Examination of Aquatic Acidification Index (AAI) component variability and implications for characterizing atmospheric and biogeochemical nitrogen processes.

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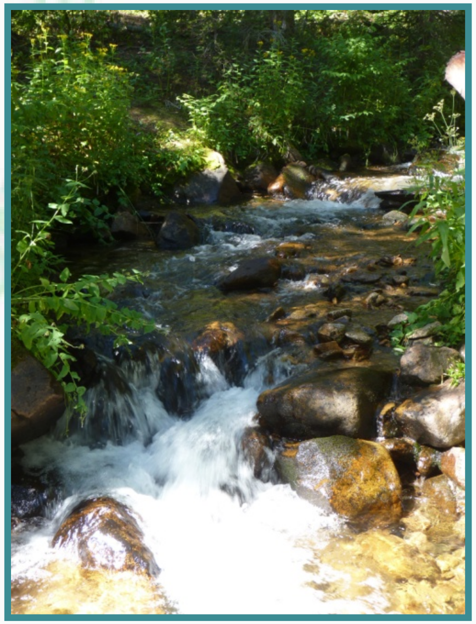


Policy Background

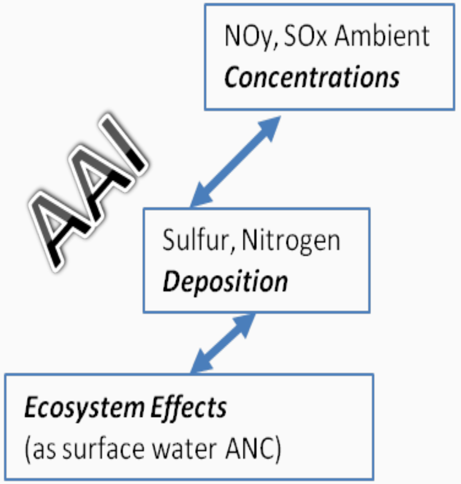
NAAQS Secondary Standard NOx/SOx: EPA's Final Rule
"after a 5 plus year science review and assessment"

- *Current secondary standards afford inadequate protection*
- *Decision not to move forward with a new standard based on AAI concept*
- *Conduct a pilot studies field program in 3-5 ecoregions:*
  - *"to collect and analyze data so as to enhance our understanding of the degree of protectiveness that would likely be afforded by a standard based on the AAI…"*

Background

The *Aquatic Acidification Index (AAI) relates:*

- Ambient concentration NOx/SOX (i.e., SOx as SO2 and SO4, and NOy)
- Resulting level of acidifying deposition
- Environments ability neutralize acidifying deposition (i.e. CL)
- Potential ecological effects associated with acidifying deposition (i.e. ANC)
- Contribution of ammonia to acidification process



Translating a linked atmospheric-biogeochemical construct in NAAQS terminology

AAI derivation

$$CL_{N+S} = ([BC]_0^* - [ANC_{lim}])Q + Neco$$

Start with CL expression:
Define a potential ANC based on the relative difference between CL and deposition

Ambient indicators

$$[ANCp] = [BC]_0 + Neco/Q - Dep_{NHx}/Q - T_{NOy}Conc_{NOy}/Q - T_{SOx}Conc_{SOx}/Q == AAI_{WB}$$

Translating a linked atmospheric-biogeochemical construct in NAAQS terminology

$$AAI_{WB} = [BC]_0 + Neco/Q - Dep_{NHx}/Q - T_{NOy}Conc_{NOy}/Q - T_{SOx}Conc_{SOx}/Q$$

Water quality

Air observations of NOy/SOx

LEVEL, FORM

$$AAI = F1^{*} - F2 - F3Conc_{NOy} - F4Conc_{SOx}$$

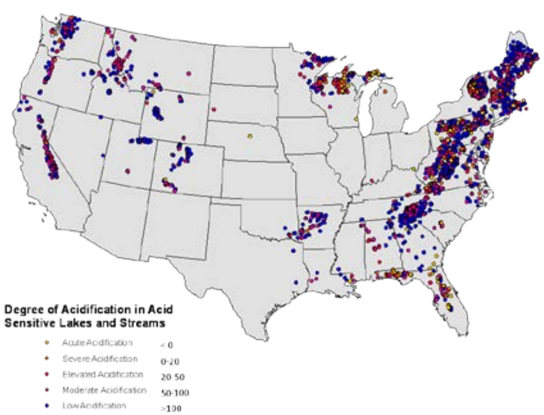
<u>Biogeochemical</u>
Base cation supply
Nitrogen neutralization

Reduced N (NHx) deposition

Concentration to deposition translators, Tratios

Charge balance between major cations supplied by ecosystem and acidifying anions contributed by deposition: interpreted as the potential ANC water bodies would realize from an atmospheric state.

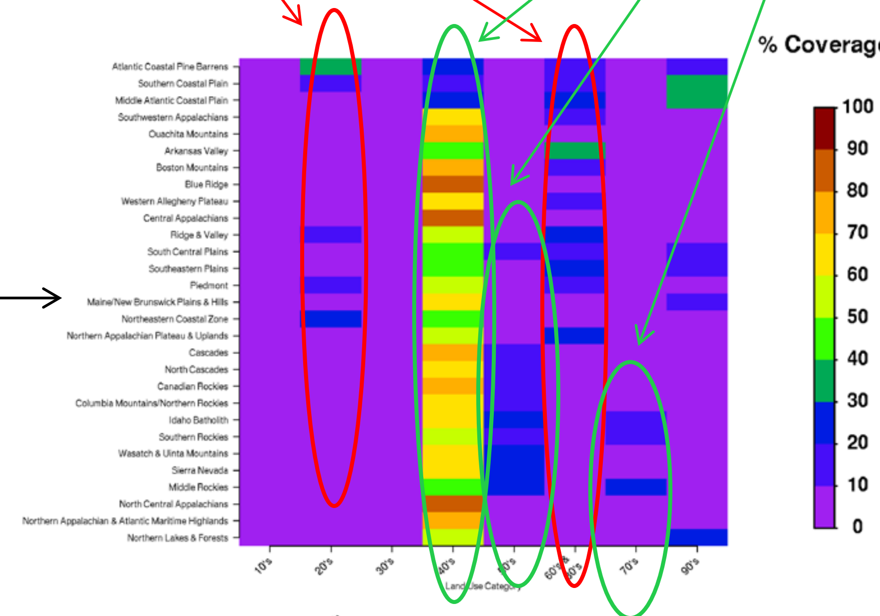
Accommodating homogeneity and heterogeneity in a national application – spatial aggregation

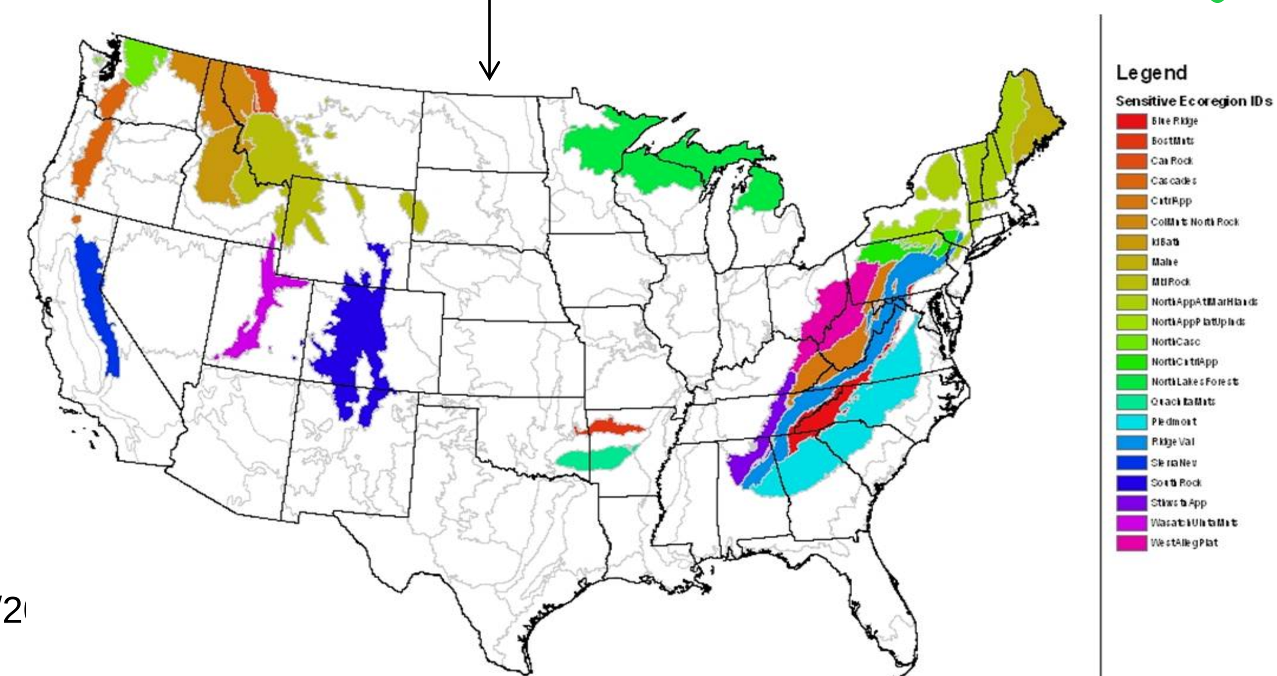


Objective - to focus on sensitive areas (based on ANC –left panel) and are likely to benefit (using NLCD rt. panel) from reductions in deposition segregated into similar biogeochemical attributes (Omernik ecoregions – below)

Developed/Ag

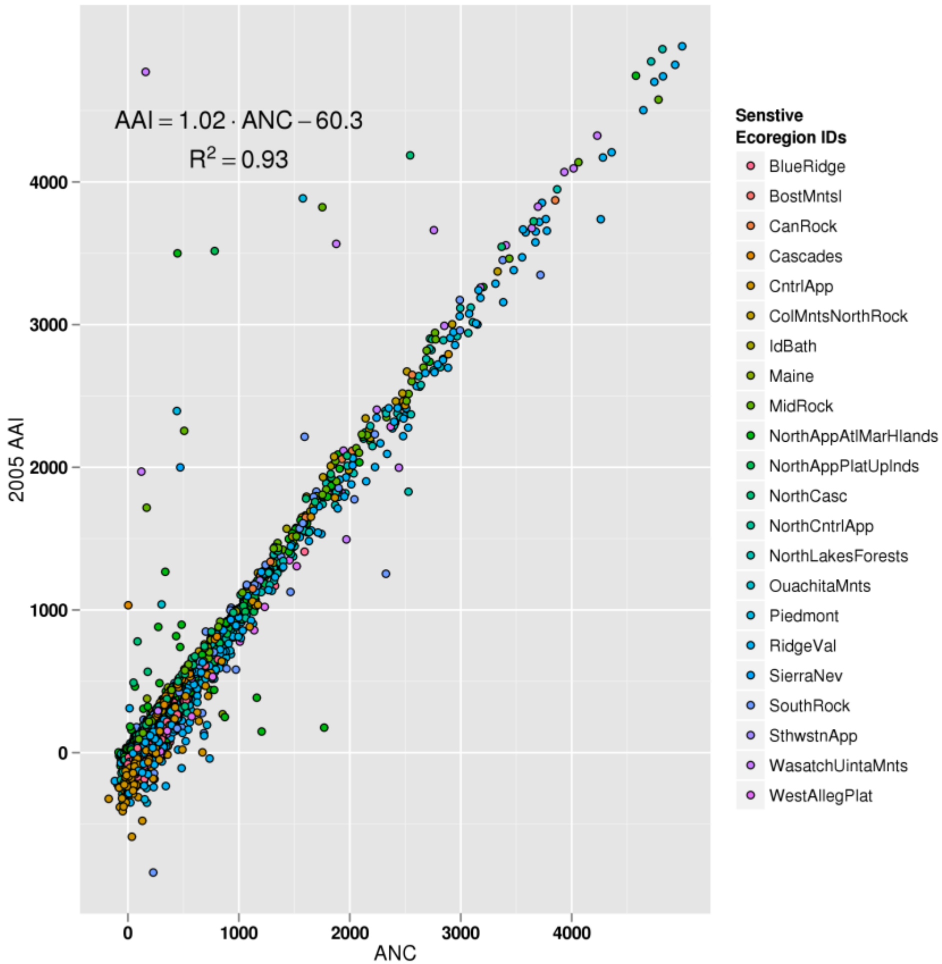
forests, shrubs, grasses

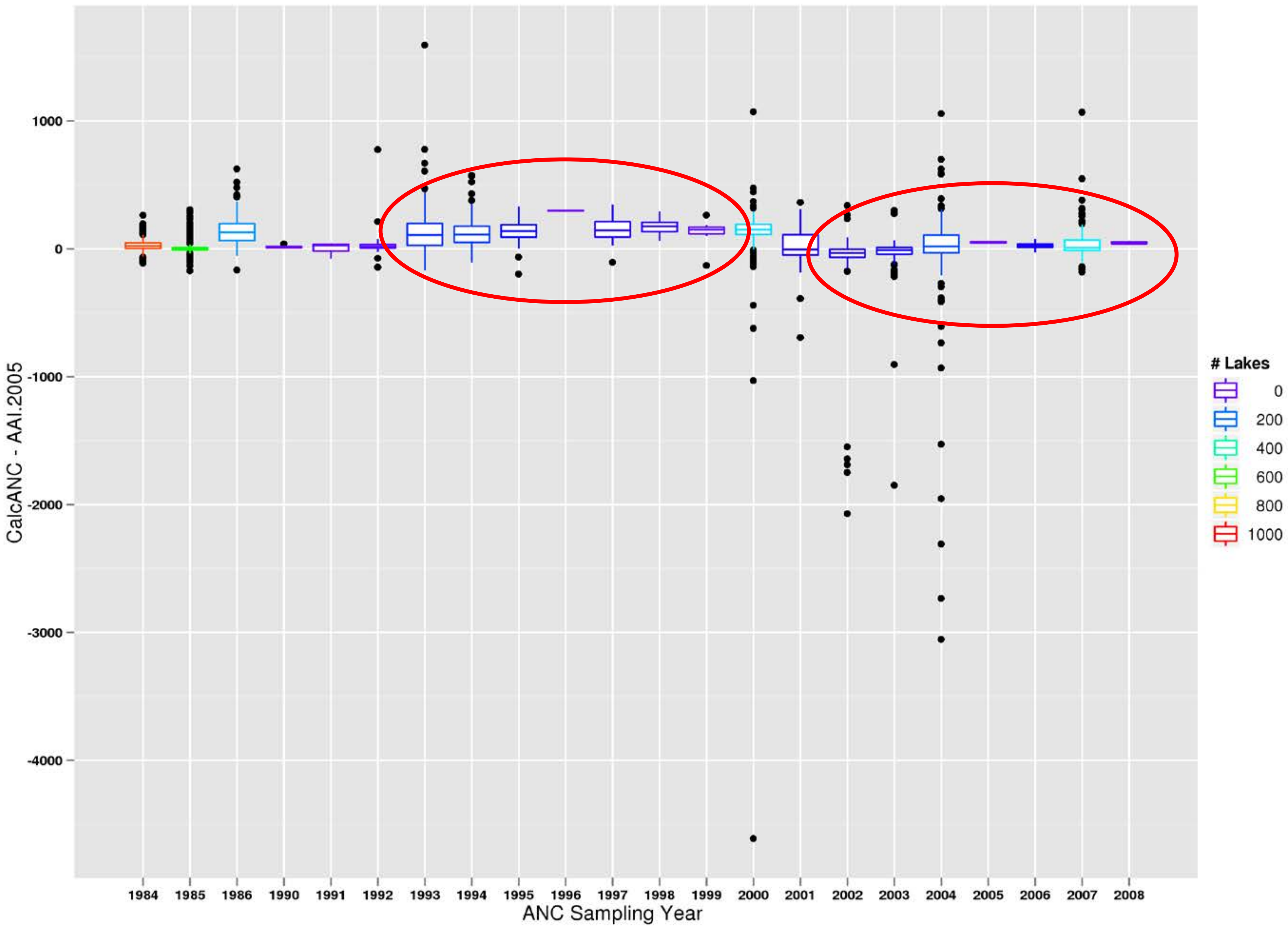




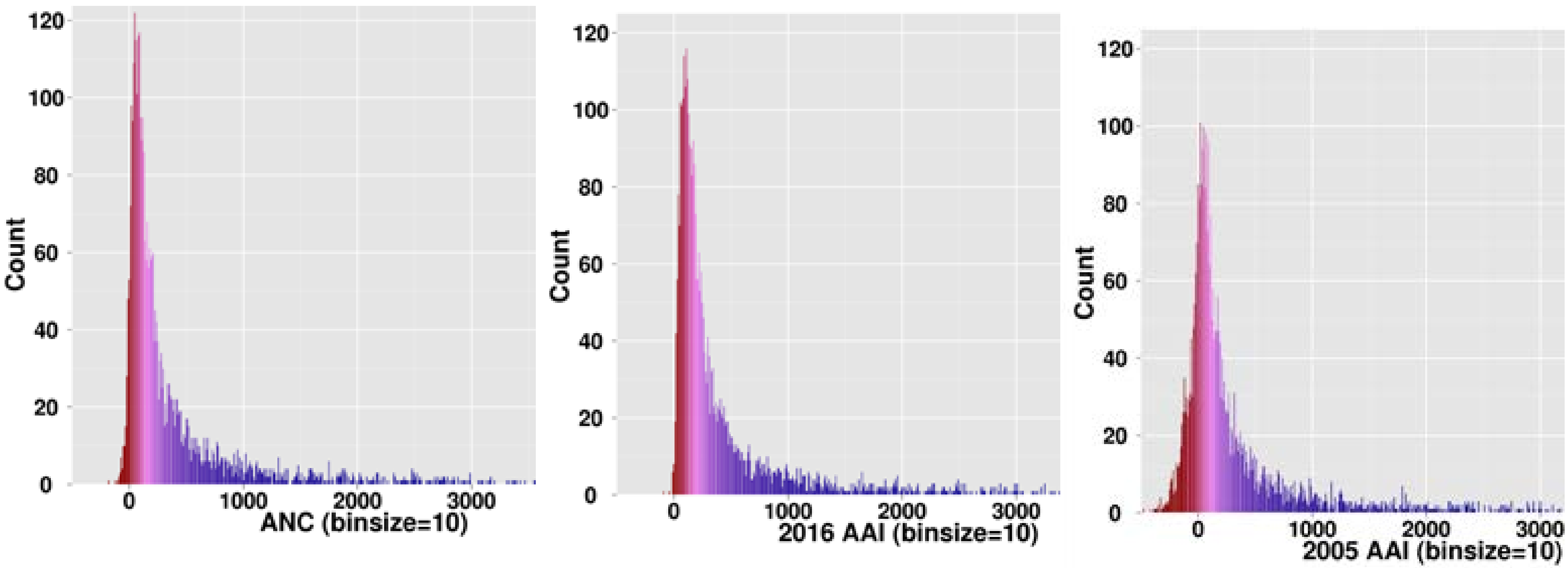
Does this work?

Comparison of calculated AAI values with observed ANC Offset due to possible deposition bias and SS assumptions – lag in cation leaching rates, sulfate adsorption/release, possibly associated with water quality sampling periods



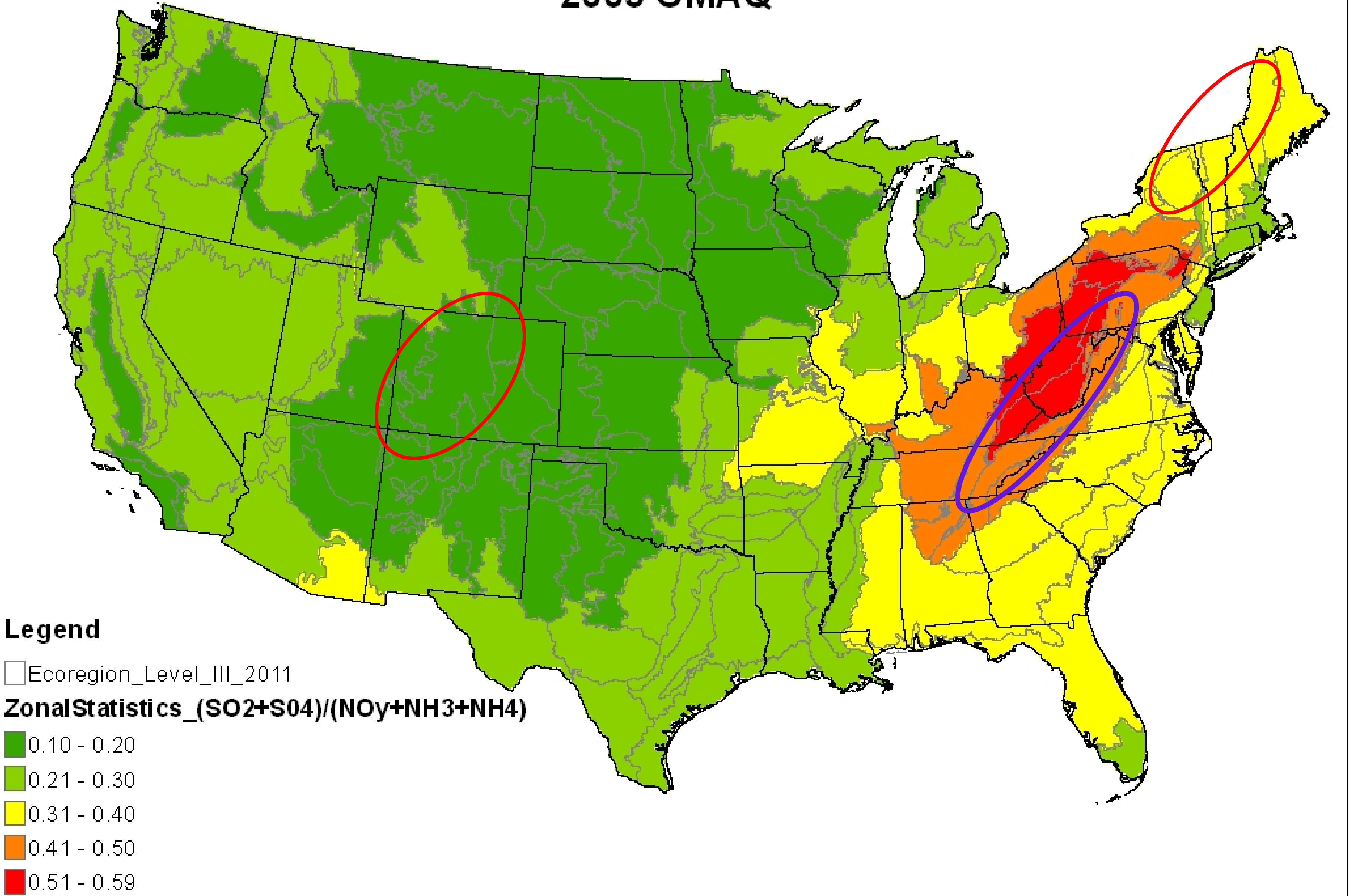


Differences (ANC-AAI) segregated by water quality sampling year

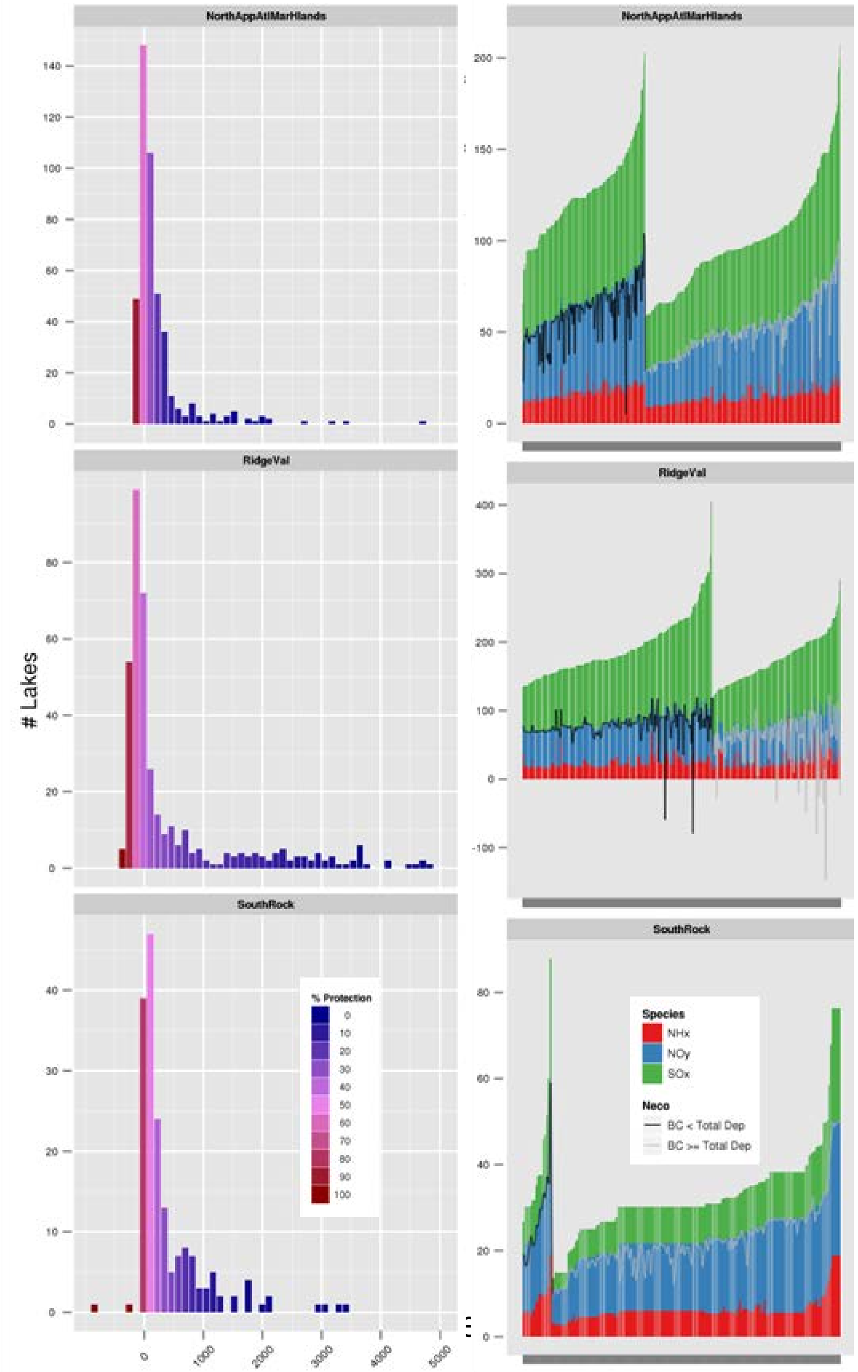


National distributions of observed ANC, 2005 AAI_{WB} and 2016 AAI_{WB}.

SOx/(NOy+NHx) Annual Average Concentration (ppb) Ratio per Ecoregion
--2005 CMAQ--



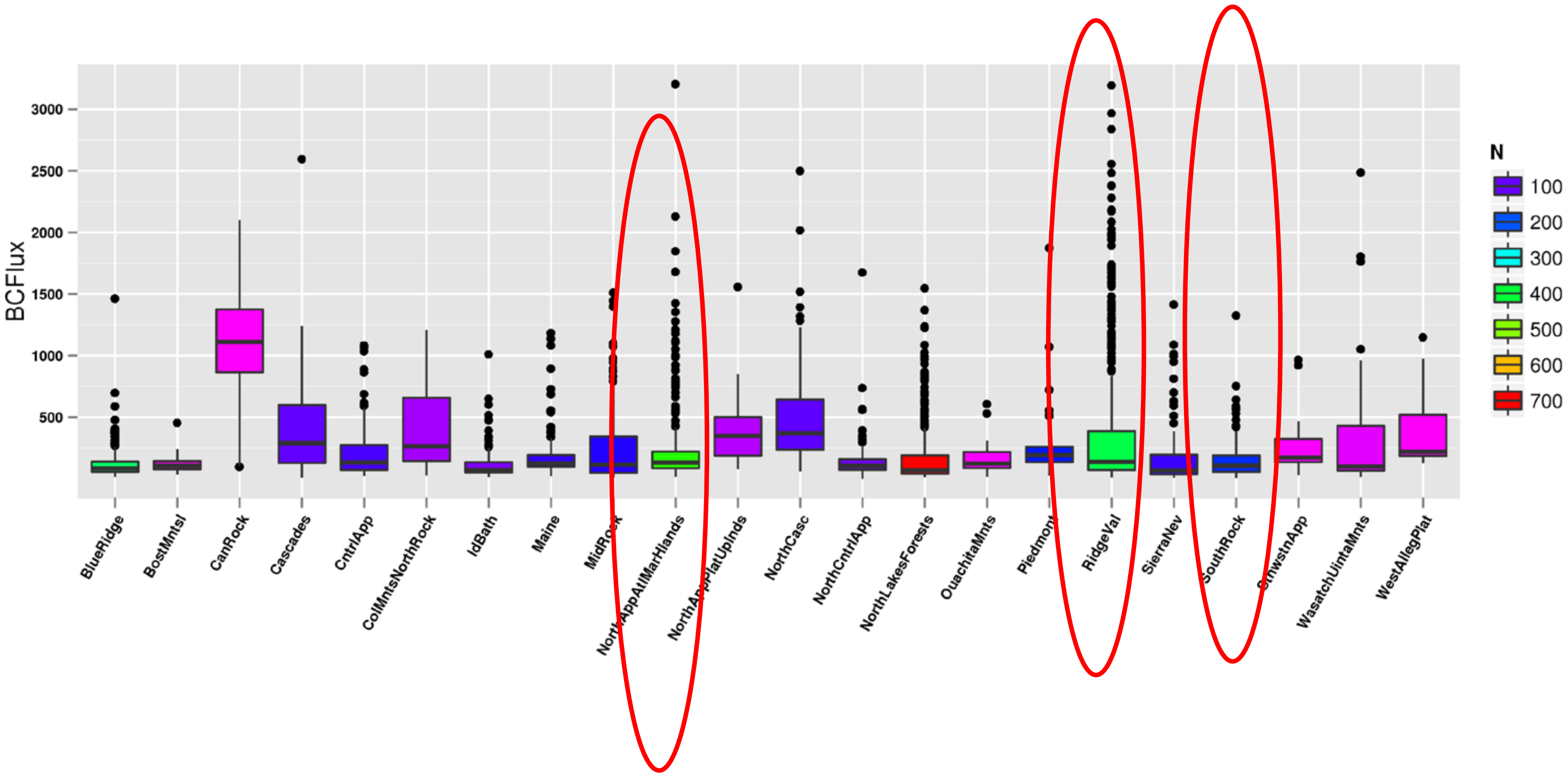
Example AAI_{WB} Distributions (left) for 3 regions and deposition and base cation flux components (right)



Adirondacks

Central Appalachians
(Ridge and Valley)

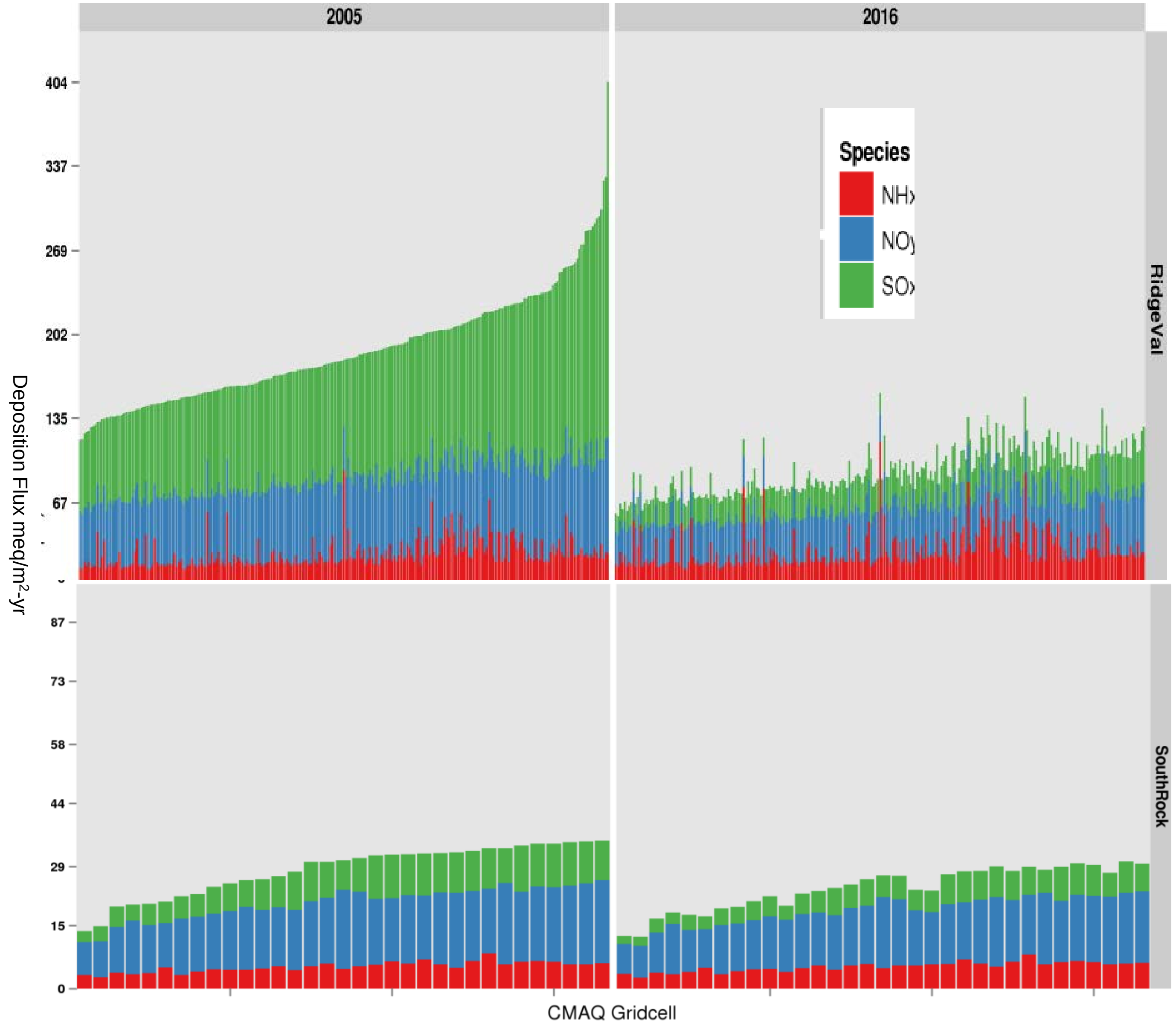
Southern Rockies



Variations in pre-industrial base cation flux

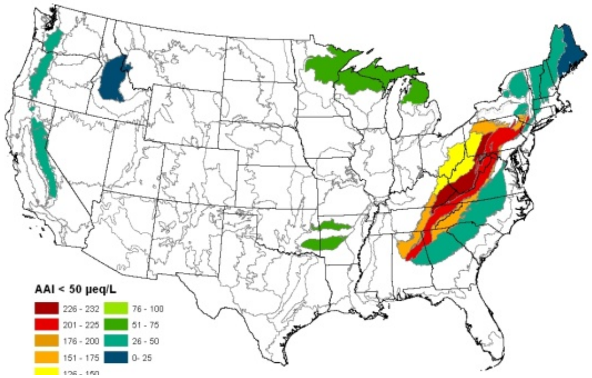
Deposition components For Appalachian (top) and Rocky Mtn. regions for 2005 (left) and 2016.

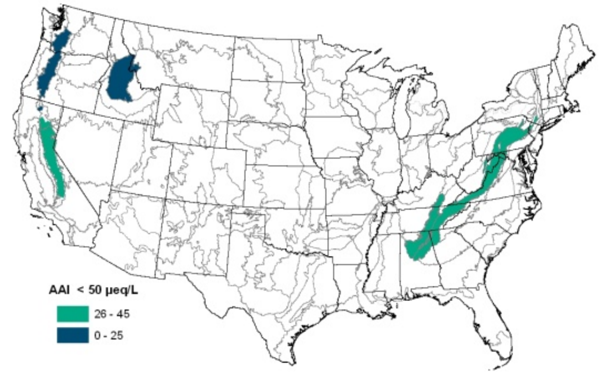
Transition from S –N contribution in East. Elevated importance of NHx everywhere

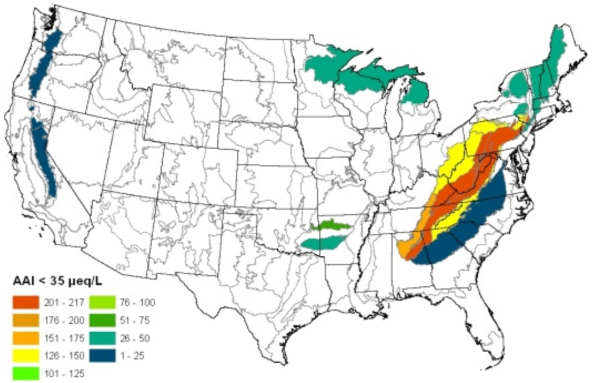


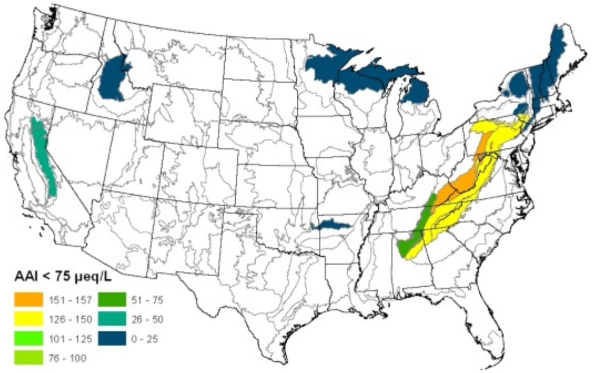
Combining Level (target ANC) and Form (% lakes protected)

2005 (left) and 2016 (right) AAI Exceedances for cases 50/90 (top); 35/90 (middle) and (75/70).









Consider

- *Accommodating data scarcity in a national application*
  - Would a standard
    - reduce the ratio of modeled data/observations?
    - enable focus on area's with more complex response behaviors (e.g., central Appalachians)?
    - Increase S,T commensurability between atmospheric and water sampling campaigns?
    - Increase range and consistency of water quality sampling in western systems?
- Tradeoff between averaging quantities and respecting heterogeneity
- Use of dynamic water quality models to characterize relative importance of simplified process parameterizations