Overview of Critical Loads Efforts in the U.S.

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Overview

- CL Refresher
  - What are critical loads?
  - What are they used for?
- An example – CLs & program assessment
- Current and past CL efforts in the U.S.
- Remaining CL implementation issues
- CL pilot projects – addressing implementation issues
- A Vision for CL use and implementation

From Science to Policy: Ecosystem Thresholds and Critical Loads

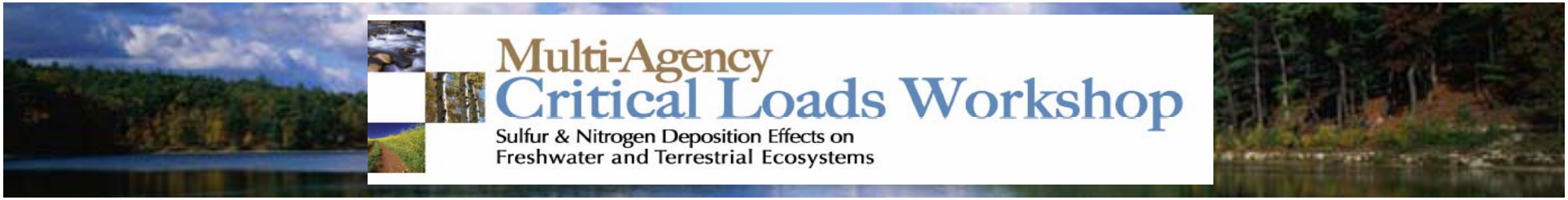
"**Critical Load" is a term used to describe:**

- Has air pollution reached a tipping point (threshold) for causing harmful effects to plants, animals, soils, or water?
- What amount of N or S deposition causes that tipping point?*

Critical loads are then used in policy and management contexts to determine:

•Are current policies and programs protecting ecosystems from reaching the tipping point or, if the point has been reached, assisting in recovery?

*especially relevant to NADP



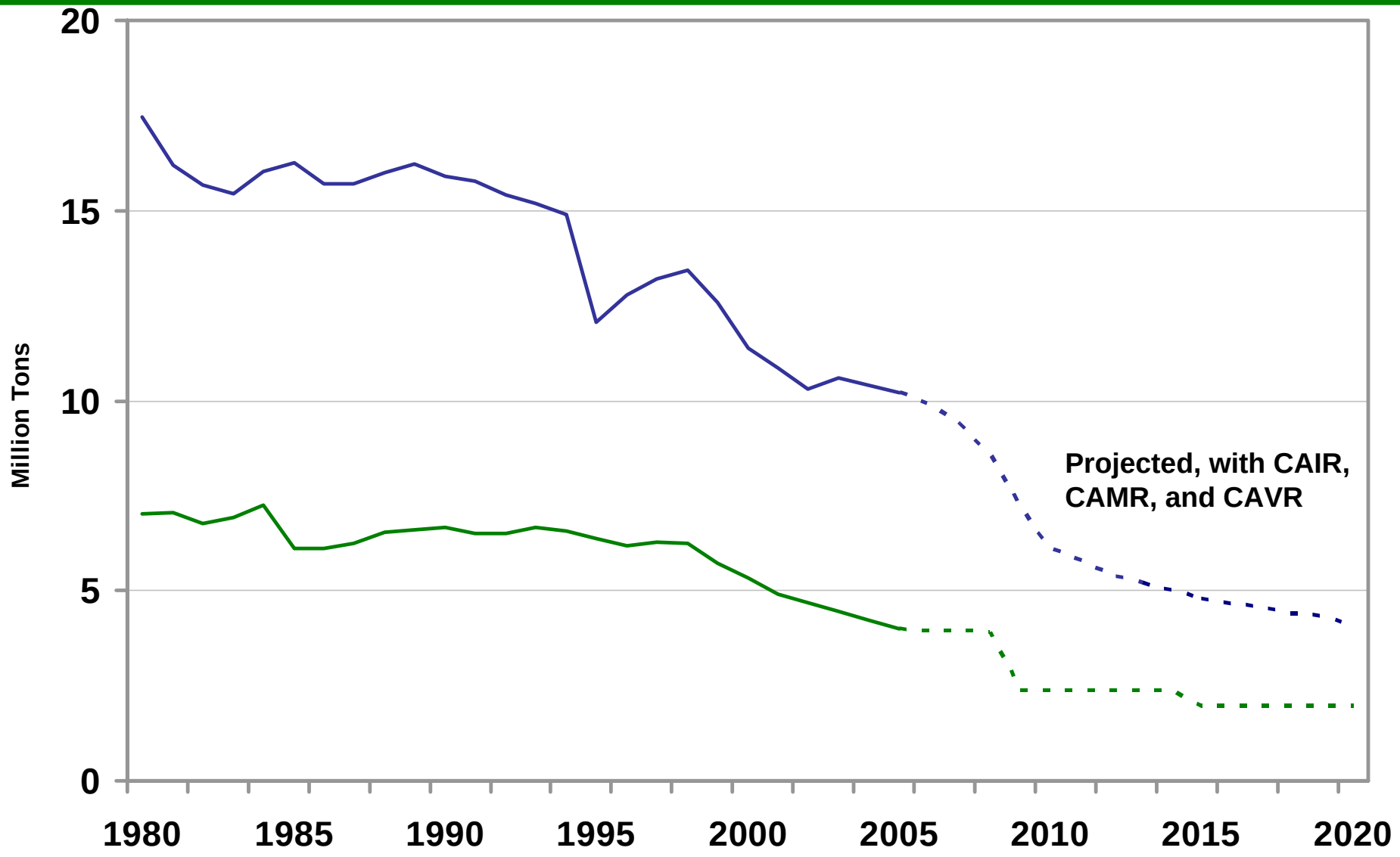
Disturbance	Receptor type	Pollutant	Possible biological indicators	Examples of critical indicator responses	Possible chemical variables	Examples of chemical thresholds
Acidification						
	Terrestrial	SO4, NO3, NH4	Sugar maple, Norway spruce	Crown condition, mortality, seedling death	Soil % base saturation, soil Ca/Al ratio, exchangeable Mg, exchangeable Al, foliar nutrients	Soil base saturation = 20% Soil Ca/Al = 1.0
	Aquatic	SO4, NO3, NH4	Brook trout, species composition, zooplankton, invertebrates	Presence/absence, species richness, species loss	Surface water ANC(g), pH, inorganic Al	ANC = 0-100µeq/L
Eutrophication						
	Terrestrial	NO3, NH4	Native grasses, native shrubs	Relative species abundance, total biomass	Soil C/N, extractable soil N, nitrification rates	Soil C/N = 20
	Aquatic	NO3, NH4	Diatom assemblages	Species composition	Surface water NO3, chl_a, N:P	Lake NO3 = 10µmol/L

Table 1 Examples of Critical Loads Receptors, Indicators, and Thresholds
Modified from presentations by T. Sullivan, G. Lawrence, C. Driscoll, and B.J. Cosby, 2006.

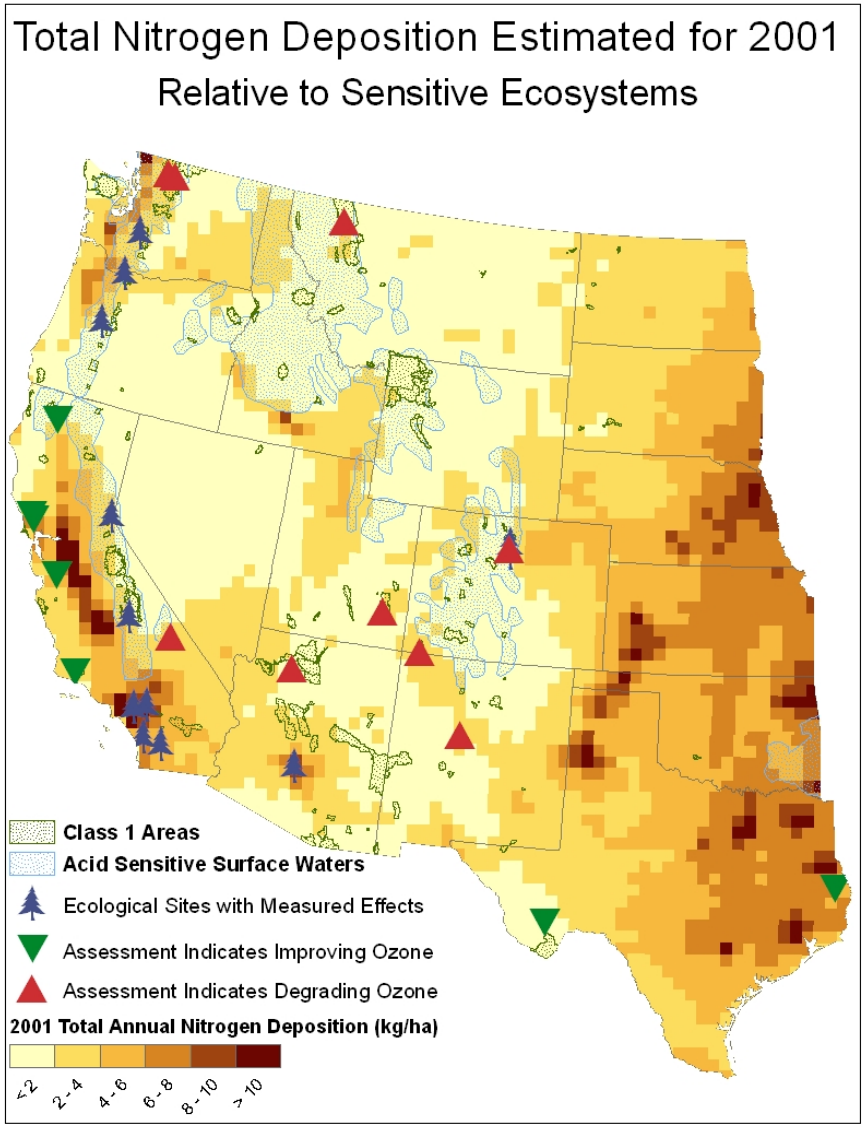
Critical Loads and Ecosystem Protection

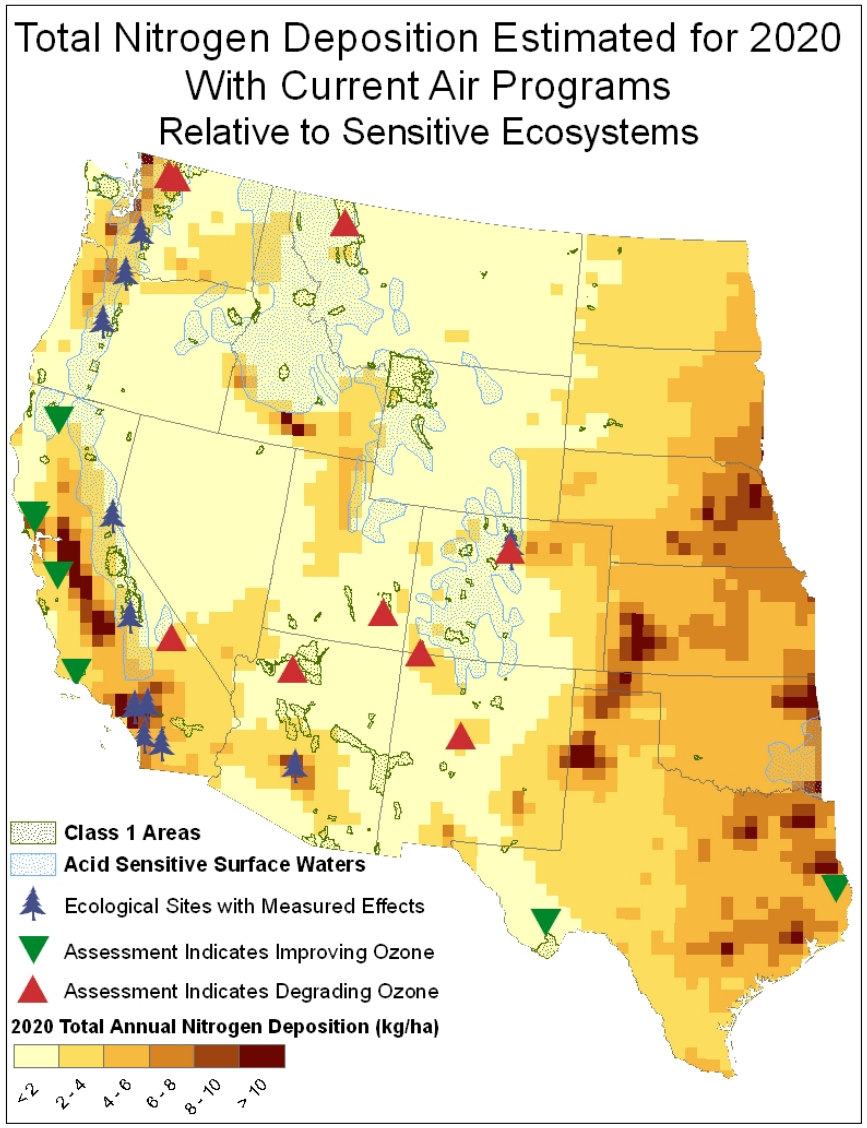
- Current mechanisms under the Clean Air Act to protect ecosystems
  - Emission reduction programs (e.g., Title IV Acid Rain Program)
  - Title I Secondary National Ambient Air Quality Standards
  - Title I Prevention of Significant Deterioration – NOx Increment Rule
- New emissions reduction programs
  - Clean Air Rules of 2005 (CAIR, CAVR)
- Potential new legislation and reduction programs

Nationwide SO_2 and NO_x Emissions from the Power Sector



Projected Change in Nitrogen Deposition
Western Sensitive Ecosystems, Ozone trends



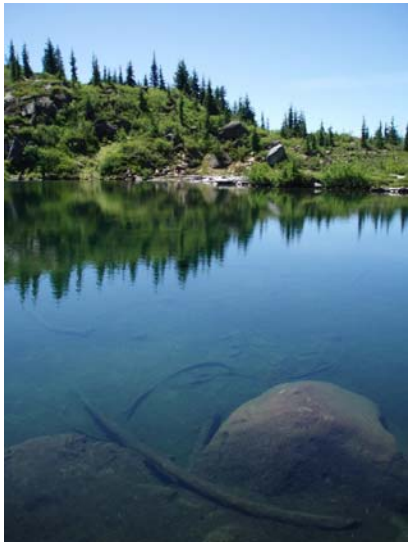


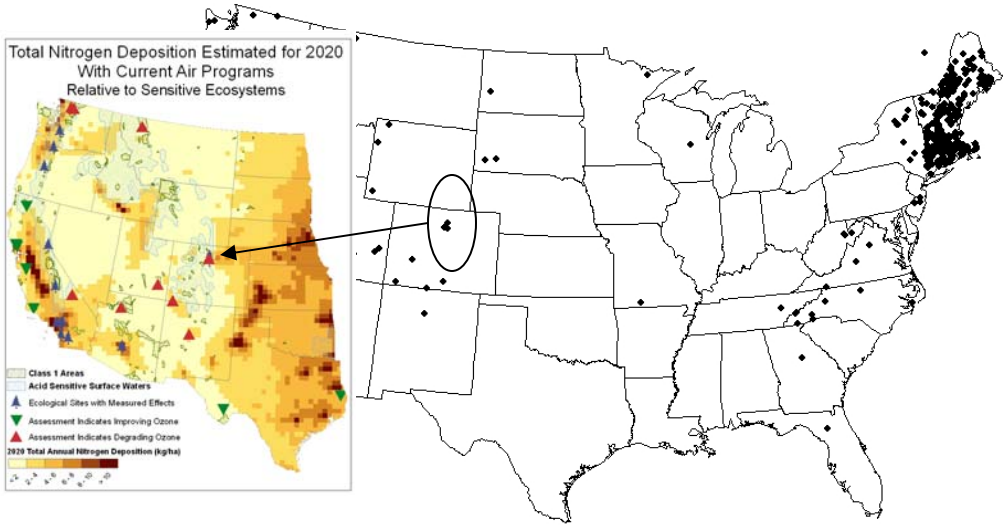
Critical Loads Efforts in the U.S.

- Past and current CL projects in the US
  - Select display (geo coordinates available; ~700 data points)
  - Empirical and modeling approaches
  - S & N deposition related
  - Multiple issues (e.g., acidification, eutrophication, forest & aquatic ecosystems)

Example of Empirical Critical Load Approach

- **High elevation lakes in Colorado Front Range**
- **Sensitive to N Deposition (Species Diversity)**
- **NADP/CASTNET - 5 kg\ha N**
- **Critical Load estimates**
  - Acidification – 4 kg\ha N wet + dry (Williams & Tonnessen 2000)
  - Eutrophication – 1.5 kg\ha N dry (Baron 2006)
- **Projected N dep**
  - **1.24 – 2.5 kg\ha N**
  - **Up to 6.5 kg\ha N**

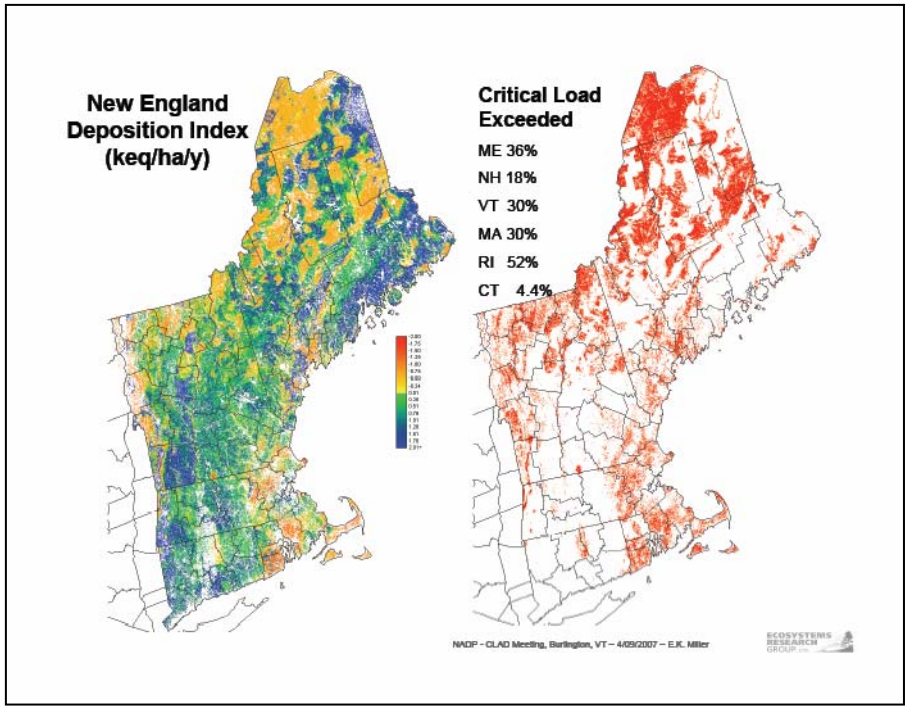




Steady-State Modeling Critical Load Efforts

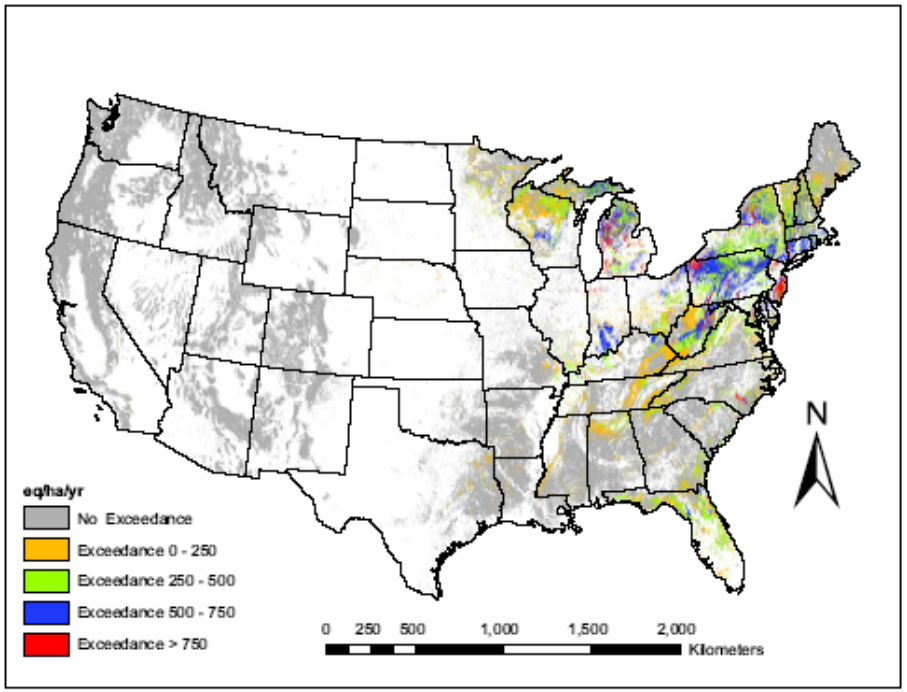
- Extensive application of steady-state modeling
- Focus on acid deposition impacts on forest ecosystems

Miller et al – NEG-ECP project



Percent of Forest Area with S+N Deposition Exceeding the Critical Load for Acidification

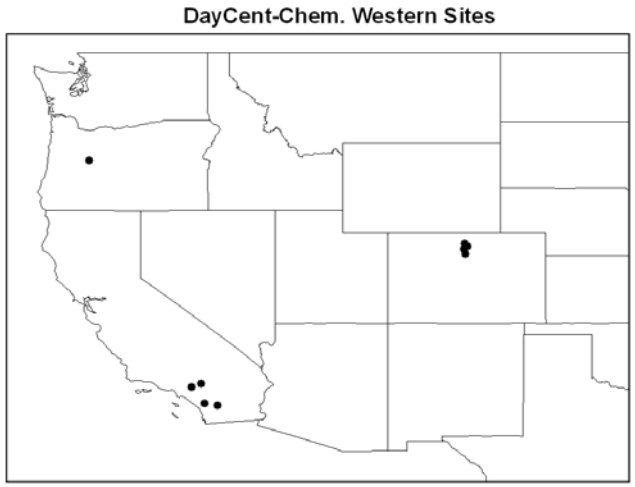
McNulty et al – ES&T (2007)



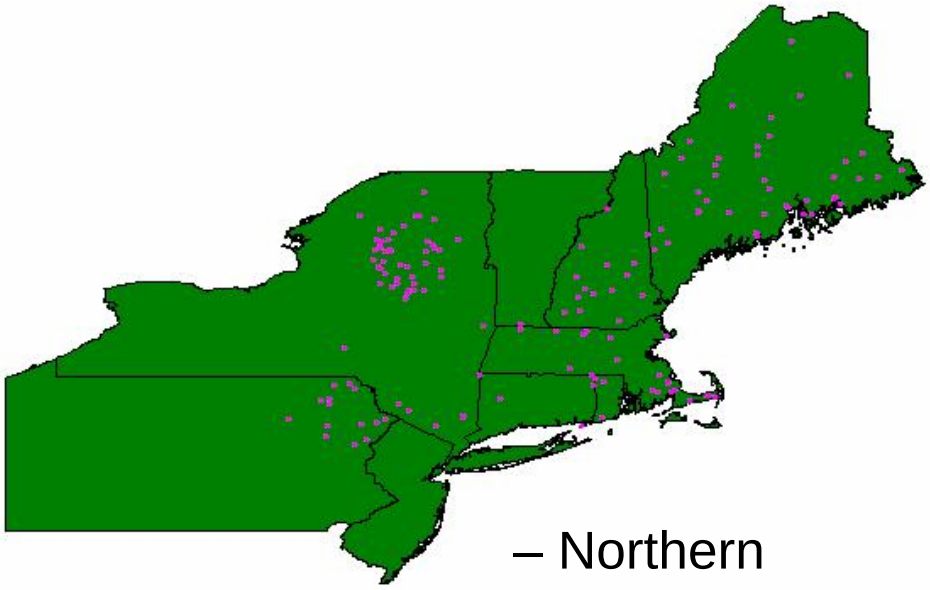
Average Annual Exceedance of the Critical Acid Load for Forest Soils

Dynamic Modeling Critical Load Efforts

Dynamic models have been used at eastern & western sites



– LTER & Experimental Forests
– DayCent-Chem



– Northern New England & Adirondacks sites
– MAGIC, VSD, PnET-BGC

Critical Loads Issues

- What resources do we care about?
  - Science/policy dialogue on resources, systems, indicators
- Do we have the right models?
  - Evaluation and comparison of models, including pilot applications (e.g., steady-state vs. dynamic models)
- Do we have the data?
  - Broad set of data needed to drive dynamic models
- How best to communicate data and results?
  - Data presentation and aggregation from site-specific to regional/national
- How do we know if projected loads are protecting ecosystems?
  - Deposition and environmental monitoring in relation to modeled loads
- How do we accommodate system change?
  - Understanding the consequences of disturbance, land use change, climate change, etc.

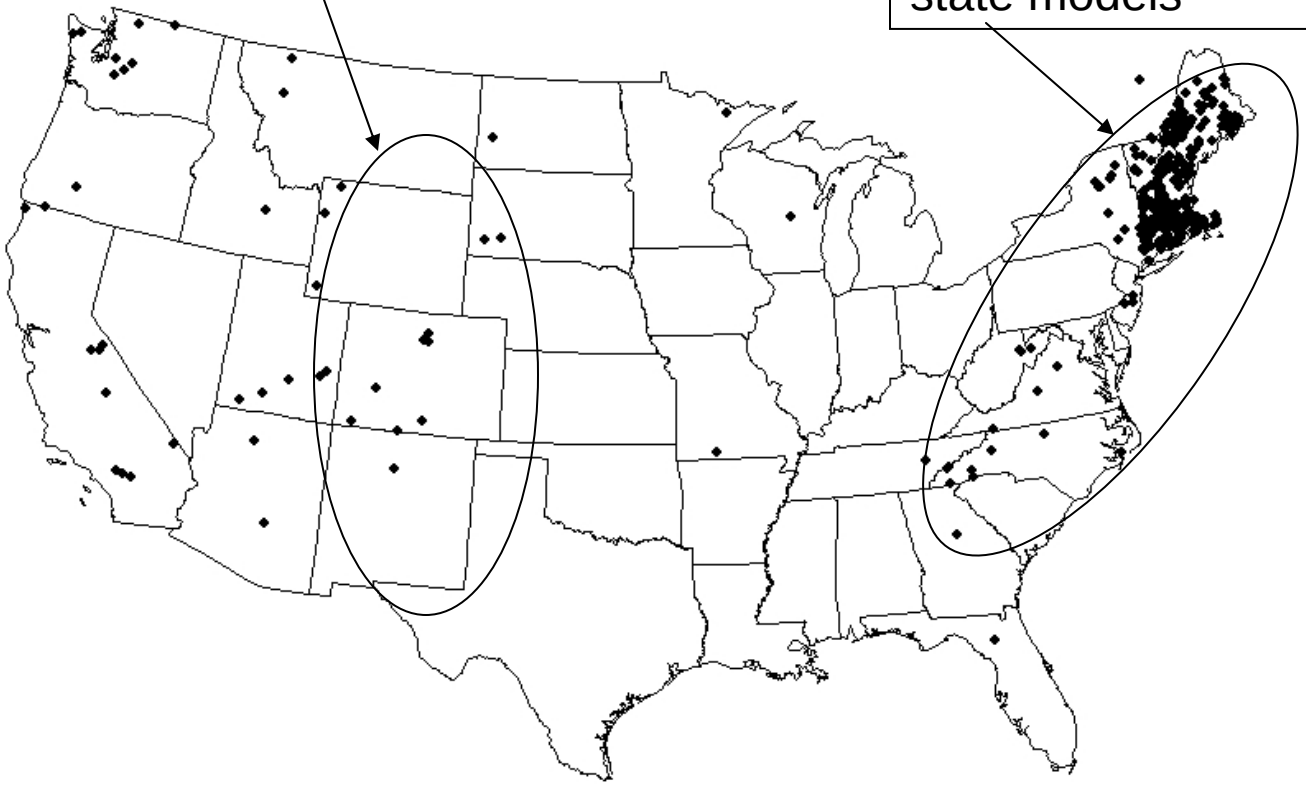
Multi-Agency Pilot Projects

- **Pilot Project Goals:**
  - **Explore development of critical loads for S and/or N effects**
  - **Evaluate utility of critical loads for policy/management use**
  - **Identify R&D gaps for future work**
- **Defined geographic area at multi-site to regional scale**
- **Addresses specific N & S deposition-related environmental issues**
- **Appropriate methods/models are available for use or adaptation**
- **Sufficient data for effective method/model application**
- **Accepted indicators available for tracking ecological response**
- **Sufficient monitoring (deposition and ecological response)**
- **Interested stakeholders (Federal, State, Tribal, Local)**
- **Well-defined project plan and products available within two years**

Multi-Agency Pilot Projects

Area: Rocky Mountain region
System: High elevation lakes
Pollutant: N & S
Effects: Acid; eutrophication
Approach: Empirical

Area: Eastern U.S.
System: lakes, streams, forests
Pollutant: N & S
Effects: Acidification
Approach: Dynamic & steady-state models



A Vision for Critical Loads

Nitrogen [illegible] Sites