Developing Reference Conditions, Indicators, Field Methodology, and Indices of Biotic Integrity for a National Lakes Survey

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Project Overview

- Develop a quantitative process for selecting reference lakes. Provide a list of candidate reference lakes in the Northeast and Northwest (EPA regions 1,2, and 10)
- Provide input and make recommendations for ecological indicators, survey design, and field methods for the national lake project
- Develop a fish Index of Biotic Integrity (IBI) for Northeast Lakes based on 1991-95 EMAP survey data

What is Reference Condition?

- **Minimally Disturbed Condition** - condition of lakes in the absence of significant human disturbance (e.g., “natural,” “pristine” or “undisturbed”)

- **Least Disturbed Condition** –found in conjunction with the best available physical, chemical and biological habitat conditions given today’s state of the landscape - defined by a set of explicit criteria to which all reference sites must adhere

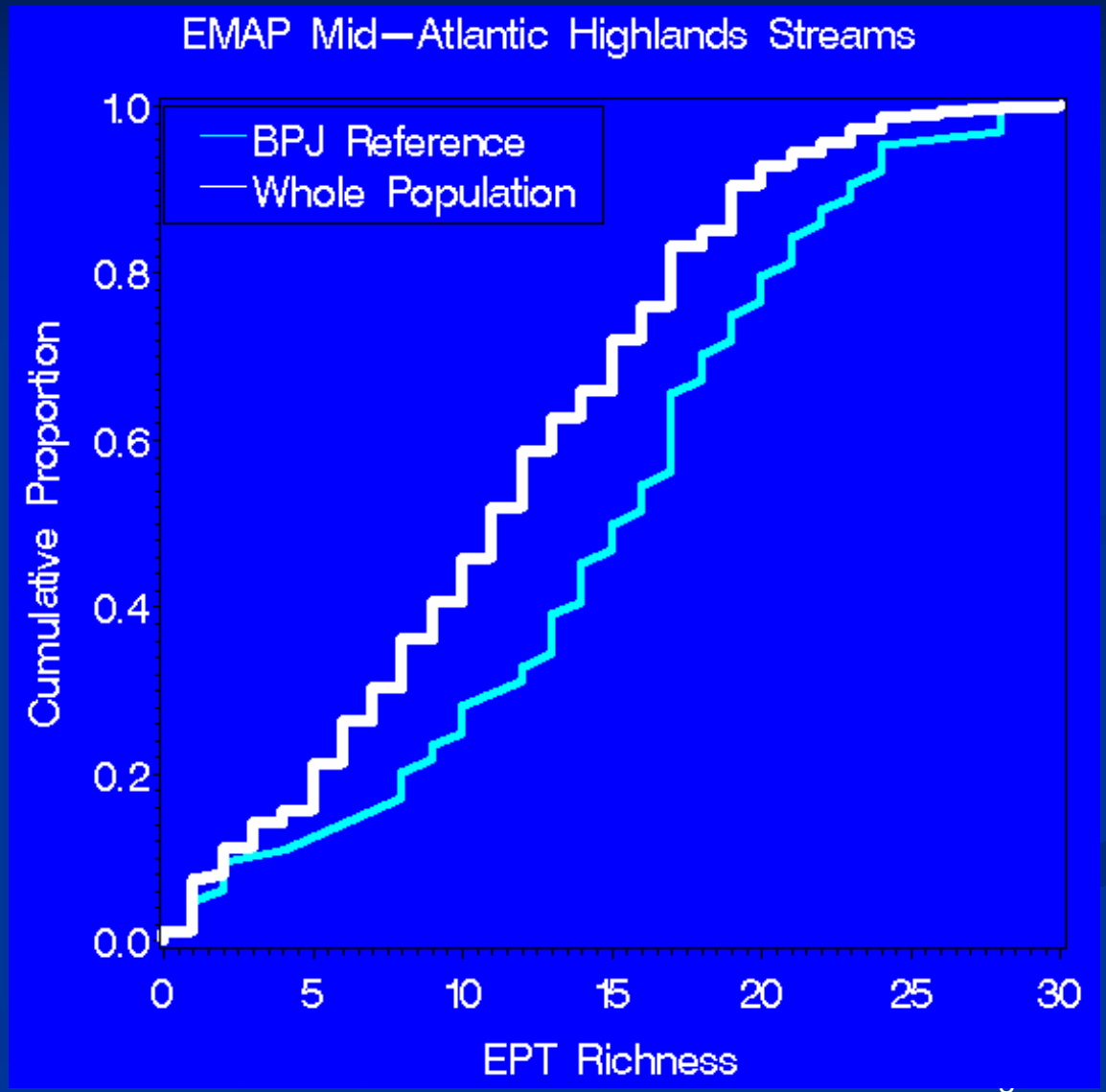
Why do we want to select and sample reference lakes?

- Provide benchmark for evaluation of ecological condition
- Identify potentially-achievable recovery targets for lake conditions
- Due to rarity, undisturbed lakes will likely NOT be selected using a randomized site selection process in disturbed ecoregions, and so need to be specifically targeted

How are reference sites chosen?

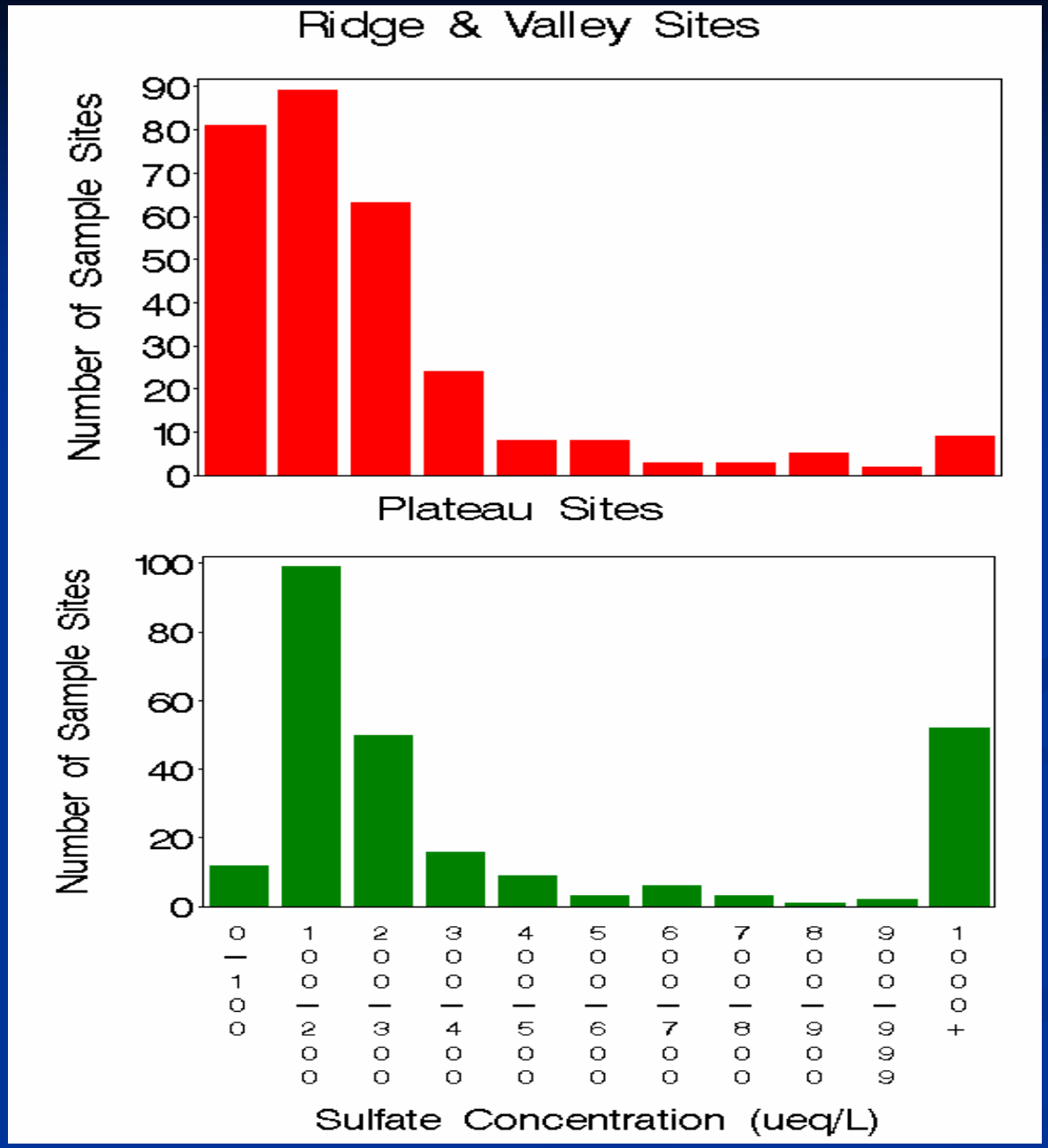
- Often chosen by best professional judgment (BPJ)
- BPJ sites have varying and unknown quality

- **Alternative:** Filter survey data for physical-chemical stressors to identify best sites



Mid-Atlantic Highlands EMAP Stream Example

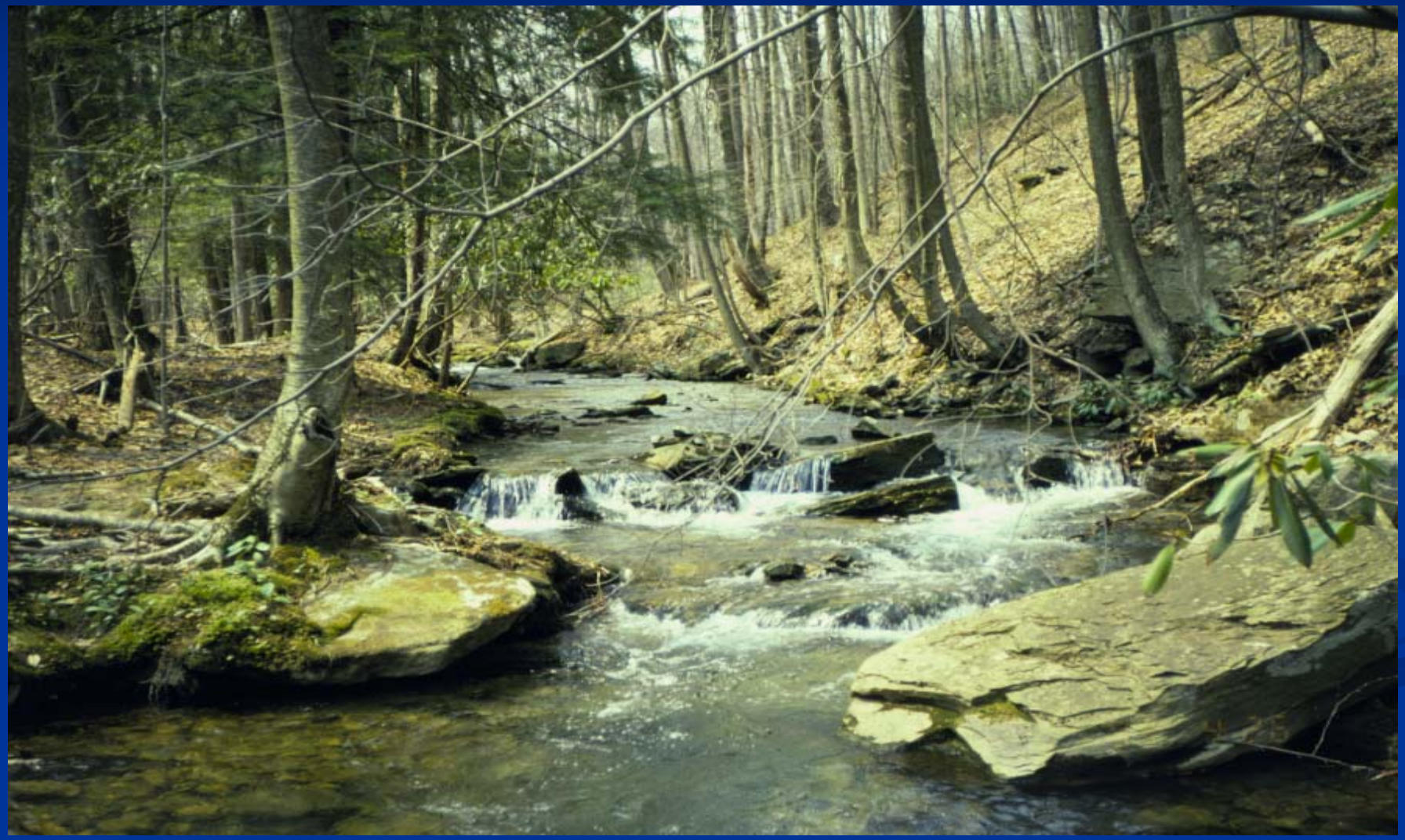
- Screen all sites and remove those with:
  - Sulfate > 400 µeq/L (~20 mg/L)
  - Acid Neutralizing Capacity (ANC)< 50µeq/L (pH ~6)
  - Total phosphorus over 20 µg/L
  - Total nitrogen over 750 µg/L
  - Chloride > 100 µeq/L (~3.5 mg/L)
  - Mean RBP habitat score less than 15

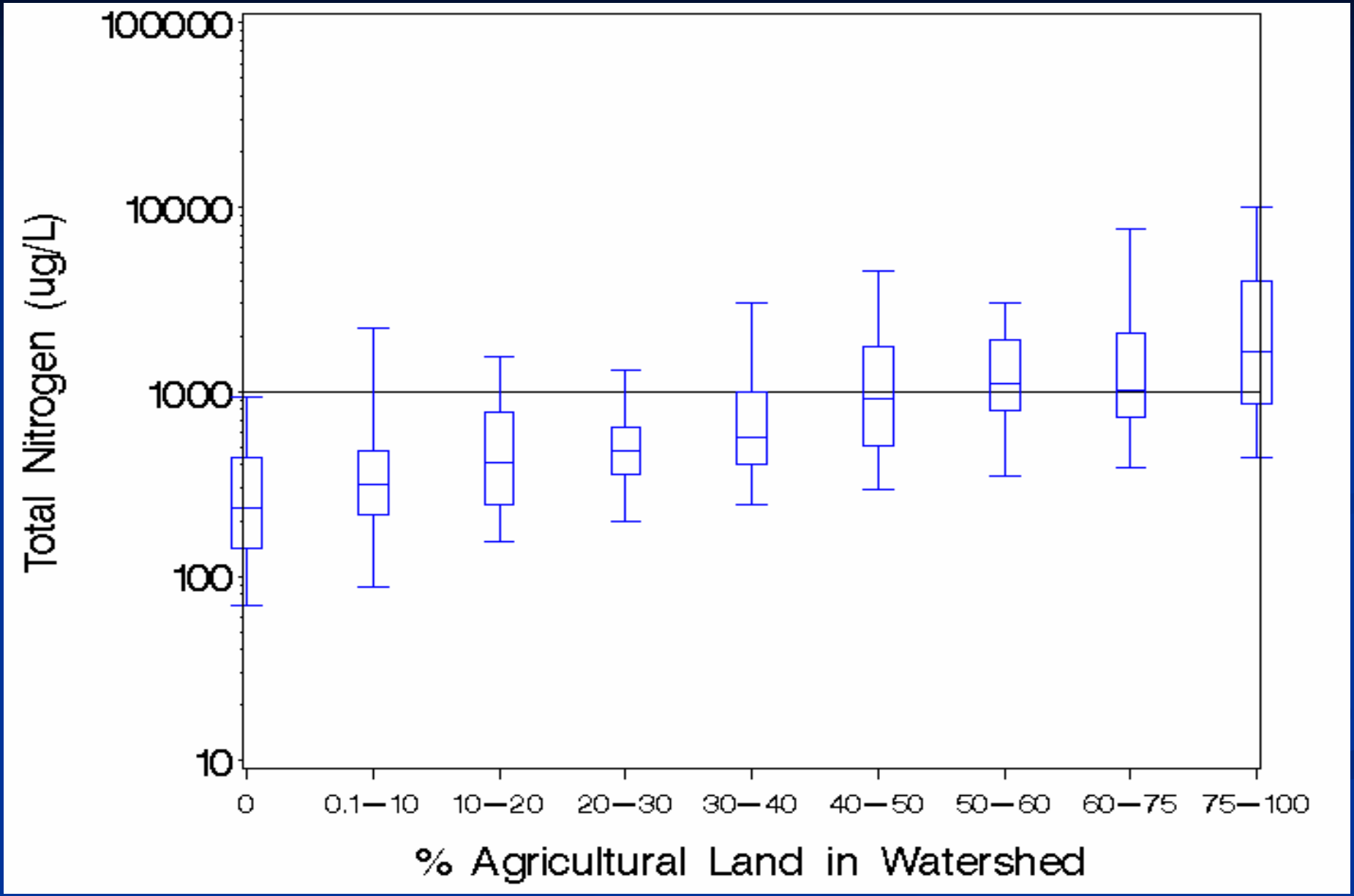


- Expected stream sulfate from deposition in this region is 100-300 µeq/L
- Bimodal sulfate histogram in Plateau. Mining not common in Ridge & Valley (except for Anthracite Belt)
- Sites with SO_4>400 µeq/L classified as non-reference

Contrary Creek, Virginia
pH=3, SO_4=5,000 μeq/L

Montgomery Creek, PA
pH=5.1, SO_4=175 µeq/L

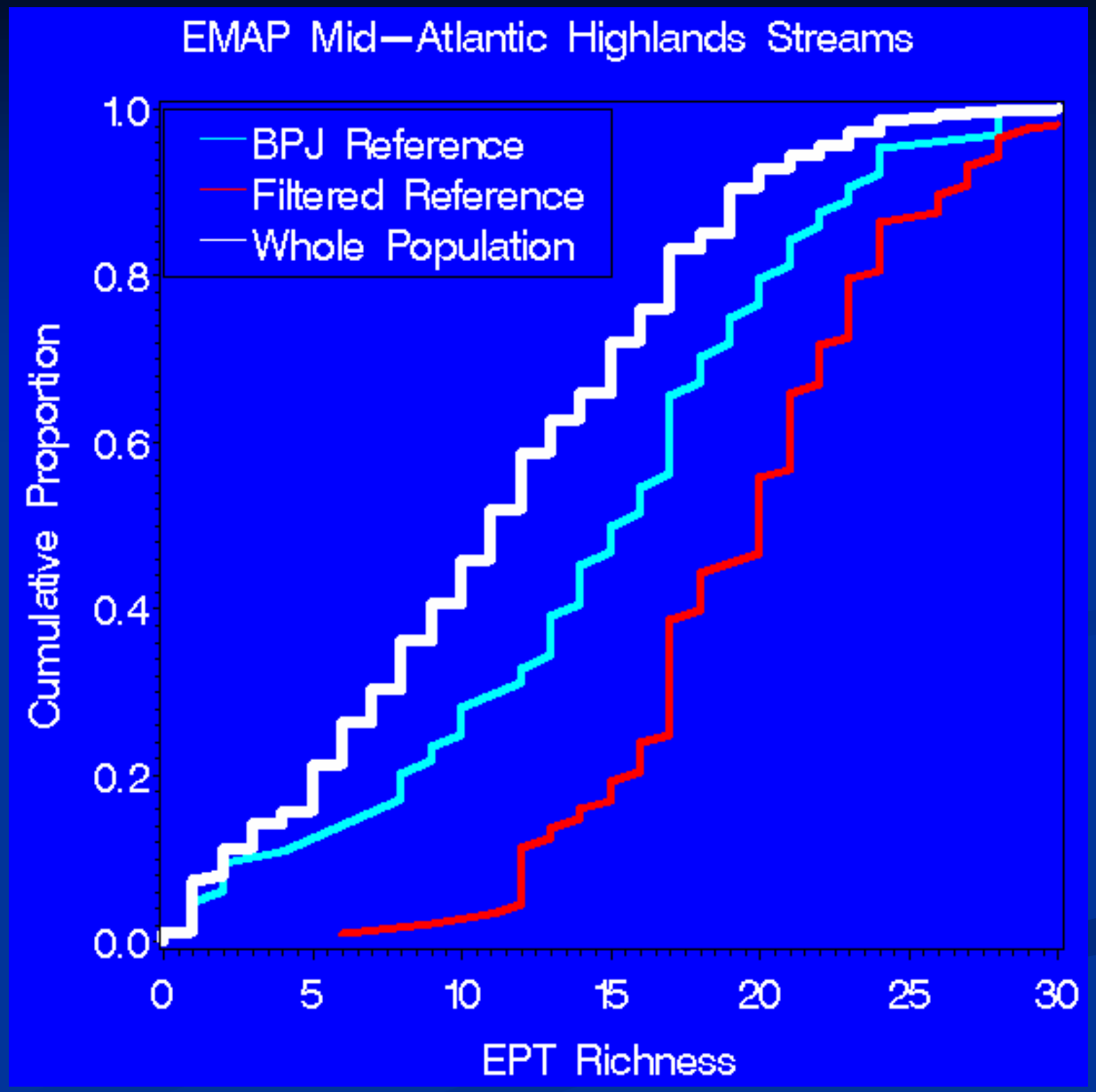



100000
10000
1000
100
10
Total Nitrogen (ug/L)
0
0.1—10
10—20
20—30
30—40
40—50
50—60
60—75
75—100
% Agricultural Land in Watershed

Filtering produced a set of Reference Sites with higher EPT Richness scores than BPJ

Advantages of Filtered Sites

- Fewer poor biological condition sites
- Have a much more rigorous definition of “reference”



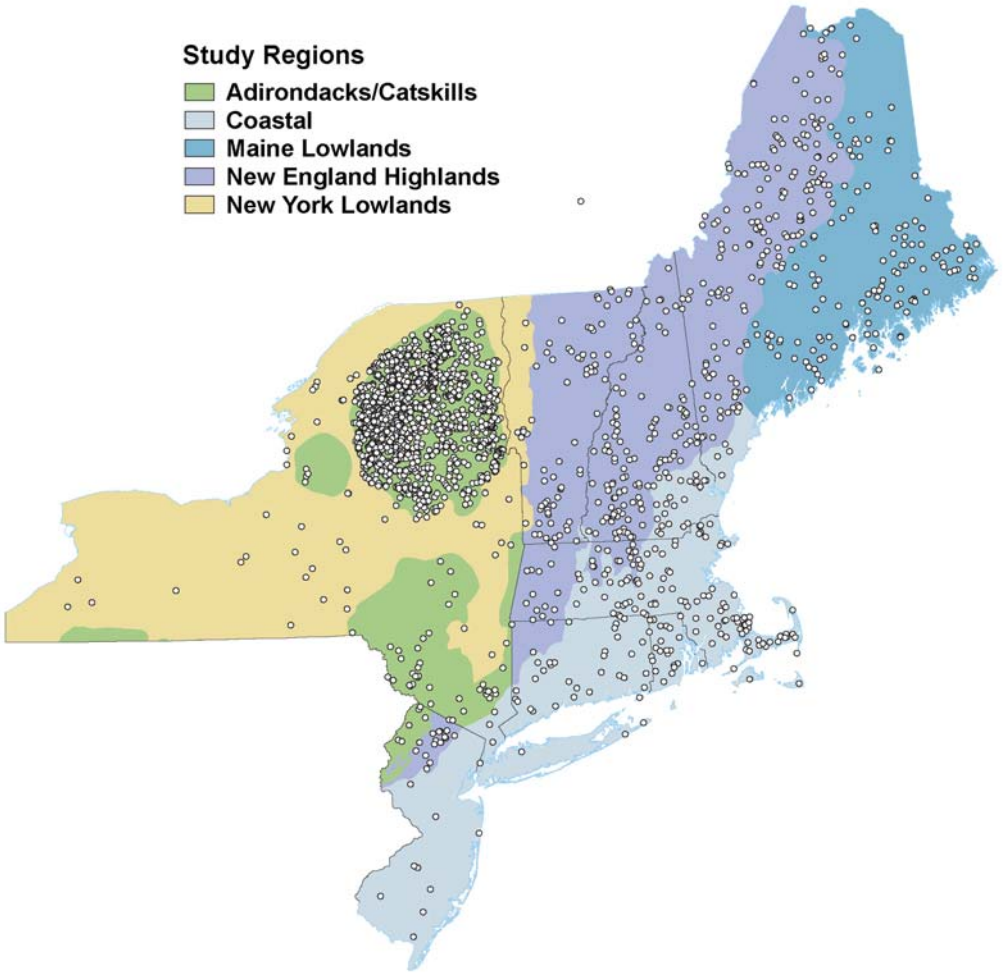
Lake Project Approach

- Compile available lake databases that contain necessary screening data
- Develop ecoregion-specific screening criteria to make a first screen of the data for least-disturbed lakes
- GIS, local information, and air photo examination of screened lakes to develop list of candidate reference lakes for field sampling along with the probability sample

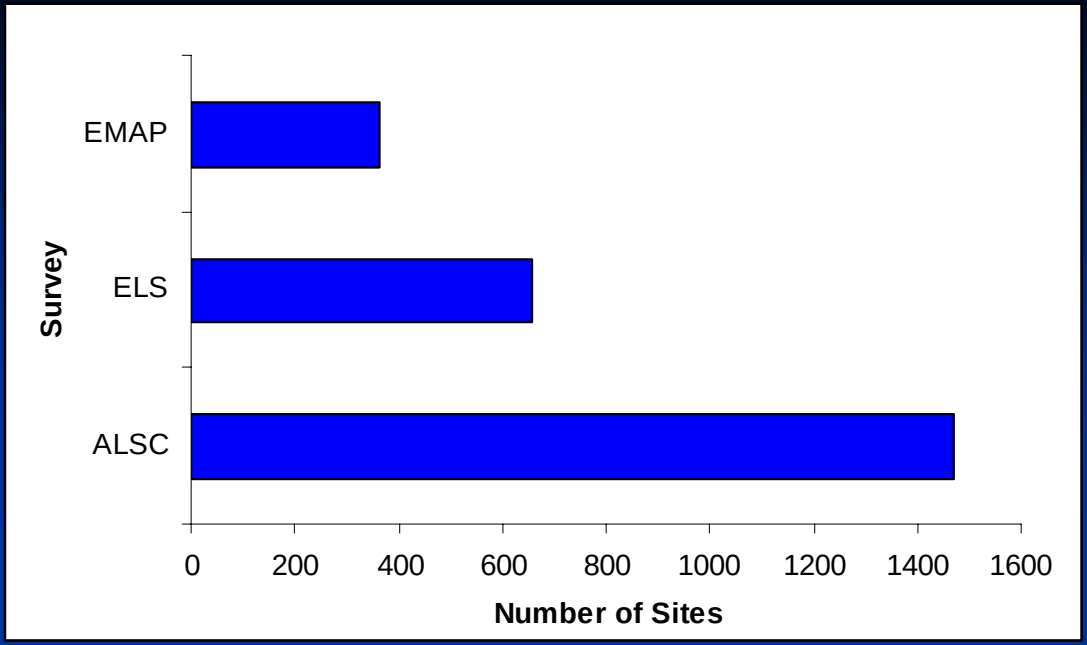
Northeastern U.S. Lake Screening

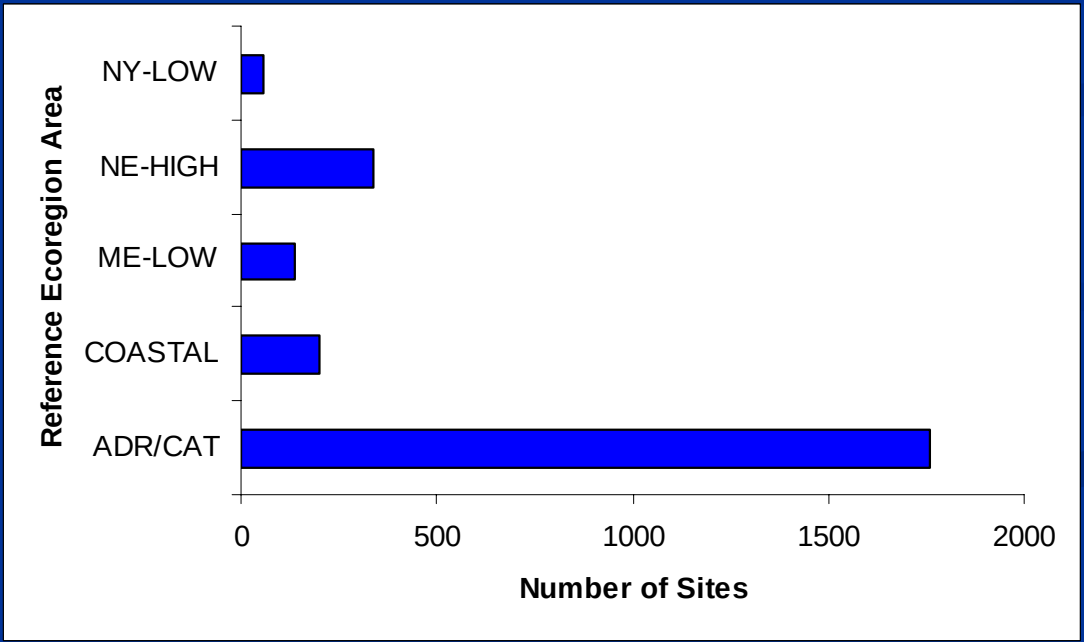
- Compiled available databases from Eastern Lake Survey, Adirondack Lake Survey Corp. and EMAP Pilot survey.
- Contacted States for available state databases
- Minimum Required Data for Screening
  - Acid Neutralizing Capacity, Sulfate, Chloride
  - Nitrate, Total P
  - Site Info: Lat/Long, Lake Area

Level III Aggregated Ecoregions for Northeast Lakes

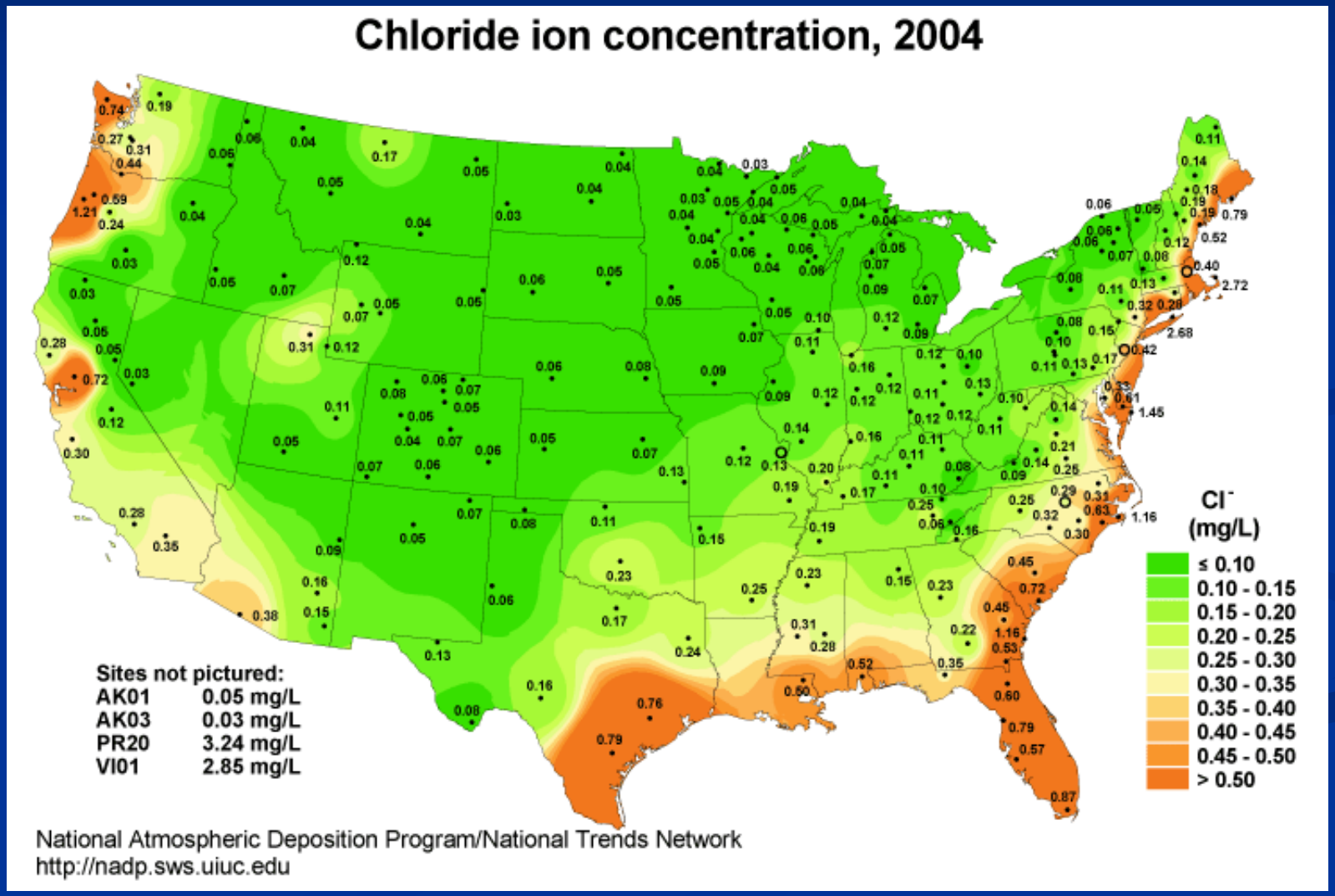


Number of Lakes in EMAP, ELS, and ALSC Databases

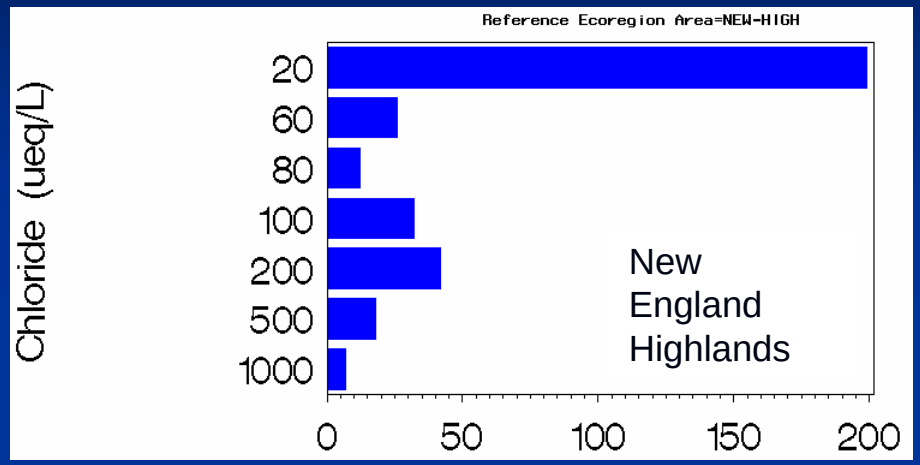


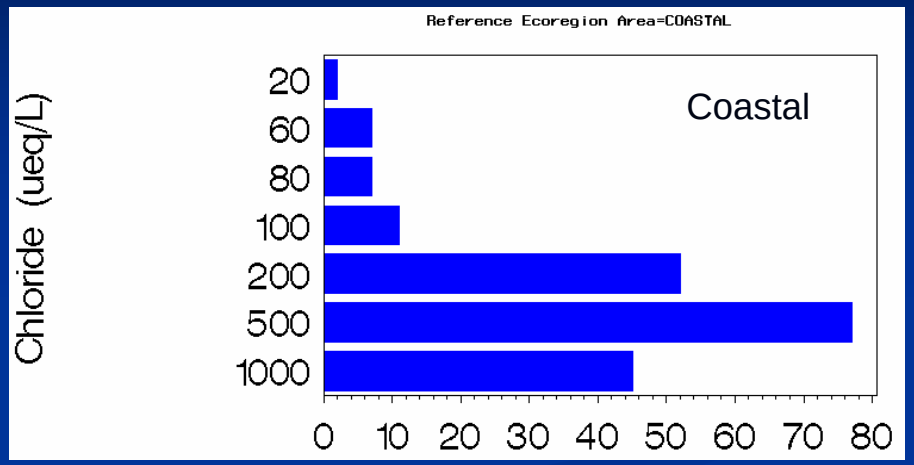


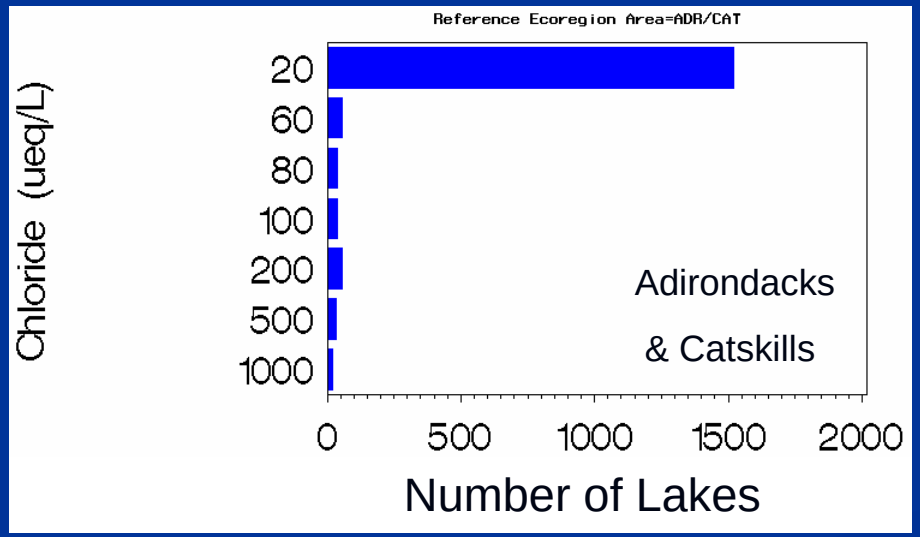
Deriving Screening Criteria: Chloride in Wet Deposition

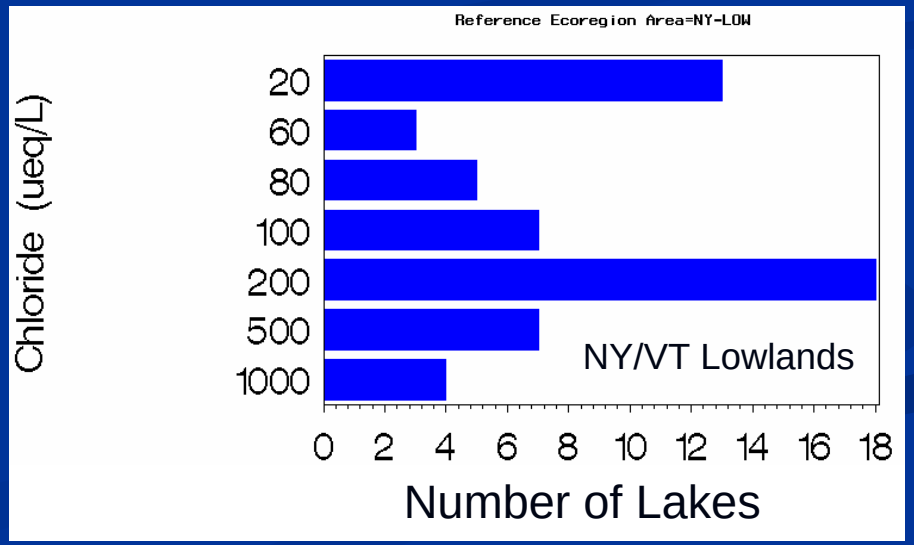


Chloride Frequency Histograms









Total Phosphorus (ug/L) Criteria

Ecoarea	EPA Nutrient Criteria Doc.	25th Percentile* Total Population	75th Percentile* Undisturbed**
Adirond./Catsk.	8.0	7.0	19.0
New Eng. Upl.	8.0	7.6	12.6
Coastal	8.0	11.0	13.0
ME Lowlands	8.0	8.0	27.0
NY/VT Lowland	14.8	6.0	83.0

* Percentiles from EMAP estimates, ** Undisturbed=< 5% Ag + Urban LULC

Screening Criteria by Ecoarea

Criteria	New England Uplands	NY/VT Lowlands
ANC (ueq/L)	50 (and DOC < 6)	50 (and DOC < 6)
Sulfate (ueq/L)	200	300
Chloride (ueq/L)	25	100
Nitrate (ueq/L)	5	5
Total P (ug/L)	10	20

Lakes Meeting Screening Criteria

Eco Area	% of Total	# Lakes 1-50 ha	# Lakes > 50 ha
Adirondack/Catskill	22	48	16
NY/VT Lowlands	25	11	3
New England Upl.	28	66	29
Coastal	13	18	8
Maine Lowlands	31	19	24

Detailed Site Screening

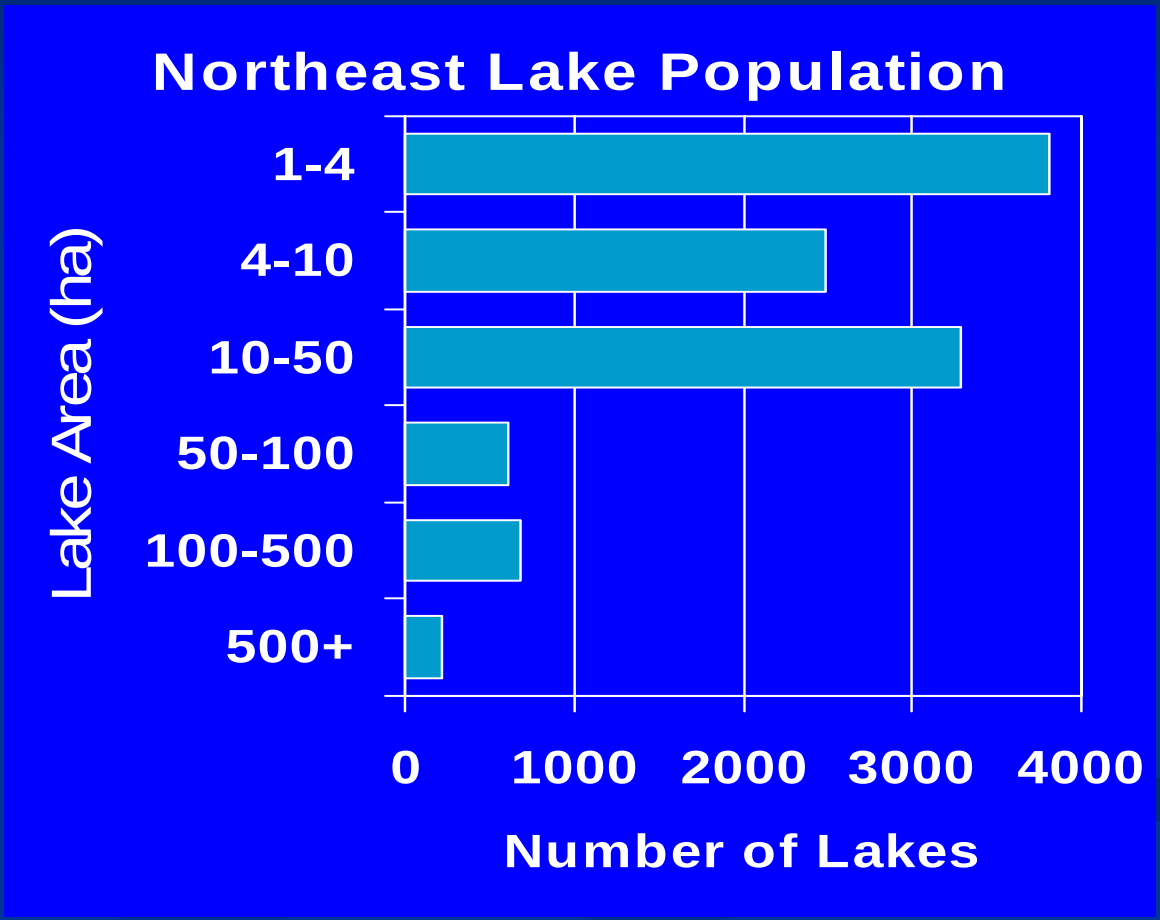
- Watershed Delineation from DEM
- Watershed Disturbance Assessment
  - High-resolution digital orthophotos
  - USGS 1:24,000 topographic quads
  - State agency GIS roads data
- Local Information
- Introduced Fish

Classification of Reference Lakes

- Make sure there's enough reference lakes in specific classes?
  - Ecoregion
  - Lake Size
  - Hydrologic Type (Drainage, Seepage)
  - Water Type (Clearwater, Blackwater)
- Combinations of Classes?
  - e.g., Ecoregion by Lake Size

Population Estimates from EMAP Northeast Lake Survey

- 11,089 lakes defined,
  - 1 – 10,000 ha
  - ≥ 1 m max depth and
  - ≥ 100 m^2 open water
- Hydrologic Type
  - 45% Natural Drainage
  - 7% Seepage
  - 48% Artificial
- 92% were Clearwater (DOC < 10 mg/L)



Challenges

- Deciding on important classes to cover with reference sites
  - Depends partly on the selected sample indicators
- Large Lakes
  - Relatively few of them and they usually have more human influence
- Include Artificial Lakes?
  - What is reference conditions for Reservoirs?
- Exclude lakes with introduced fish species?