Network Measurements in the US National Atmospheric Deposition Program and the WMO Global Atmosphere Watch

Richard S. Artz
NOAA Air Resources Laboratory
College Park, Maryland, USA

July 17, 2013

National Atmospheric Deposition Program

World Meteorological Organization
Weather • Climate • Water

GAW

Atmospheric Deposition

Atmospheric deposition remains a major environmental issue in several parts of the world due to concerns over:

- acid deposition
- eutrophication
- trace metal deposition
- ecosystem health
- biogeochemical cycling
- global climate change

In more recent years, concerns have expanded from wet deposition alone to include such considerations as:

- air concentrations
- dry deposition and surface-air exchange
- estimation of total deposition

Project Background

- Understanding of major chemical constituents in precipitation the US and Europe dates back to approximately 1955. ARL involvement began approximately in 1970 with the first continuous monitoring program.

- ARL presently manages about 10 major ion precipitation chemistry stations as a contribution to the US National Atmospheric Deposition Program. ARL mercury measurements are also tied to NADP.

- NOAA/ARL has chaired NADP on several occasions and is a key member of the Executive and Budget Steering Committees. Other major agencies include USGS, EPA, and NPS.

- ARL has contributed leadership to the World Meteorological Organization under several programs beginning with the Background Air Pollution Monitoring Program in the 1970s and currently chairs the WMO Global Atmosphere Watch Science Advisory Group for Precipitation Chemistry.

- The key focus of our activities has been to ensure that data of high and known quality are properly quality assured, archived, and made available to the research community.

- Current activities focus on maintaining current operational functions, outreach to under-sampled regions of the globe, and application of products.

National Atmospheric Deposition Program

- National Trends Network

  NTN provides a long-term record of the acids, nutrients, and base cations in U.S. precipitation.
- Atmospheric Integrated Research Monitoring Network

  AIRMoN reports daily measurements for studying and modeling atmospheric processes
- Mercury Deposition Network

  MDN measures total mercury in precipitation
- Atmospheric Mercury Network

  The AMNet reports atmospheric concentrations for determination of mercury dry deposition
- Ammonia Monitoring Network

  The AMON measures air concentrations of ammonia using passive monitors

NADP has added subnetworks as new issues have surfaced that could not be met using existing methods.

NADP Operating Philosophy

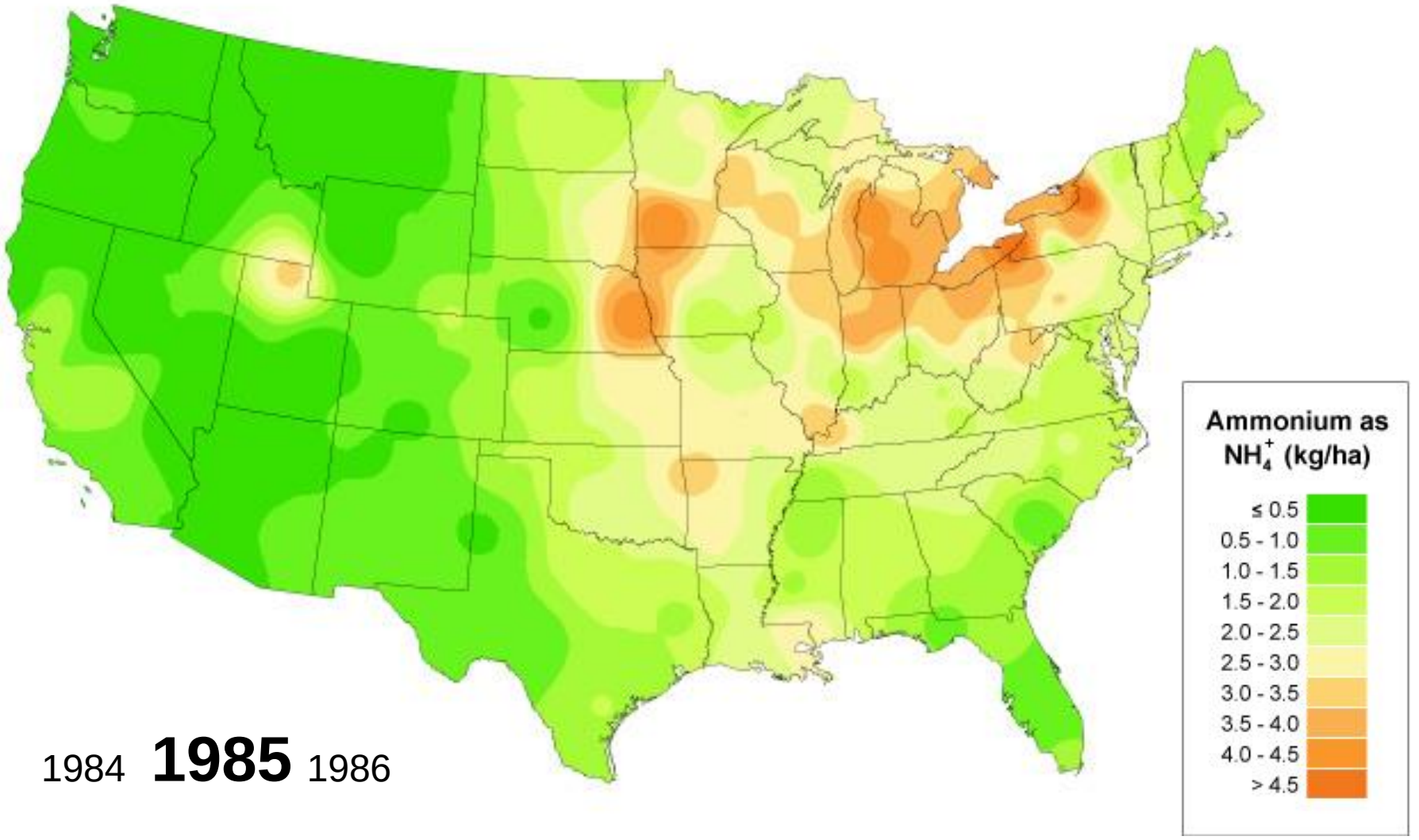
- Minimize uncertainty
  - Common siting protocols
  - Common field measurement protocols
  - Well established laboratory protocols
  - Limited set of approved field hardware
  - One central laboratory serving many sites
  - Established quality assurance/quality control protocols
  - Routine auditing
- Share all data
  - Available online
  - Easy to download
  - Proper attribution

NADP Operating Philosophy -- continued

- Data analysis and publications
  - Make common maps available online as budget permit
  - Focus on network operations, not publications, aside from network manuals and procedures
- Network philosophy
  - Data are worth more in aggregate than from single stations
  - Data must be of high, known, and uniform quality.
  - Avoidance of political discussions. Multiple agendas served
  - Focus on data collection and reporting
  - Encourage publications from contributing organizations and from anyone else who wants to use this information

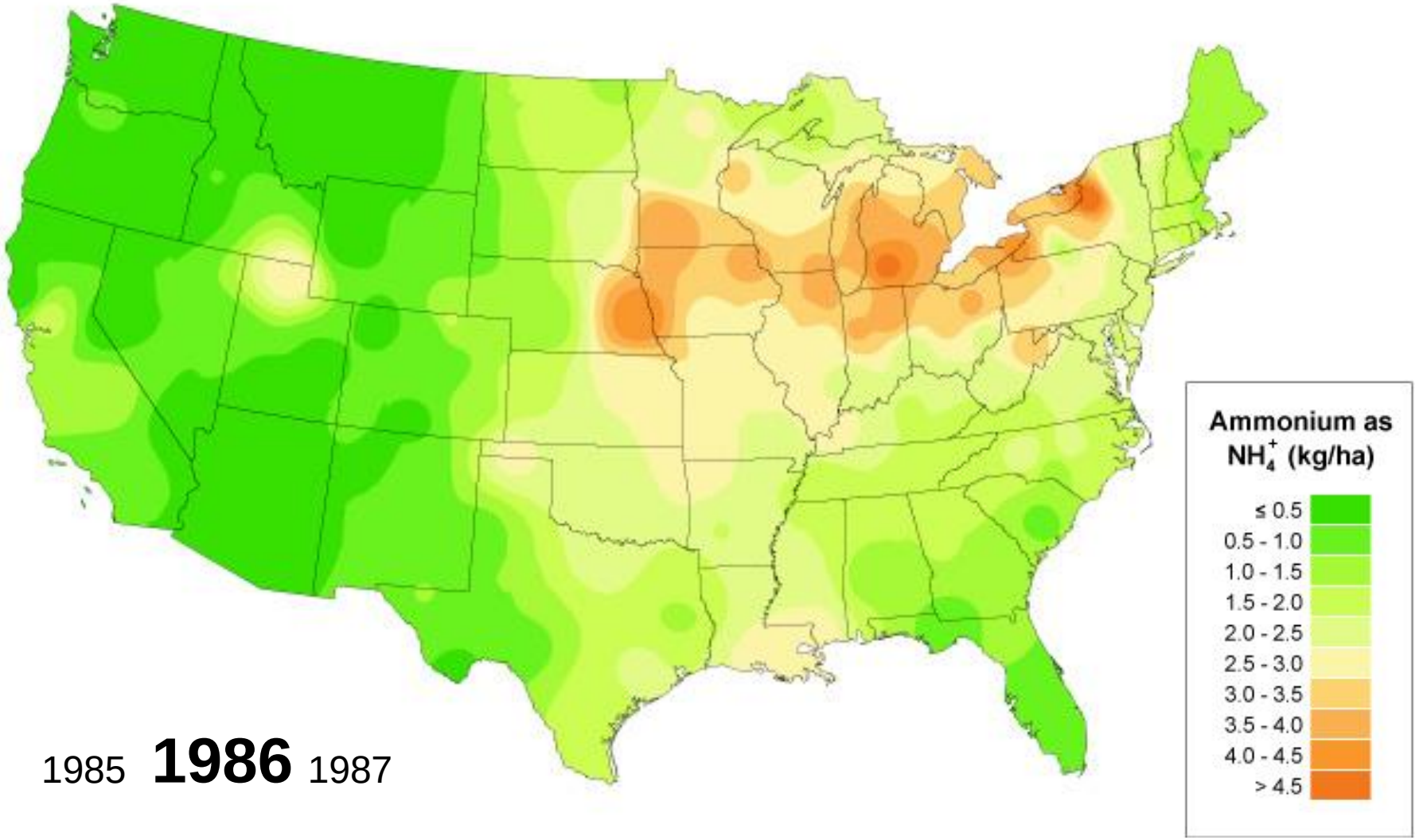
Product Example #1:
Ammonium Deposition in U.S. Precipitation

Ammonium Ion Wet Deposition 1985-2008



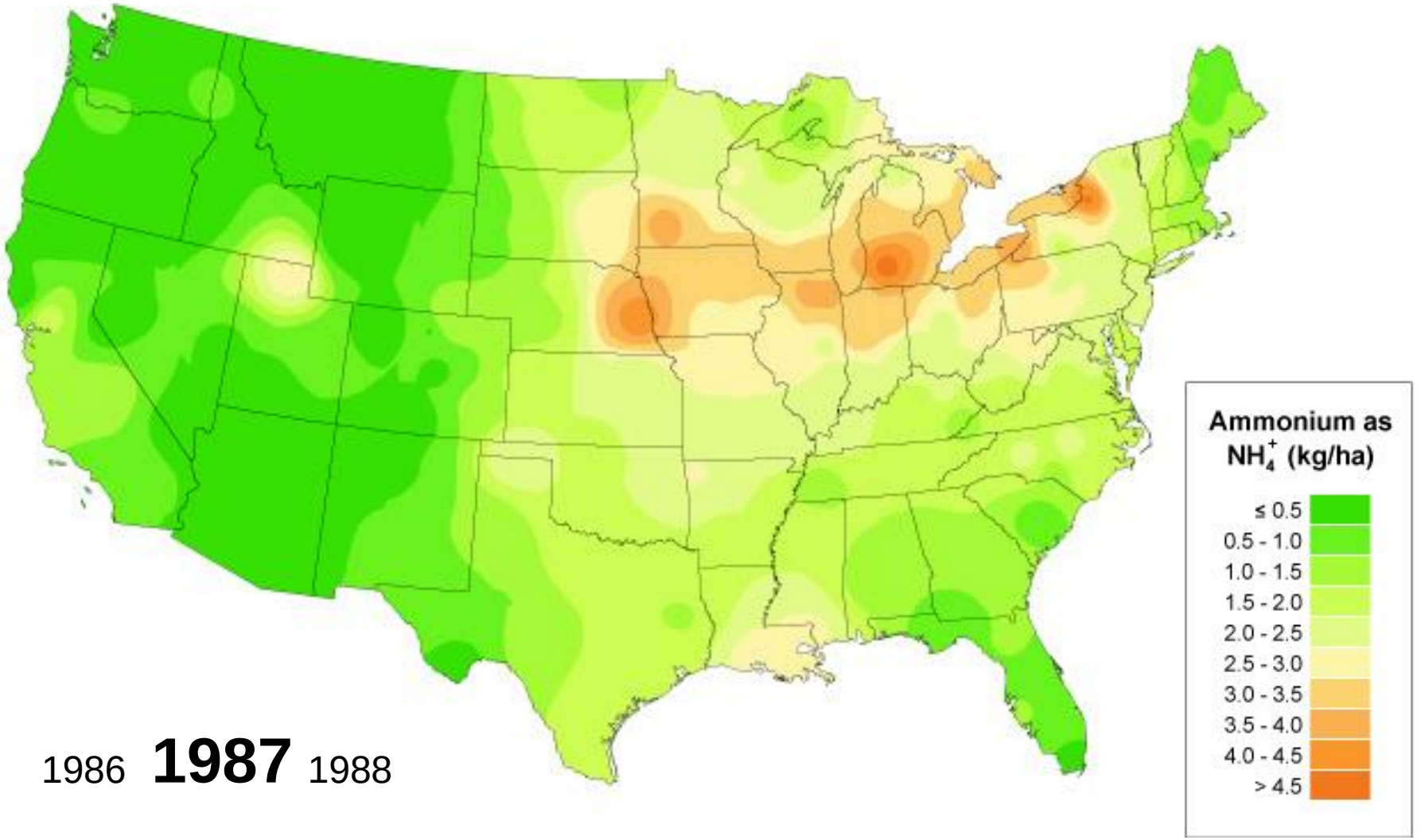
1984 **1985** 1986

Ammonium Ion Wet Deposition 1985-2008



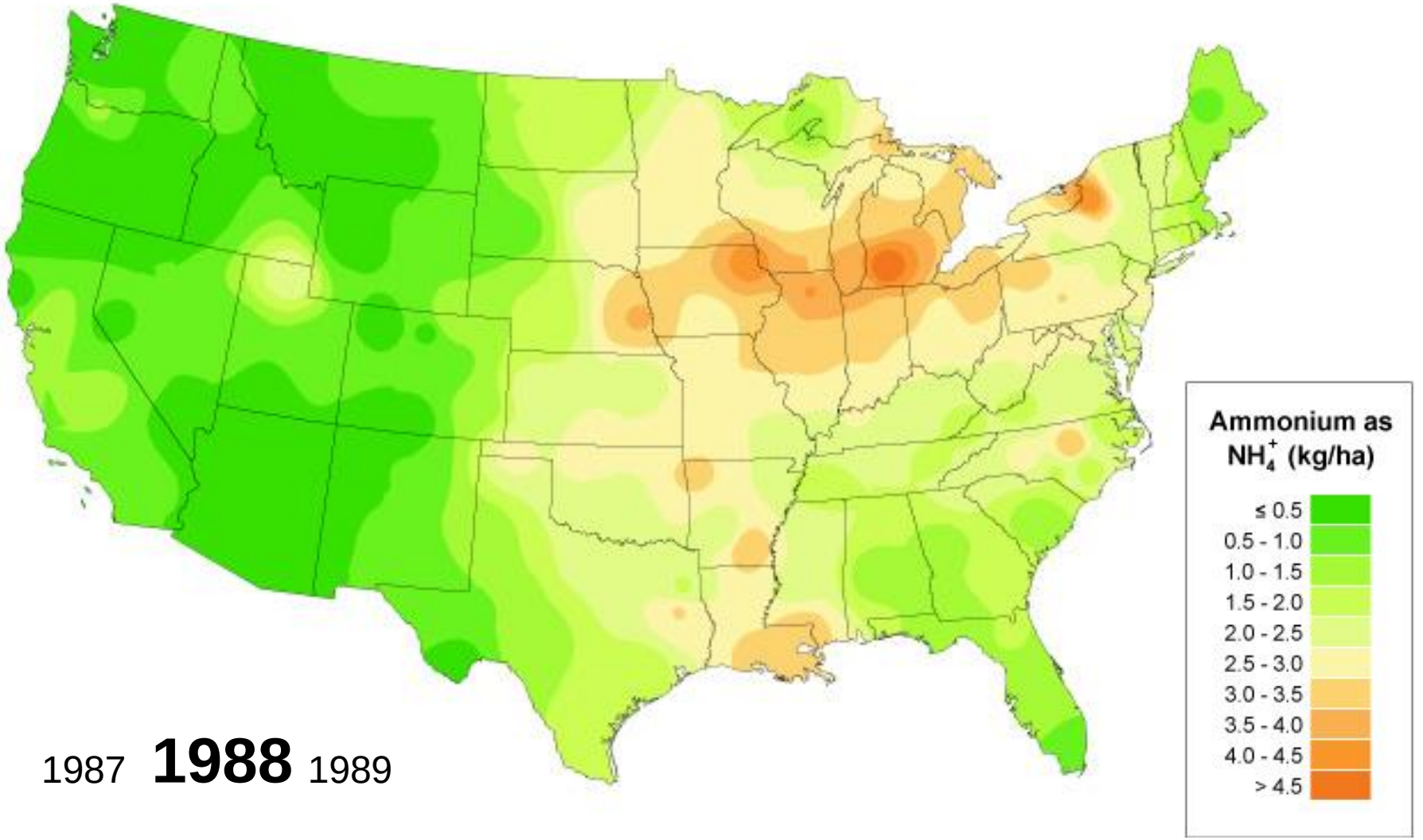
1985 **1986** 1987

Ammonium Ion Wet Deposition 1985-2008



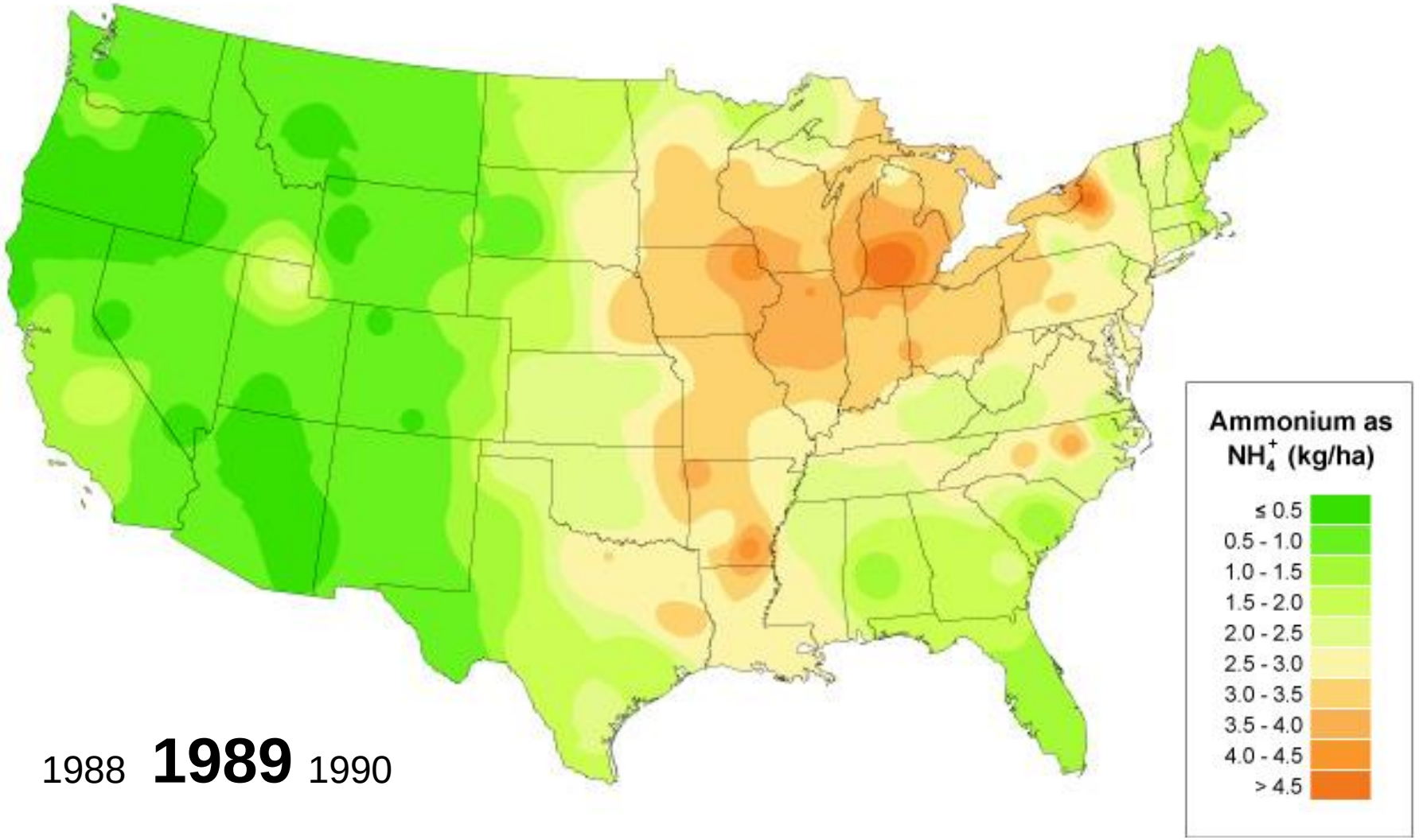
1986 **1987** 1988

Ammonium Ion Wet Deposition 1985-2008



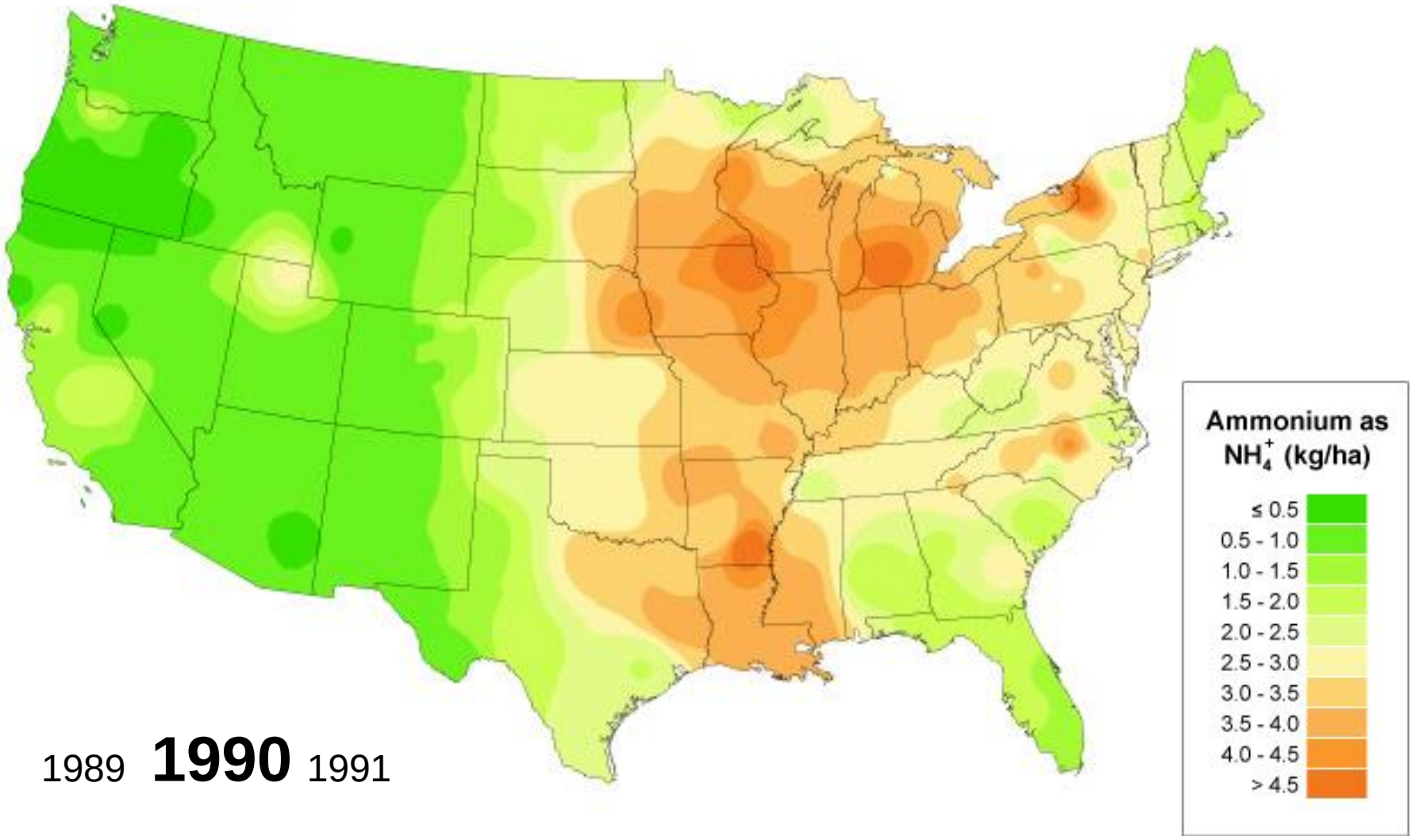
1987 **1988** 1989

Ammonium Ion Wet Deposition 1985-2008



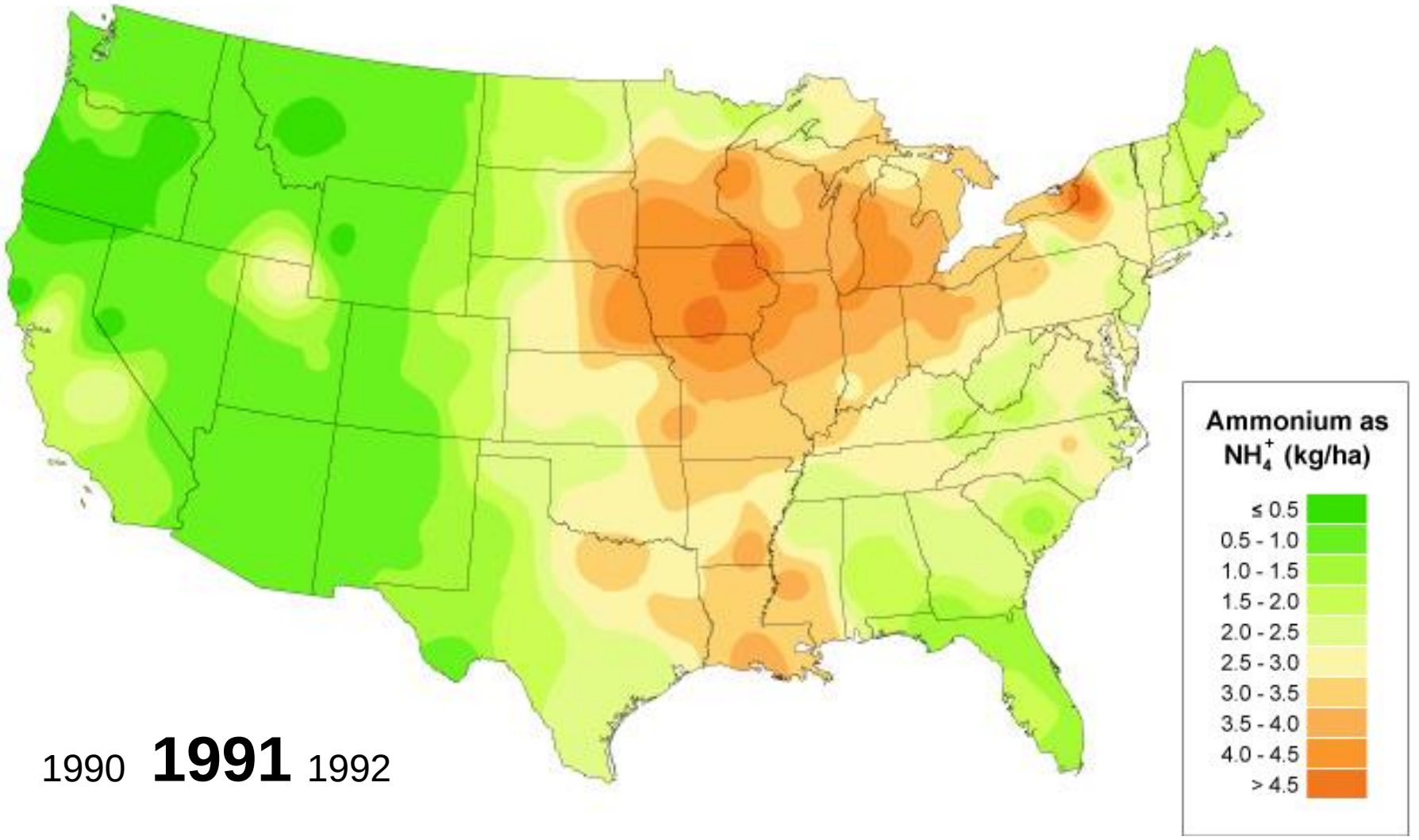
1988 **1989** 1990

Ammonium Ion Wet Deposition 1985-2008



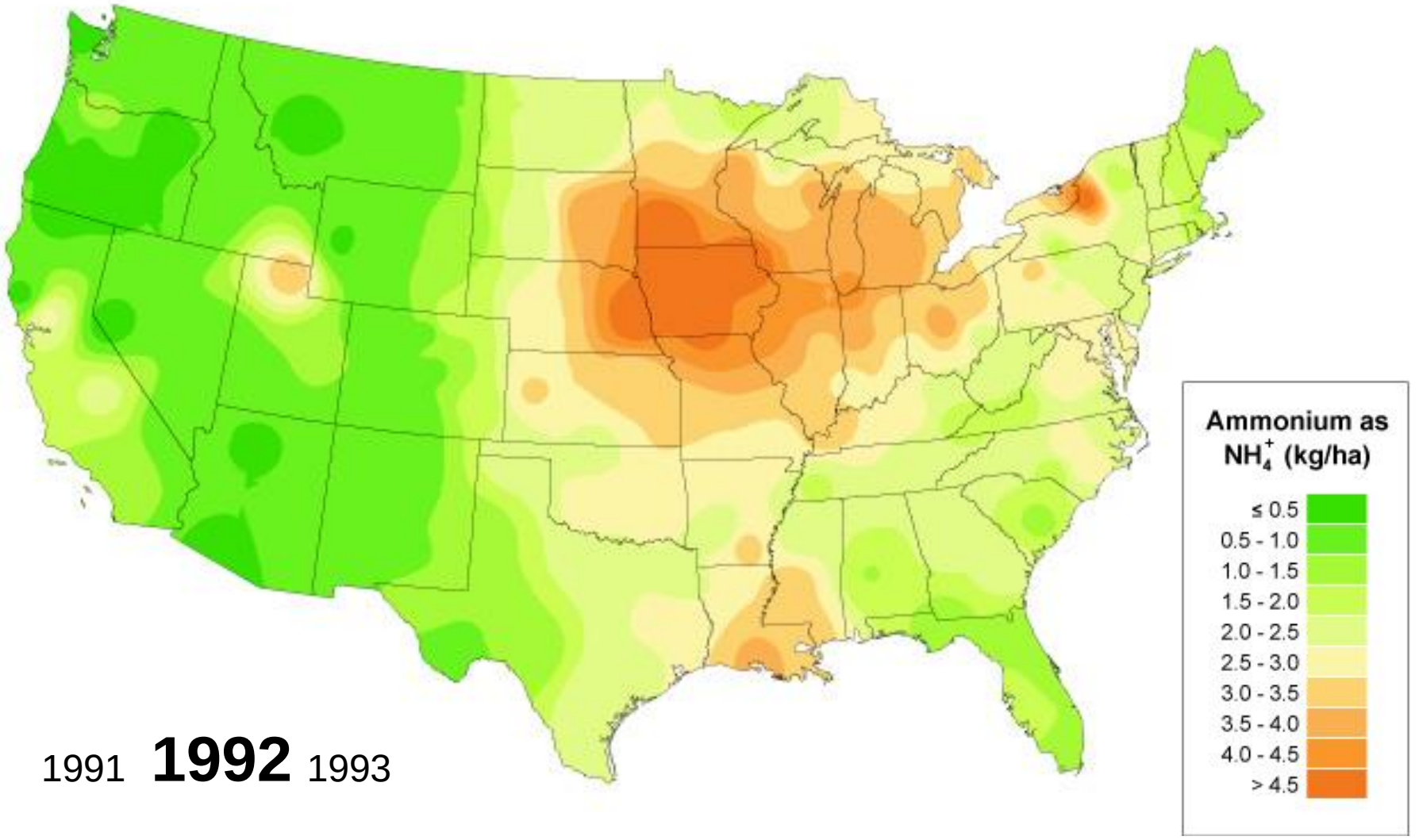
1989 **1990** 1991

Ammonium Ion Wet Deposition 1985-2008



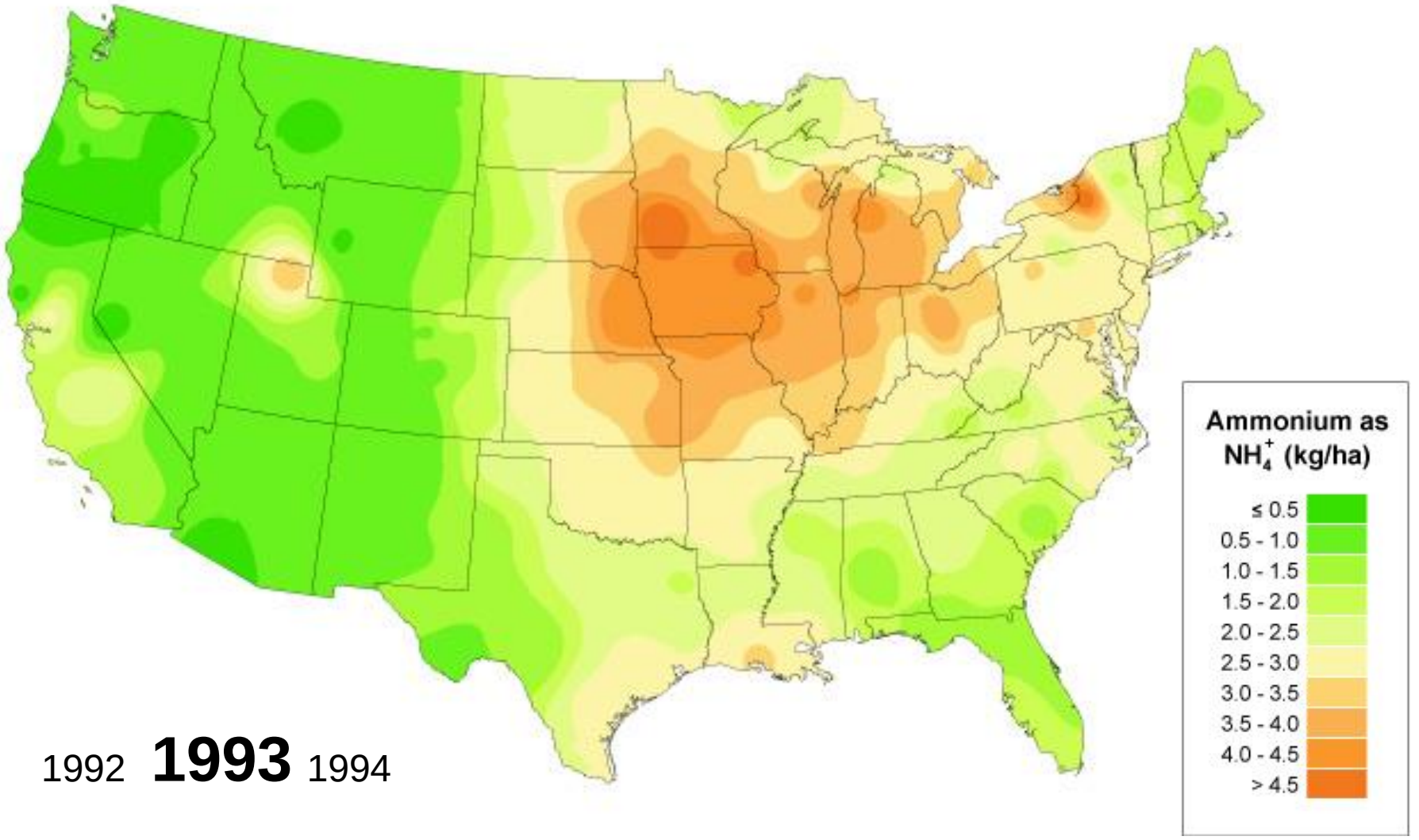
1990 **1991** 1992

Ammonium Ion Wet Deposition 1985-2008



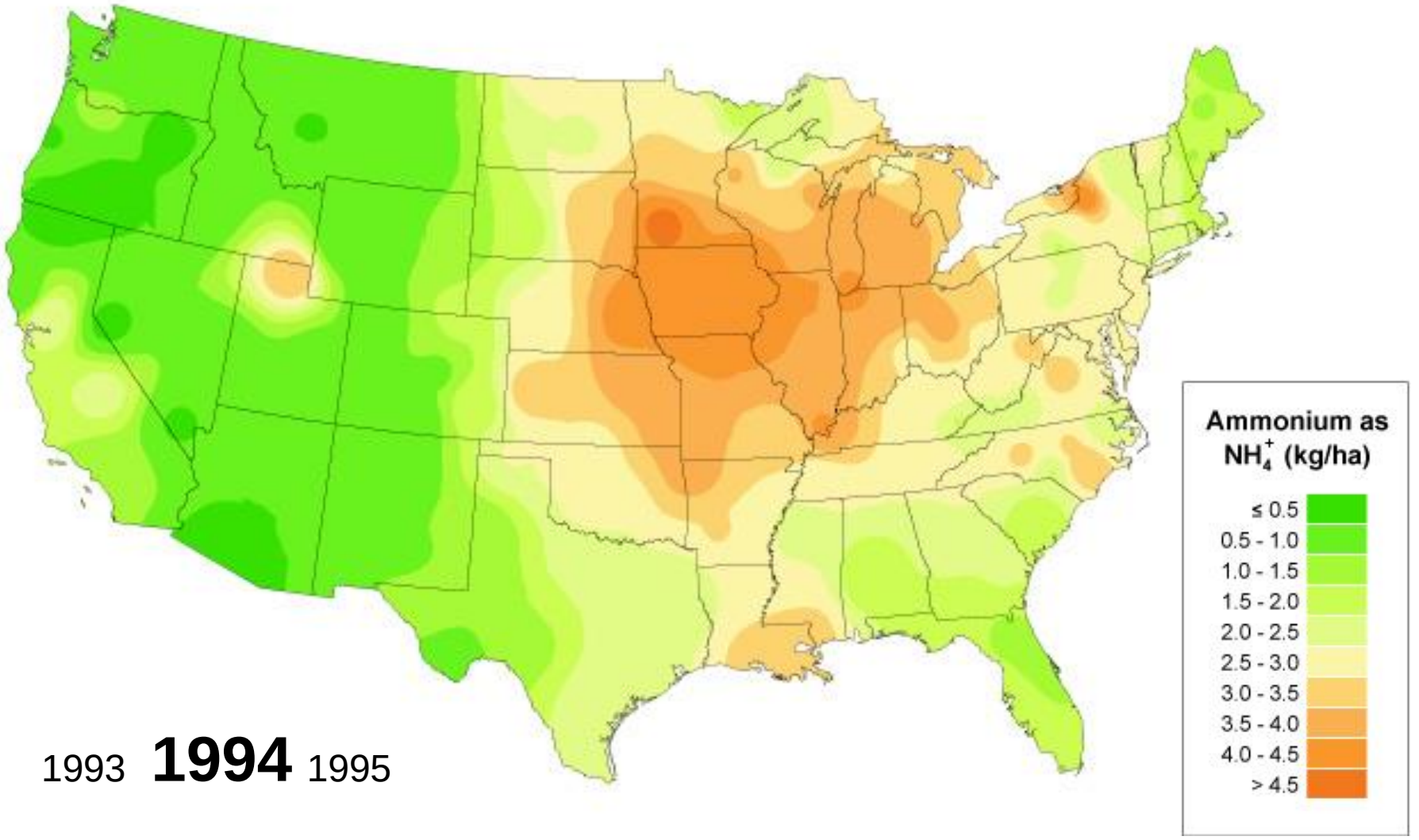
1991 **1992** 1993

Ammonium Ion Wet Deposition 1985-2008



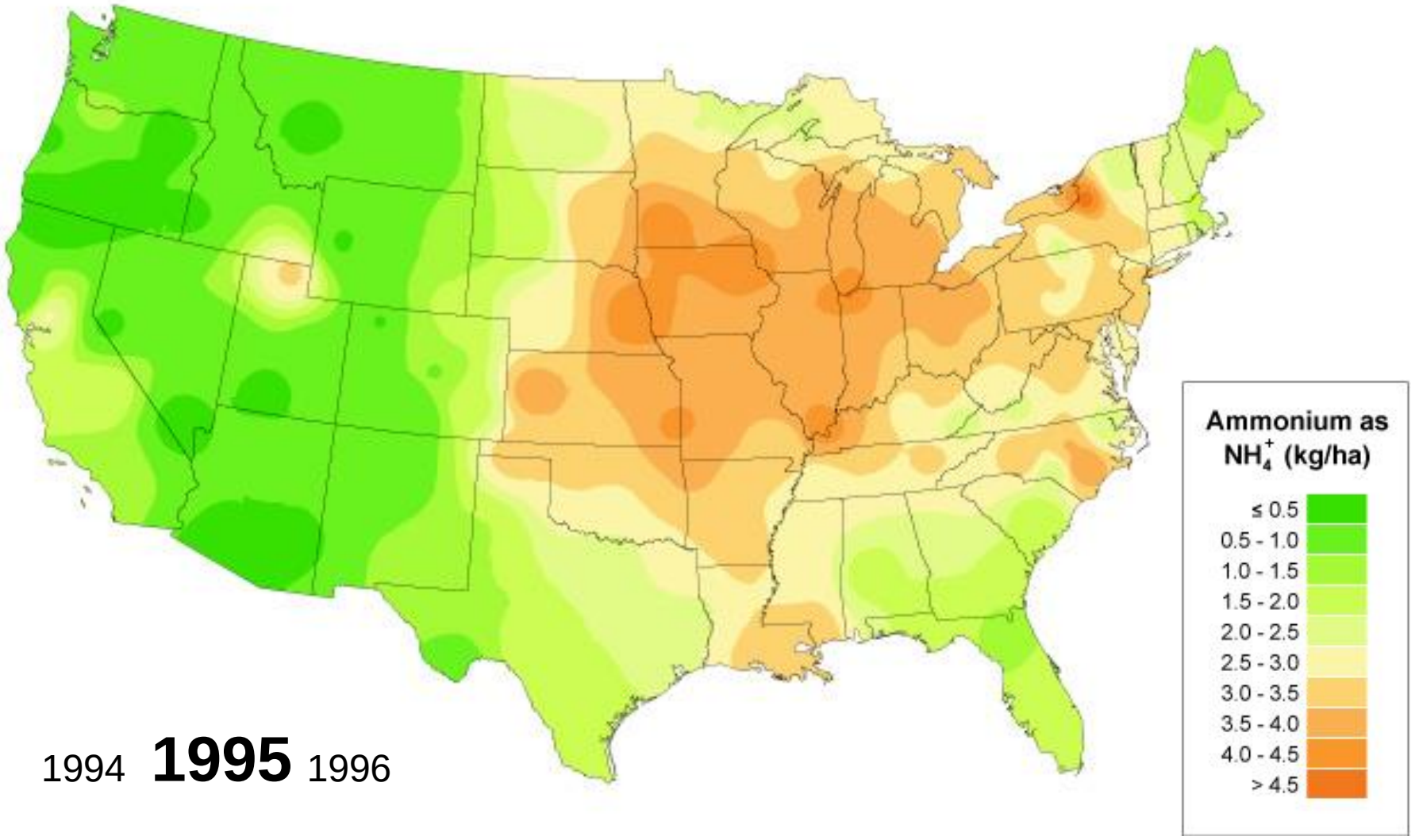
1992 **1993** 1994

Ammonium Ion Wet Deposition 1985-2008



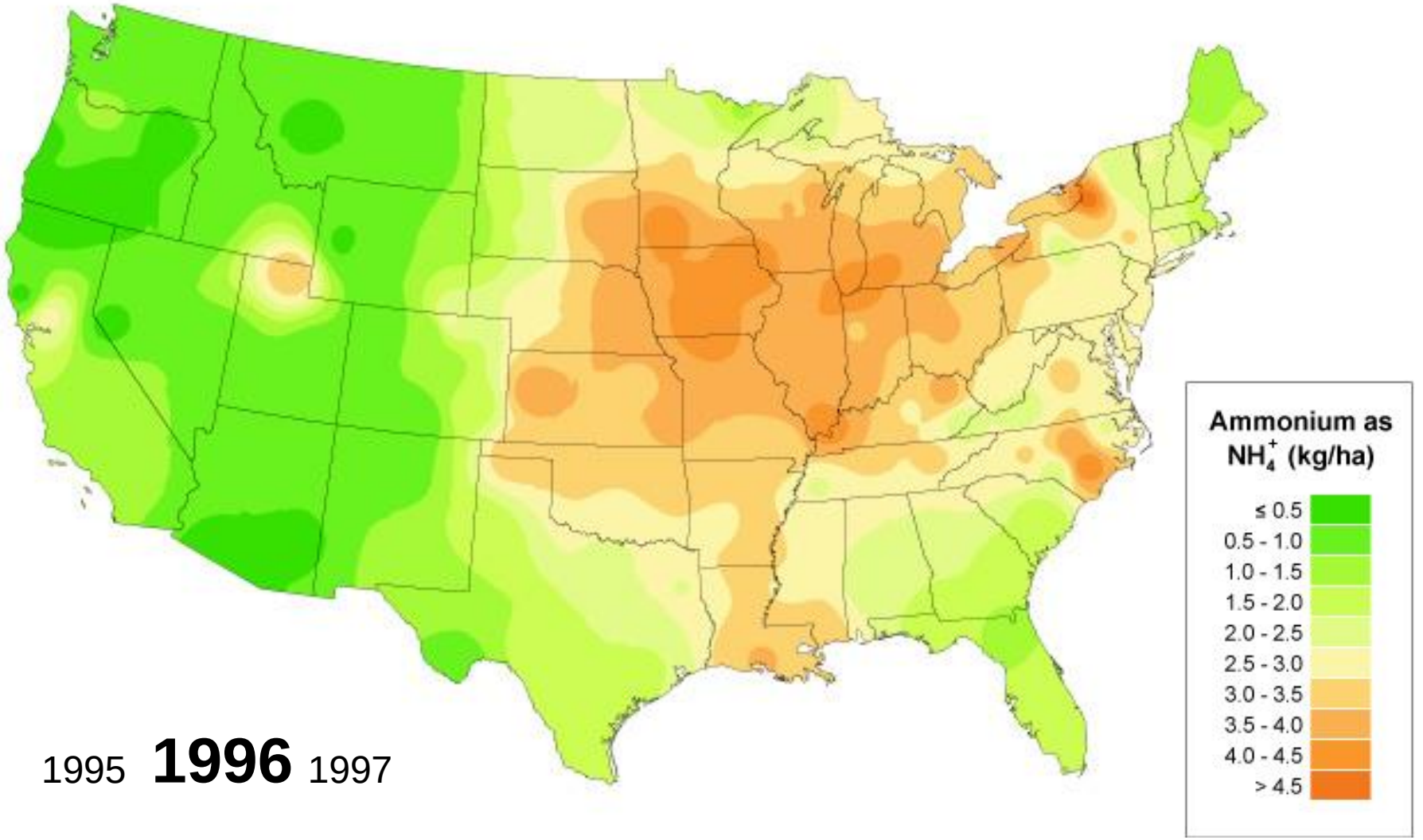
1993 **1994** 1995

Ammonium Ion Wet Deposition 1985-2008



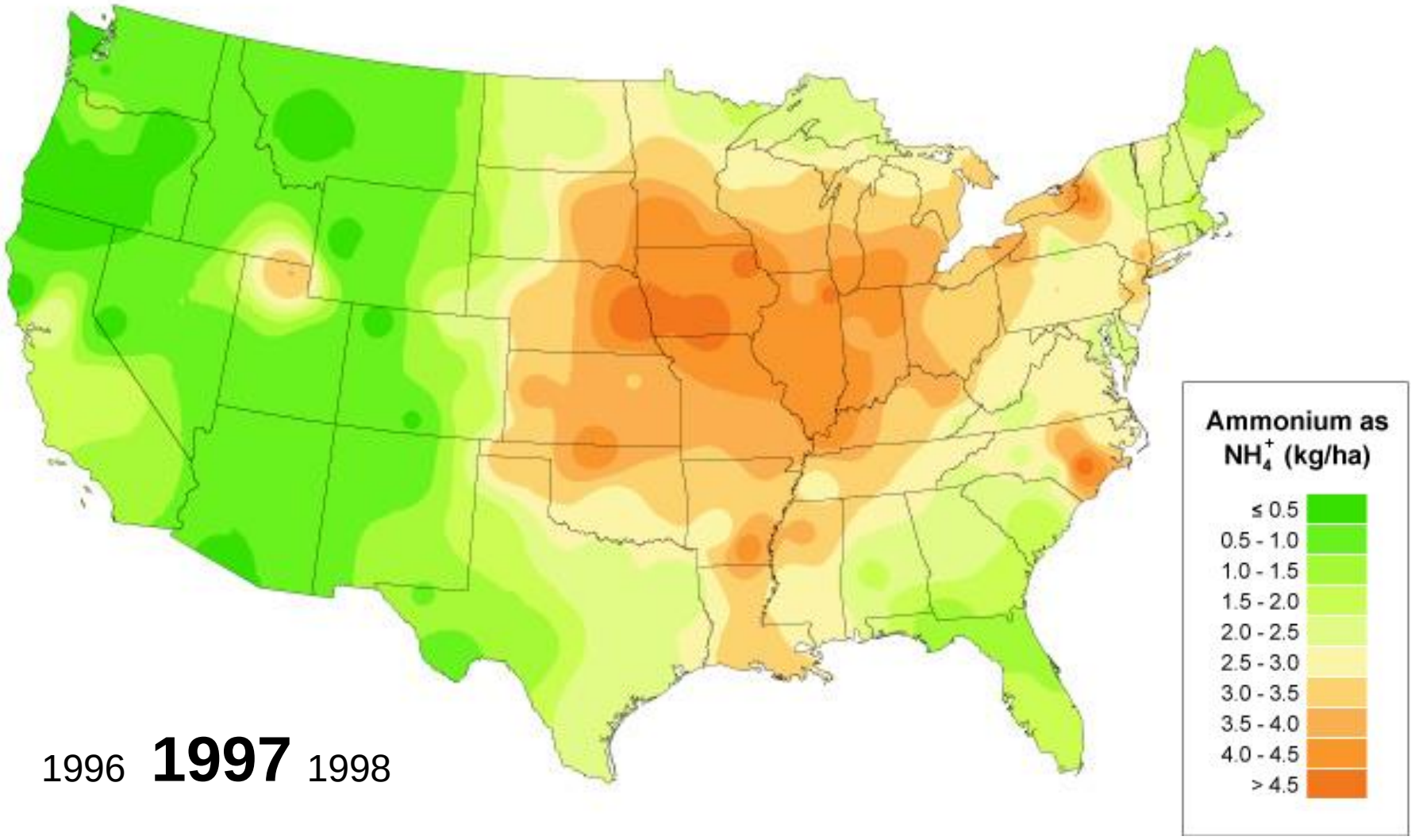
1994 **1995** 1996

Ammonium Ion Wet Deposition 1985-2008



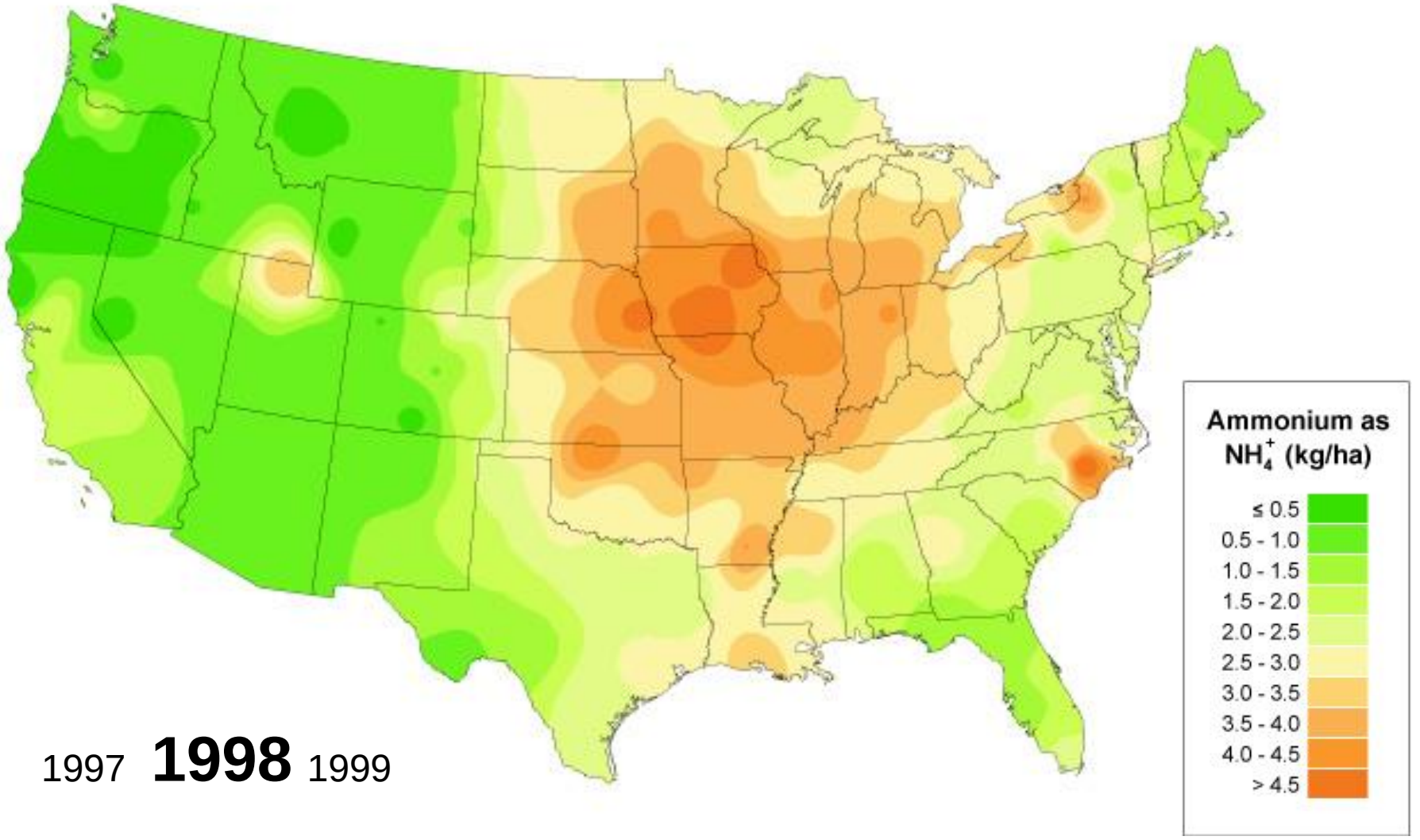
1995 **1996** 1997

Ammonium Ion Wet Deposition 1985-2008



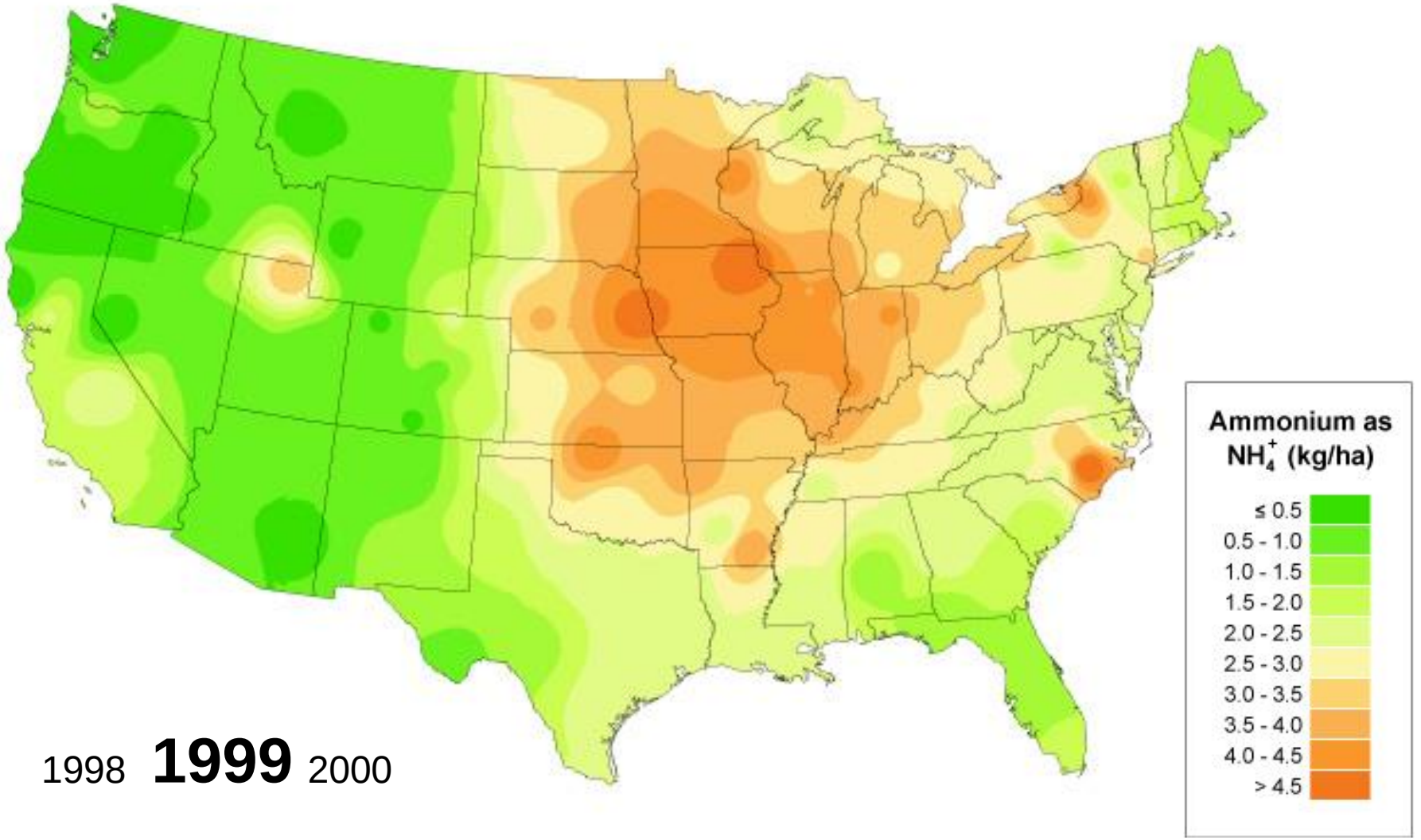
1996 **1997** 1998

Ammonium Ion Wet Deposition 1985-2008



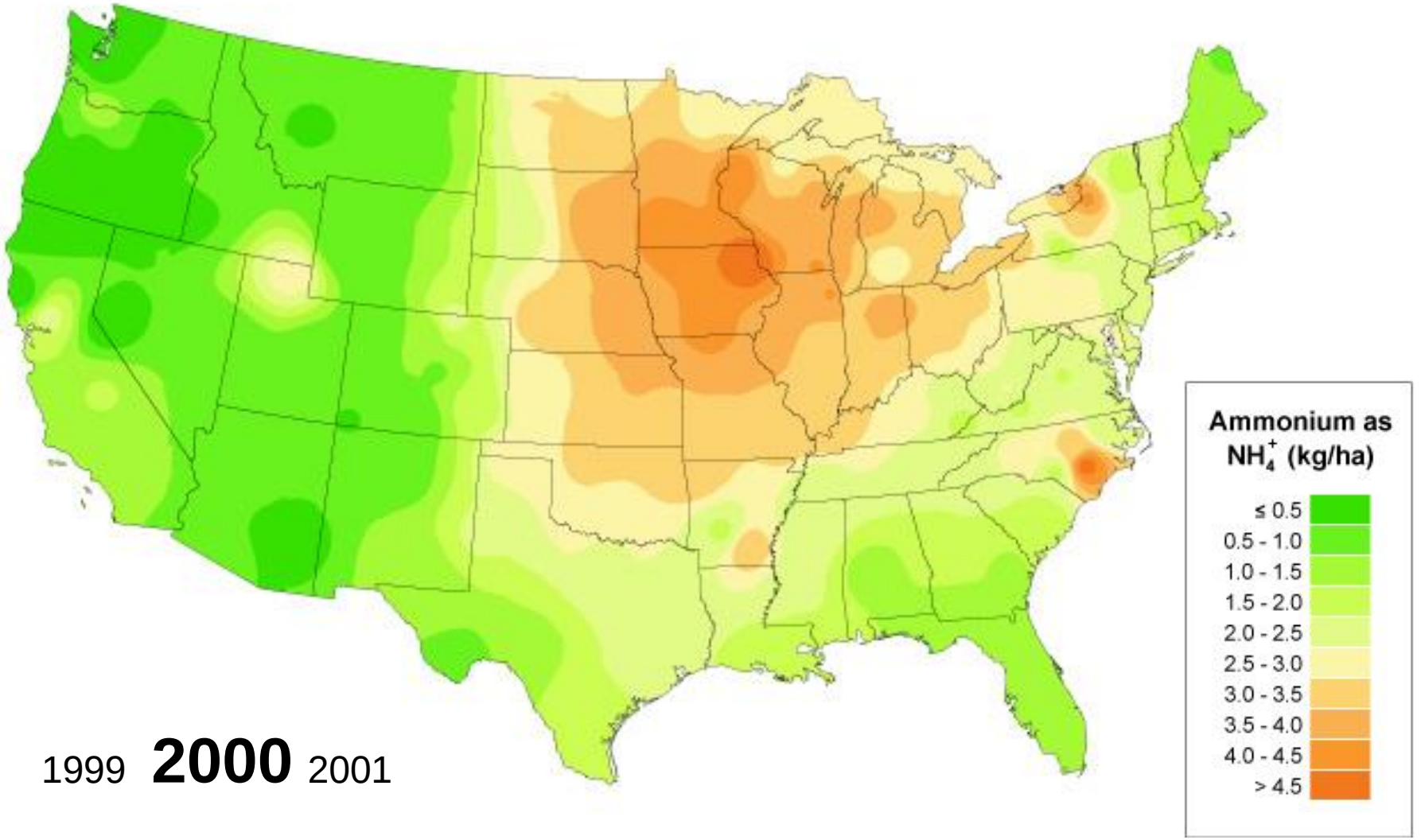
1997 **1998** 1999

Ammonium Ion Wet Deposition 1985-2008



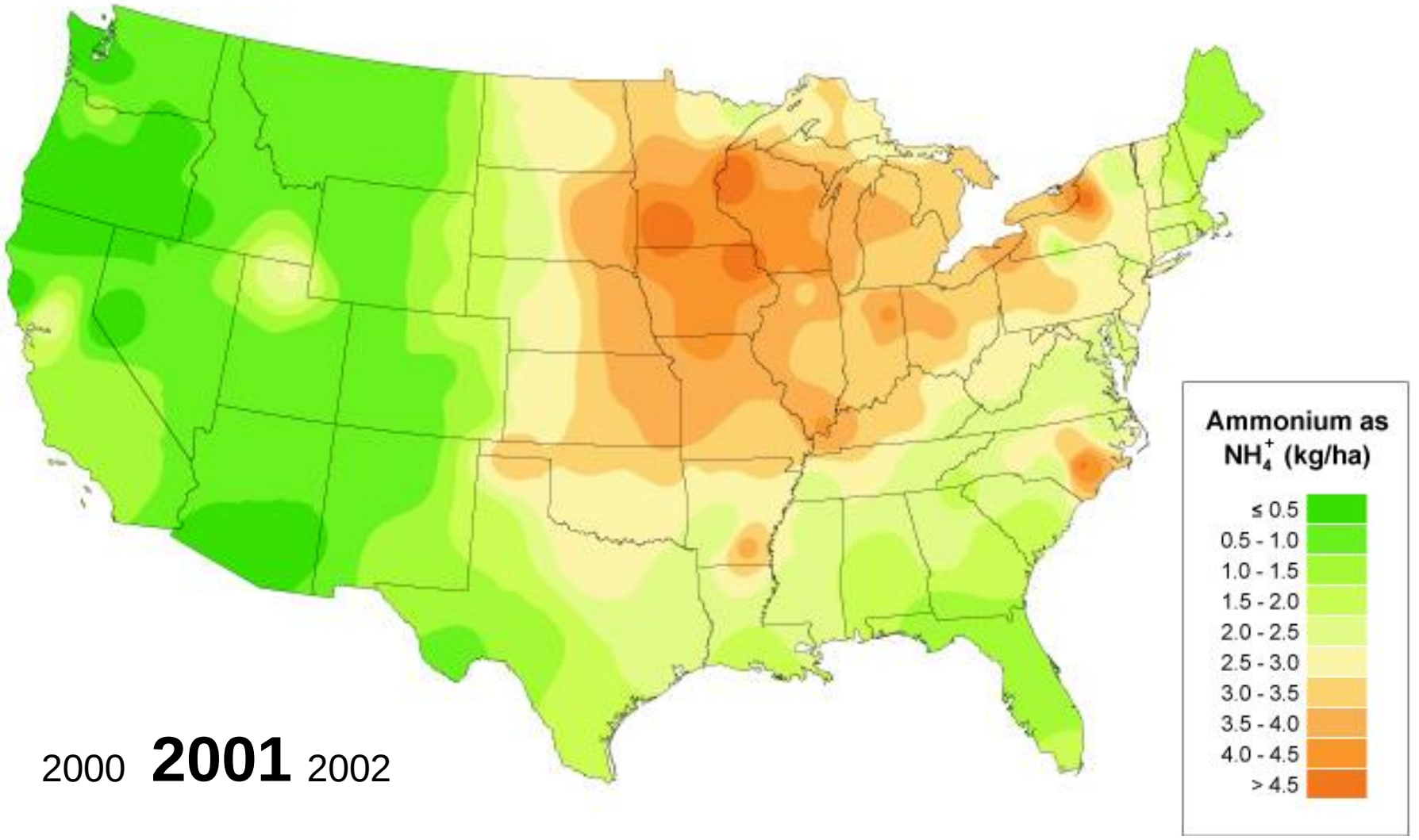
1998 **1999** 2000

Ammonium Ion Wet Deposition 1985-2008



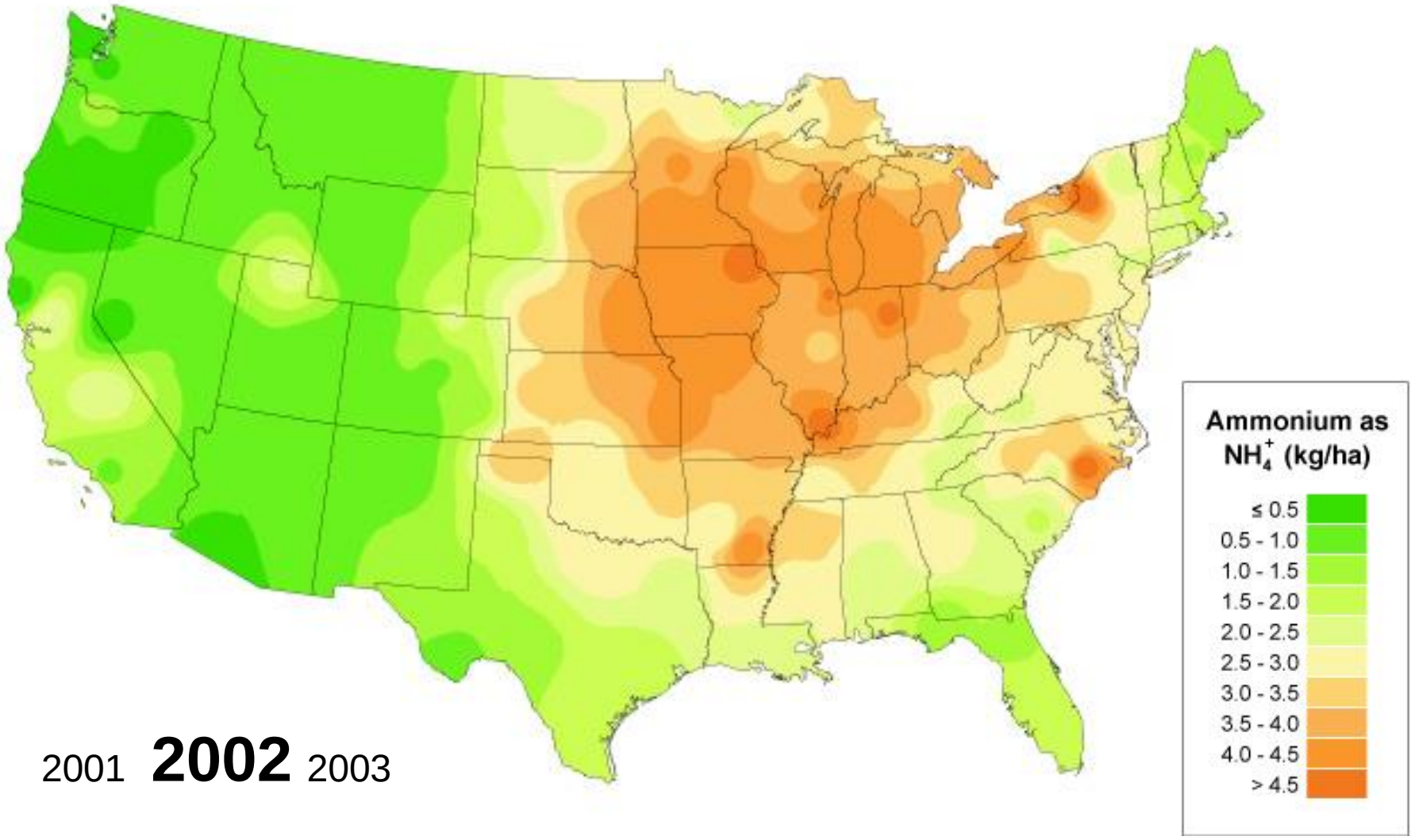
1999 **2000** 2001

Ammonium Ion Wet Deposition 1985-2008



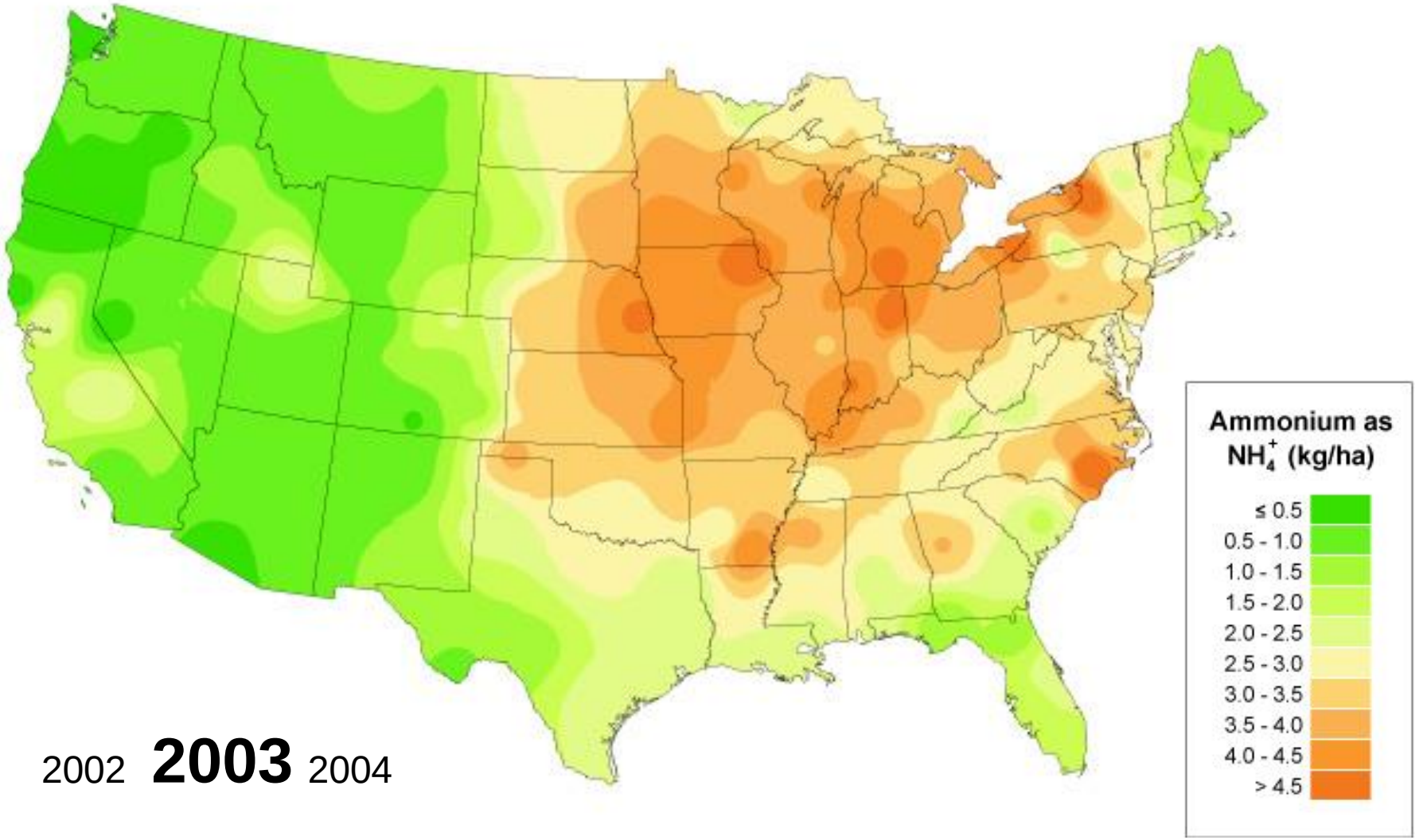
2000 **2001** 2002

Ammonium Ion Wet Deposition 1985-2008



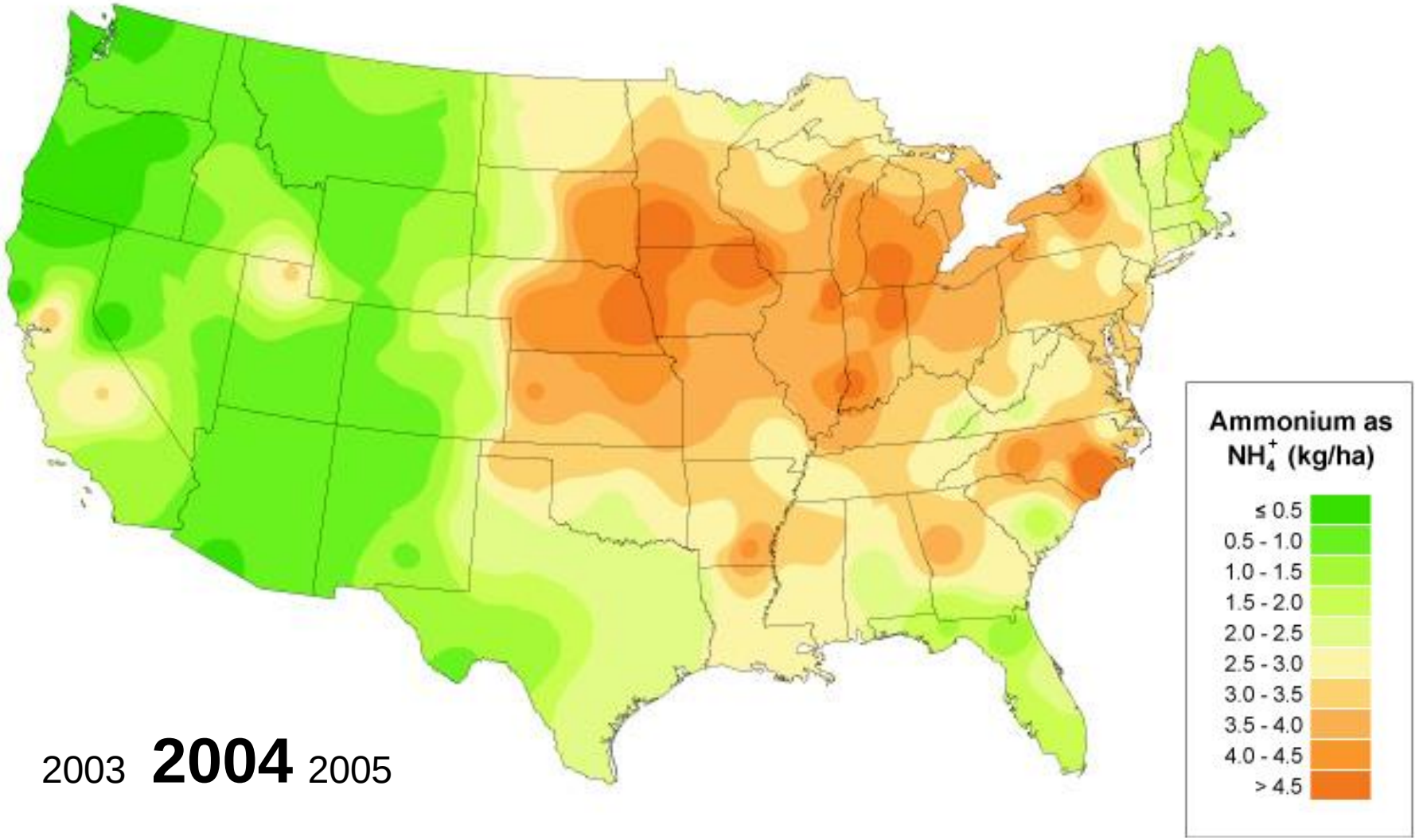
2001 **2002** 2003

Ammonium Ion Wet Deposition 1985-2008



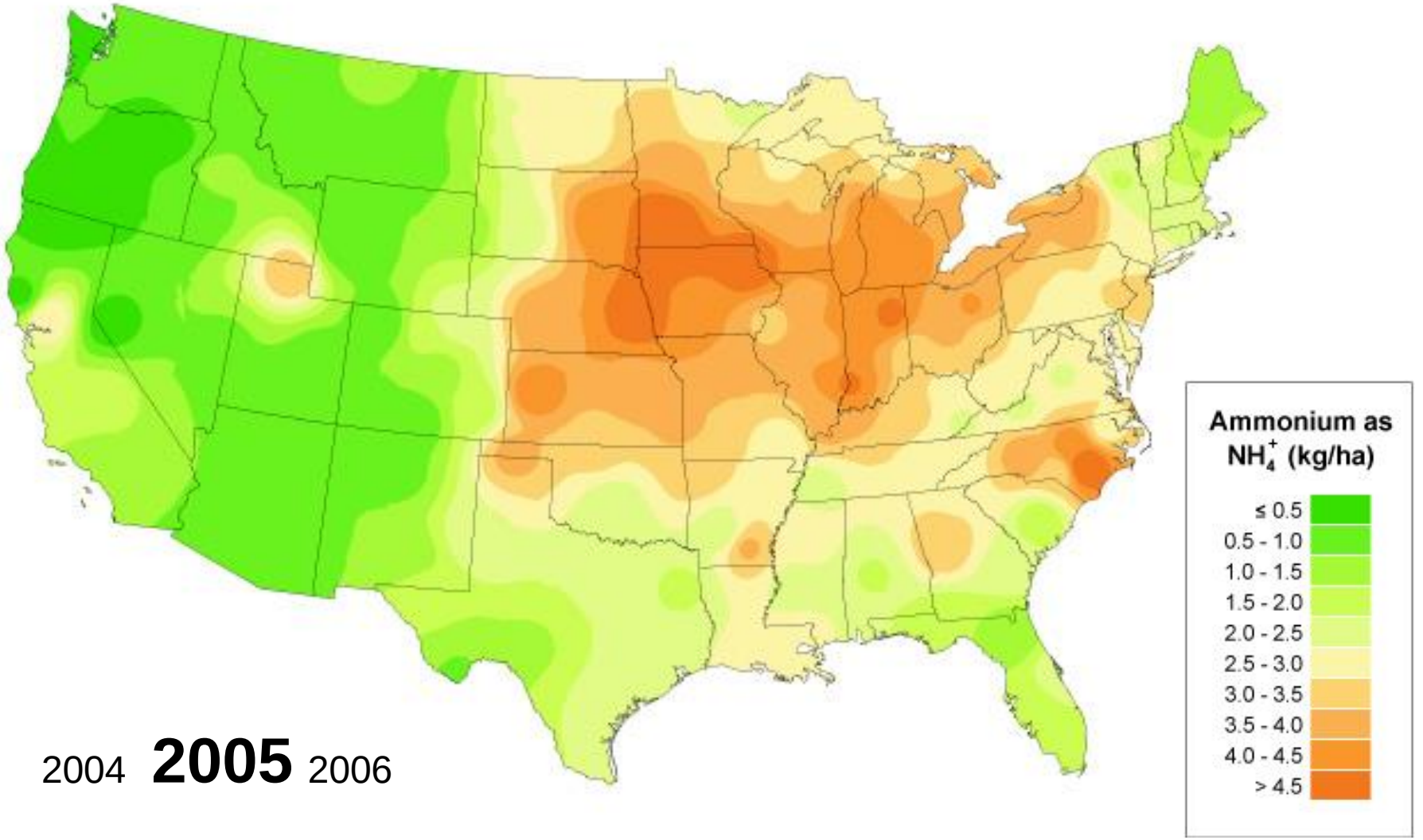
2002 **2003** 2004

Ammonium Ion Wet Deposition 1985-2008



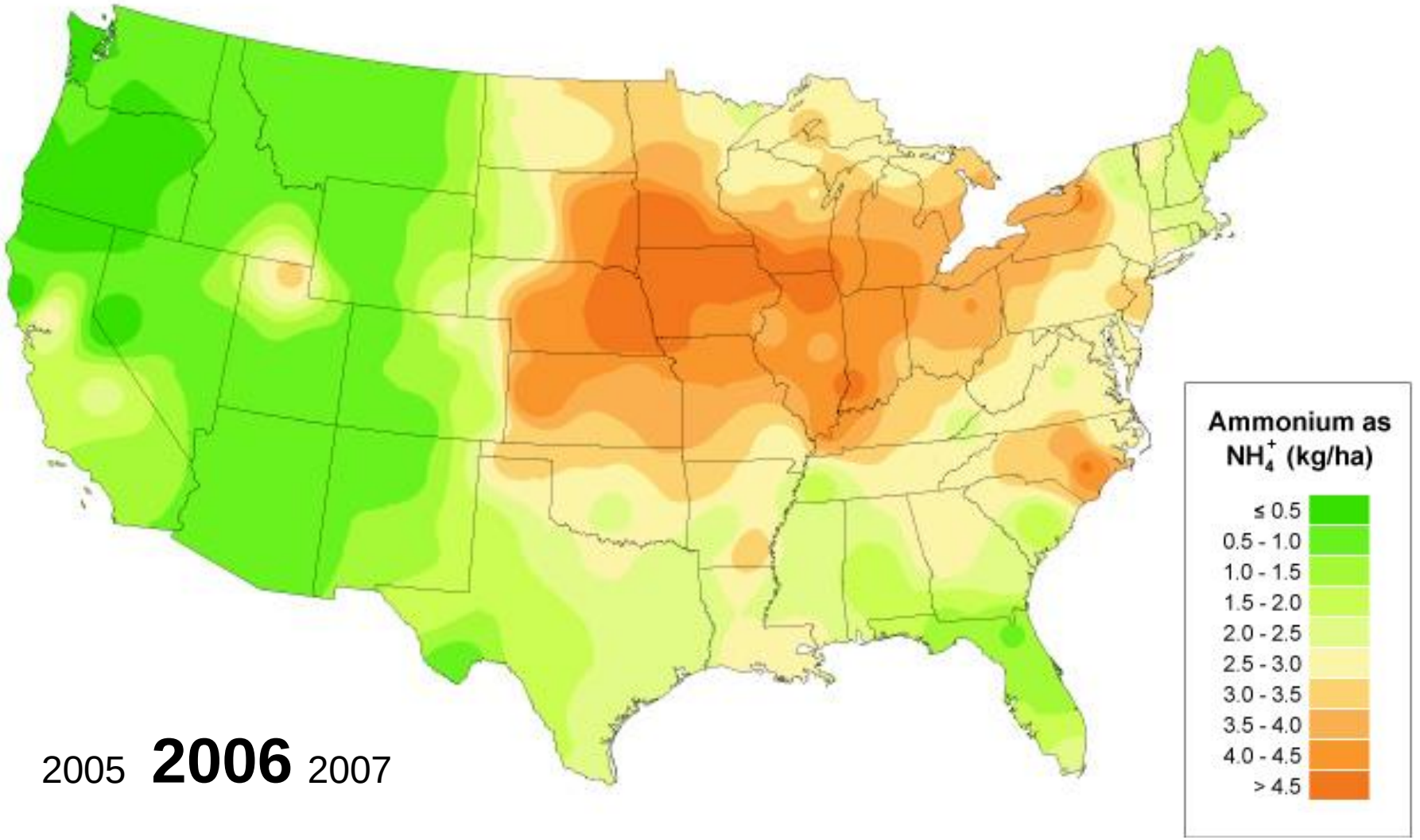
2003 **2004** 2005

Ammonium Ion Wet Deposition 1985-2008



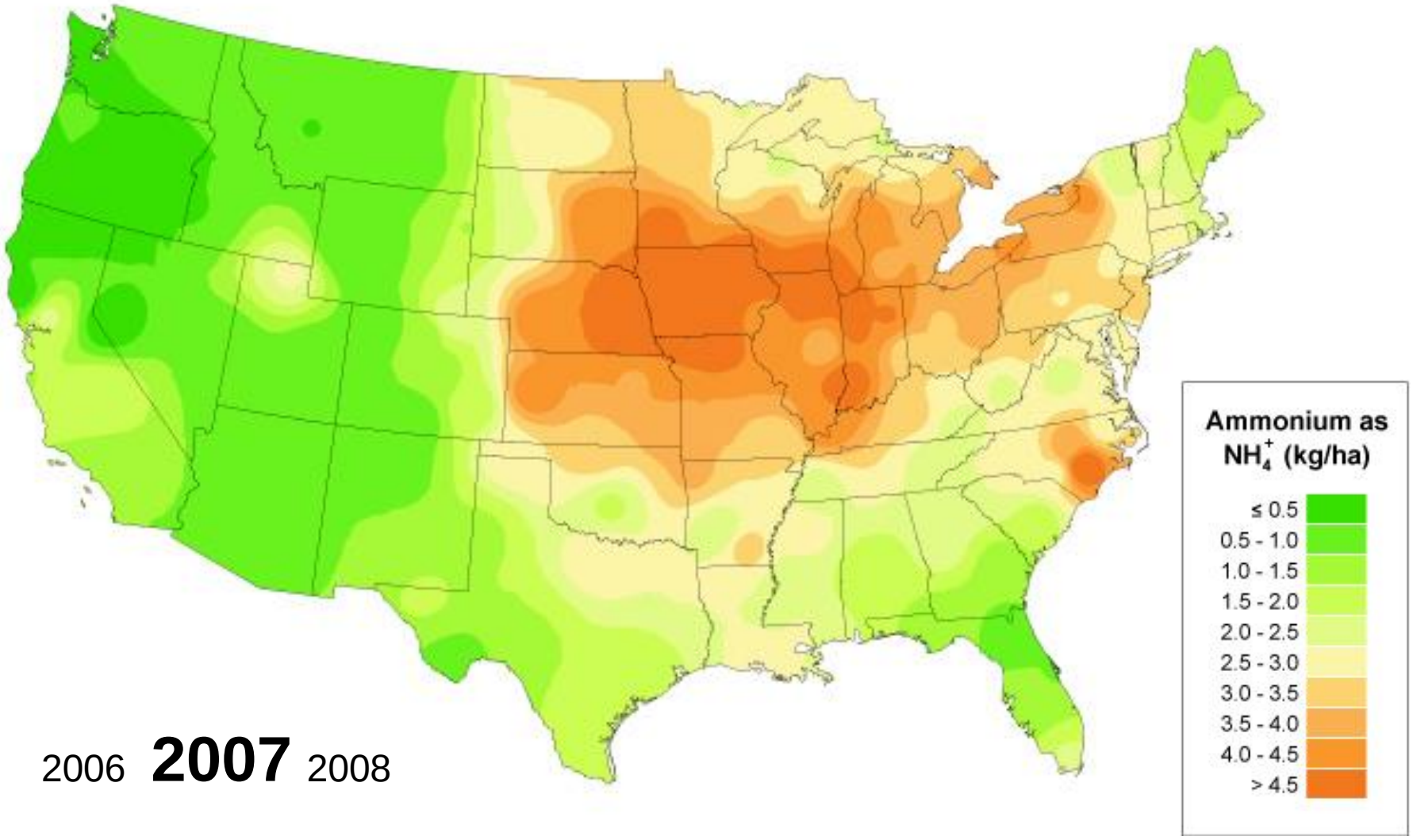
2004 **2005** 2006

Ammonium Ion Wet Deposition 1985-2008



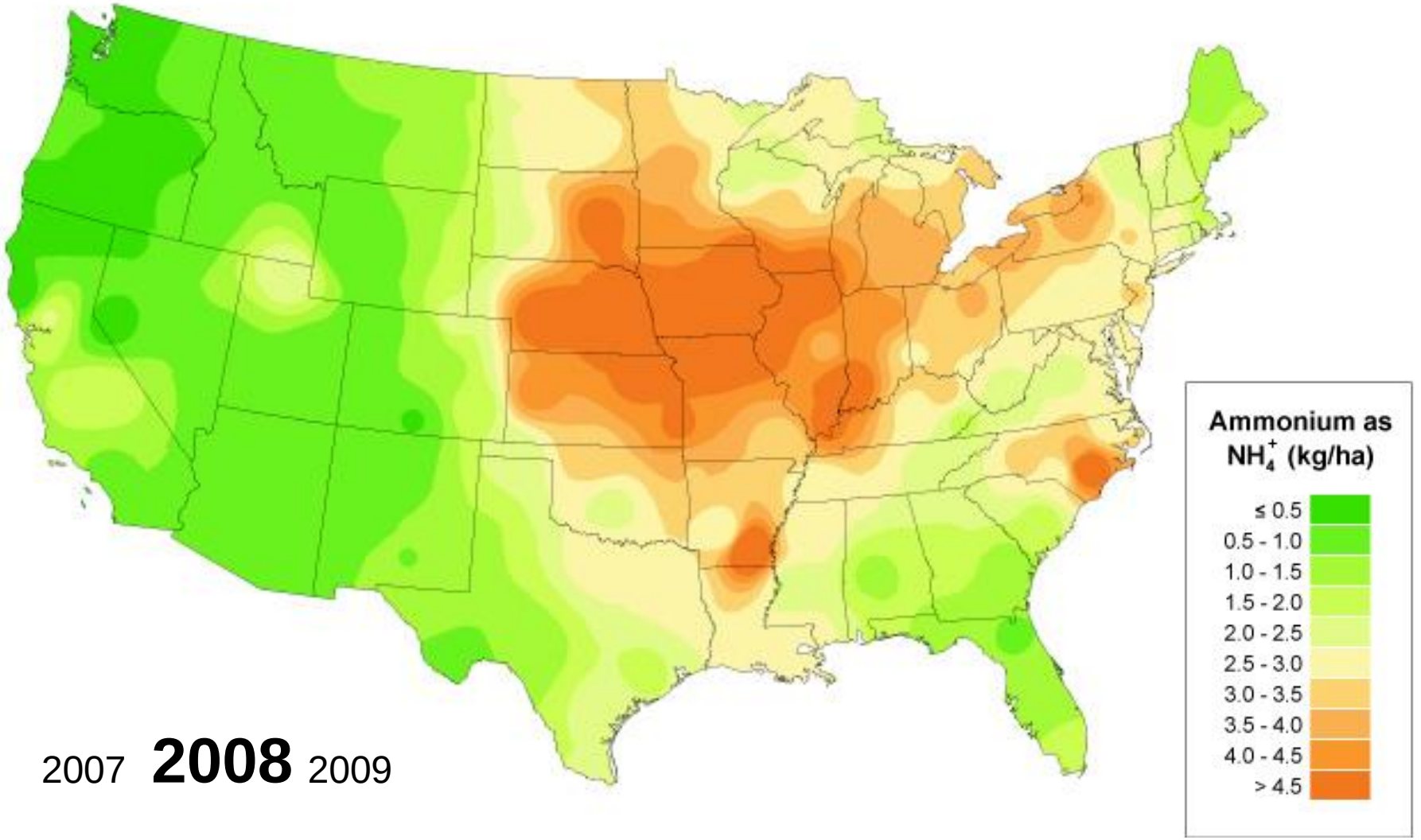
2005 **2006** 2007

Ammonium Ion Wet Deposition 1985-2008



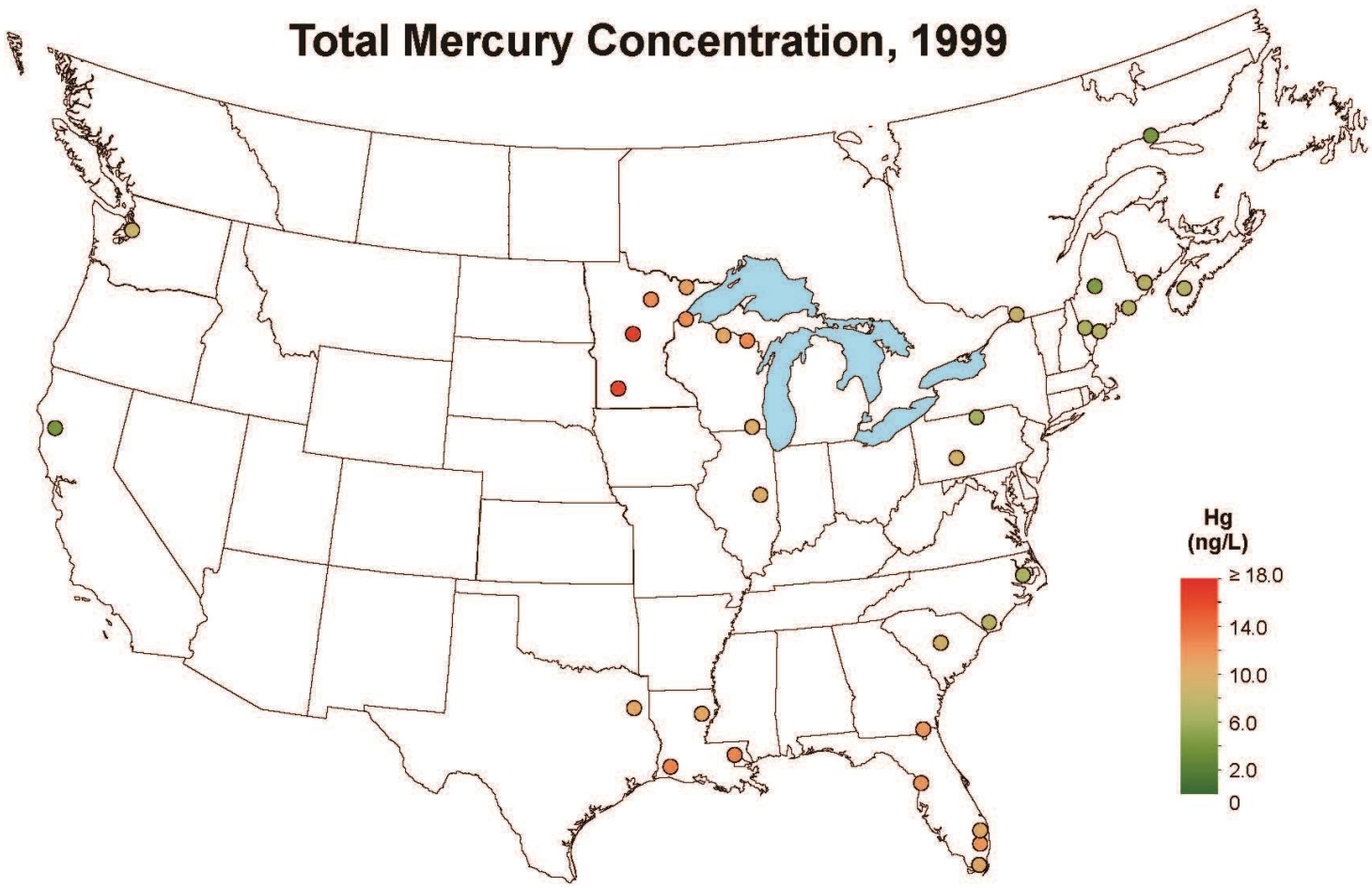
2006 **2007** 2008

Ammonium Ion Wet Deposition 1985-2008

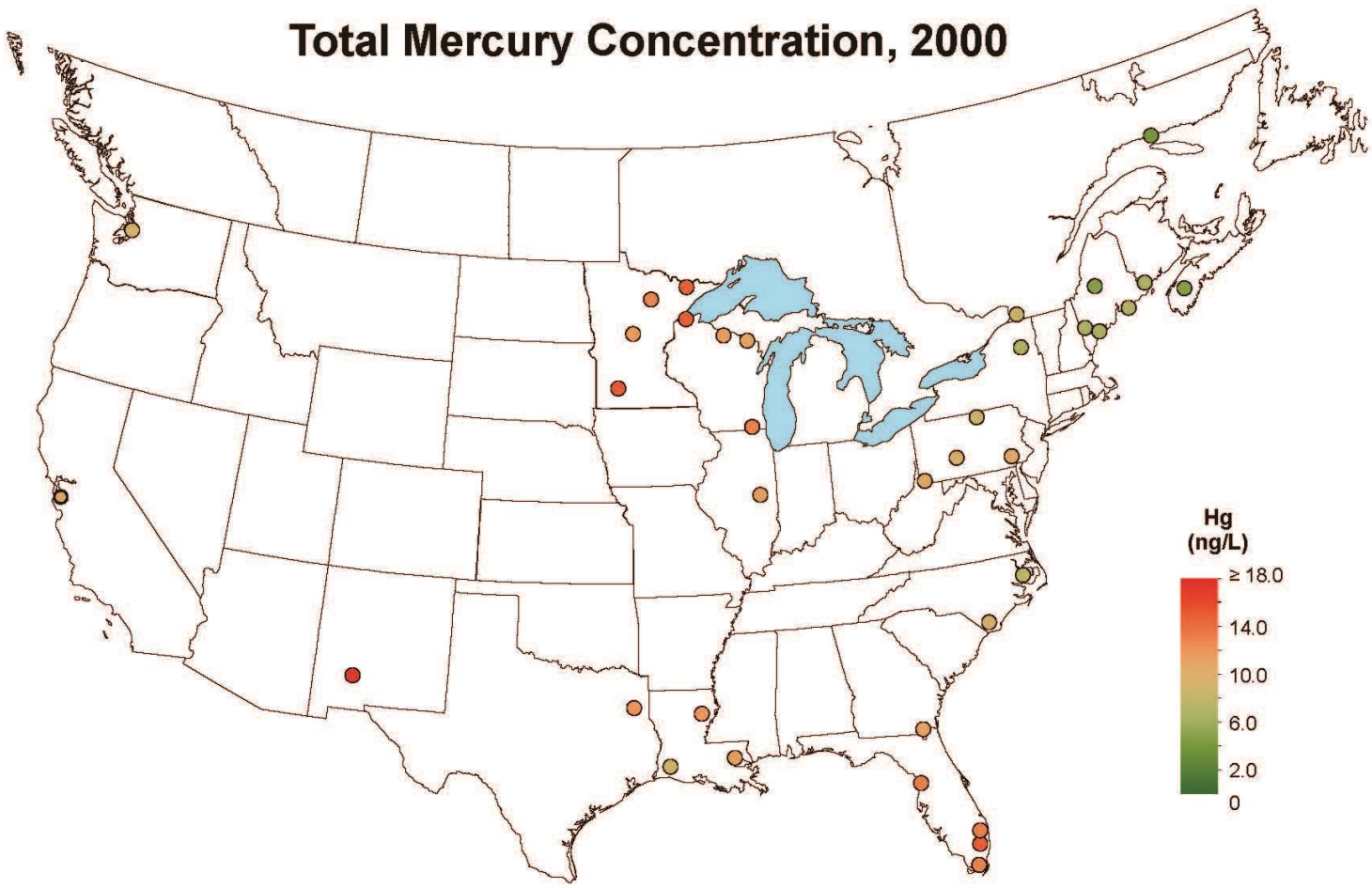


2007 **2008** 2009

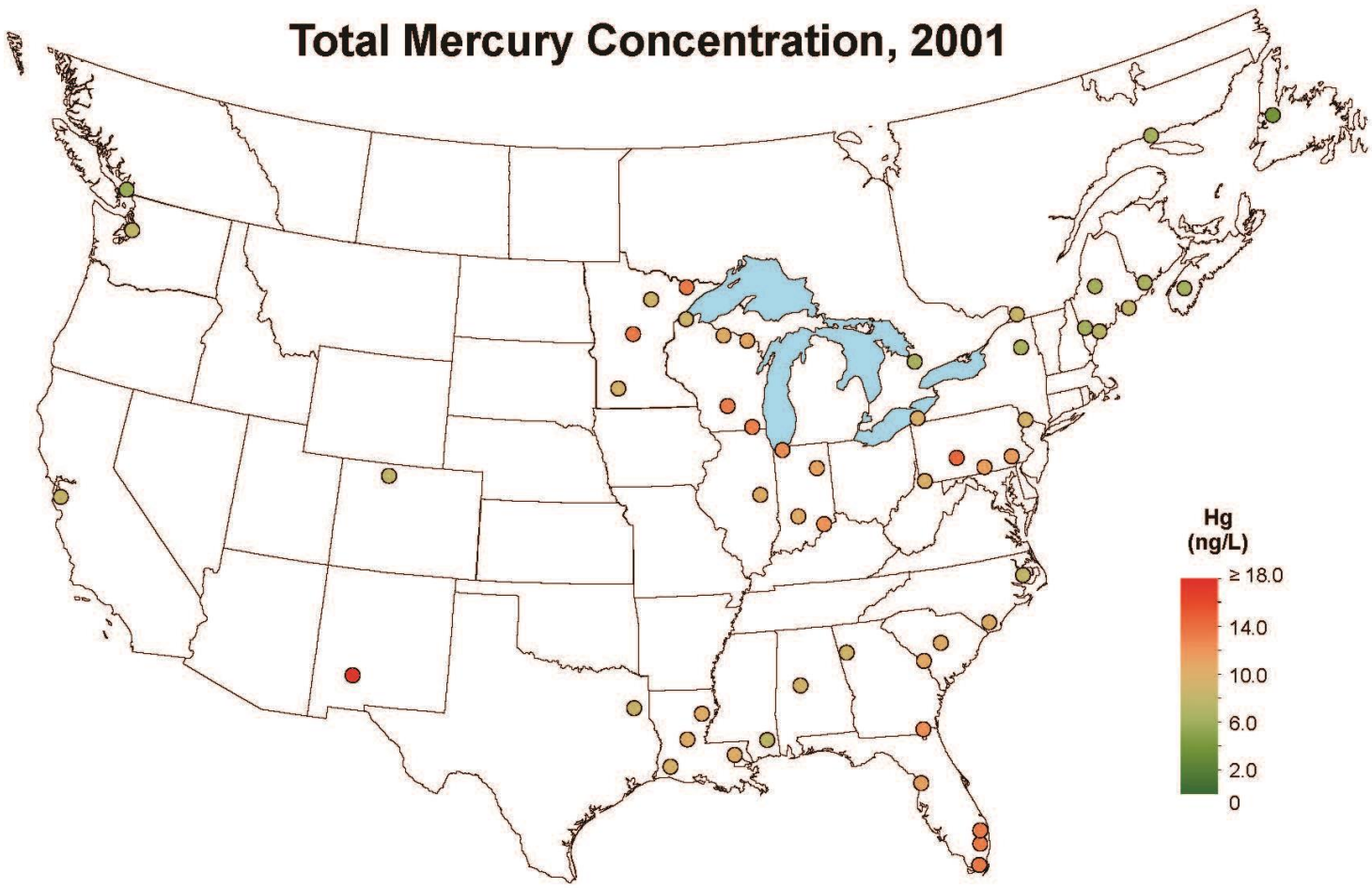
Product Example #2:
Mercury in North American Precipitation



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

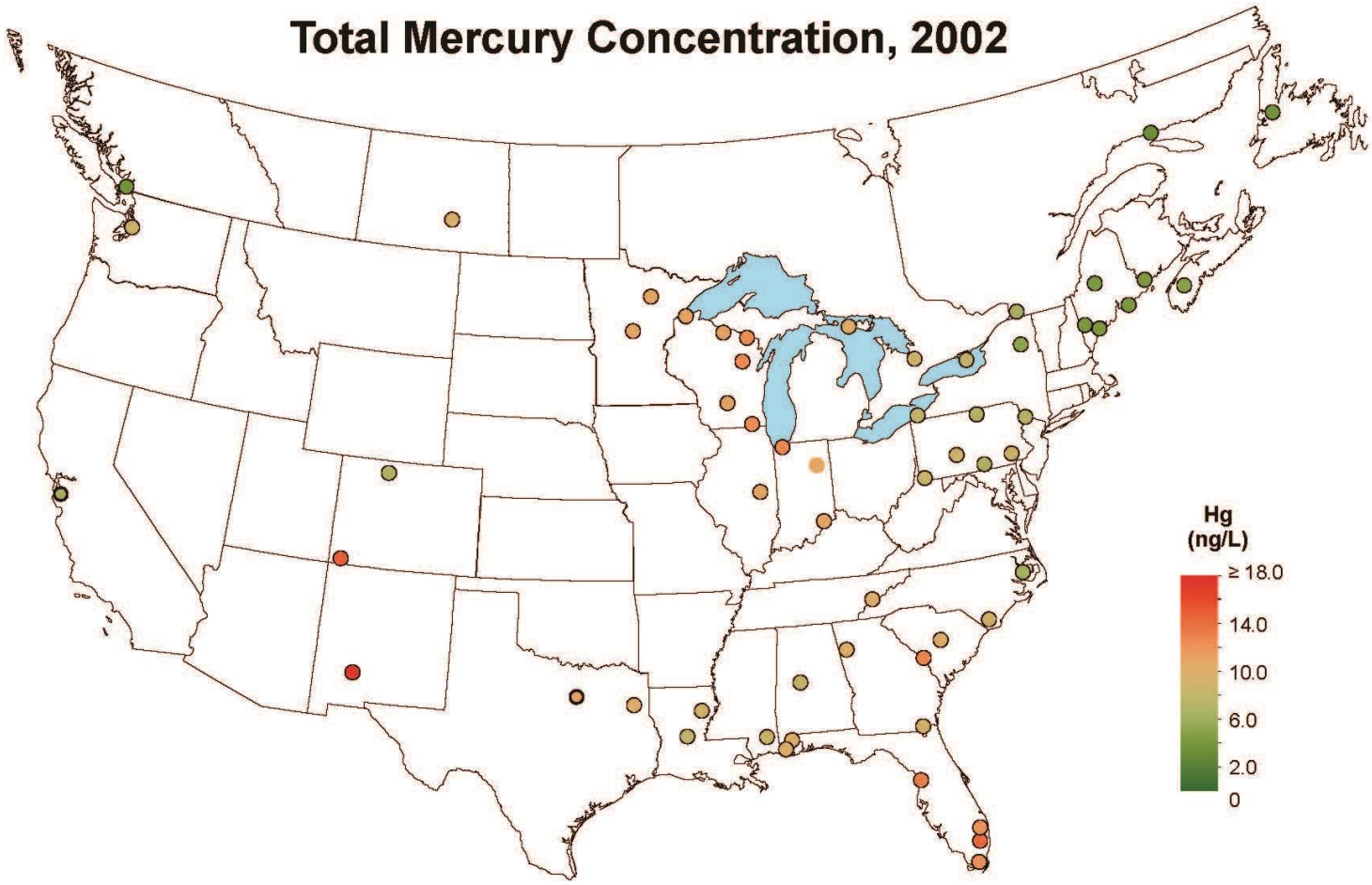


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

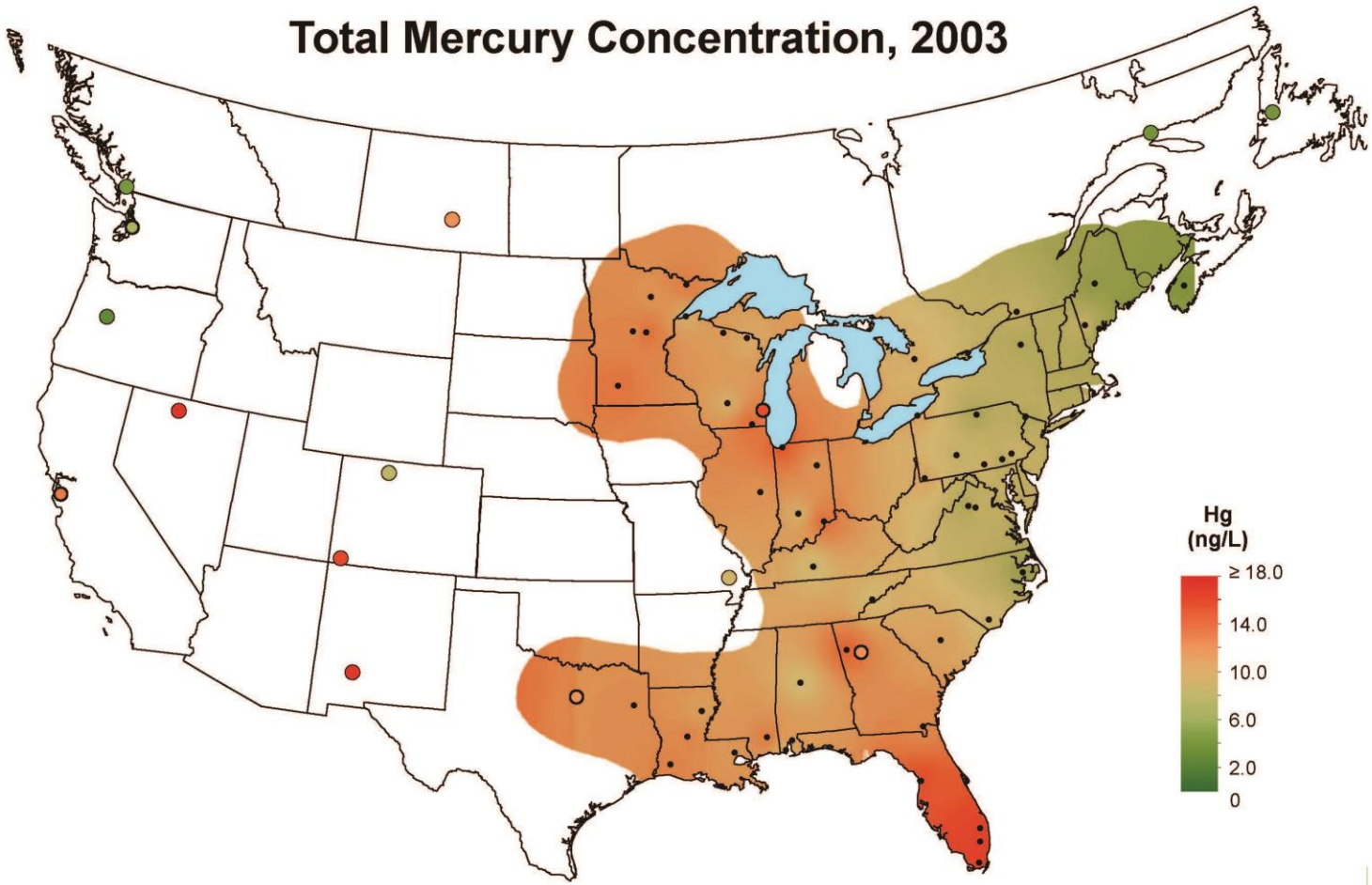


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

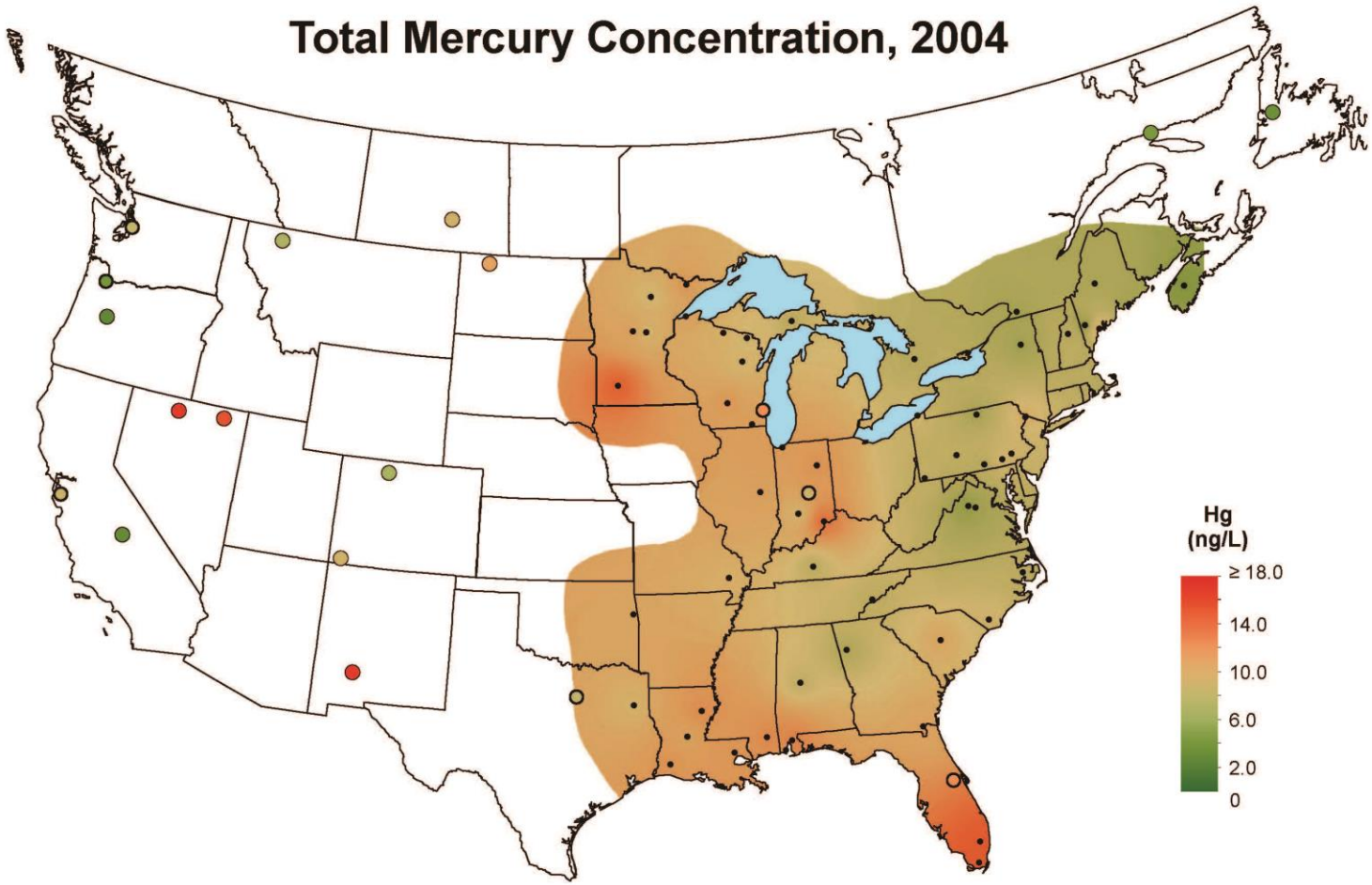
Total Mercury Concentration, 2002



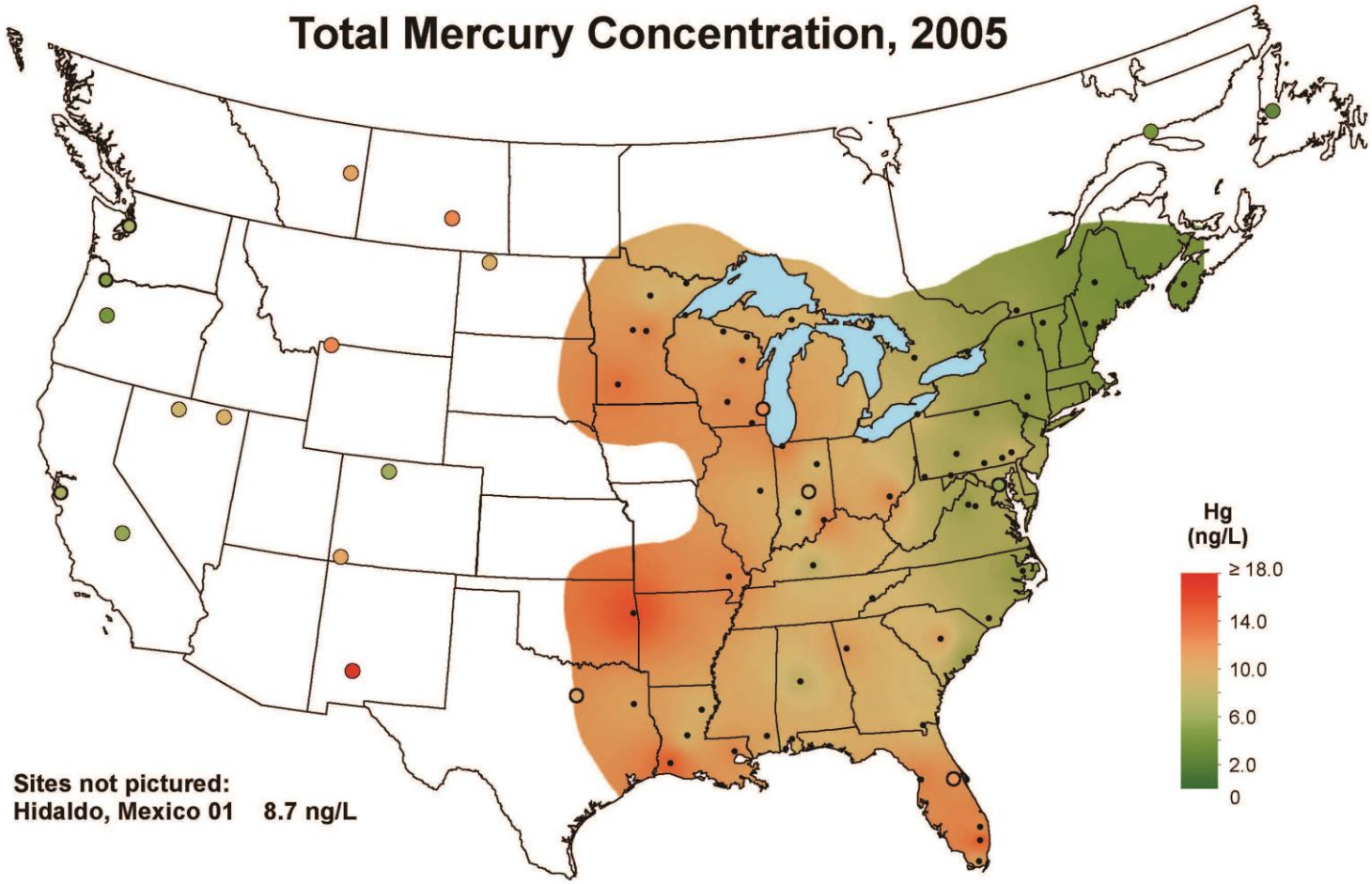
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



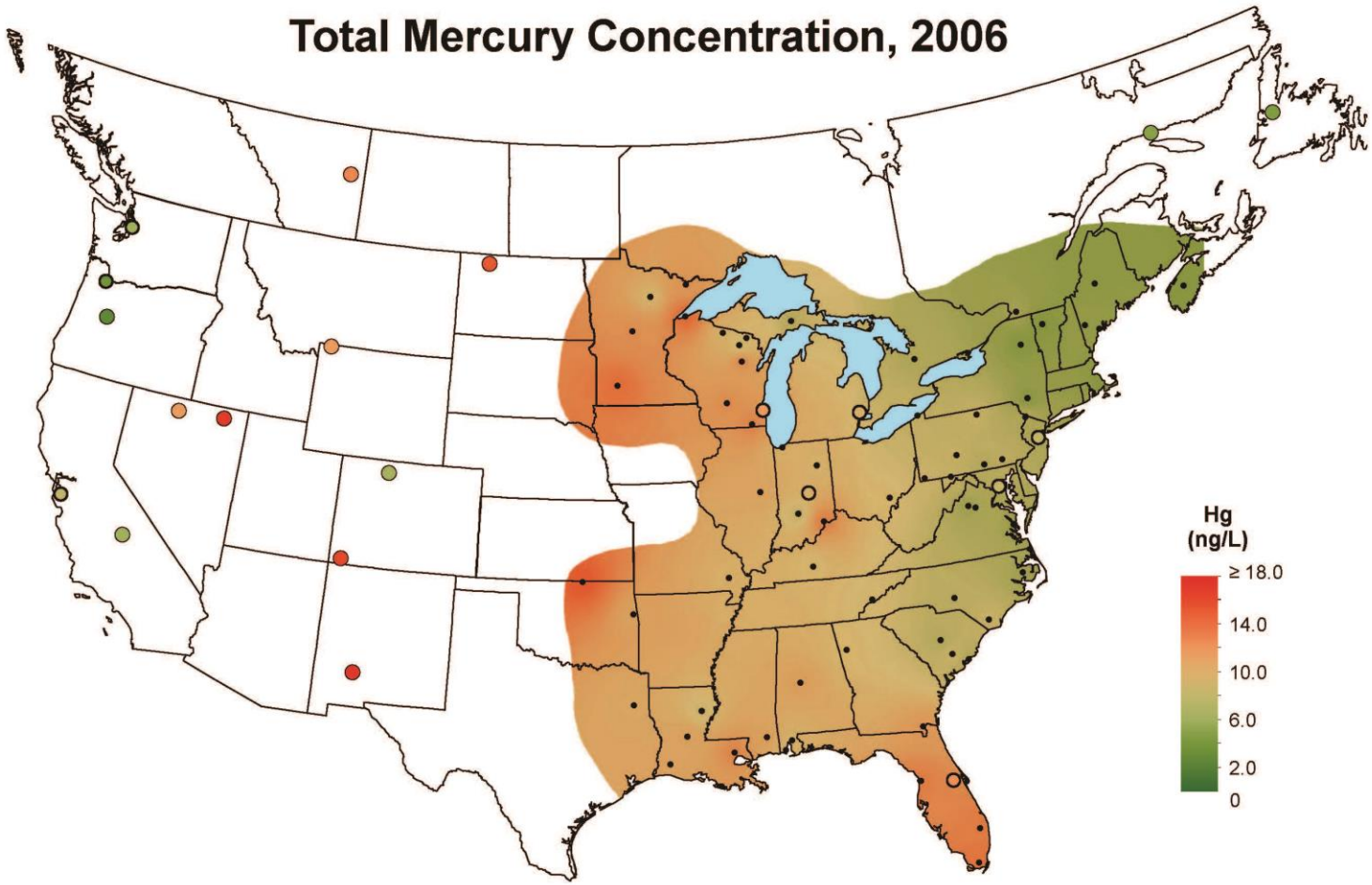
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



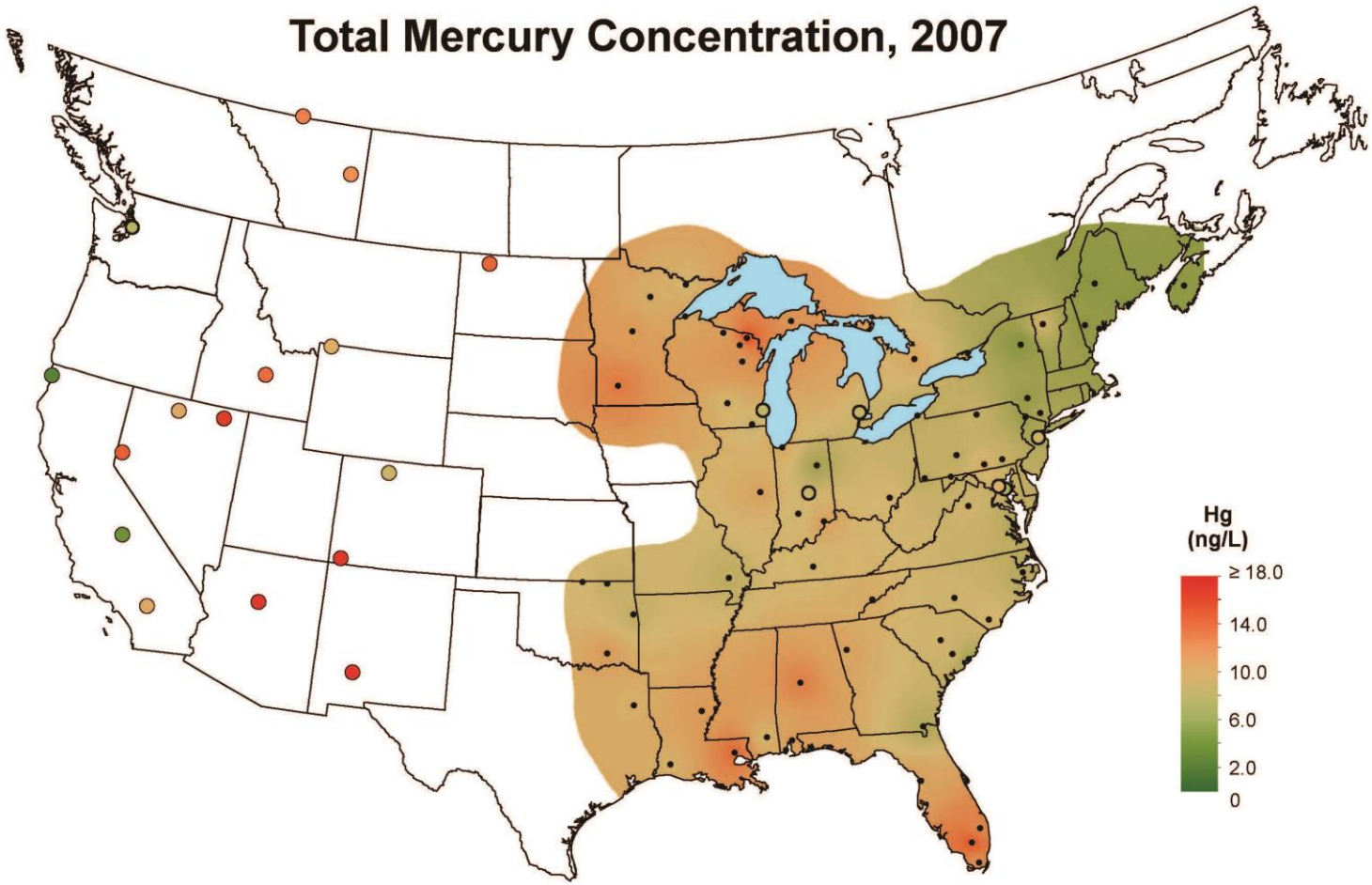
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



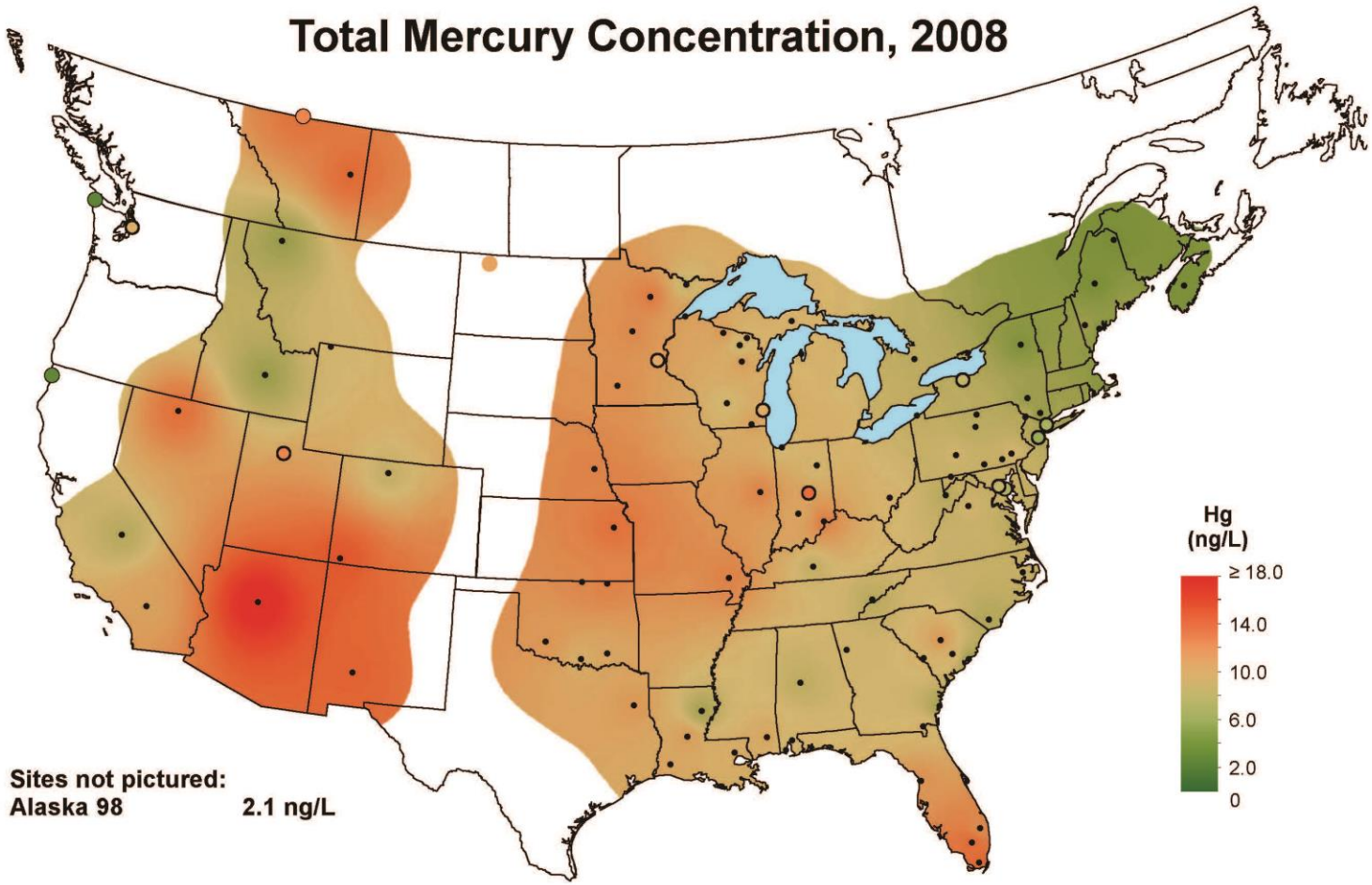
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



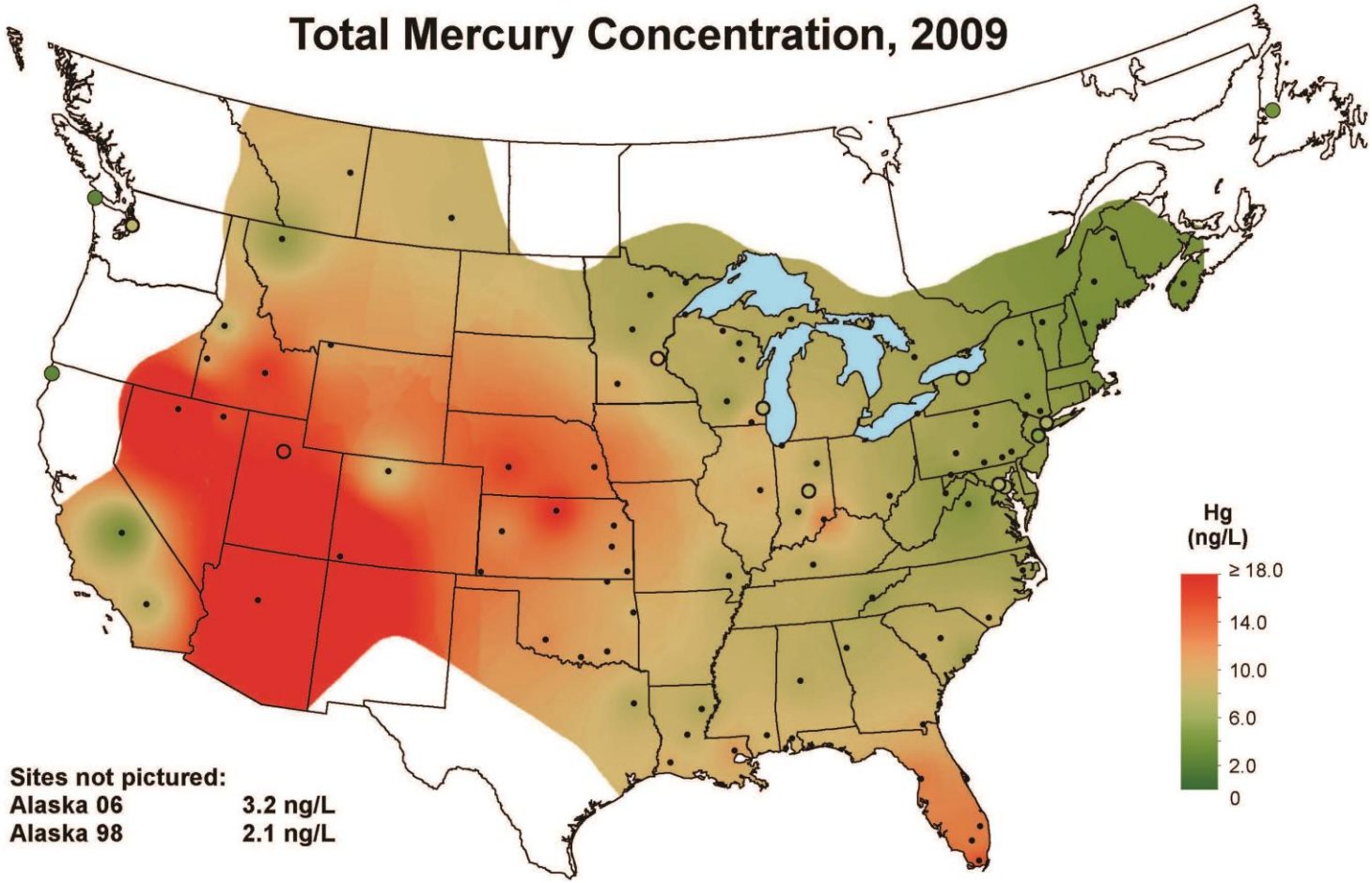
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



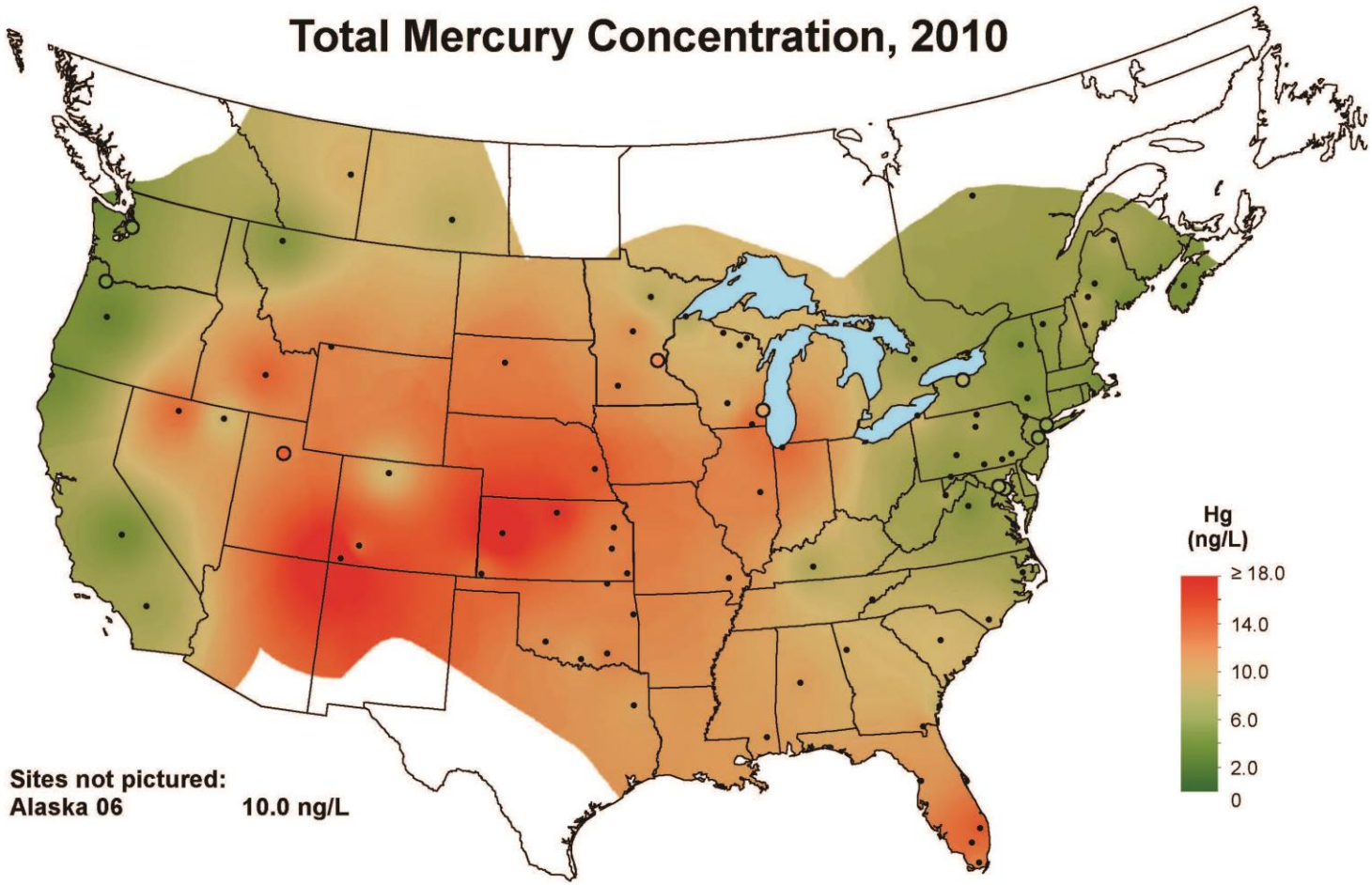
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



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

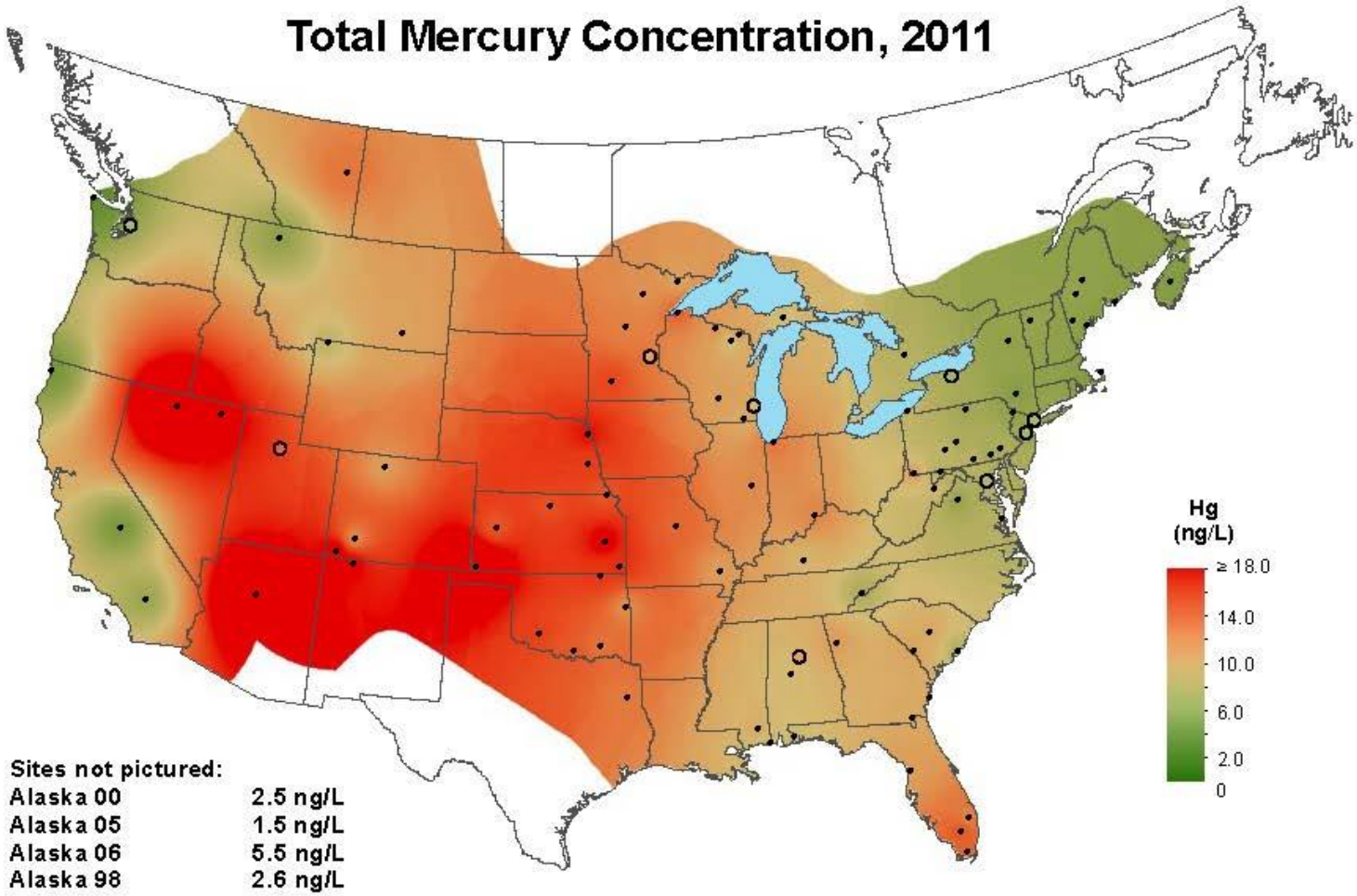


National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



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

Total Mercury Concentration, 2011



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

WMO Global Atmosphere Watch
Current Activities

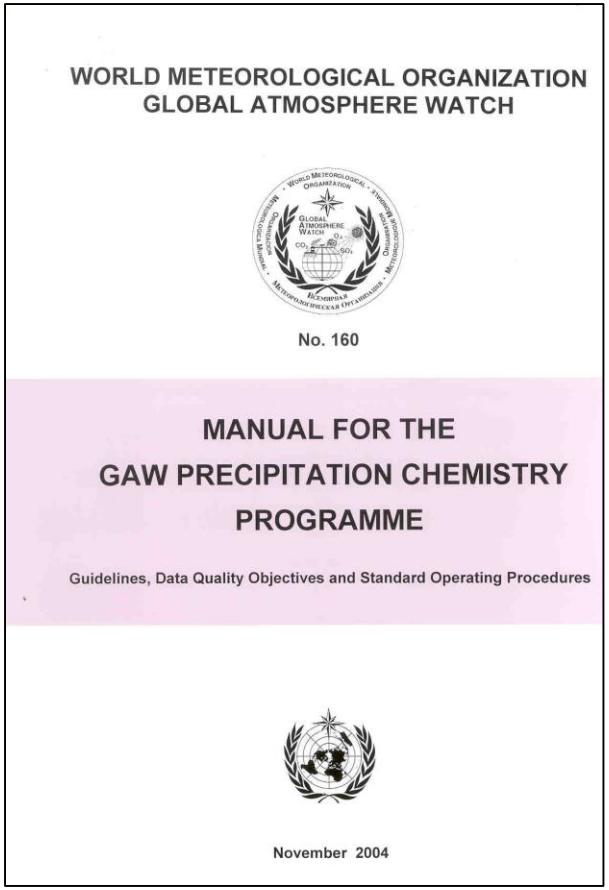
- Development and Maintenance of the
  - Guidance Manual
  - Quality Assurance/Science Activity Center
  - World Data Center for Precipitation Chemistry

- Second Global Deposition Assessment

http://qasac-americas.org/ http://wdcpc.org

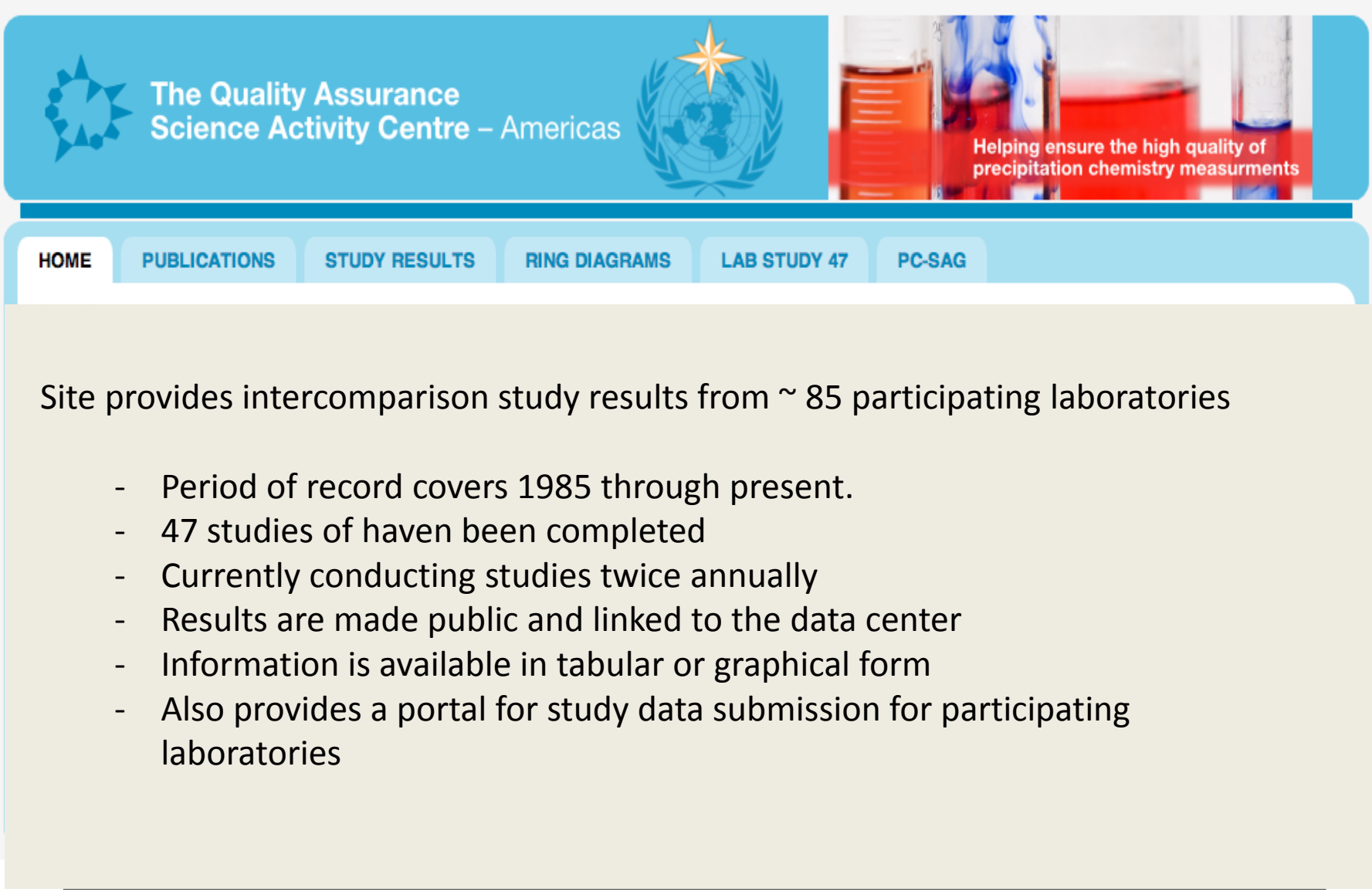
Manual for the GAW Precipitation Chemistry Programme

1. **Introduction**
2. **Siting**
3. **Field Protocols**
4. **Laboratory Operations**
5. **Data Management**
6. **Quality Control and Quality Assurance**



http://qasac-americas.org/sites/default/files/GAW-Precip%20Chem%20Manual%20No.160.pdf

QA SAC – AMERICAS Home Page



Site provides intercomparison study results from ~ 85 participating laboratories

- Period of record covers 1985 through present.
- 47 studies of haven been completed
- Currently conducting studies twice annually
- Results are made public and linked to the data center
- Information is available in tabular or graphical form
- Also provides a portal for study data submission for participating laboratories

The Quality Assurance Science Activity Centre – Americas

HOME | PUBLICATIONS | STUDY RESULTS | RING DIAGRAMS | LAB STUDY 47 | PC-SAG

LIS Study 47

- Study Summary
- Ring Diagrams
- Study Data HTML
- Study Data CSV

LIS Study 47

Select Data Sets

1. Choose Action:

- Download
- View

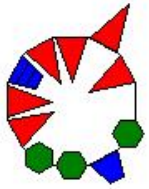
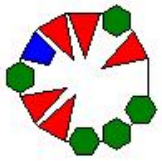
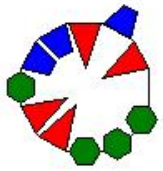
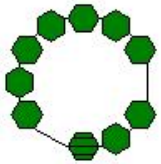
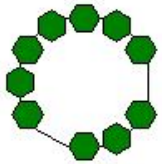
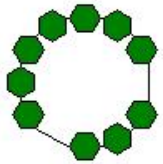
Would you like to download data files or view data?

2. Choose Data:

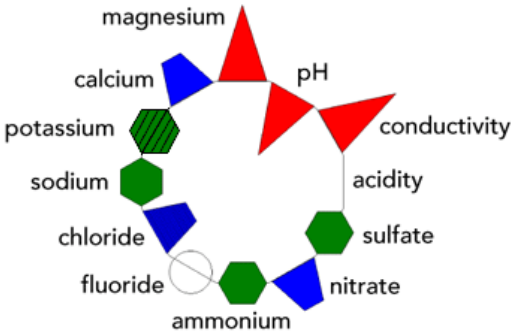
- Ring Diagrams
- HTML Table

Lab Intercomparison Study Data

All labs, LIS 2012 47 Ring Diagrams

Lab	Sample #1	Sample #2	Sample #3
700001 USA			
700003 USA			

Measurement Key



An example of two U.S. labs, one that performs well and one with some analytical problems.

World Data Center for
Precipitation Chemistry

HOME | DATA | PUBLICATIONS | CONTACT

Precipitation Chemistry Labs and Stations

Select Lab
Select Station
Select WMO Region

Lab 700035 Switzerland

Location: Region 6, Europe

Swiss Federal Laboratories for
Materials Science & Technology (EMPA)
Überlandstrasse 129
Dübendorf

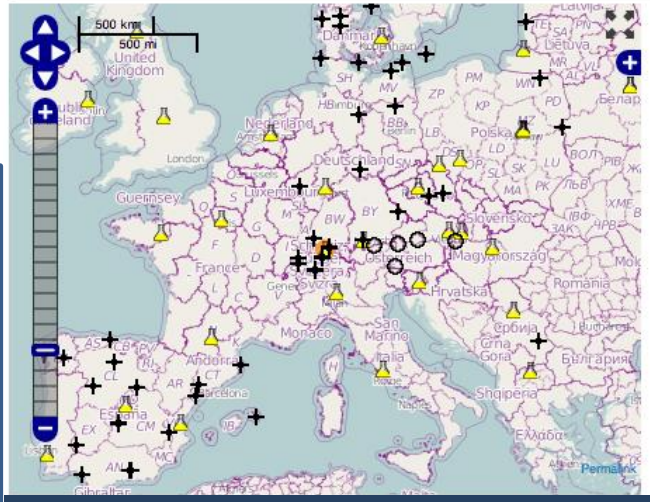
CH-8600 SWITZERLAND

Website:
http://www.empa.ch/plugin/template/empa/704/*/---/l=1

Stations Served:
- Tänikon
- Payerne
- Jungfraujoch
- Chaumont
- Rigi
- Jungfraujoch
- Payerne
- Rigi
- Tänikon

Intercomparison Data:
Select LIS Study

Lab 700035 Switzerland



Laboratory Information

- Lab Website link
- List of stations served by the lab
- Link to Ring Diagrams for lab

WMO Global Atmosphere Watch
Current Activities

- Development and Maintenance of the
  - Quality Assurance/Science Activity Center
  - World Data Center for Precipitation Chemistry
  - Updating the Guidance Manual

- Second Global Deposition Assessment

The WMO 2013
Global Precipitation Chemistry and Deposition Science Assessment

Objective: To review and synthesize the state of the science of the ion composition of precipitation and ion deposition on global and regional scales.

Key Science Questions on a Global and Regional Scale:

- What do measurements and model estimates of precipitation chemistry, precipitation amount and wet, dry and wet+dry deposition of sulfur, nitrogen, mineral base cations, sea-salt, organic acids, acidity (pH), and phosphorous show globally and regionally?
- How has wet and dry deposition of major ions changed since 2000 and, where information and data are available, since 1990 as a result of changing precursor anthropogenic emissions?
- What are the major gaps and uncertainties in our knowledge?

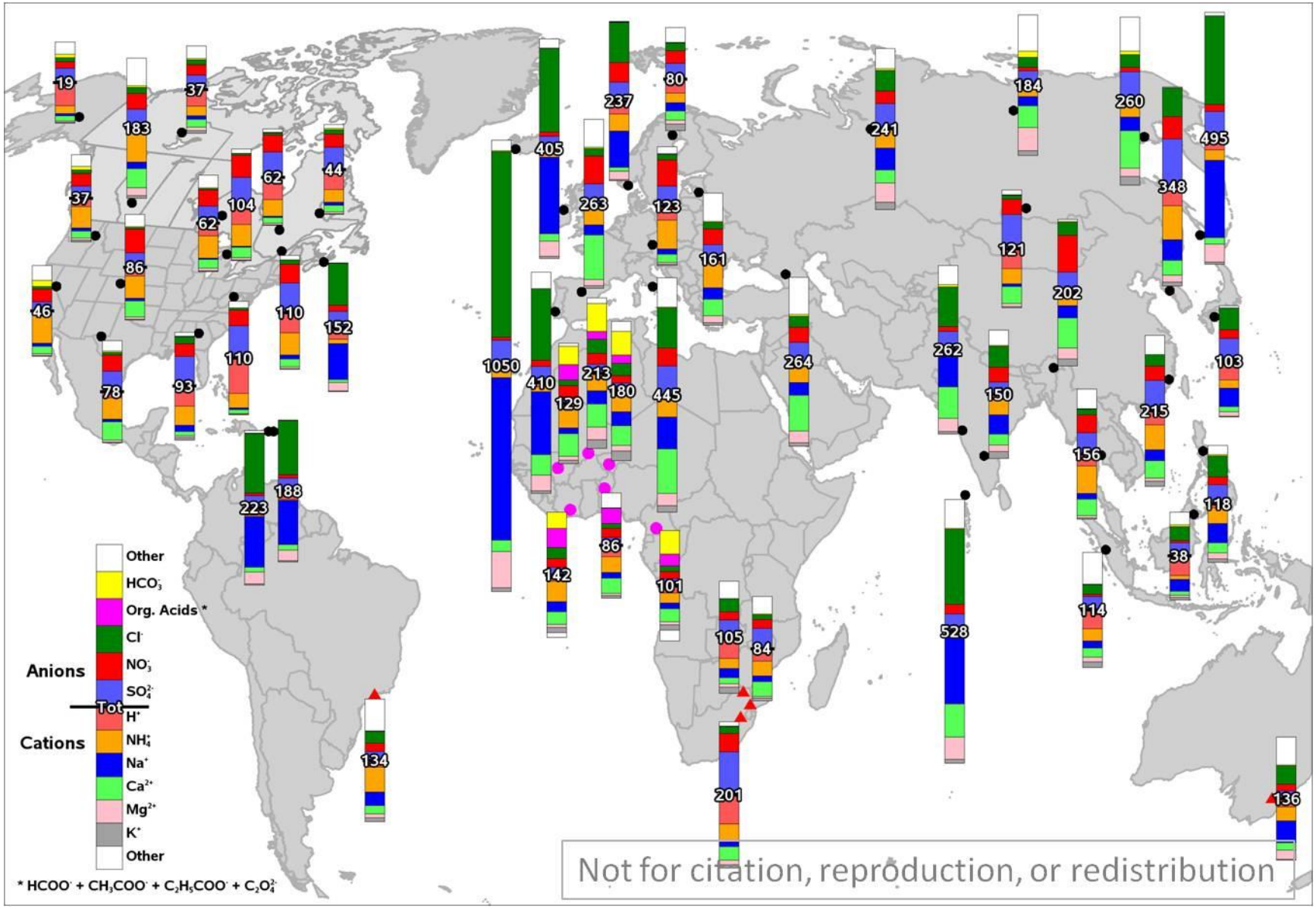
Approach:

- Assessment co-led by Environment Canada (Vet and Carou) and ARL (Artz)
- 2000 to 2002 and 2005 to 2007
- Global and Regional scales, including oceans
- Combined measurement and modelling results to provide global coverage

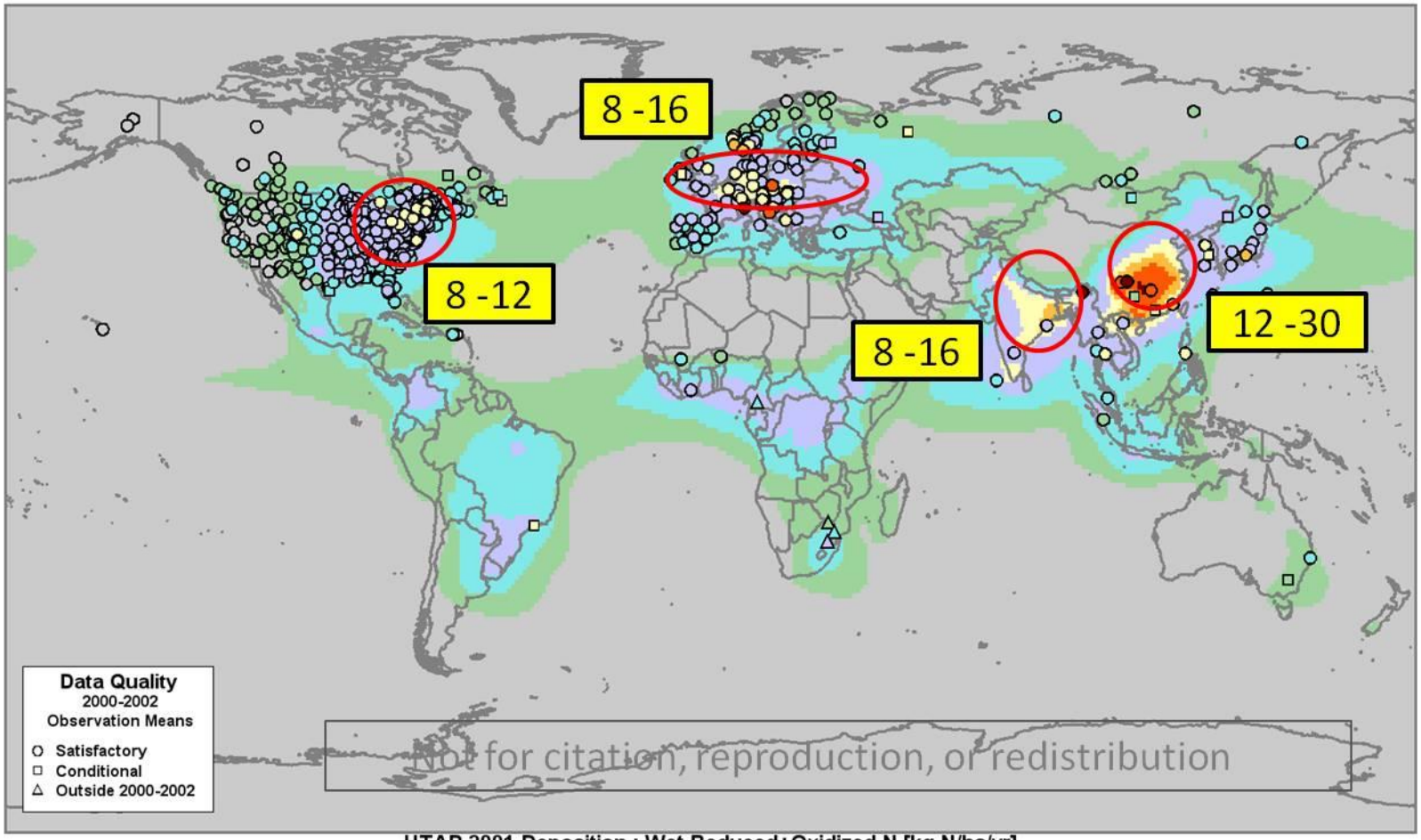
Target Audience:

- Nitrogen cycling – both oxidized and reduced for air quality and eutrophication applications
- Critical loads community
- Climate change modelers to close mass balances
- Global reference data sets for the modeling community

Measurement Results: 2005-2007 Mean Global Ion Composition (µeq/L)



$N_{oxidized}$ + $N_{reduced}$ wet deposition (kg N/ha/yr) – 2000-2002 annual wet deposition and 2001 modeled wet deposition



Things to Consider

- Central laboratory versus distributed?
- Mechanical versus electronic gauges
- Build hardware locally or buy it from US or Europe?
- Site maintenance – vegetation
- Splash problems
- WMO Lab Intercomparison Study
- Quality assurance – lab and field
- Data archival and reporting