

& Northeastern

Characterization of the Winter Midwestern Particulate Nitrate Bulge

Marc L. Pitchford

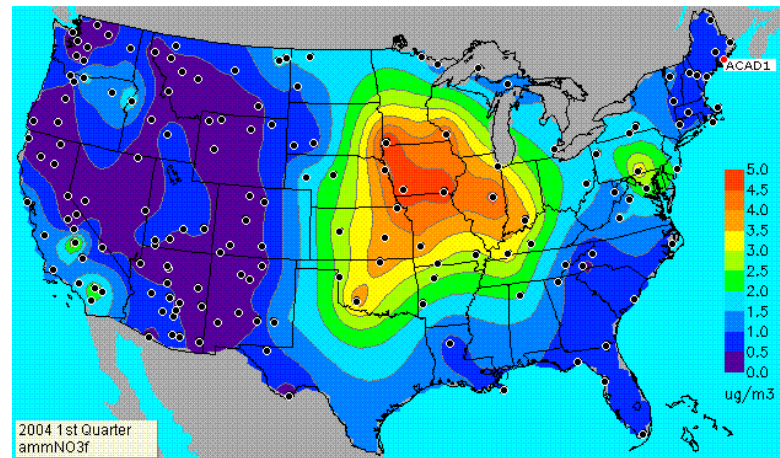
National Oceanic and Atmospheric Administration

Bret A. Schichtel & William C. Malm

National Park Service

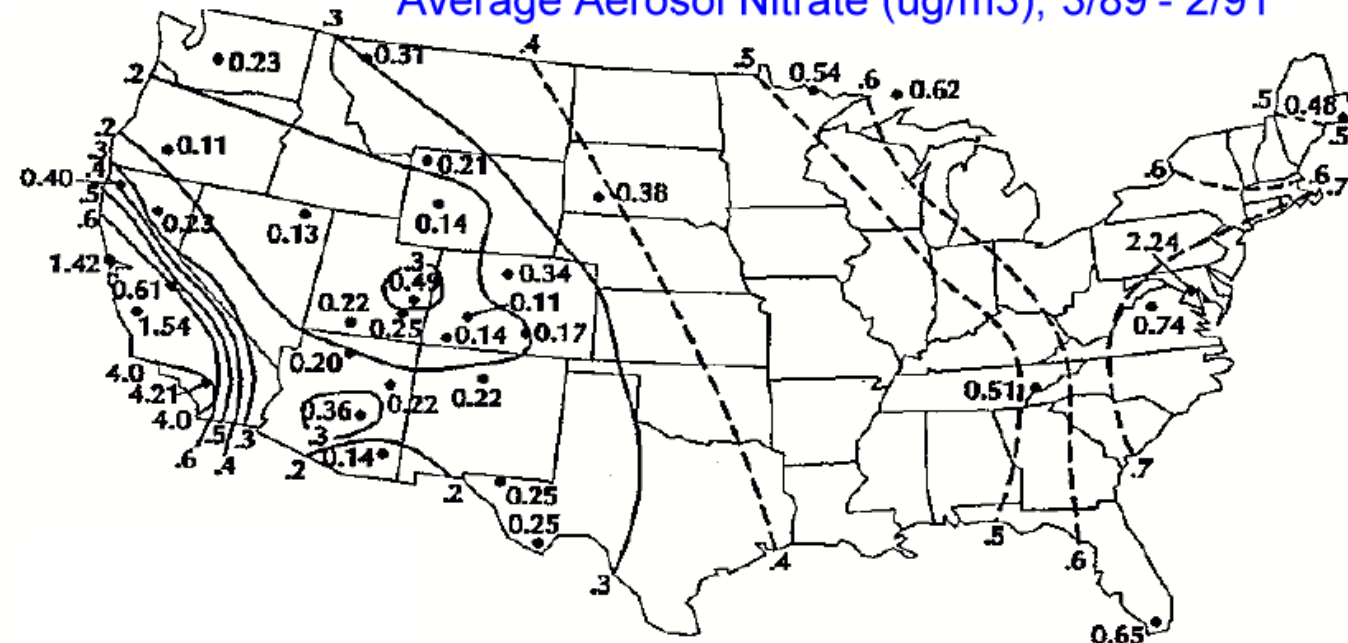
Richard L. Poirot

Vermont DEC – APCD



An Update, with a few Eastern twists, on a paper Marc presented at the A&WMA International Visibility Specialty Conference in Moab, UT, April 2008

Average Aerosol Nitrate ($\mu\text{g}/\text{m}^3$), 3/89 - 2/91

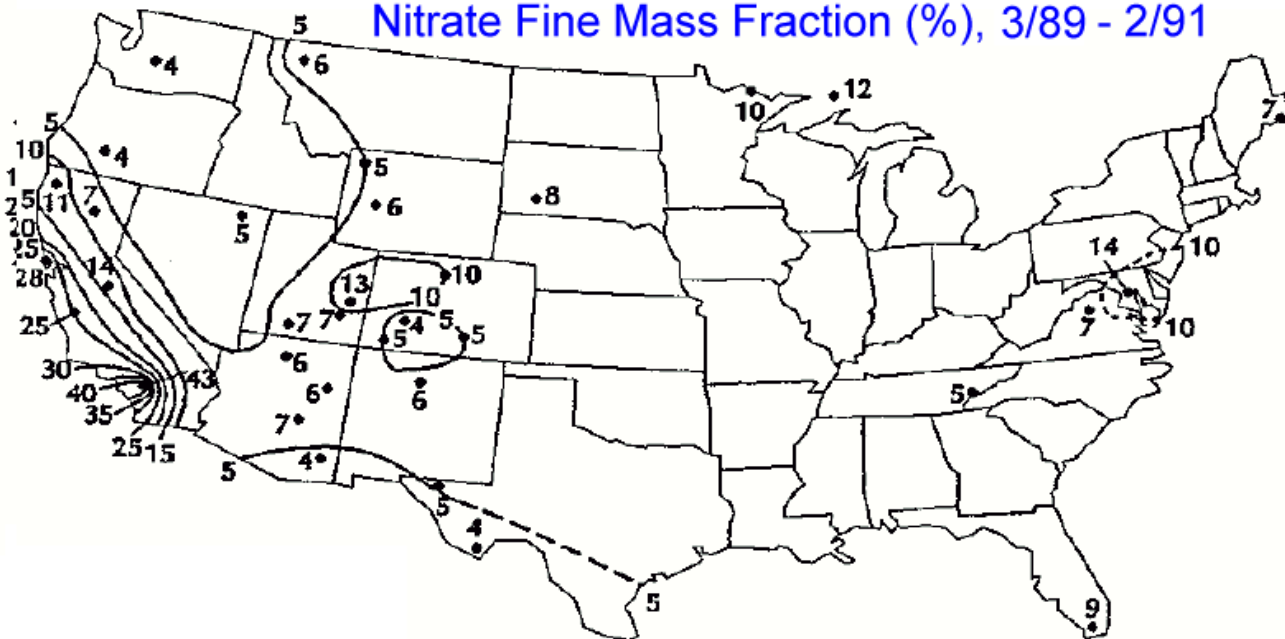


National Aerosol Nitrate Map

Based on First 3 years of IMPROVE data, March 1989 through Feb 1991

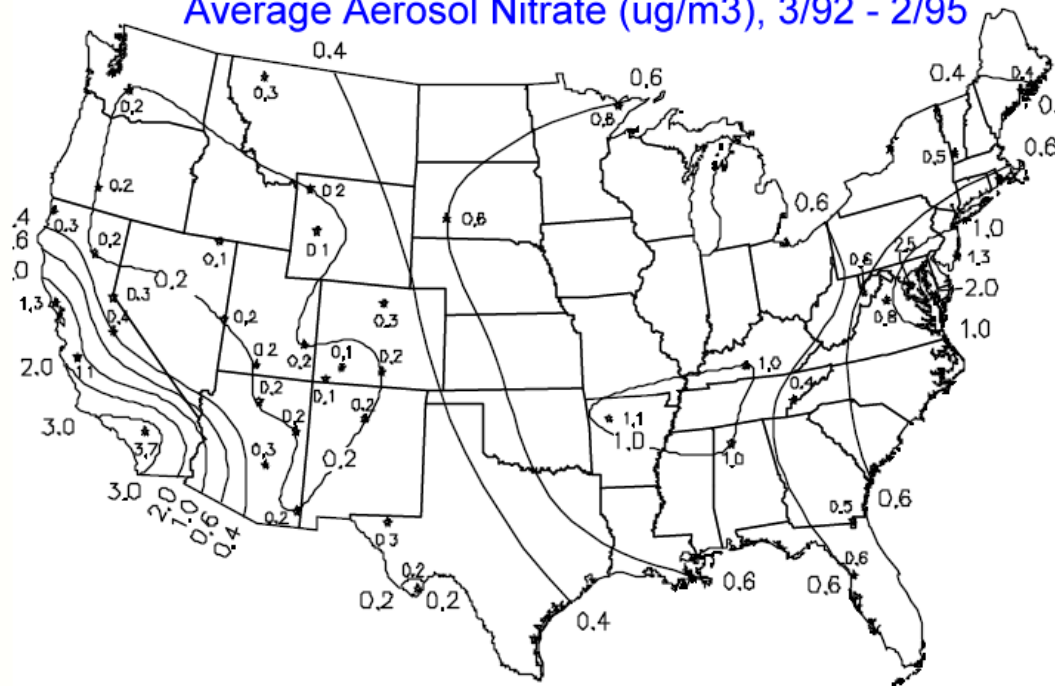
36 IMPROVE sites

Nitrate Fine Mass Fraction (%), 3/89 - 2/91



From: *Spatial and Temporal Patterns and the Chemical Composition of the Haze in the United States: An Analysis of Data from the IMPROVE Network, Report I* (1993)

Average Aerosol Nitrate ($\mu\text{g}/\text{m}^3$), 3/92 - 2/95

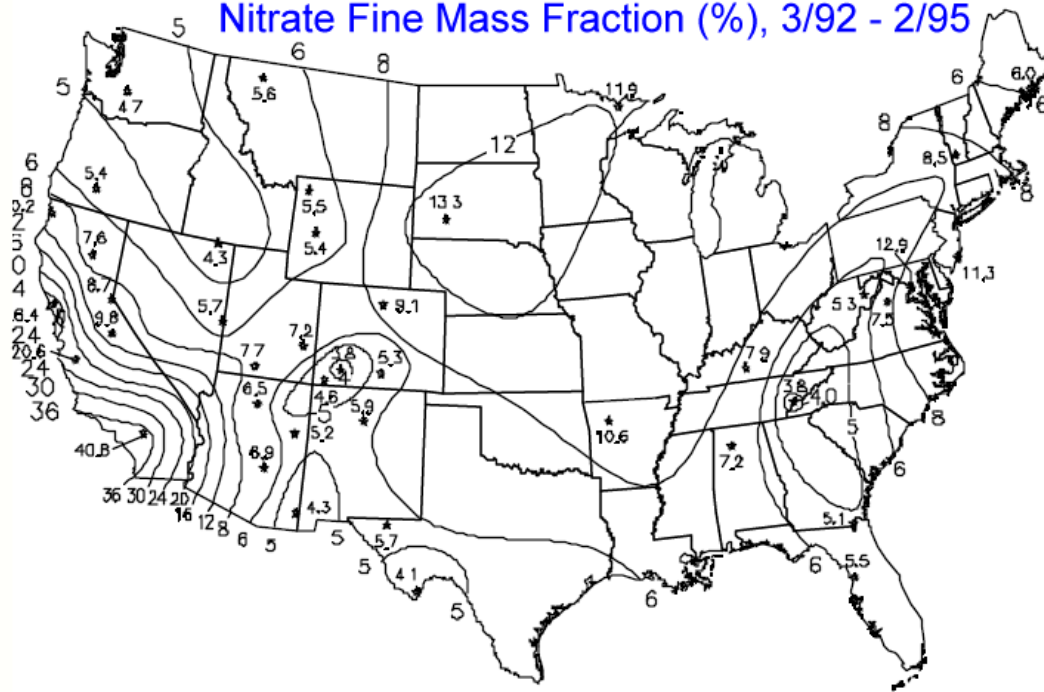


National Aerosol Nitrate Map

Based on 2nd 3 years of IMPROVE data, March 1992 through Feb 1995

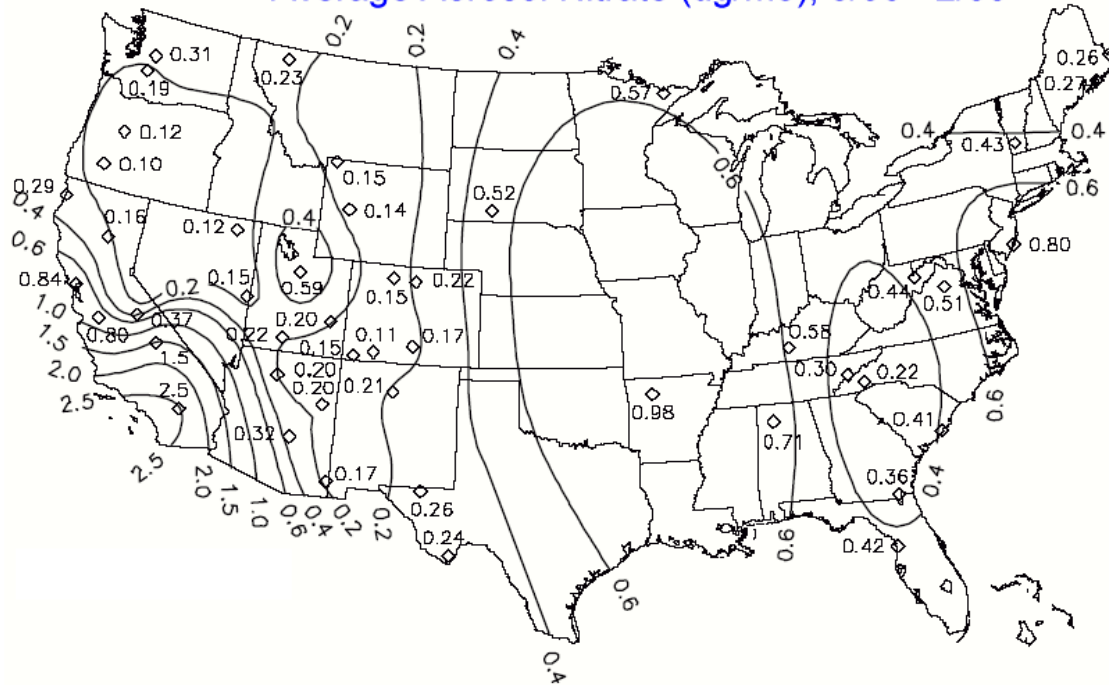
43 IMPROVE sites

Nitrate Fine Mass Fraction (%), 3/92 - 2/95



From: *Spatial and Seasonal Patterns and Long Term Variability of the Composition of the Haze in the United States: An Analysis of Data from the IMPROVE Network, Report II (1996)*

Average Aerosol Nitrate ($\mu\text{g}/\text{m}^3$), 3/96 - 2/99

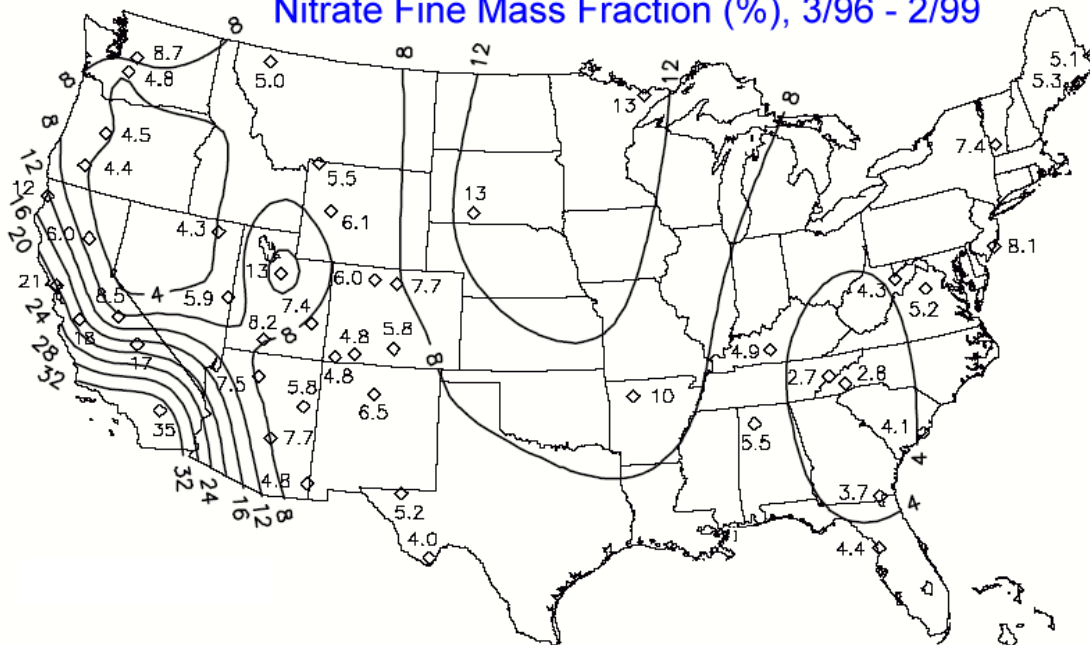


National Aerosol Nitrate Map

Based on 3rd 3 years of IMPROVE data, March 1996 through Feb 1999

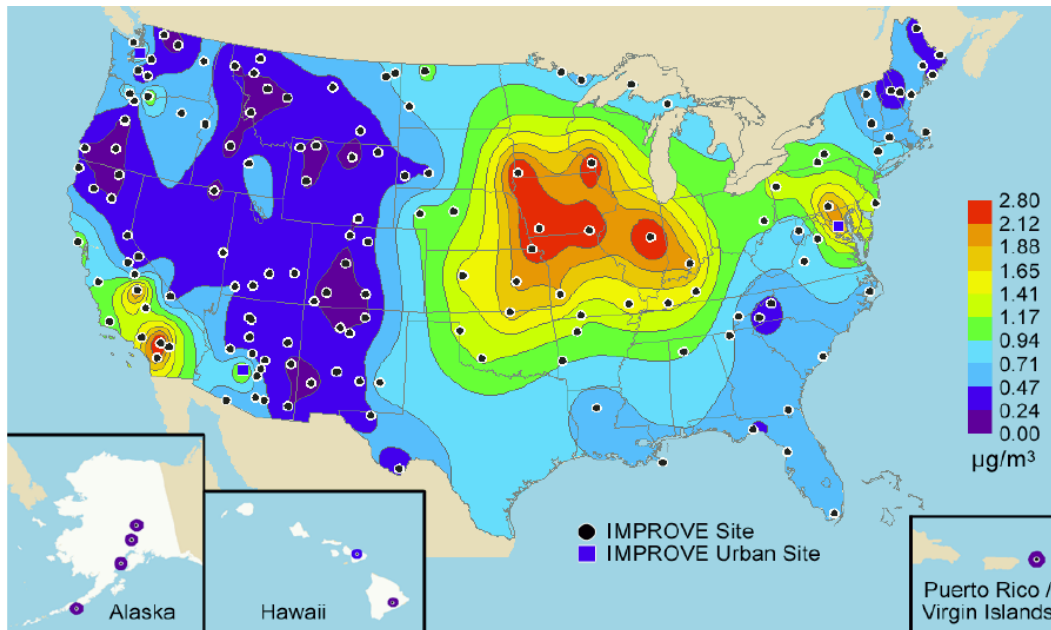
45 IMPROVE Sites

Nitrate Fine Mass Fraction (%), 3/96 - 2/99



From: *Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report III (2000)*

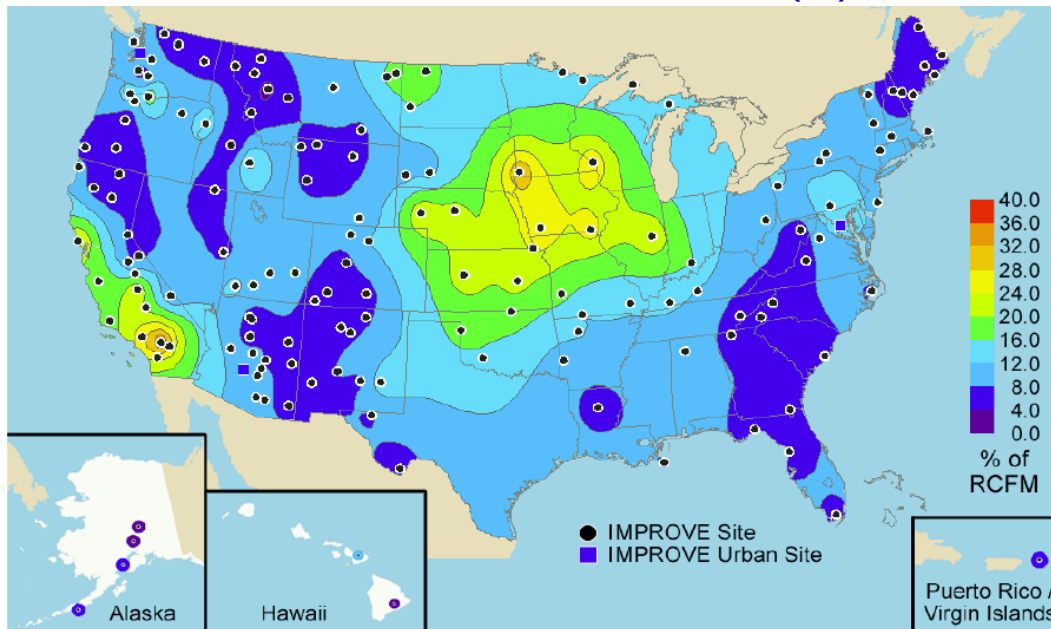
Average Aerosol Ammonium Nitrate ($\mu\text{g}/\text{m}^3$), 2000-04



National Aerosol Nitrate Map

Based on 5 years of
IMPROVE data,
Jan 2000 through
Dec 2004

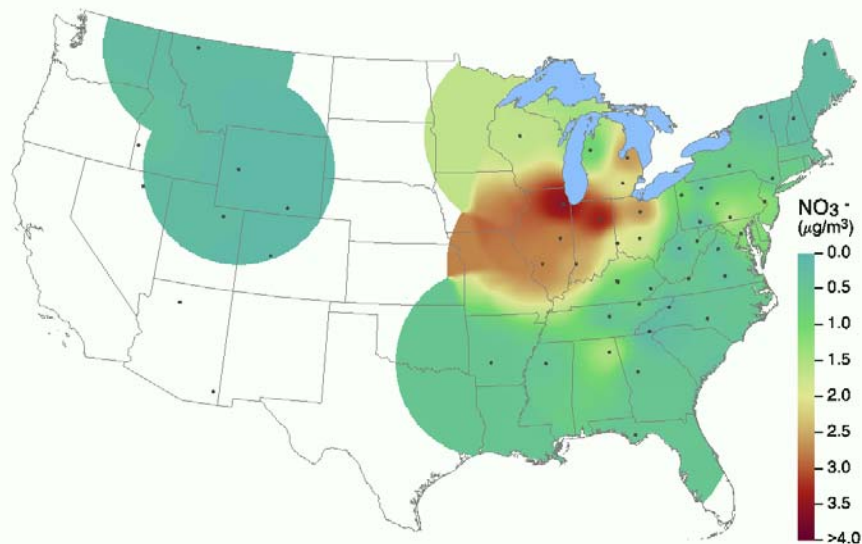
Ammonium Nitrate Fine Mass Fraction (%) 2000-04



157 IMPROVE Sites

From: *Spatial and
Seasonal Patterns and
Temporal Variability of
Haze and its
Constituents in the
United States: Report IV
November 2006*

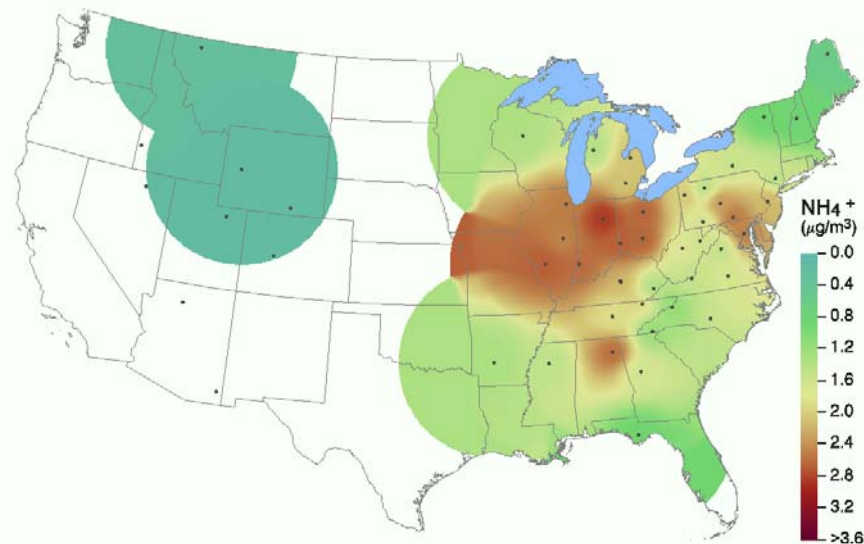
CASTNET PM Nitrate: 1989-1991



Source: CASTNET

USEPA/CAMD 08/01/06

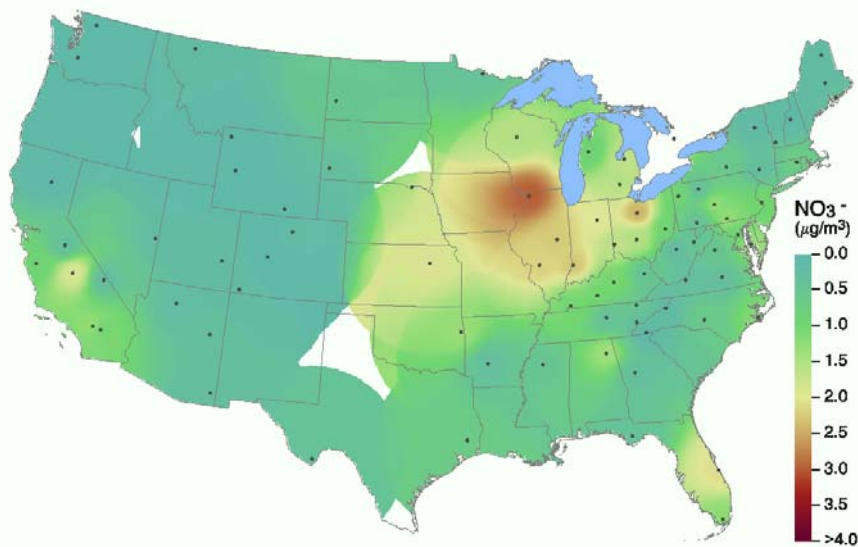
CASTNET PM Ammonium: 1989-1991



Source: CASTNET

USEPA/CAMD 08/01/06

CASTNET PM Nitrate: 2005-2007

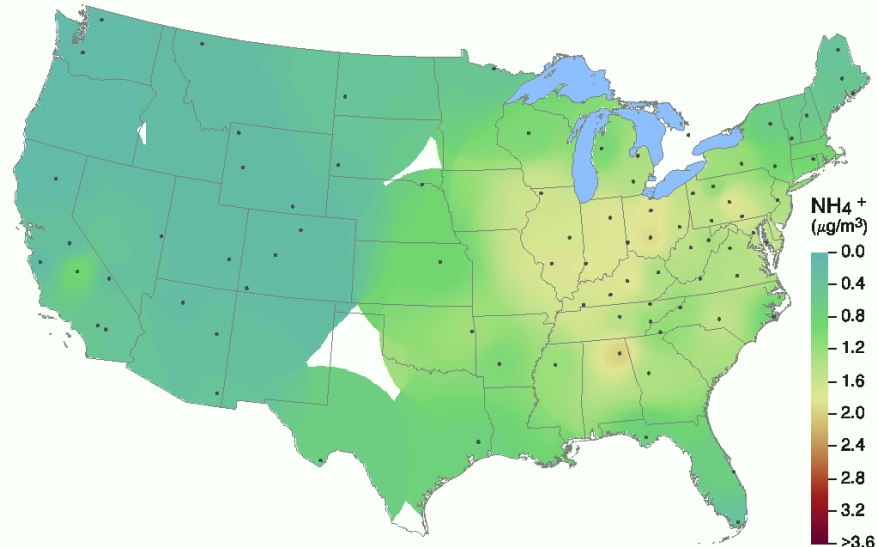


Source: CASTNET

USEPA/CAMD 07/29/08

[/data/camnet/g0207/na3_p0207.gif](#)

CASTNET PM Ammonium: 2005-2007

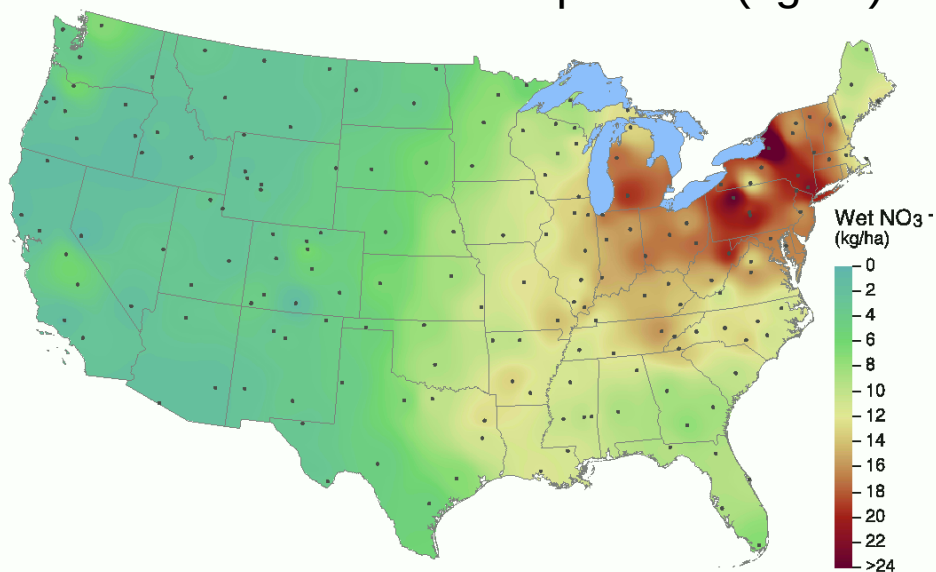


Source: CASTNET

USEPA/CAMD 07/29/08

[/data/camnet/g0207/na4_p0207.gif](#)

1989-91 Wet NO₃⁻ Deposition (kg/ha)

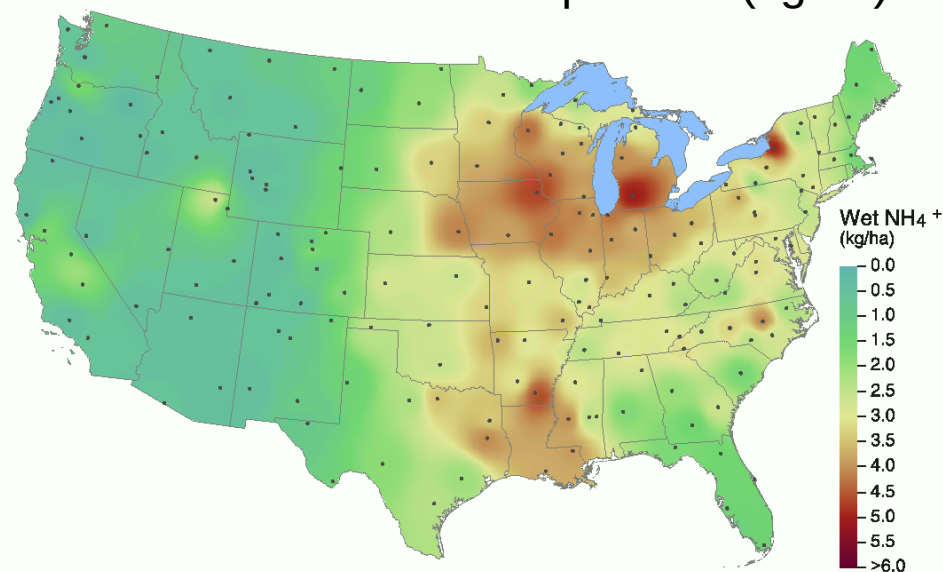


Source: NADP

USEPA/CAMD 08/01/06

[http://nadp.slcr.gov/camd/08/01/06/16/16_4-8001.gif](#)

1989-91 Wet NH₄⁺ Deposition (kg/ha)

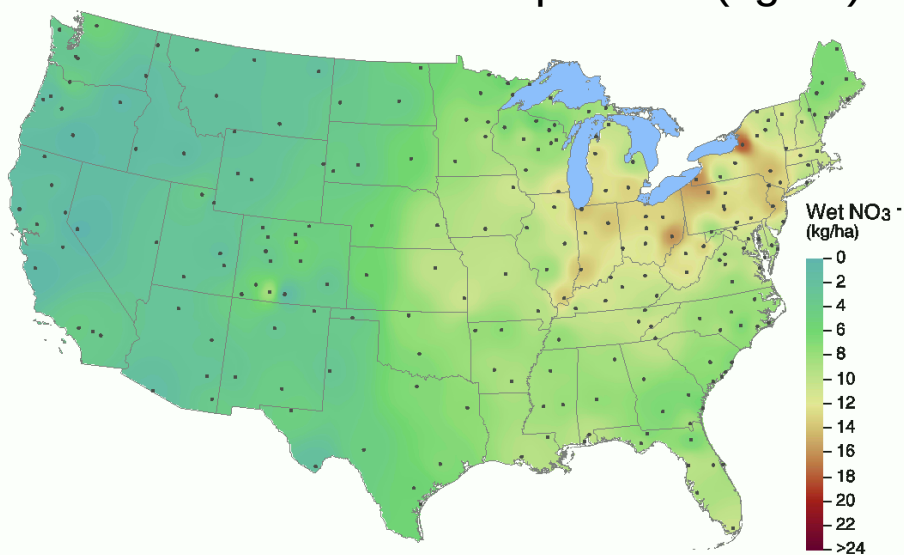


Source: NADP

USEPA/CAMD 08/01/06

[http://nadp.slcr.gov/camd/08/01/06/16/16_4-8001.gif](#)

2005-07 Wet NO₃⁻ Deposition (kg/ha)

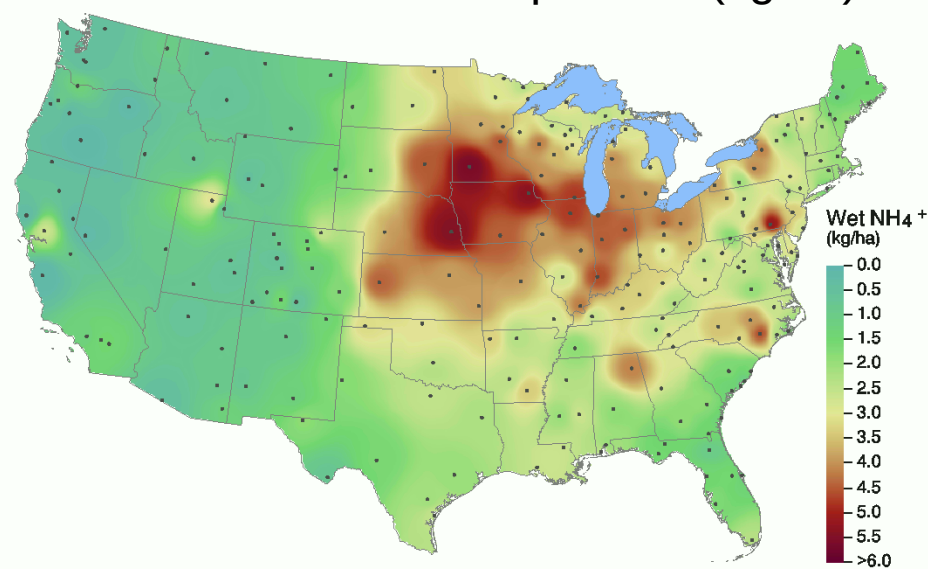


Source: NADP

USEPA/CAMD 07/29/08

[http://nadp.slcr.gov/camd/07/29/08/16/16_4-8001.gif](#)

2005-07 Wet NH₄⁺ Deposition (kg/ha)

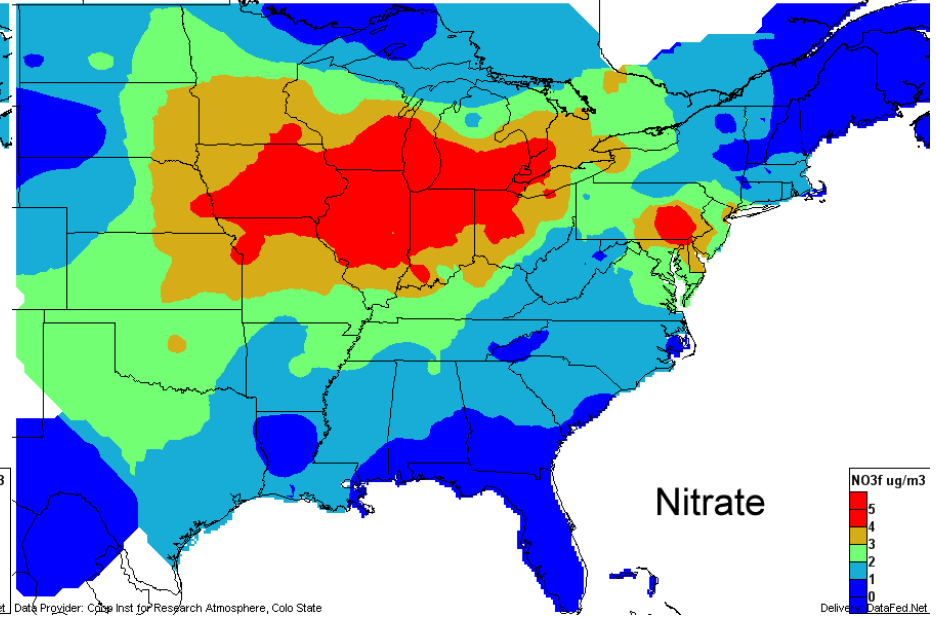
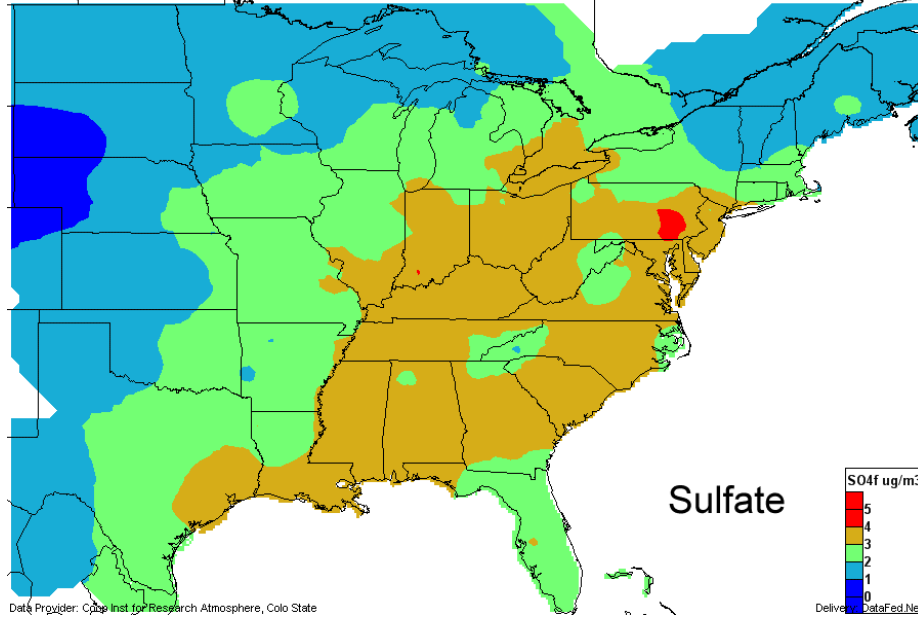
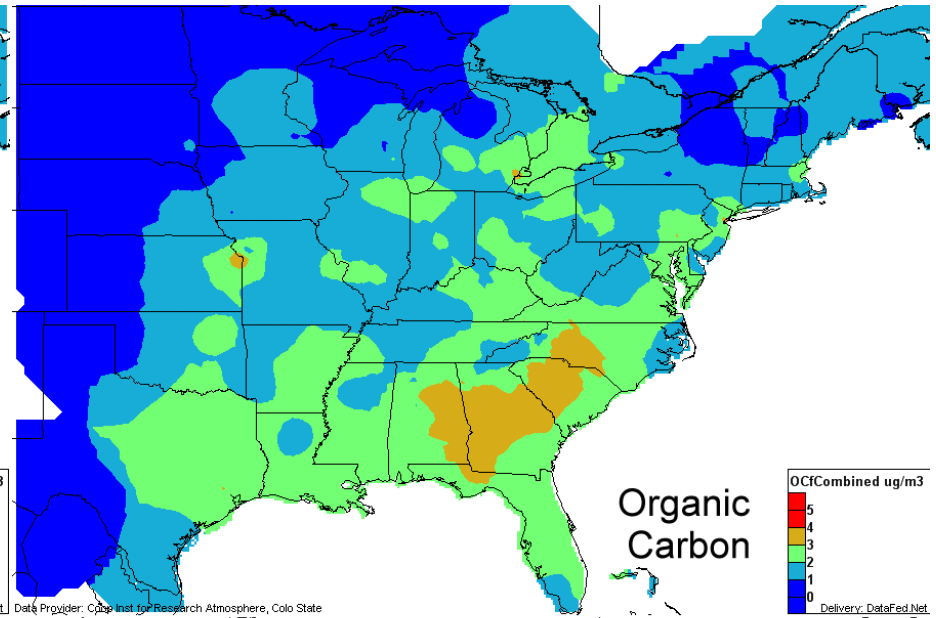
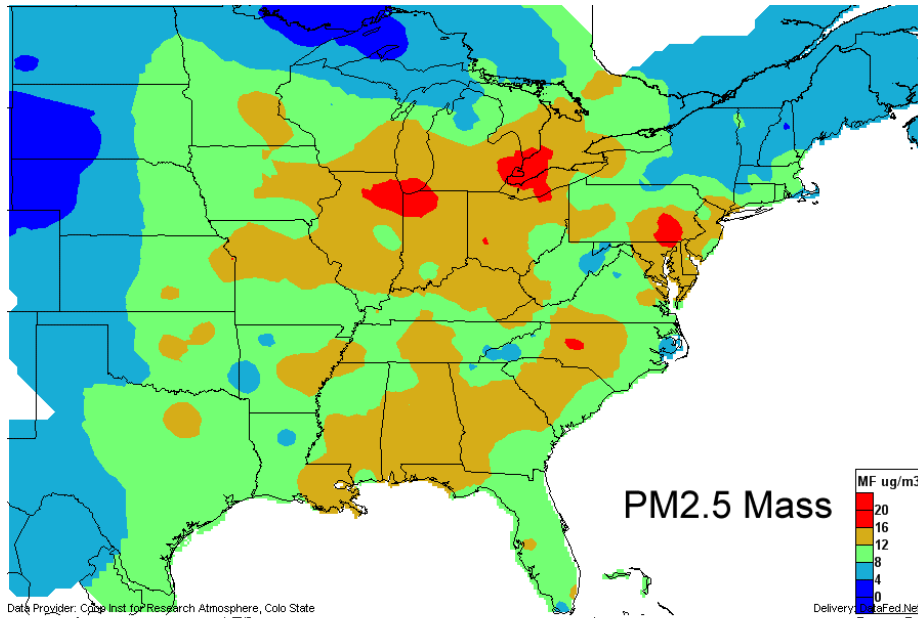


Source: NADP

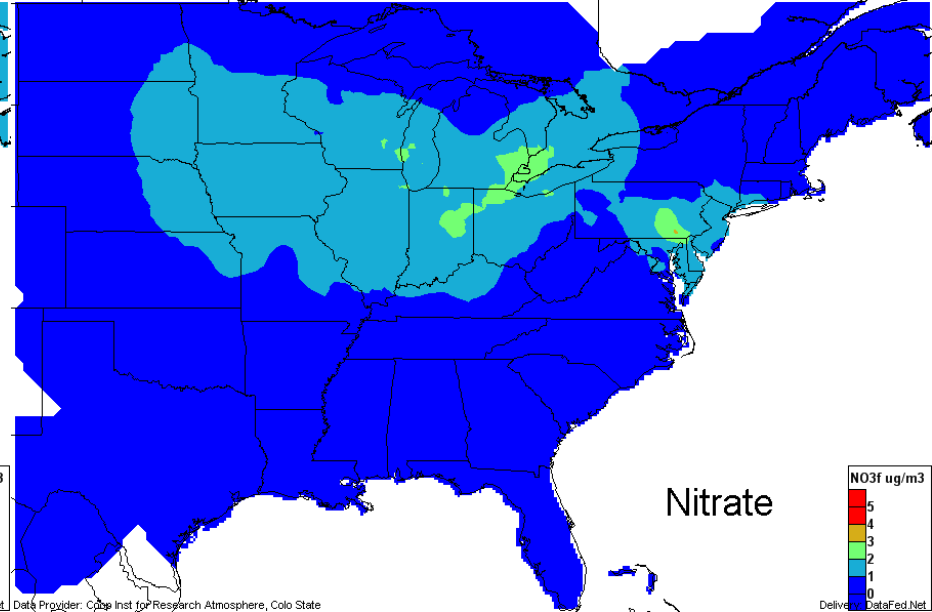
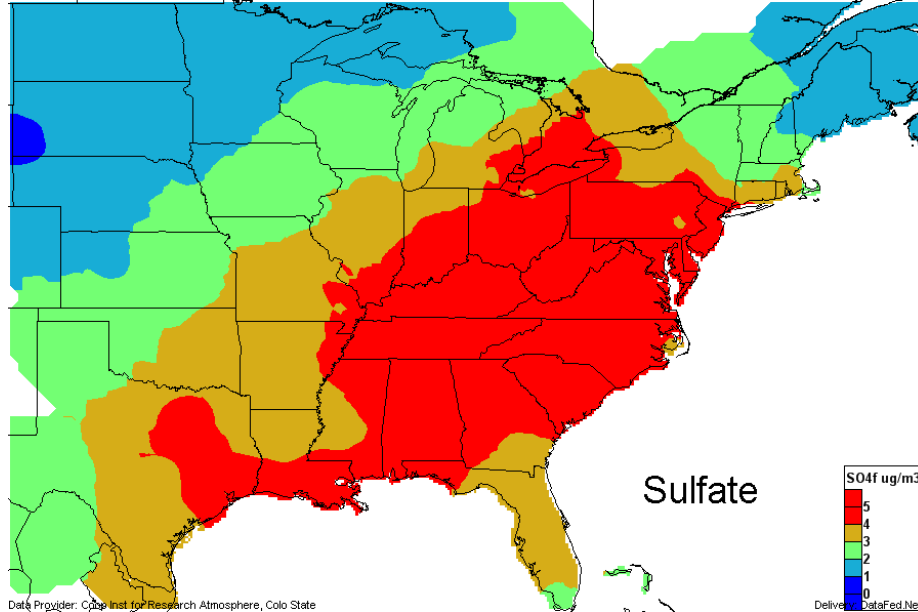
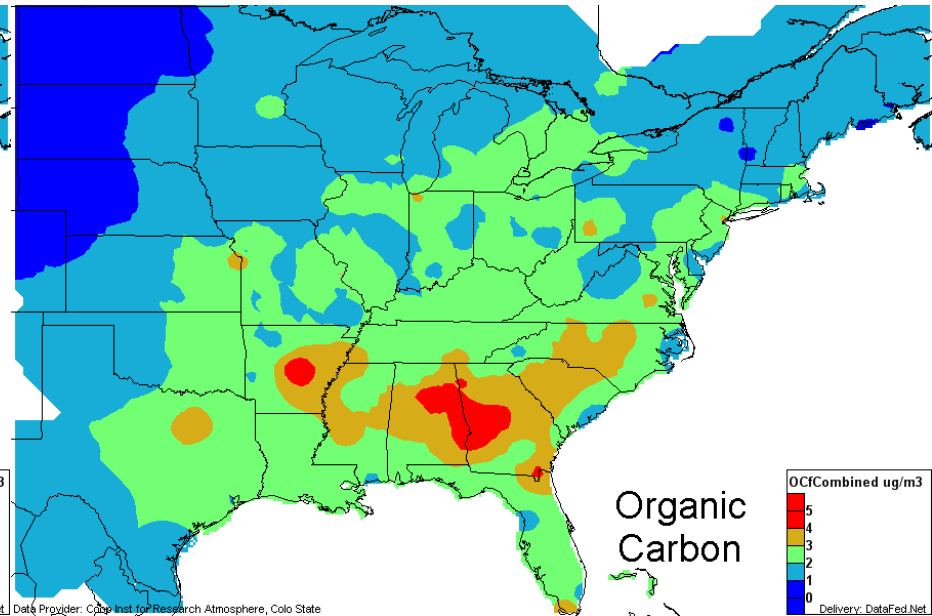
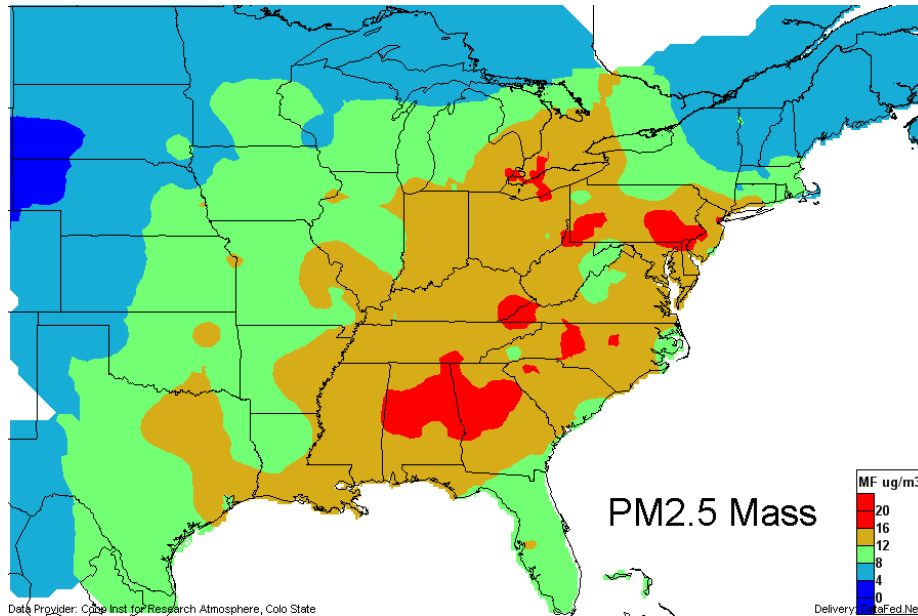
USEPA/CAMD 07/29/08

[http://nadp.slcr.gov/camd/07/29/08/16/16_4-8001.gif](#)

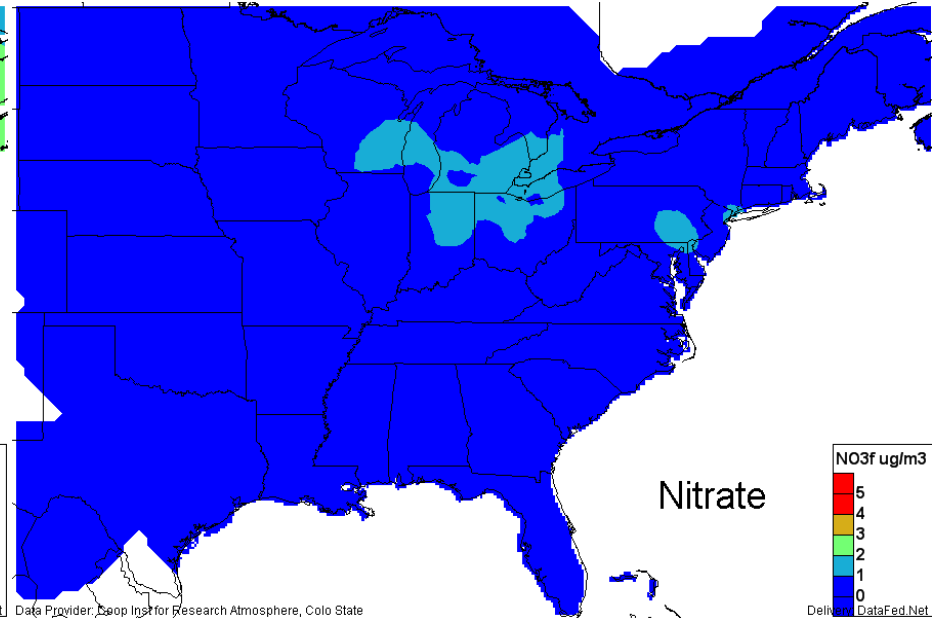
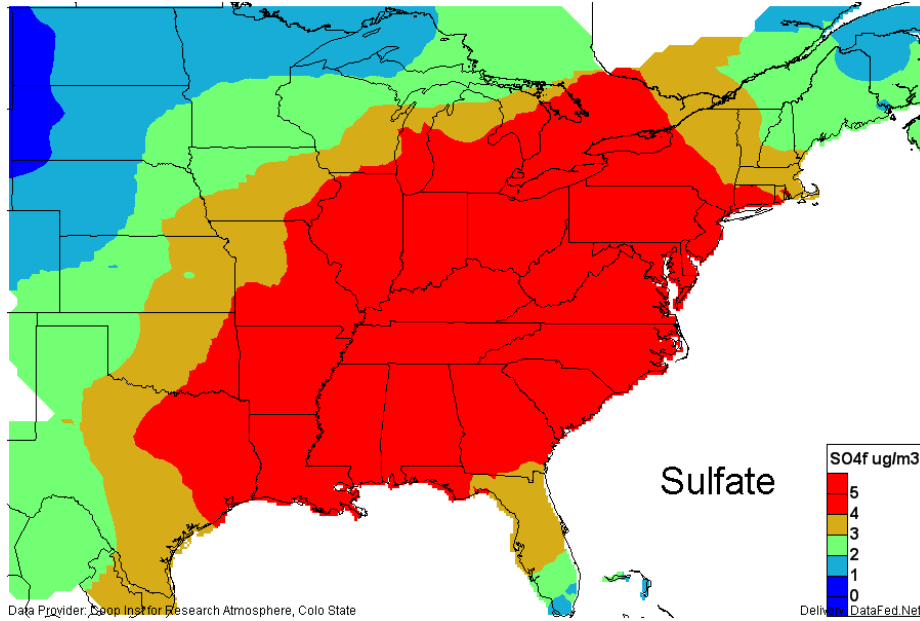
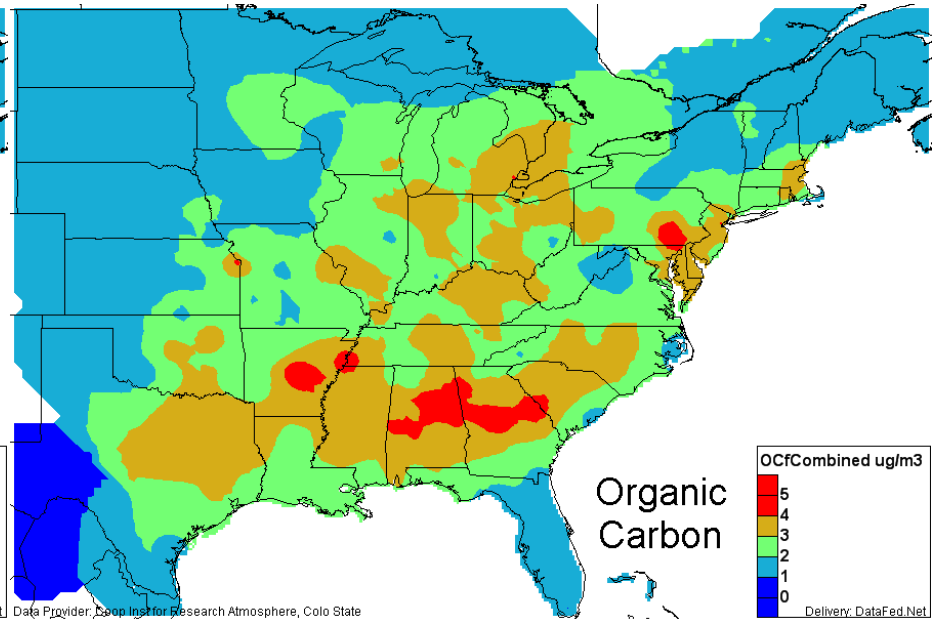
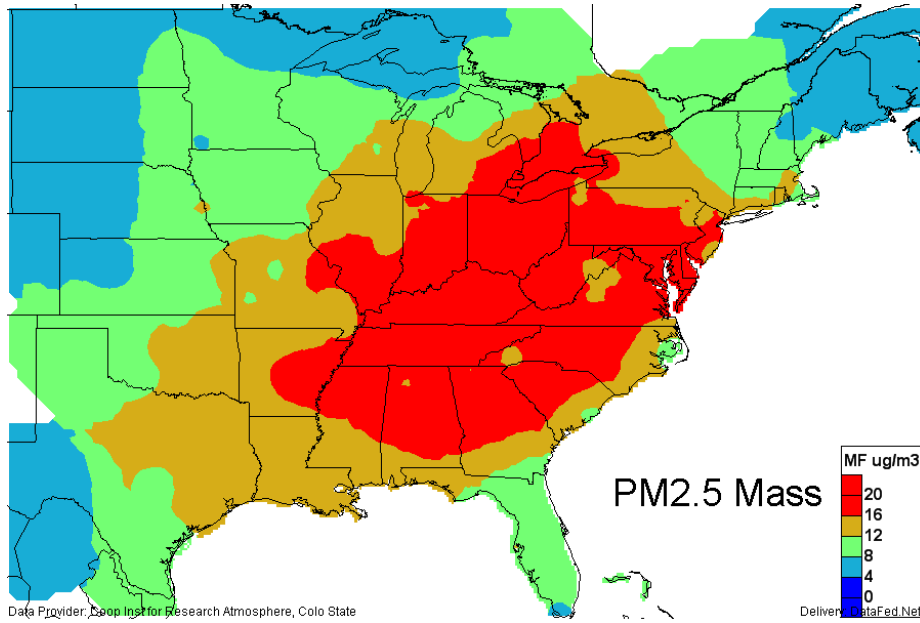
1st Quarter (JFM) 2002-2006 Fine Mass & Species from IMPROVE + CSN



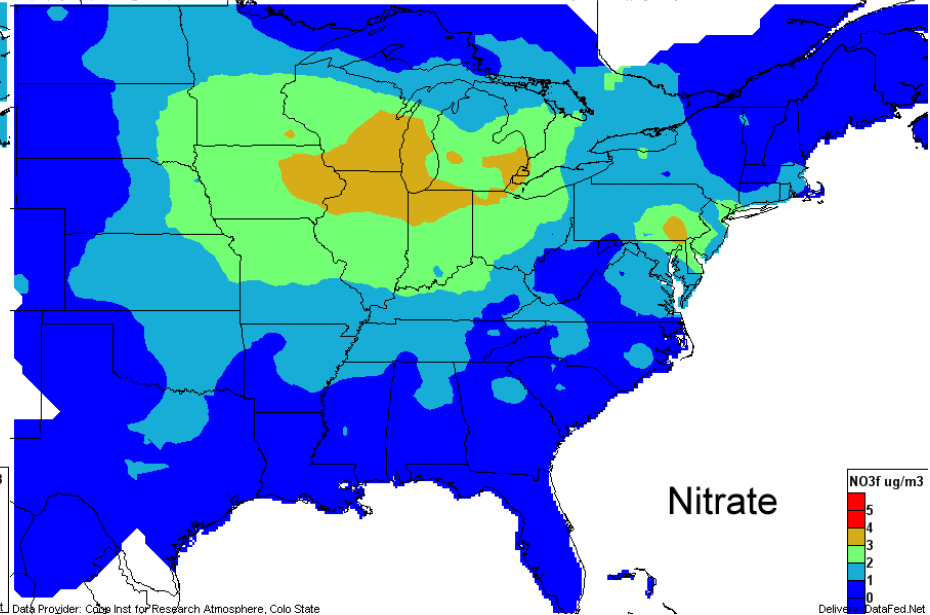
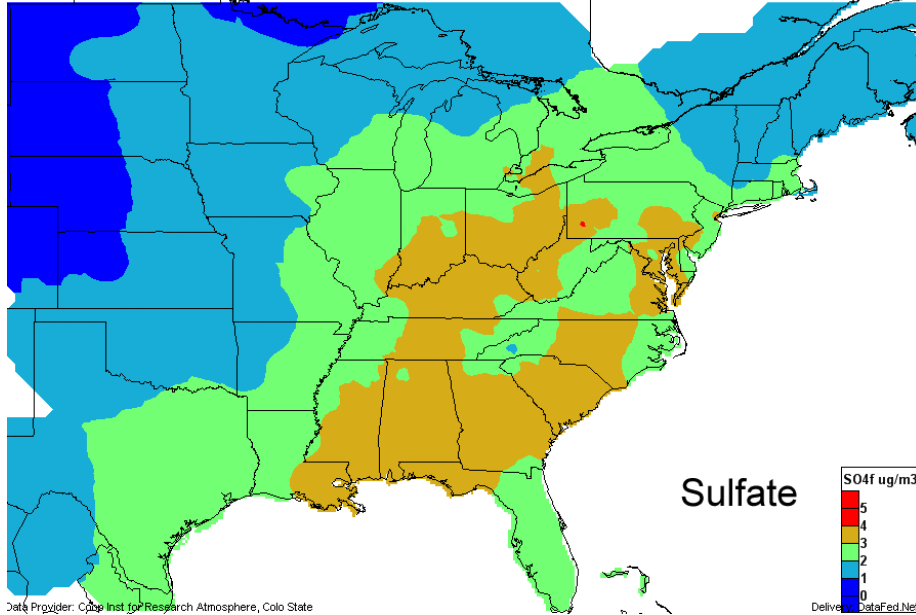
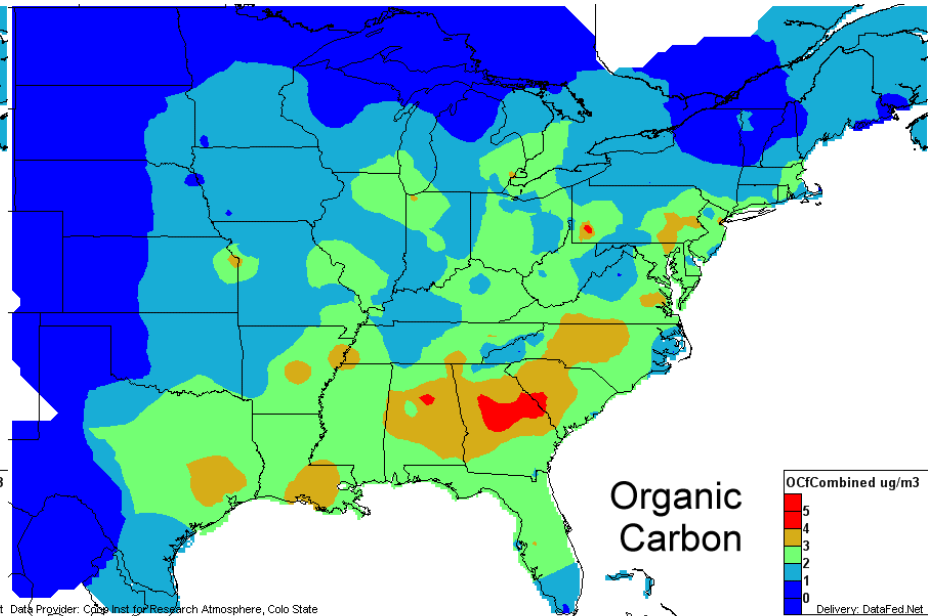
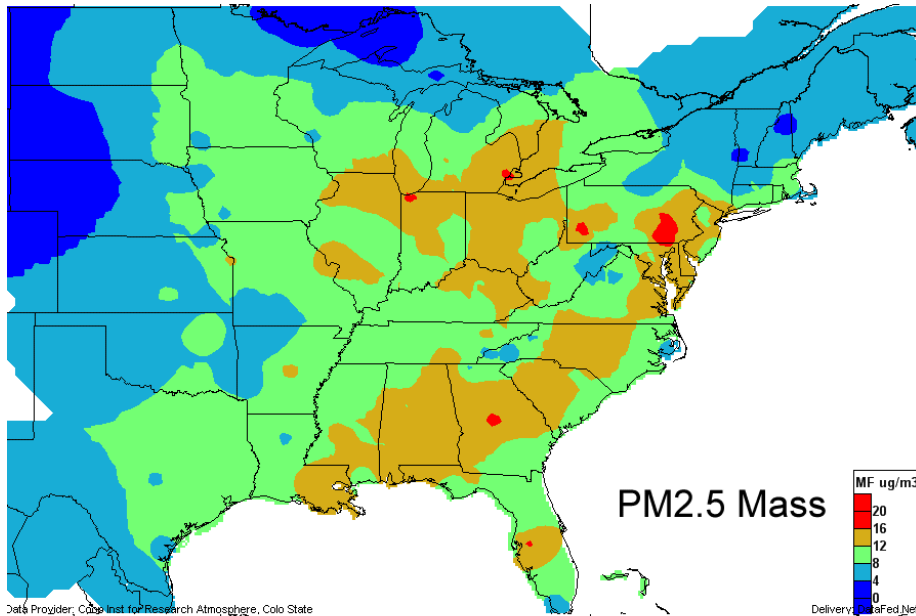
2nd Quarter (AMJ) 2002-2006 Fine Mass & Species from IMPROVE + CSN



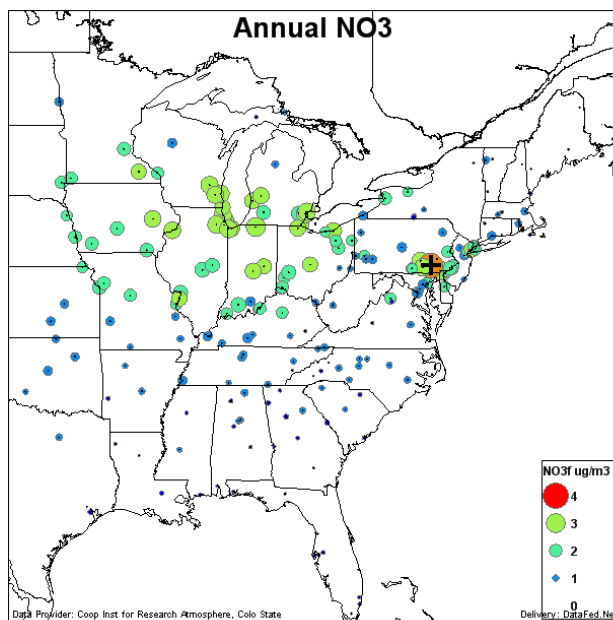
3rd Quarter (JAS) 2002-2006 Fine Mass & Species from IMPROVE + CSN



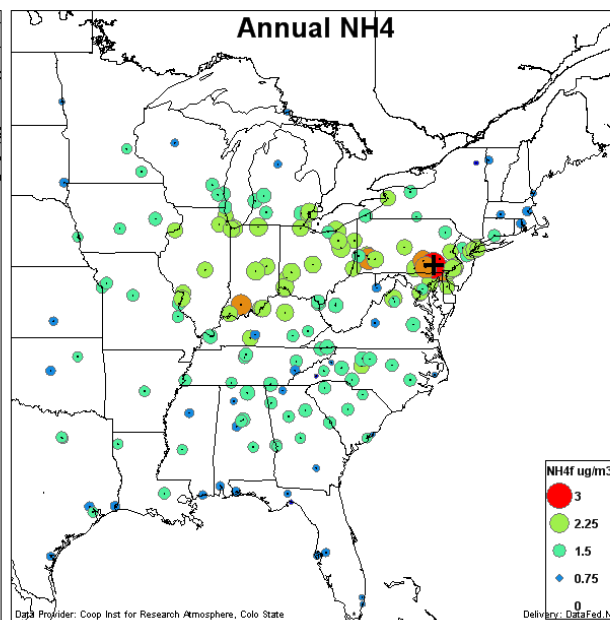
4th Quarter (OND) 2002-2006 Fine Mass & Species from IMPROVE + CSN



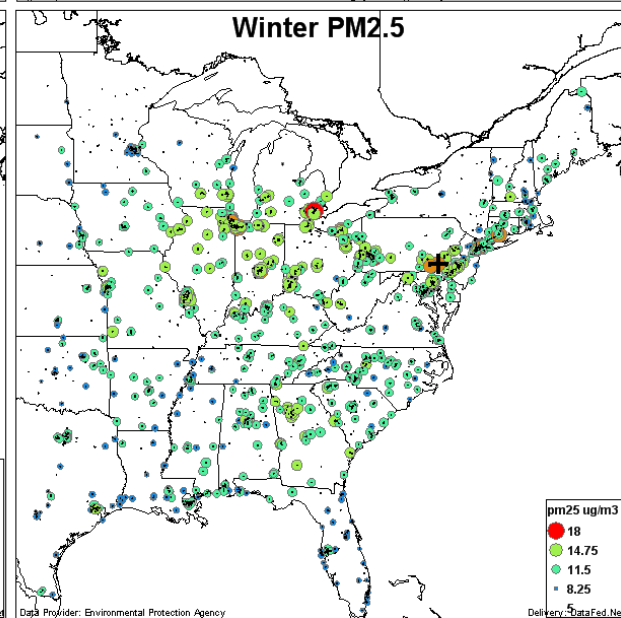
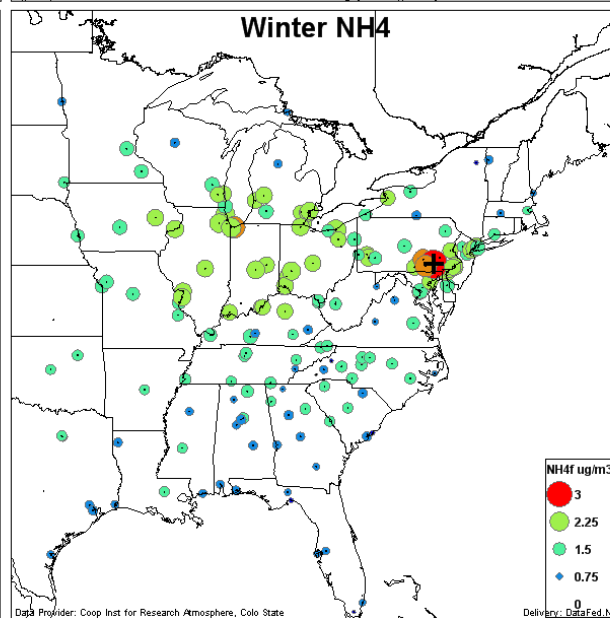
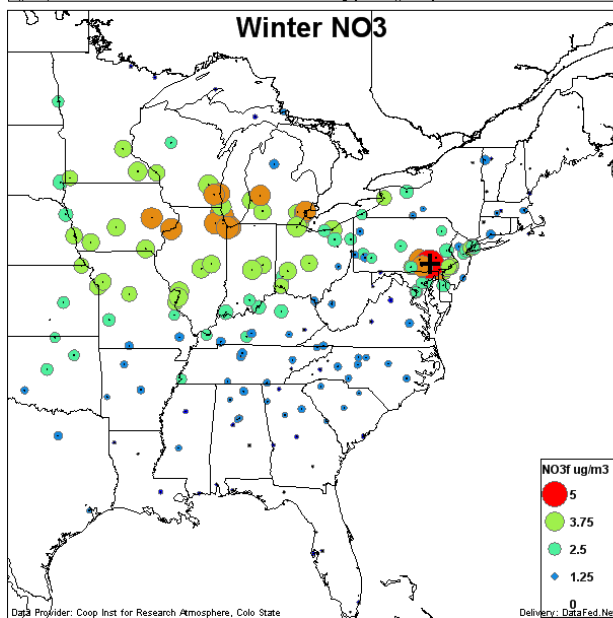
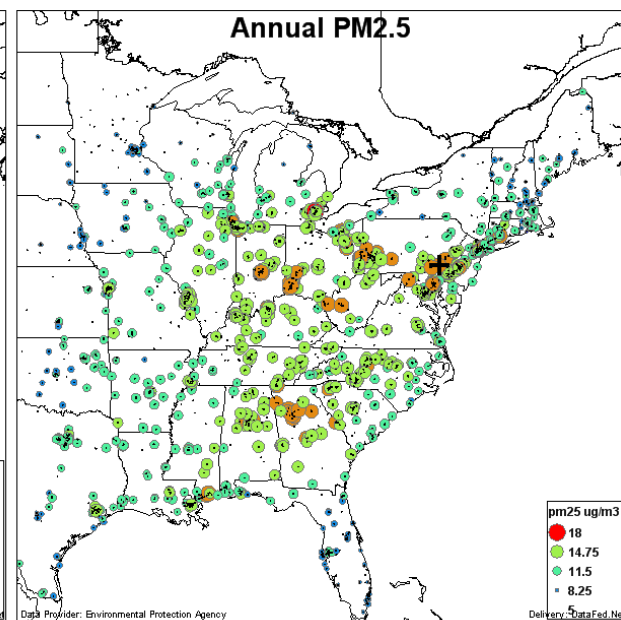
PM2.5 Nitrate



PM2.5 Ammonium



PM2.5 Mass

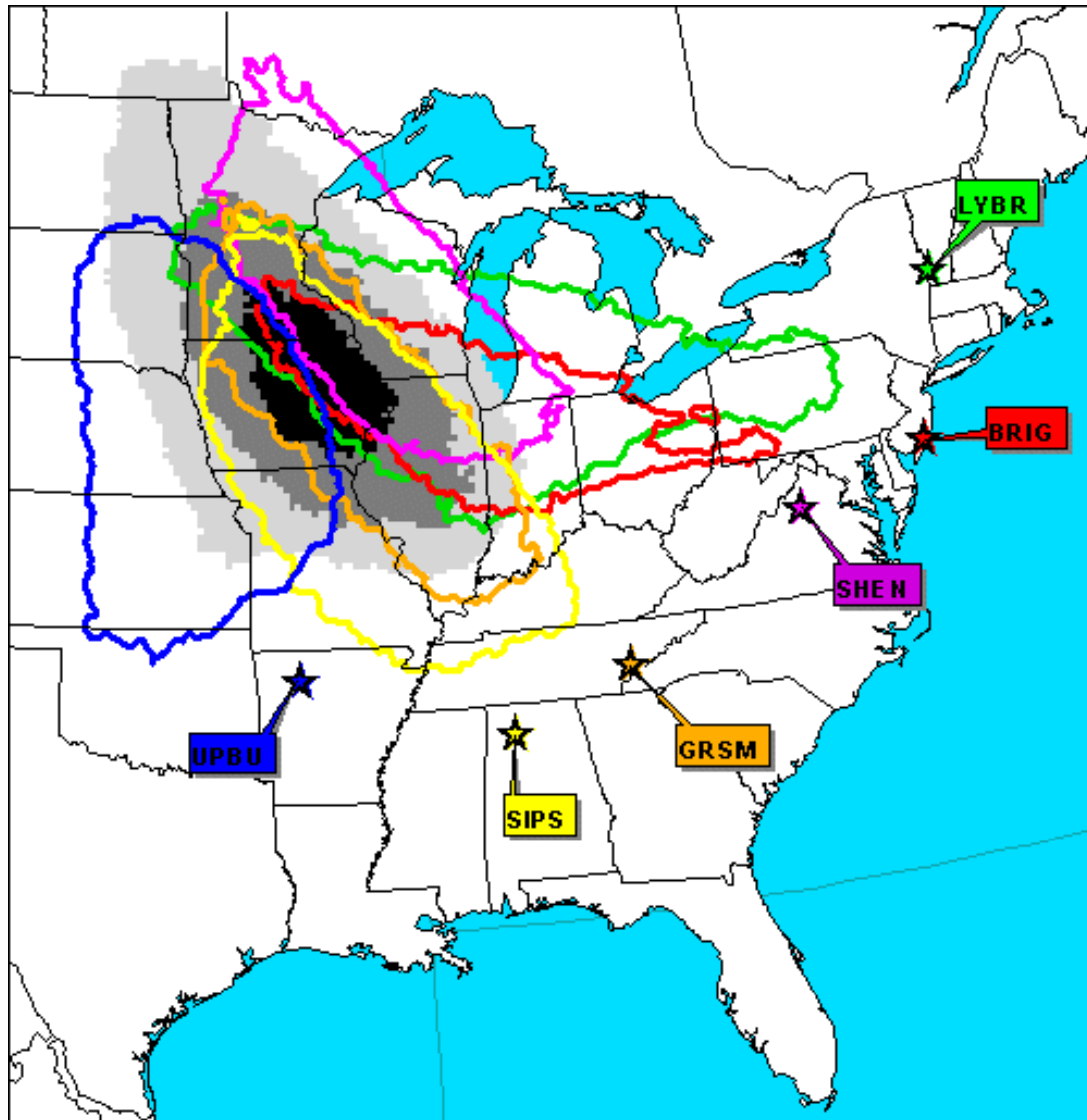


IMPROVE + CSN

CSN-ONLY

FRM

Incremental Probability Fields for High Nitrate at 6 IMPROVE Sites, 1992-2004



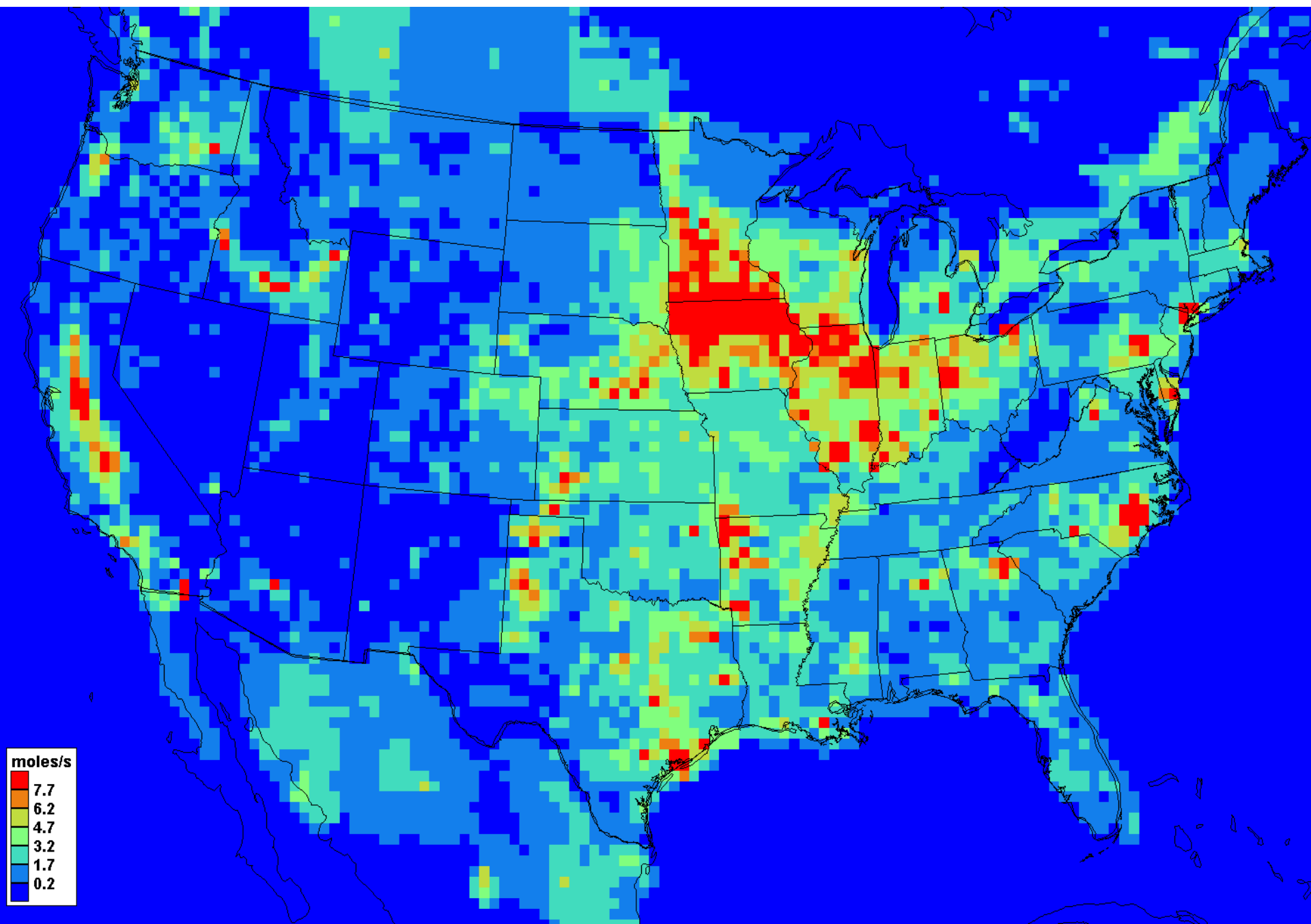
Incremental Probability
Fields for High (top 20%)
Nitrate, 1992- 2004 from
Pitchford et al. (2008) at 6
Class 1 IMPROVE sites

Contour Intervals:

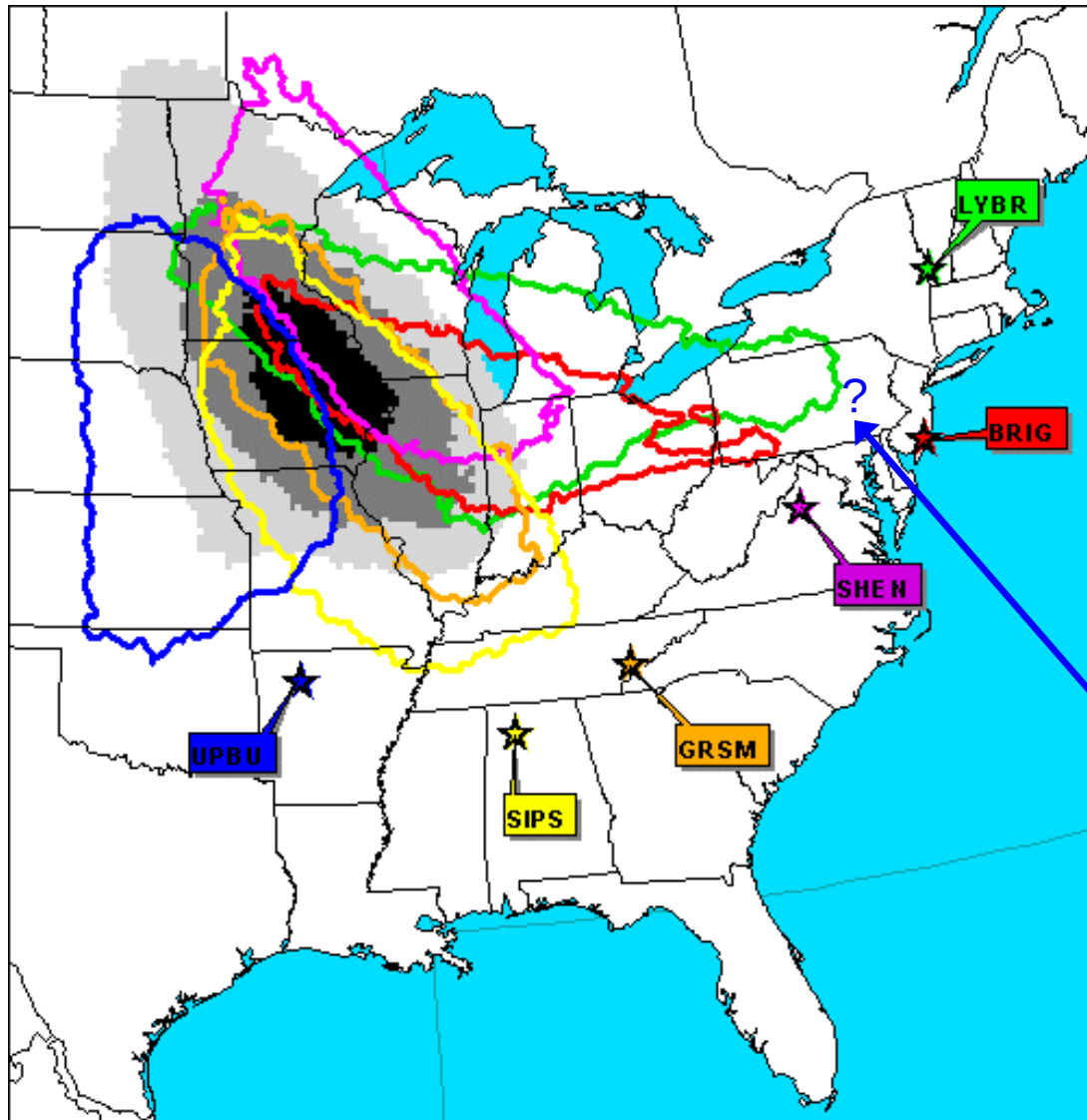
IP = 0.001

Shaded Area =
6-site Average

Spring NH₃ Emissions from WRAP (from Marc P)



Incremental Probability Fields for High Nitrate at 6 IMPROVE Sites, 1992-2004

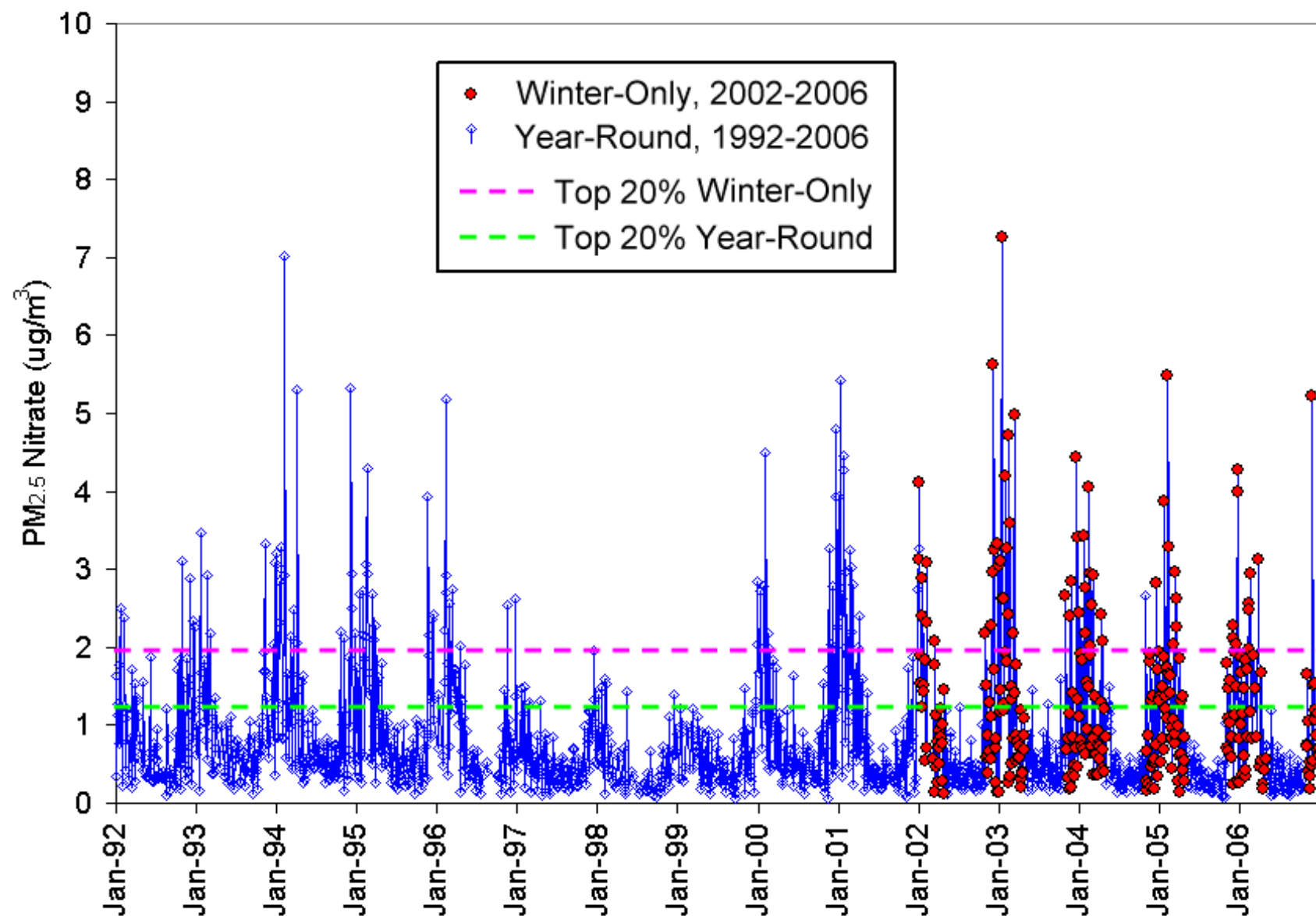


Incremental Probability Fields for High (top 20%) Nitrate, 1992- 2004 from *Pitchford et al. (2008)* at 6 Class 1 IMPROVE sites

Note: of these sites, Only Brigantine is East of the Appalachians

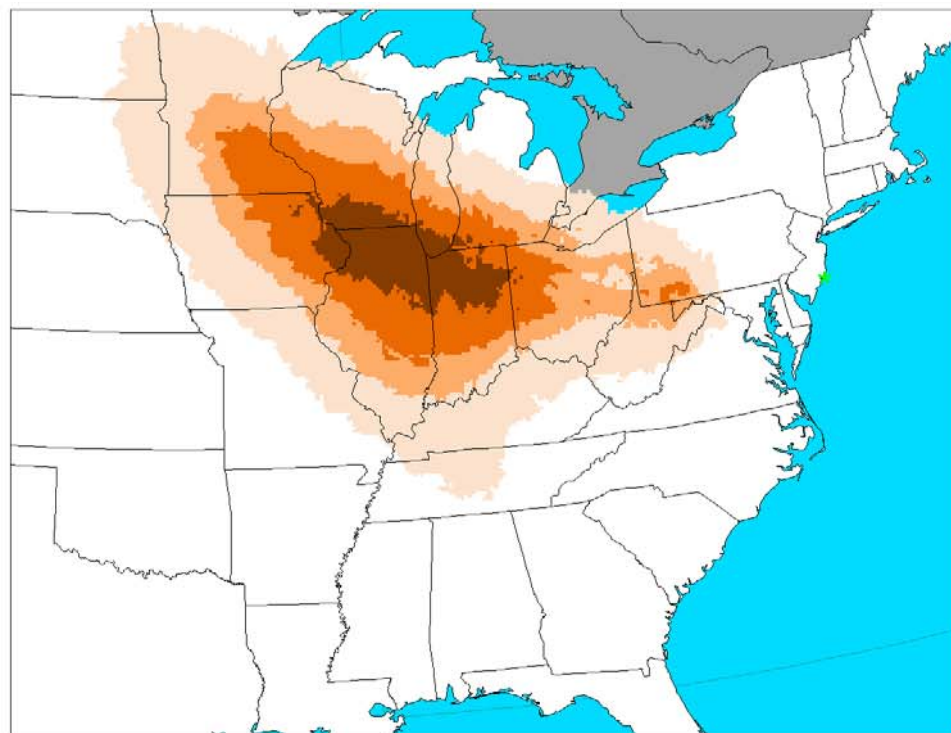
How Come SE PA area of High NH₃ emissions didn't show up at Brigantine?

Initial Incremental Probability Analysis of High (Top 20%) Nitrate focused on year-round data from 1992-2004; More recent analysis focused on Winter-only 2002-06

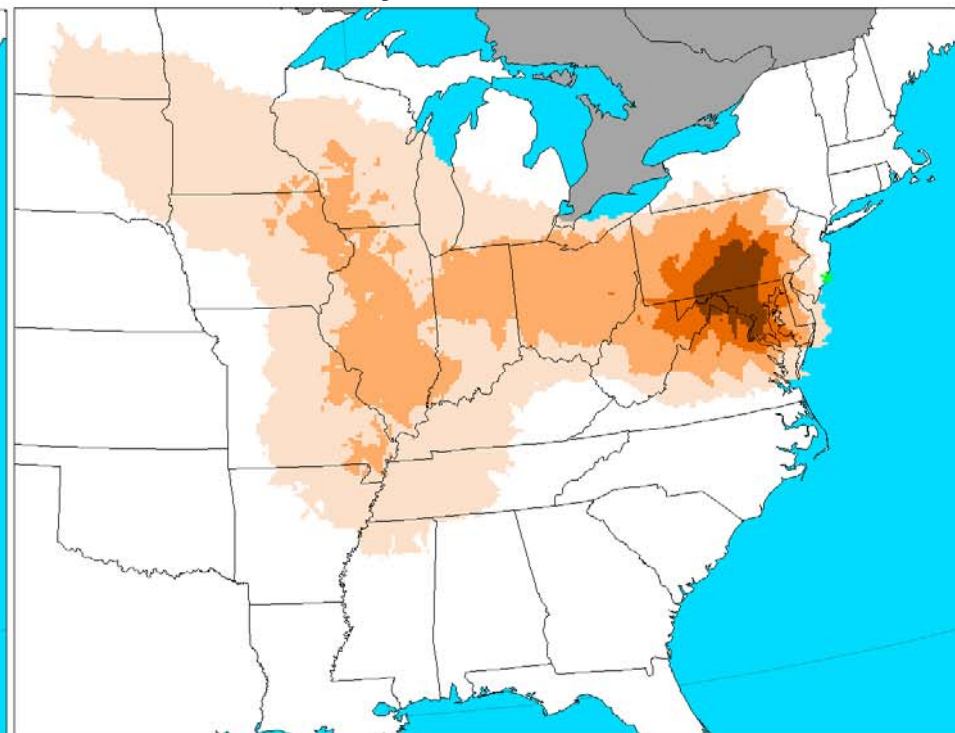


Incremental Probability Fields for “High” (top 20%) PM_{2.5} Nitrate at Brigantine NWR
based on

Year-Round Data, 1992-2006



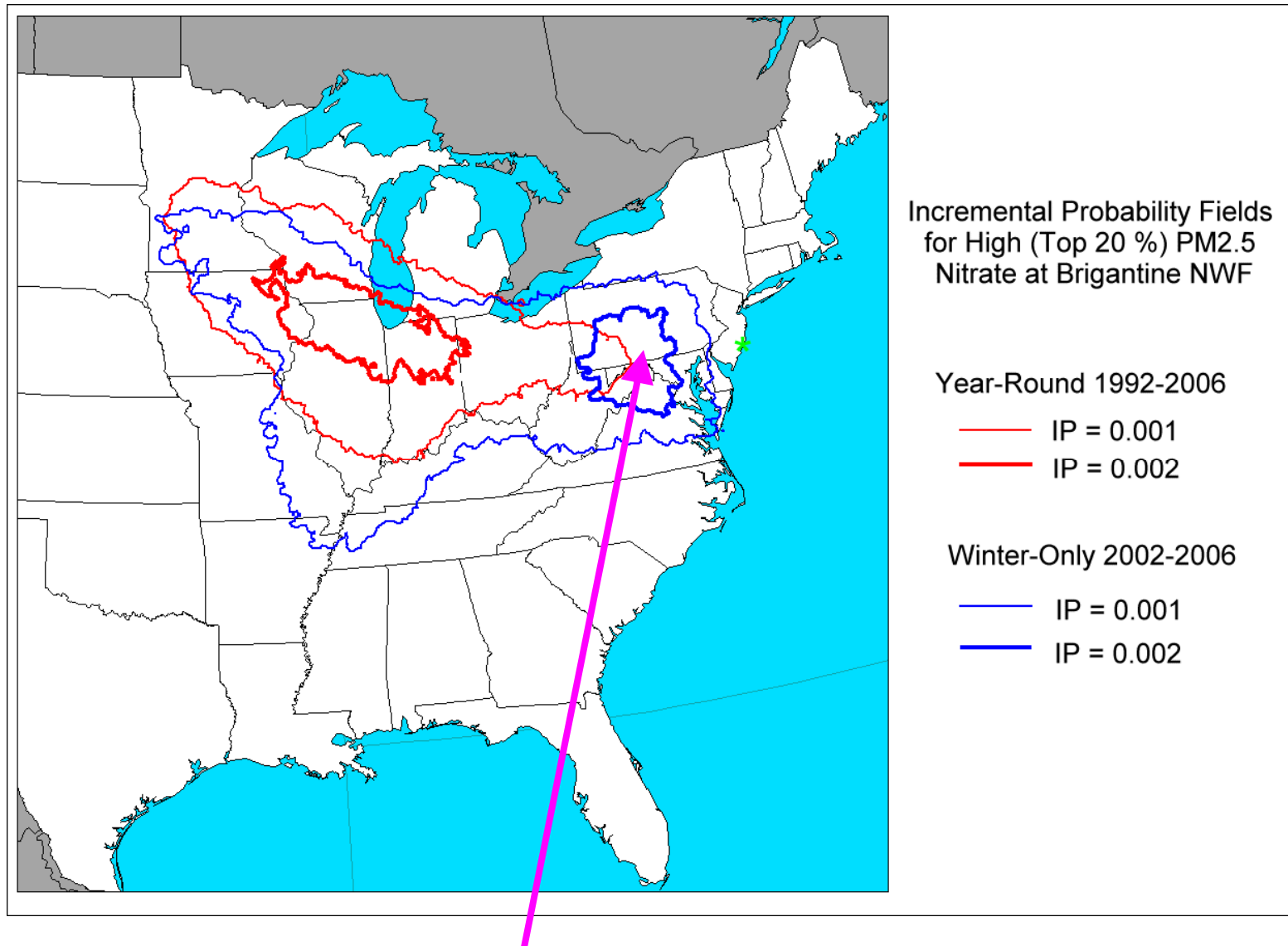
Winter-Only Data, 2002-2006



Where “High” NO₃ is > 1.2 ug/m³

Where “High” NO₃ is > 2 ug/m³

Incremental Probability Fields for High (top 20%) Nitrate at Brigantine NWR based on Year Round Data 1992-2006 (Red) vs. Winter-Only 2002-06 (Blue)



Note Greater Emphasis of Closer Sources when recent Winter-only data are used

Incremental Probability
Fields for High (top 20%)
Winter Nitrate, 2002-06
for 7 MANE-VU sites in
MA, CT, NY, NJ, DE, MD
& DC

Contour intervals:

IP = 0.002

Shaded Area =

7-site Average

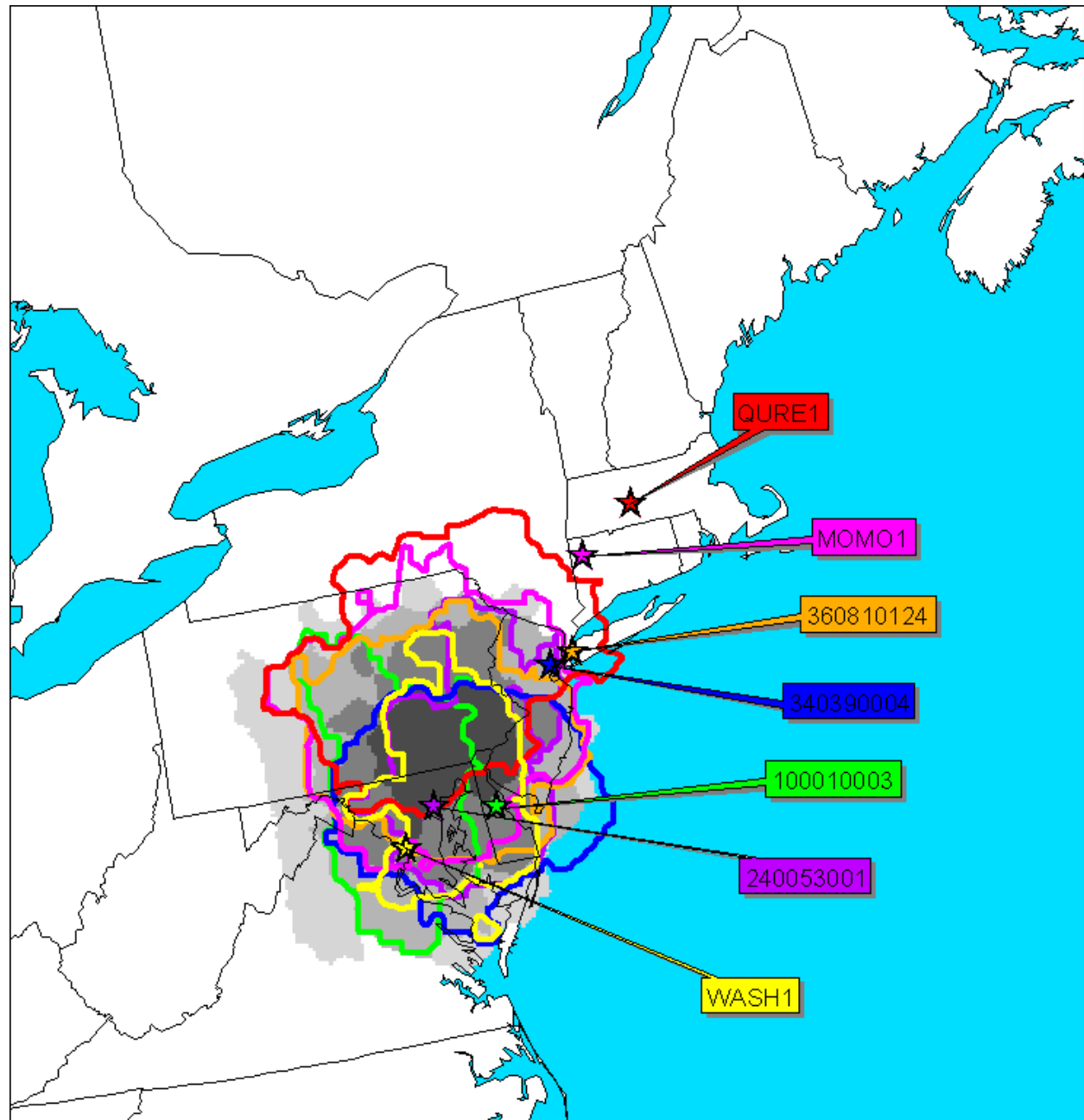
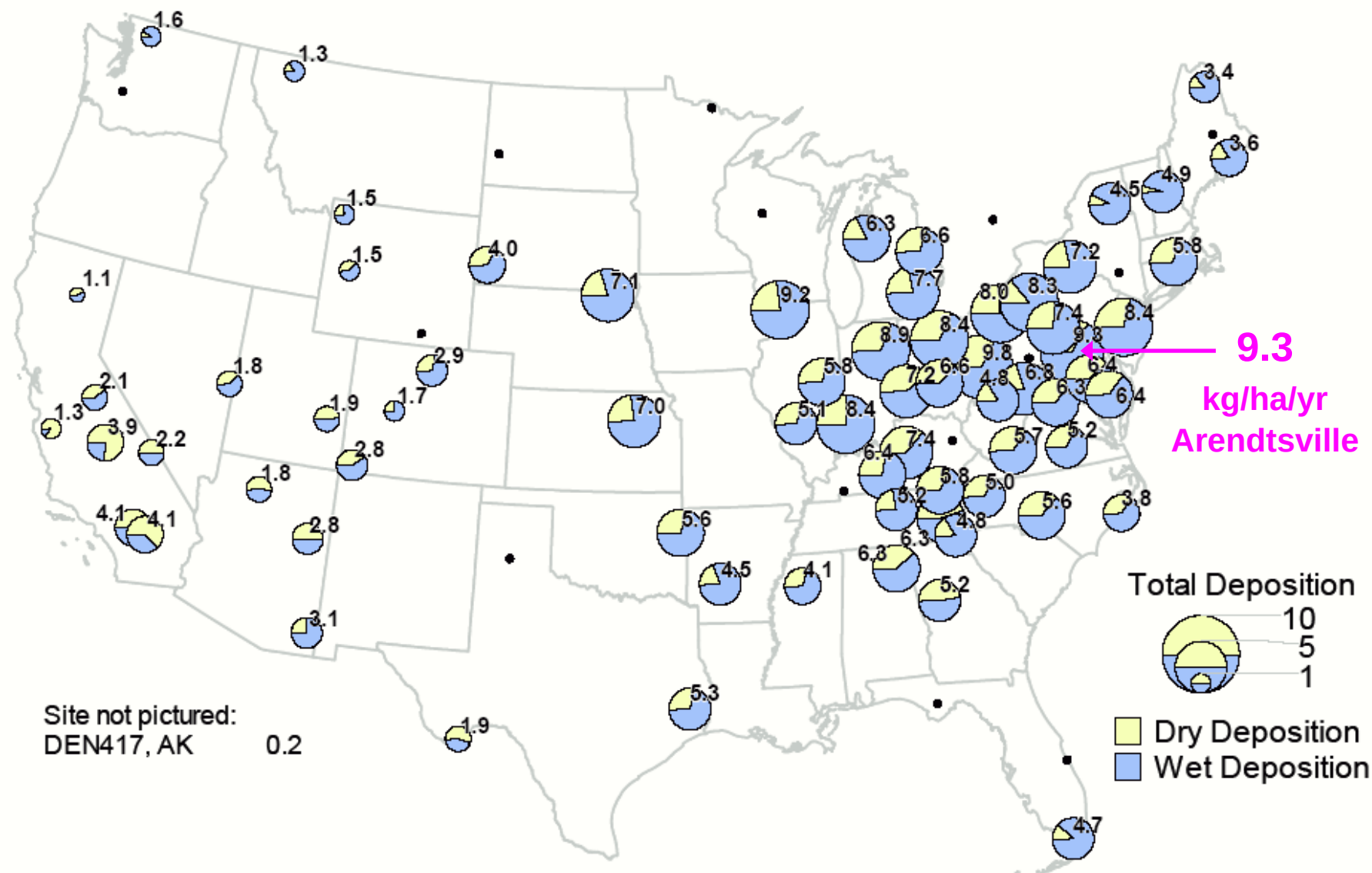


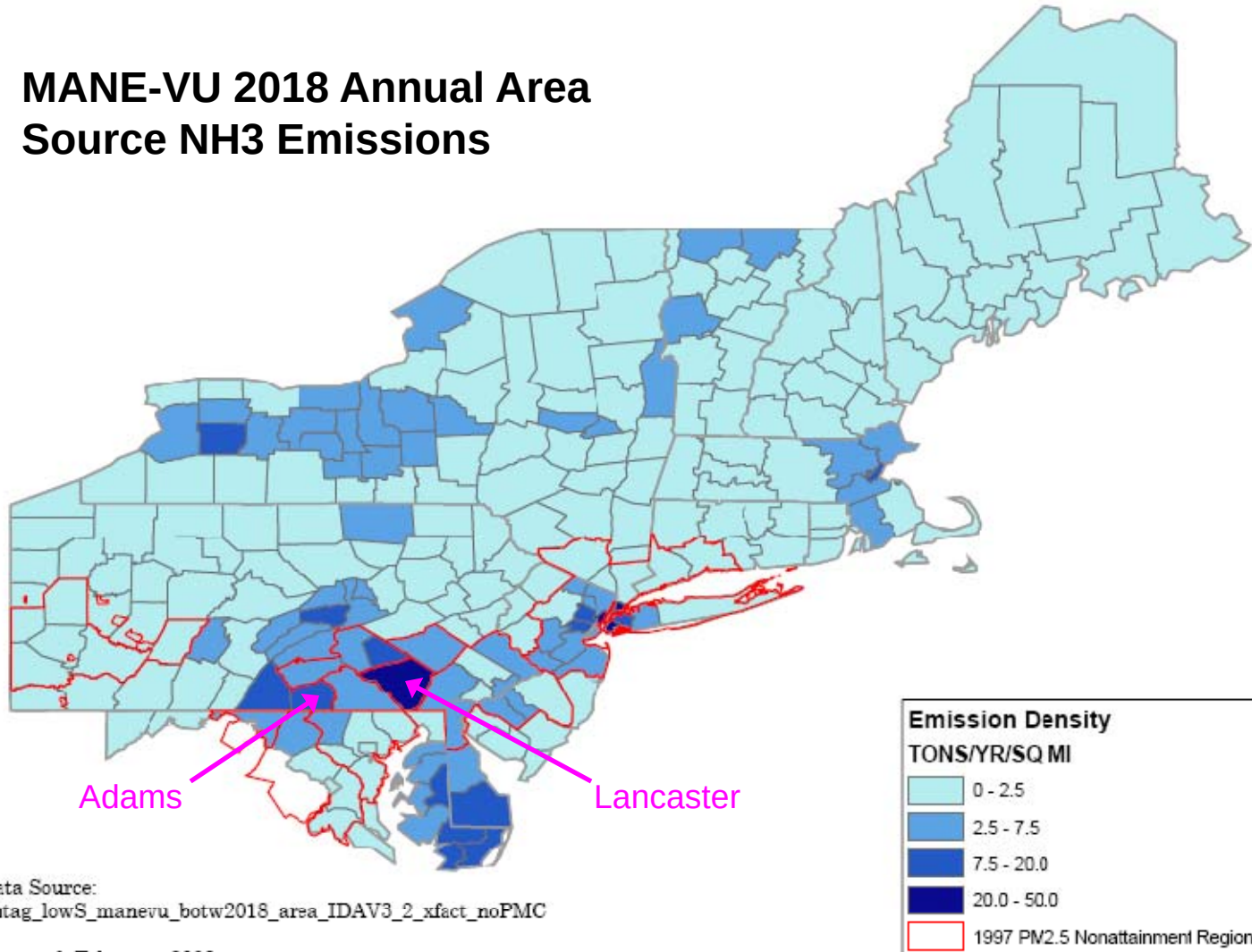
Figure 3-7 Total (Dry + Wet) Nitrogen Deposition (kg/ha/yr) for 2007

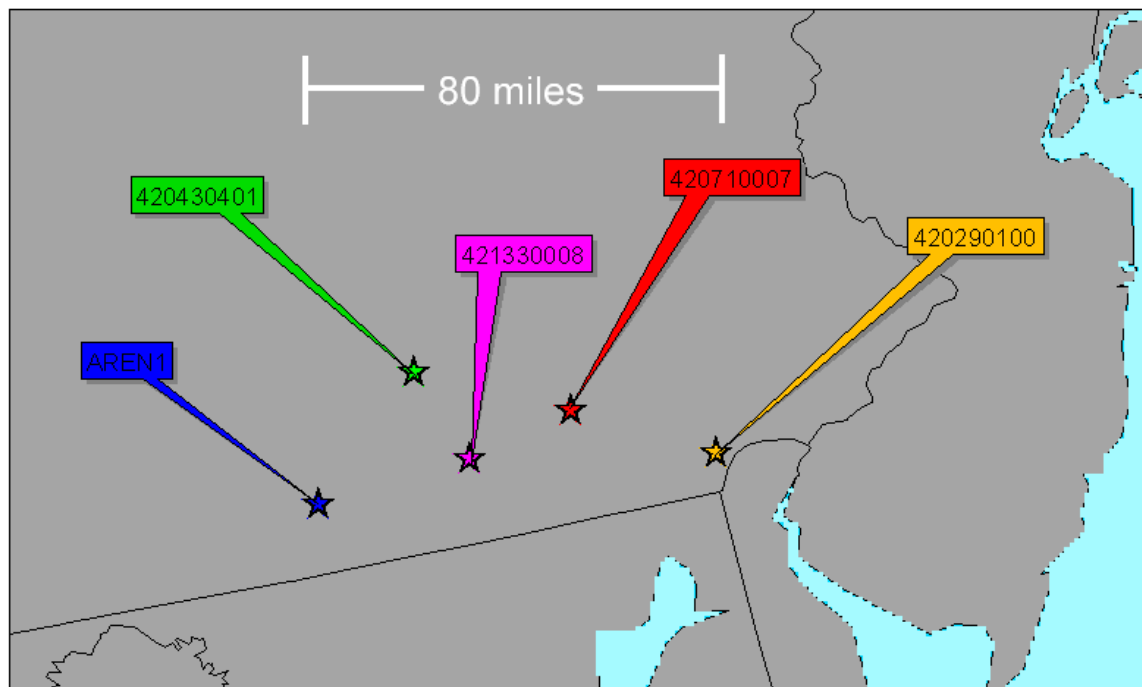


From CASTNET 2007 Annual Report

INVENTORY PROJECTS - MARAMA 2008

MANE-VU 2018 Annual Area Source NH₃ Emissions

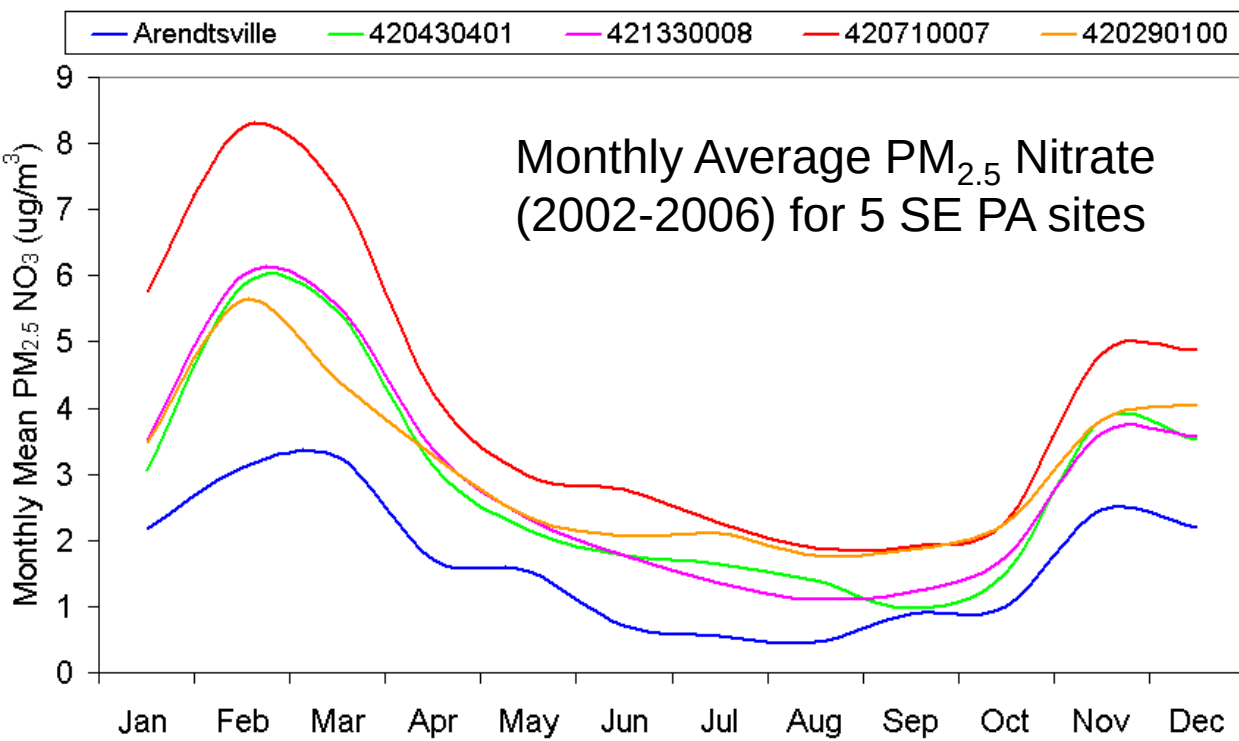




Steep Gradient in $\text{PM}_{2.5}$ Nitrate at Eastern PA $\text{PM}_{2.5}$ speciation sites.

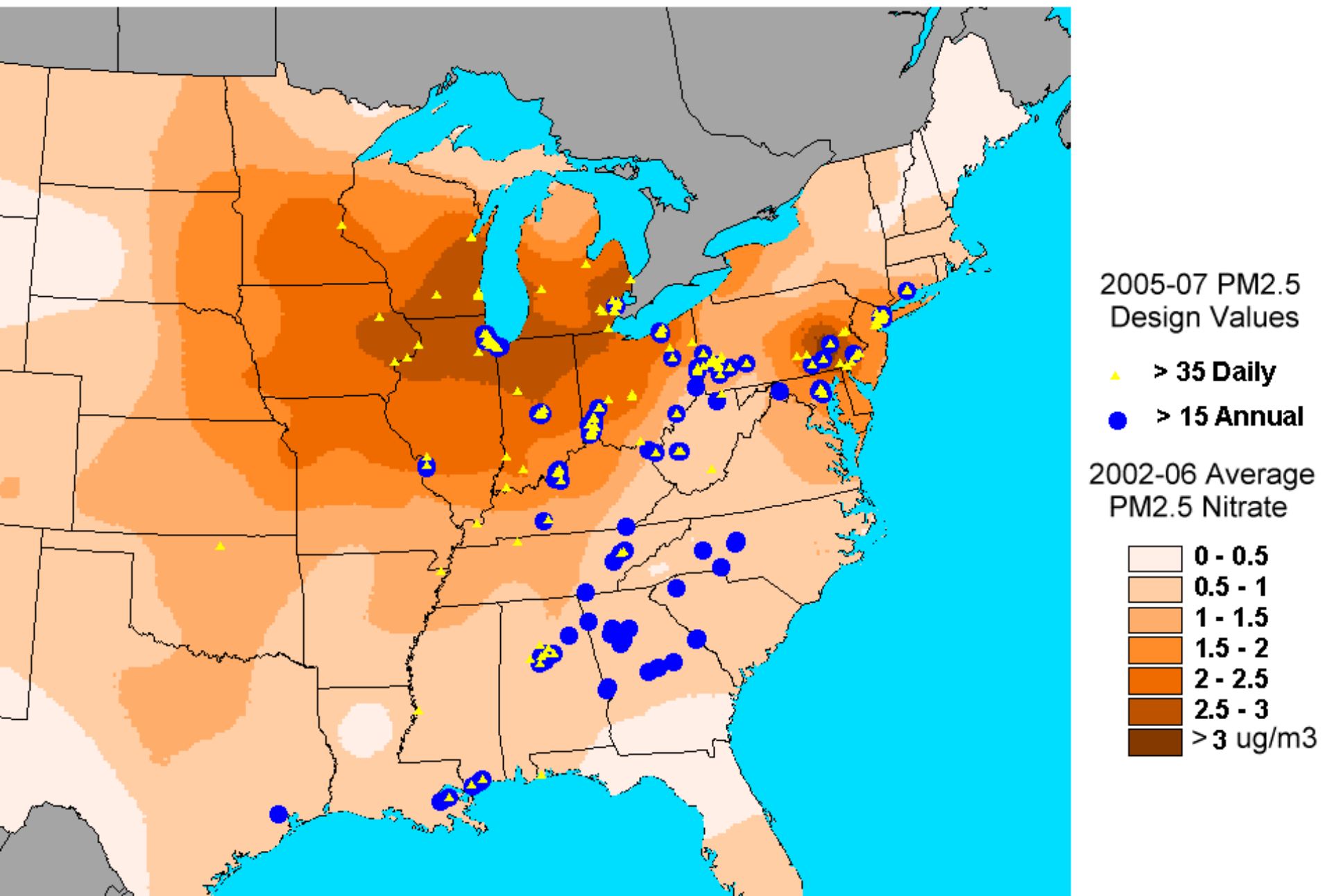
Factor of 2 difference in Average $\text{PM}_{2.5}$ Nitrate over 80 mile distance.

Arendtsville, PA Site in IMPROVE, CASTNet, and NADP networks, is on the upwind (western) edge of high NH_4NO_3 Region.



Millersville PA NADP site (Lancaster County) has Wet NH_4 deposition about 50% > Arendtsville PA (Adams County), 55 mi east.

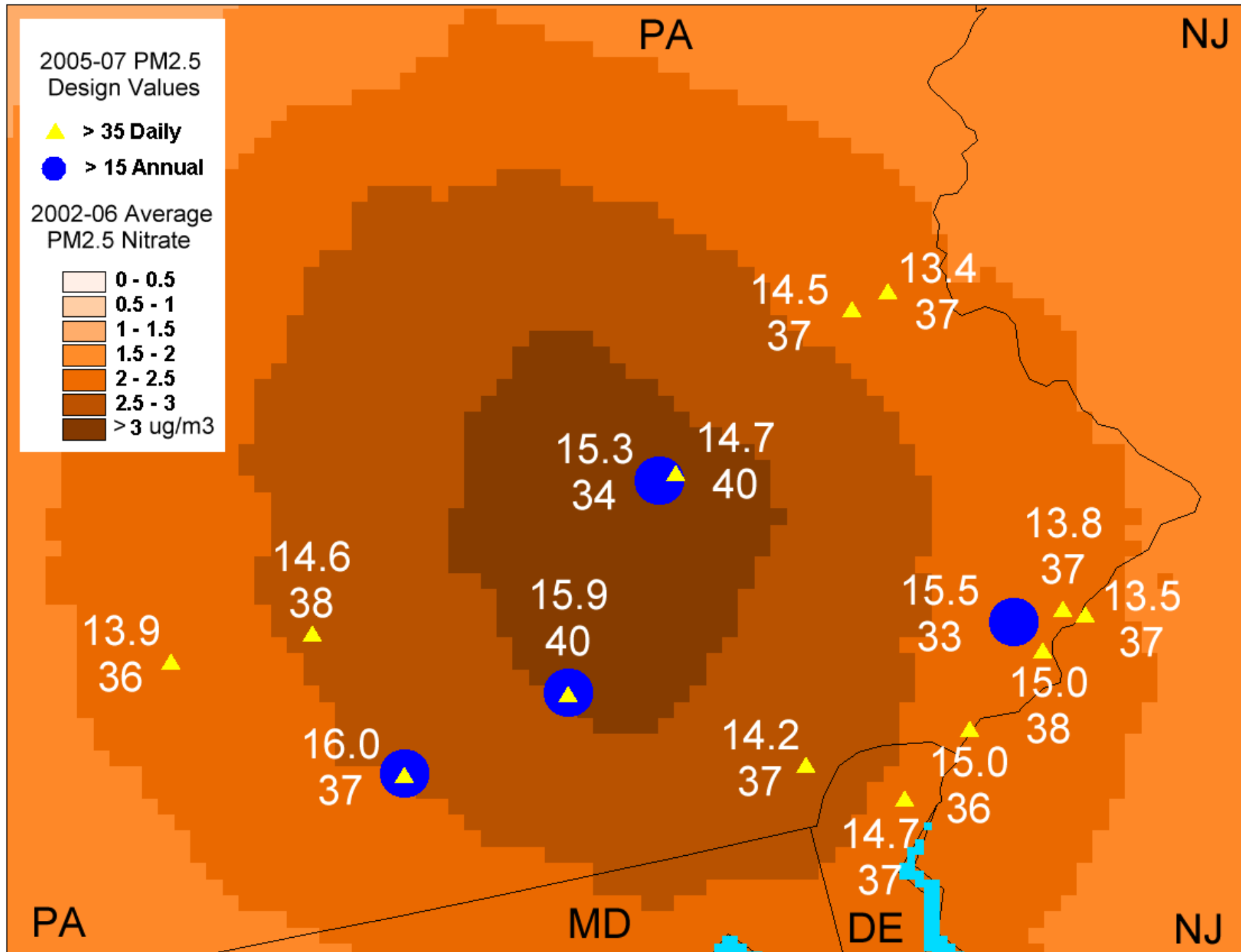
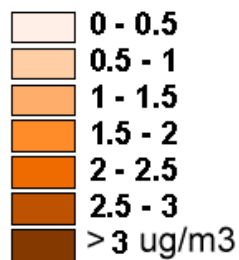
Annual Average PM_{2.5} Nitrate & 2005-2007 PM_{2.5} Design Values > NAAQS



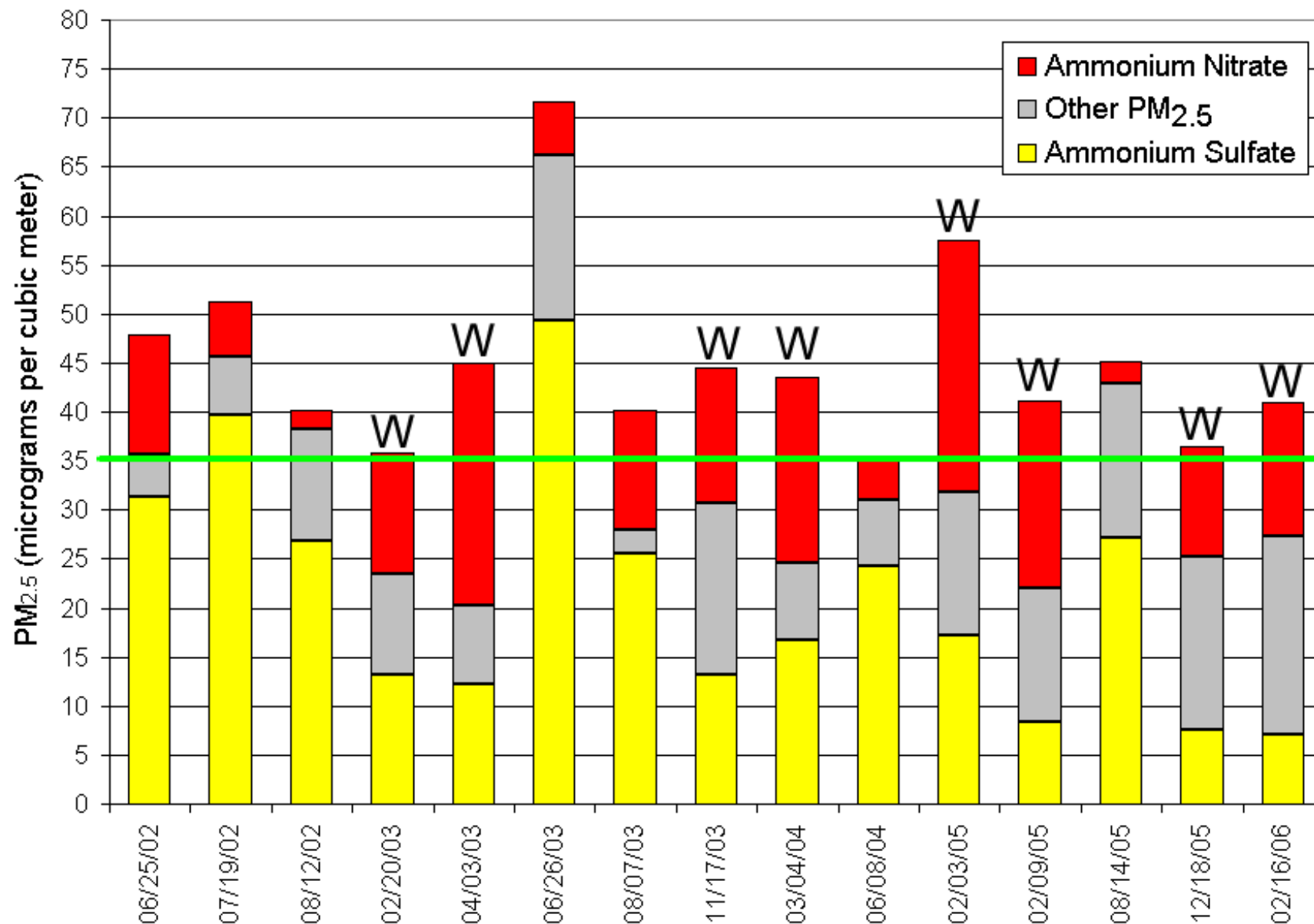
2005-07 PM2.5
Design Values

- ▲ > 35 Daily
- > 15 Annual

2002-06 Average
PM2.5 Nitrate



PM_{2.5} Exceedance Days in Lancaster PA (420710007), 2002-2006 (on days with speciation data)



Effectiveness measured as the PMCAMx predicted change in inorganic PM_{2.5} for a domain-wide 50% reduction in precursor emissions: black shading for NH₃, gray for NO_x, and white for SO₂ (Pinder *et al.*, 2007)

