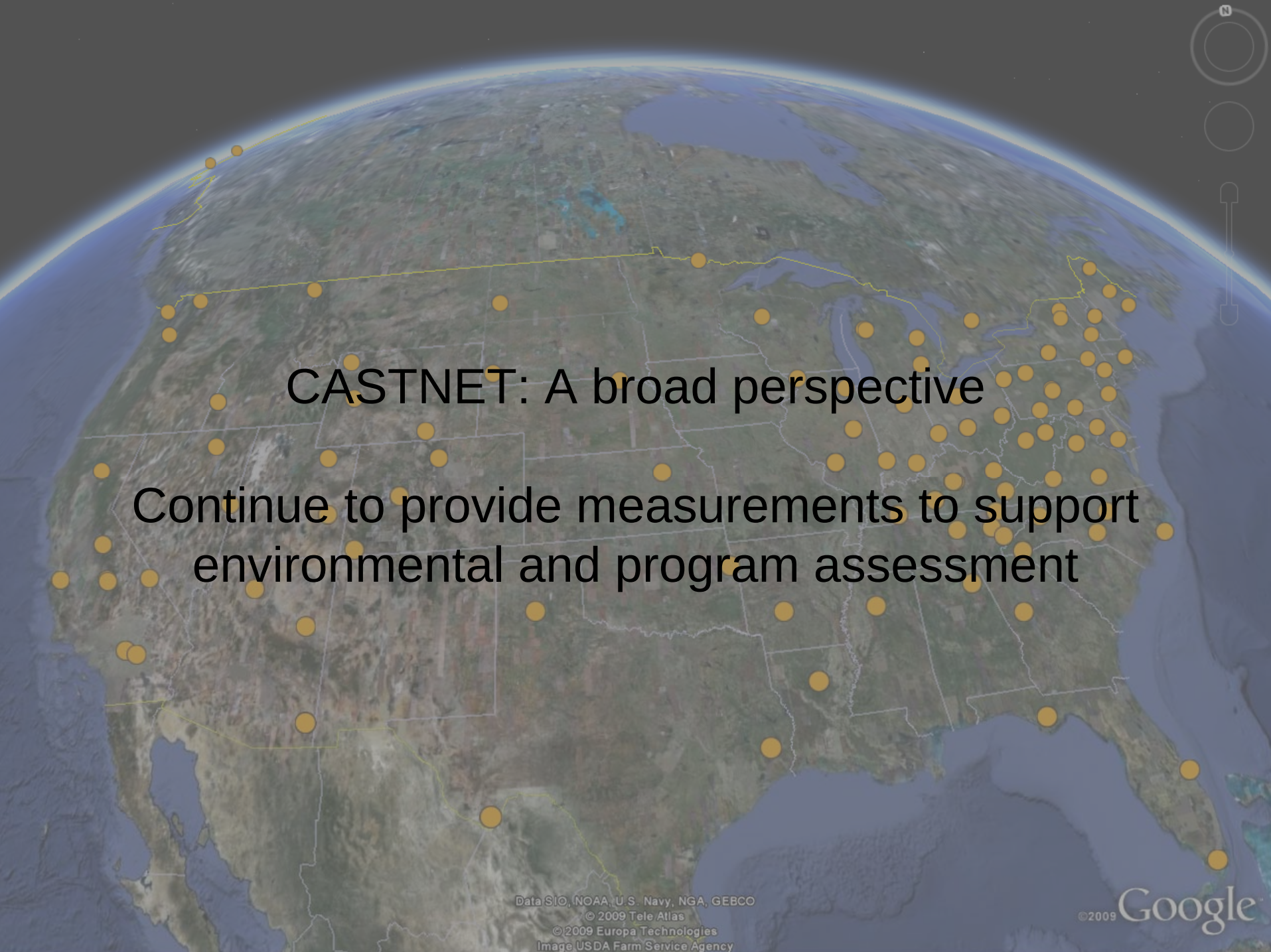
Clean Air Status & Trends Network (CASTNET) Workshop

August 20 and 21, 2009

Research Triangle Park, North Carolina, USA

Santee Sioux Tribe

Alabama-Coushatta


CASTNET: A broad perspective
Continue to provide measurements to support environmental and program assessment
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Welcome, Introductions, and Purpose

Purpose:

Provide input to EPA and NPS on modernizing CASTNET's monitoring approach to reflect advances in monitoring technology and assessment needs.

Overview of the workshop

Overview of workshop:

Part 1: Strengthening the foundation

- Background and description of EPA, NPS, and modeling needs and objectives
- Statement of network objective questions for community
- Introduction of network design tools
- Breakout session 1.
- Reporting of breakout group results
- Synthesis of results and recommendations

Part 2: Building on the foundation

- Background for breakout session 2.
- Breakout session 2.
- Reporting of breakout group results
- Synthesis of results

Background and objectives of CASTNET

- Objectives
- History
- Lessons Learned

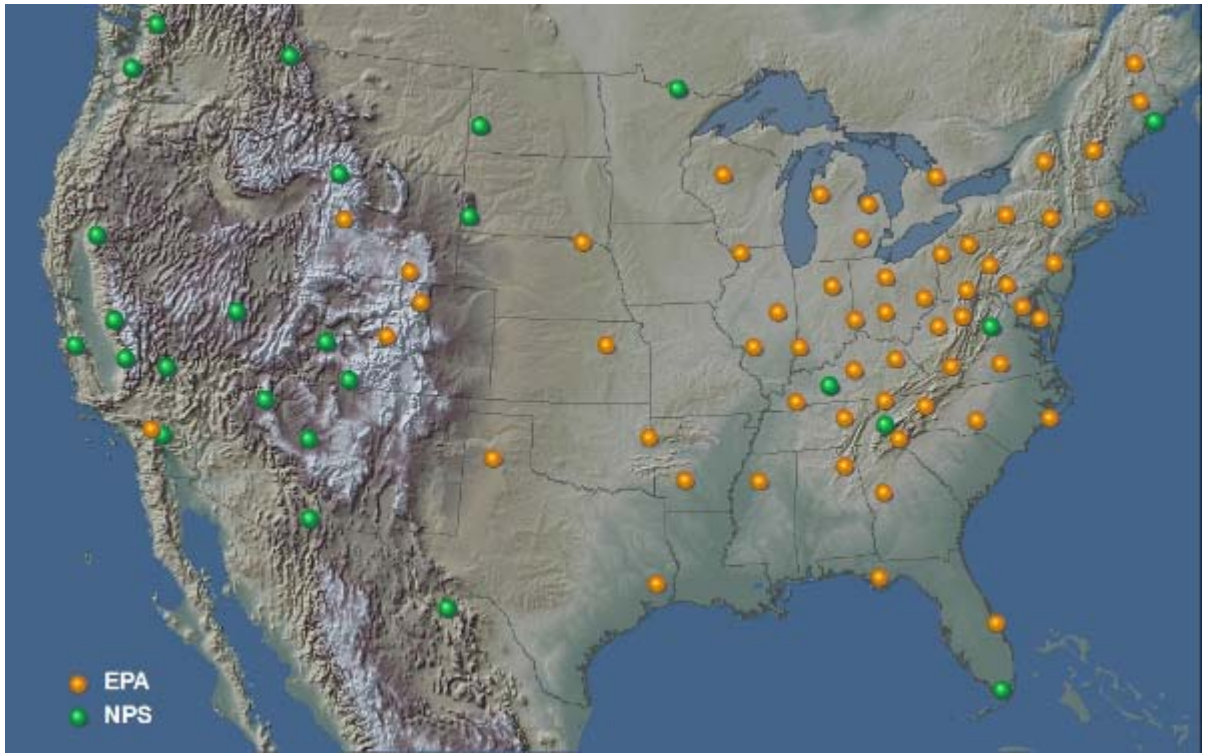
Background and objectives of CASTNET

Objectives

- Monitor the status and trends in regional air quality and atmospheric deposition
- Provide information on the contribution of atmospheric pollution to ecosystem conditions
- Provide measurements for validating and improving atmospheric models

Current CASTNET Monitoring Program

- Operating since 1987
- Currently 80+ sites in 40 states (2 collocated)
- Weekly ambient concentrations of gaseous (HNO3 &SO2) and particle species
- Continuous (hourly) meteorology & O3

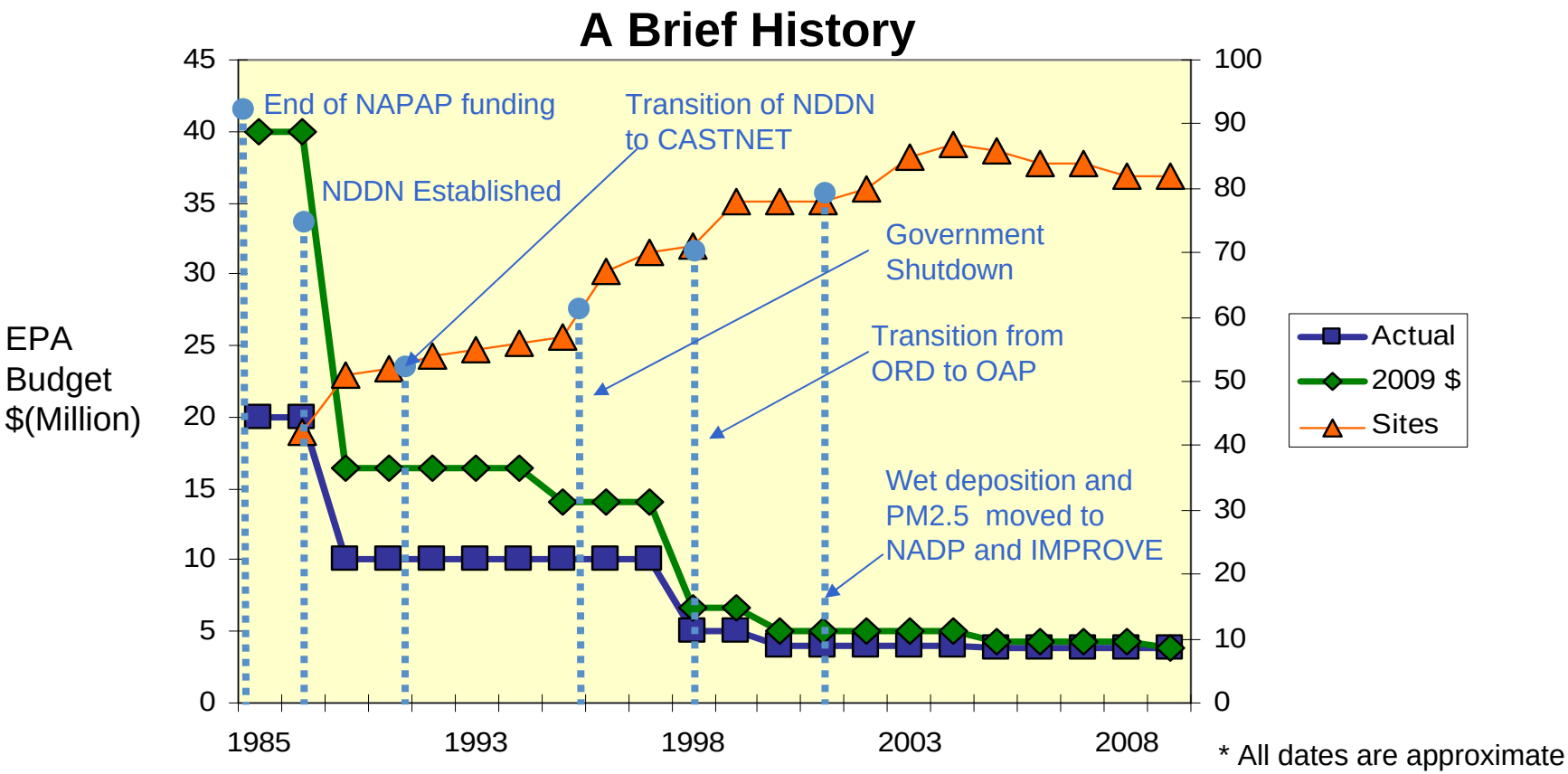


- Sites are located in rural and often ecologically important locations, including 27 National Parks
- Dry deposition is estimated using an inferential model

Background and objectives of CASTNET

What do we do well?

- Relatively inexpensive (or learning to do more with less)

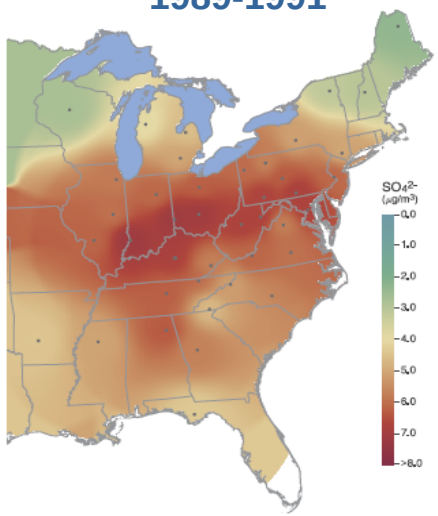


Background and objectives of CASTNET

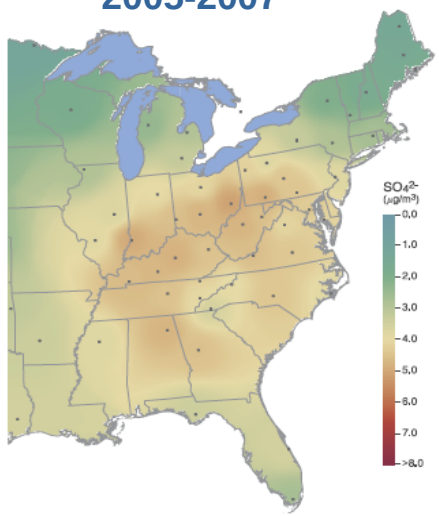
What do we do well?

- Relatively inexpensive
- Consistent measurements for over 20 years (see above)
  - Measurements are comparable over temporal and spatial scales
  - Many long-term sites

Annual Mean Ambient Sulfate Concentration, 1989-1991



Annual Mean Ambient Sulfate Concentration, 2005-2007



Background and objectives of CASTNET

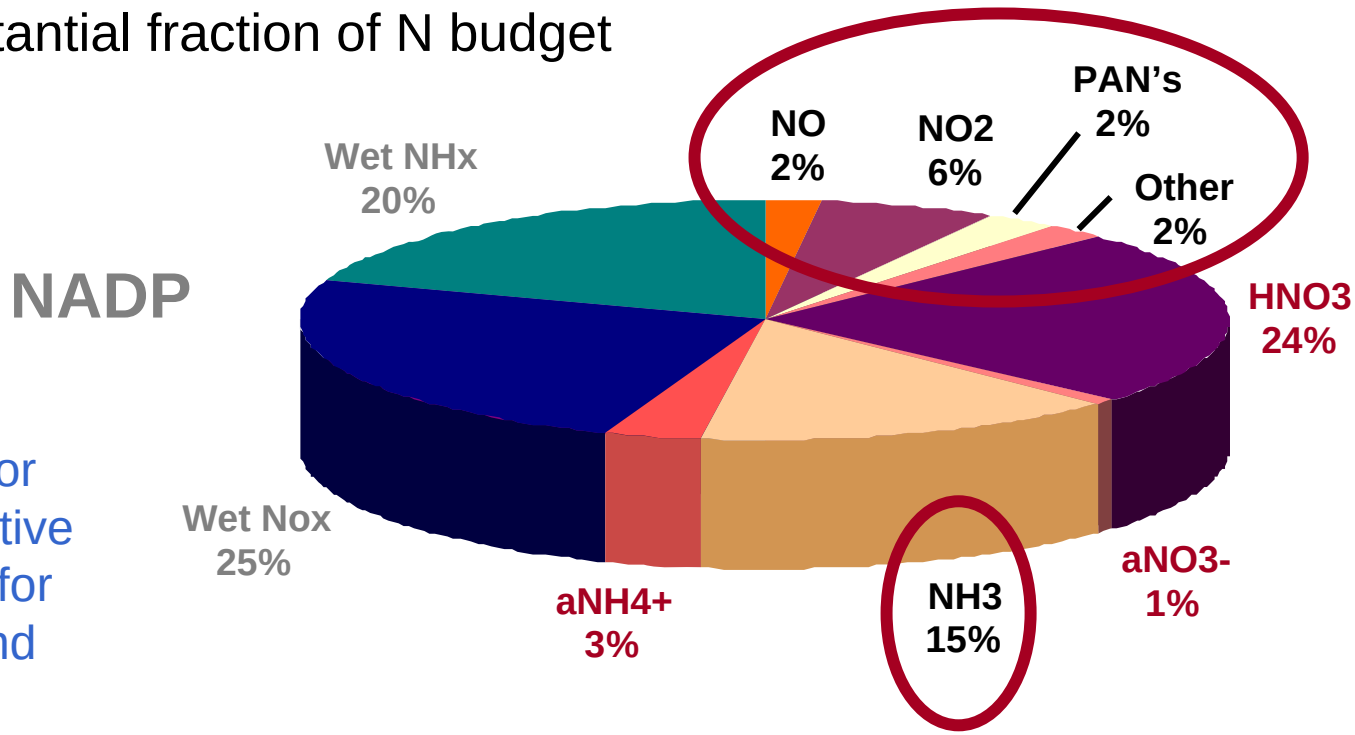
What do we do well?

- Relatively inexpensive
- Consistent measurements for over 20 years (see above)
  - Measurements are comparable over temporal and spatial scales
  - Many long-term sites
- We do sulfur well (Not so much N species)
- Suite of collocated measurements
  - Rural ozone
  - Continuous meteorology
  - Major ions
- Rural measurements
  - Regionally representative
  - Less affected by local sources

Background and objectives of CASTNET

What are the limitations?

- Consistent measurements over 20 years
  - Outdated measurements, known problems
- Missing substantial fraction of N budget



CMAQ predictions for components of reactive nitrogen deposition for Chesapeake Bay and watershed

Background and objectives of CASTNET

What are the limitations?

- Consistent measurements over 20 years
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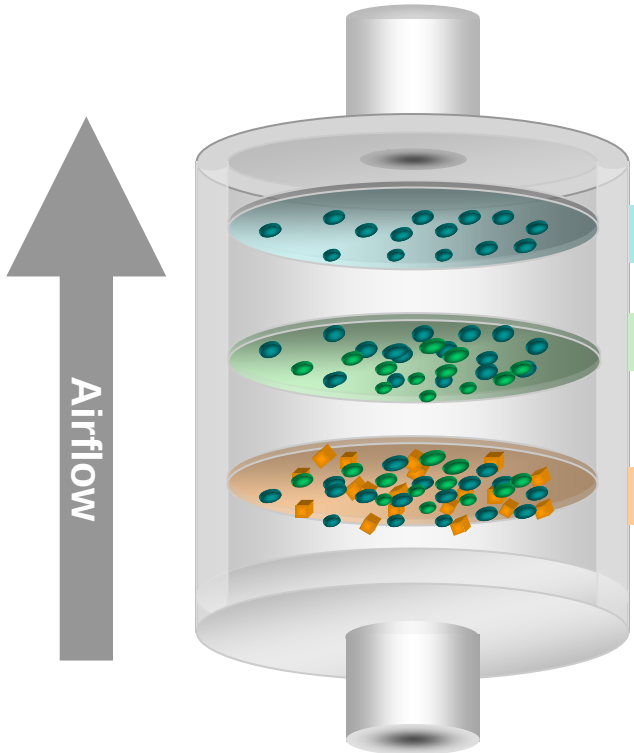
- Missing substantial fraction of N budget
- Undefined bias in nitrate/nitric acid fractions

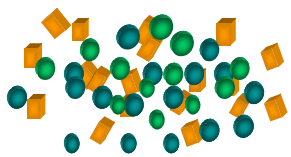
CASTNET 3-Stage Filterpack

Gas and particle concentrations in air are measured by filter packs and then used to estimate daily dry deposition



Whatman	Gaseous • SO_2
Nylon	Gaseous • HNO_3 • SO_2
Teflon	Particulate • SO_4^{2-} • NO_3^- • NH_4^+ • Ca, Na, Mg • Cl

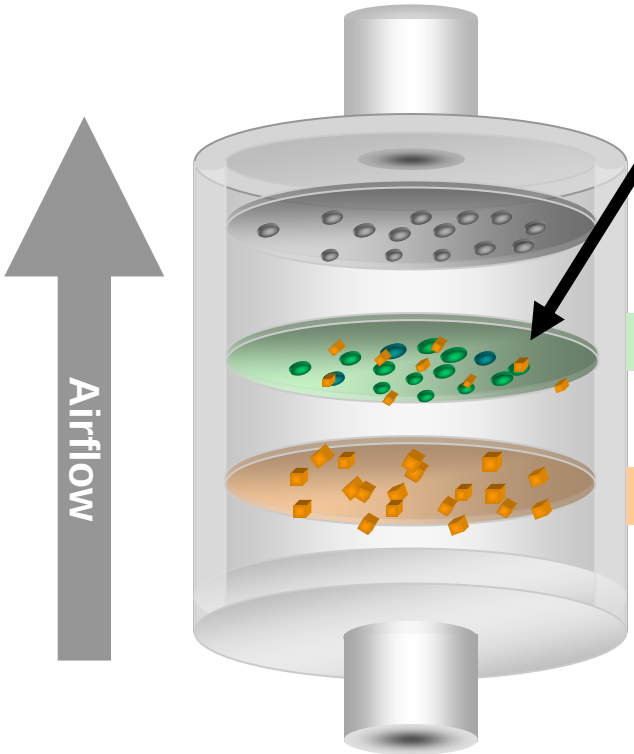
Gases and Particles



Filter packs are open-faced, with no size exclusion

- 20% of S and N deposition can be from coarse particles
- HNO_3 reacts with inlets

CASTNET 3-Stage Filterpack



Volatilization of HNO_3 and NH_3 from particles may cause a bias in CASTNET filterpack data

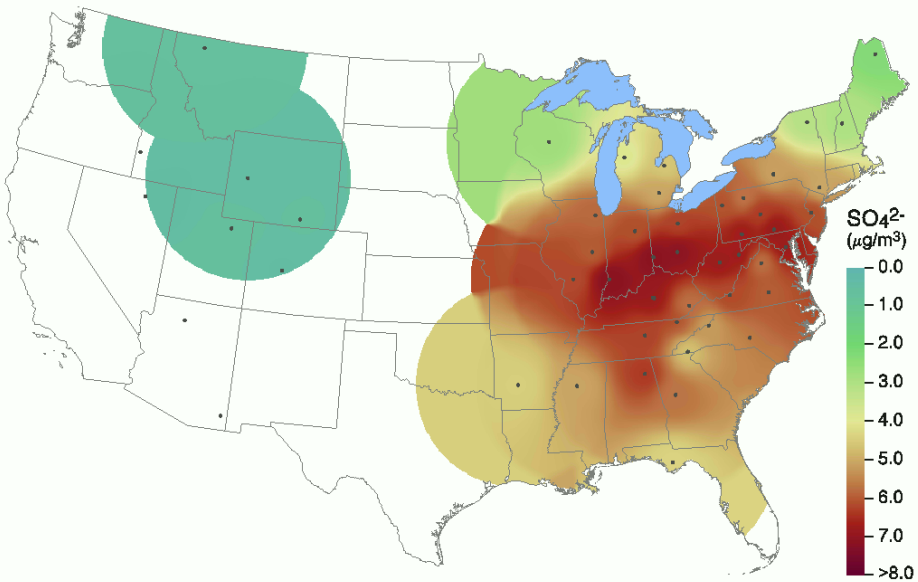
Nylon	Gaseous • HNO_3 • SO_2	+	< 10% positive bias for HNO_3
Teflon	Particulate • SO_4^{2-} • NO_3^- • NH_4^+ • Ca, Na, Mg • Cl	-	< 10% negative bias for particulate NO_3^- and NH_4^+

Background and objectives of CASTNET

What are the limitations?

- Limited geographic extent

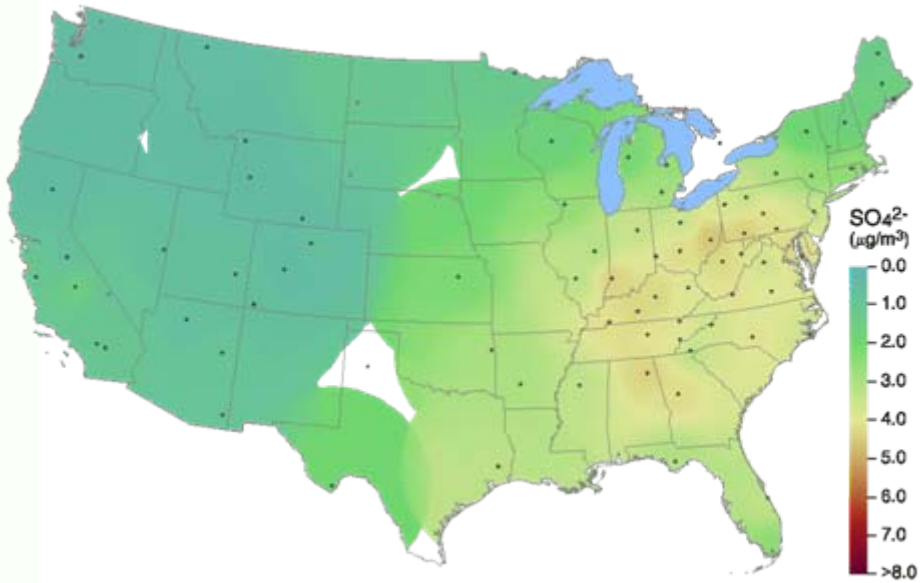
Annual Mean Ambient Sulfate Concentration, 1989-1991



Source: CASTNET

USEPA/CAMD 08/01/06

Annual Mean Ambient Sulfate Concentration, 2006-2008



Source: CASTNET

USEPA/CAMD 08/13/09

Background and objectives of CASTNET

What are the limitations?

- Consistent measurements over 20 years
  - Outdated measurements, known problems
- Missing substantial fraction of N budget
- Undefined bias in nitrate/nitric acid fractions
- Limited geographic extent
- Point estimates of dry deposition on a continuous landscape
- We don't measure dry deposition
  - No verification of dry deposition models through direct measurement
- Weekly air quality measurements
- Poorly defined community of users/stakeholders
  - Legacy issues (acid rain)

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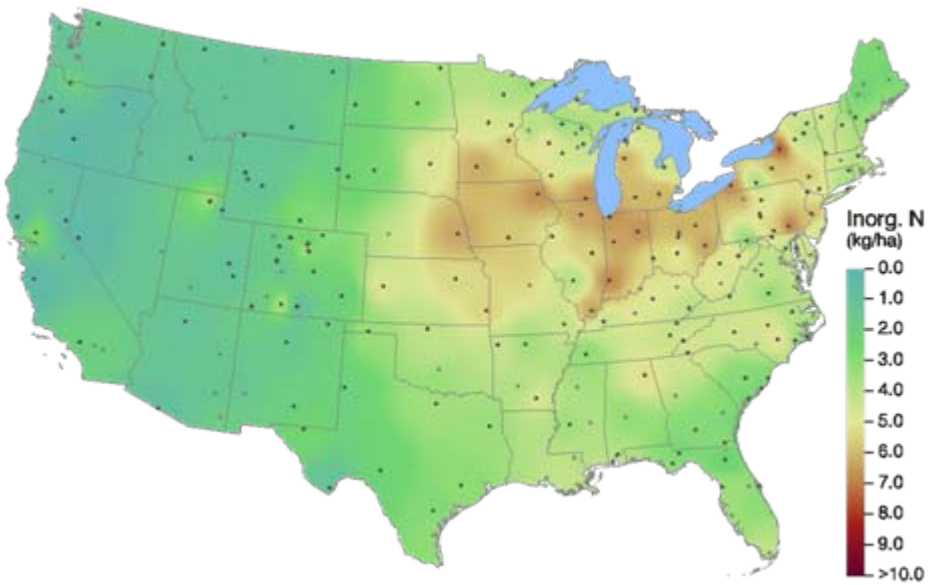
Background and objectives of CASTNET

What are the limitations?

- Point estimates of dry deposition on a continuous landscape

Annual Mean Wet Inorganic Nitrogen, 2005-2007



Annual Mean Wet+Dry Deposition, 2005-2007

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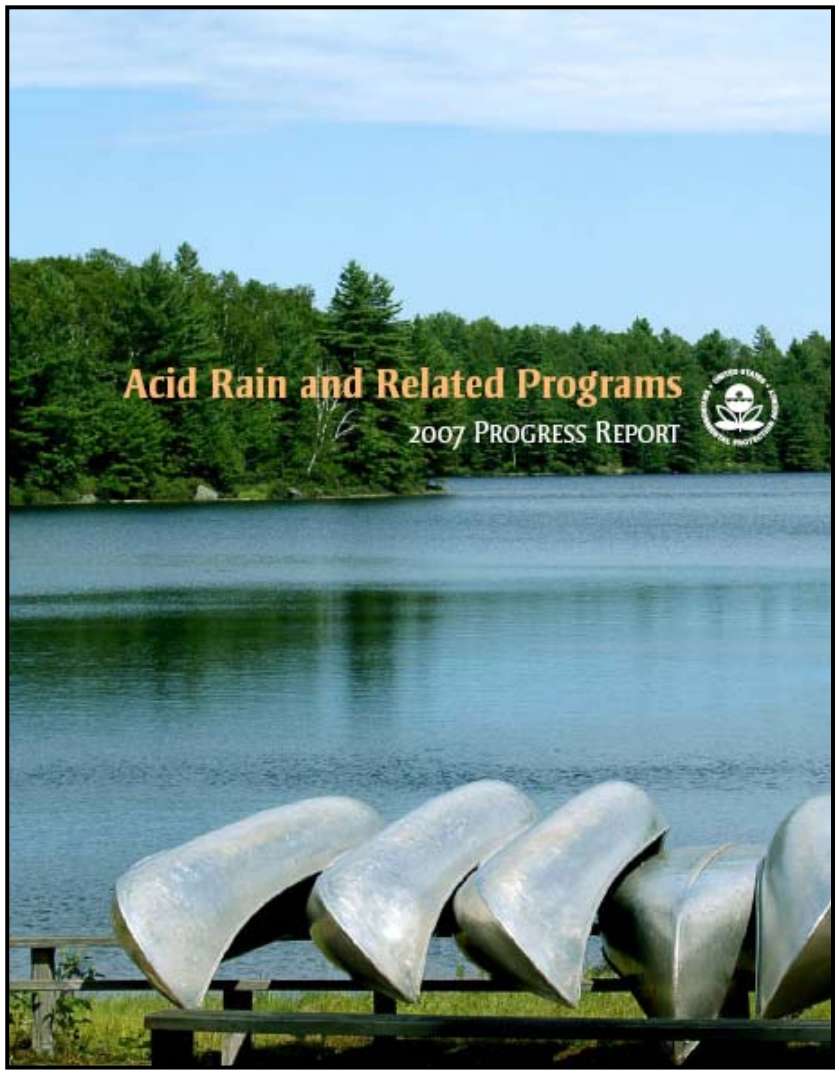
EPA program assessment

Program assessment:

Acid Rain Program
NOx Budget program
Ozone
Ecological assessment

EPA program assessment



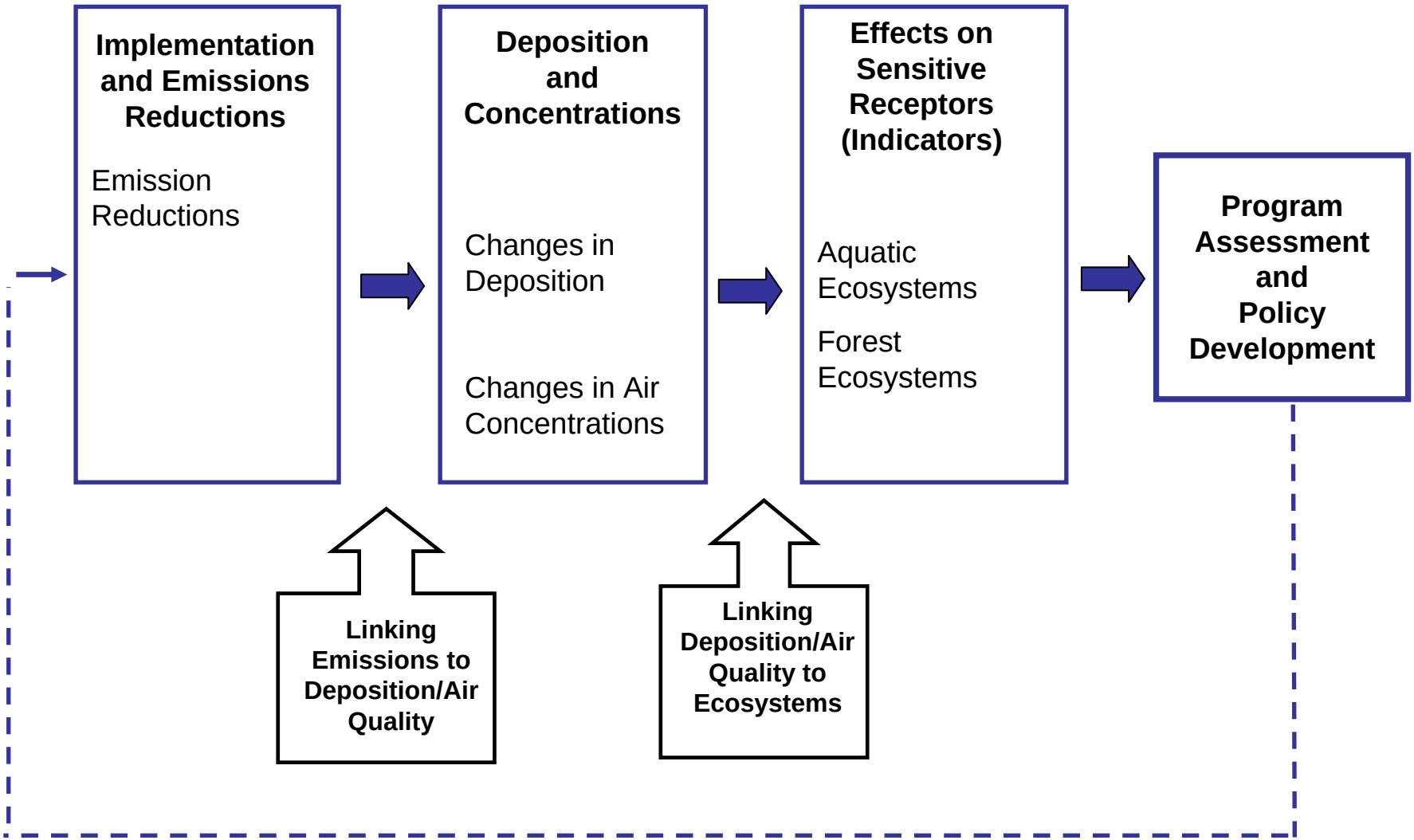
Environmental Analyses and Assessment

- Acid Rain Program
- NOx Budget Trading Program
- Other programs. E.g., Clean Air Interstate Rule

What do we mean by “accountability”?

- Accountability refers to tracking and evaluating environmental results to assess the efficacy of air pollution control efforts
- Two key questions for policy analysis and program accountability
  - Has a policy/program achieved the intended environmental and human health goal?
  - Are further emissions reductions necessary to achieve intended results (e.g., ecosystem protection)?

Framework for Program Assessment and Accountability (Ecosystem Assessment Example)

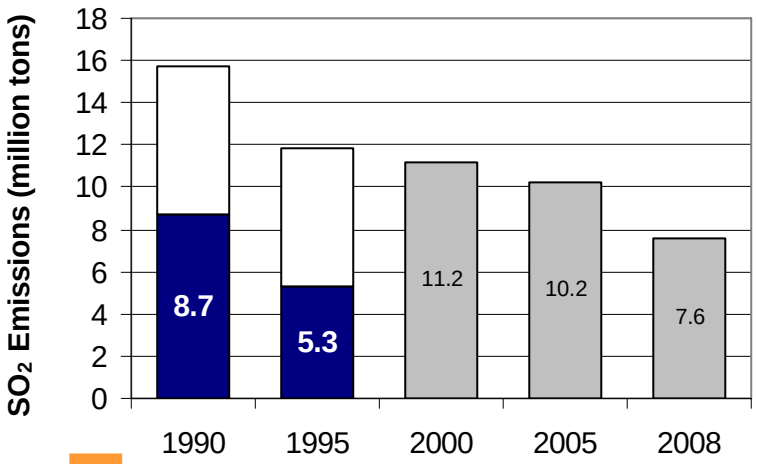


Relationships of Concern for Accountability

- Emission controls → Emissions
- Emissions → Ambient concentrations of precursors
- Ambient concentrations of precursors → Air Quality/Deposition
- Air quality/Deposition → Exposure
- Exposure → Effects on aquatic and terrestrial ecosystems

Accountability: An Acid Rain Example

SO_2 Emissions Under the ARP



Data comes from many partners and is transparent and accessible for all to use

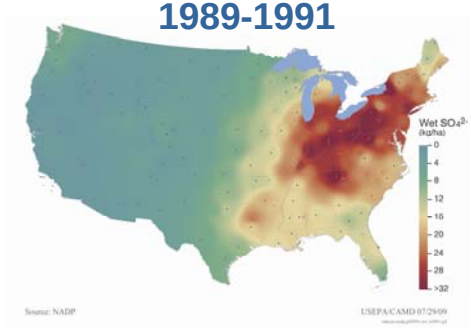
Acid Lake Response

Trend Slopes for LTM Sites in Four Eastern U.S. Regions, 1990–2006

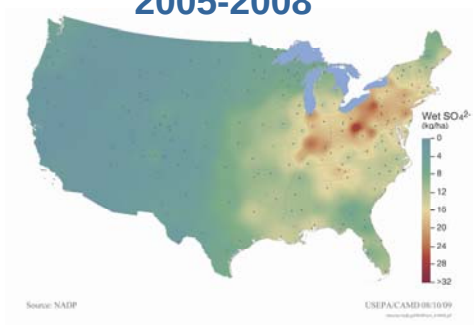
Region	Sulfate SLOPE	Nitrate SLOPE	ANC SLOPE
New England	-2.3	-0.02	0.185
Adirondacks	-2.23	-0.31	0.82
Appalachian Plateau	-2.36	-0.18	0.80
Ridge/Blue Ridge	0.10	-0.125	0.03

Wet Sulfate Deposition

Annual Mean Wet Sulfate Deposition, 1989-1991

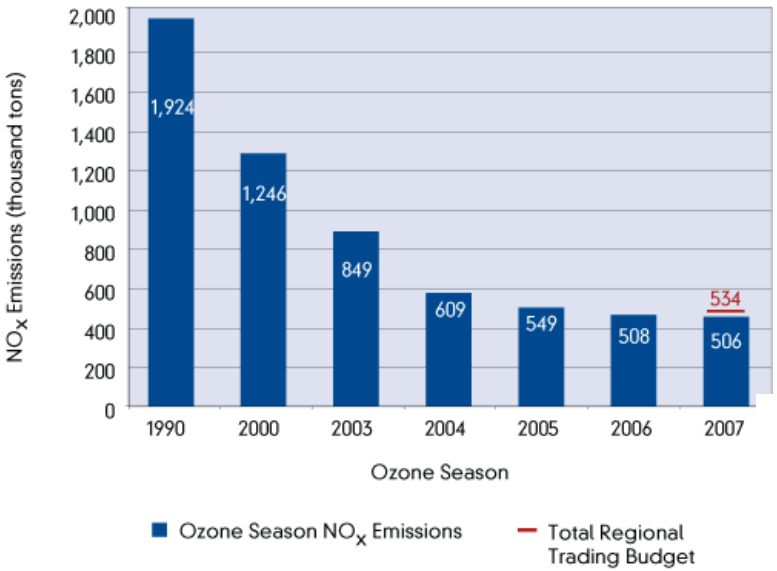


Annual Mean Wet Sulfate Deposition, 2005-2008



Accountability: An NBP Example

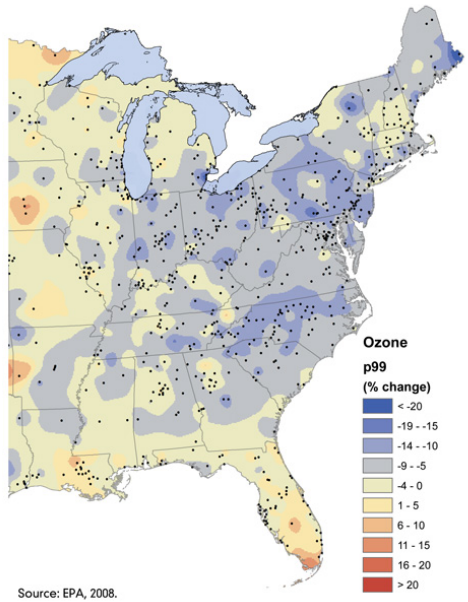
Ozone Season NO_x Emissions



Source: EPA, 2008.

Connecting policy implementation & environmental response

Ozone concentrations



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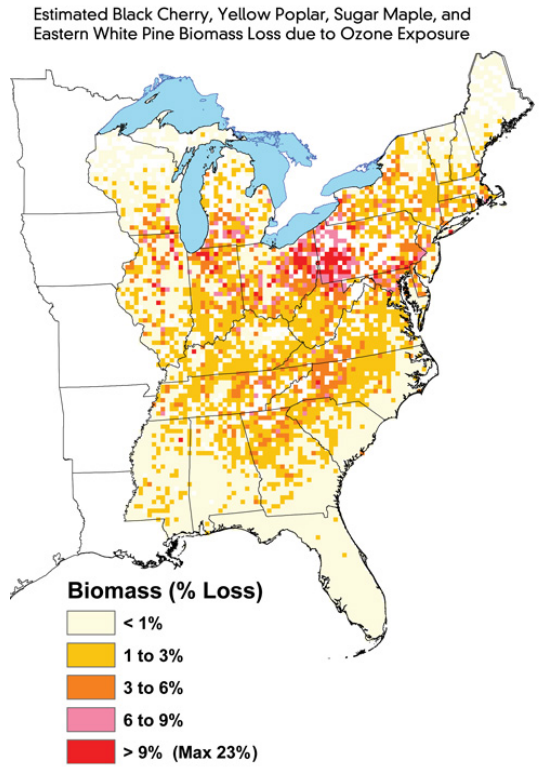
Ecological Response



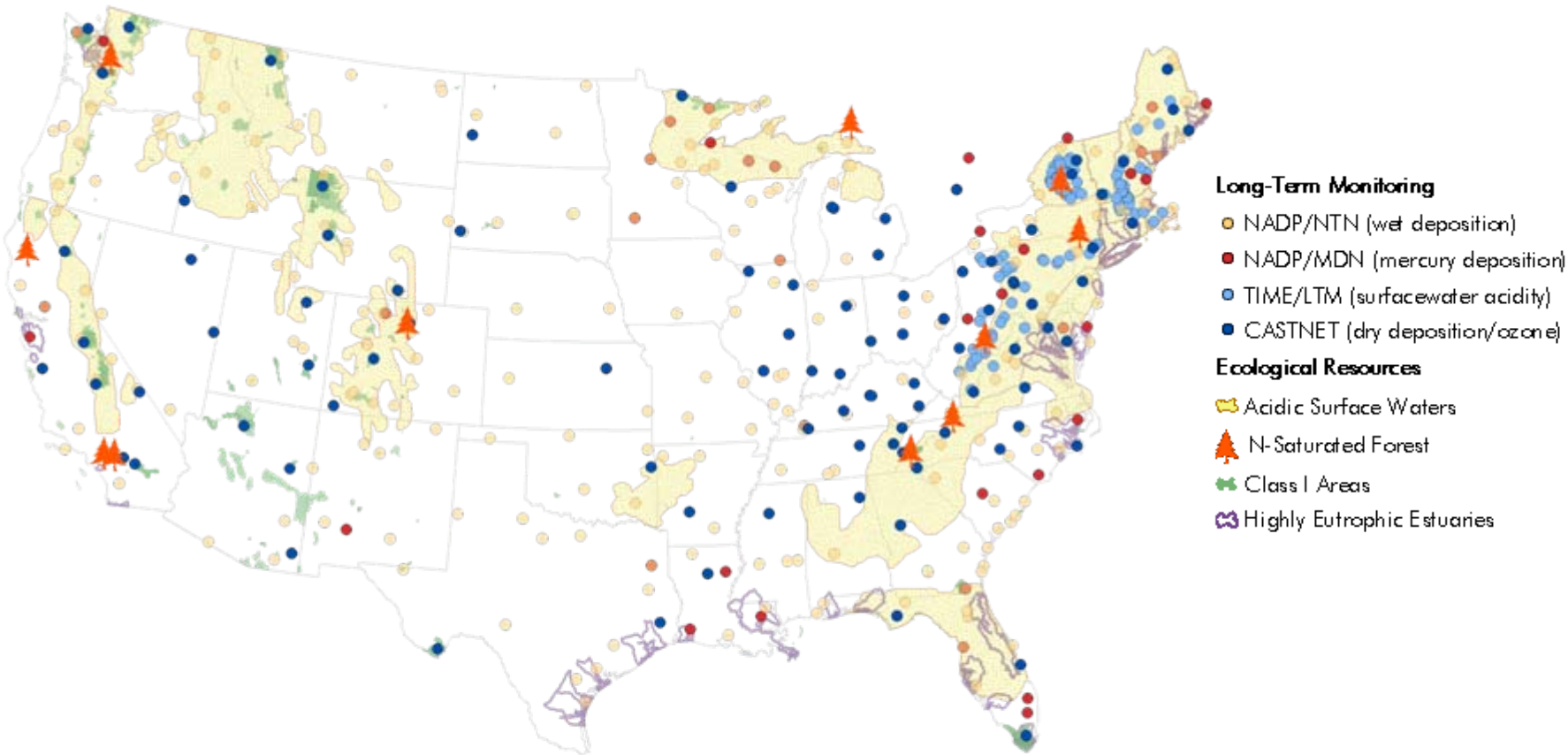
Source: EPA, 2008.

What Does the Future Look Like?

- Further substantial regional and national SO_2 & NO_X reductions – what role for CASTNET?
  - Acid Rain Program and Clean Air Transport Rule
  - Utility MACT
  - Ozone and PM NAAQS
  - Secondary SOx/NOx NAAQS?
  - Potential multi-pollutant control legislation?
- Thinking bigger – ammonia? Total reactive N?
- And bigger – Climate change?
- And biggest – coupled biogeochemical cycles?
  - C, N, S – separate in policy, but not in nature

The Big Challenge for Environmental Monitoring?

Environmental Monitoring Networks



……..To this?

NPS Perspective – Use of CASTNet Data

- Ecosystem Assessment
  - determine compliance with current and future NAAQS secondary standards for ozone and NOx/SOx
  - estimate dry portion of total deposition
  - develop critical loads
    - relate on-site air concentration and deposition data to ecosystem health
    - inputs to ecological models that determine critical loads
    - validate CMAQ modeling output which can provide deposition estimates at many parks

Use of CASTNet Data (continued)

- Temporal and Spatial Trends
  - provides information on changing air quality
- Source Apportionment Modeling
  - attribution of each species to its source is needed to develop emission control strategies
- Assessment of other effects of these species in NPS units (visibility, human health, etc.)

Issues

- Important species are not measured
- Accuracy with which some species are measured
- Time scale of measurement (doesn't support source attribution, models)
- Deposition is not measured but estimated for points
- Spatial representation is poor
  - network distribution is uneven
  - deposition data can't be interpolated
- Inferential model not useful for ecosystem approach

NPS Operational Constraints

- Retain enough ozone monitors for rural representation (most of NPS sites)

- NPS does not have highly trained operators – complexity of sites must be considered

- Budget is flat – no new initiative funds

Species of interest

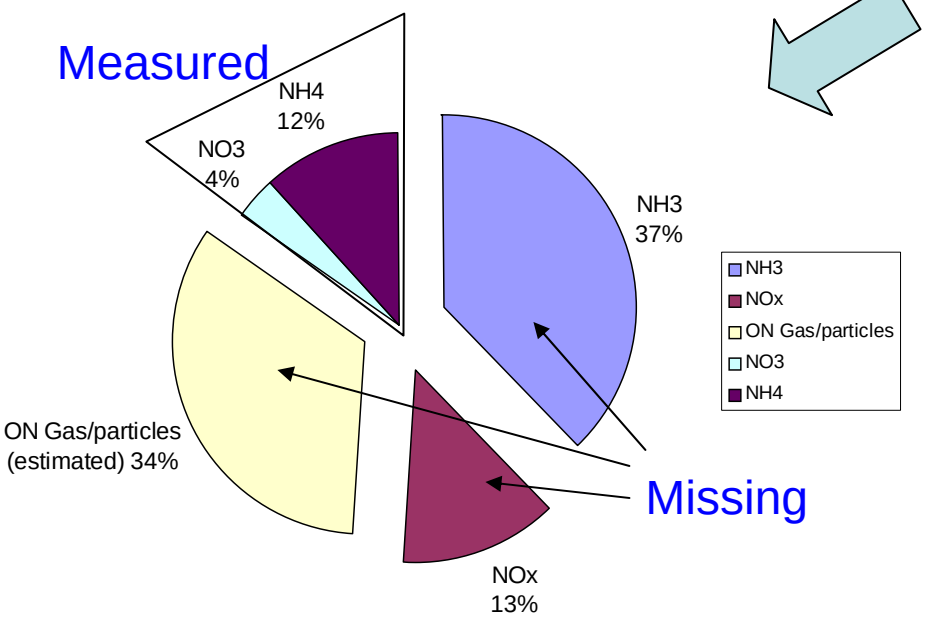
- Dry Species (Measured)
  - SO_2, SO_4
  - HNO_3, NO_3
  - NH_4
- Dry Species (Missing)
  - NH_3
  - NO_x (NO and NO_2)
  - Reduced organic gases (Aliphatic amines …..)
  - Oxidized organic gases (PAN - alkyl nitrates …)
  - Reduced and oxidized organic nitrogen containing particulates

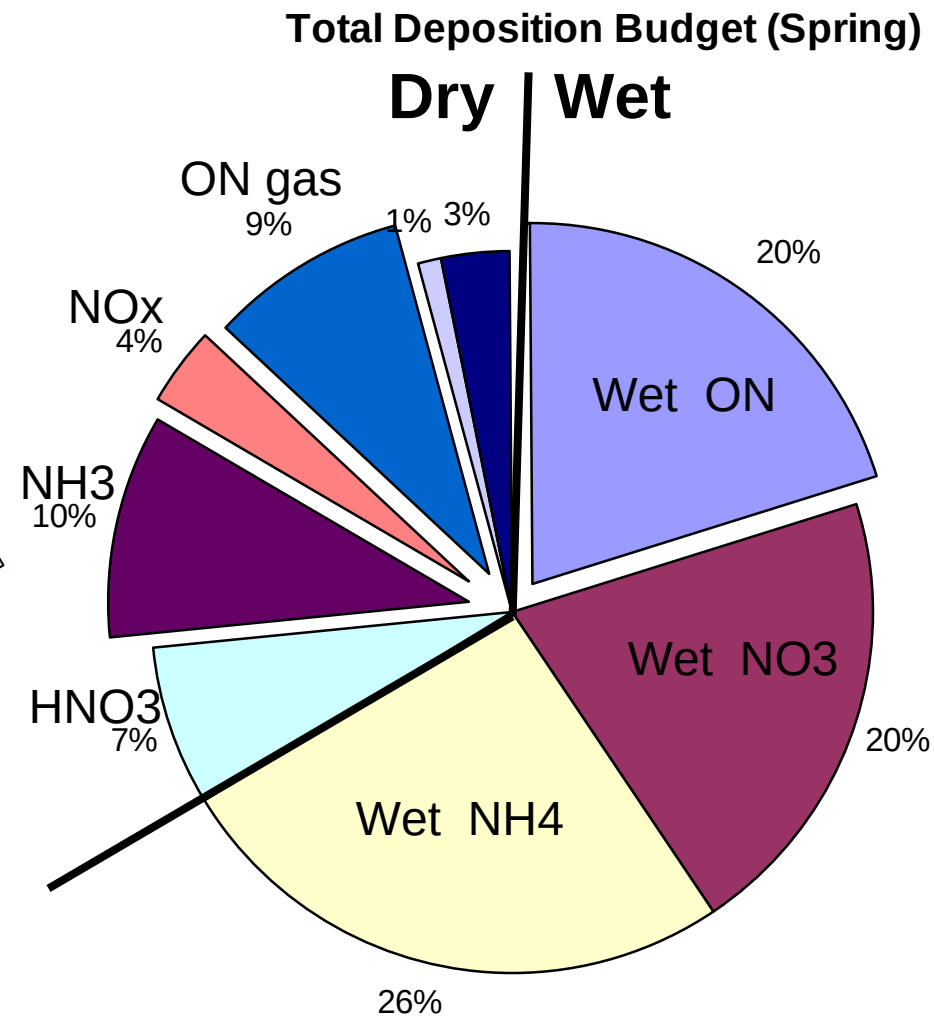
Accuracy/Uncertainty

- SO_2/SO_4 measured reasonable well for both wet and dry
- Nitrogen is problematic across the board
  - Cut-point is ill defined (coarse vs fine)
  - HNO_3/NO_3 split has large error
  - NH_4 error (underestimated) may be on order of 20-50%

NPS program assessment

Why the missing parts matter





ROMANS data

Some Possible Changes

- Drop model and calculate deposition from average Vd and concentrations
  - Eliminate met monitoring at most locations
- Add a filter to the existing filter pack to get NH_3
- Replace current filter pack with automated system for better time resolution
- Use combined networks: Add NH_3, SO_2, and HNO_3 to the IMPROVE
- Measure total ON gas/particles at some sites

Other Recommendations

- Use EPA NCORE network to get Total Chemically Reactive Nitrogen (NOy + NHx)
- Put more emphasis on Class I areas, parks, wilderness areas, etc
- Redistribute the sites for complete and better spatial representation

Model uses and evaluation

Definitions/Components of Evaluation Uses

- Operational Evaluation:
  - Are we getting the right answer?
- Dynamic Evaluation:
  - Are we getting the right amount of change across time?
- Diagnostic Evaluation:
  - Are we getting the right/wrong answer for the right reason (also, understanding the Operational and Dynamic results)
- Inverse Modeling:
  - Assuming the transport, transformation and deposition are correct, are we inputting the right emissions?
- Module Evaluation:
  - Are the loss processes/amounts correct?

Model uses and evaluation

Current Uses of CASTNET for Model Evaluation

- Operational Evaluations:
  - Air Concentrations
    - O_3, NH_4^+, T-NO3, SO_2, $SO_4^=$
      - Biases in NO_3^- and HNO_3 are of concern

- Dynamic Evaluations
  - Air Concentrations
    - Total S and O_3

- *Cannot* Do:
  - Inverse modeling
  - Dynamic evaluation on oxidized-N or reduced-N
  - Diagnostic evaluation
  - Dry deposition module evaluation

Model uses and evaluation

Desired Uses of CASTNET for Model Evaluation

Support All 5 Components of Model Evaluation

- Operational, Inverse, Dynamic Evaluations:
  - Need spatial coverage
- Diagnostic, Module Evaluations:
  - Need species completeness and high temporal resolution
- Operational/Diagnostic/Dynamic Evaluations:
  - Need spatial gradients for more stringent testing
- Dry Deposition Module Evaluation
  - Need a roving surface flux site capability

=> Need a mix of station types in the design ($ constraints)

Model uses and evaluation

Desired Uses of CASTNET for Model Evaluation (cont.)

- Fill in major gap of NH_3 for Operational Evaluation and Inverse Modeling
  - Need NH_3 and NH_X (monthly, state of atmosphere – all inorganic species)
  - Would like NO_Y + all basic inorganic species for Dynamic Evaluations

- Modernize to allow Diagnostic Evaluation with Hourly Data
  - There are nighttime issues (diurnal patterns)
  - Day-to-day variation: well mixed is best test period, currently
  - Support for diagnostic tests on state of the atmosphere
  - All inorganic gas & particle S&N species + total oxidized N (i.e., NO_Y)
  - Fill in deposition budget gaps: NH_3, NO_X, NO_Y, PAN
  - Fill in diagnostic test gaps: NO_X, NO_Y (NO_Z=NO_Y-NO_X), NH_3 (Gas Ratio)
  - Fill in dynamic evaluation gaps (nitrogen): NO_Y, NO_X, NH_3, PAN