Atmospheric Deposition of Nitrogen in the Chesapeake Watershed and Tidal Bay

The Chesapeake Bay TMDL's
Midpoint Assessment
WQGIT Meeting

October 8, 2014

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and the CBP Modeling Team

Chesapeake Bay Program
Science, Restoration, Partnership

Atmospheric Deposition Overview

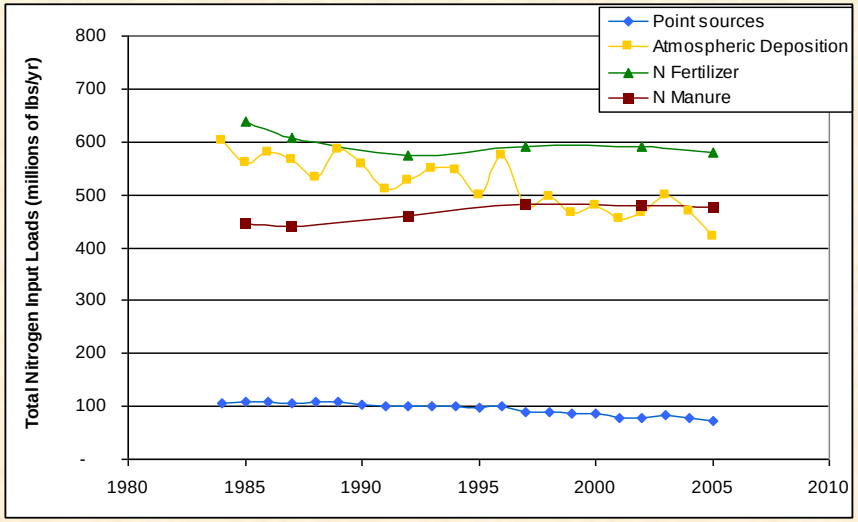
- State of the science and progress in atmospheric deposition reductions:

  Atmospheric deposition is among the highest N loads in the Chesapeake watershed and tidal Bay, but it also has also high estimated N reductions.

- Future reductions are likely, but at reduced rate.

- New bi-directional ammonia CMAQ initial results.

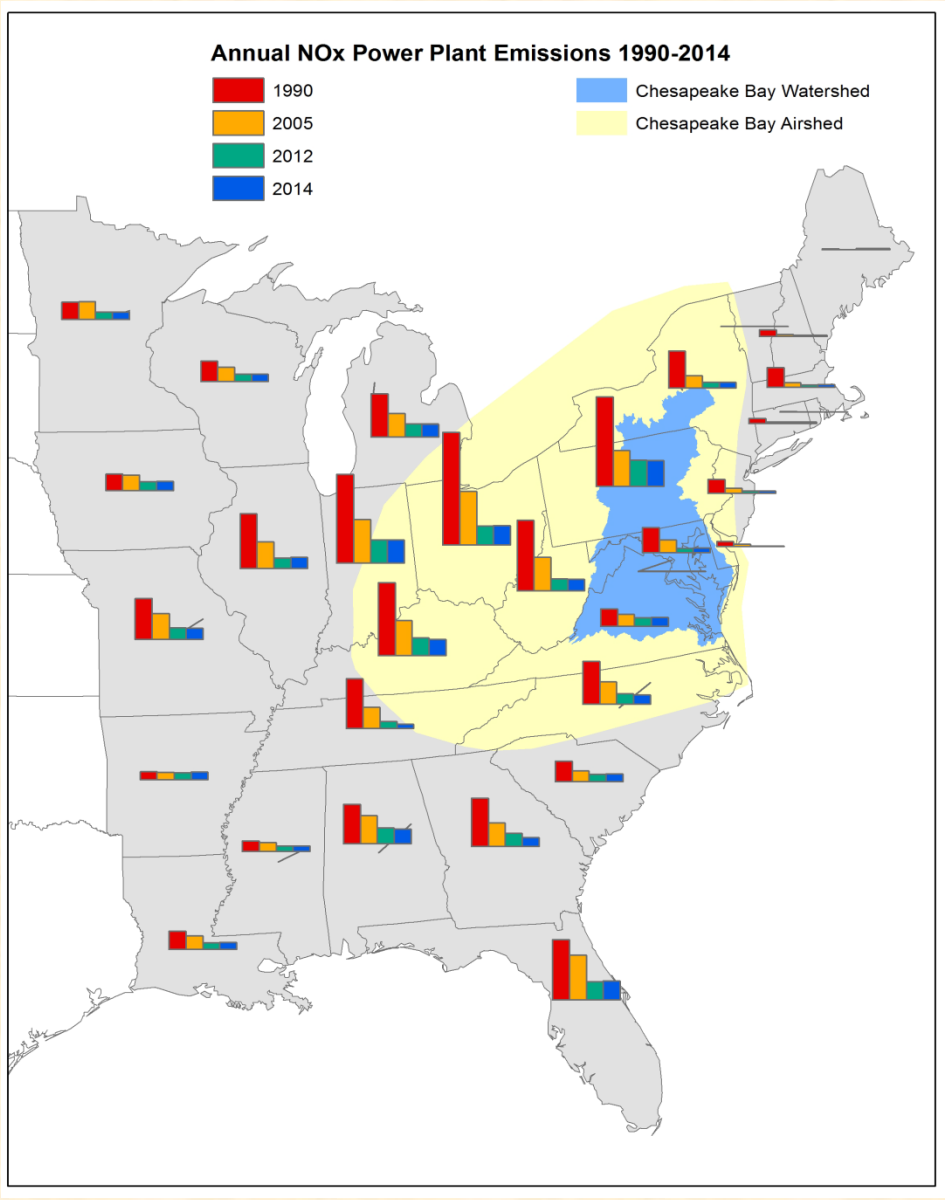
- Wet deposition work planned.



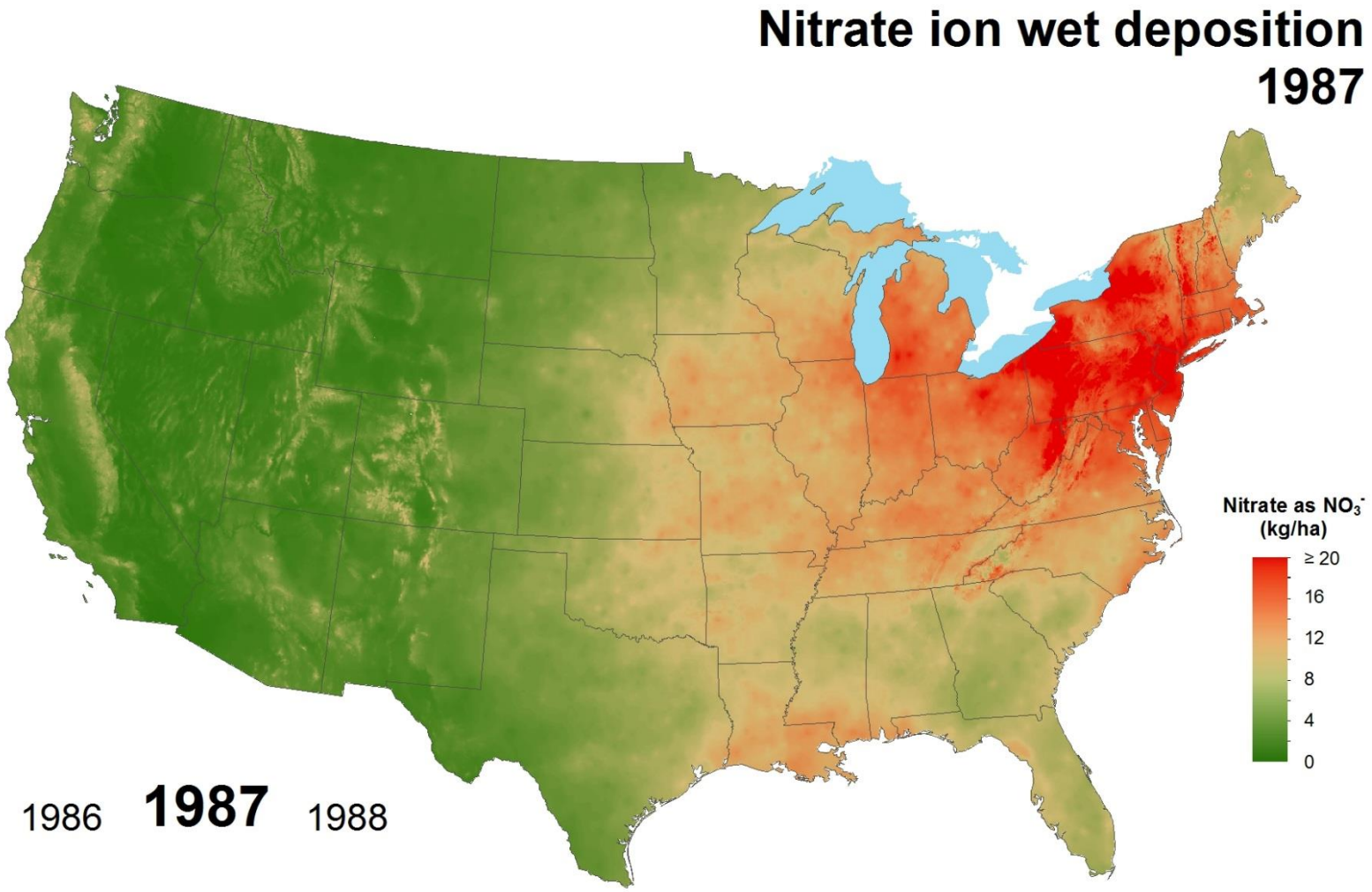
Progress Storyline: air emissions declining

- Atmospheric deposition of nitrogen were among the highest TN inputs in watershed ~595 million pounds in 1985 (compared to ~105 million pounds in 1985 for point source loads).

- The 2020 estimates of atmospheric deposition of nitrogen in the Chesapeake watershed are 326 million pounds, a 45 percent reduction. In contrast point source TN loads are estimated to be reduced by 50% percent from 1985 to 2025.



Atmospheric Deposition Background: Air Nitrogen Deposition Declining



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

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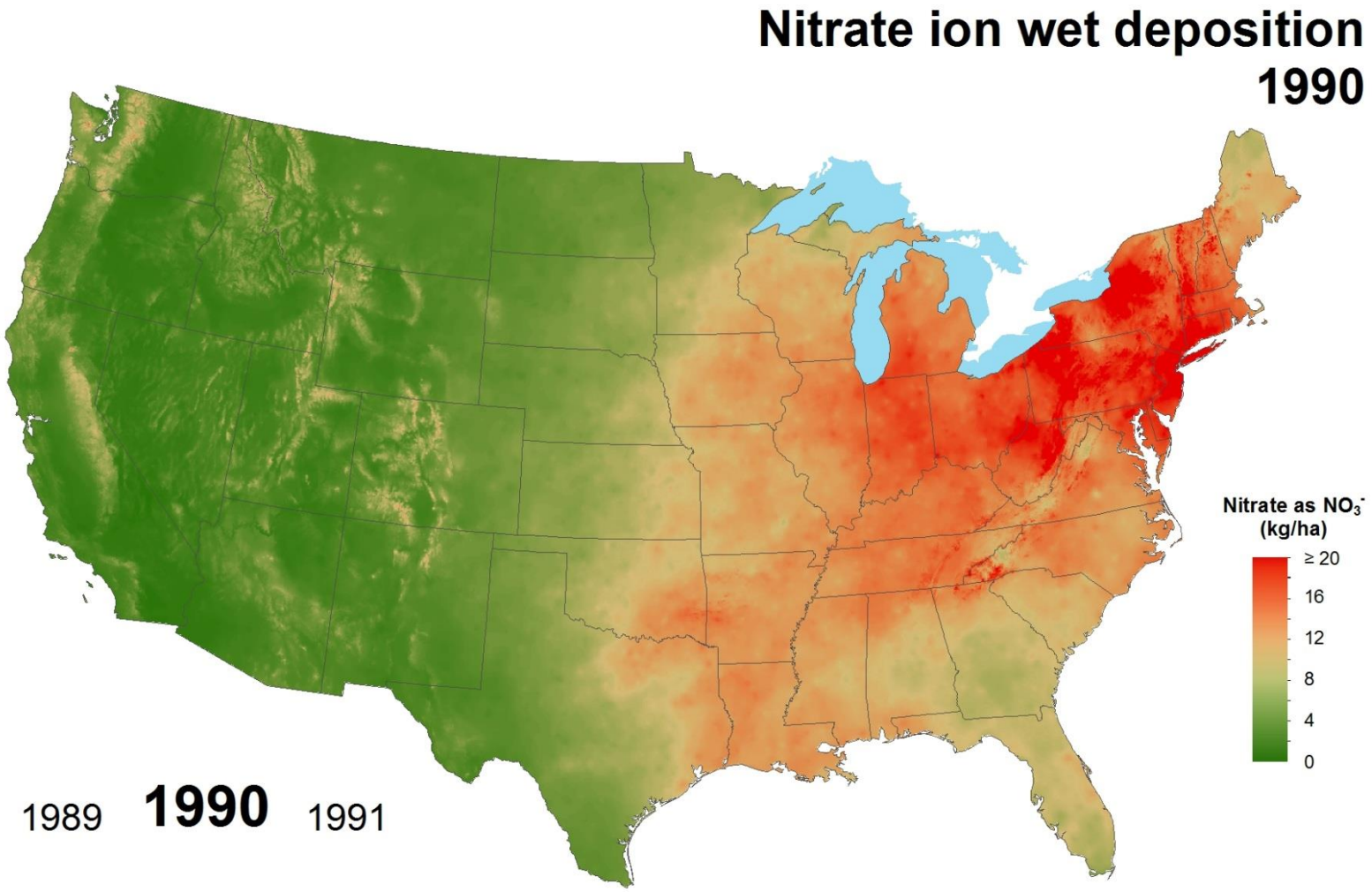

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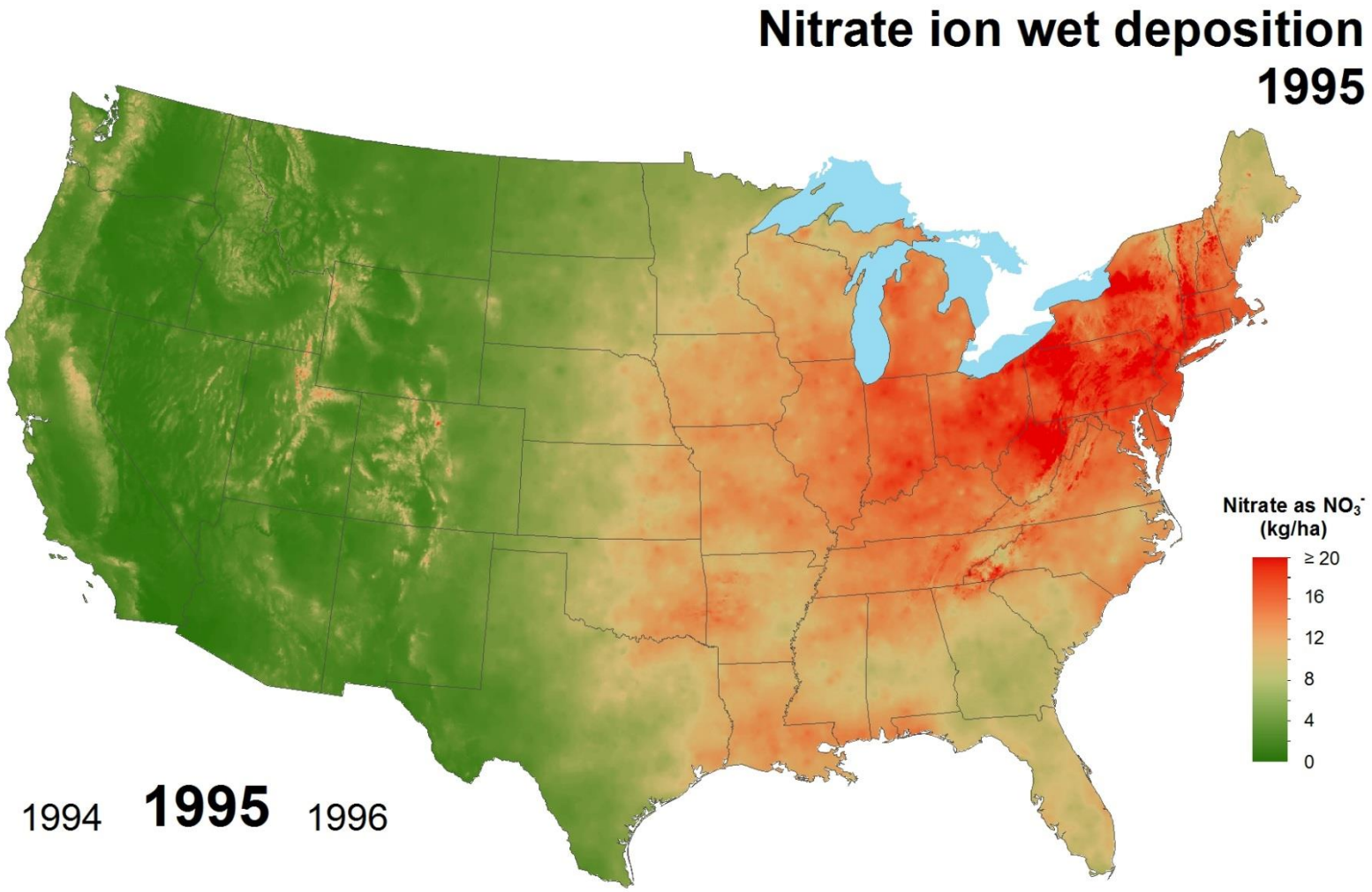

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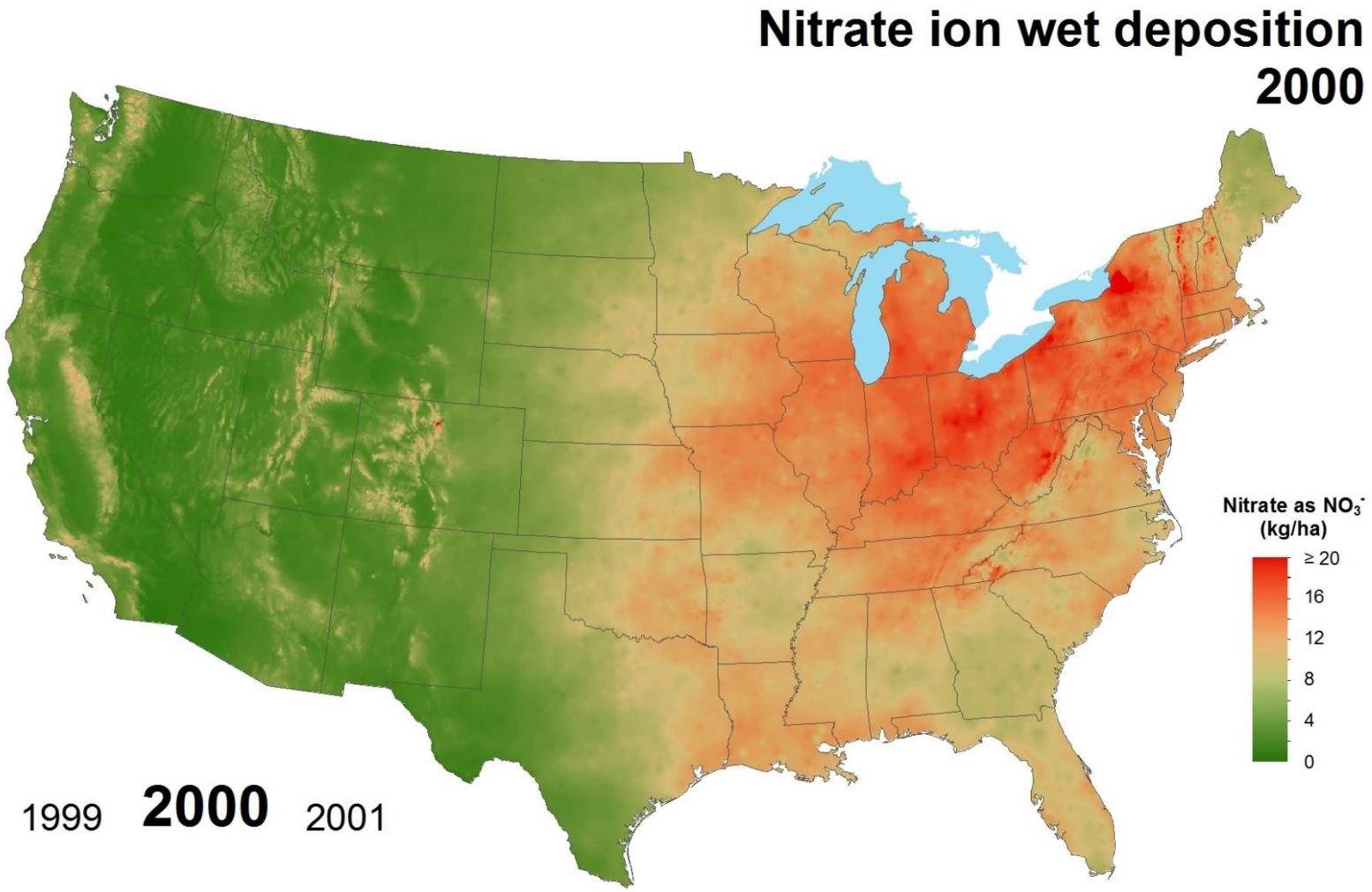

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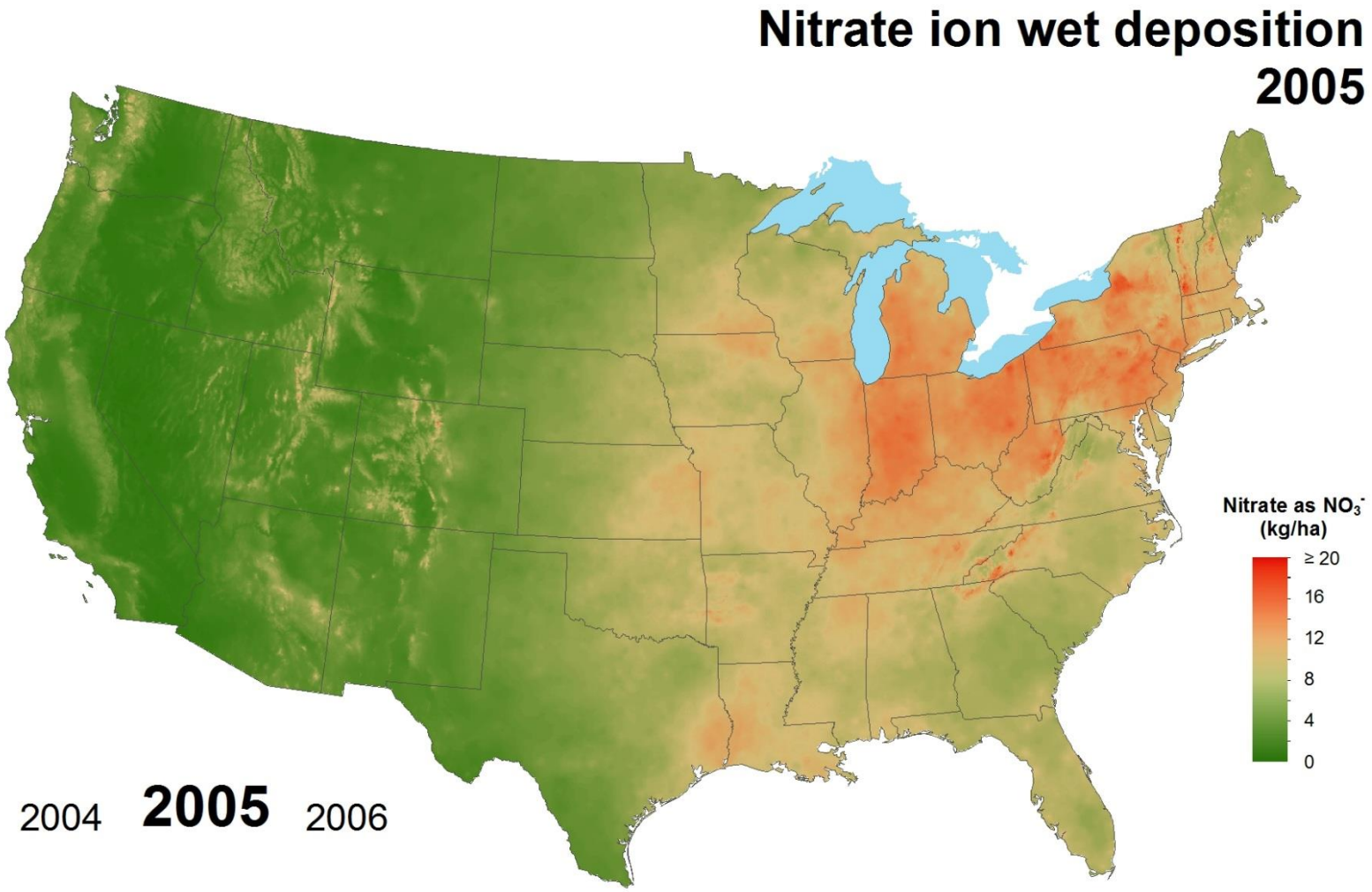

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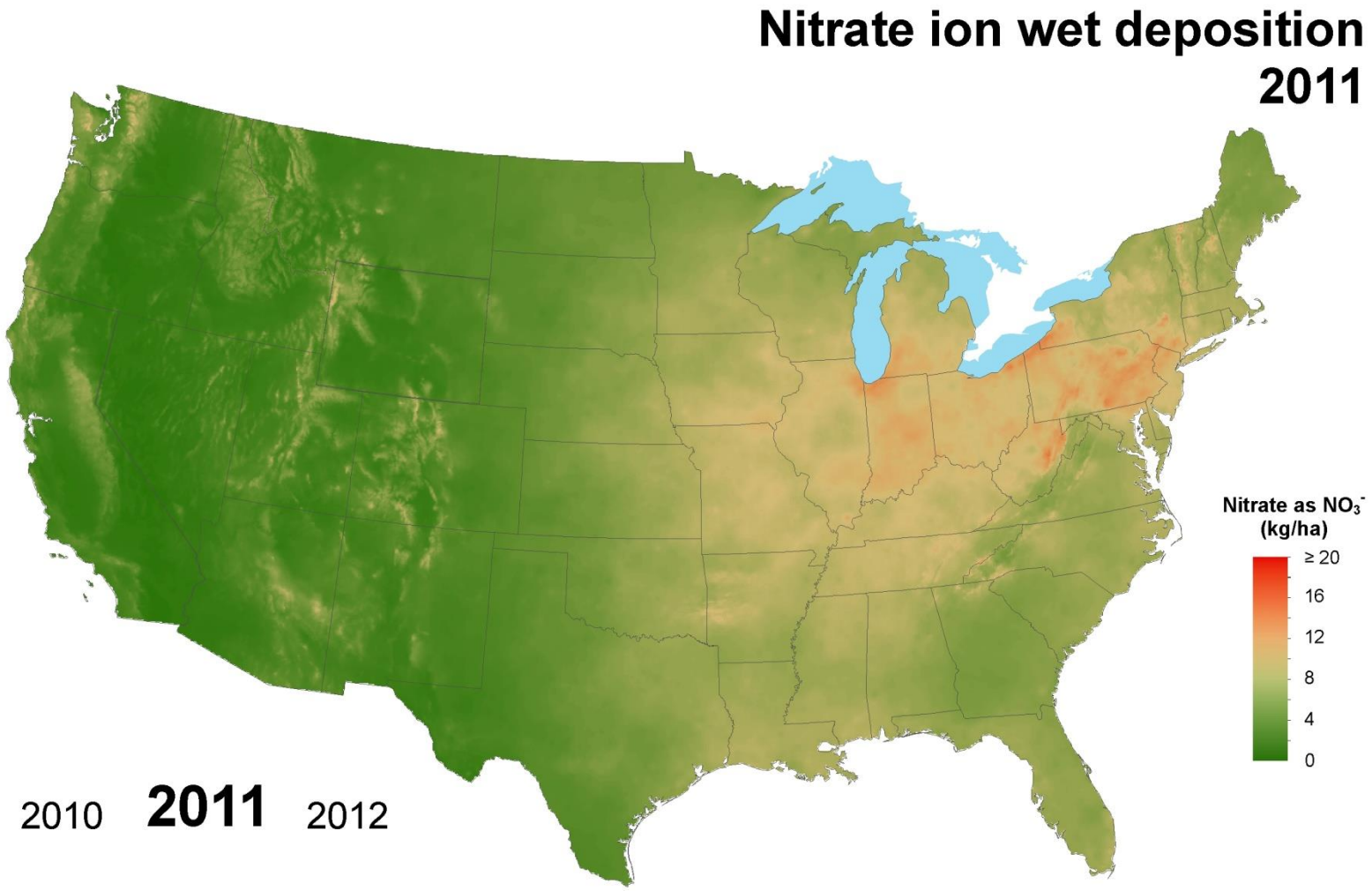

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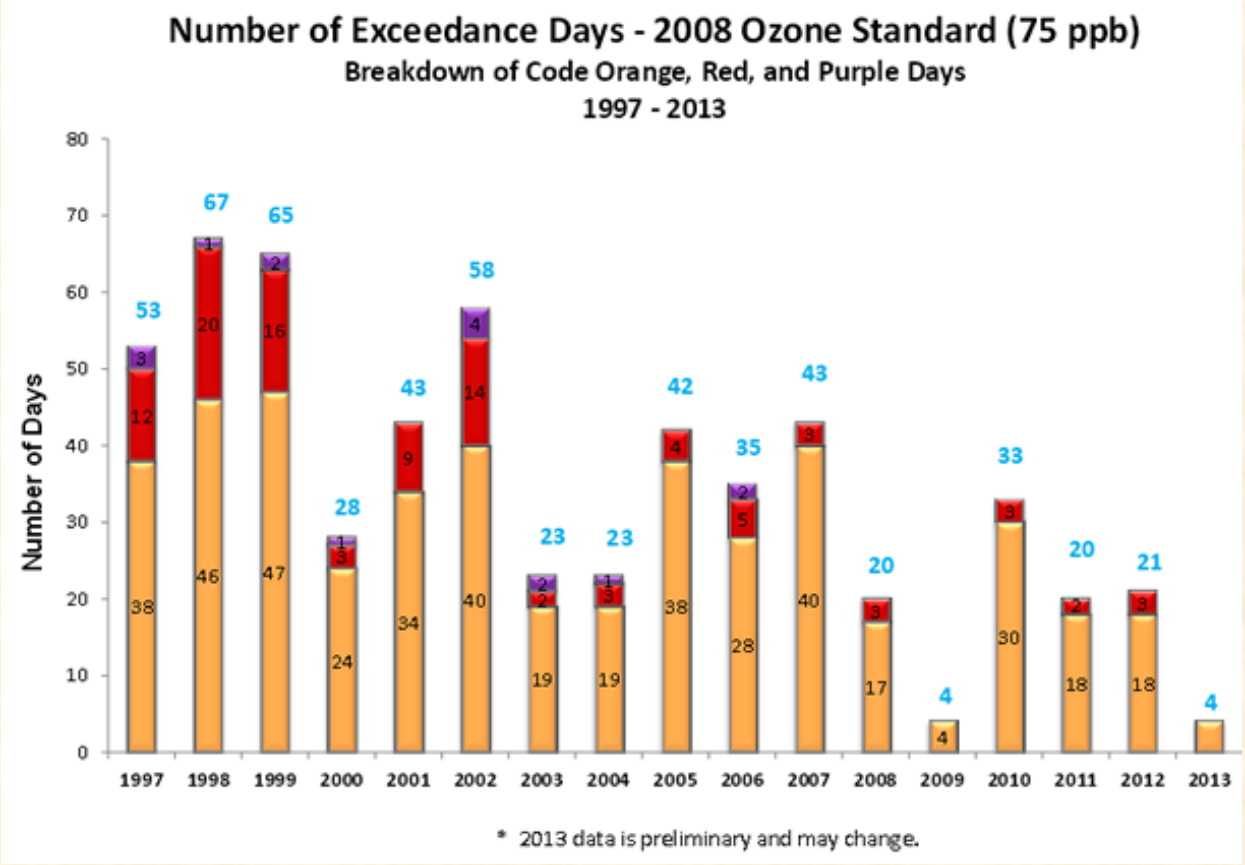
Atmospheric Deposition Background: Air Quality Improving

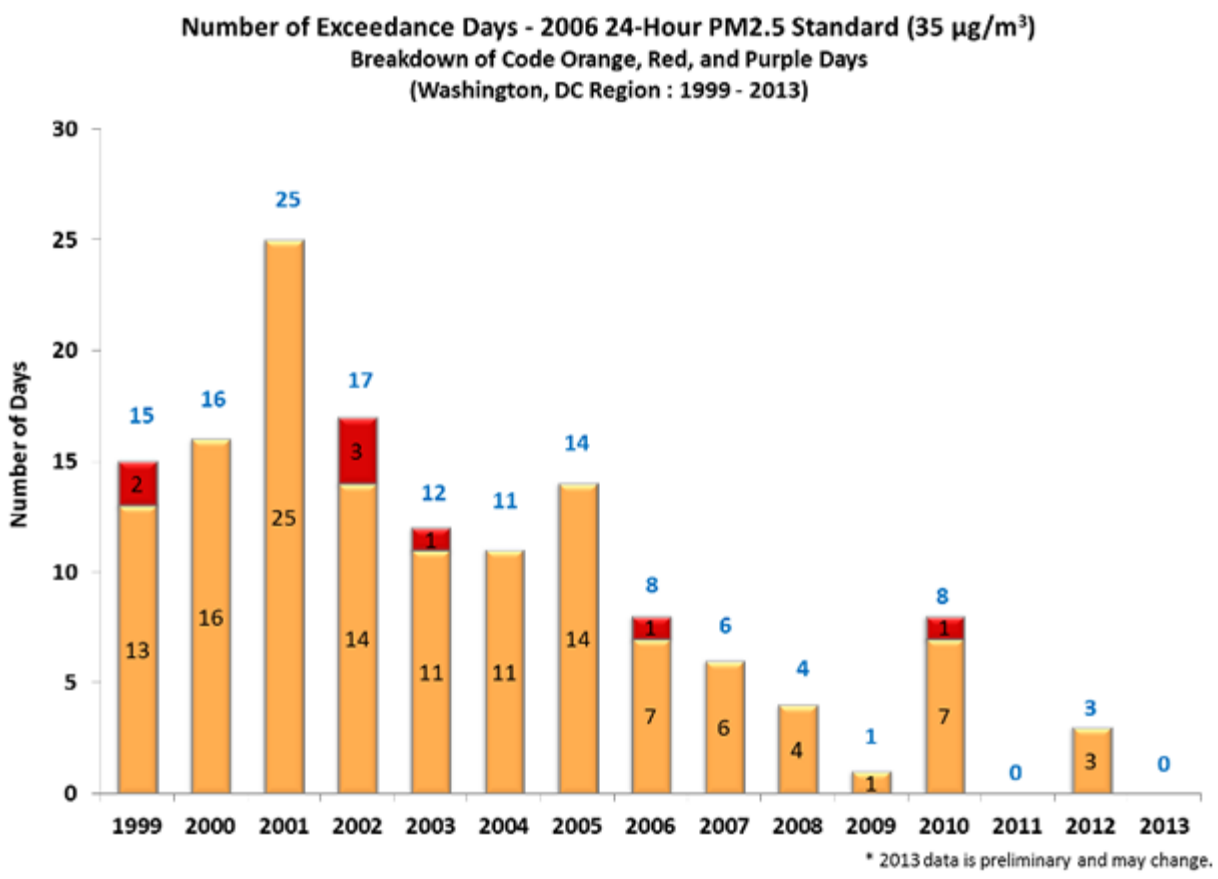
The reductions in atmospheric deposition of nitrogen are due to national rules based on human health air quality standards.

The Chesapeake and other coastal watersheds on the East and Gulf coasts have reaped the “nitrogen cascade” benefits of NOx emission reductions.



Source: Washington Post “Breathing easier: Washington, D.C.’s remarkable improvement in air quality” by Jason Samenow. September 26, 2013.

Atmospheric Deposition Background: Air Quality Improving



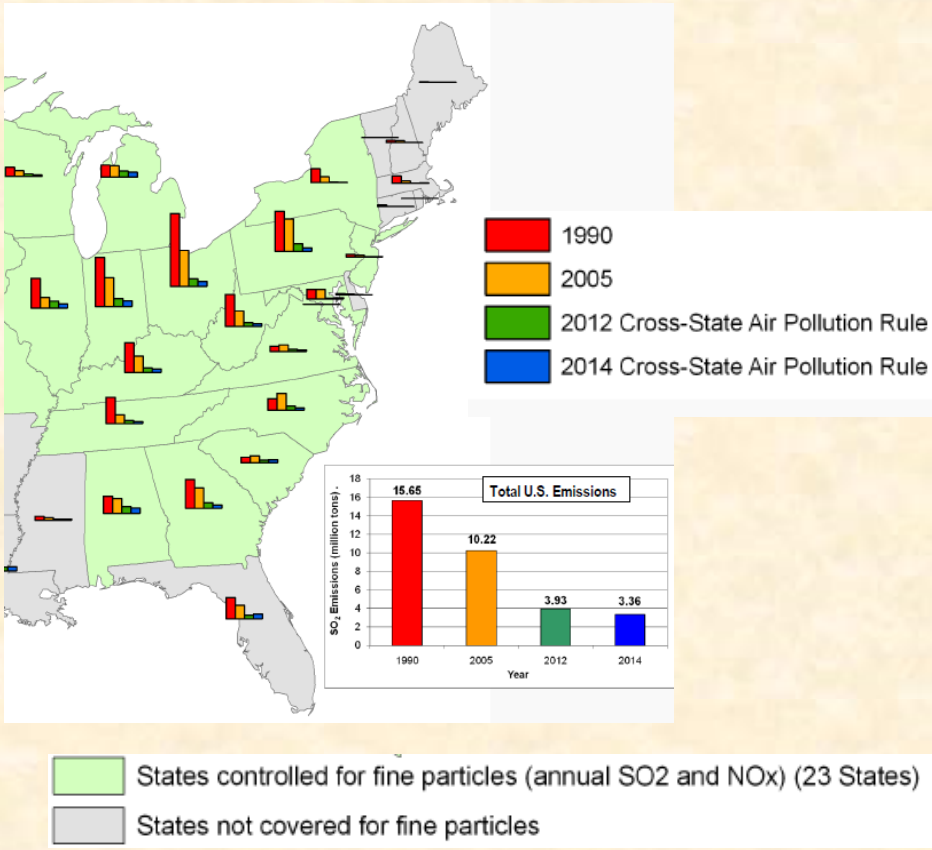
Source: Washington Post "Breathing easier: Washington, D.C.'s remarkable improvement in air quality" by Jason Samenow. September 26, 2013.

But, we have now largely met the region's air quality standards and the trend will now flatten out as the emphasis is on maintaining air standard achievements. **"Past performance is not indicative of future results."**

Future Declines in NOx Emissions

- Tier 3 Fuel Rule in 2017
- Proposed reduction in primary ozone standard from (75 ppb to 70-60 ppb)
- Proposed Carbon Rule
- Continued implementation of CAFE standards

Annual NOX Power Plant Emissions 1990-2014



Source: U.S. EPA Office of Air and Radiation, 2014. Presentation on *Cross-State Air Pollution Rule*

Nitrogen Concentrations in Headwater Streams Are Also Decreasing as a Direct Result

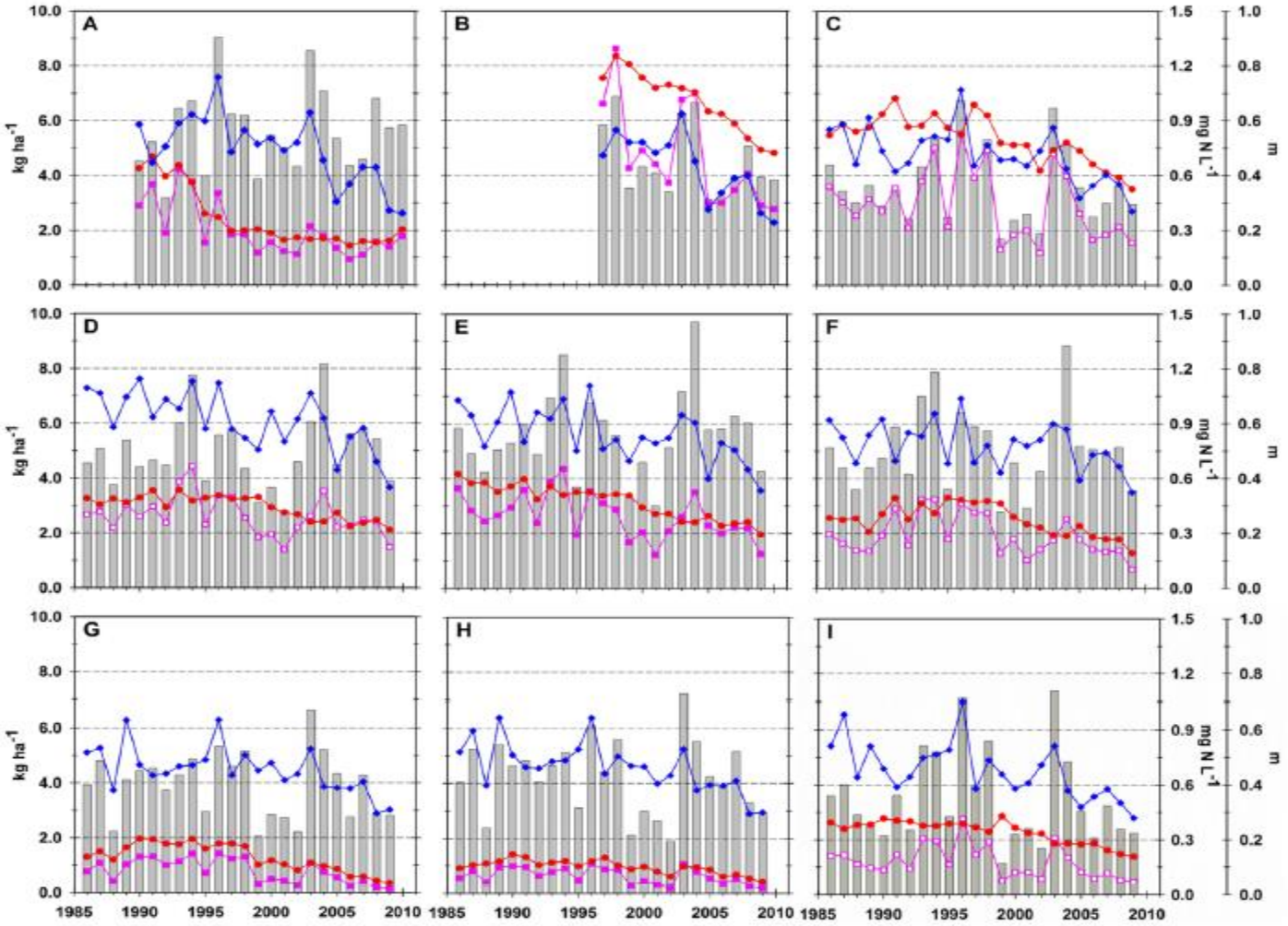


Figure 2. Temporal patterns (1986–2009) in annual (1) nitrate-N yields (kg ha^{-1}, pink lines/squares), (2) areal N deposition (kg ha^{-1}, blue lines/diamonds), (3) nitrate-N concentrations (mg N L^{-1}, red lines/circles), and (4) runoff (m, gray bars) for the nine study; letters correspond to watersheds identified in Figure 1. Time series illustrated with solid symbols produced statistically significant linear trends (see details in Table S2, Supporting Information).

Source: Eshleman et al. 2013. Surface Water Quality is Improving due to Declining Atmospheric N Deposition. *Environmental Science and Technology 47:12193-12200.*

Responding to New Scientific Findings:

- Determine if forests more responsive than currently simulated
  - It could be that forests are more responsive to atmospheric deposition than current CBP models.
  - Direct comparisons are difficult:
    - CBP uses wet and dry deposition; ES&T article uses wet only.
    - CBP estimates TN discharge from watersheds; ES&T article measures nitrate only.
- Factor findings into Phase 6 watershed model
  - More analysis will be done to take advantage of this new research during the Phase 6 Model development for application during the 2017 Midpoint Assessment.

New CMAQ Scenarios Being Prepared:

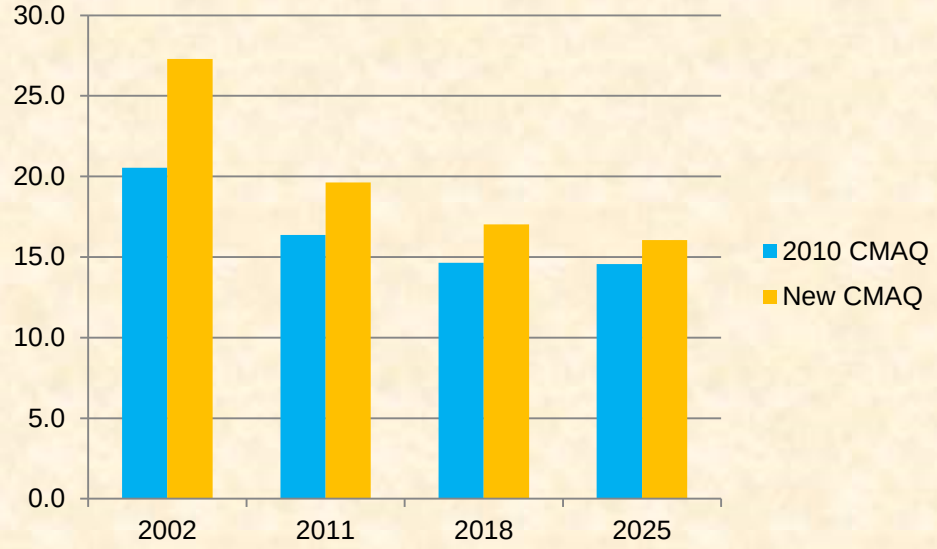
The 2002, 2011, 2018, and 2025 CMAQ Scenarios are developed with CMAQ 5.0.2 which is the latest release. It has bidirectional ammonia simulated and all scenarios use a full year of meteorology of 2011. The WRF met model is used for the meteorological data.

The CMAQ model has a domain of all the US including some of southern Canada and some Northern Mexico. The CMAQ uses a 12 km grid size across the domain. The backcast scenario is to 2002.

All scenarios use 2011 NEI emission inventories and the EGU forecasts were by the IPM model. Mobile emissions were provided by the MOVES T3FRM, which was also used for the Tier 3 Rule. (A new version of MOVES just came out in 2014 but this version was not used.)

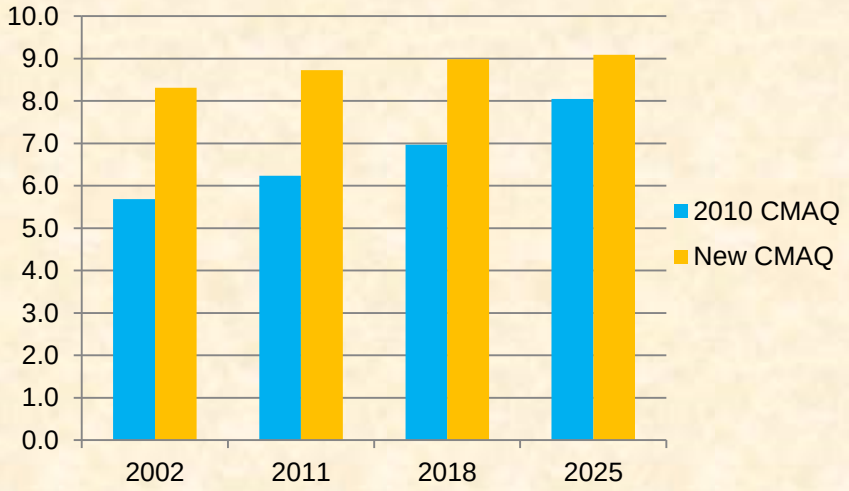
The new CMAQ runs will be applied in the integrated models used for Phase III WIPs in 2017.

Comparison of CMAQ 2010 and 2017 Loads



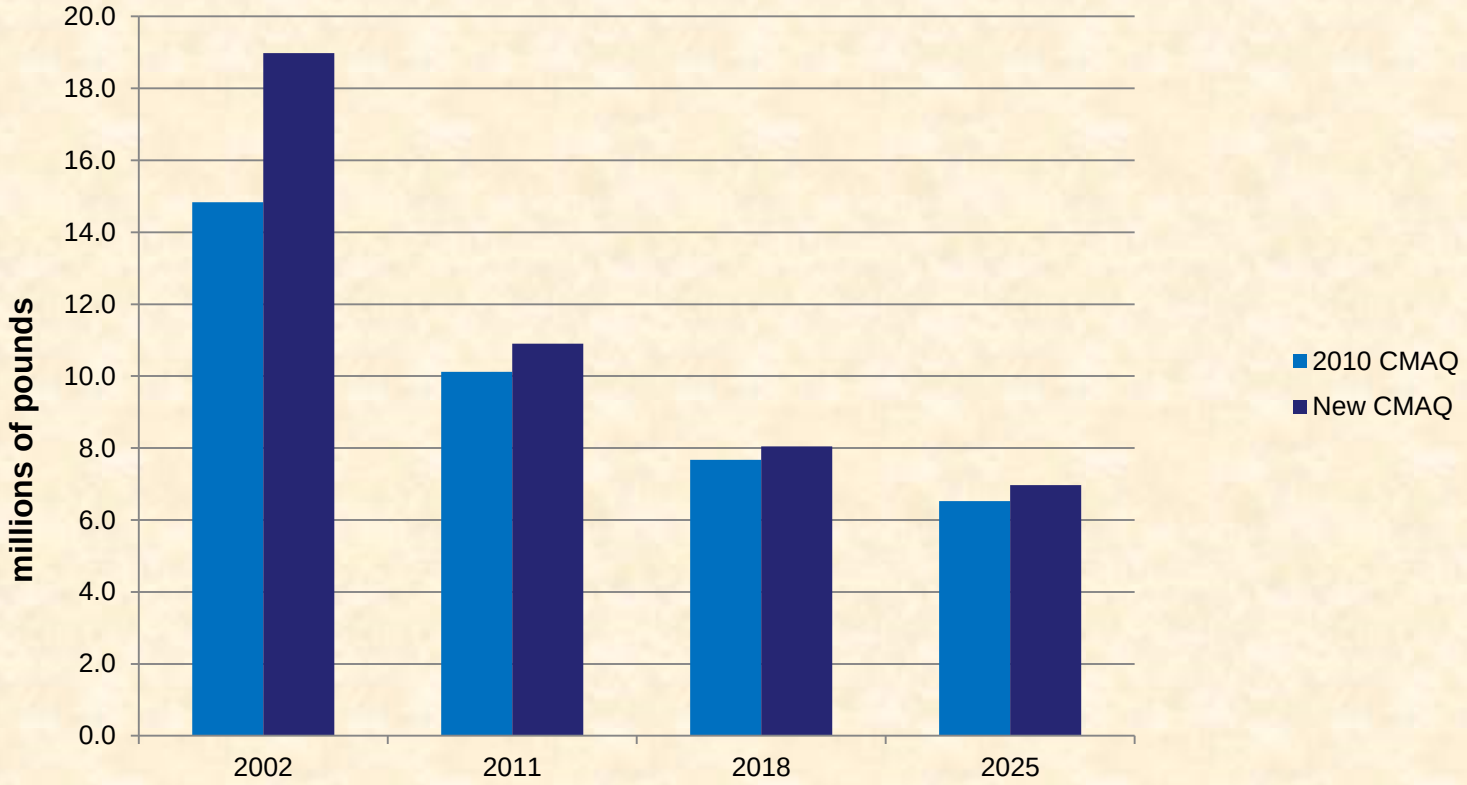
Comparison of DIN loads to tidal Chesapeake from 2010 and 2017 CMAQ scenarios (units in millions of pounds)

Comparison of Reduced (NH_4^+) loads to tidal Chesapeake from 2010 and 2017 CMAQ scenarios (units in millions of pounds)



Preliminary findings

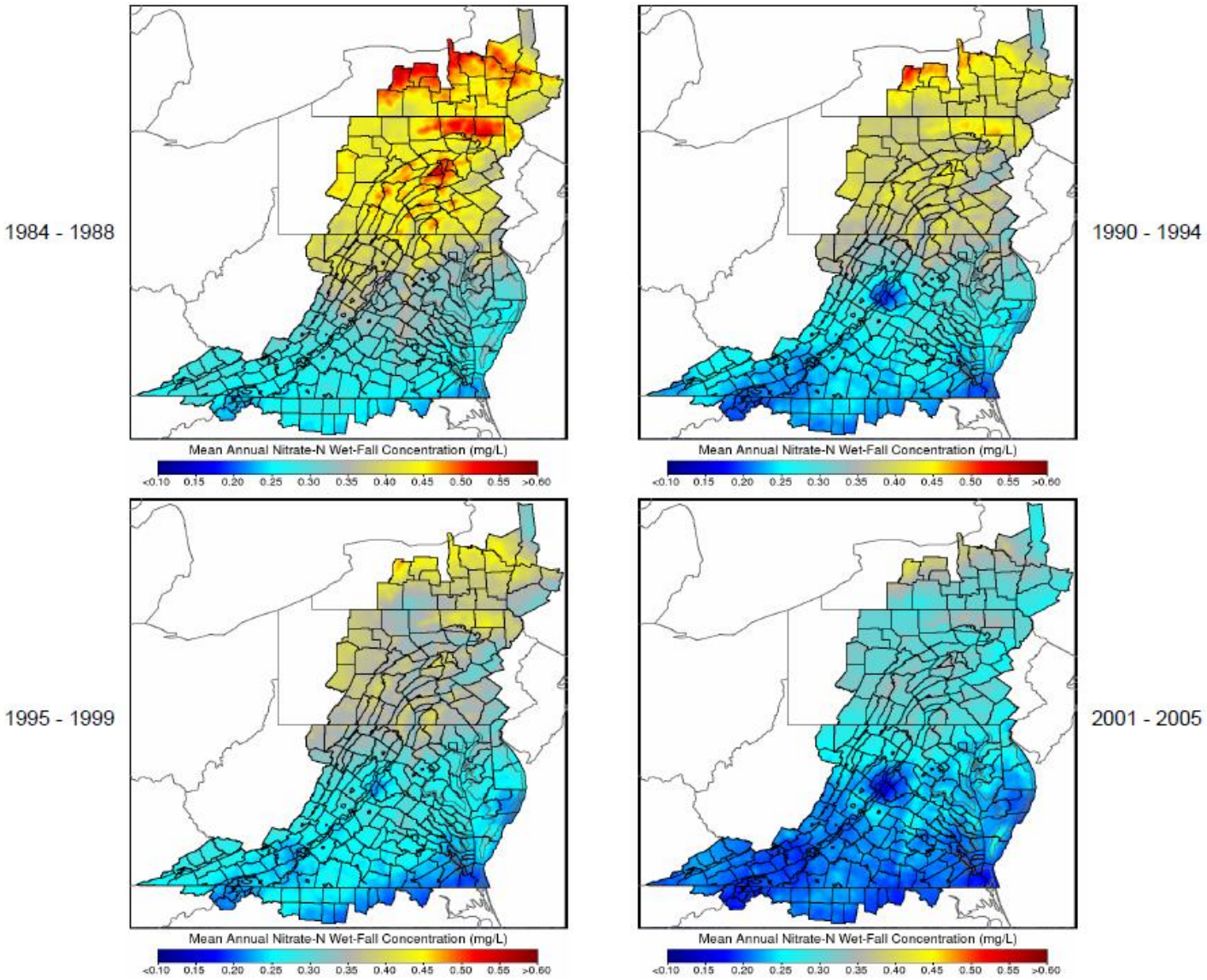
Comparison of NOx loads to Tidal Chesapeake from 2010 and 2017 CMAQ Scenarios



Better chemistry and better data sets (inclusion of lighting generation of NOx, better mobile data, more actuate diurnal profile of CAFO emissions, etc.) leads to 2002 estimates of DIN deposition about 33% higher in the new CMAQ than the previous version, yet the new CMAQ 2025 estimate is about the same as our previous 2020 Air Allocation scenario.

Preliminary findings

The NADP Regression Model for the 1983-2013 period is also being developed for the 2017 Airshed Model



Mean annual nitrate-nitrogen (NO_3-N) wet-fall concentrations across the Chesapeake Bay Watershed region during four, 5-year summary periods as estimated by the Phase 2 daily nitrate wet-fall concentration model.

Conclusions:

• We've simulated and observed considerable reductions in atmospheric deposition of nitrogen from 1985 to the present.

• Reductions in atmospheric deposition are expected to continue, but at a reduced pace.

• The new Airshed Model is being developed with load estimates from both the bidirectional CMAQ simulation and the Penn State NADP Regression Model. Both elements will be operational by June 2015 and provide new atmospheric deposition inputs for the calibration of the Phase 6 and 2017 version of the WQSTM.