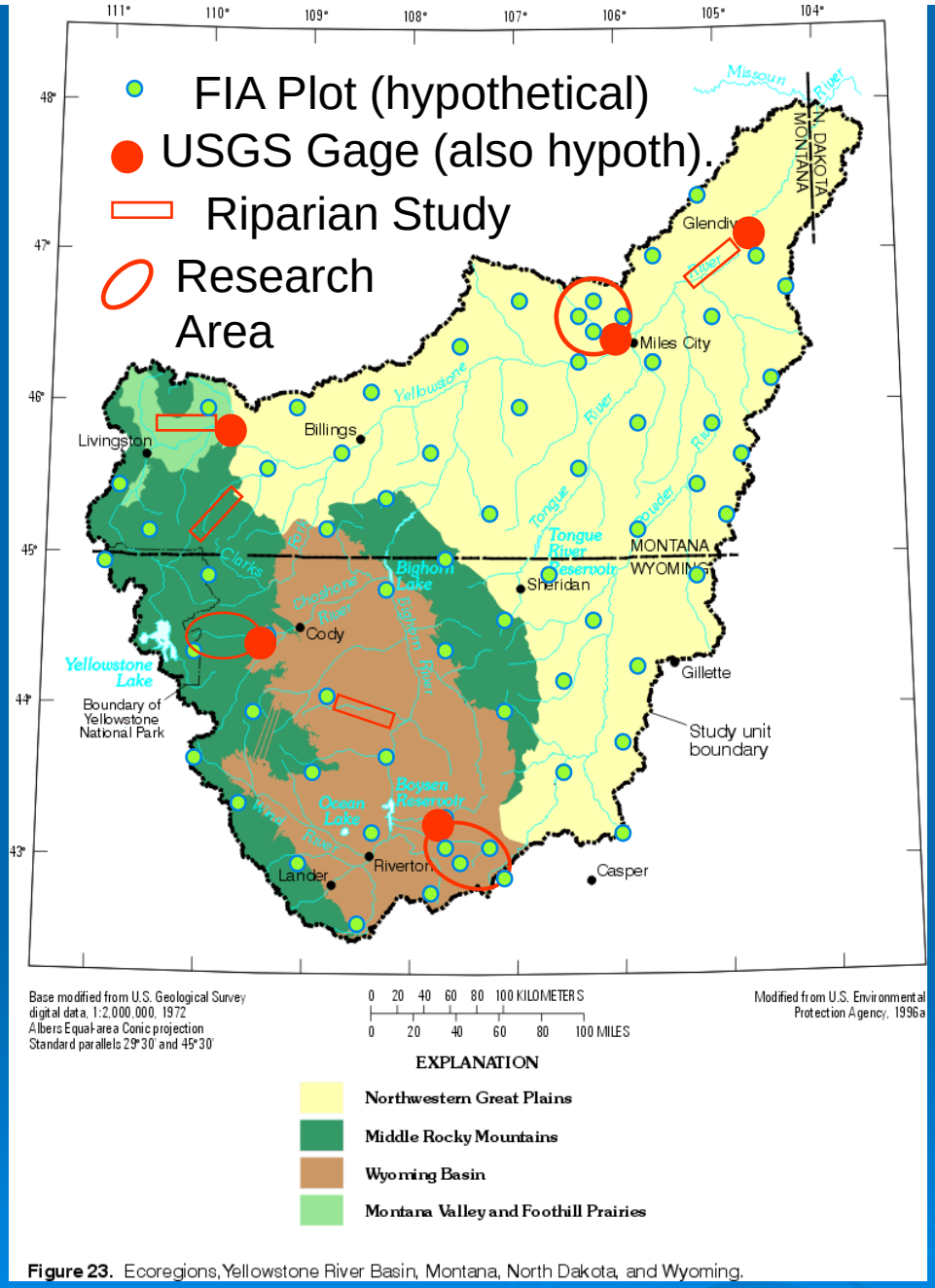
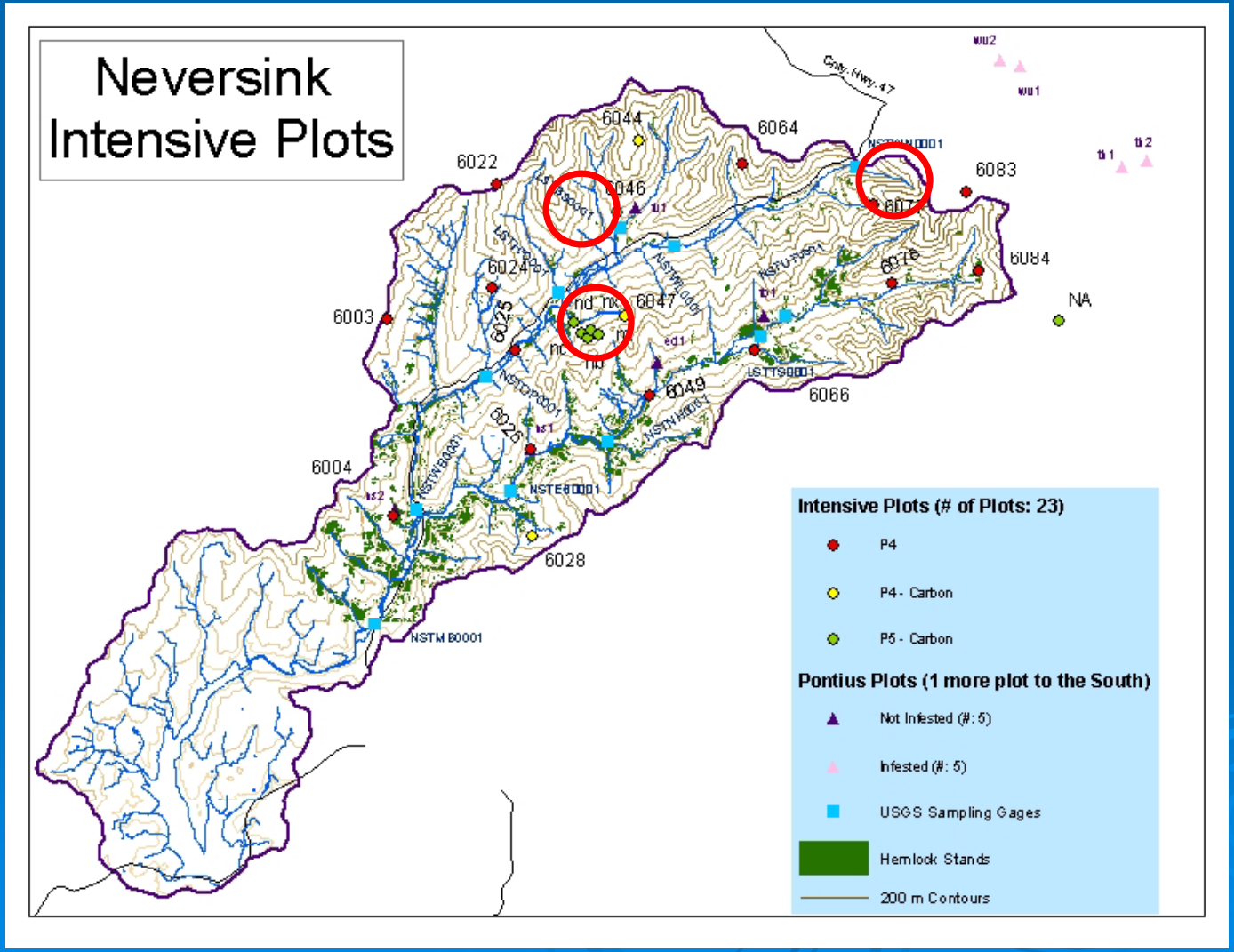


Figure 23. Ecoregions, Yellowstone River Basin, Montana, North Dakota, and Wyoming.

The Watershed as a landscape frame of reference

- Forest/landscape and hydrologic data collected intensively within each study watershed.
- Survey data (FIA plot grid) for linking to broader watershed or region.
- Models linking datasets for basin-wide water, energy, and carbon budgets.

Ca Depletion/N-Saturation Intensification Study: Tier 1 at the Neversink River Watershed in the Delaware River Basin



- Nested USGS streamgages
- Collaborative research areas
- Intensified FHM grid throughout the watershed
- Soil and forest research plots (birch and sugar maple)
- Manipulation watershed