Nutrient budgets watershed ecosystems?

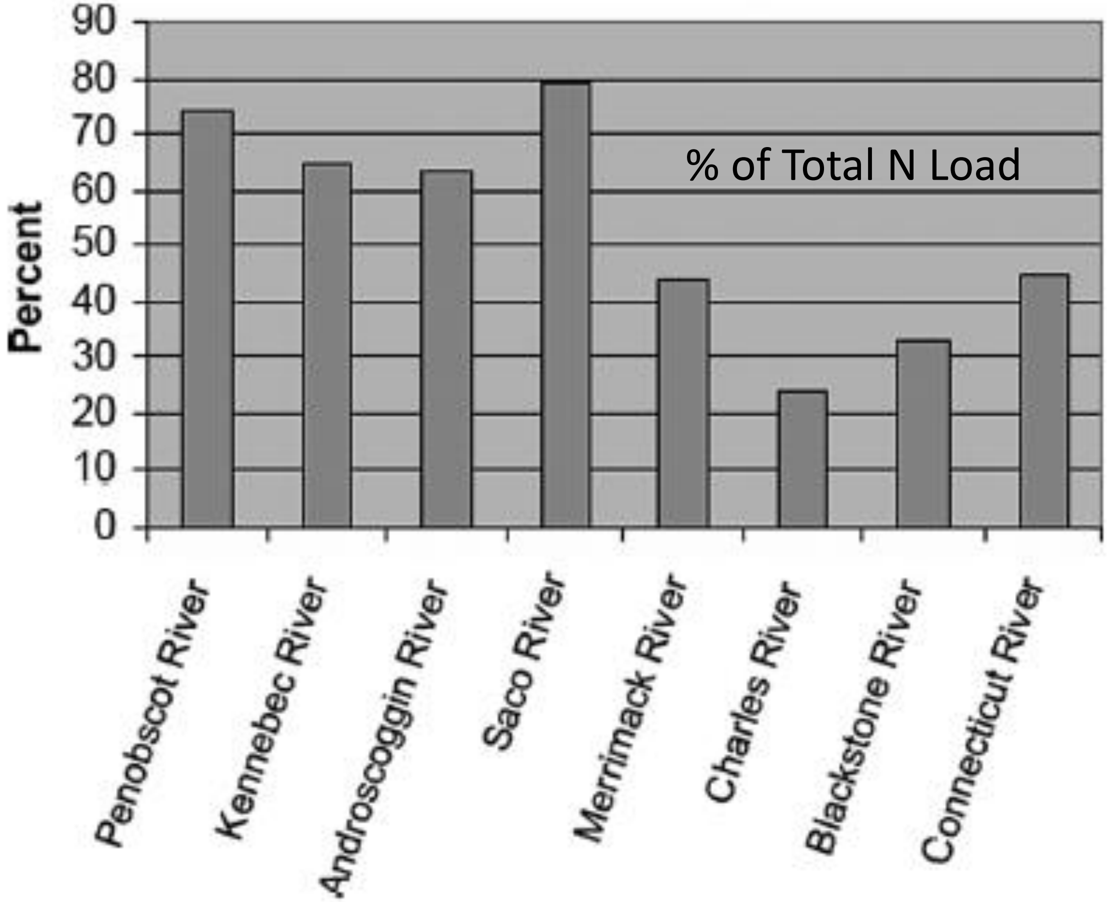
Atmospheric deposition can represent a large proportion of total load

- Depends on watershed characteristics, airshed, etc.
- Coastal areas can be as high as 80% of total load (Northeast U.S.)
- Other surface waters

  High elevation or remote lakes (P deposition?)

  Watersheds with historically high loads (N and S)

How much N from atmospheric deposition?



Howarth and Rielinger 2003

Discovery of acidic deposition and effects
Solution to pollution is not dilution!

Chapter 20

The Discovery of Acid Rain at the Hubbard Brook Experimental Forest: A Story of Collaboration and Long-term Research

Gene E. Likens and Scott W. Bailey

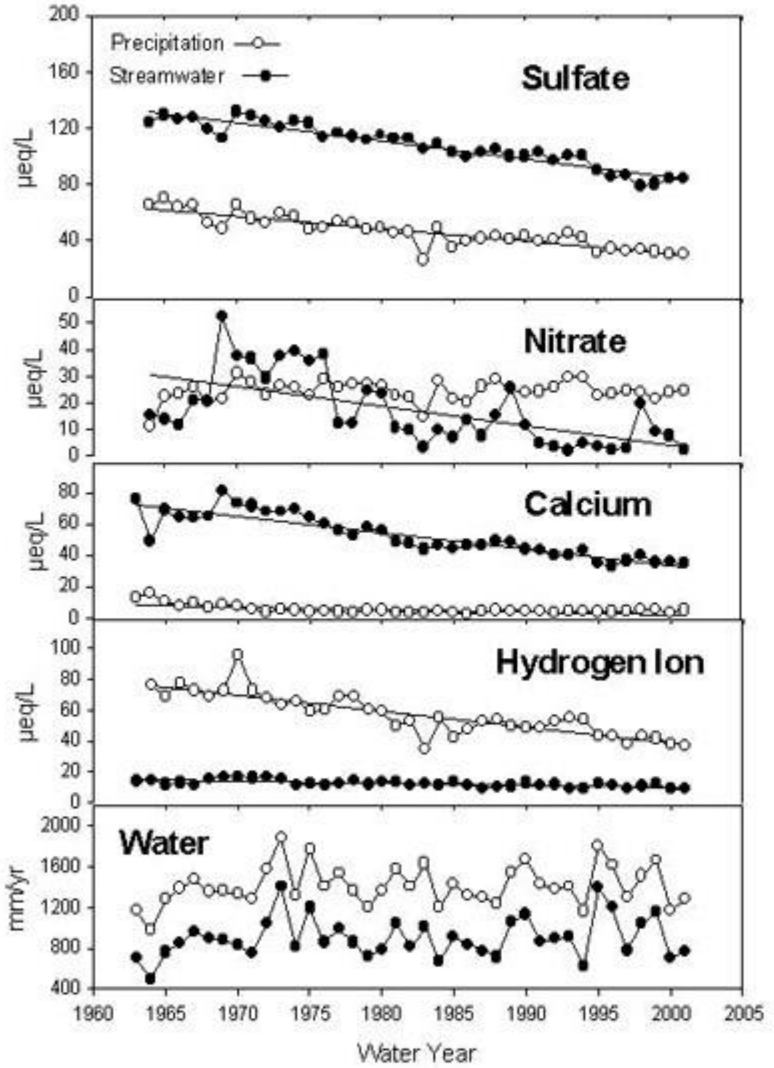
Abstract The 3,519-ha Hubbard Brook Experimental Forest (HBEF) was established in 1955 as the primary hydrological research facility in the northeastern USA. In 1963, FH Bormann, GE Likens, NM Johnson, and RS Pierce initiated the Hubbard Brook Ecosystem Study (HBES) to assess mass balance water and chemical budgets using gauged watersheds. From the study's inception, rain and snow inputs to the HBEF were unusually acid. Using back trajectories for air masses, HBES long-term data showed clearly that sulfate deposition at HBEF was strongly related to SO_2 emissions hundreds or thousands of kilometers distant. Other research showed that acid rain started in eastern North America in the 1950s. Reductions in emissions since 1970, primarily of SO_2 due to federal regulations, caused ~60% decline in acidity at HBEF since 1963. It required 18 years of continuous measurement to fit a significant linear regression to these data, showing the value of long-term measurements. HBEF data showed calcium depletion as a major impact of acid deposition. Other results showed slowed forest growth. In 1999, wollastonite (a calcium silicate mineral) was added experimentally to an entire watershed in an amount roughly equivalent to the amount estimated to have leached in the previous 50 years. Early results suggest positive survival and growth responses in sugar maple. The long-term data from the HBES suggest that changes in federal regulations to reduce emissions have reduced sulfate in both precipitation and stream water, demonstrating a positive link between high quality long-term research and public policy.

Keywords Hubbard Brook Ecosystem Study · Acid rain · Calcium depletion · Clean Air Act · Sulfate deposition · Long-term measurements

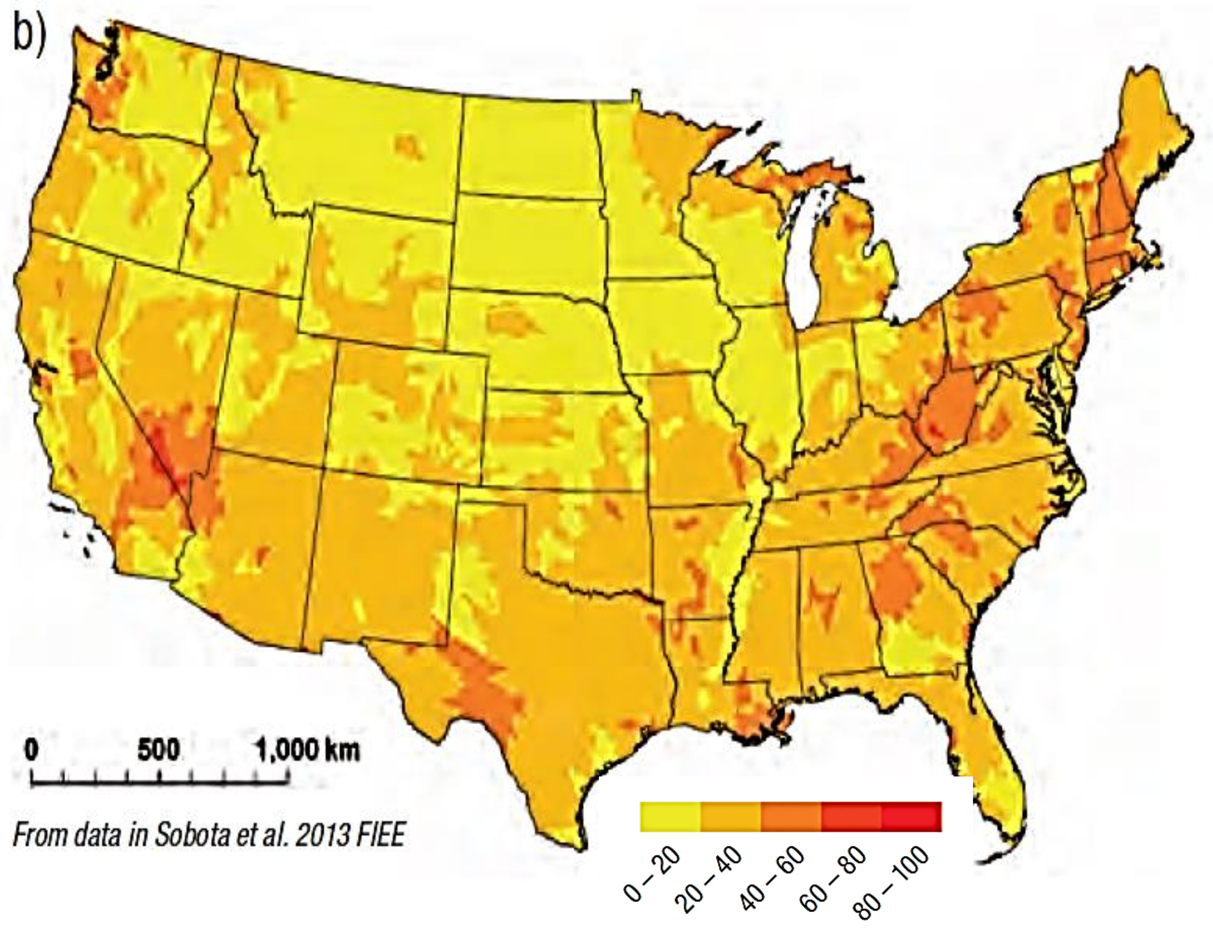
S. W. Bailey (✉)
Northern Research Station, USDA Forest Service, 234 Mirror Lake Road, North Woodstock, NH 03262, USA
Phone: 603-726-8902
e-mail: swbailey@fs.fed.us

G. E. Likens
Cary Institute of Ecosystem Studies, Millbrook, NY, USA
Department of Ecology and Environmental Biology, University of Connecticut, Storrs, CT, USA

D. C. Hayes et al. (eds.), *USDA Forest Service Experimental Forests and Ranges*, 463
DOI 10.1007/978-1-4614-1818-4_20, © Springer New York 2014

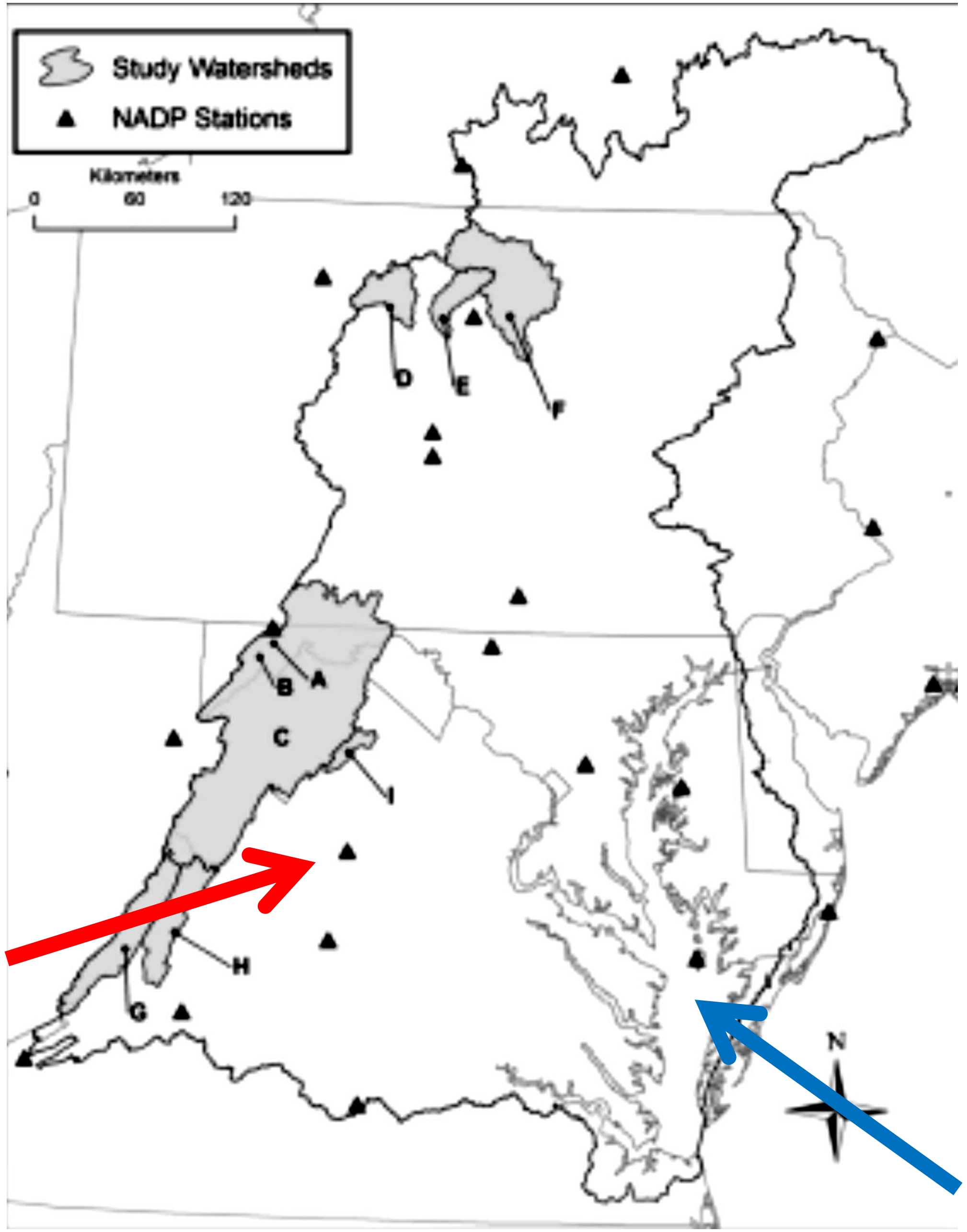


Now nutrient enrichment biggest water quality challenge



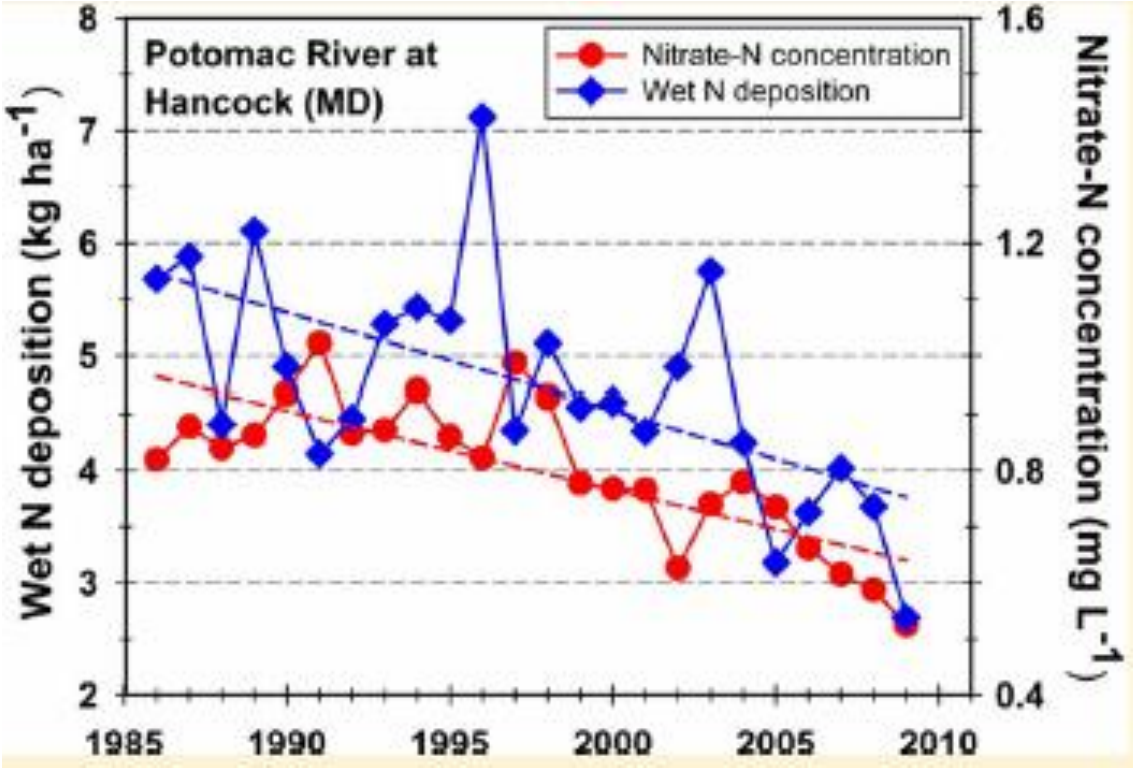
Source: Compton et al. 2015

- More sources of N than S, and biologically mediated
- Little known about P deposition (where, how much)



- Wet N deposition and nitrate-N concentration coupled
- Suggests forests N saturated

Eshleman et al. 2013



25-45% of total N load from deposition

Water and Air Integrated Monitoring (WAIM)

National Atmospheric Deposition Program Spring Meeting

Louisville, KY, Monday April 24, 2017, from 2:30-5:30 EST

Table 2 – Water quality data sources used to develop surface water critical loads.

Program name, sampling period	Collecting group	Web link	References	Number of points
EPA long term monitoring (LTM) – Adirondacks – annual average from 1992 to 2010	ALSC	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et al. (2003)	60
EPA long term monitoring (LTM) – Maine – annual average 1992–2007	UNH	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et al. (2003)	30
EPA long term monitoring (LTM) – Vermont – annual average 1992–2007	State of VT	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et al. (2003)	37
EPA long term monitoring (LTM) – Catskills – annual average 1992–2007	USGS	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et al. (2003)	4
EPA long term monitoring (LTM) – Pennsylvania – annual average 1992–2007	PSU	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et al. (2003)	5
EPA long term monitoring (LTM) – VTSSS – annual average 1992–2007	UVA	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et	
EPA long term monitoring (LTM) – Upper Midwest	EPA	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Eilers et al.	
EPA long term monitoring (LTM) – Colorado	EPA	http://www.epa.gov/airmarkt/assessments/TIMELTM.html	Stoddard et	
Eastern Lakes Survey dataset (ELS) 1984	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/els.html	U.S. EPA (19	
EPA-EMAP Northeast Lake Survey 1991–1994	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/nelakes.html	U.S. EPA (19	
EPA Regional EMAP (RMAP) Program 1993	EPA	http://www.epa.gov/emap2/remap/html/one/data/index.html	DiFranco et	
EPA-EMAP Mid-Appalachian Highland Assessment (MAHA) 1994–1996	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/mastreams/9396/index.html	U.S. EPA (20	
EPA-EMAP Mid-Atlantic Integrated Assessment (MAIA) 1997–1998	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/mastreams/9798/index.html	Stoddard et	
EPA National Stream Survey (NSS) 1986	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/nss.html	U.S. EPA (19	
Virginia Trout Stream Sensitivity Study (VTSSS) Surveys 1987 and 2000	UVA	http://swas.evsc.virginia.edu/		
EPA National Wadeable Stream Survey (WSA) 2007	EPA	http://www.epa.gov/owow/streamsurvey/web_data.html	U.S. EPA (20	
EPA Western Lake Survey (WLS) 1985	EPA	http://www.epa.gov/emap2/html/data/surfwatr/data/wls.html	Eilers et al. and U.S. EP.	
EPA-EMAP Western Stream & River Survey 2000–2004	EPA	http://www.epa.gov/esd/land-sci/water/streams.htm	Stoddard et	
EPA National Lake Survey 2010	EPA	http://www.epa.gov/lakessurvey	U.S. EPA (20	
USFS Forest Service Water Quality Data	USFS	http://views.cira.colostate.edu/web/SiteBrowser/fswq.aspx		
USGS Water-Quality Data for the Nation	USGS	http://waterdata.usgs.gov/nwis/qw		
Washington/Oregon Coastal Streams and Yakima River Basin 1994–1995	EPA	http://www.epa.gov/emap2/remap/html/ten/data/		
Multiagency Critical Loads Research Project: Virginia and West Virginia	E&S Environmental Chemistry	http://www.esenvironmental.com/projects_multiagency.htm	Sullivan et and Driscoll	
Multiagency Critical Loads Research Project: Northeast	Ecosystems Research Group, Ltd.	http://www.ecosystems-research.com/index.htm	Miller (2011	

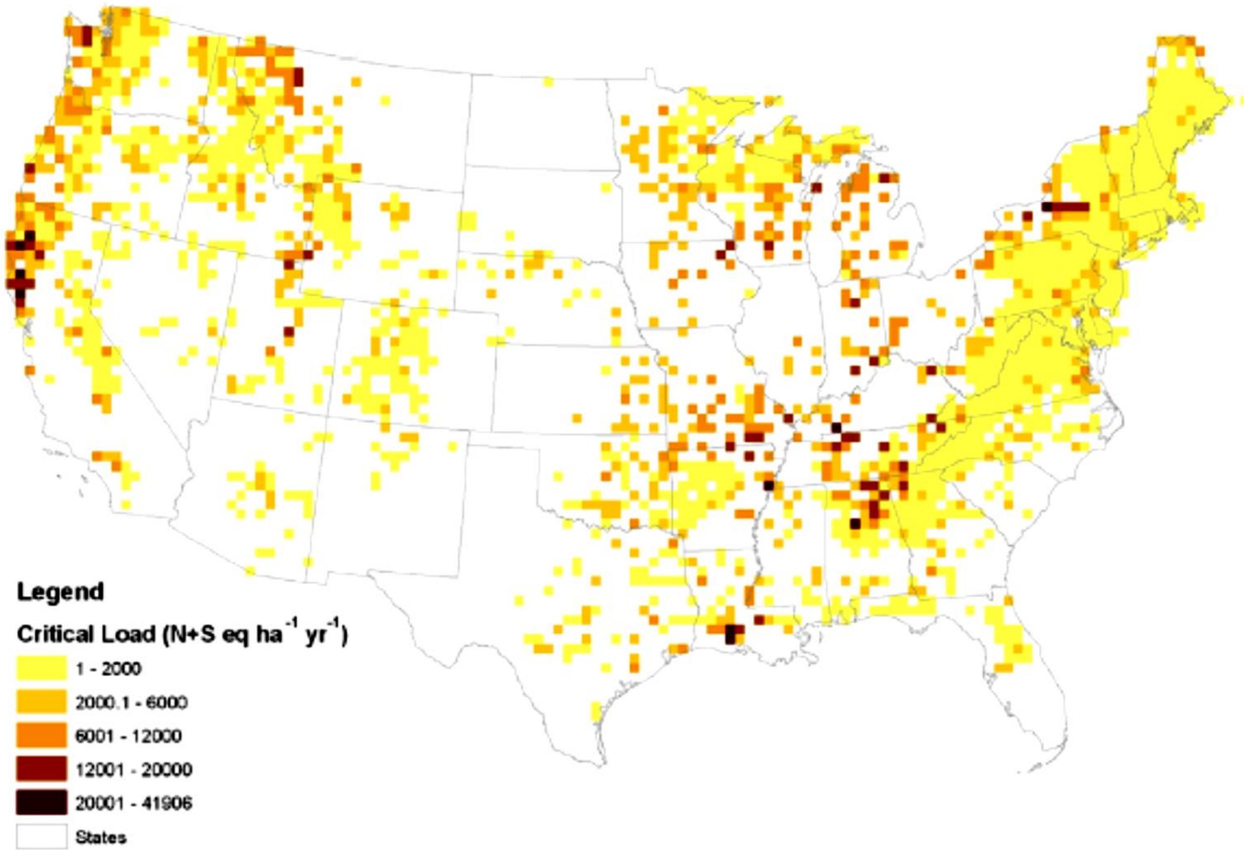
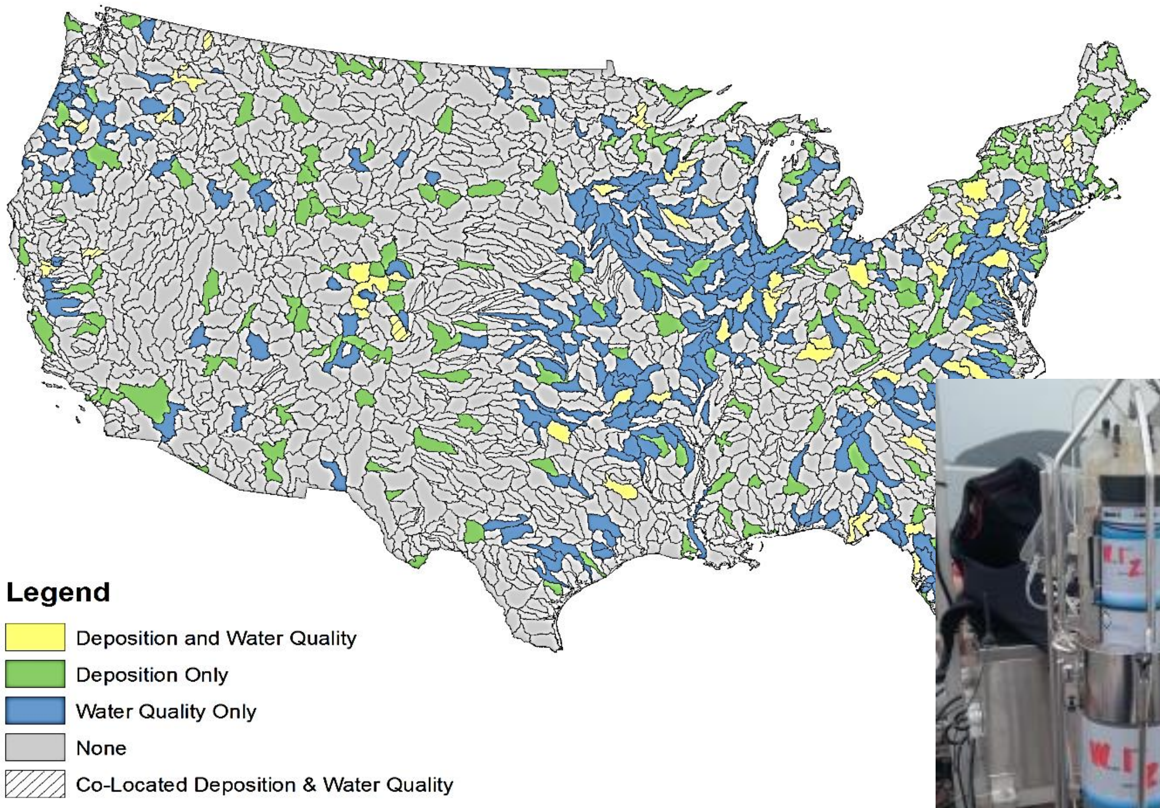
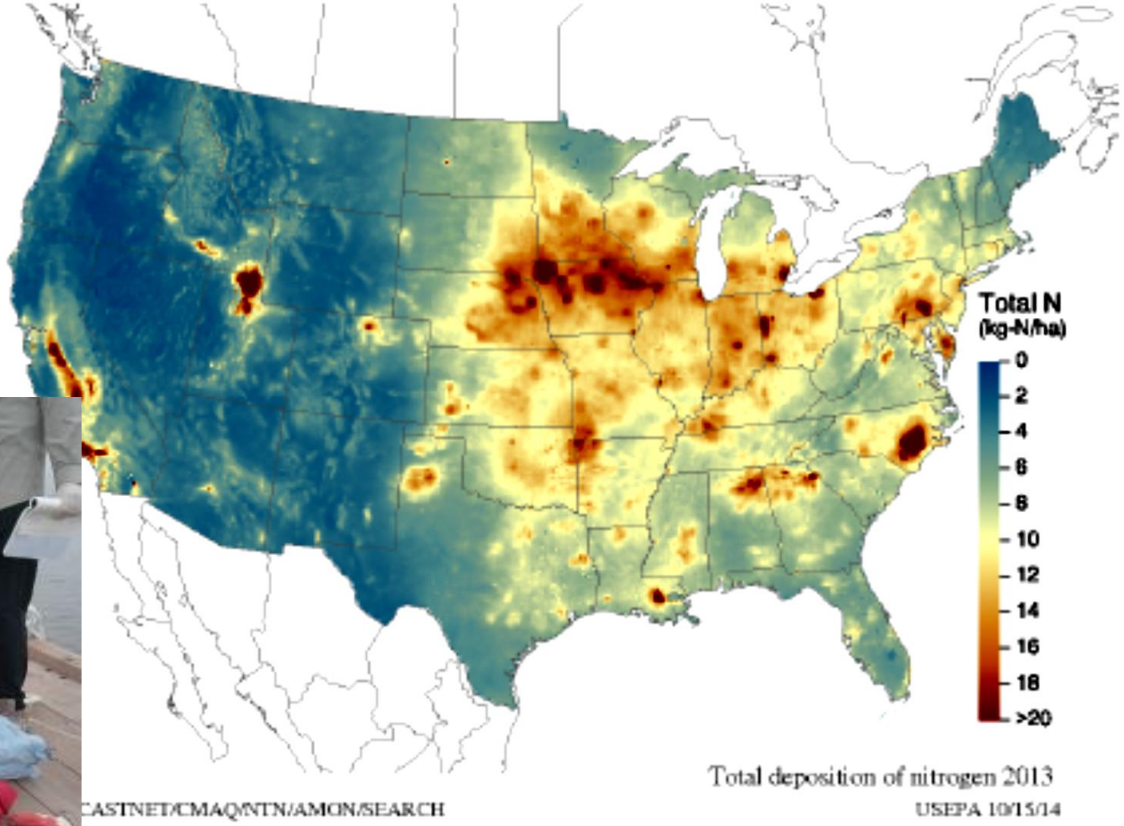


Table 3 – Aquatic status categories in the U.S. (Burns et al., 2011; U.S. EPA, 2009b).

ANC levels	Expected ecological effects
<0 microequivalents per Liter (μeq/L)	Complete loss of fish populations is expected. Planktonic communities hav and are dominated by acidophilic forms. The numbers of individuals in present are greatly reduced.
0–20 μeq/L	Highly sensitive to episodic acidification. During episodes of high acid depo populations may experience lethal effects. Diversity and distribution of declines sharply.
20–50 μeq/L	Fish species richness is greatly reduced (more than half of expected specie average, brook trout populations experience sub-lethal effects, including loss of health and reproduction (fitness). Diversity and distribution of zooplankton communities decline.
50–100 μeq/L	Fish species richness begins to decline (sensitive species are lost from lakes). Brook trout populations are sensitive and variable, with possible sub-lethal effects. Diversity and distribution of zooplankton communities begin to decline as species that are sensitive to acid deposition are affected.
>100 μeq/L	Fish species richness may be unaffected. Reproducing brook trout populations are expected where habitat is suitable. Zooplankton communities are unaffected and exhibit expected diversity and distribution.

Integrated water and air quality monitoring?





What's next?

Assessing where we have comparable data

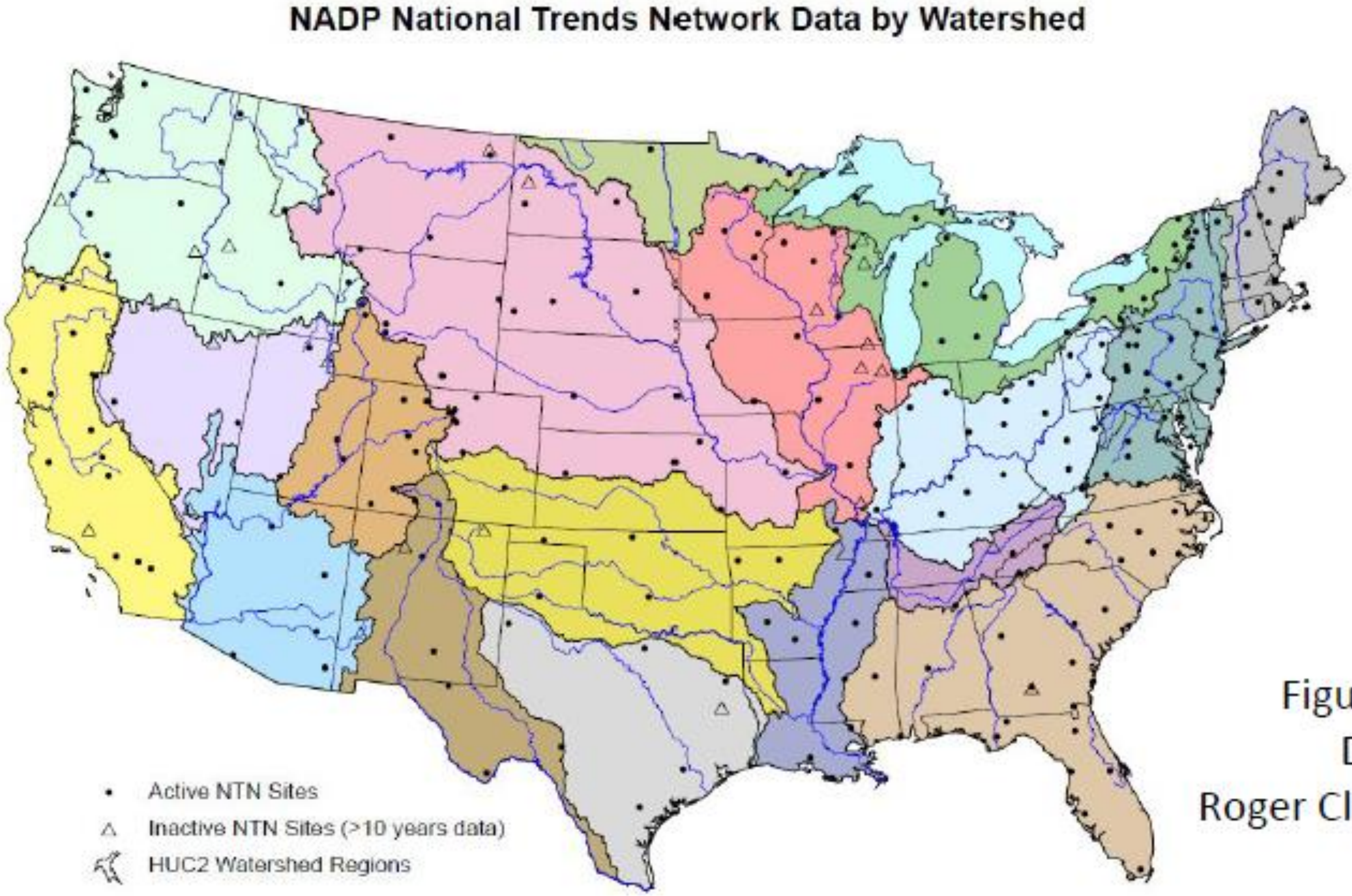
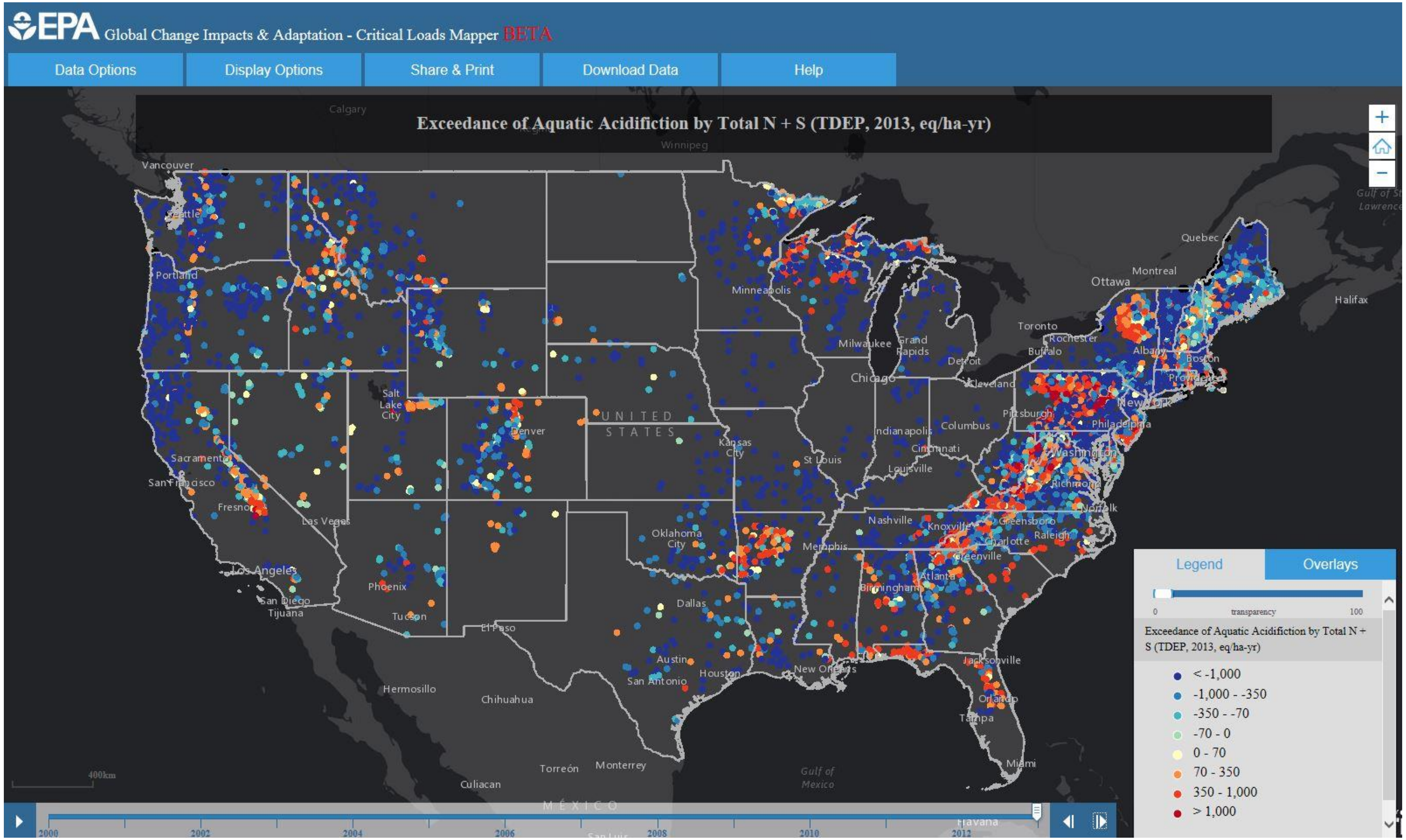


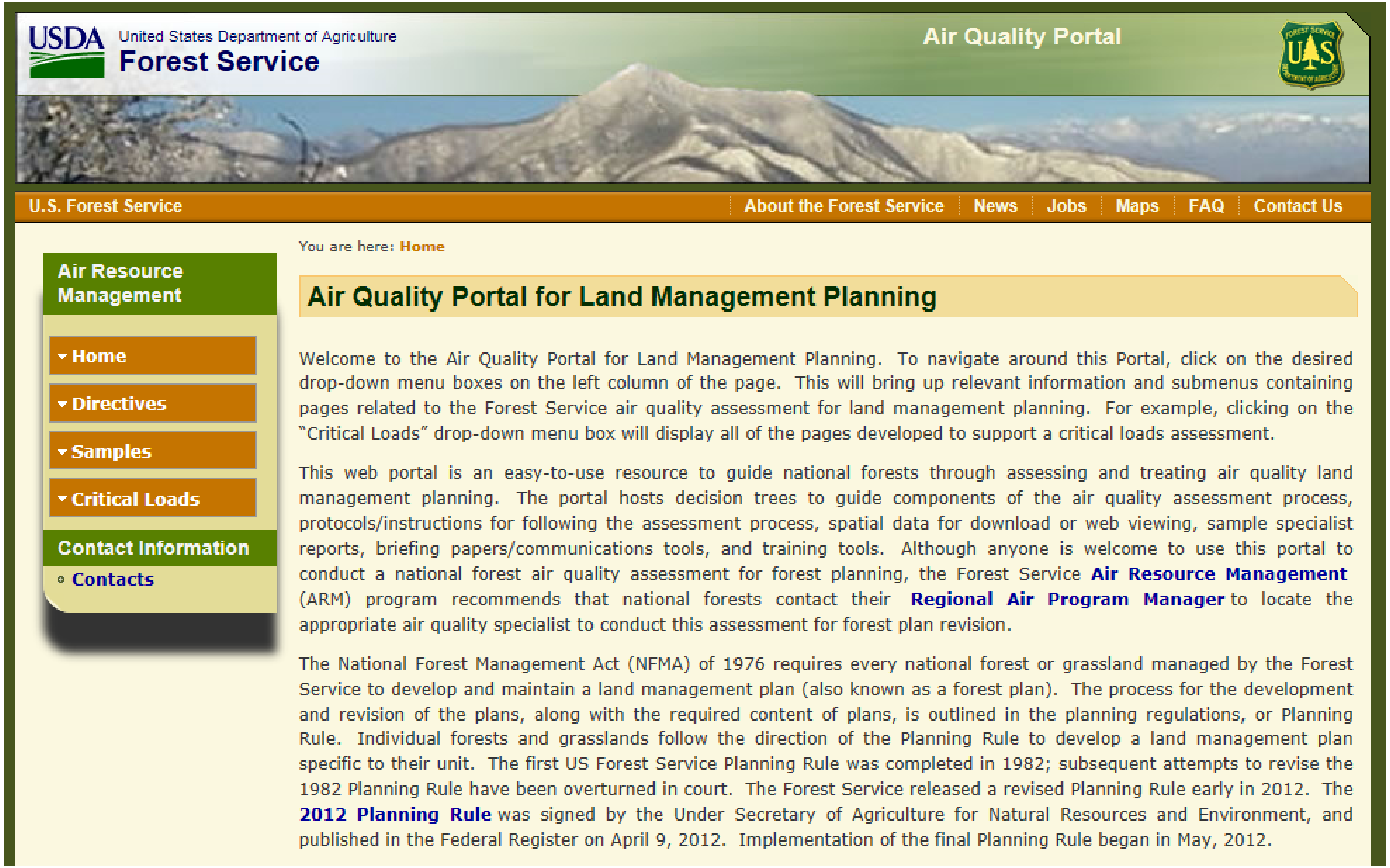
Figure credit:
David Gay
Roger Claybrooke

Critical loads mapper

https://globalchange.epa.gov/



Air quality portal


USDA United States Department of Agriculture
Forest Service

Air Quality Portal

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Air Resource Management

- Home
- Directives
- Samples
- Critical Loads

Contact Information

- Contacts

You are here: Home

Air Quality Portal for Land Management Planning

Welcome to the Air Quality Portal for Land Management Planning. To navigate around this Portal, click on the desired drop-down menu boxes on the left column of the page. This will bring up relevant information and submenus containing pages related to the Forest Service air quality assessment for land management planning. For example, clicking on the "Critical Loads" drop-down menu box will display all of the pages developed to support a critical loads assessment.

This web portal is an easy-to-use resource to guide national forests through assessing and treating air quality land management planning. The portal hosts decision trees to guide components of the air quality assessment process, protocols/instructions for following the assessment process, spatial data for download or web viewing, sample specialist reports, briefing papers/communications tools, and training tools. Although anyone is welcome to use this portal to conduct a national forest air quality assessment for forest planning, the Forest Service **Air Resource Management** (ARM) program recommends that national forests contact their **Regional Air Program Manager** to locate the appropriate air quality specialist to conduct this assessment for forest plan revision.

The National Forest Management Act (NFMA) of 1976 requires every national forest or grassland managed by the Forest Service to develop and maintain a land management plan (also known as a forest plan). The process for the development and revision of the plans, along with the required content of plans, is outlined in the planning regulations, or Planning Rule. Individual forests and grasslands follow the direction of the Planning Rule to develop a land management plan specific to their unit. The first US Forest Service Planning Rule was completed in 1982; subsequent attempts to revise the 1982 Planning Rule have been overturned in court. The Forest Service released a revised Planning Rule early in 2012. The **2012 Planning Rule** was signed by the Under Secretary of Agriculture for Natural Resources and Environment, and published in the Federal Register on April 9, 2012. Implementation of the final Planning Rule began in May, 2012.