Use Of NADP Mercury Deposition Network For Measuring Potential Effect Of National (MATS) And Global (Minamata Protocol) Hg Reduction Regulations

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2-Penn State University, Department of Ecosystem Science & Management

3-University Of Illinois, National Atmospheric Deposition Program.

3-Environement Canada, Meteorological Service of Canada | Service météorologique du Canada

4-Environment Canada, Climate Change, Science and Technology Branch

Use Of NADP Mercury Deposition Network For Measuring Potential Effect Of National (MATS) And Global (Minamata Protocol) Hg Reduction Regulations

National Atmospheric Deposition Program

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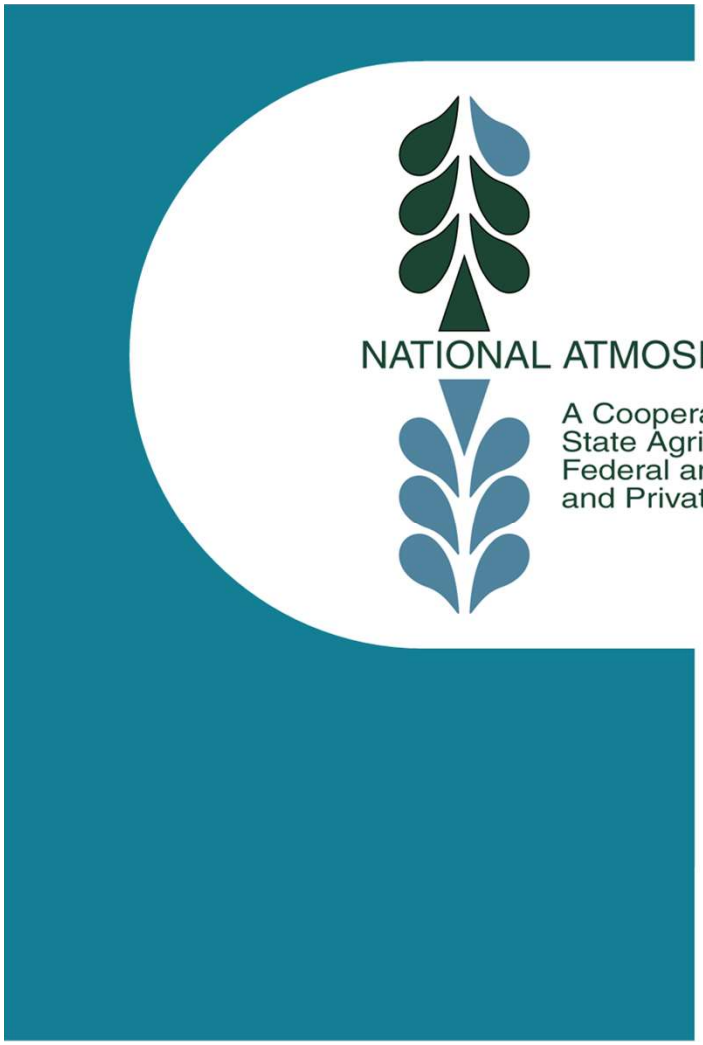
Long-term Monitoring Program In Support Of Research On The Effects Of Atmospheric Chemical Deposition



NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

A Cooperative Research Support Program of the
State Agricultural Experiment Stations (NRSP-3)
Federal and State Agencies
and Private Research Organizations

NADP

National Research Support Project #3

- A Long-term Monitoring Program
In Support of
Research on the Effects of Atmospheric
Chemical Deposition

National Atmospheric Deposition Program

3 Precipitation Monitoring Networks

- Measure wet deposition of pollutants
- National Trends Network (NTN)
- Atmospheric Integrated Research Monitoring Network (AIRMON)
- Mercury Deposition Network (MDN)

Species Measured by the NADP

acidic species

free acidity (or pH), sulfate, nitrate, chloride

nutrients

nitrate, ammonium, orthophosphate

earth crustal base cations

calcium, magnesium, potassium

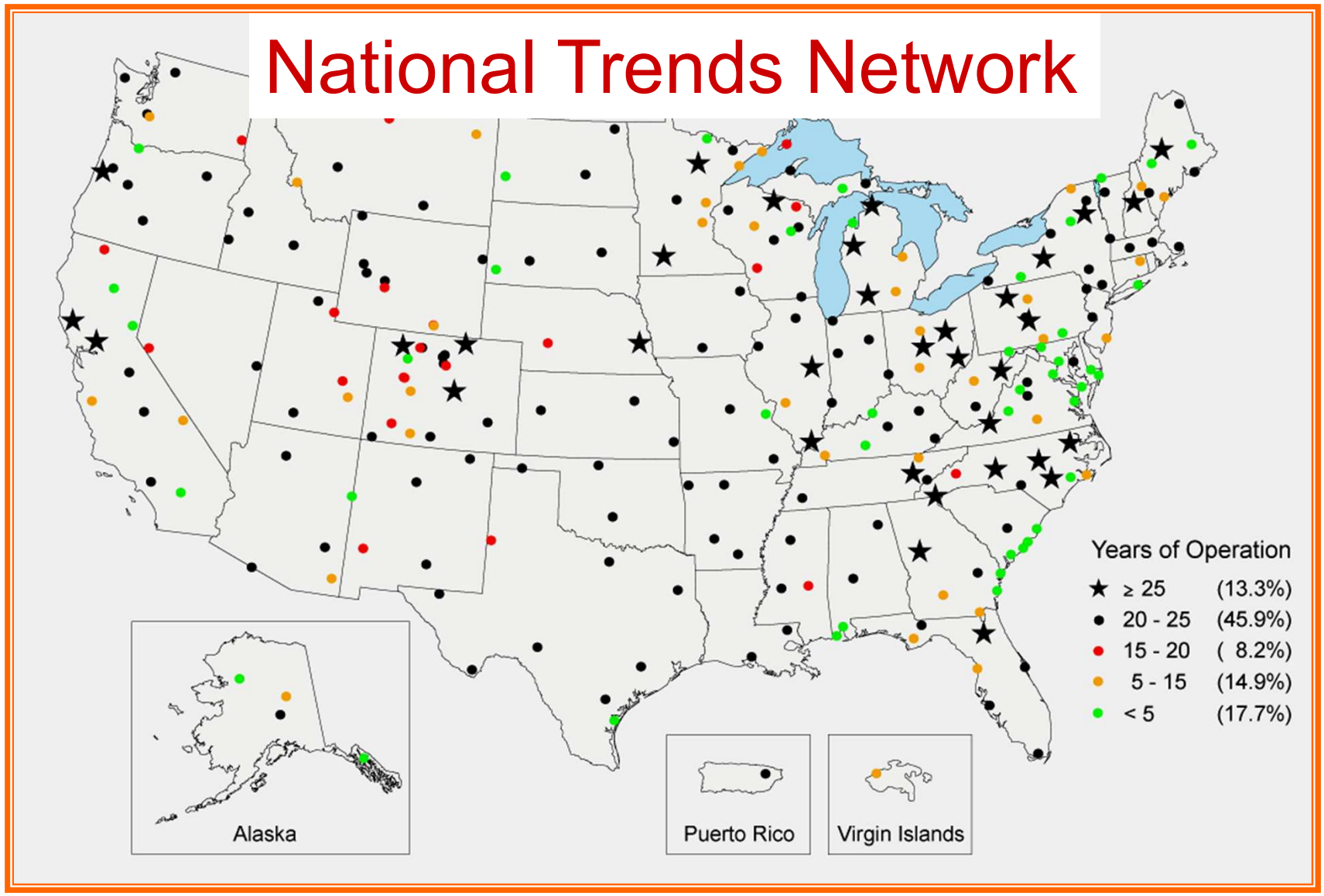
salts

sodium and chloride

heavy metals

mercury, trace metals (MDN)

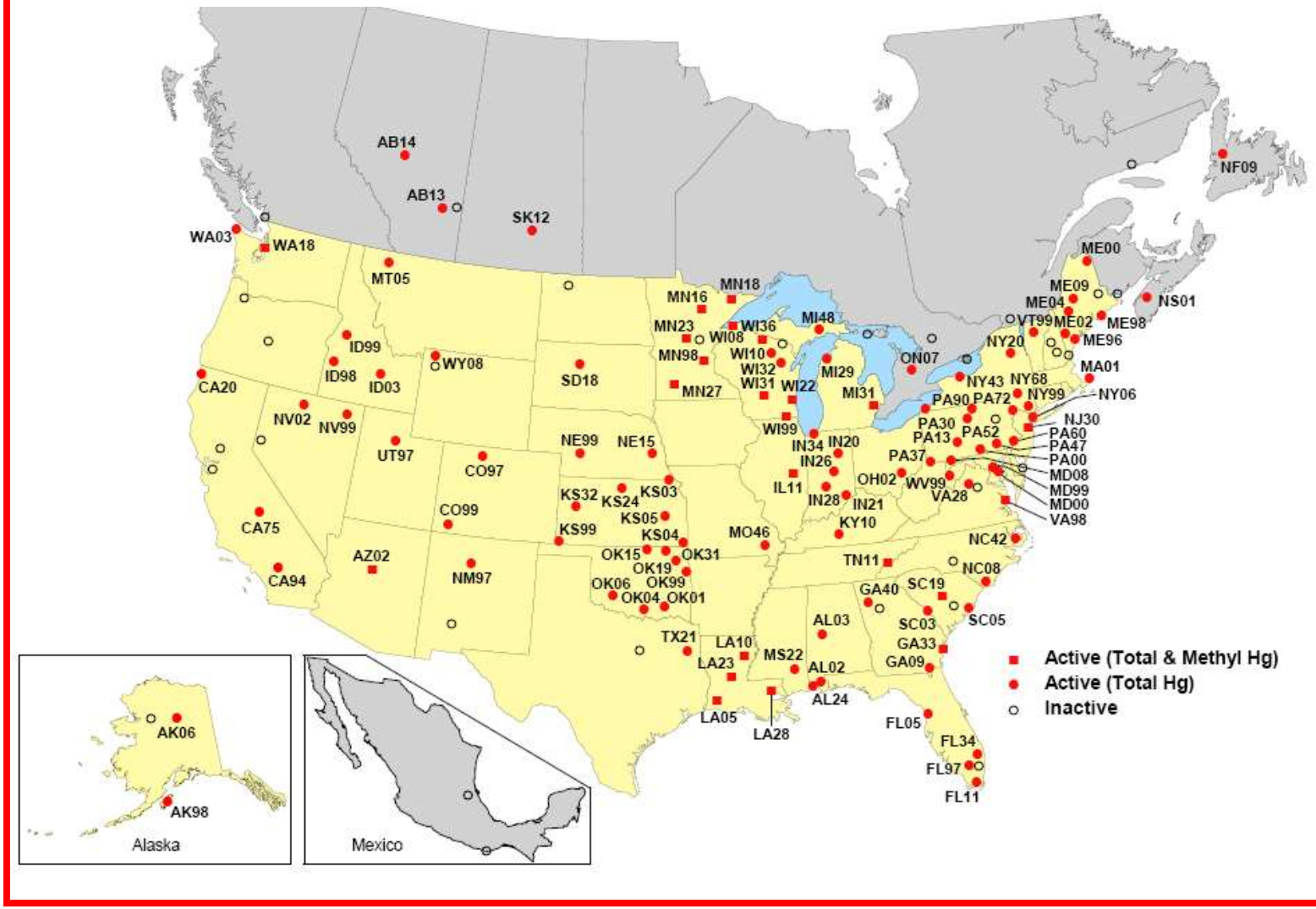
NADP Precipitation Monitoring Sites



~ 350 Monitoring Stations

NADP Precipitation Monitoring Sites

Mercury Deposition Network



~110 MDN Monitoring Stations

National Atmospheric Deposition Program

A Cooperative Research Program

- Owned/operated by diverse sponsoring agencies

Federal Agency Members

The National Park Service

energy.gov
U.S. DEPARTMENT OF ENERGY

TVA

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

EPA United States Environmental Protection Agency

NAPAP

USDA Forest Service
Caring for the Land and Serving People

USGS
science for a changing world

USDA

AIR RESOURCES LABORATORY

OAR
noaaresearch

NOAA

U.S. FISH & WILDLIFE SERVICE

States and Tribal Organizations

Other Research Organizations

Environment Canada

Environnement Canada

Environnement Québec

Service météorologique du Canada

SMC

MSC

Meteorological Service of Canada

bp

National Atmospheric Deposition Program

Key To Success Of NADP:

A Standardized Monitoring Network

- North American Coverage (NTN Good/MDN ?)
- All Sites Conform To Same Equipment Siting Protocol
- All Sites Use Same Standardized Sampling Equipment
- All Sites Use Same Field Sampling Protocol
- All Sites Use High Quality Central Hg Analysis Lab
- High-Level Field + Laboratory Quality Assurance
- Internal/External Quality Programs

Mercury Deposition Network Site

Digital Rain Gauge
Leading Ridge, PA

MDN Mercury Sampler
Goddard State Park, PA

Mercury Wet Deposition

Hg concentration in precipitation (ng/L)

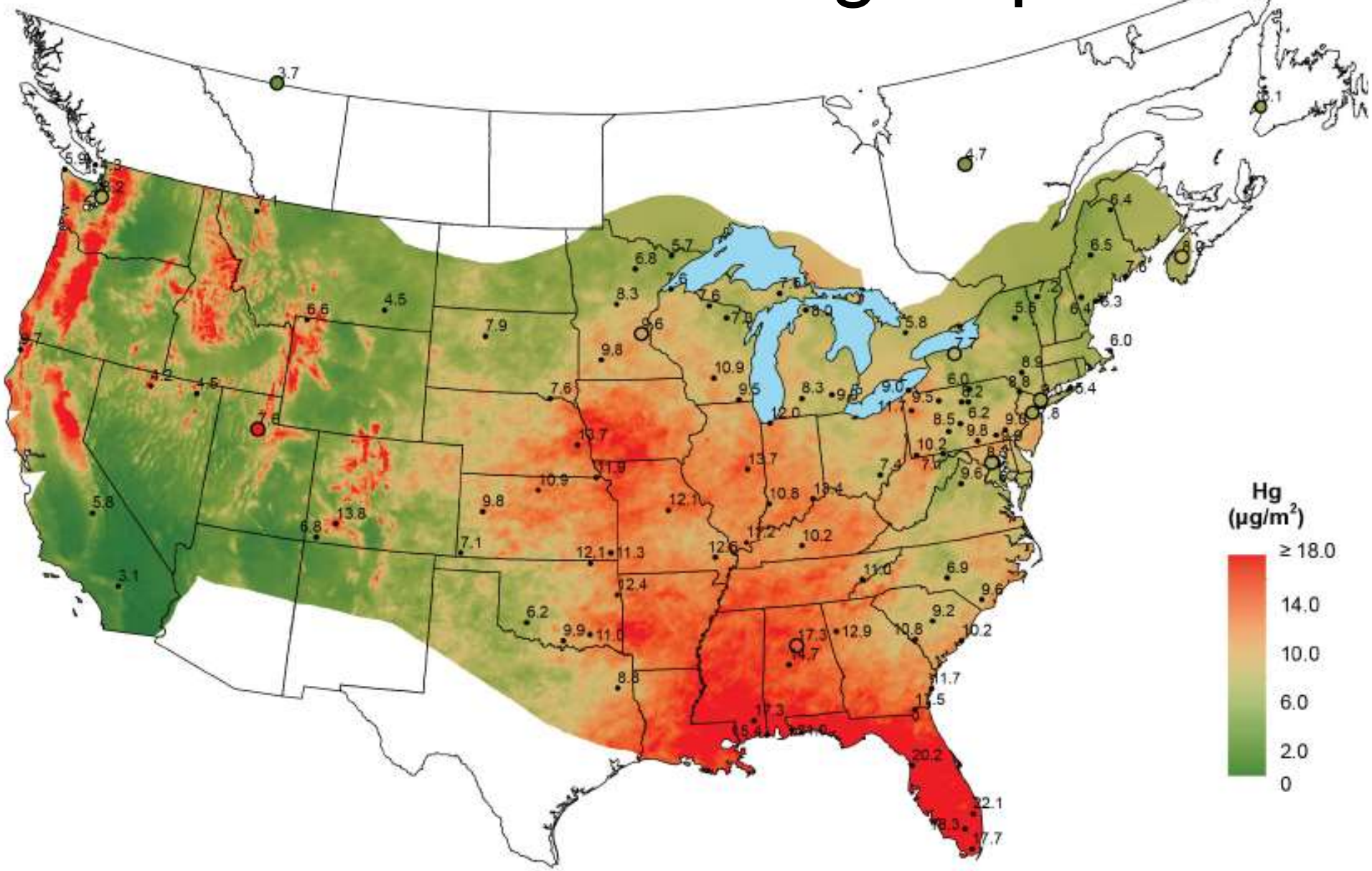
x precipitation amount =

Hg wet deposition ($ng/m^2/wk$ or $\mu g/m^2/yr$)

NADP Mercury Deposition Network Annual Hg Deposition Summary Maps

- **Each MDN Site:**
  - Measures7-Day Integrated (weekly) Wet Deposition Precipitation Concentration (52 weeks Per Year)
  - Measure Precipitation Depth At Each Site
  - Calculate Hg Deposition (ng Hg/m^2/year)
- **Annual Hg Deposition Summary Maps:**
  - Continuous Color Gradient Map Incorporating An External, Highly Resolved Precipitation Dataset (PRISM)

Annual 2014 MDN Hg Deposition



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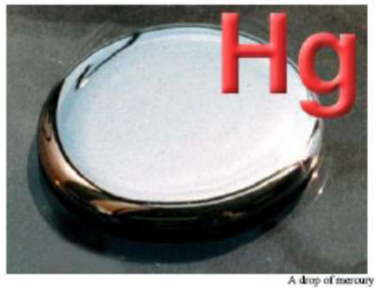


A drop of mercury

The Mercury Problem

1) Elemental Gaseous Hg Is Emitted Into The Atmosphere through either combustion emissions or natural process (i.e. forest fires)
2) Some forms of Hg will fall once it is emitted.
3) Elemental Gaseous Hg can travel hundreds/thousands of miles until it is oxidized and falls out as wet Hg or dry Hg deposition.
4) Once Hg wet/dry deposited to aquatic ecosystems these systems can convert the mercury to the toxic, bioaccumulative form of Methyl Mercury.
5) Mercury enters the food chain and works its way into fish, wildlife and humans.

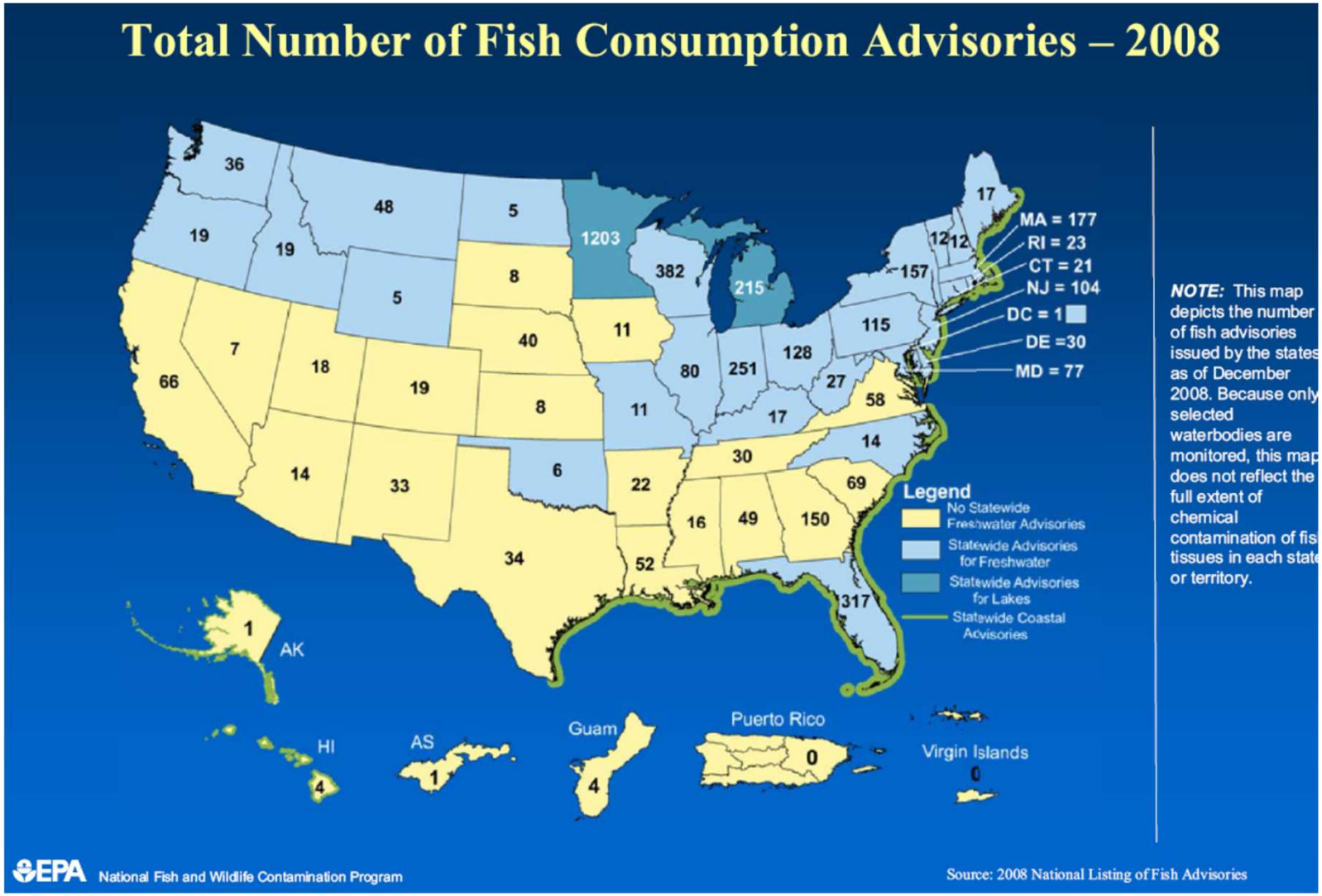
Atmospheric Transport and Deposition Of Mercury To Water Bodies Is Dominant Pathway

Input Of Mercury To Water Bodies

“Between 40%-75% is likely by wet deposition”

(Sorensen et al., 1997; Scherbatskoy et al., 1997; Lamborg et al., 1995; Mason et al., 1997; Landis and Keeler, 2002; Mercury 2006 Committee Statement)

Need For Monitoring Hg Deposition



National Atmospheric Deposition Program **Mercury Deposition Network**

Monitoring Mercury Deposition

A Key Tool to Understanding the Link between Emissions and Effects

State and Provincial Hg fish consumption advisories have increased to include:

- **4,249 advisories in 50 states which represent:**
  - **-43% of the Nation's total lake acres**
  - **-39% of the Nation's total river miles**
  - **-42% of the Nations coastal waters and**
  - **-100% of the Great Lakes**

National Atmospheric Deposition Program **Mercury Deposition Network**

Impacts Of Hg Deposition
EPA National Rivers And Streams Assessment

2008-2009 EPA NRSA Summary Results:

- **"Elevated Levels In Fish Are The Leading Cause Of Fish Consumption Advisories In The US"**
- **"All Fish Measured Contained Quantifiable Levels Of Hg"**
- **"¼ Of Urban River Miles Assessed Measured Hg In Fish > 300PPB Human Health Advisory**
- **"Results Demonstrate The Pervasive Nature Of Mercury Deposition In Watersheds of the US And Subsequent Accumulation In Fish"**

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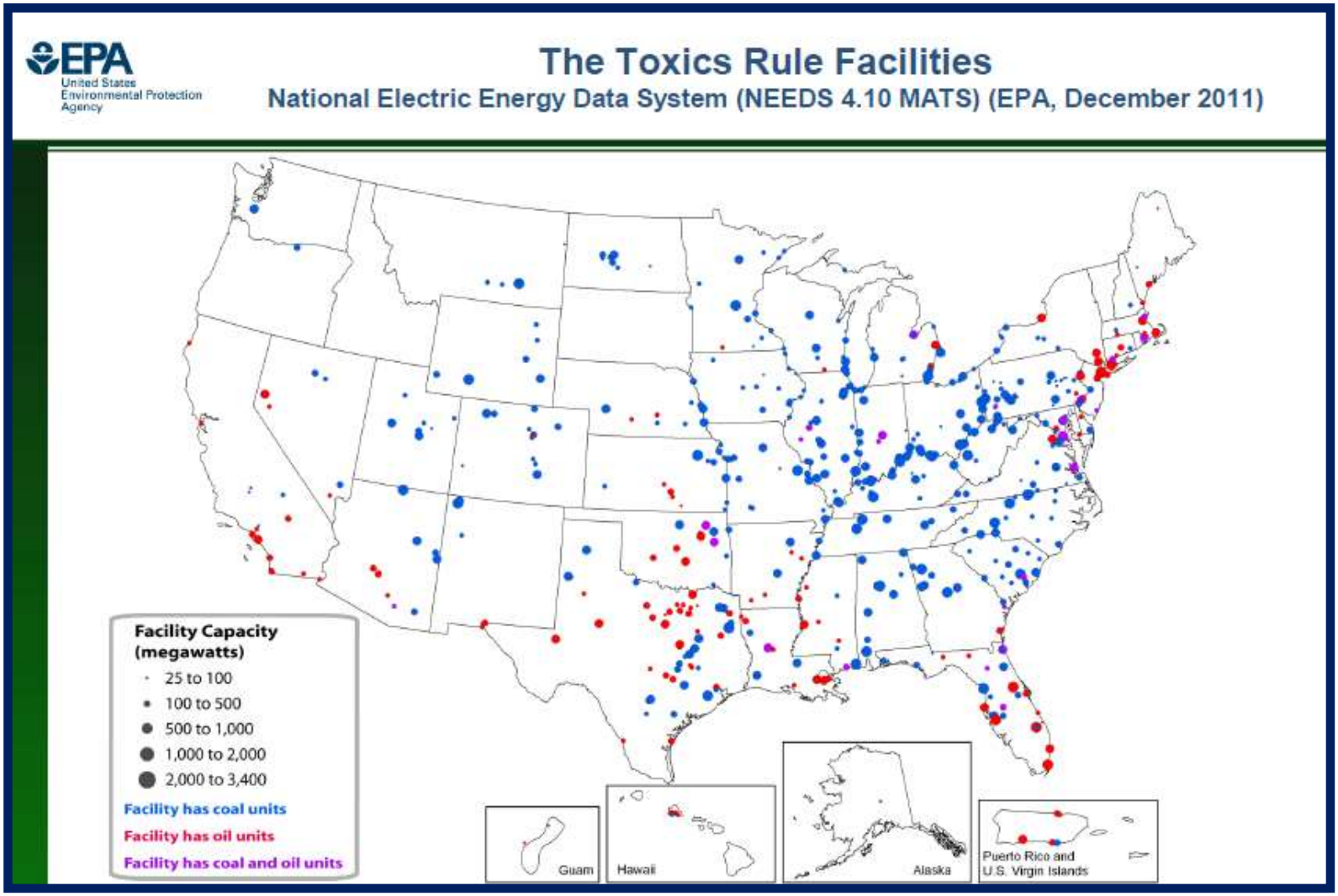
Mercury Air Toxics Standard (MATS) Implementation Date: April 2015



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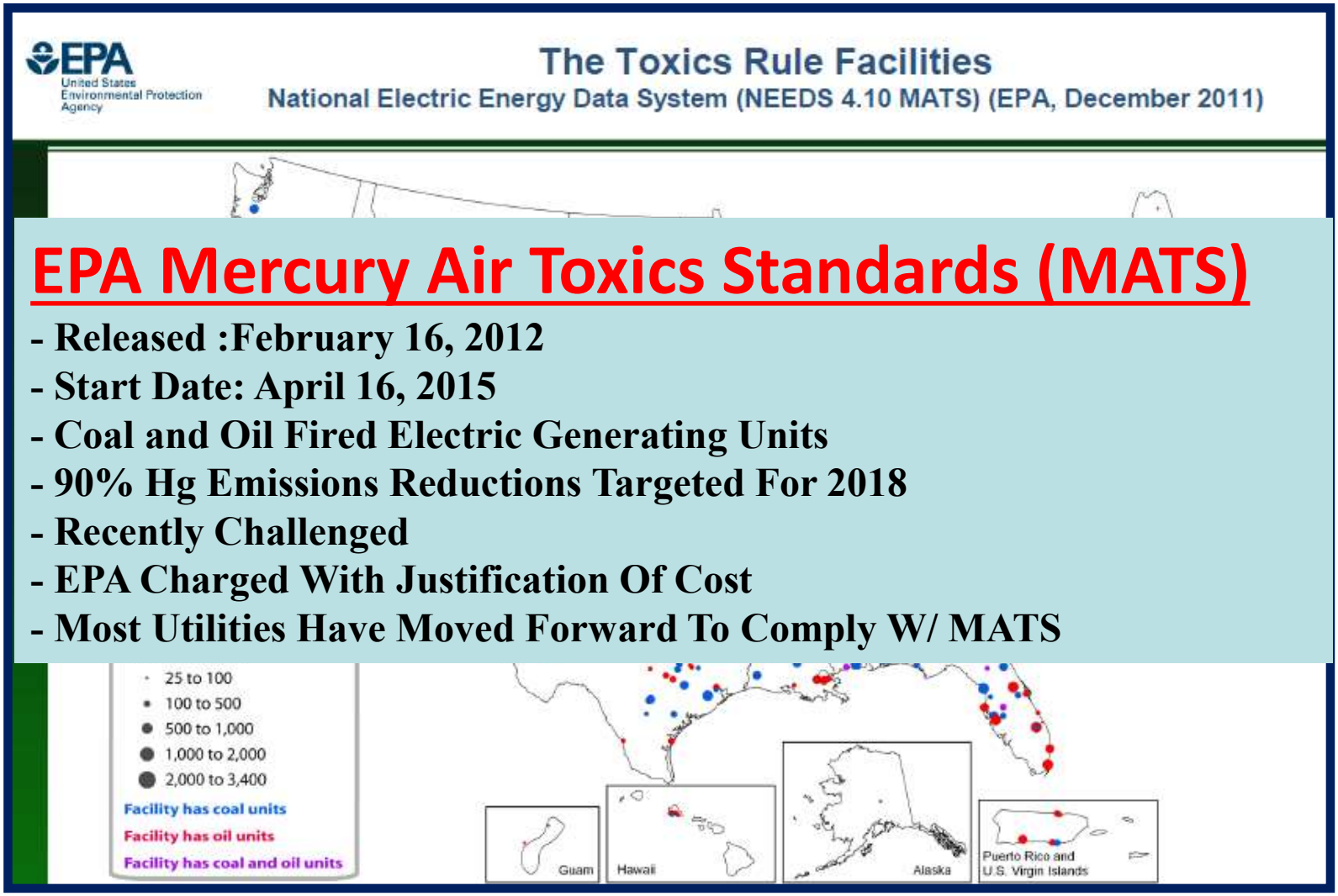

EPA Mercury Air Toxics Standards (MATS)

- Released :February 16, 2012
- Start Date: April 16, 2015
- Coal and Oil Fired Electric Generating Units
- 90% Hg Emissions Reductions Targeted For 2018
- Recently Challenged
- EPA Charged With Justification Of Cost
- Most Utilities Have Moved Forward To Comply W/ MATS

Importance Of Monitoring Mercury Deposition

Global Mercury Emissions Treaty

- ***United States Signs and Ratifies Minimata Convention***
- **140 Countries, Legally Binding**
- **Deals with world-wide emissions and discharges of a pollutant that threatens the health of millions,**
- **Agreed risk to human health and environment was so significant that accelerated action needed**
- **Toxic, persistent and subject to long-range transport**
- **High levels of mercury in certain fish / human health concern**

Global Treaty on Mercury Pollution Gets Boost From United States

UNEP's Achim Steiner Welcomes First Ratification of the Minamata Convention on Mercury.

Nairobi, 7 November 2013 - The United States has strengthened the international effort to bring down emissions and releases of a notorious heavy metal after simultaneously signing and ratifying the Minamata Convention on Mercury.

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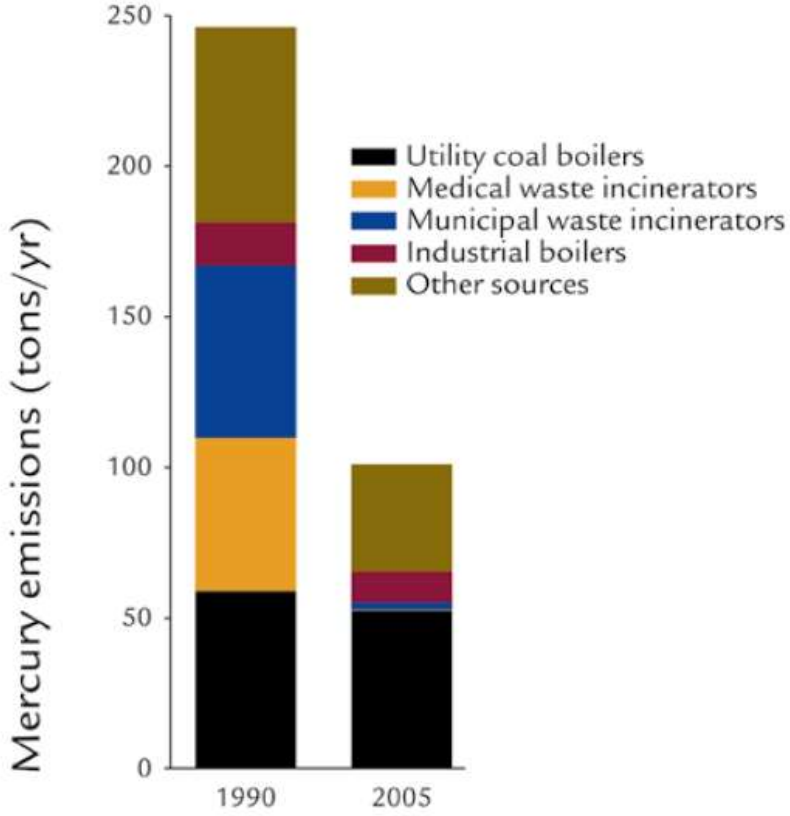
Potentially Decreasing US Hg Emissions Vs Potentially Increasing International Hg Emissions

Total U.S. and Global Mercury Emissions from Human Activities

3a



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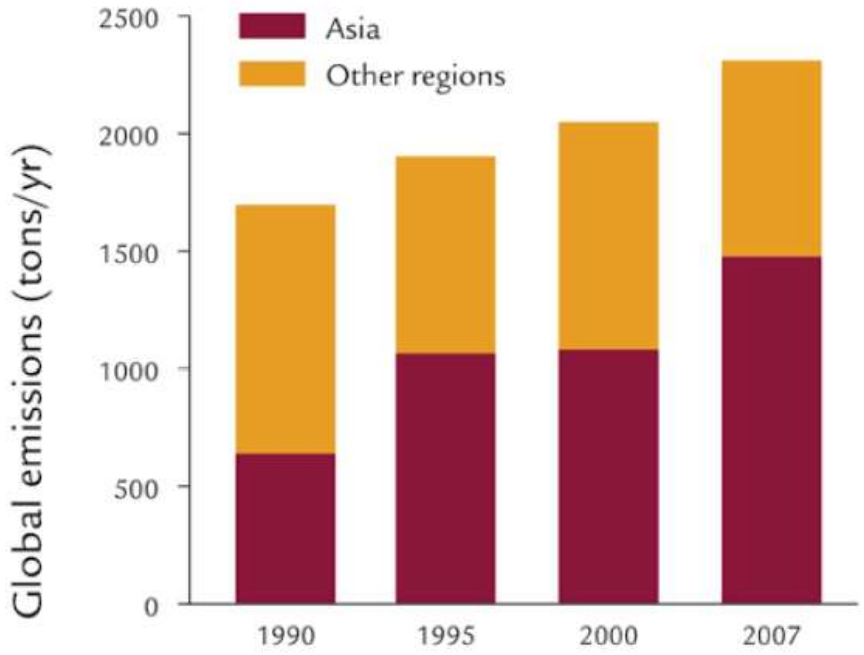

Potentially Decreasing US Hg Emissions Vs Potentially Increasing International Hg Emissions

Total U.S. and Global Mercury Emissions from Human Activities

- Current Regulations Focus On Measuring Hg Emission (At "Smoke Stack")
- With Long Range Transport Of Hg And International Sources increasing
  - Important To Measure Hg As Direct Input To The Environment
    - Are Local / Regional Hg Emissions/Deposition Decreasing?
    - Some Scientist Estimate 90% Of Hg Deposition In North America Is From Non North American Sources

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Importance Of Monitoring Mercury Wet Deposition

The Mercury Deposition Network Is The Only North American Scale Network In Place To Measure The Affects Of Hg Emission Reductions In The Environment

1) Decrease In Mercury Deposition Measured?

- ***Important To Measure Potential Hg Reductions In Wet Deposition To Assess Policy and If Expected Emission Controls Are Working***

2) No Hg Deposition Reductions Measured?

- ***No Hg Reductions is an equally important find and could indicate that other mercury sources are at play (i.e. global (non-NA based) sources of mercury).***

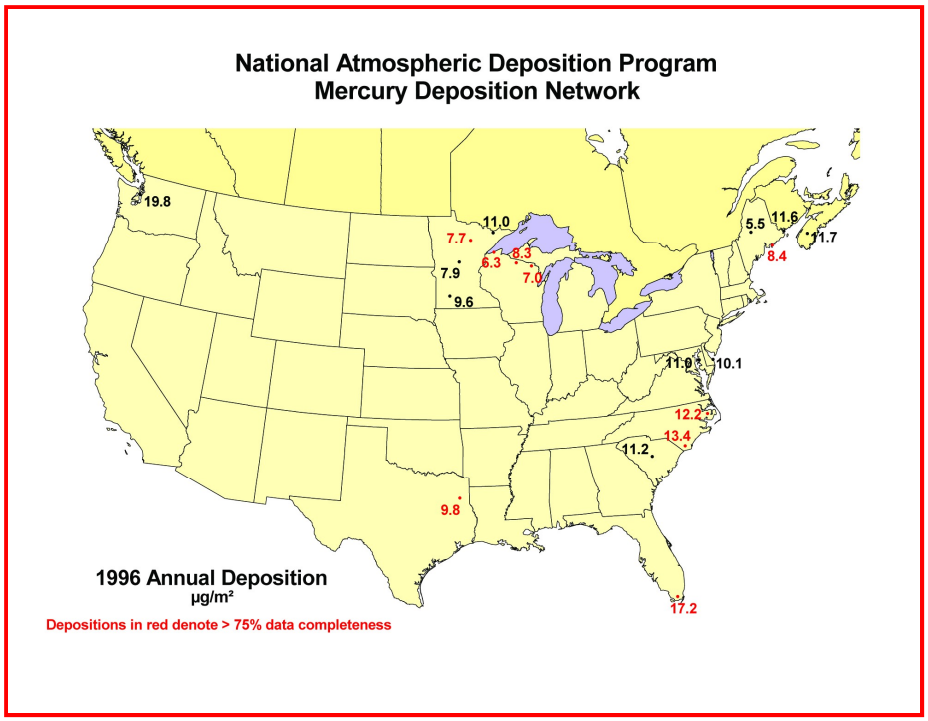
3) Increase In Hg Deposition?

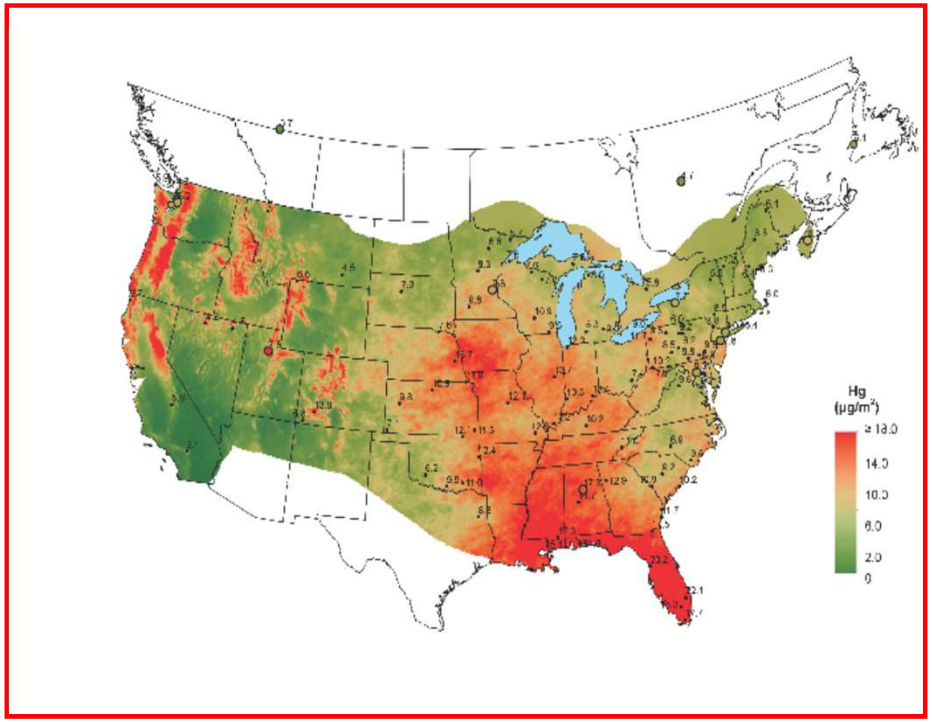
- ***Are US Based Controls Reducing Enough Hg Emissions?***
- ***Are Non-US Based Sources Now Dominant And International Policy Now The Focus?***

NADP Mercury Deposition Network
20 Year Anniversary (1996-2016)

Eurofins Frontier Global Sciences

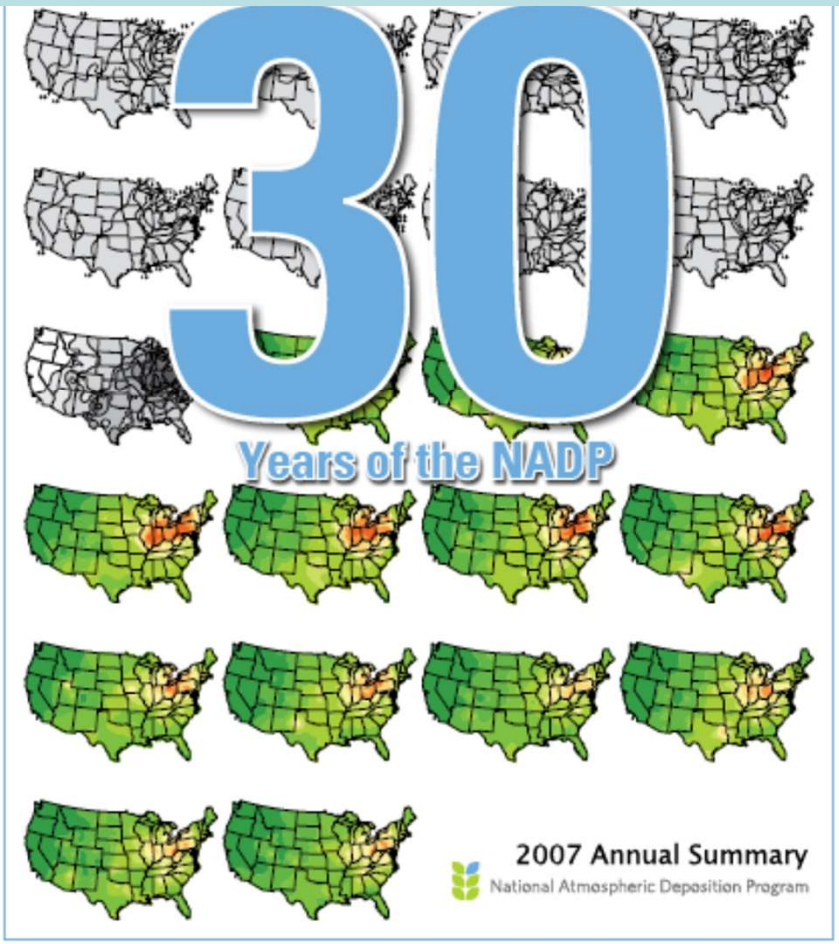
- 20 Years As Mercury Analytical Laboratory For MDN
- 20 Years As MDN Site Operations Center
- 20 Years Of Innovation, Collaboration And Network Support





National Atmospheric Deposition Program

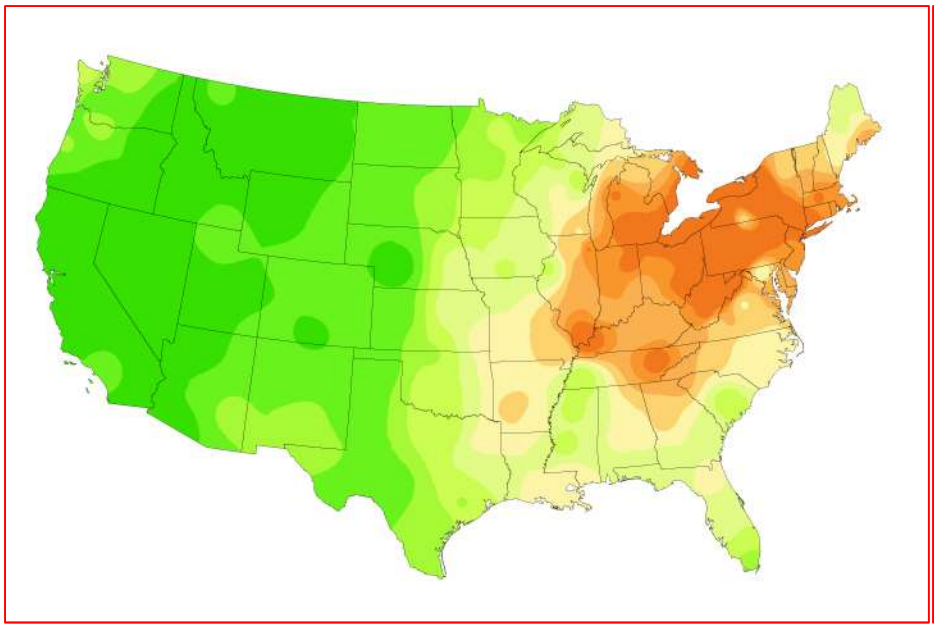
National Trends Network (Acid Rain Network)

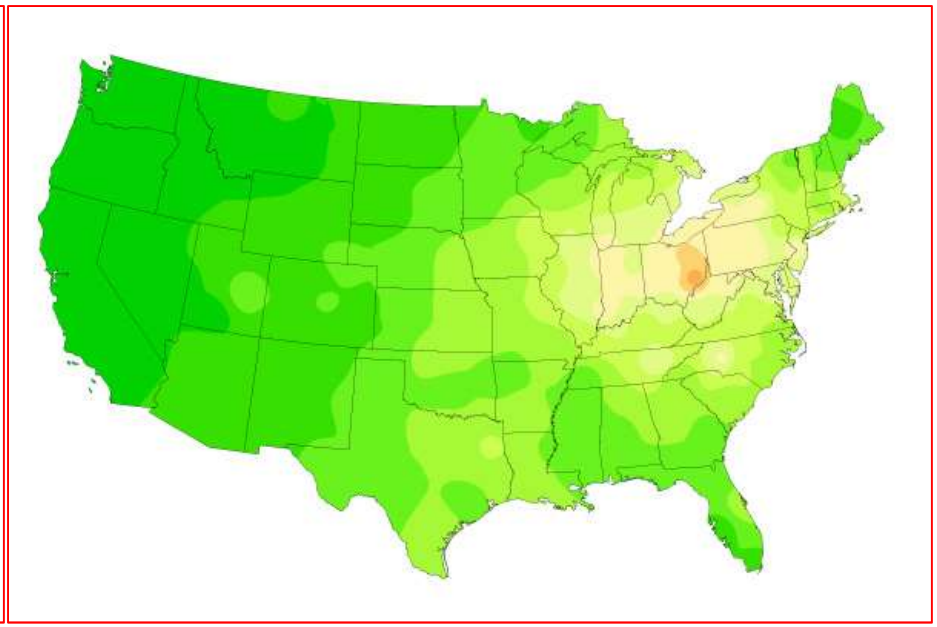


National Atmospheric Deposition Program

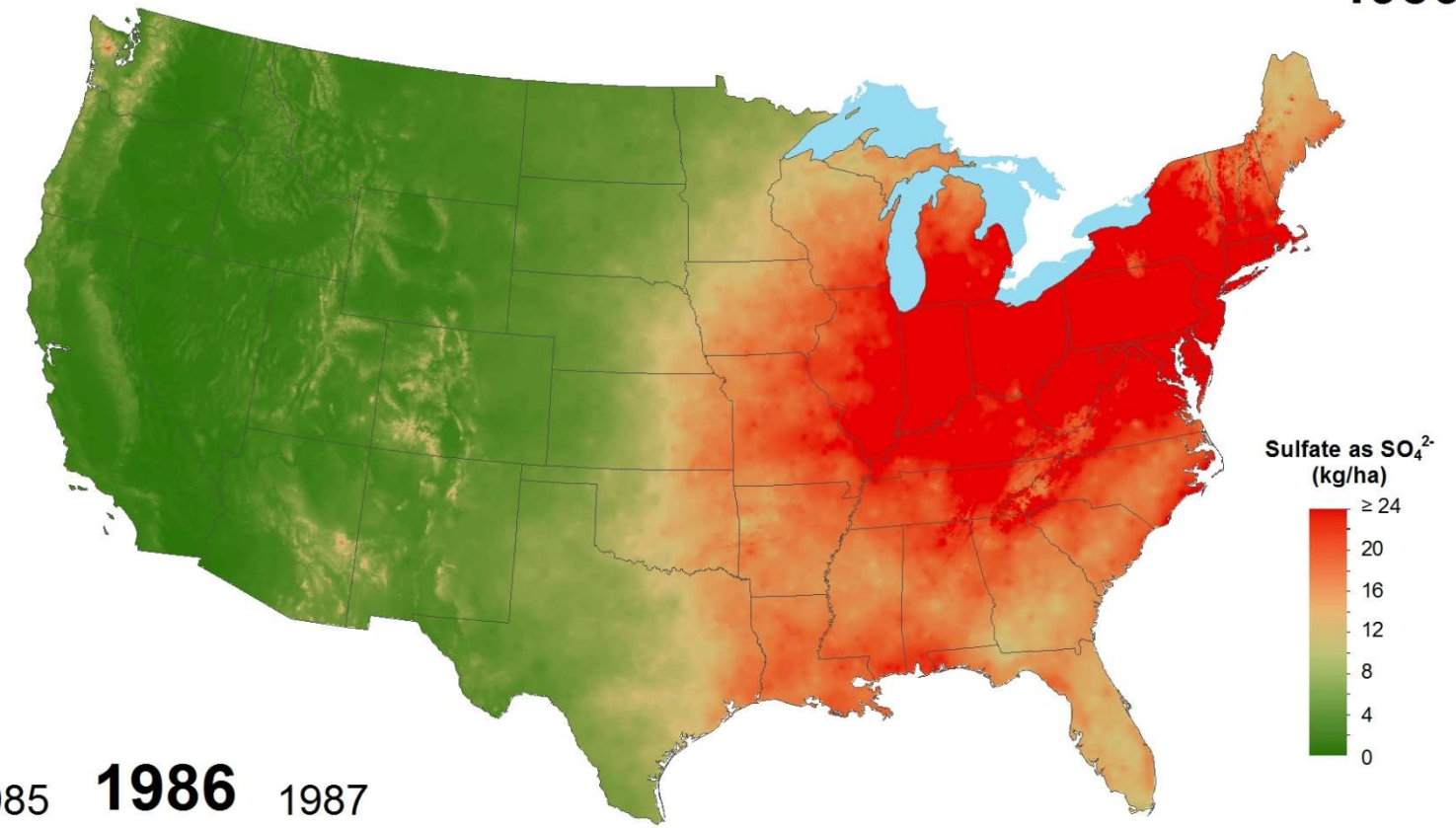
Sulfate Deposition Reductions 1985-2012

Will We See The Same For Hg After MATS/Minamata?





Sulfate ion wet deposition
1986



1985 **1986** 1987

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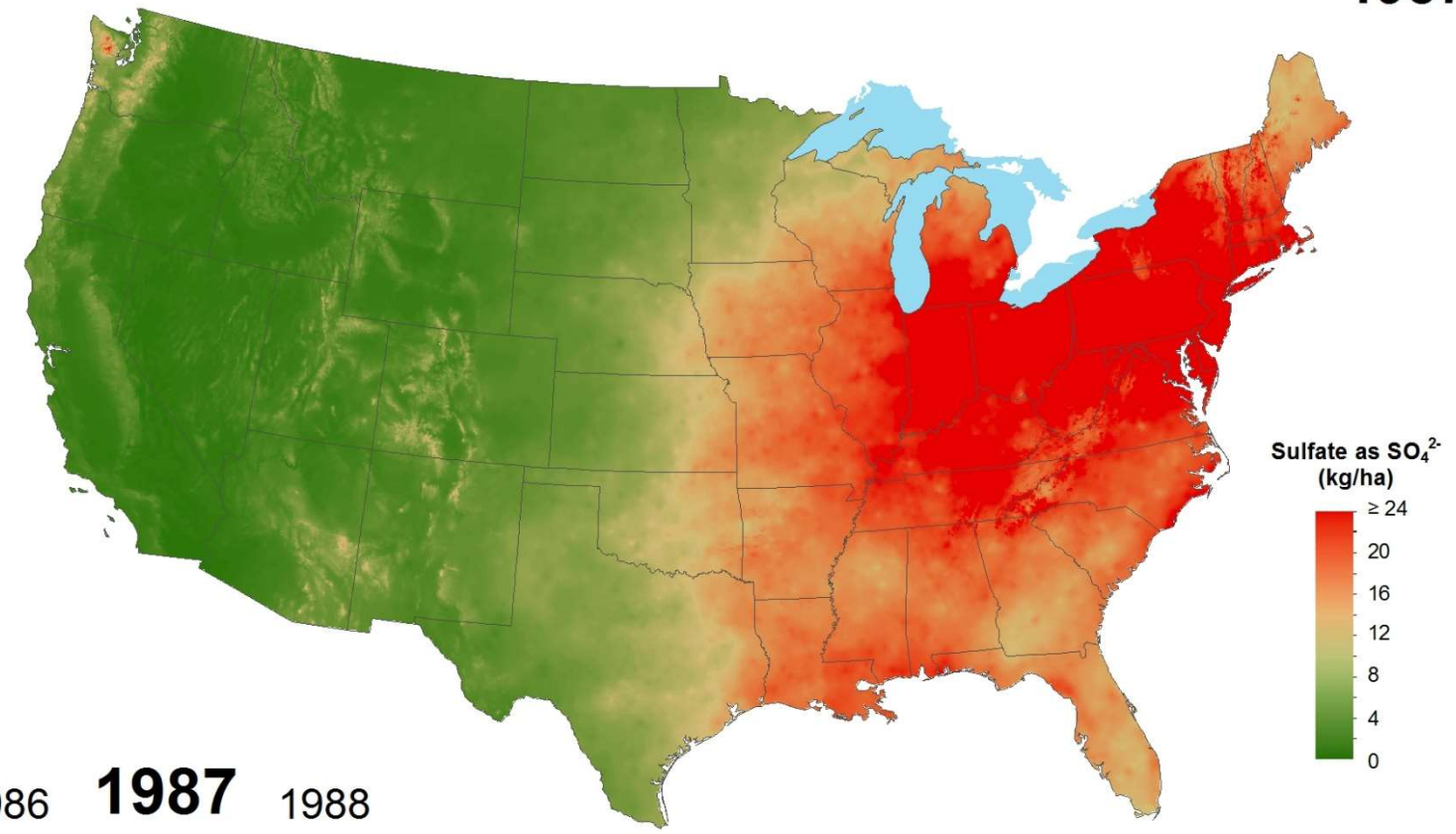
1987



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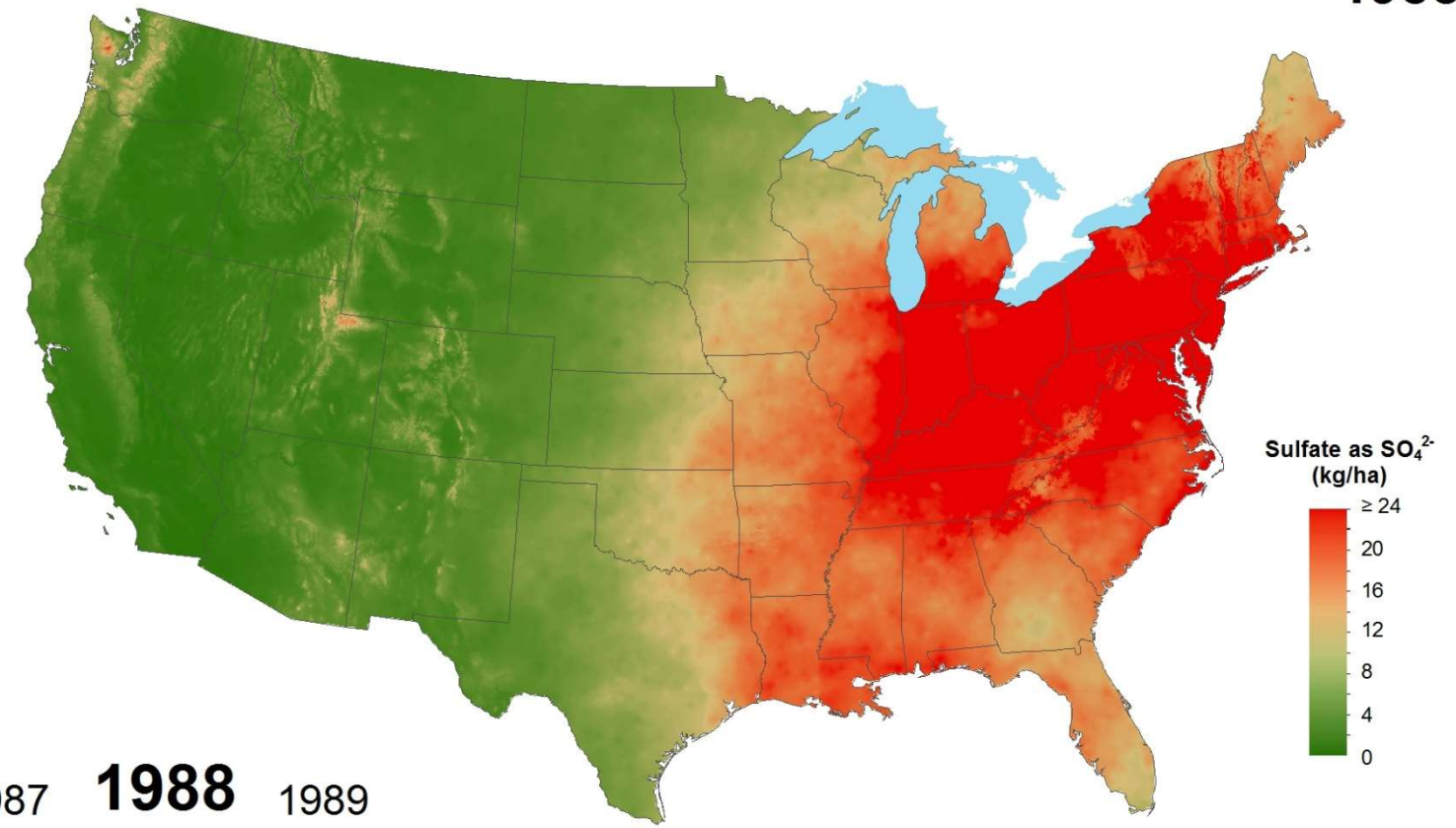

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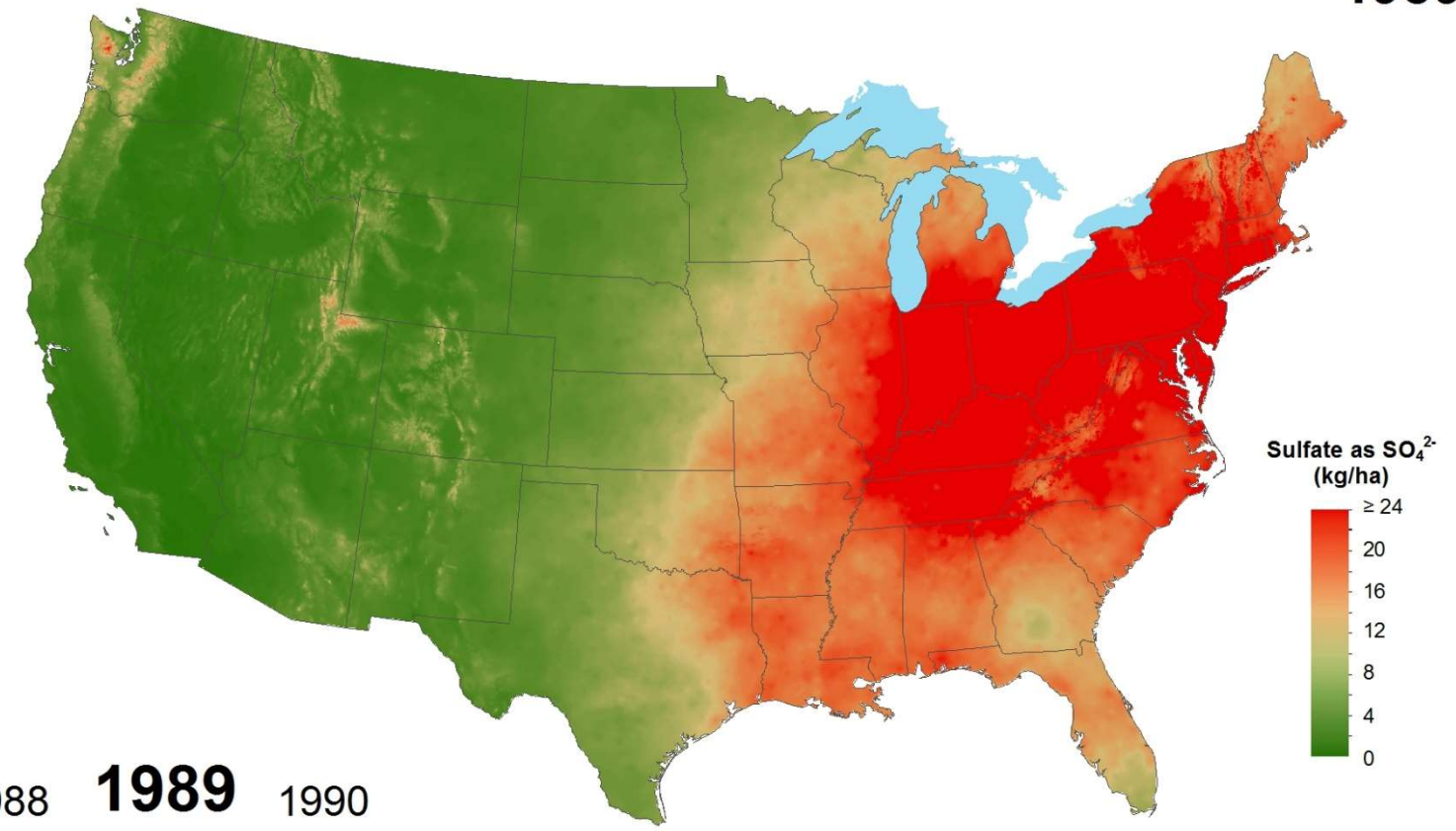

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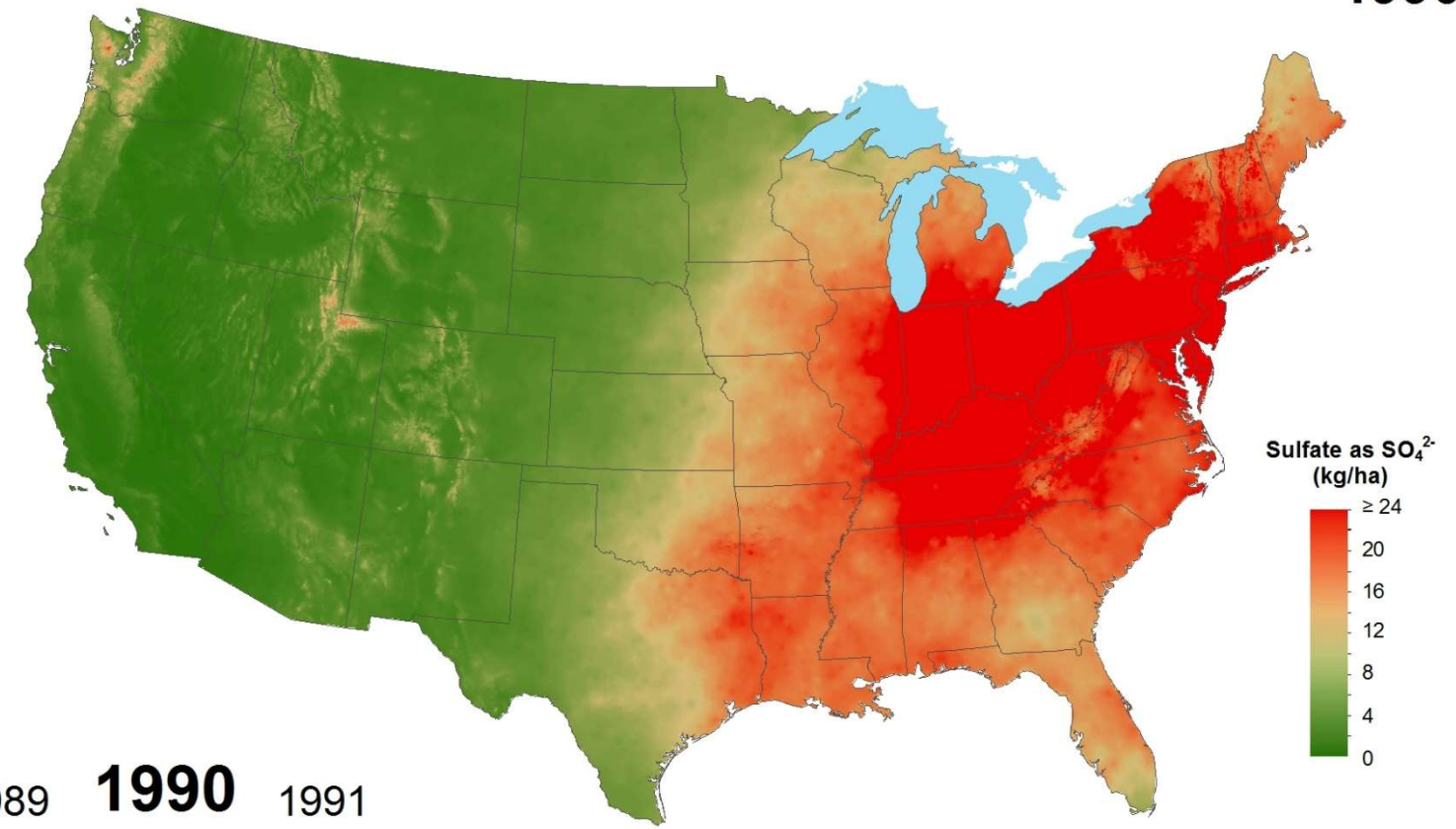

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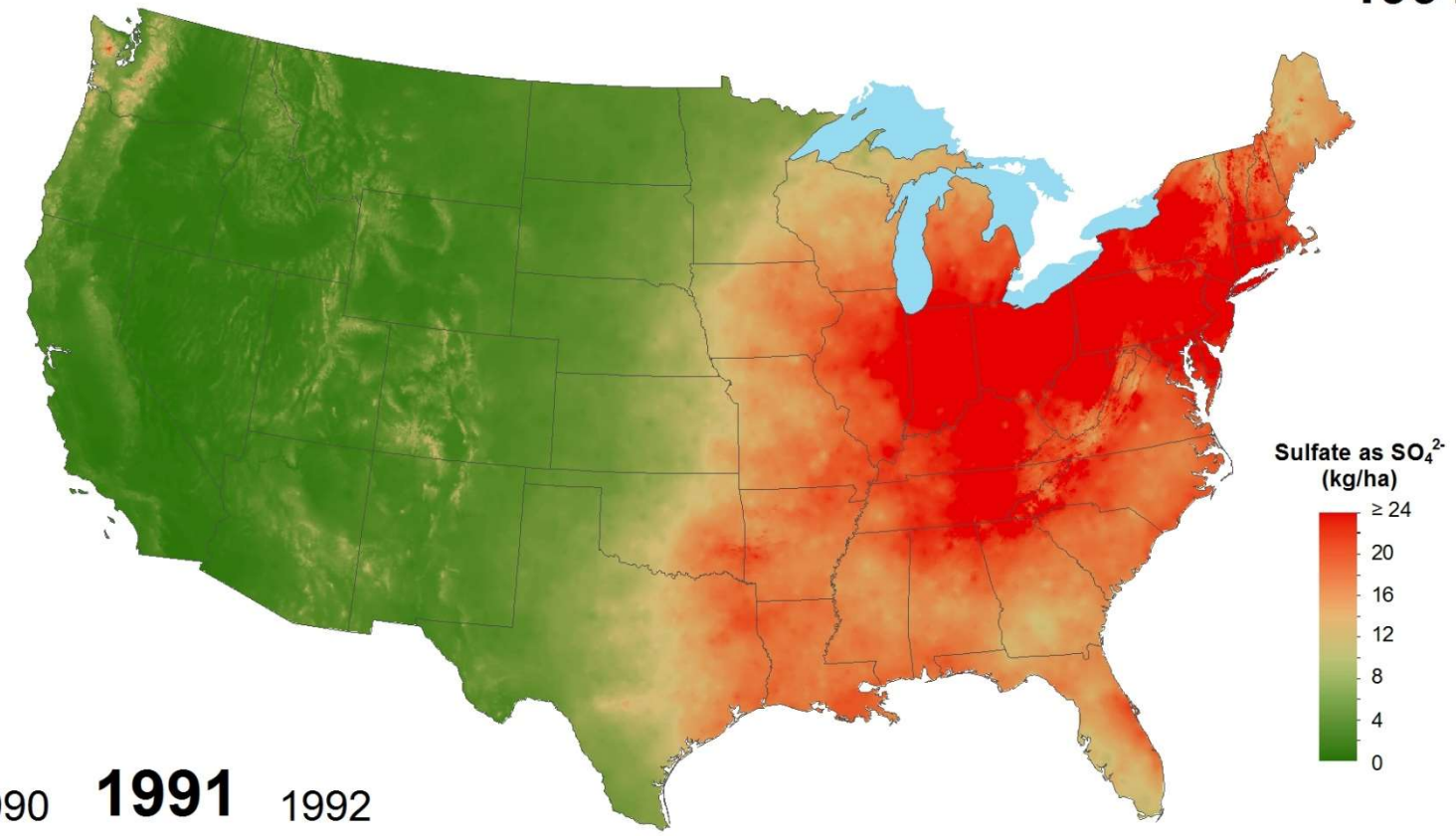

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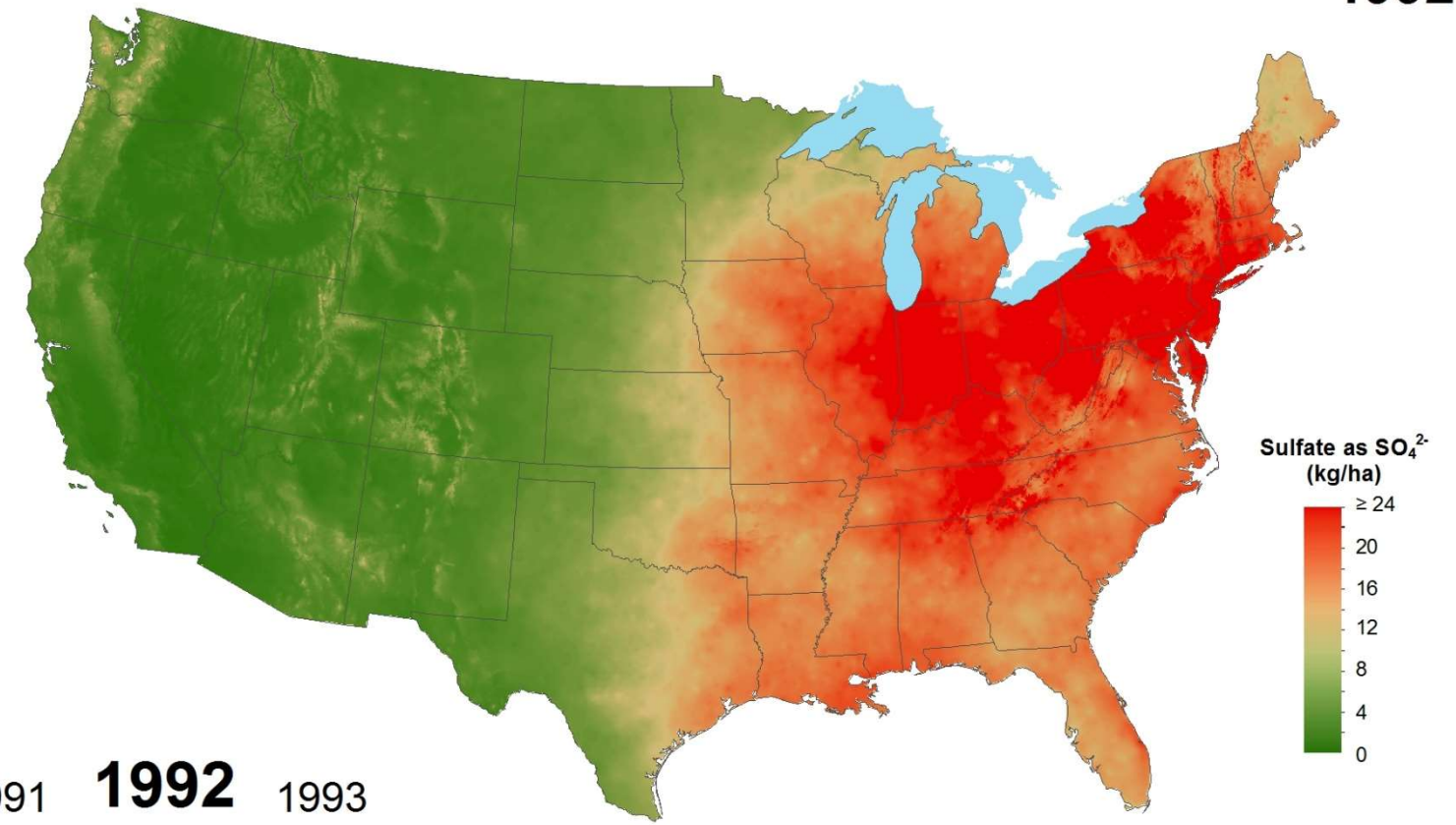

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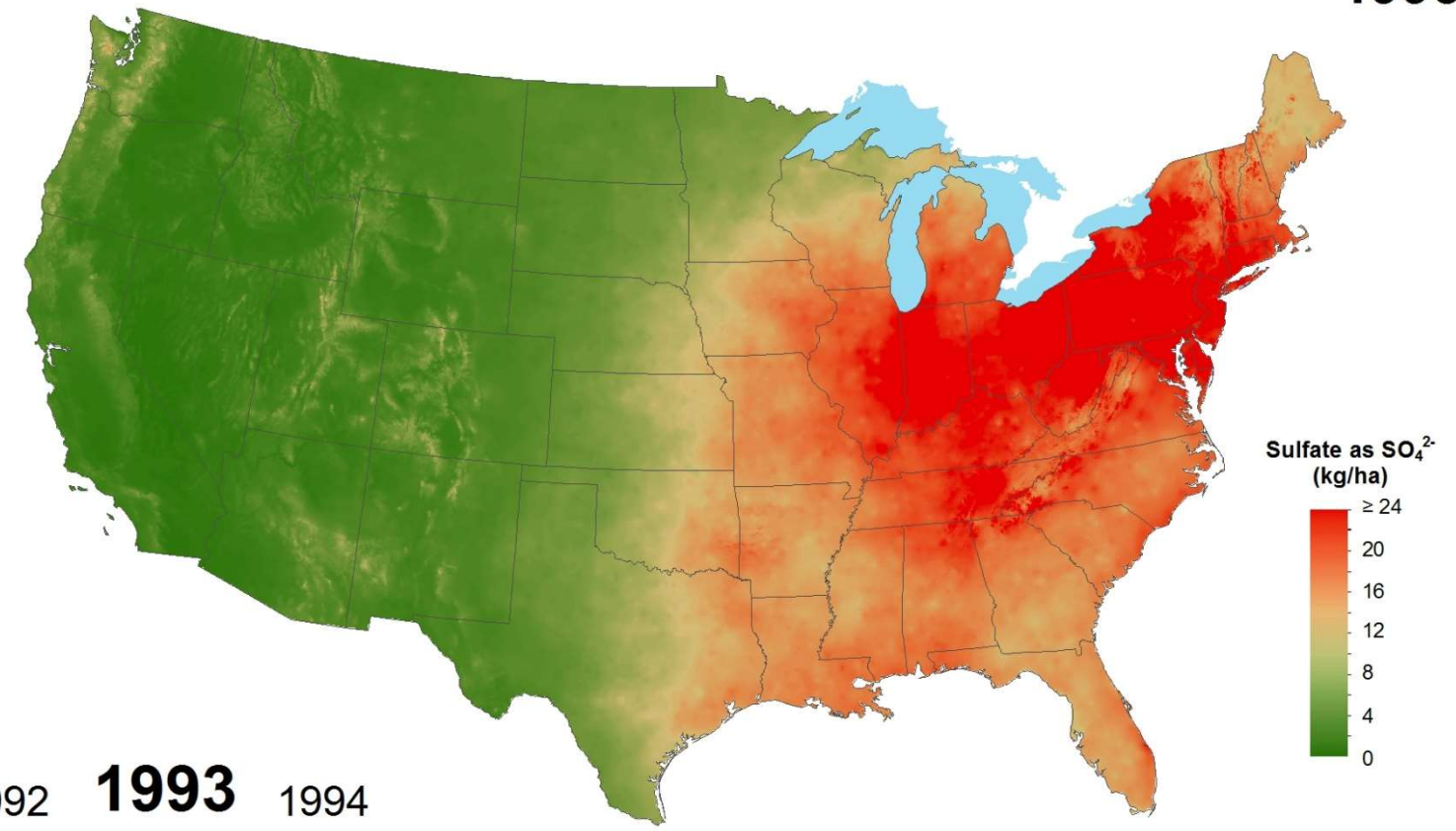

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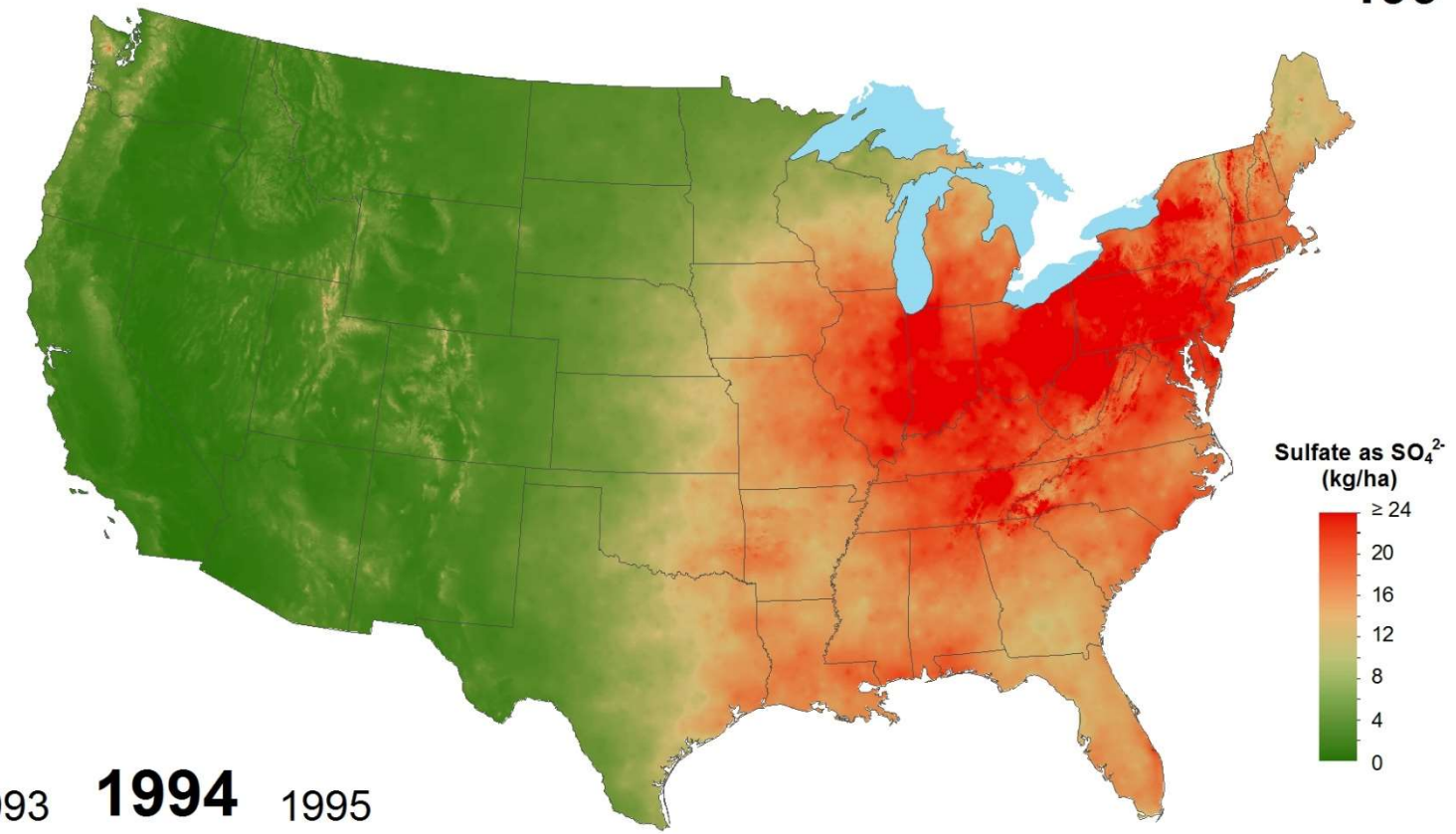

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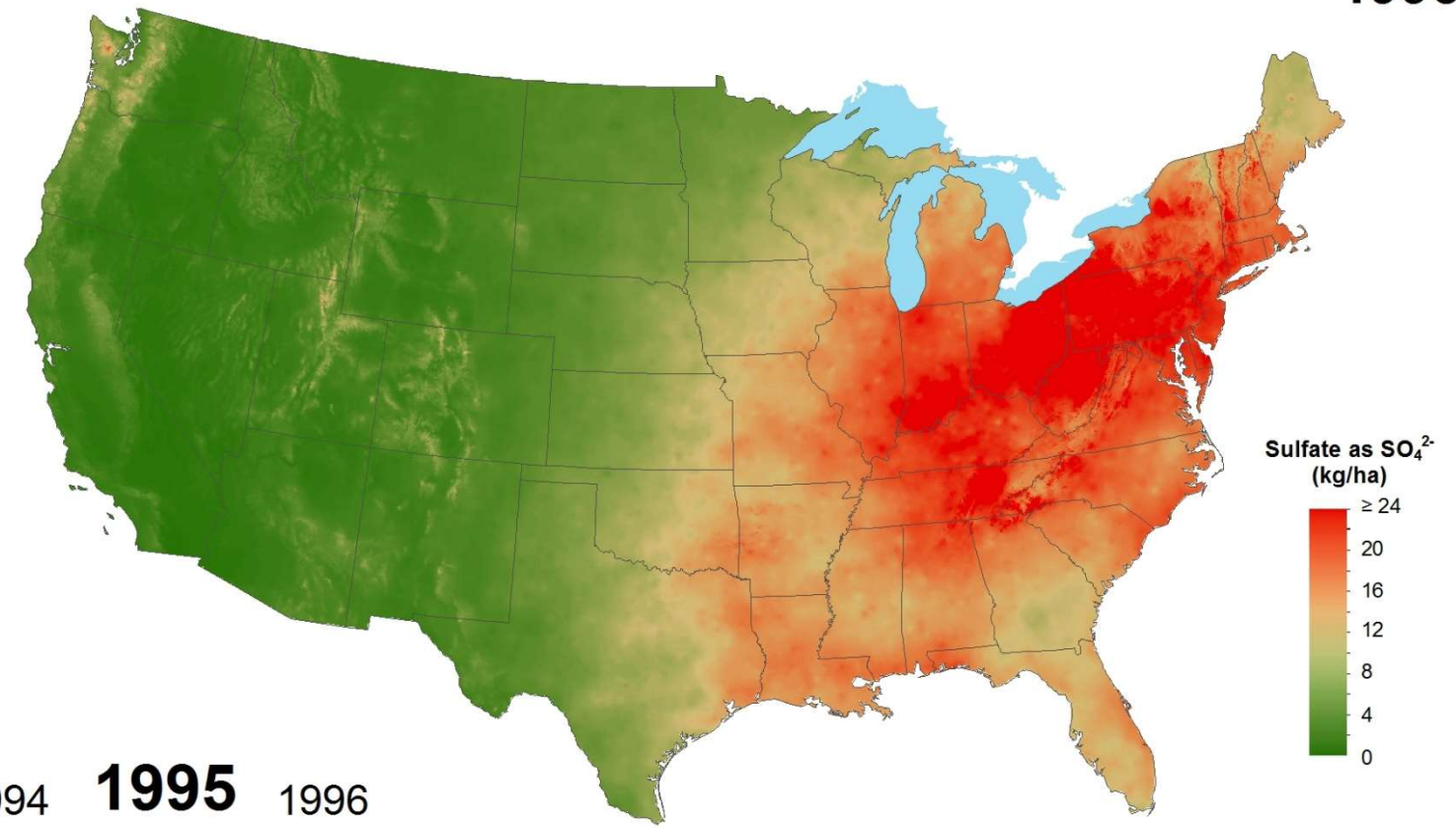

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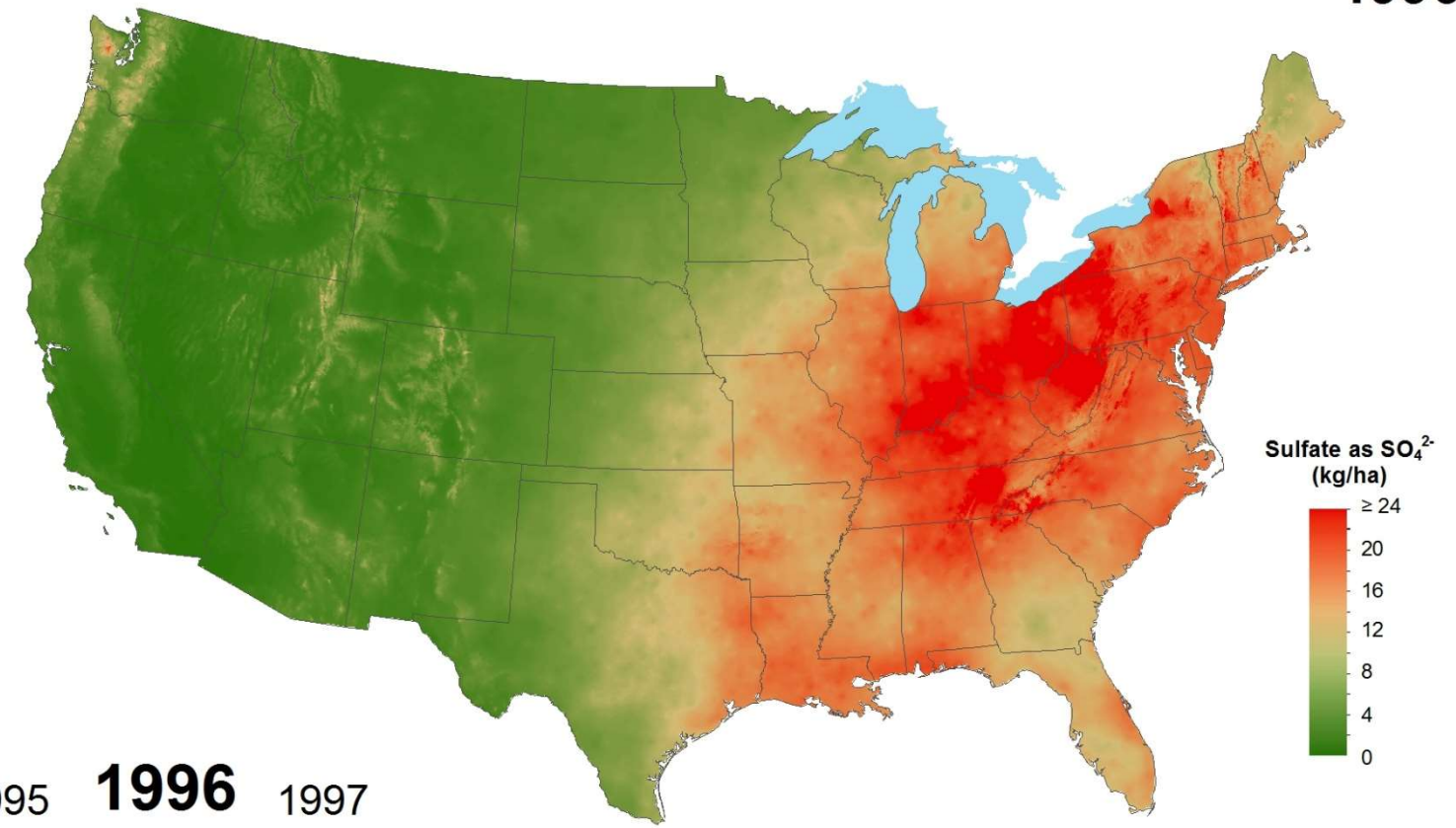

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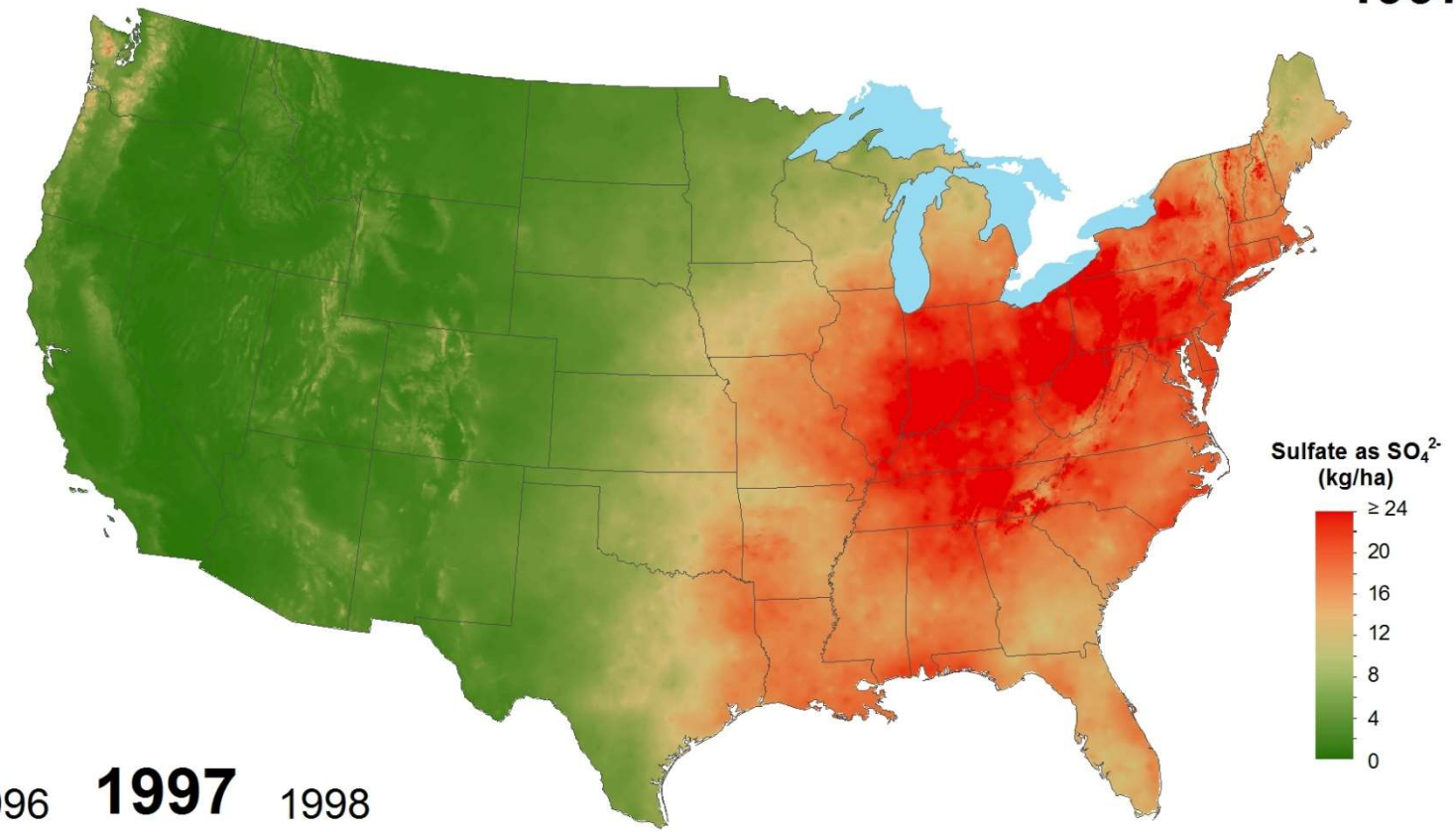

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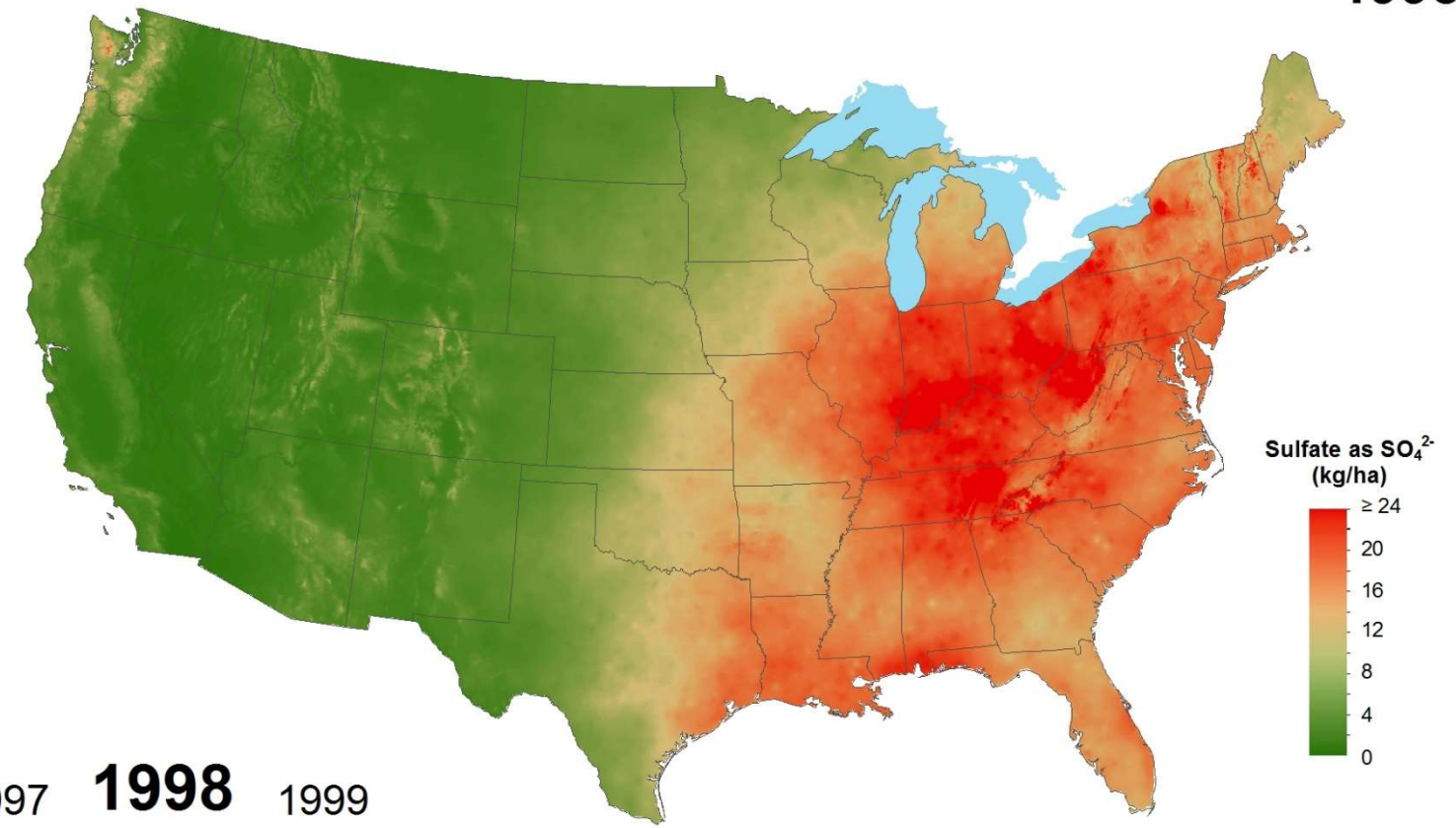

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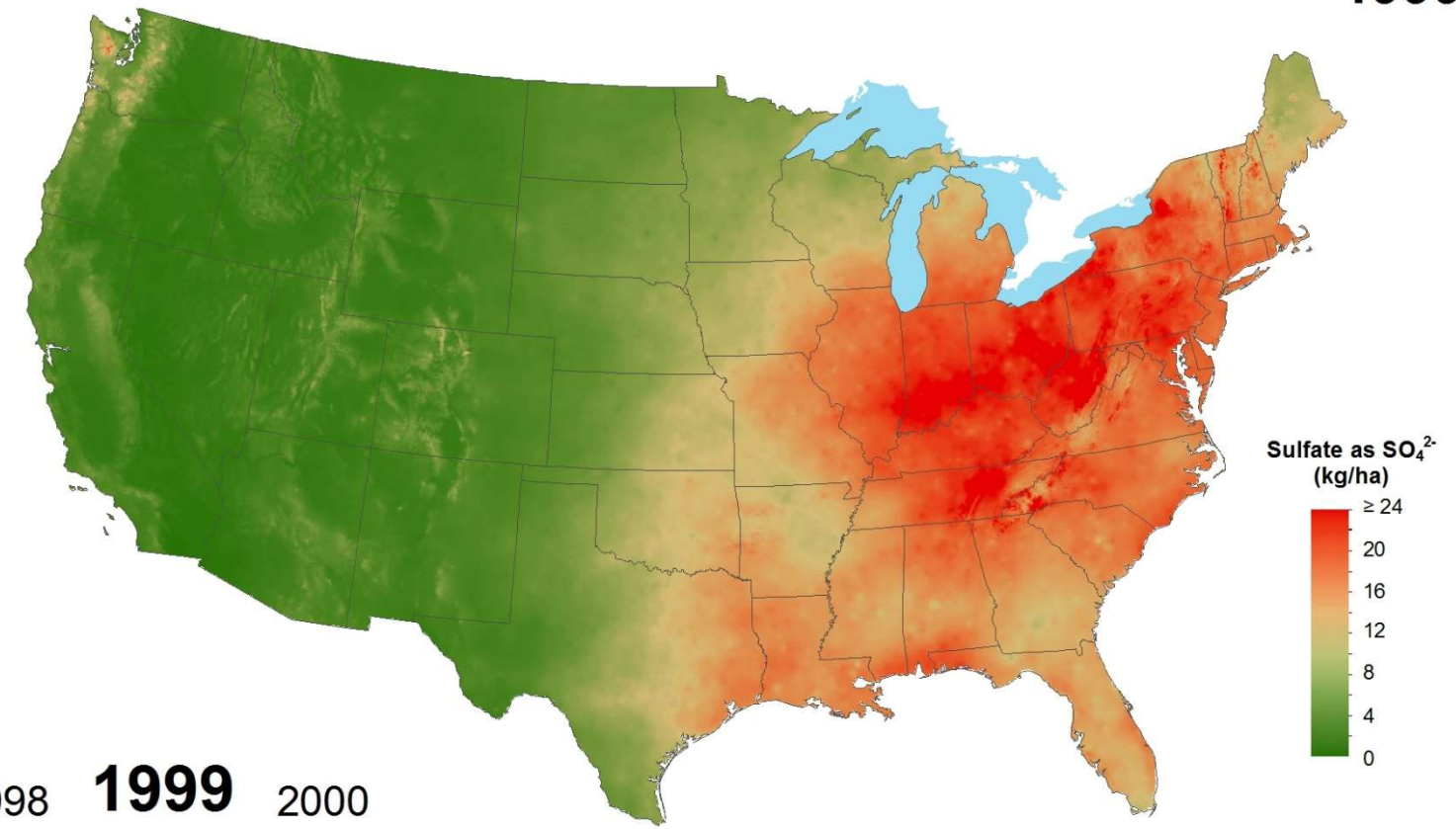

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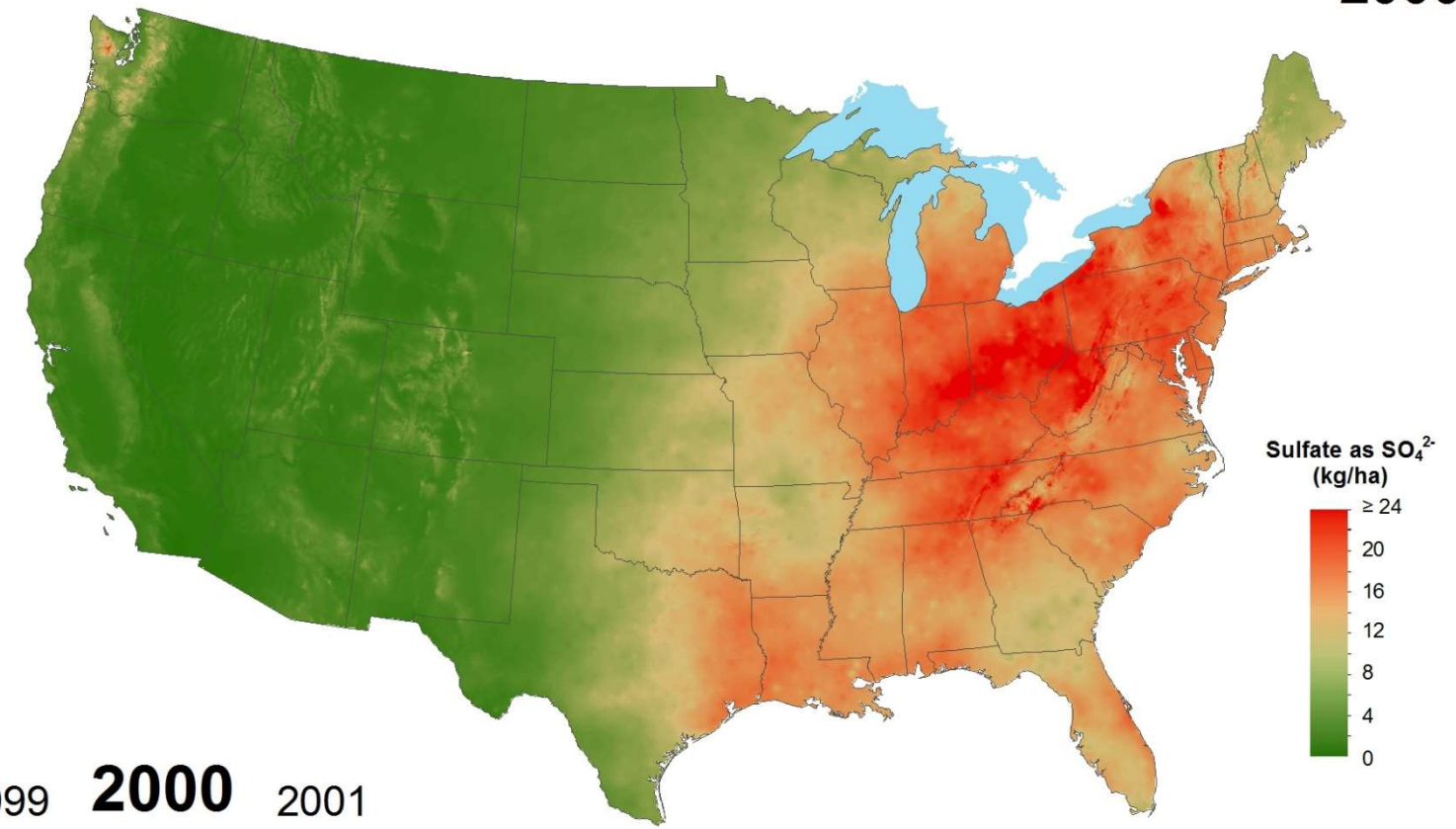

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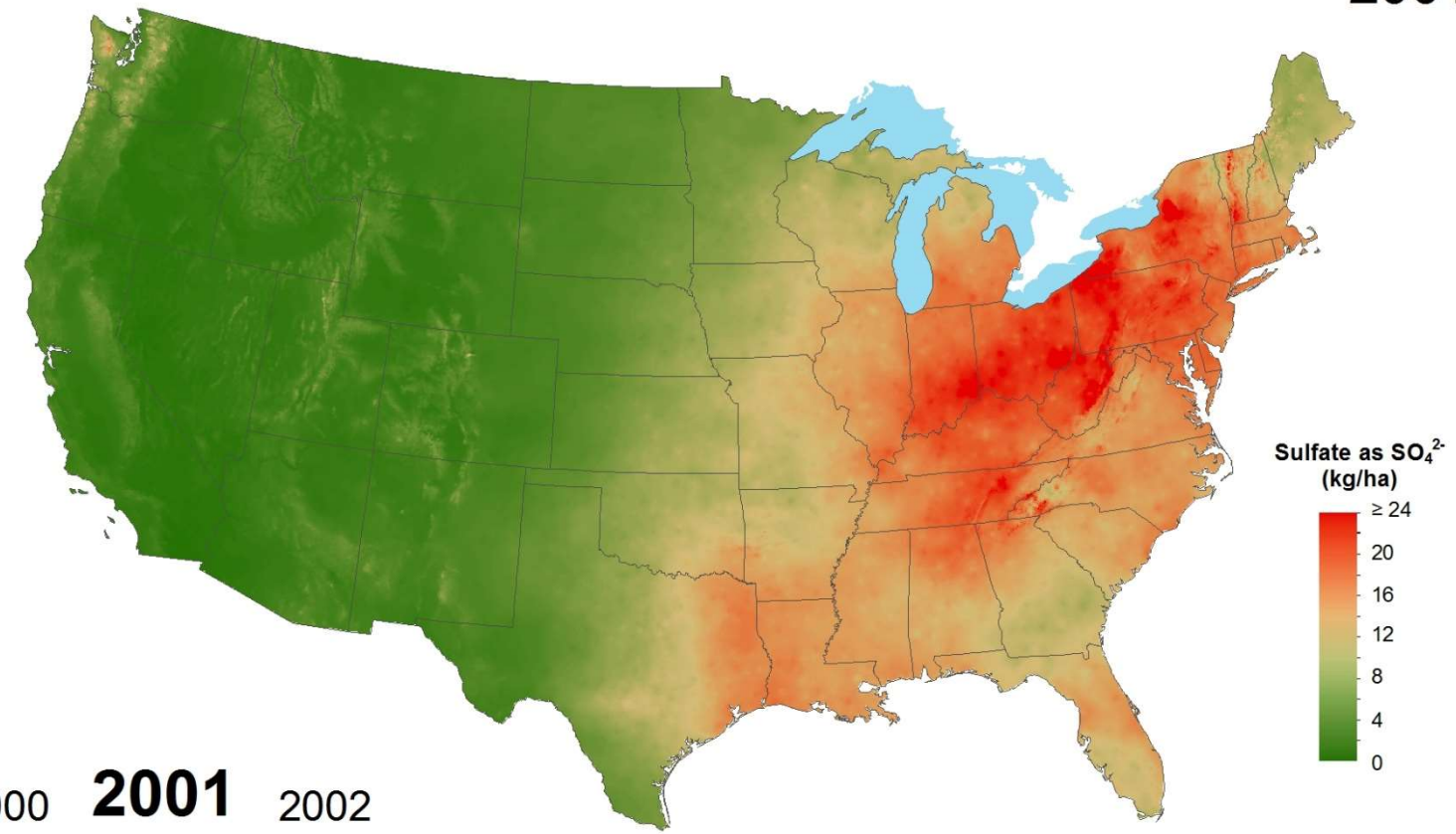
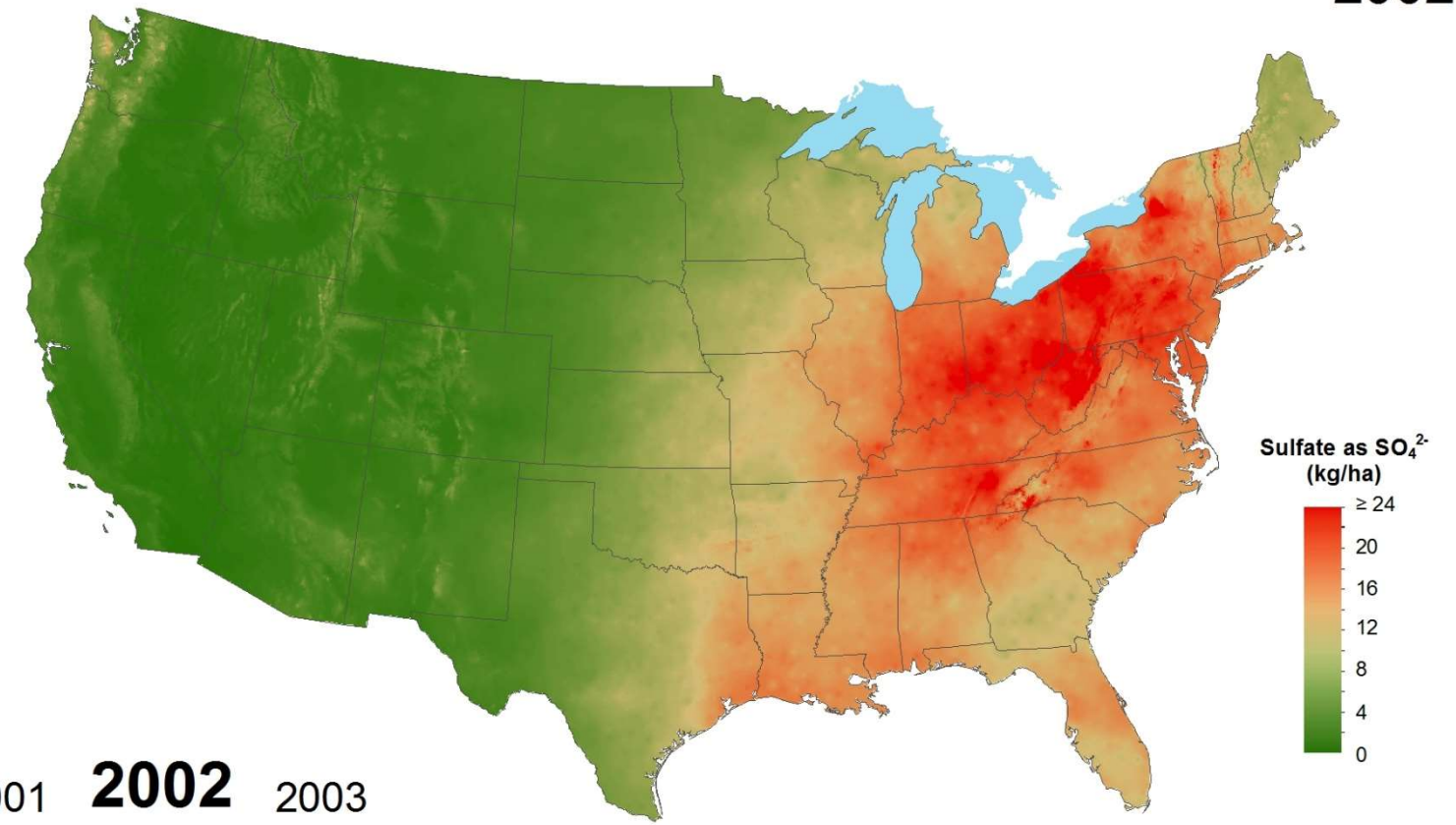
2001



2000 **2001** 2002

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

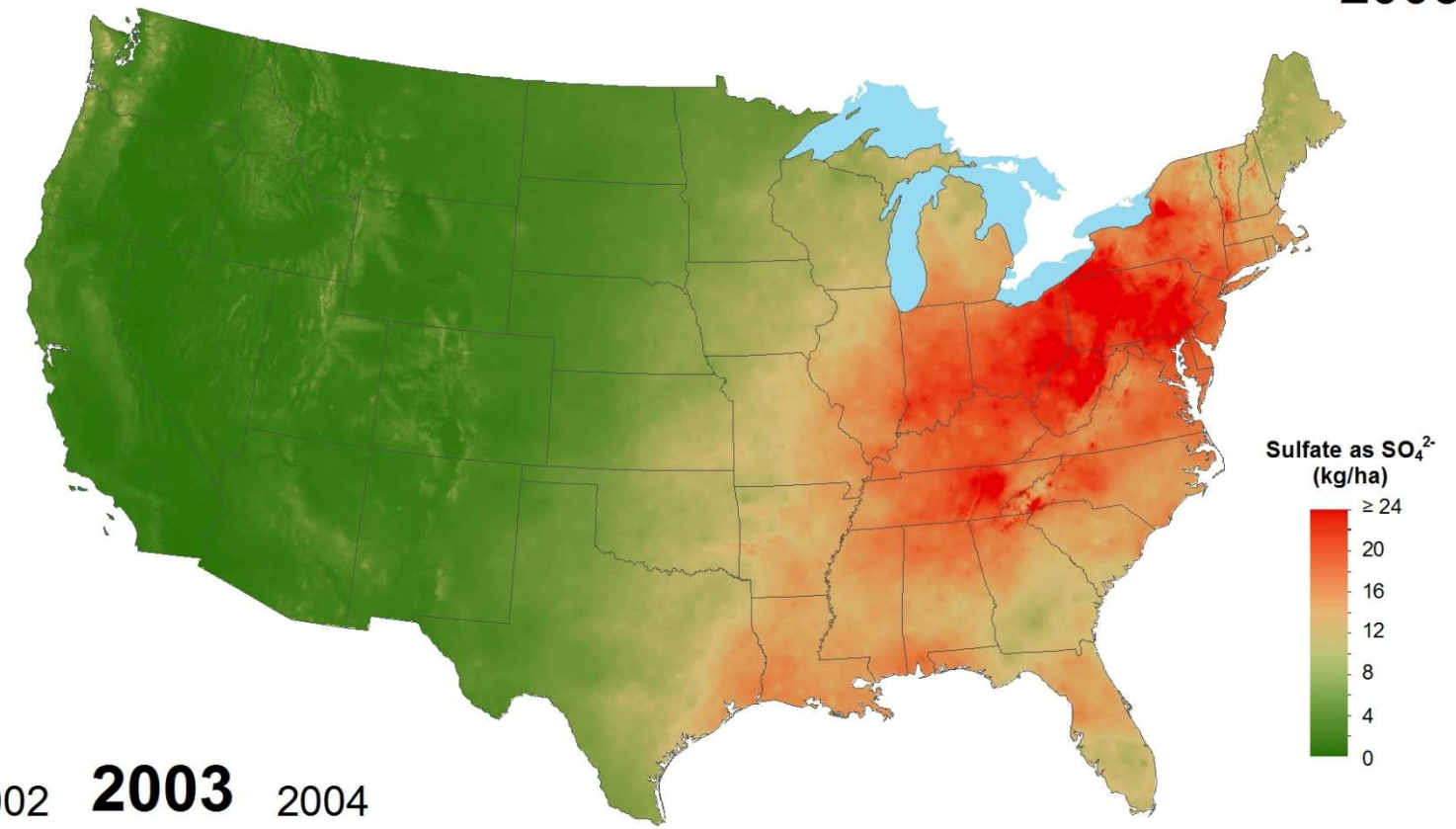
Sulfate ion wet deposition
2002



2001 **2002** 2003

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

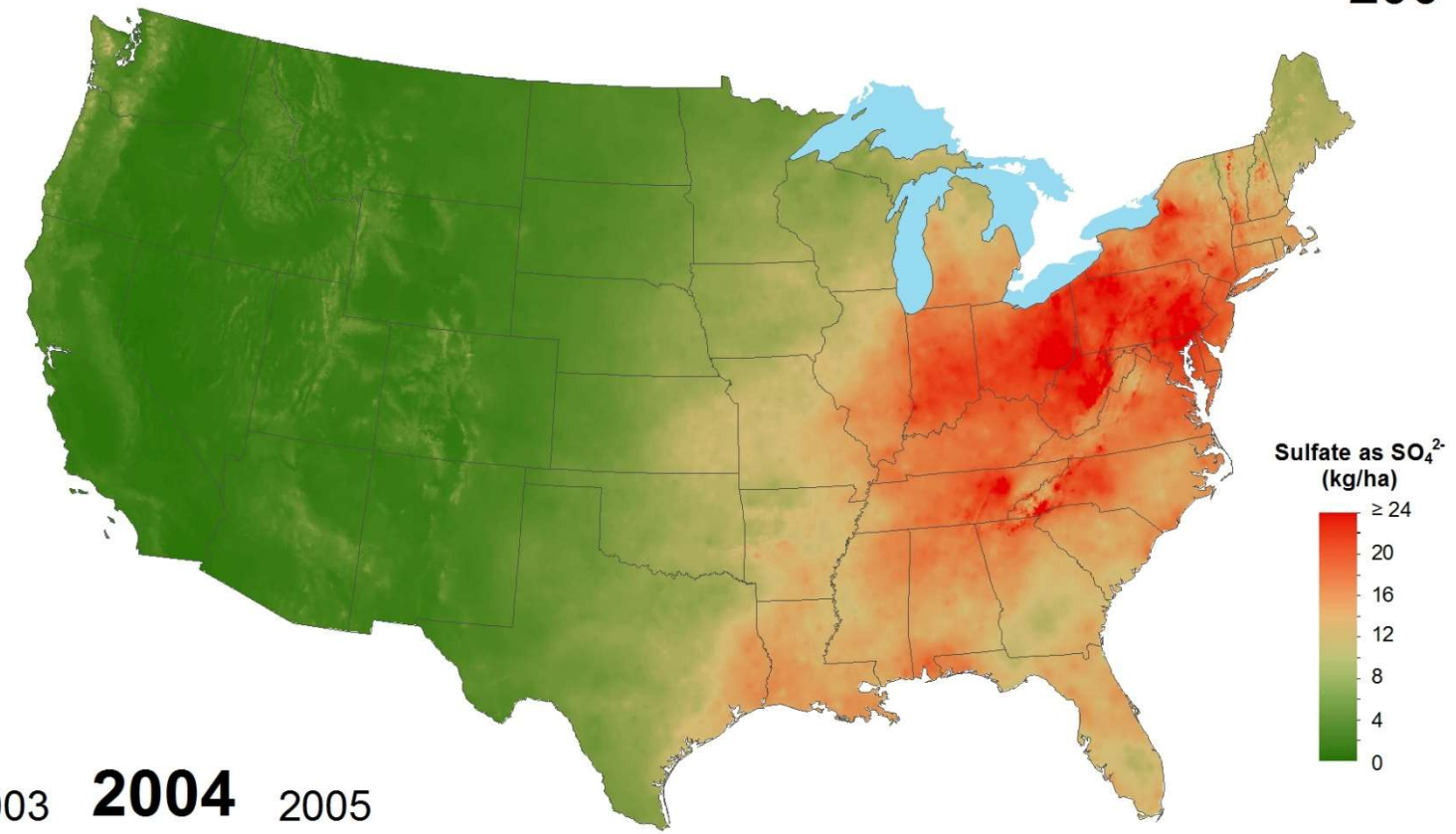
Sulfate ion wet deposition
2003



2002 **2003** 2004

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

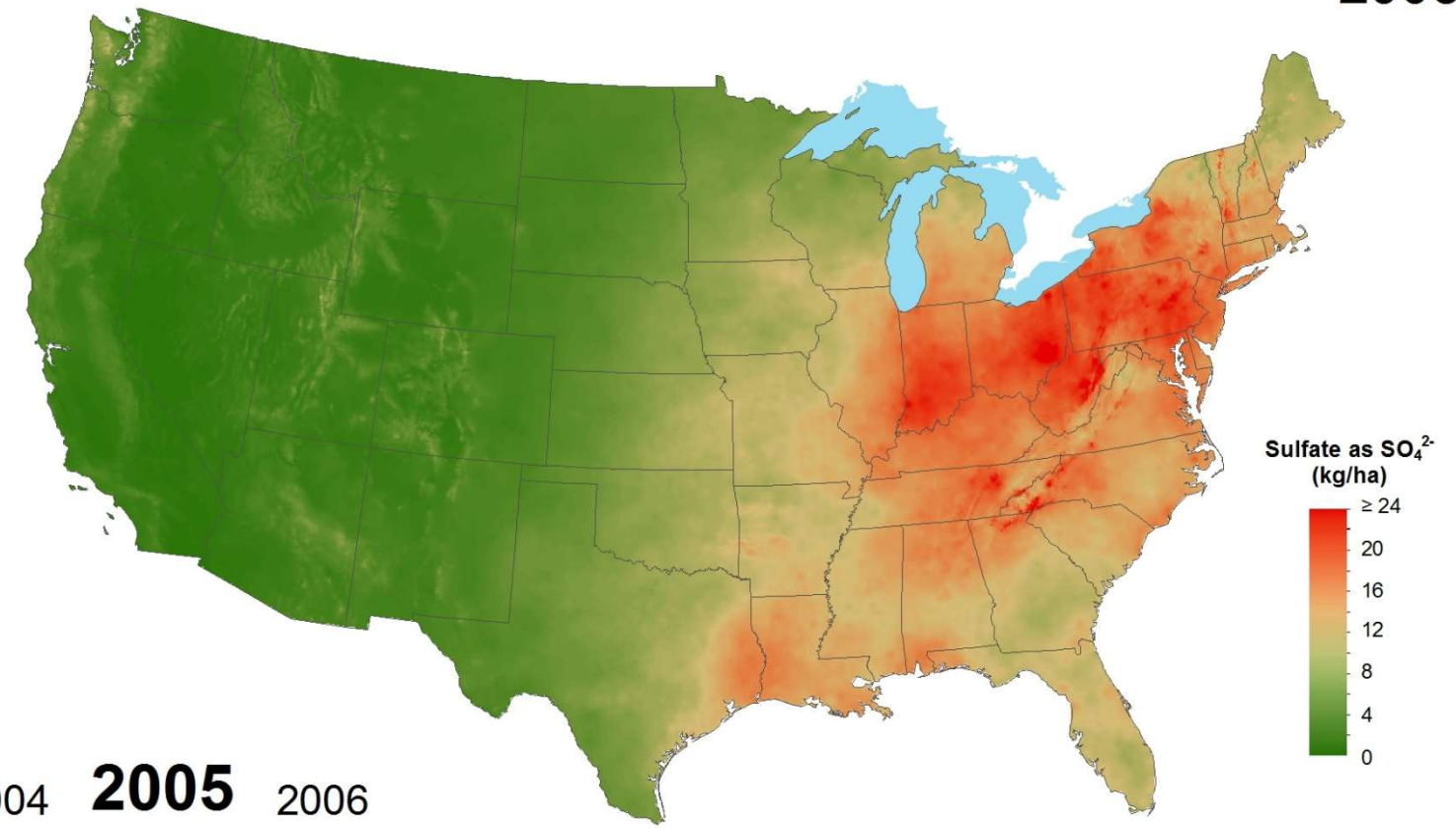
Sulfate ion wet deposition
2004



2003 **2004** 2005

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

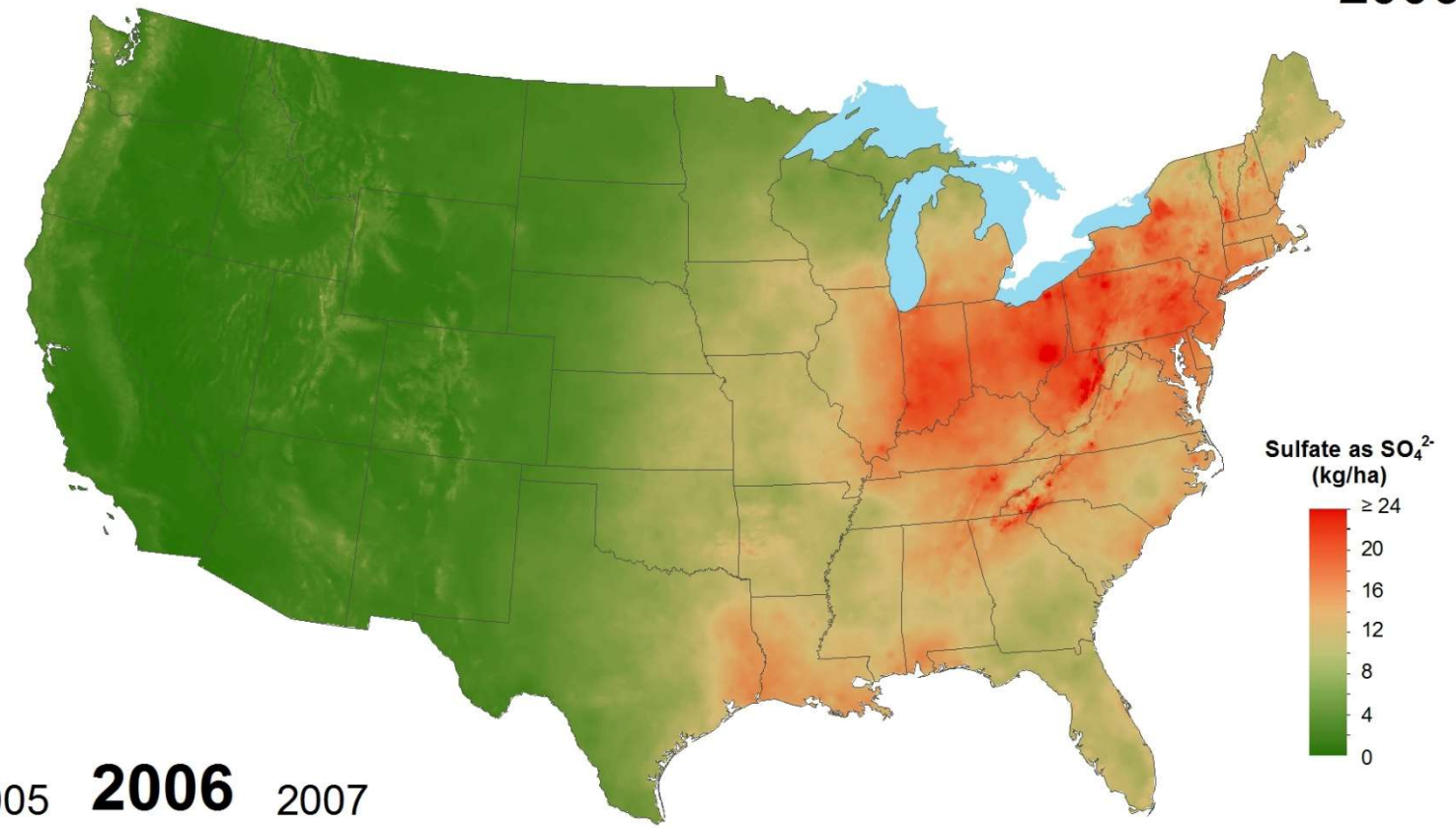
Sulfate ion wet deposition
2005



2004 **2005** 2006

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

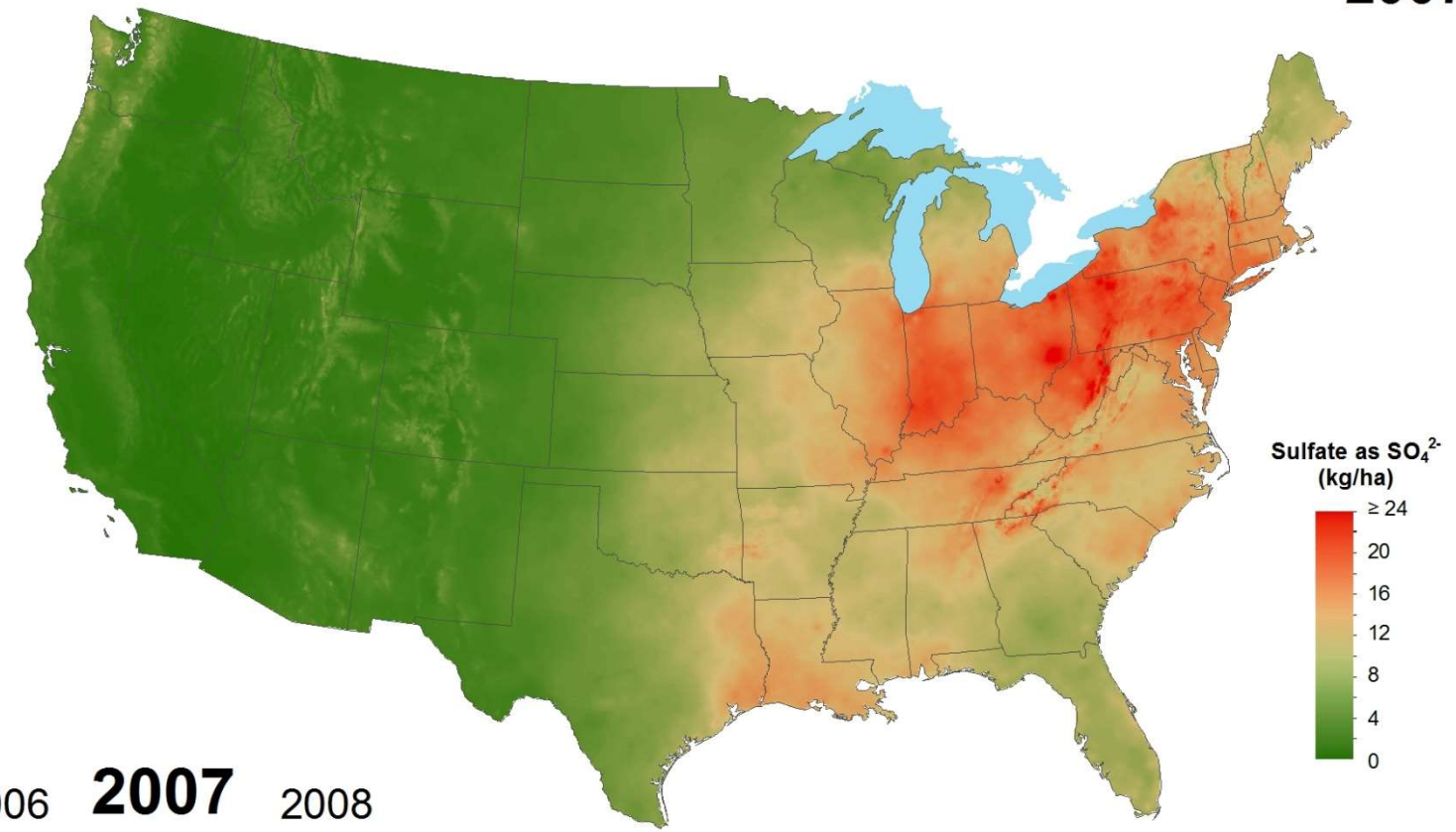
Sulfate ion wet deposition
2006



2005 **2006** 2007

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

Sulfate ion wet deposition
2007



2006 **2007** 2008

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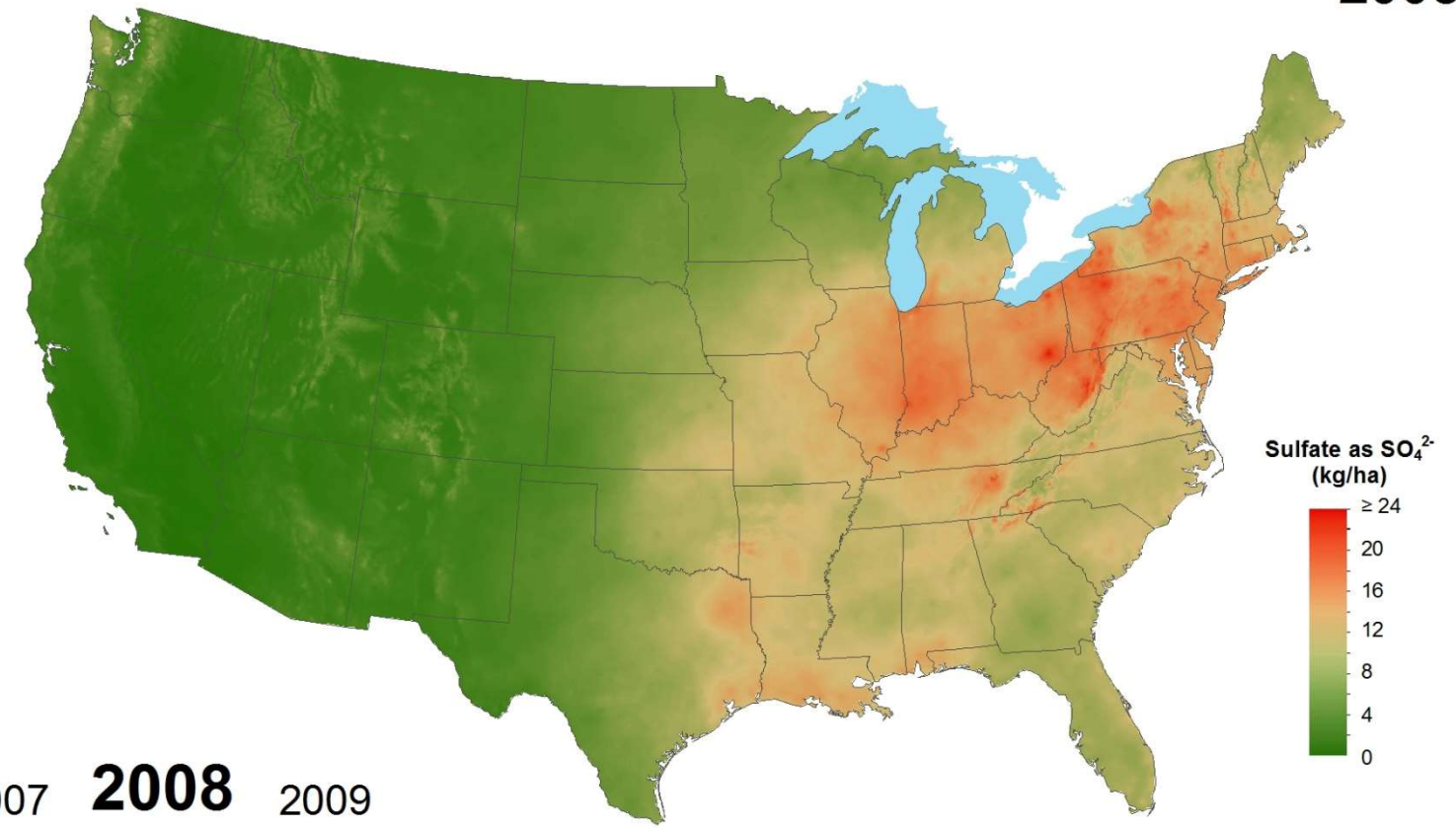
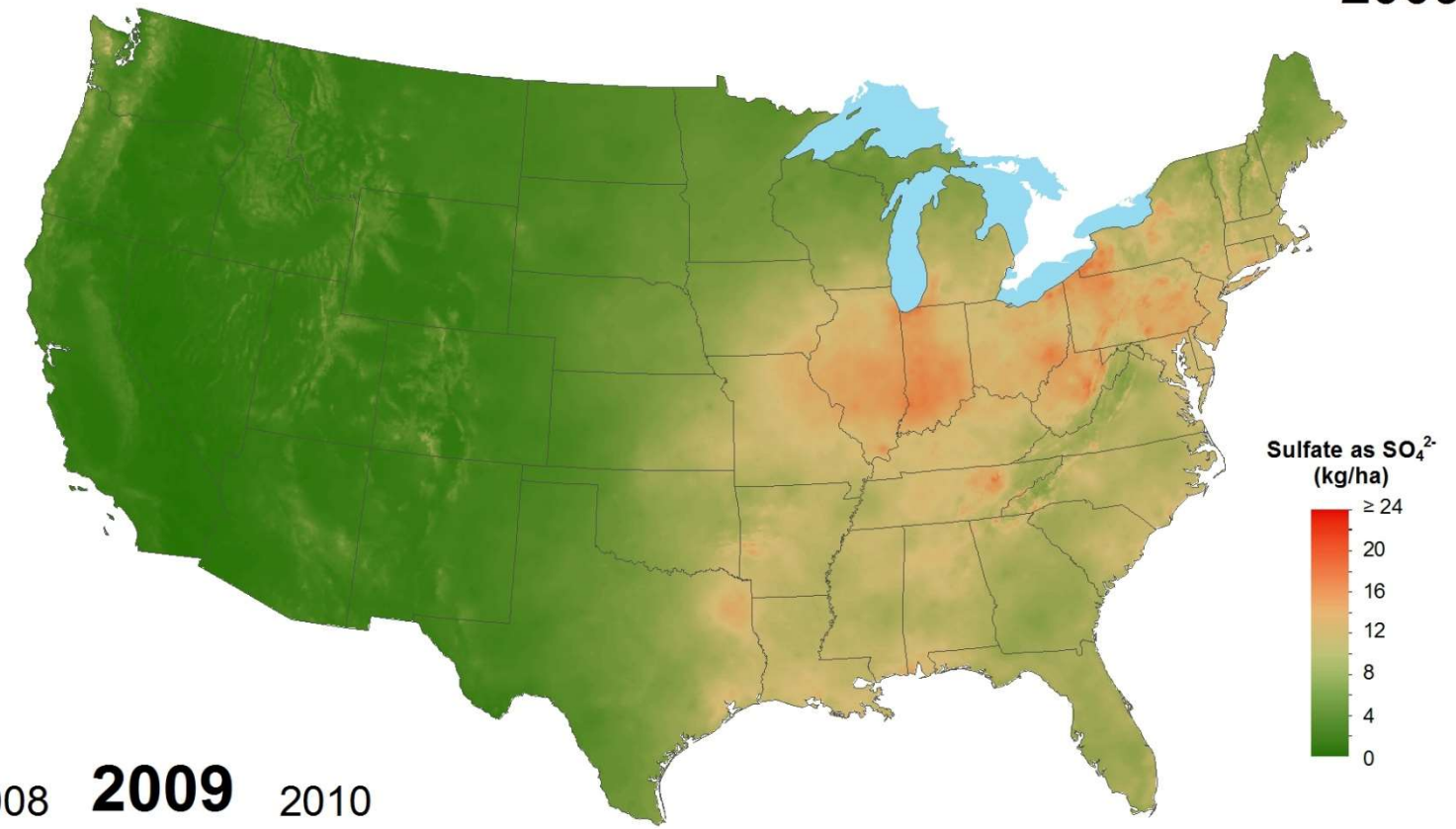
Sulfate ion wet deposition
2008



2007 **2008** 2009

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

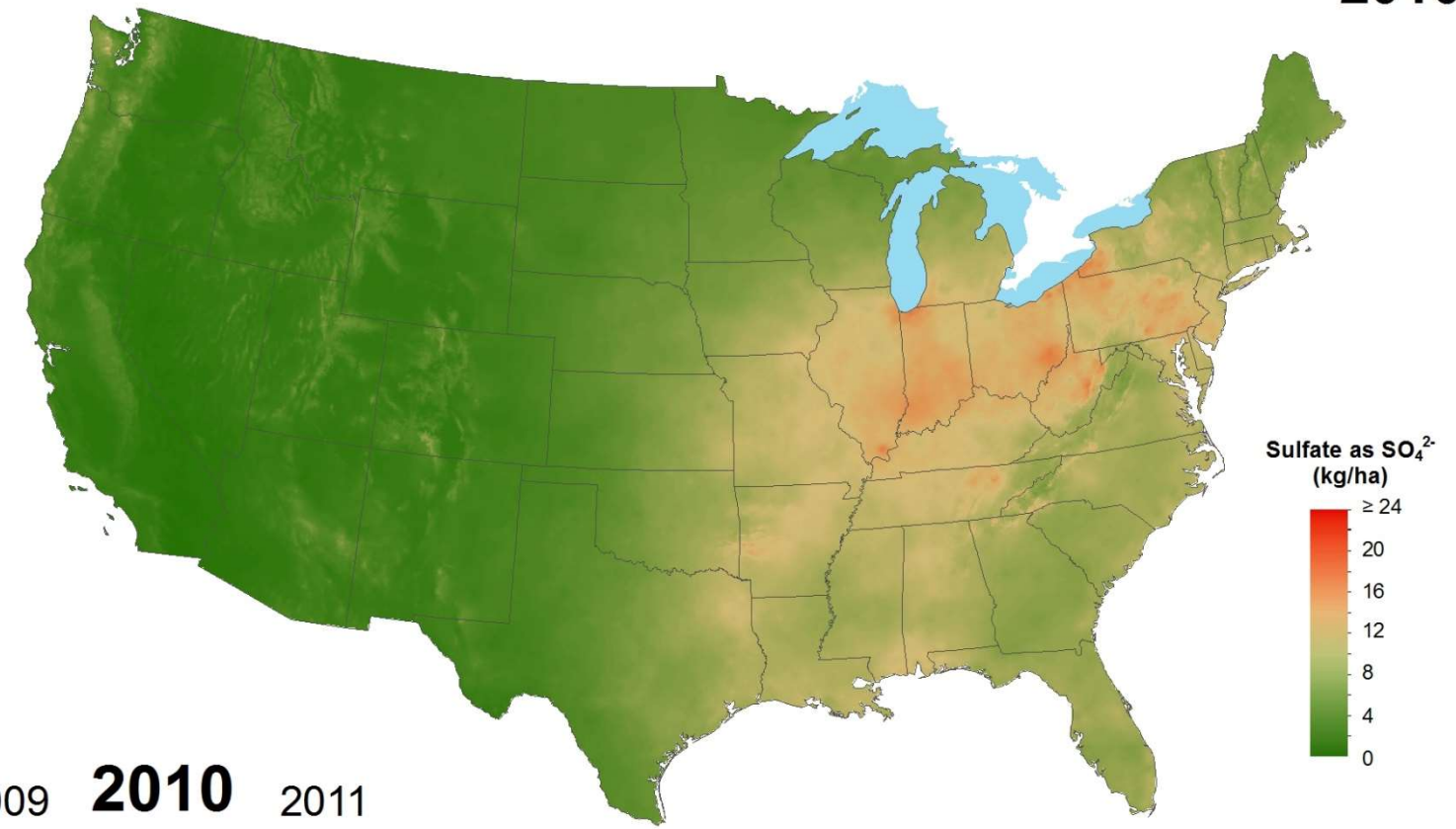
Sulfate ion wet deposition
2009



2008 **2009** 2010

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

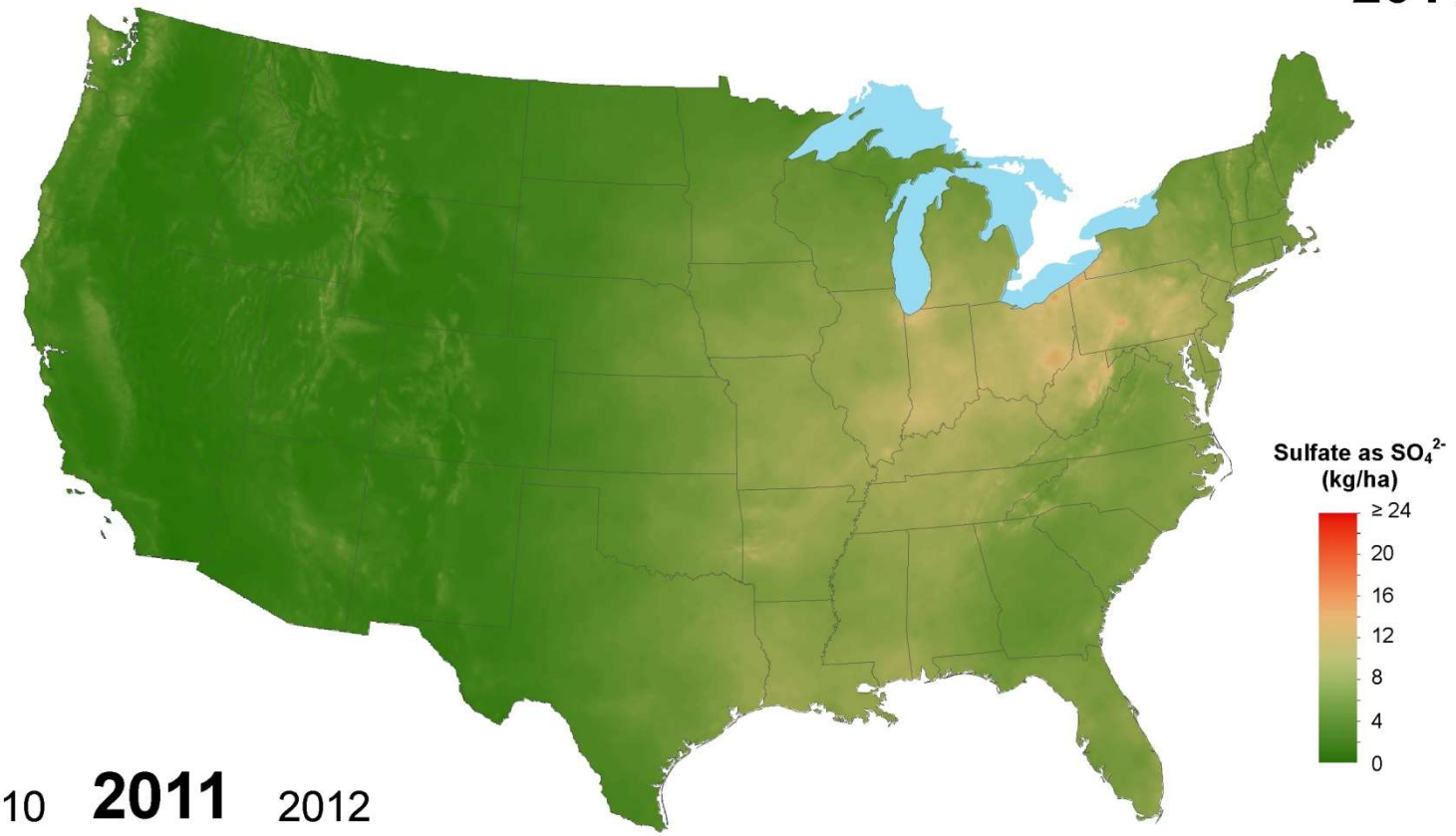
Sulfate ion wet deposition
2010



2009 **2010** 2011

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

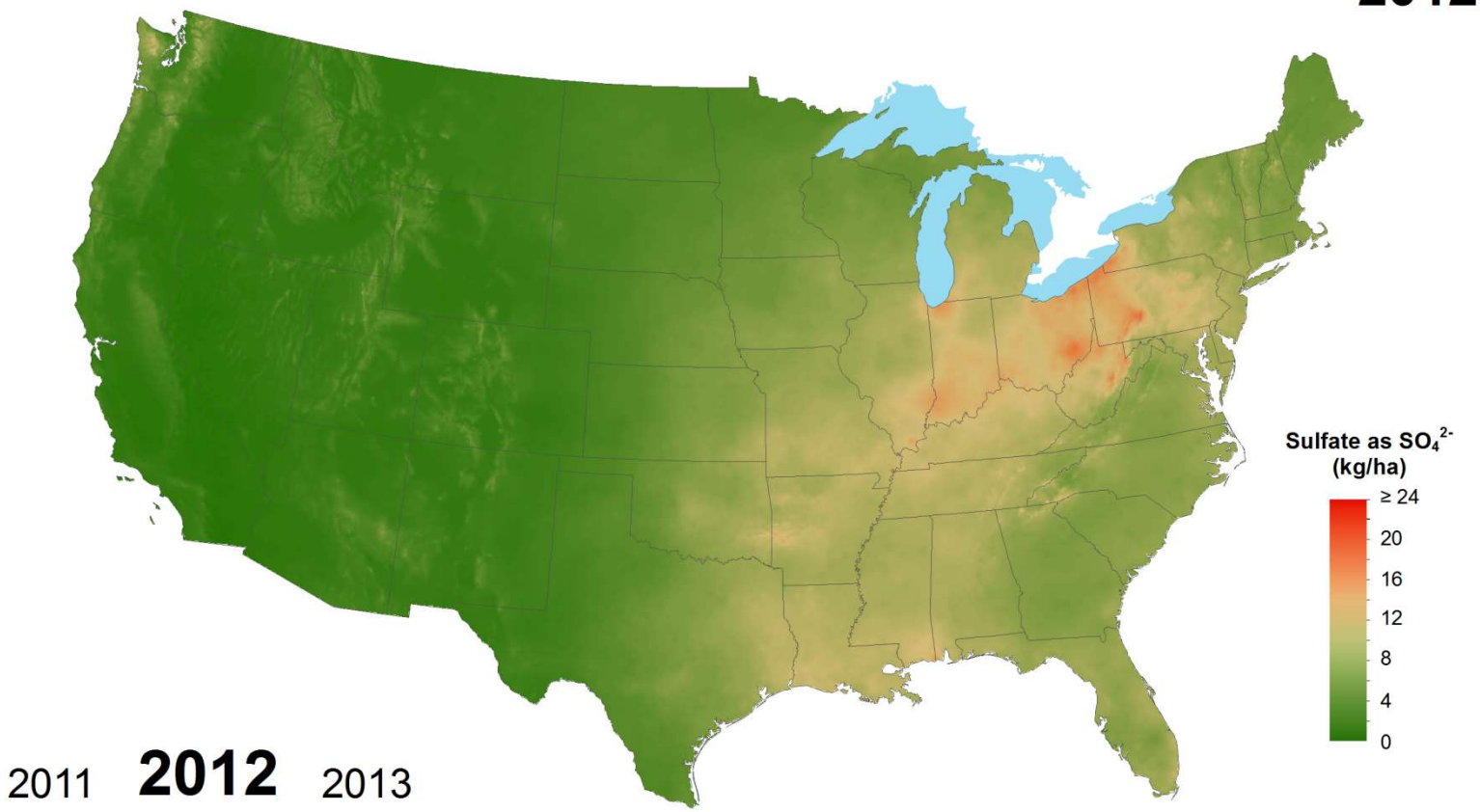
Sulfate ion wet deposition
2011



2010 **2011** 2012

National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

Sulfate ion wet deposition
2012



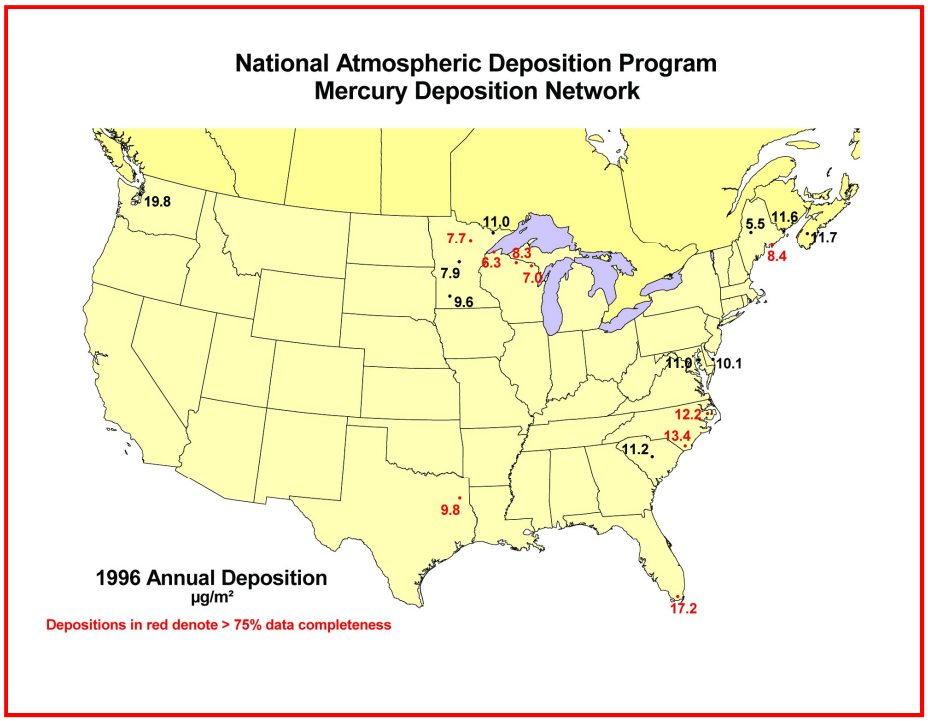
2011 **2012** 2013

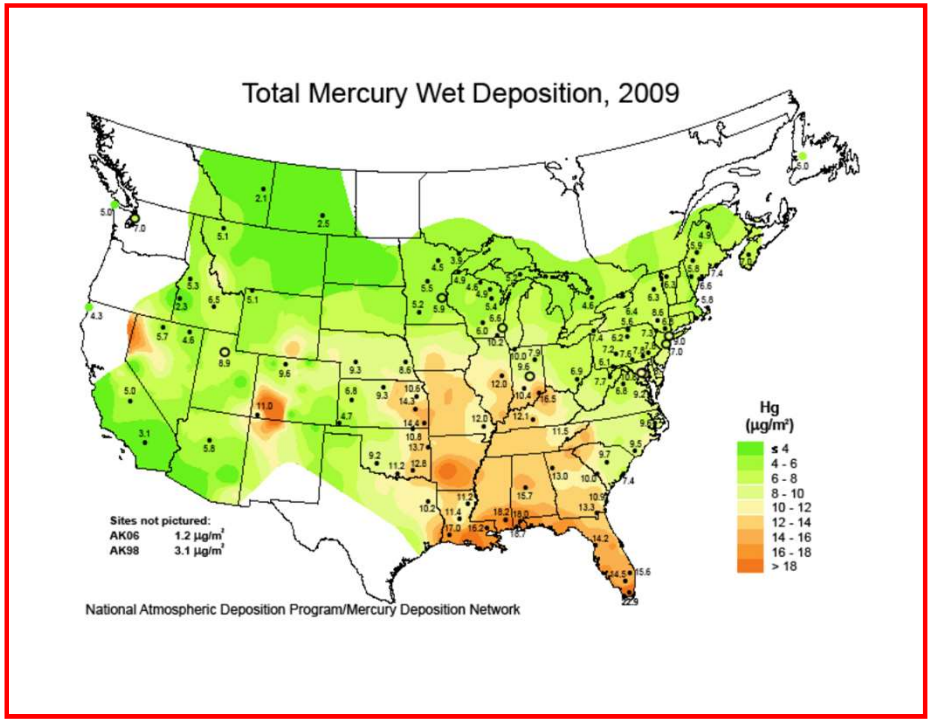
National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

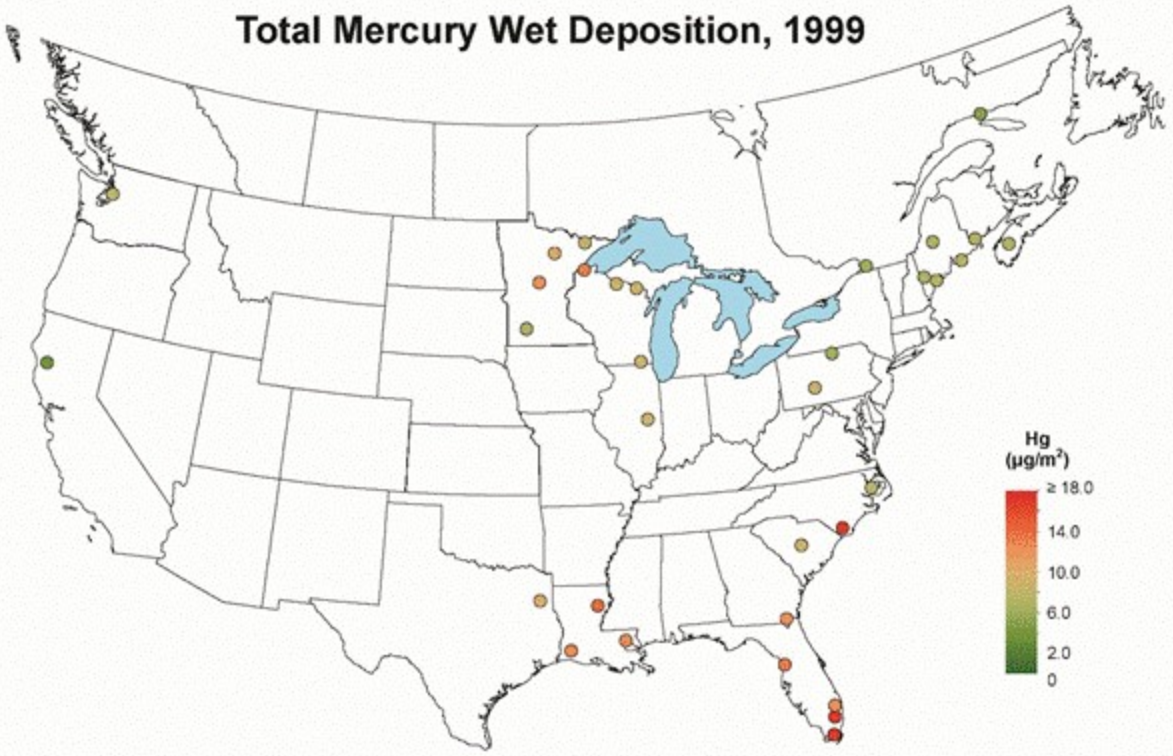
NADP Mercury Deposition Network 1996-2016

Monitoring Hg And Metals In Precipitation

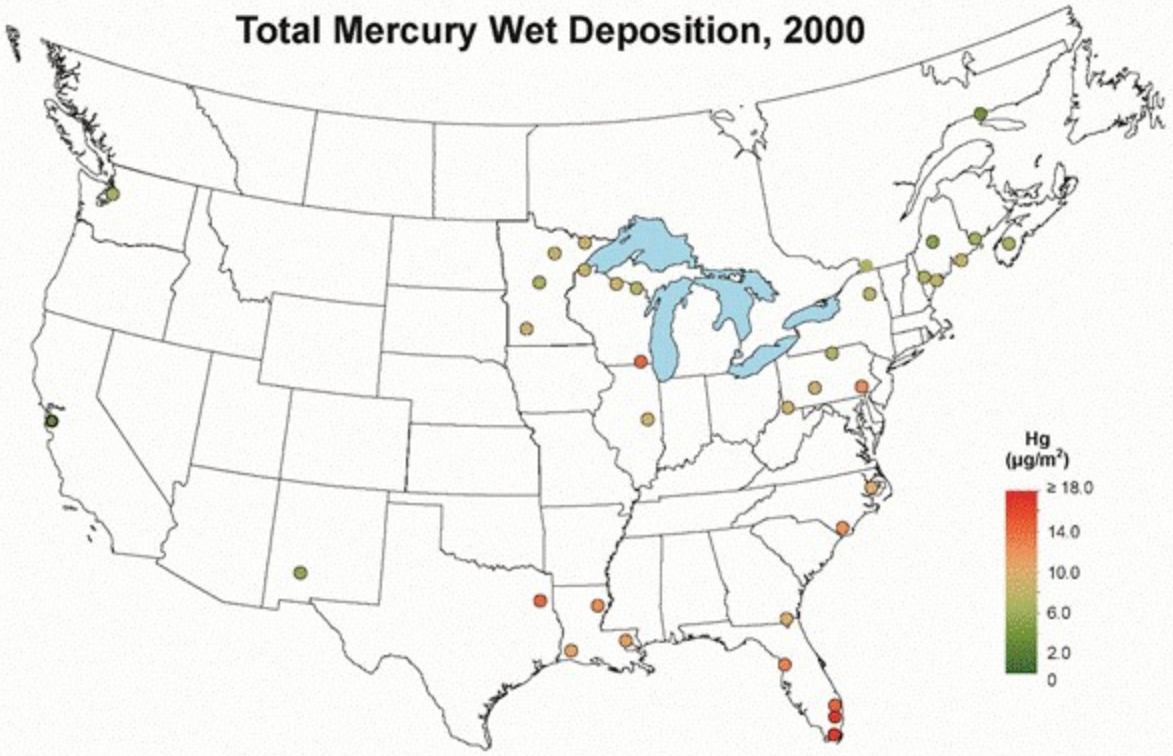
Will we see the same reductions for mercury as we did with Sulfur?



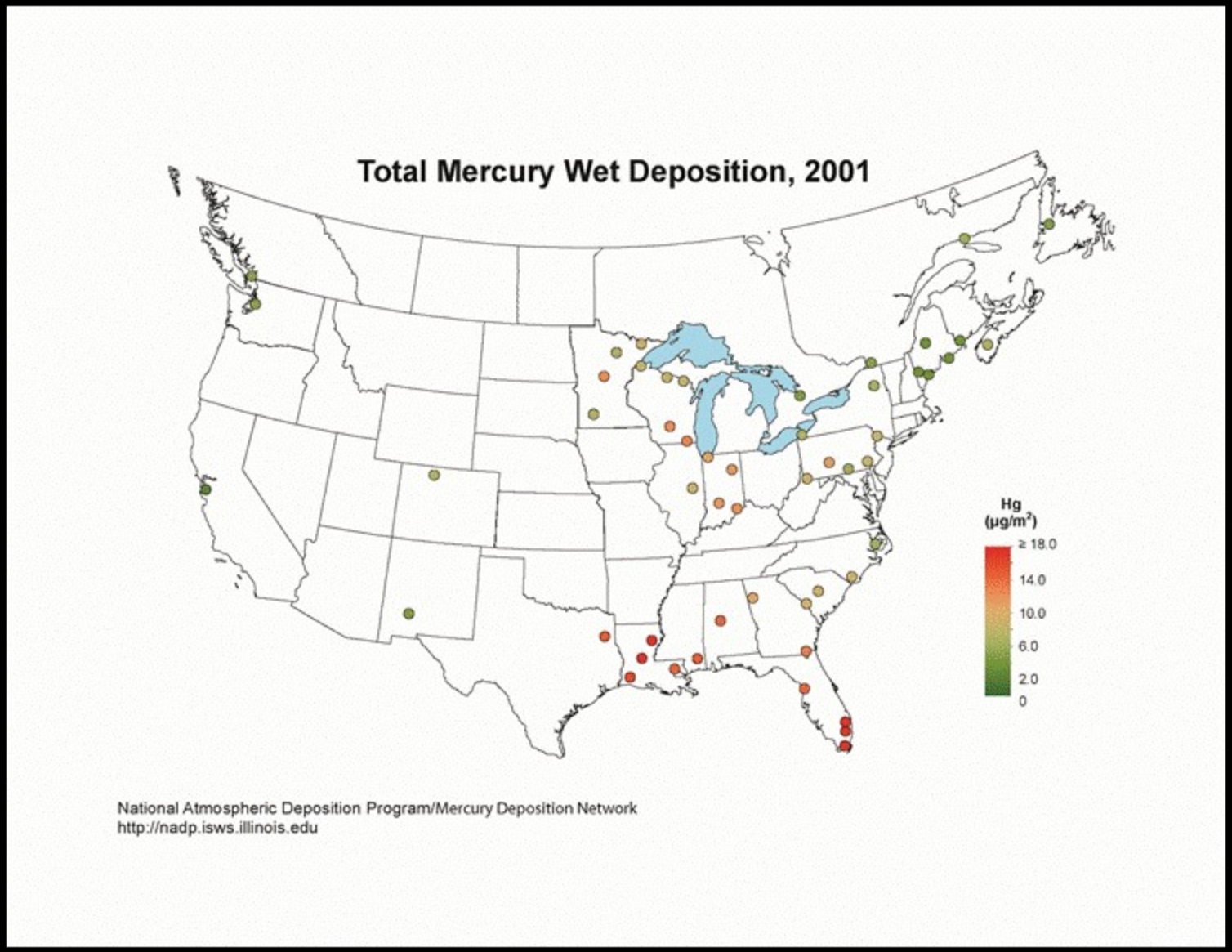


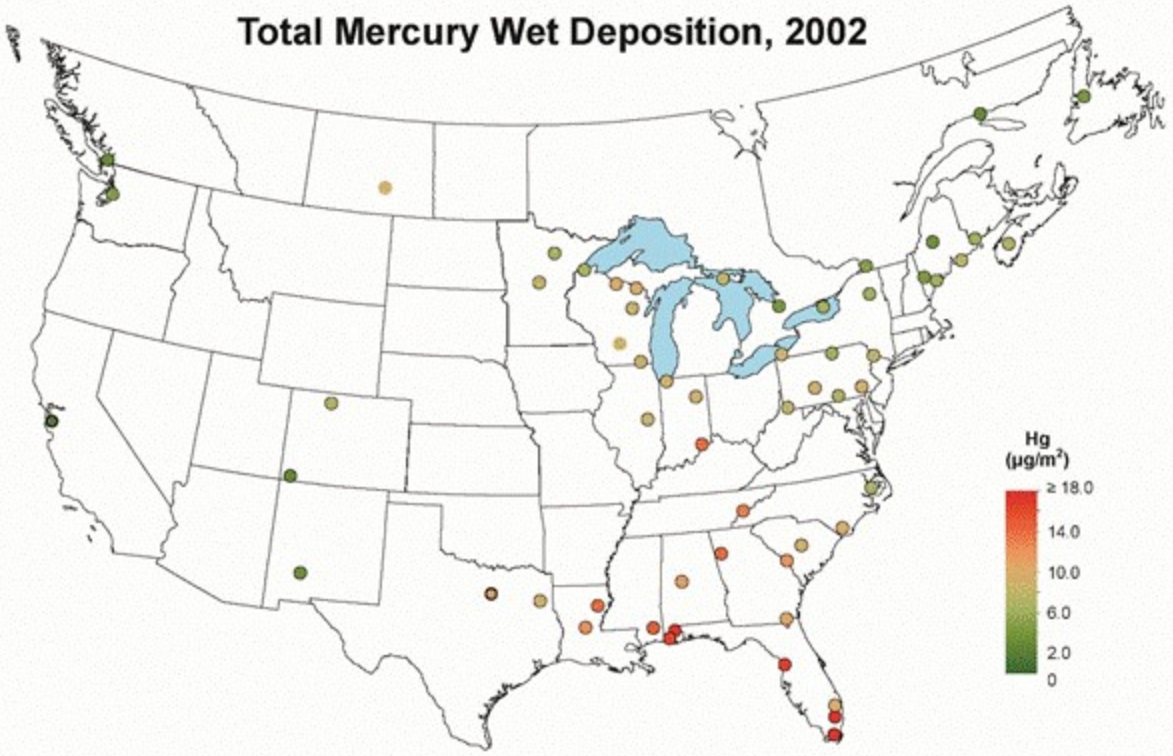


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

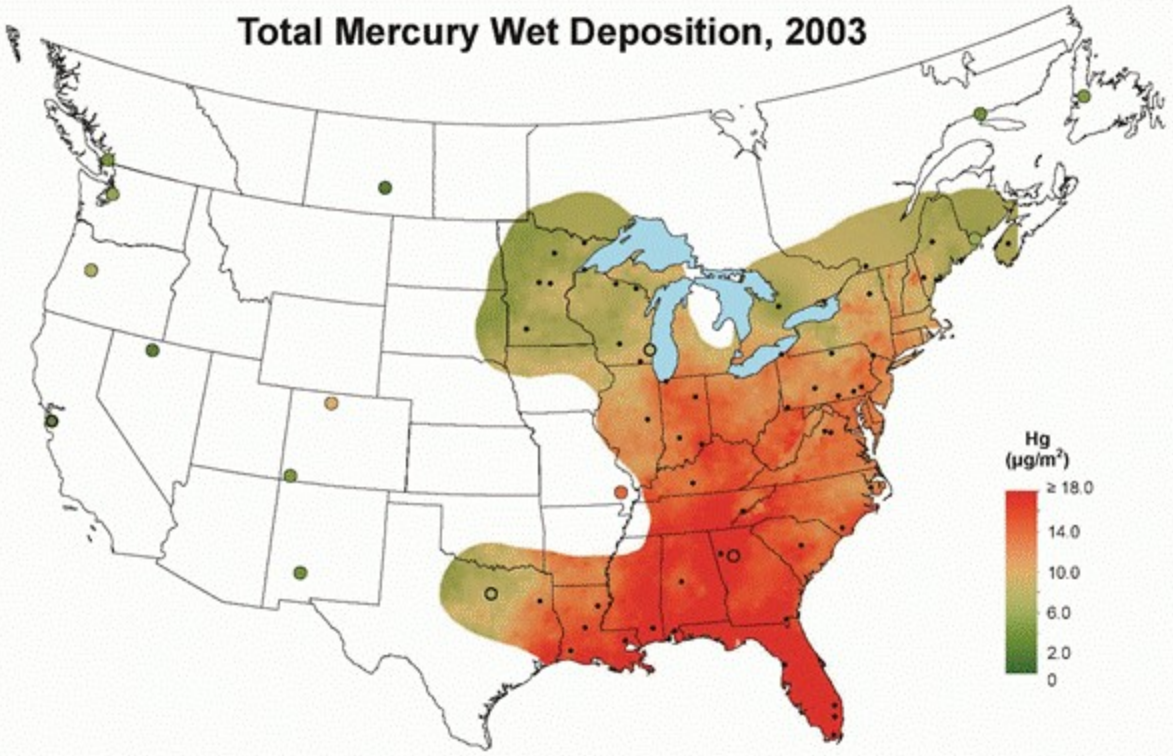


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

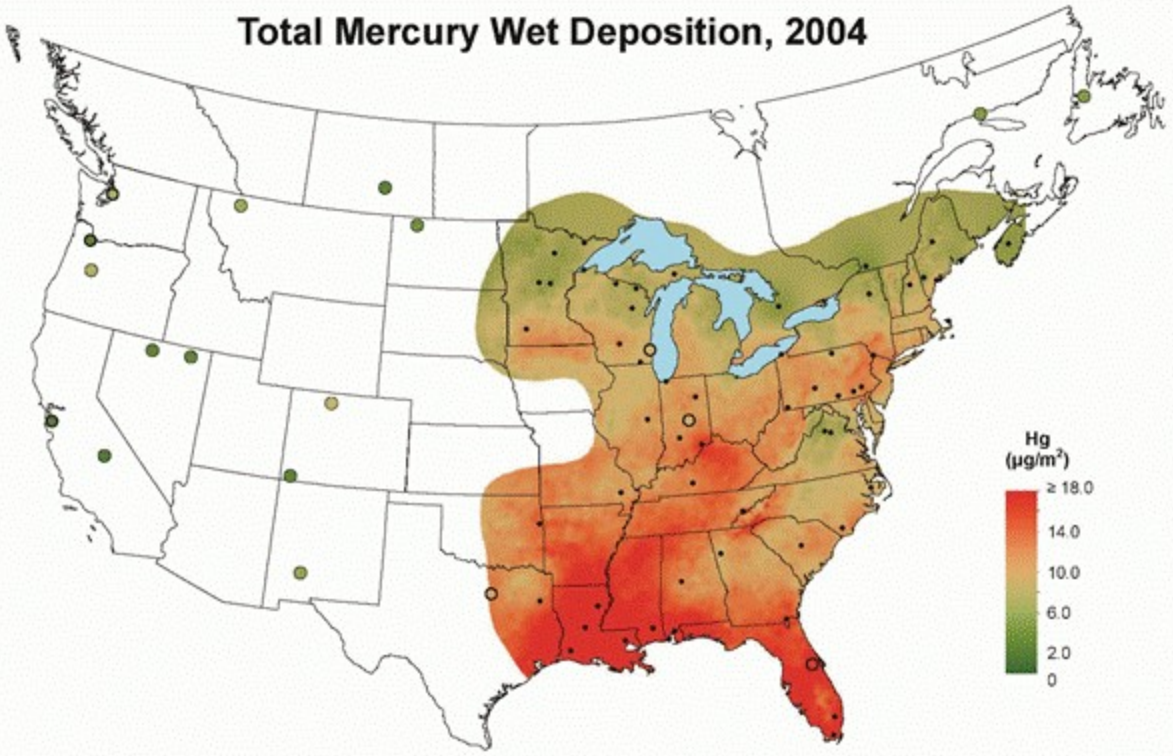

Total Mercury Wet Deposition, 2001
Hg
(µg/m²)
≥ 18.0
14.0
10.0
6.0
2.0
0
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



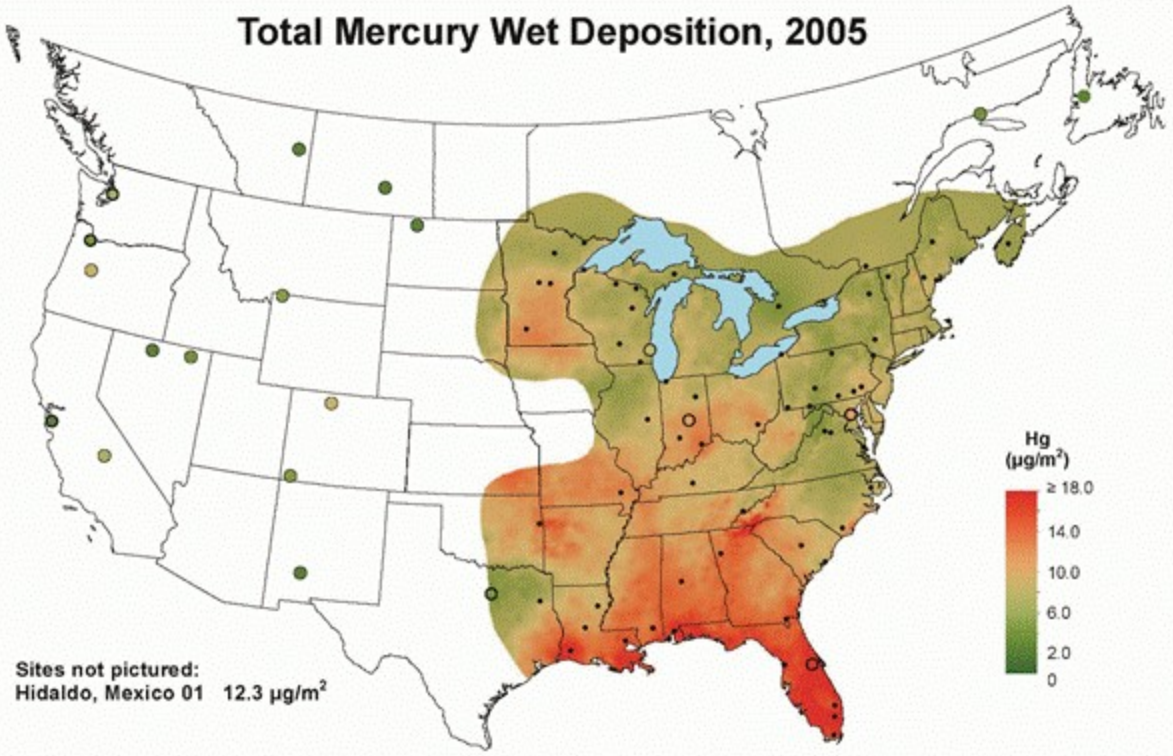
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



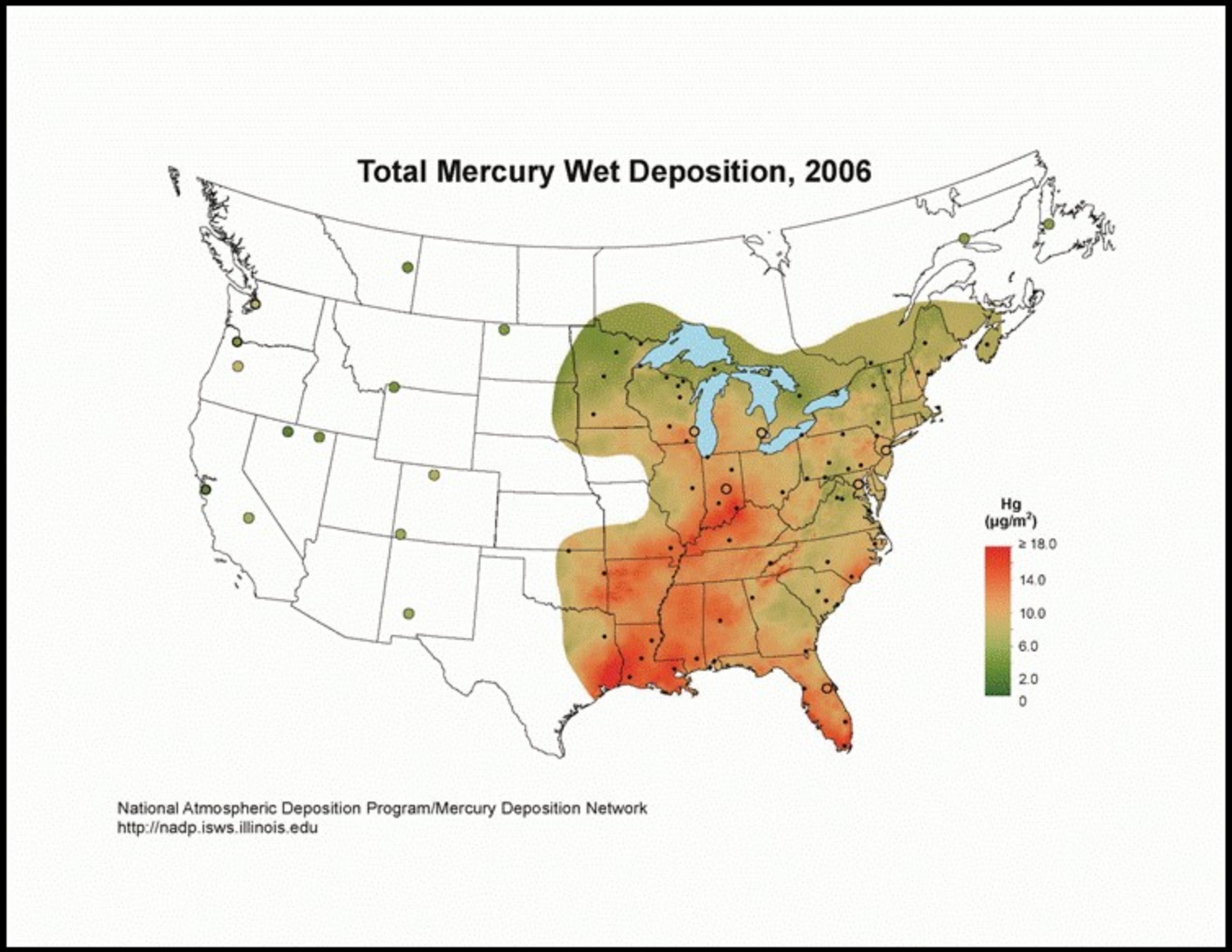
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

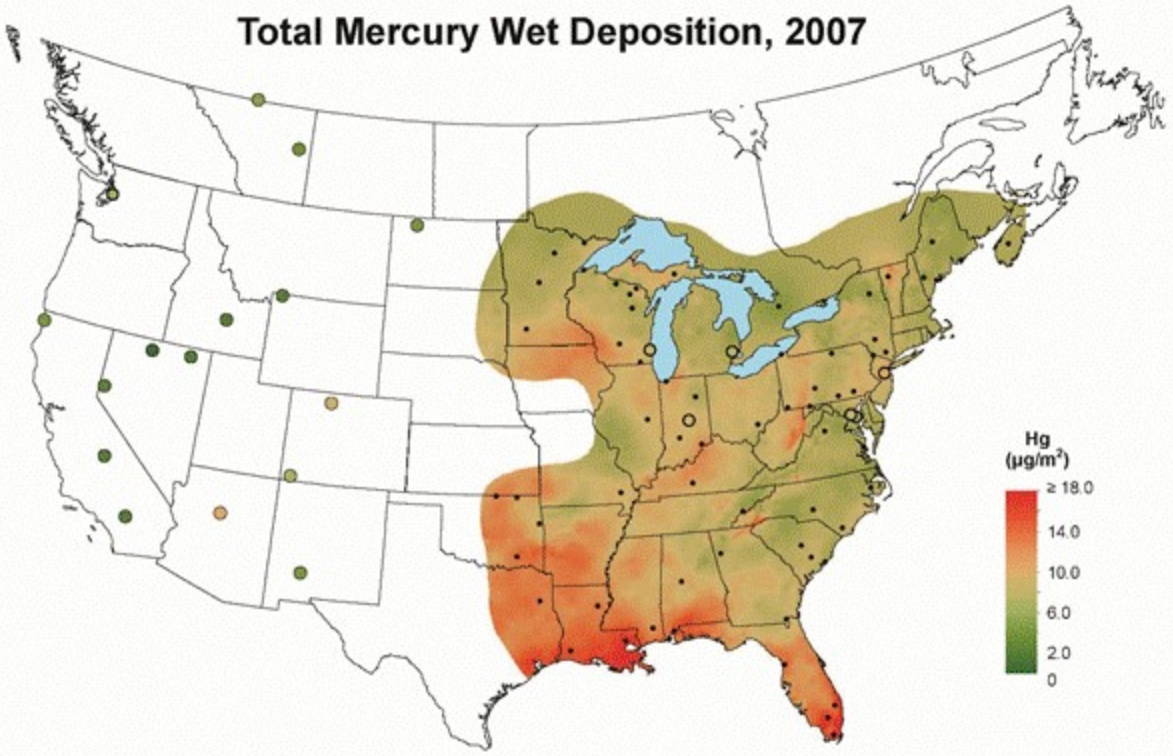


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

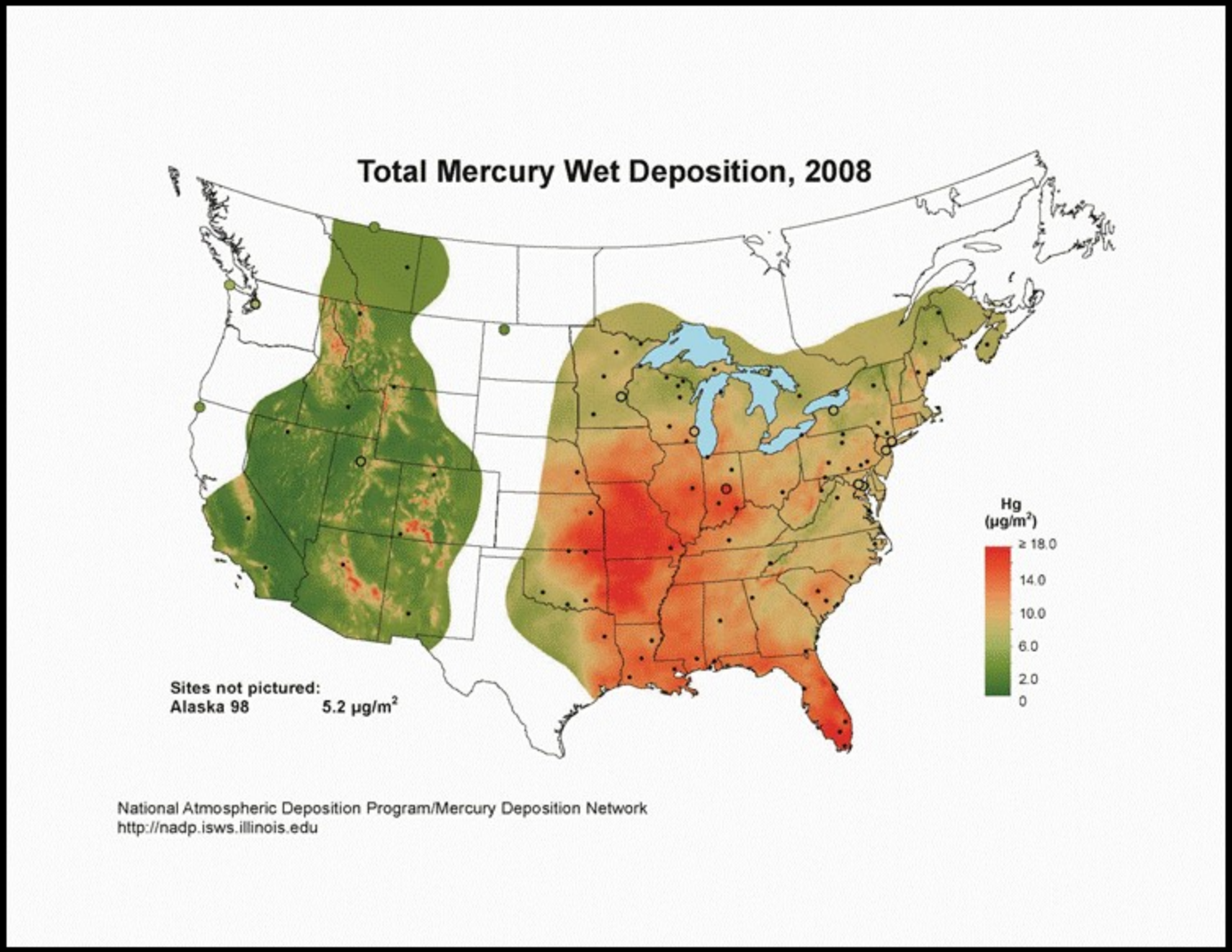


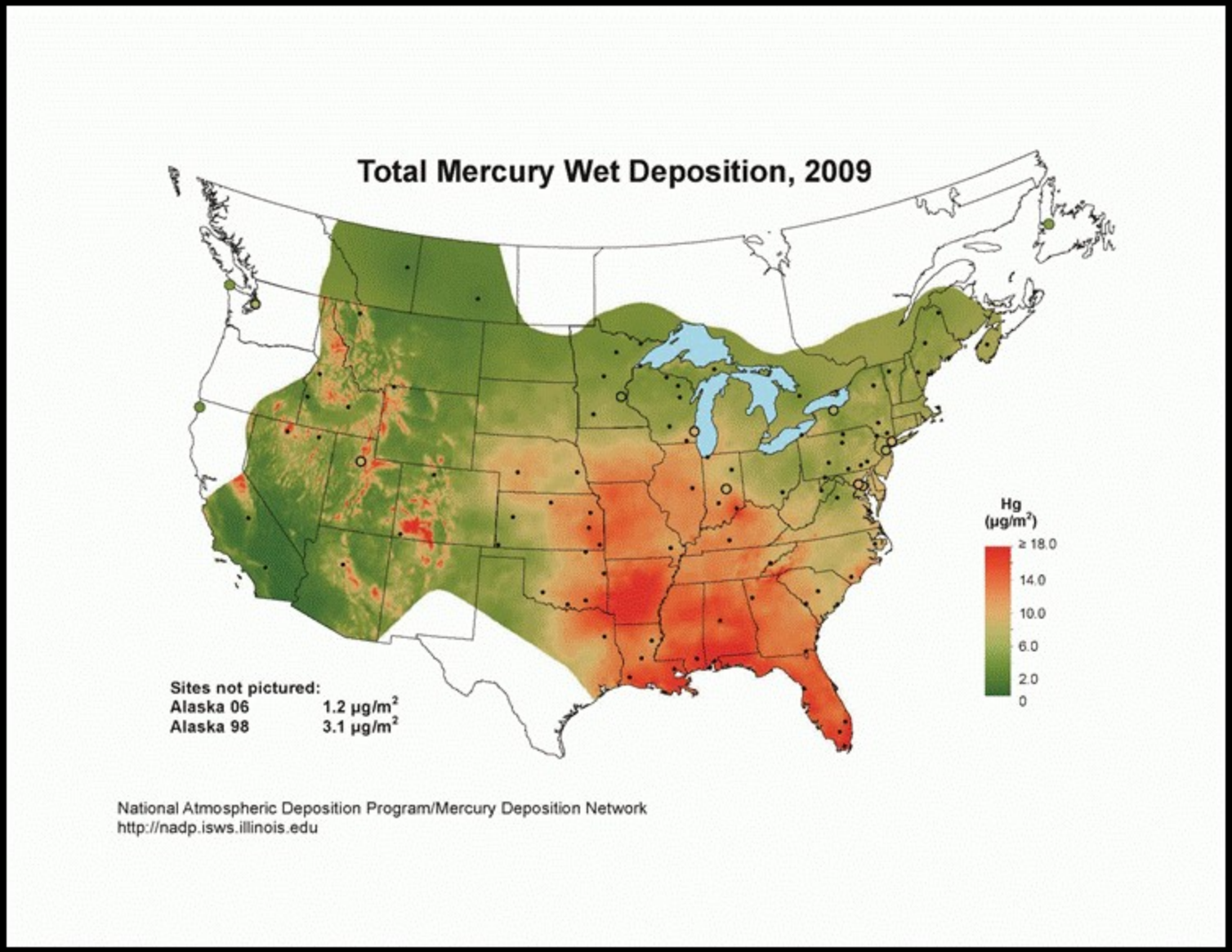
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

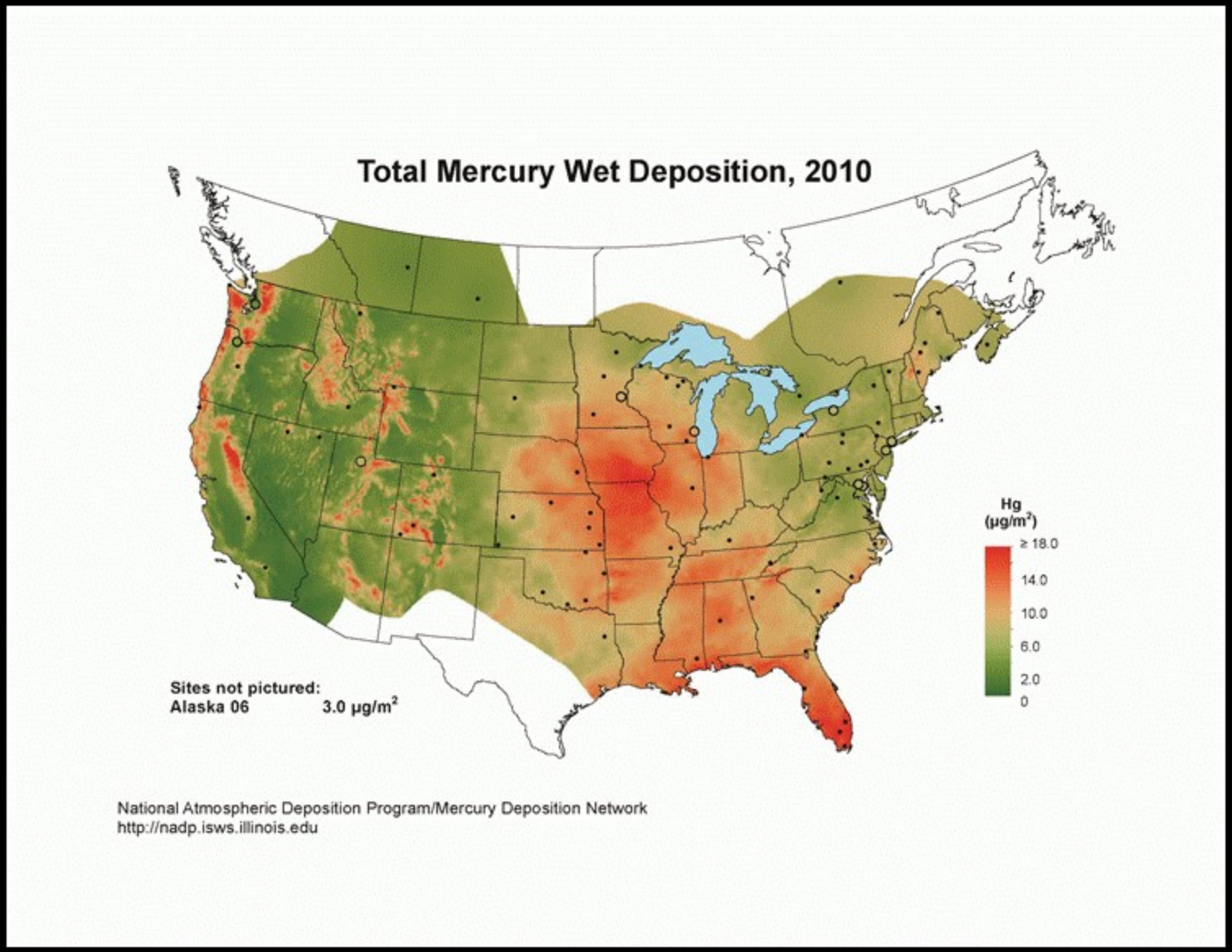

Total Mercury Wet Deposition, 2006
Hg
(µg/m²)
≥ 18.0
14.0
10.0
6.0
2.0
0
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



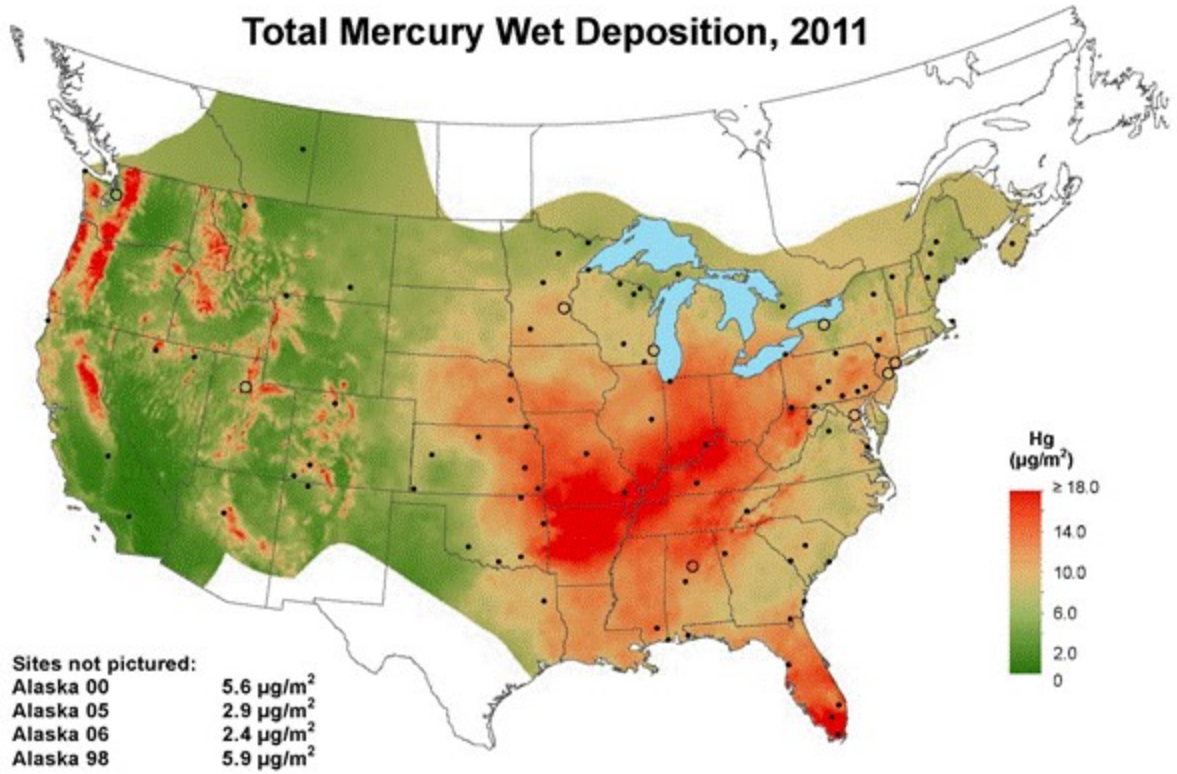
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu


Total Mercury Wet Deposition, 2008
Hg
(µg/m²)
≥ 18.0
14.0
10.0
6.0
2.0
0
Sites not pictured:
Alaska 98 5.2 µg/m²
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu


Total Mercury Wet Deposition, 2009
Hg (µg/m²)
≥ 18.0
14.0
10.0
6.0
2.0
0
Sites not pictured:
Alaska 06 1.2 µg/m²
Alaska 98 3.1 µg/m²
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu


Total Mercury Wet Deposition, 2010
Hg (µg/m²)
≥ 18.0
14.0
10.0
6.0
2.0
0
Sites not pictured:
Alaska 06 3.0 µg/m²
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

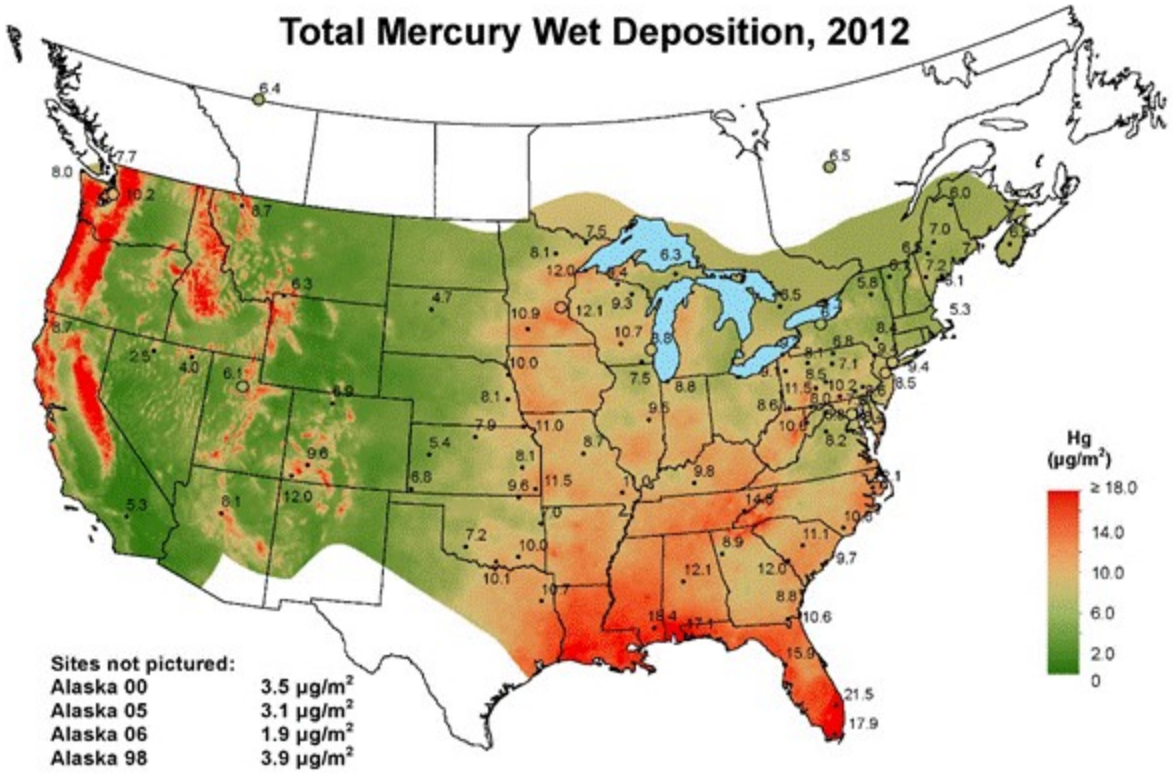
Total Mercury Wet Deposition, 2011



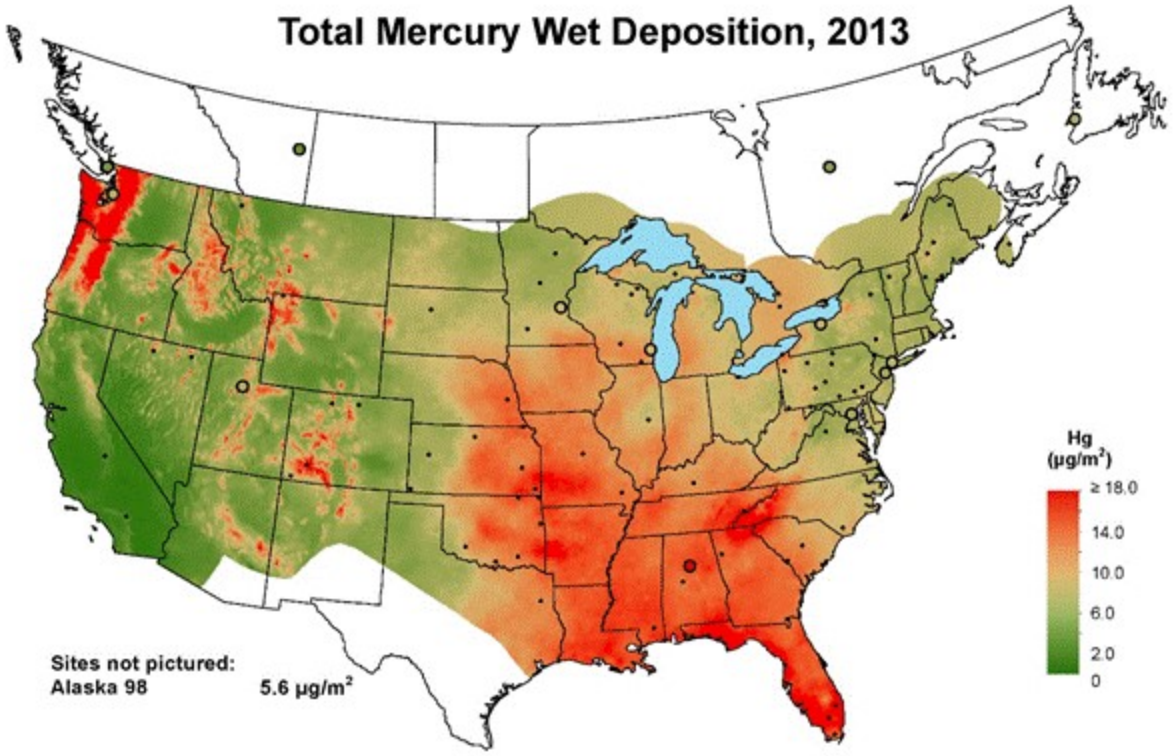
Sites not pictured:

Alaska 00	**5.6 µg/m²**
Alaska 05	**2.9 µg/m²**
Alaska 06	**2.4 µg/m²**
Alaska 98	**5.9 µg/m²**

National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

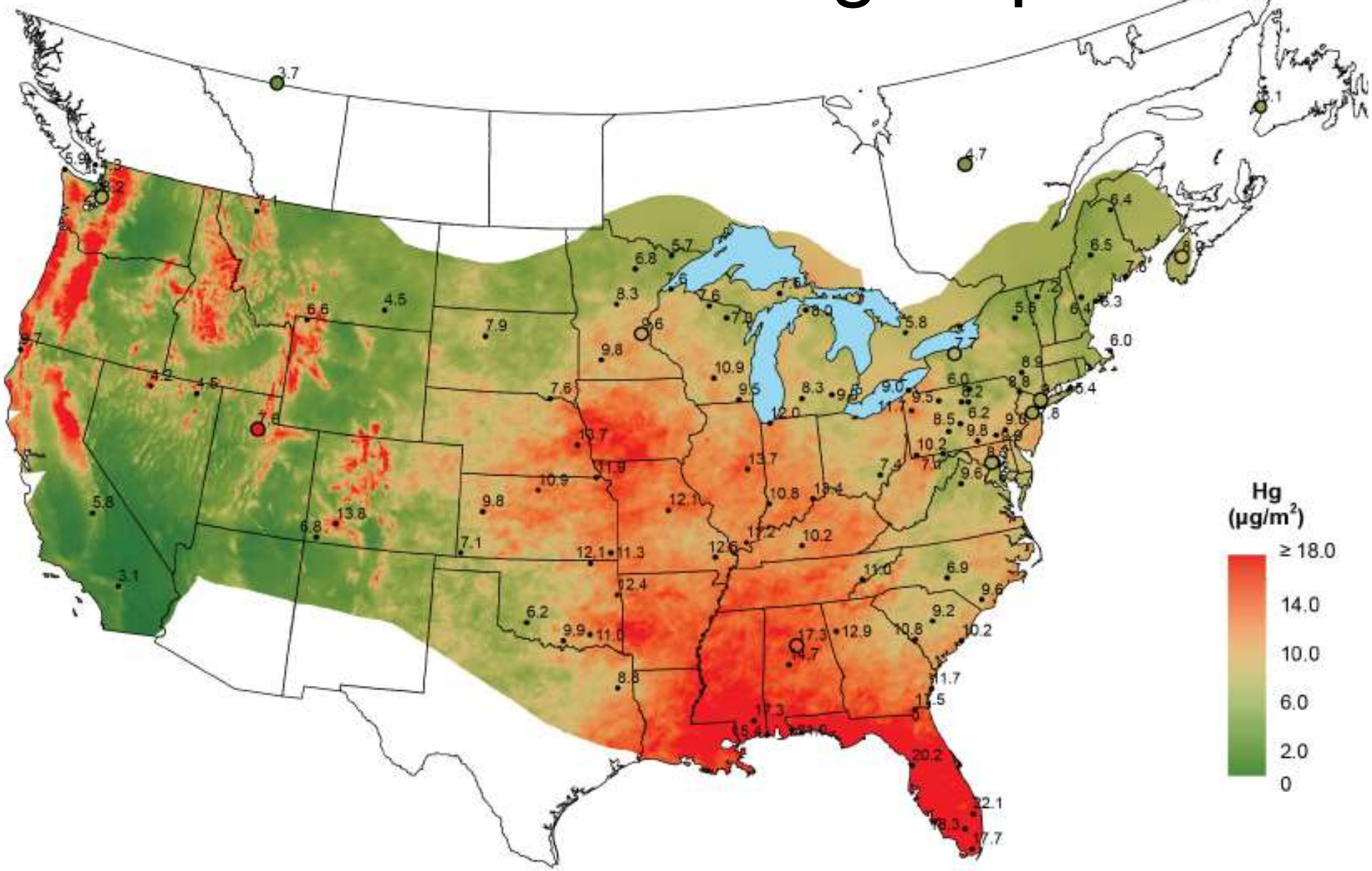


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

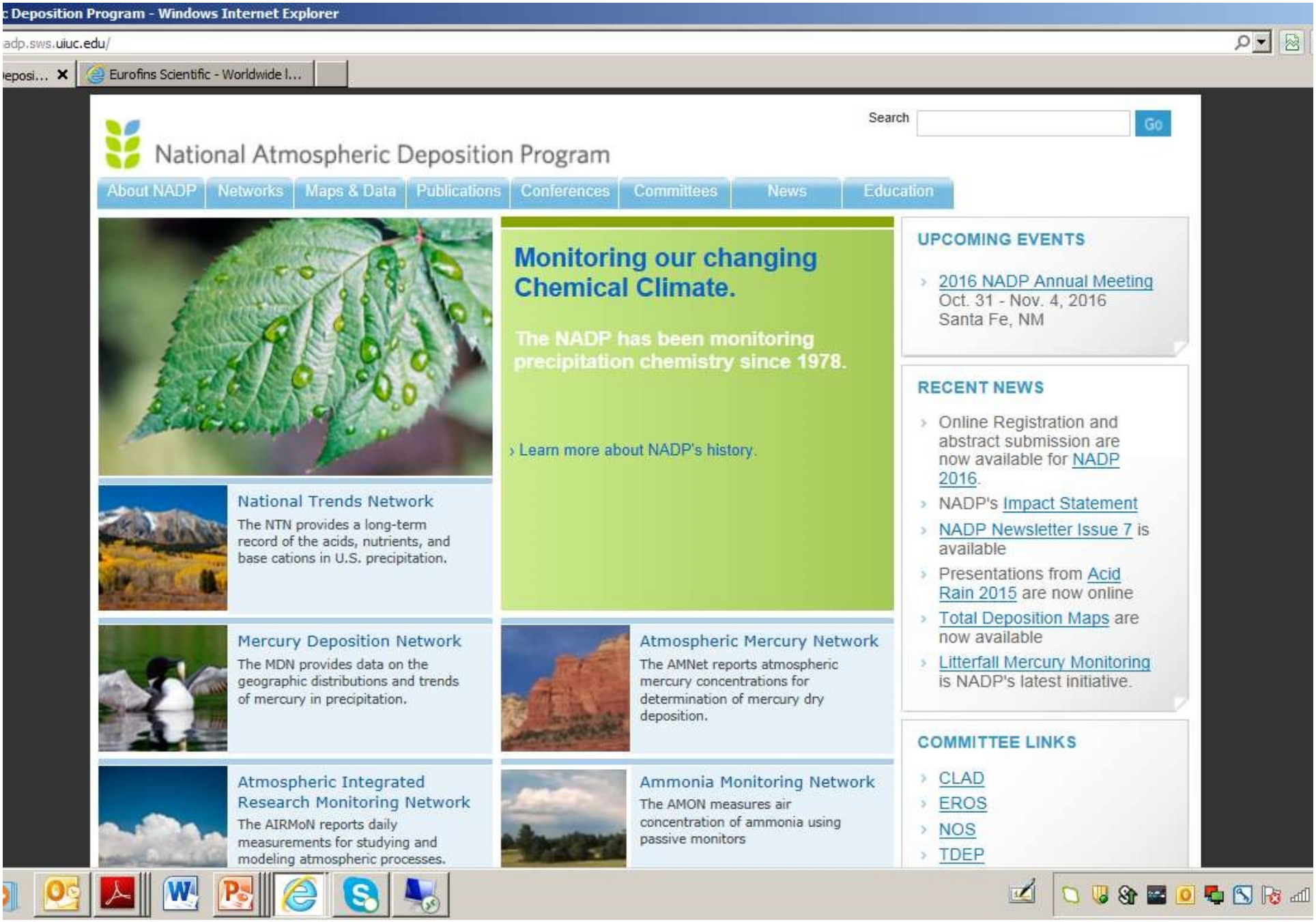
Annual 2014 MDN Hg Deposition



Use Of NADP Mercury Deposition Network For Measuring Potential Effect Of National (MATS) And Global (Minamata Protocol) Hg Reduction Regulations

National Atmospheric Deposition Program

- National Atmospheric Deposition Program
- Mercury Deposition Network
- 40-75% Of Hg Entering Water Bodies Likely Hg Deposition
- National And International Hg Regulations
  - EPA - Mercury Air Toxics Standard
  - UNEP - Minamata Convention On Mercury
- Hg Emissions Vs. Atmospheric Hg Deposition
- Role Of Mercury Deposition Network And Regulations
  - Measuring The Effect Of National/International Hg Regulations
  - Changes Could Happen Very Quickly Or Slowly Over Time
- **MDN 20 Yr Record Of Hg Deposition – Data Available Online**
- Potential For MDN To Measure Hg Deposition Trends


c Deposition Program - Windows Internet Explorer
adp.sws.uiuc.edu/
eposi...
Eurofins Scientific - Worldwide l...
Search
Go
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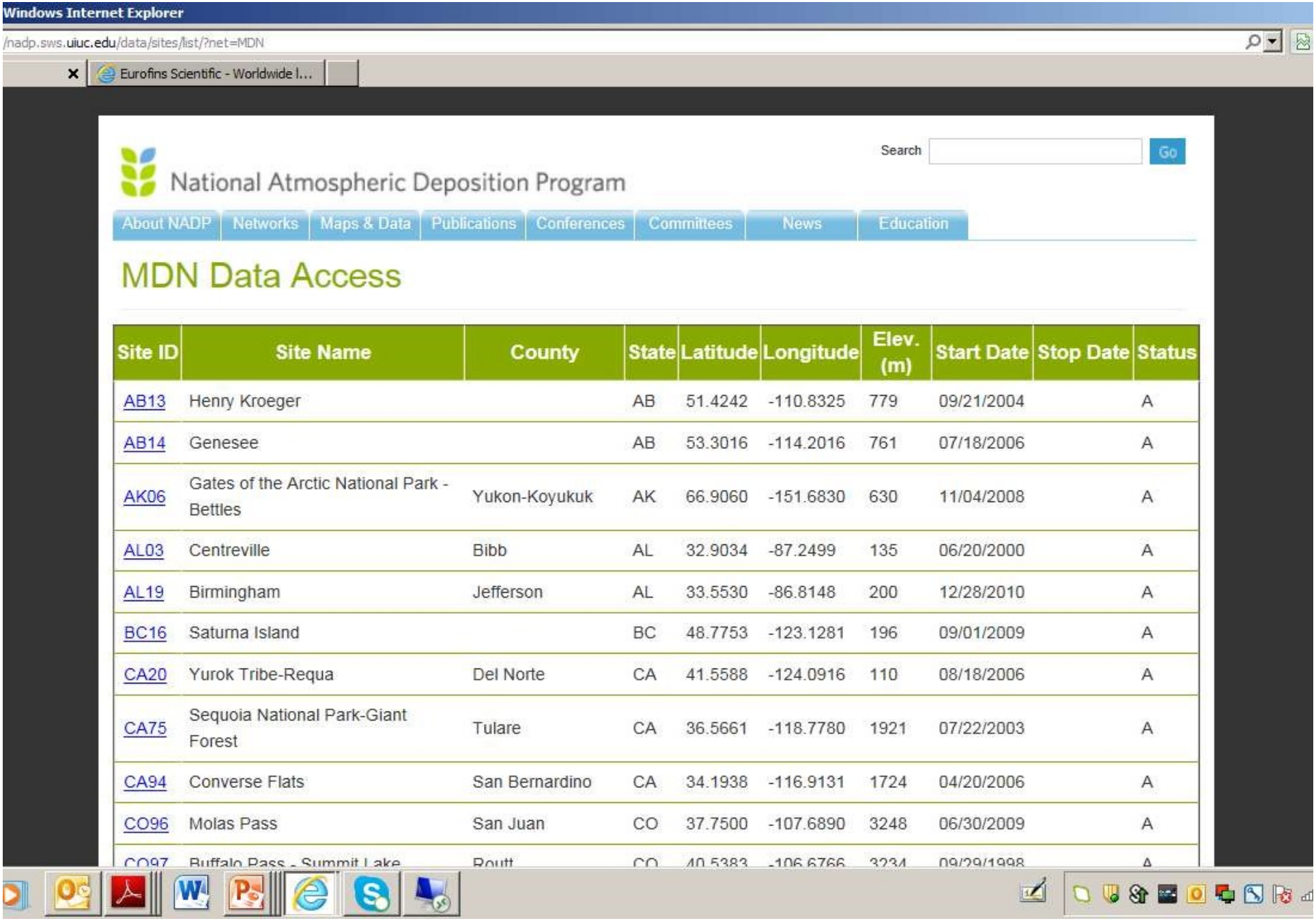
About NADP
Networks
Maps & Data
Publications
Conferences
Committees
News
Education
Monitoring our changing Chemical Climate.
The NADP has been monitoring precipitation chemistry since 1978.
› Learn more about NADP's history.
National Trends Network
The NTN provides a long-term record of the acids, nutrients, and base cations in U.S. precipitation.
Mercury Deposition Network
The MDN provides data on the geographic distributions and trends of mercury in precipitation.
Atmospheric Mercury Network
The AMNet reports atmospheric mercury concentrations for determination of mercury dry deposition.
Atmospheric Integrated Research Monitoring Network
The AIRMoN reports daily measurements for studying and modeling atmospheric processes.
Ammonia Monitoring Network
The AMON measures air concentration of ammonia using passive monitors
UPCOMING EVENTS
2016 NADP Annual Meeting
Oct. 31 - Nov. 4, 2016
Santa Fe, NM
RECENT NEWS
Online Registration and abstract submission are now available for NADP 2016.
NADP's Impact Statement
NADP Newsletter Issue 7 is available
Presentations from Acid Rain 2015 are now online
Total Deposition Maps are now available
Litterfall Mercury Monitoring is NADP's latest initiative.
COMMITTEE LINKS
CLAD
EROS
NOS
TDEP

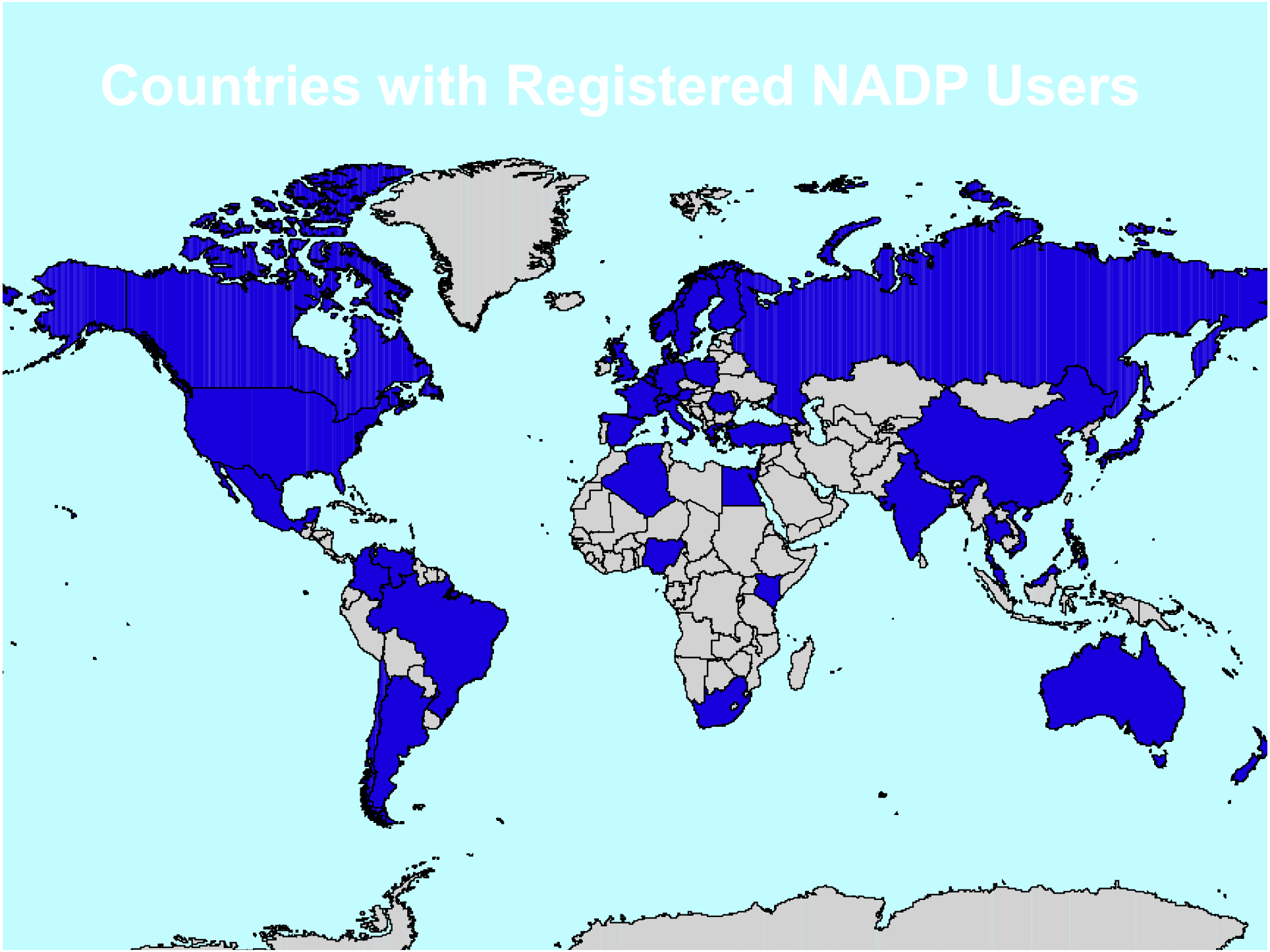


Site ID	Site Name	County	State	Latitude	Longitude	Elev. (m)	Start Date	Stop Date	Status
AB13	Henry Kroeger		AB	51.4242	-110.8325	779	09/21/2004		A
AB14	Genesee		AB	53.3016	-114.2016	761	07/18/2006		A
AK06	Gates of the Arctic National Park - Bettles	Yukon-Koyukuk	AK	66.9060	-151.6830	630	11/04/2008		A
AL03	Centreville	Bibb	AL	32.9034	-87.2499	135	06/20/2000		A
AL19	Birmingham	Jefferson	AL	33.5530	-86.8148	200	12/28/2010		A
BC16	Saturna Island		BC	48.7753	-123.1281	196	09/01/2009		A
CA20	Yurok Tribe-Requa	Del Norte	CA	41.5588	-124.0916	110	08/18/2006		A
CA75	Sequoia National Park-Giant Forest	Tulare	CA	36.5661	-118.7780	1921	07/22/2003		A
CA94	Converse Flats	San Bernardino	CA	34.1938	-116.9131	1724	04/20/2006		A
CO96	Molas Pass	San Juan	CO	37.7500	-107.6890	3248	06/30/2009		A
CO97	Buffalo Pass - Summit Lake	Routt	CO	40.5383	-106.6766	3234	09/29/1998		A

1996-2016 Mercury Deposition Network Data Available Online

- *Data Available To Anyone – Free Online*
- *http://nadp.sws.uiuc.edu/*
- *Largest, Longest Running, Standardized, Quality Assured, Peer Reviewed Data For North America*
- *Long Term Monitoring Key*
  - *Changes Could Happen Very Quickly After Hg Reductions OR*
  - *Change Could Happen Very Slowly Over Time*
  - *Without Long Term Monitoring, Increases And Decreases In Hg Deposition Could Be Missed*

Countries with Registered NADP Users



Use Of NADP Mercury Deposition Network For Measuring Potential Effect Of National (MATS) And Global (Minamata Protocol) Hg Reduction Regulations

- National Atmospheric Deposition Program
- Mercury Deposition Network
- 40-75% Of Hg Entering Water Bodies Likely Hg Deposition
- National And International Hg Regulations
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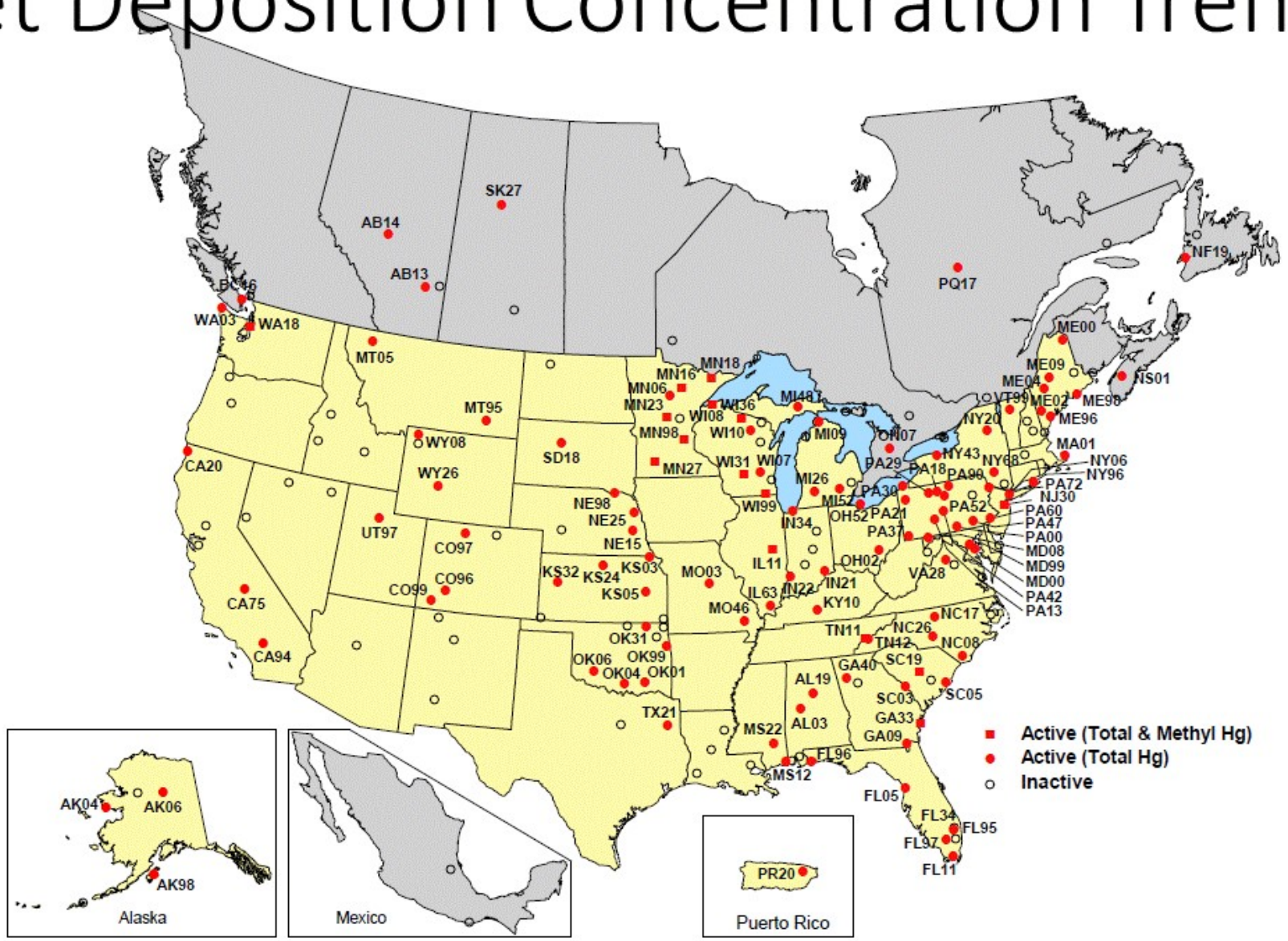
  - Measuring The Effect Of National/International Hg Regulations
  - Changes Could Happen Very Quickly Or Slowly Over Time
- MDN 20 Year Record Of Hg Deposition – Data Available Online
- **Potential For MDN To Measure Hg Deposition Trends**

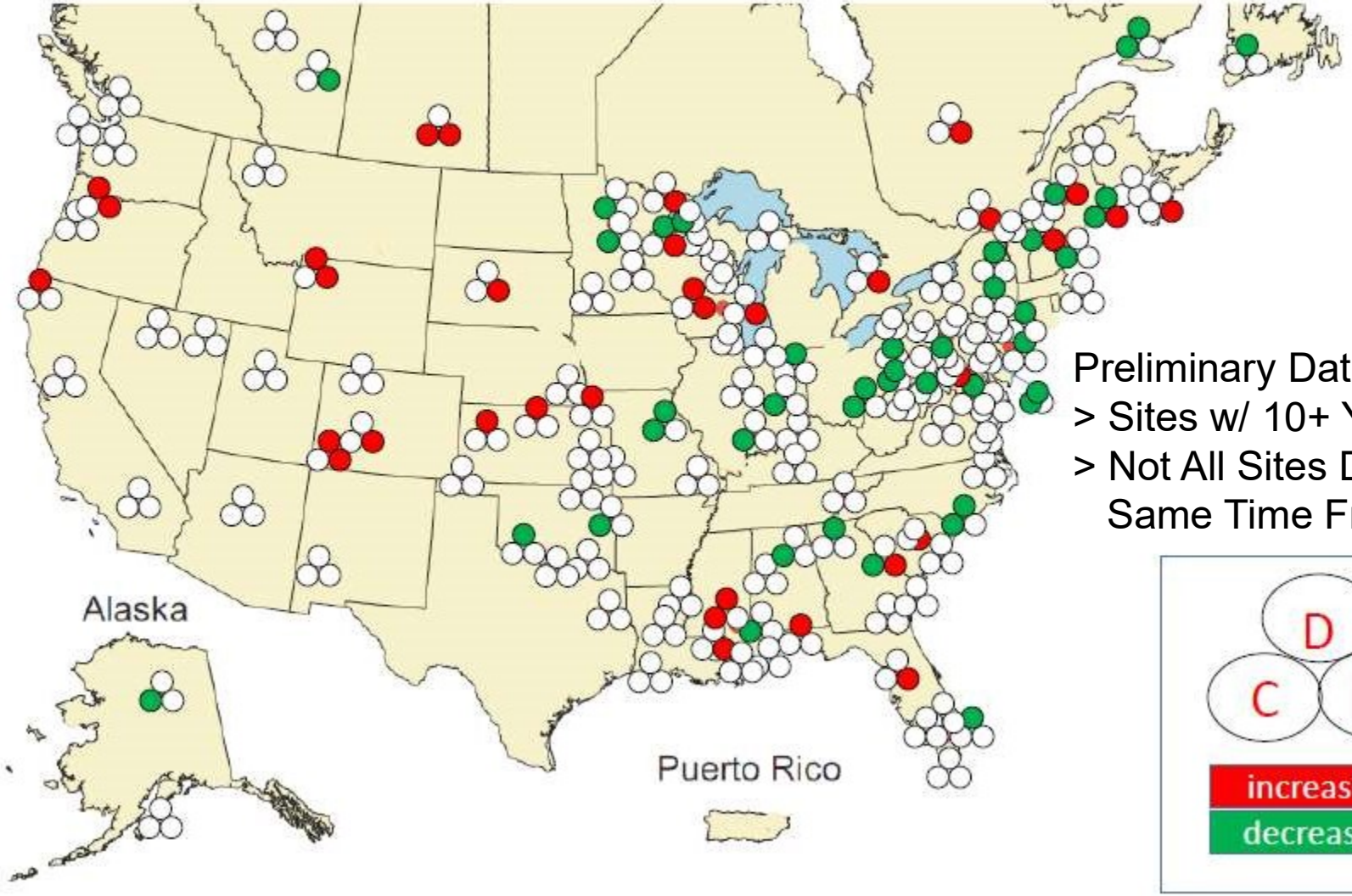
Wet Deposition Concentration Trends



MDN Wet Deposition Hg Trend Method (USGS)

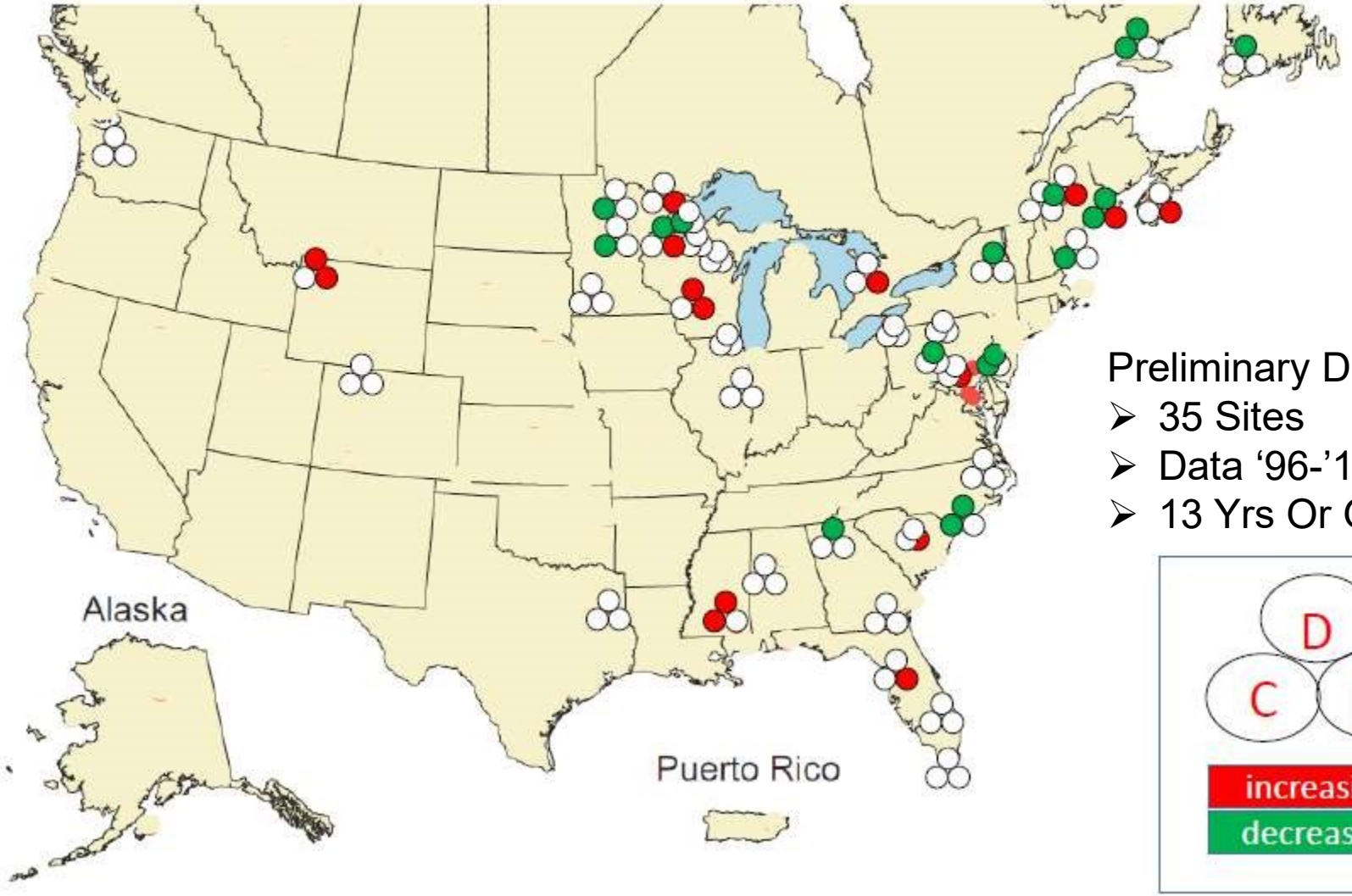
- Seasonal Kendall Test for Trends
- Seasonal Kendall Slope Estimator
  - From the “Mann Kendall” as extended by van Belle and Hughes, 1984
  - Non-parametric, normality not assumed
  - Allows for seasonality and multiple stations
  - Allows for missing data
  - From “Statistical Methods for Environmental Pollution Monitoring”, R. O. Gilbert, 1987
  - Examines differences over time
    - » Difference (obs1 – obs2) > 0, then =+1
    - » < 0, then =-1
    - » = 0, then = 0

Concentration, Precipitation & Deposition Trends (all available years, 1996-2015)



Preliminary Data
> Sites w/ 10+ Yrs
> Not All Sites Data Same Time Frame

Concentration, Precipitation & Deposition Trends (at least 160 months, 1996-2015)

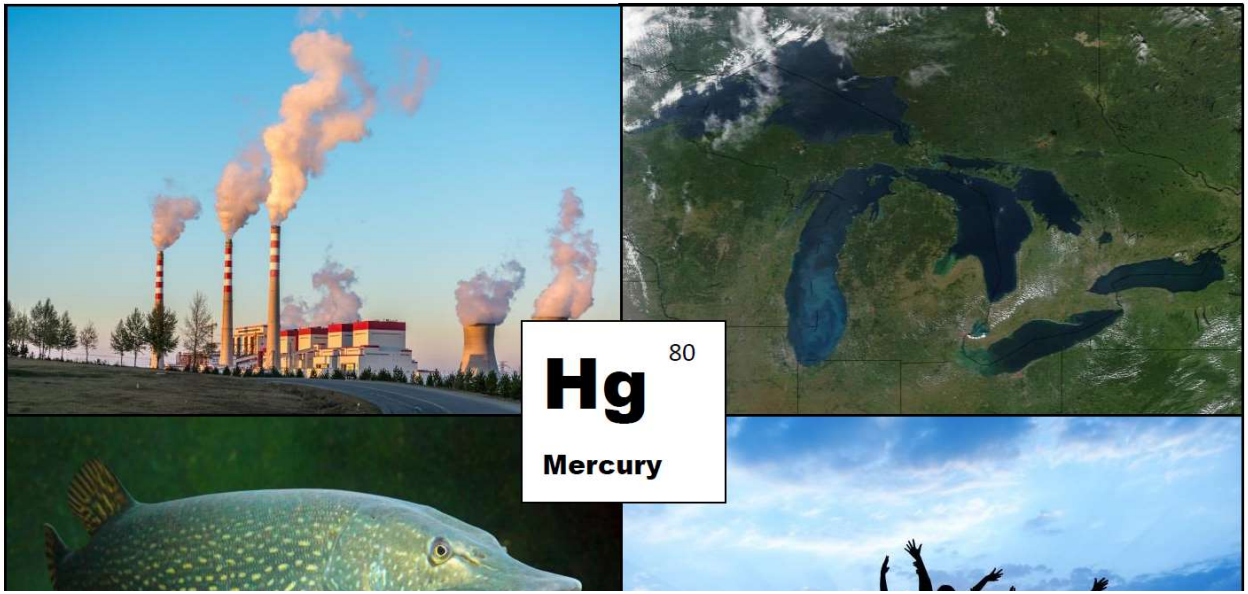


Preliminary Data

- 35 Sites
- Data '96-'15
- 13 Yrs Or Greater

International Joint Commission Report Dec 2015

ATMOSPHERIC DEPOSITION OF MERCURY IN THE GREAT LAKES BASIN



International Joint Commission
Canada and United States

Commission mixte international
Canada et États-Unis

International Joint Commission Report Dec 2015

ATMOSPHERIC DEPOSITION OF MERCURY IN THE GREAT LAKES BASIN

- Canada and US Commission to advise on matters related “research and monitoring of the Waters of the Great Lakes, including specific research and monitoring priorities
- The Commission “wishes to underscore the need for continued vigilance regarding mercury in the Great Lakes Basin
- “…requires recognition of the important role of out-of-Basin and Global air transport….
- Monitoring mercury pollution in light of persistent mercury contamination of Great Lakes Fish, **particularly as concern rises that emissions outside of the US and Canada could, through long-range atmospheric transport diminish or offset progress made by the two nations in reducing domestic emissions**.

International Joint Commission Report Dec 2015

ATMOSPHERIC DEPOSITION OF MERCURY IN THE GREAT LAKES BASIN

Join Commission Report Recommendation

- The Great Lakes region lacks an adequately and sustainably-funded, geographically diverse and consistently maintained mercury atmospheric deposition monitoring network
- **Recommends the governments increase and provide sustainable funding for an optimized binational monitoring network to track atmospheric deposition of mercury in the great lakes basin.**
- Optimal Great Lakes mercury monitoring network would consist of at least 21 stations (around US and Canada – around the Great Lakes)
- **These sites would be maintained with consistent funding over long periods of time enabling standardization of data and analysis of temporal trends**

International Joint Commission
Canada and United States

Commission mixte internationale
Canada et États-Unis

National Atmospheric Deposition Program

Mercury Disposition Network

- The Longest Running Hg Deposition Network
- Standardized and Peer Reviewed
- Easy To Join And Turn Key (Equipment, Training)
- Now National and International Drivers For Monitoring
- Needs Better Site Coverage In Order To Help Determine
  - Are We Seeing Hg Reductions In Can/US – MATS?
  - Are We Seeing Global Hg Inc/Dec – Minamata?

Use Of NADP Mercury Deposition Network For Measuring Potential Effect Of National (MATS) And Global (Minamata Protocol) Hg Reduction Regulation

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