Integrated Assessment of Economics and Science Applied to Multiple Pollutant Legislation for Electricity

Dallas Burtraw
Resources for the Future

April 1 2003

Background materials at http://www.rff.org/multipollutant

Roadmap

- **Integrated Assessment**
- **Applications**
  - 1990 CAAA
  - NOx SIP Call
- **Multi-pollutant legislation**
  - Efficient Emission Fees for SO2, NOx
  - Guidelines for Hg
  - Architecture for Carbon

Integrated Assessment: Meaning and Method

- Integration of full-form models with "internal" validity
- Emphasis on "external" integrity
- Account for correlated uncertainty
- Include assessment
- Value of additional information

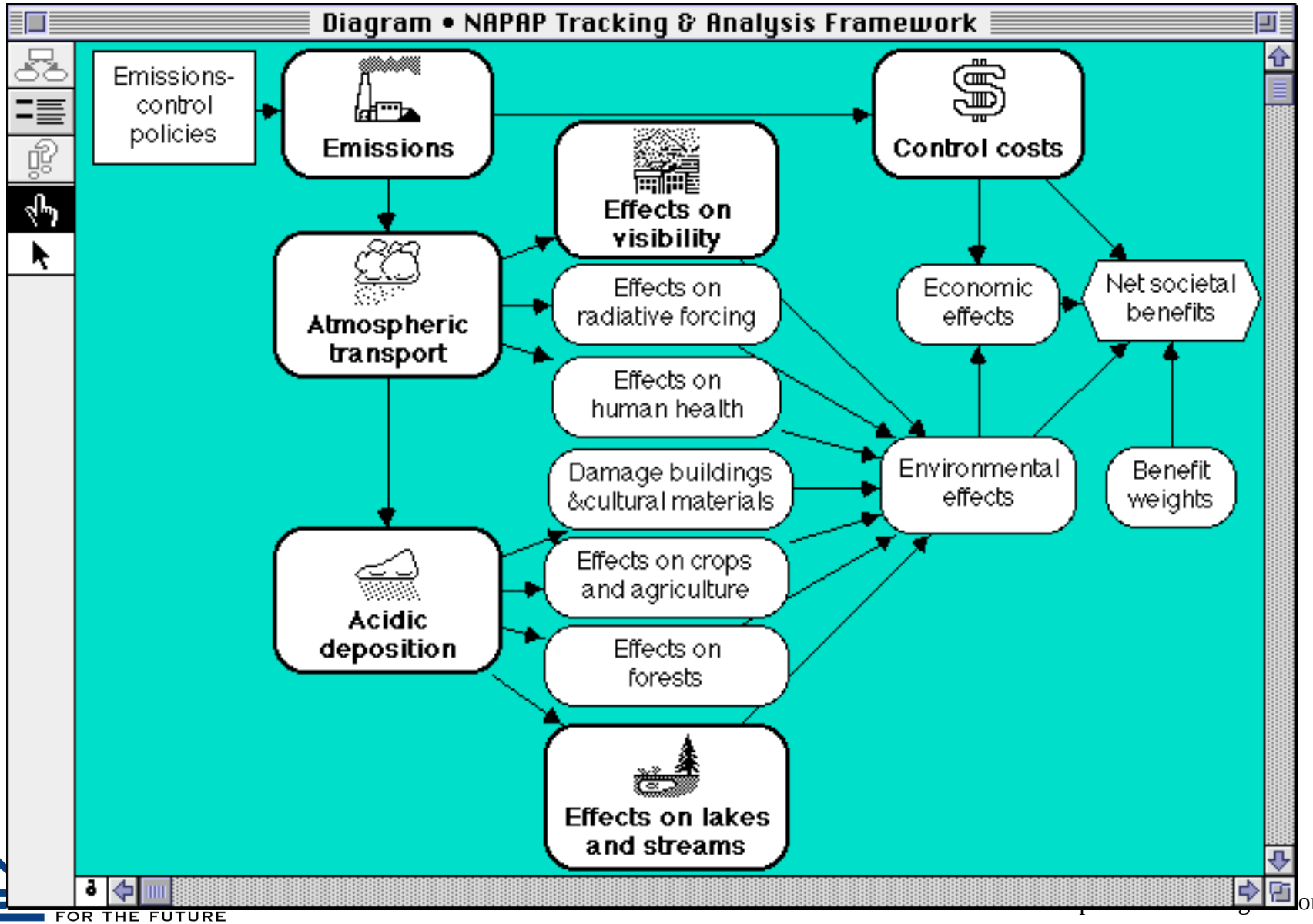
TAF Simultaneously Produced by a Distributed Team

- Adopted software engineering methods
  - Specifications, interfaces for each component
  - Library of common variables for time, space, species, etc.
- Progressive refinement based on the integrated model
- Public Domain: www.lumina.com\taflist
- Analytica platform (PC and Mac)
- Monte Carlo uncertainty analysis

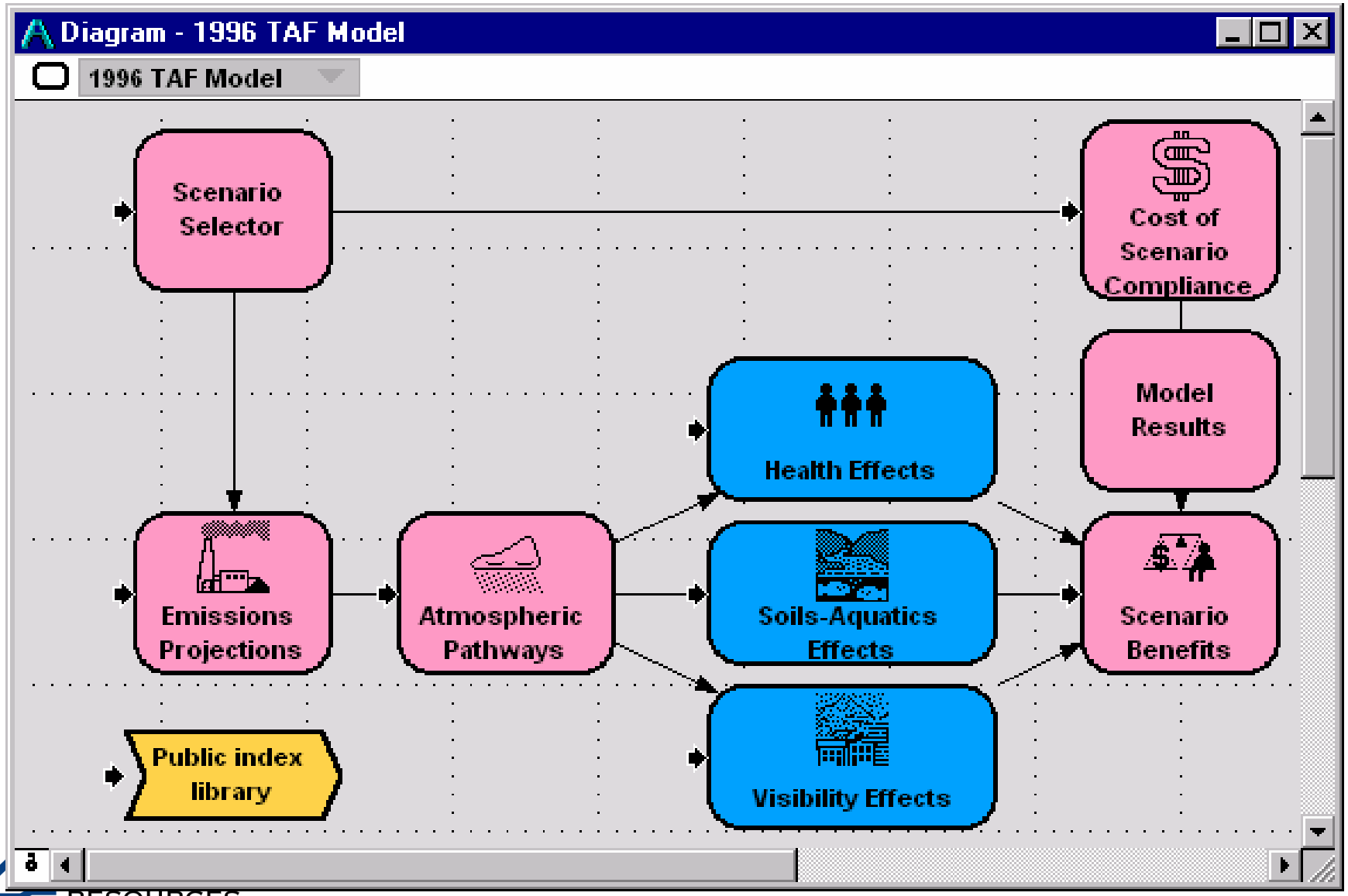
Going Forward…

- Ongoing development at RFF, U.Maine
- Technical support by ENRICH and Lumina
- Web interface

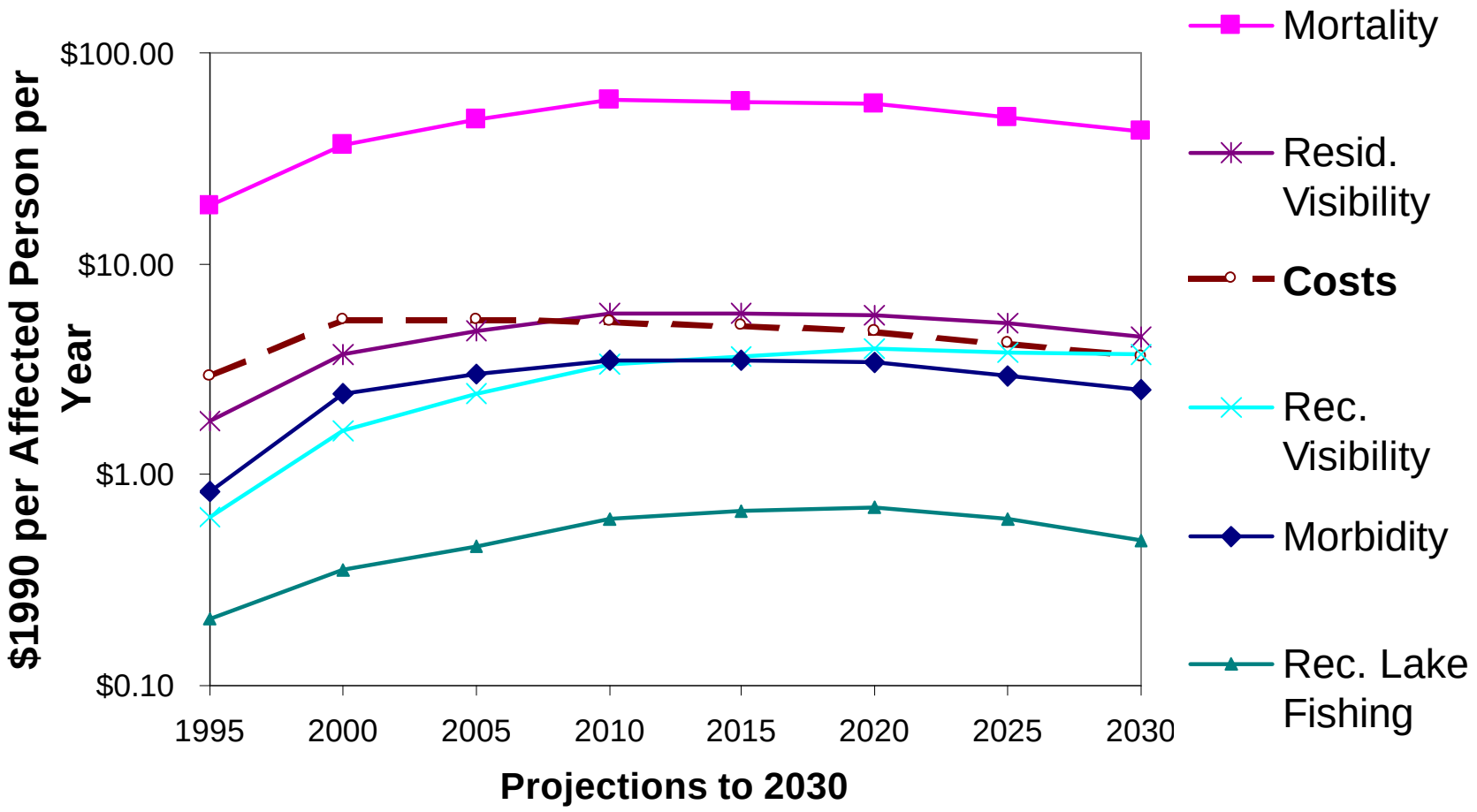
TAF- Version 1.0 (ca.1994)



TAF- Version 2.0 (ca.1996)

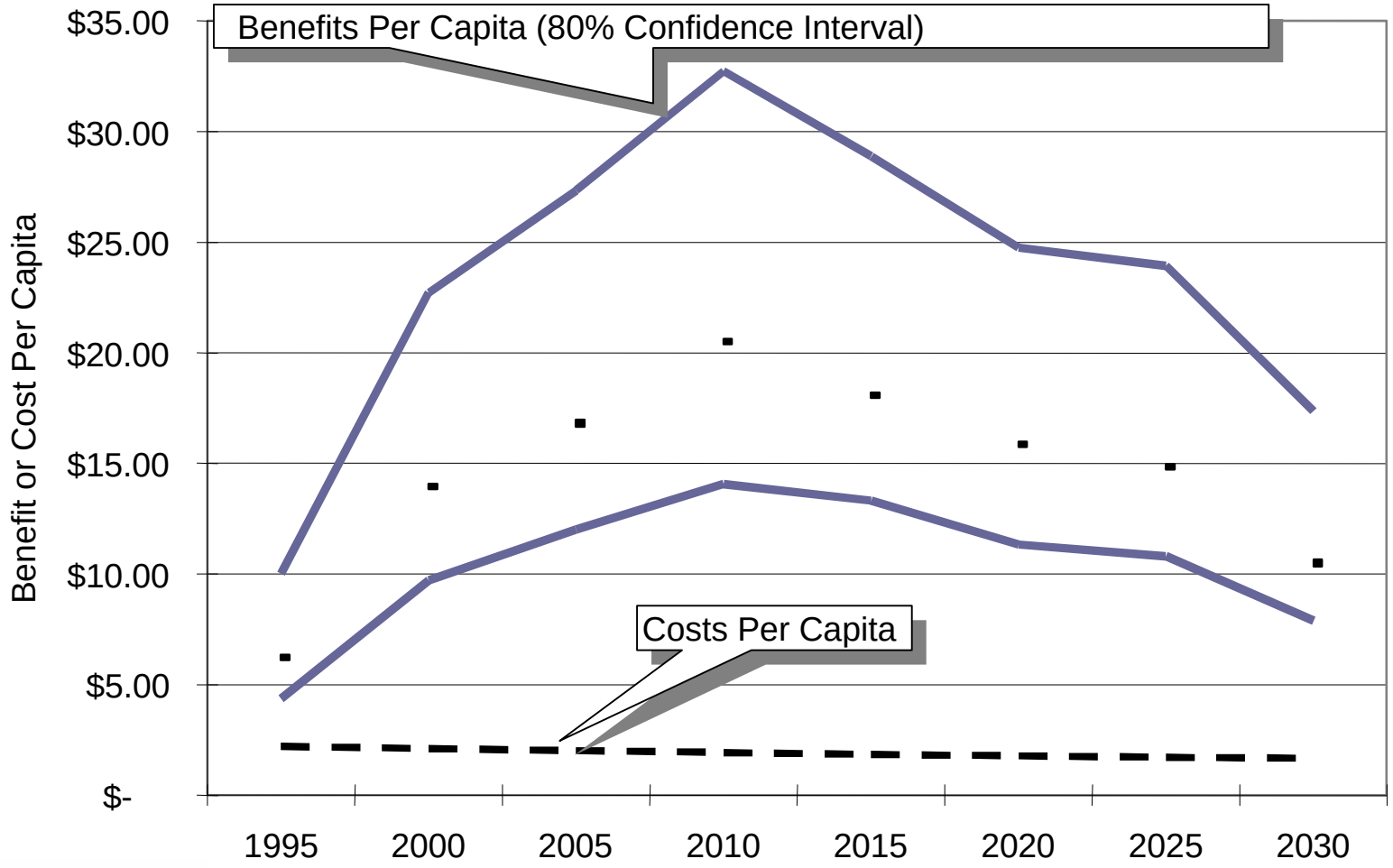


TAF Findings: Benefits and Costs of Title IV



"Integrated Assessment" (*NAPAP*, 97) and "Benefits and Costs of Title IV" (*CEP*, 98)

Uncertainty in Benefits, But Assessed Benefits Still Exceed Assessed Costs



RESOURCES FOR THE FUTURE

The Weak Links

	Expected Benefit:	***Short-Term*** Value of Additional Information:
Health: Mortality	●	●
Health: Morbidity	◉	◉
Visibility	◉	◉
Materials and Cultural Resources	◉	◉
Nonuse Values: Ecosystem Health	●	◒
Aquatics: Recreation	⊙	◒
Forests: Recreation	⊙	◒
Ag / Commercial Forestry	◒	⊙
Radiative Forcing	◉	○

Categories ● high ◎ high-mid ◒ mid ⊙ low-mid ○ low	1. Link Between Science and Economics: Are benefit endpoints well established? Does science provide infomation needed for economic analysis?	2. Economic Methods: Are economic methods adequately developed?	3. Data Availability: Is data available from science and from economics for an assessment of benefits?	4. Expected Benefit: Are expected benefits large?	5. Value of Additional Information: With the goal of improving benefit estimates, what is the relative short-term return on investment?
Health: Mortality	◎	◎	◎	●	●
Health: Morbidity	◎	◎	◎	◎	◎
Visibility	◎	◒	⊙	◎	◎
Materials / Cultural	⊙	◒	○	◎	◎
Nonuse Value: Ecosystem	⊙	⊙	⊙	●	◒
Aquatics: Recreation	◎	●	⊙	⊙	◒
Forests: Recreation	⊙	◎	○	⊙	◒
Ag. / Comm. Forestry	◎	●	◒	◒	⊙
Radiative Forcing	⊙	○	○	⊙	○

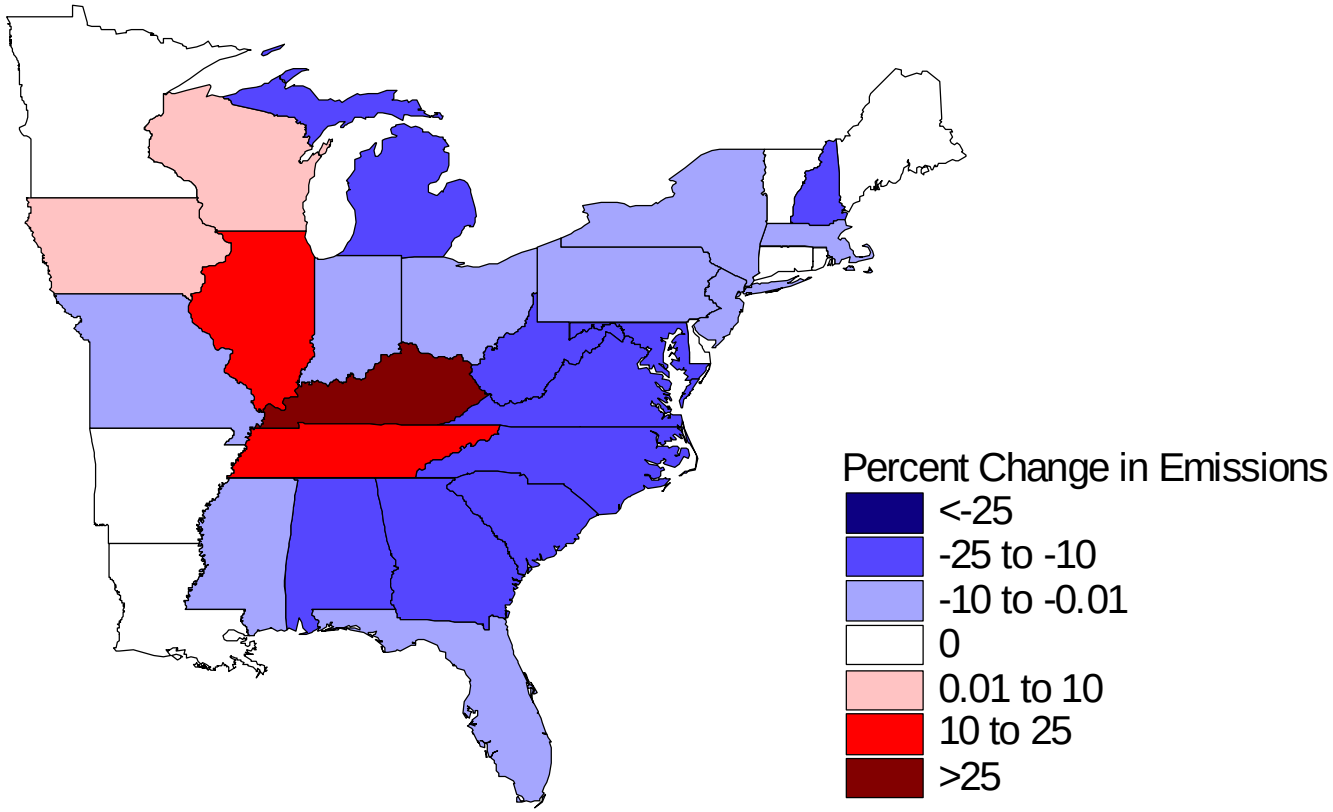
Spatial Effects of Trading

- In 1993, the NY AG sued EPA to restrict allowance sales.
- NY Assembly, later Senate, voted to constrain trades.
- 1998 agreement with Long Island Lighting Company (LILCO).
- 1998 Senator D'Amato likened long-range transport of acid rain to "airborne terrorism."

"Regional Analysis of SO2 Allowance Trading" (*EST*, 99)

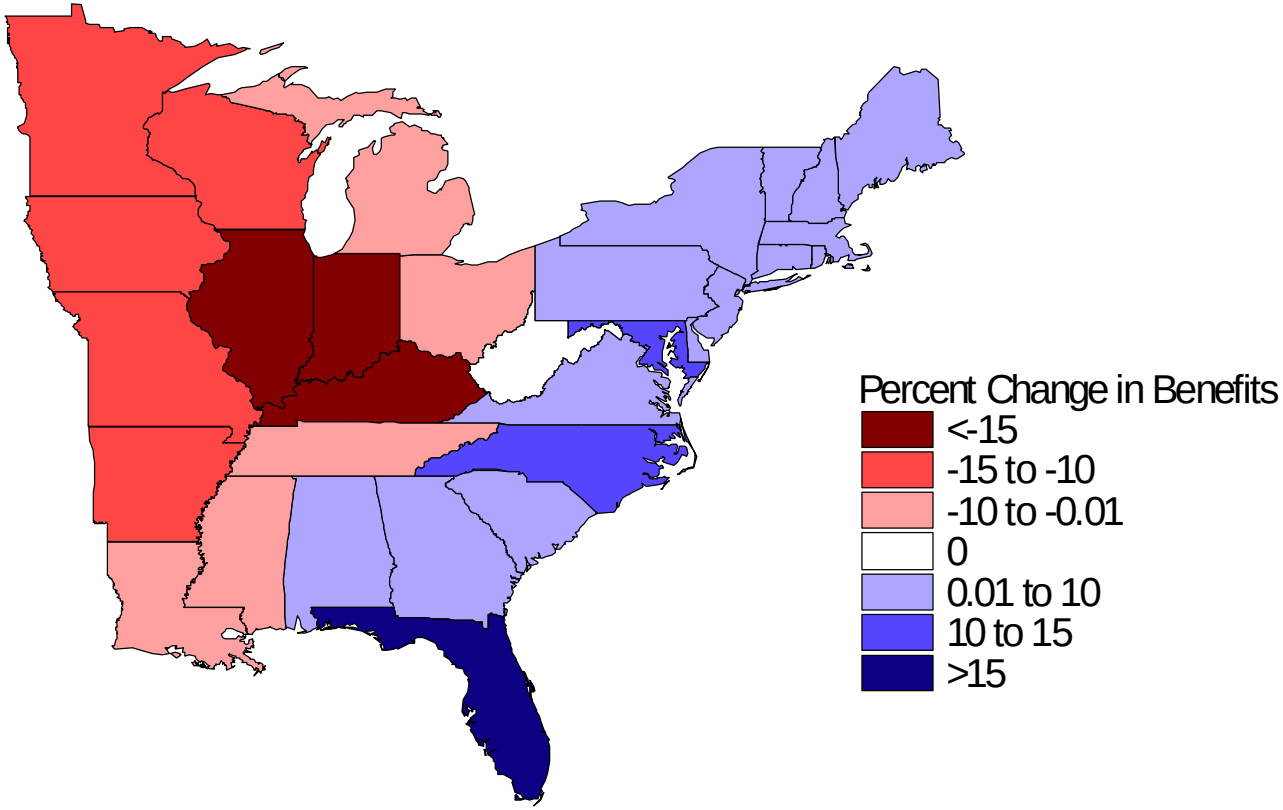
Effect of Trading on Emissions

Percent Change in Title IV Baseline
Utility Emissions Attributable to Trading for 2005



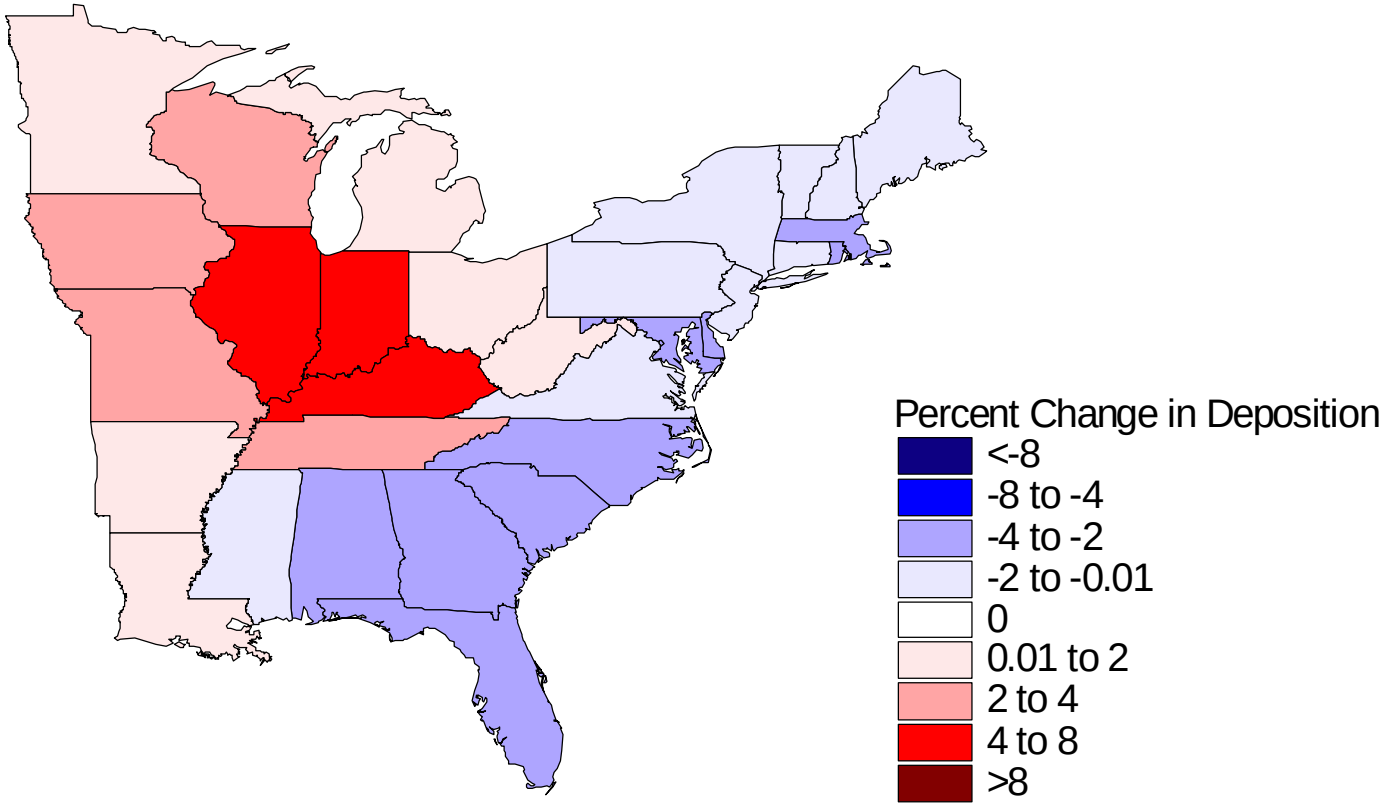
Effect of Trading on Health

Percent Change in Title IV Baseline
Benefits Attributable to Trading for 2005



Effect of Trading on Deposition

Percent Change in Title IV Baseline Sulfur Deposition Attributable to Trading for 2005



The Second Grand Experiment: NOx SIP Call

- NO_x emissions contribute to multiple problems:
  - ozone, particulates, nitrogen deposition, visibility
- Nonattainment of ozone standard provides regulatory handle for EPA NO_x SIP Call
- Policy aimed at ozone, a seasonal problem
- But, other NO_x-related effects are realized throughout the year
- Costs of NO_x control are largely fixed and capital costs.

Annual vs. Seasonal NOx Controls" (*JAWMA* 01; *Land* 03)

Question: What is the most cost-effective way to achieve NO_x reductions given full set of NO_x related problems?

Three NO_x reduction scenarios:

1. Summer cap in 19 state SIP Call region
2. Annual cap in the same SIP Call region
3. National Annual cap

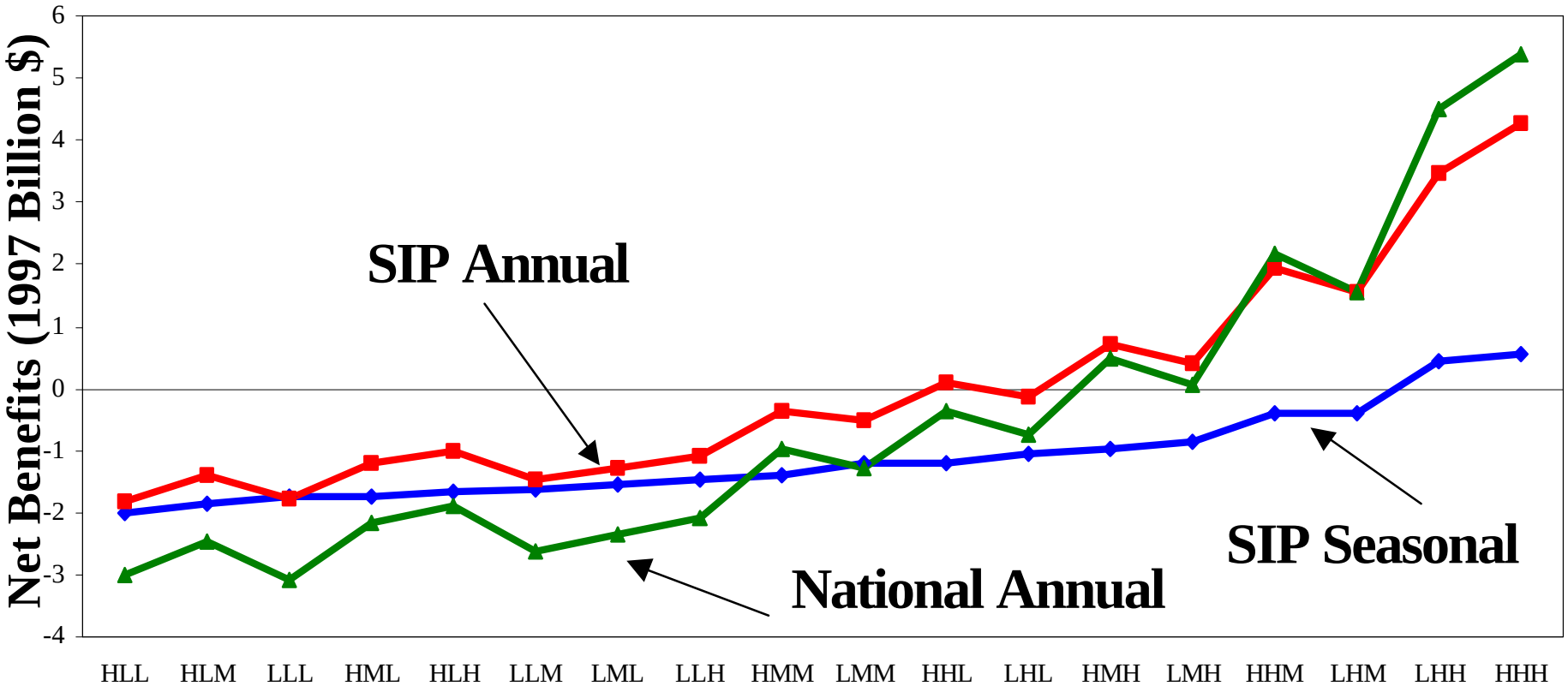
Major Uncertainties

1. Market Structure
2. Epidemiology / Mortality
3. Valuation / Mortality

RFF “Haiku” Electricity Model

- Intra-regional market modeling
  - Market equilibrium in 13 regions
  - Demand: 3 customer classes, 4 time periods, 3 seasons
  - Supply constructed using model plants
    - Defined by technology, fuel type, vintage
    - Investment and retirement
    - Emission compliance
    - Fuel market prices adjust
- Inter-regional power trading
  - Equilibrates regional prices, transmission constraints

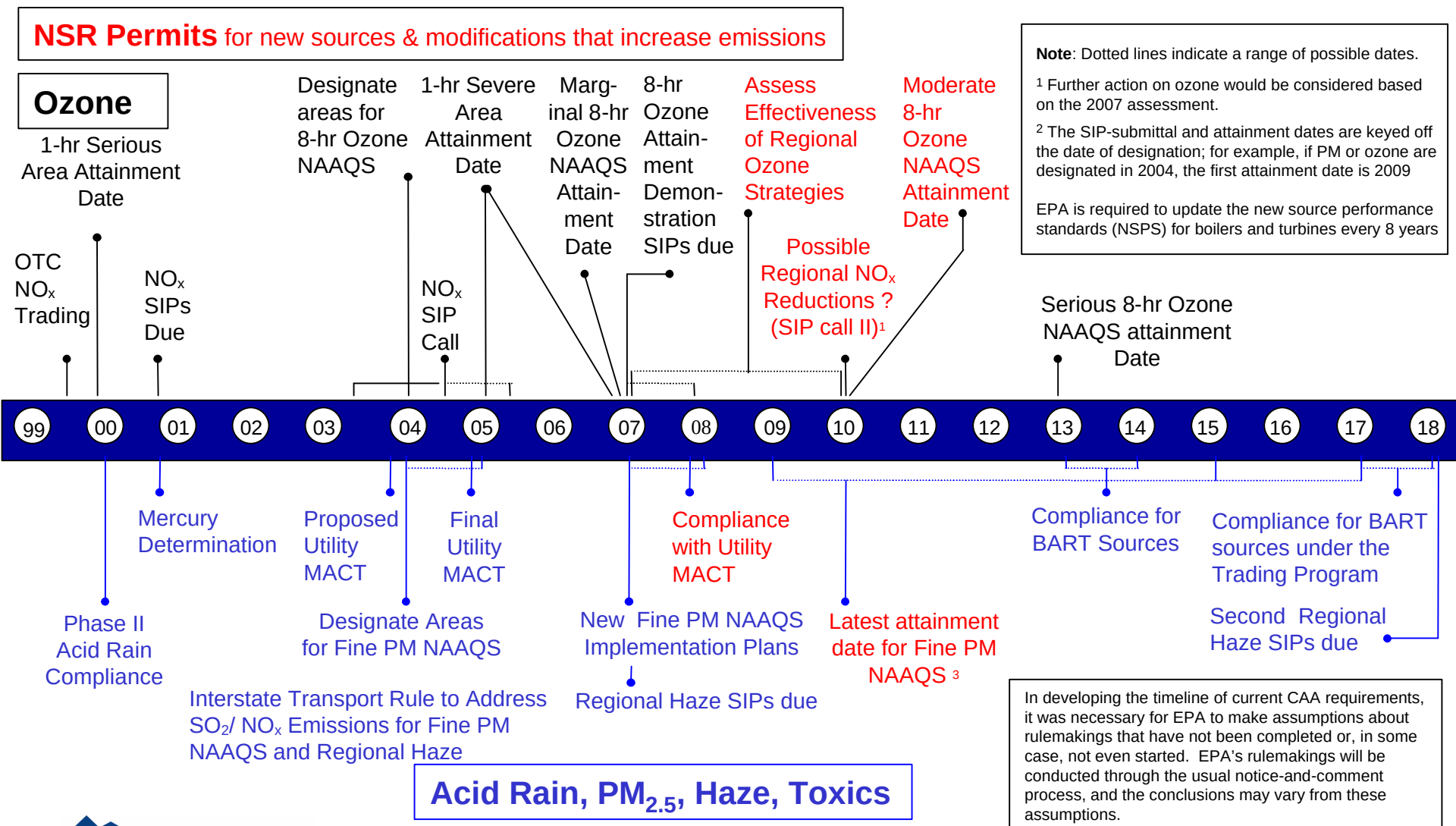
Net Benefits for the Nation, 2008



Main Findings Favor Annual NOx Controls

- Under all scenarios **SIP Annual policy** yields greater net benefits than current policy; Ohio Valley included.
- National annual policy is slightly less cost-effective than current under preferred assumptions
  …but it is more cost-effective under majority of scenarios.
- If any one assumption realizes “high” value then national annual policy is preferred to current one (SIP Seasonal).
- SIP region always realizes greatest net benefits under National Annual policy.
- Omitted benefits do not change ranking for SIP Annual

The Clean Air Act's Requirements



Note: Dotted lines indicate a range of possible dates.

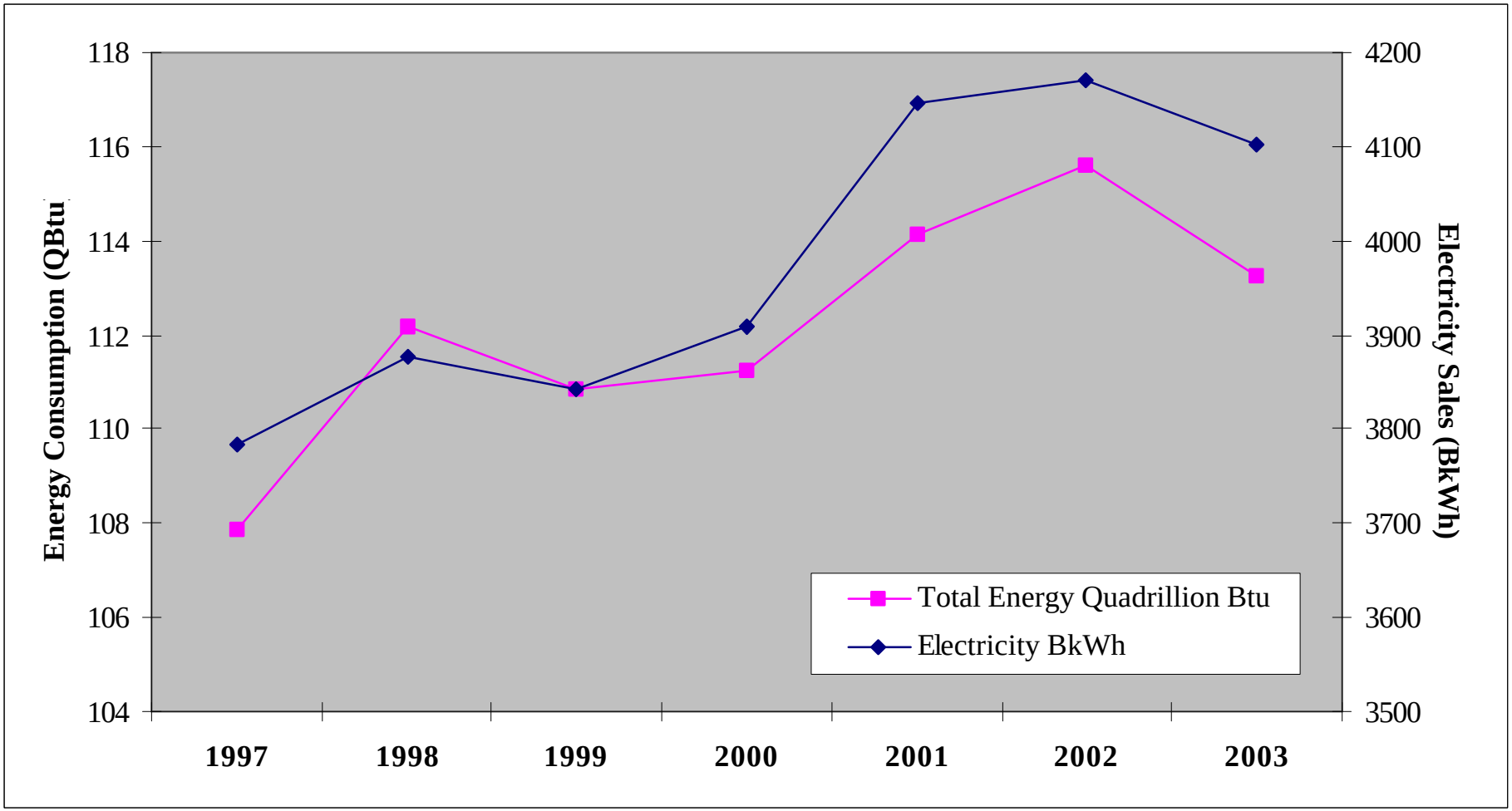
[1] Further action on ozone would be considered based on the 2007 assessment.

[2] The SIP-submittal and attainment dates are keyed off the date of designation; for example, if PM or ozone are designated in 2004, the first attainment date is 2009

EPA is required to update the new source performance standards (NSPS) for boilers and turbines every 8 years

In developing the timeline of current CAA requirements, it was necessary for EPA to make assumptions about rulemakings that have not been completed or, in some case, not even started. EPA's rulemakings will be conducted through the usual notice-and-comment process, and the conclusions may vary from these assumptions.

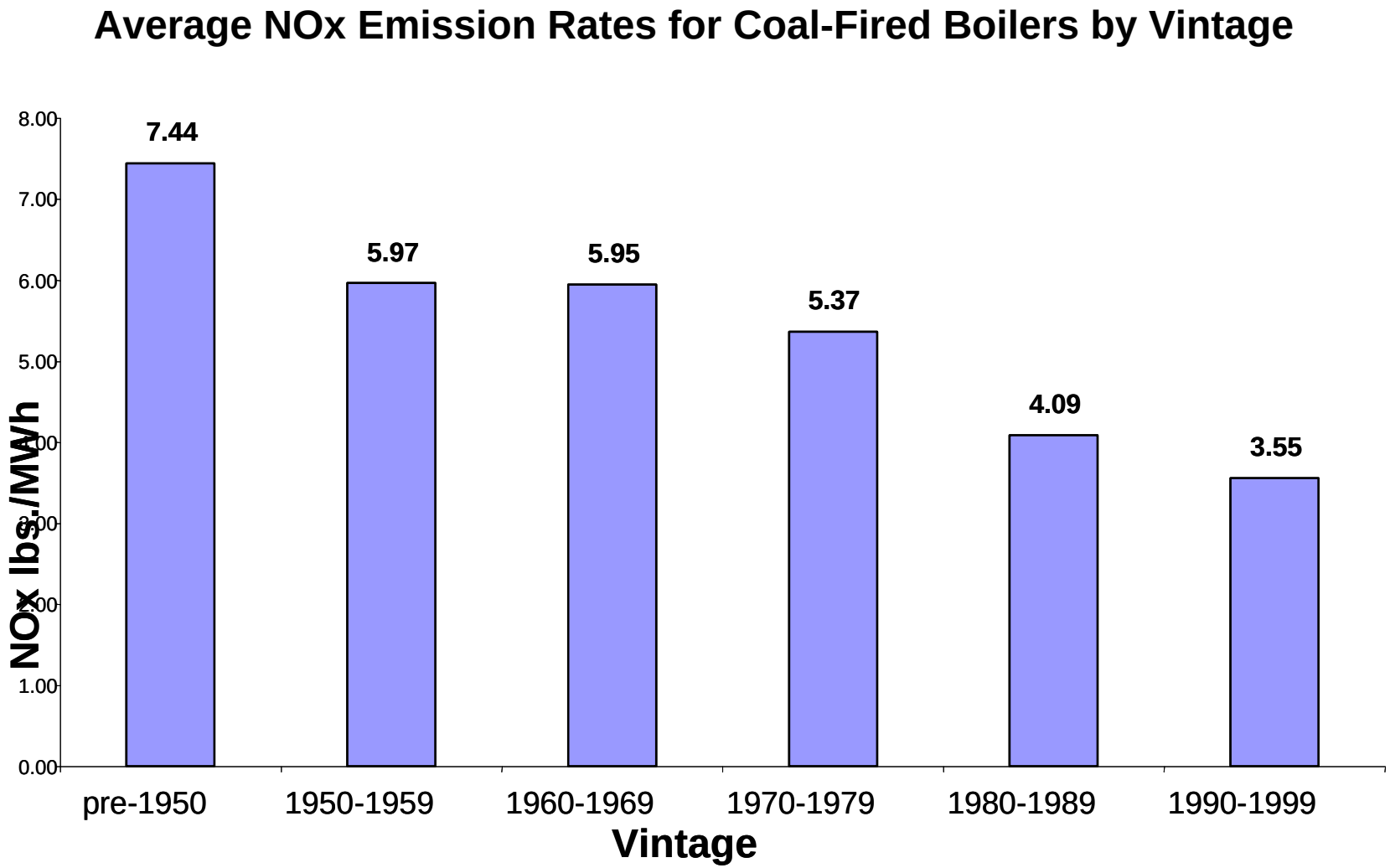
EIA forecasts over time for 2010



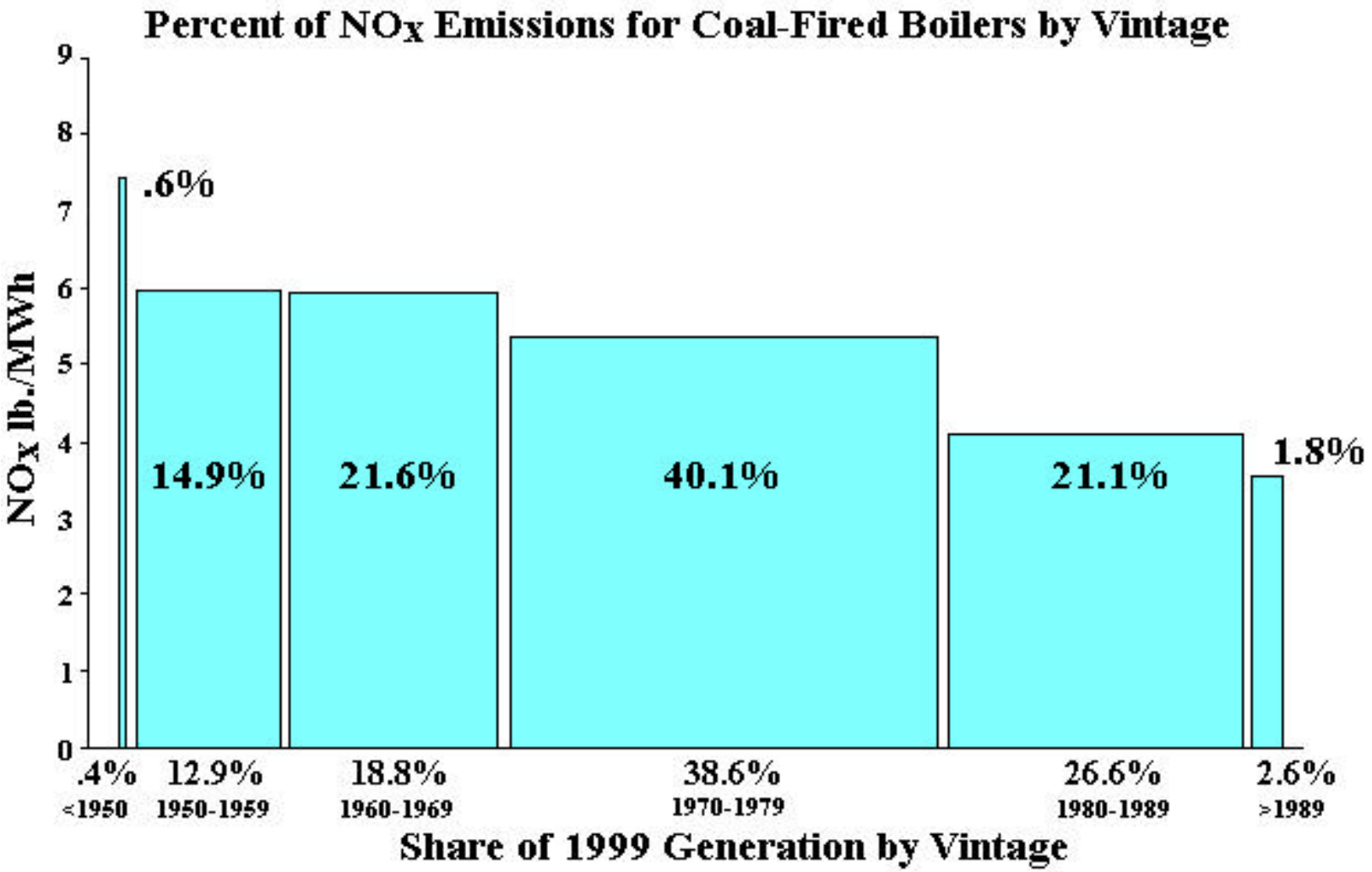
Percent of Total Generation in the Baseline

	Coal	Gas
Today	54%	15%
Forecast for 2020	48%	25%
Growth	20%	106%

Old generating units have highest emission rates…



But just a small share of emissions



Legislative Comparison of Multipollutant Proposals: S. 366, S. 485, and S. 3135.

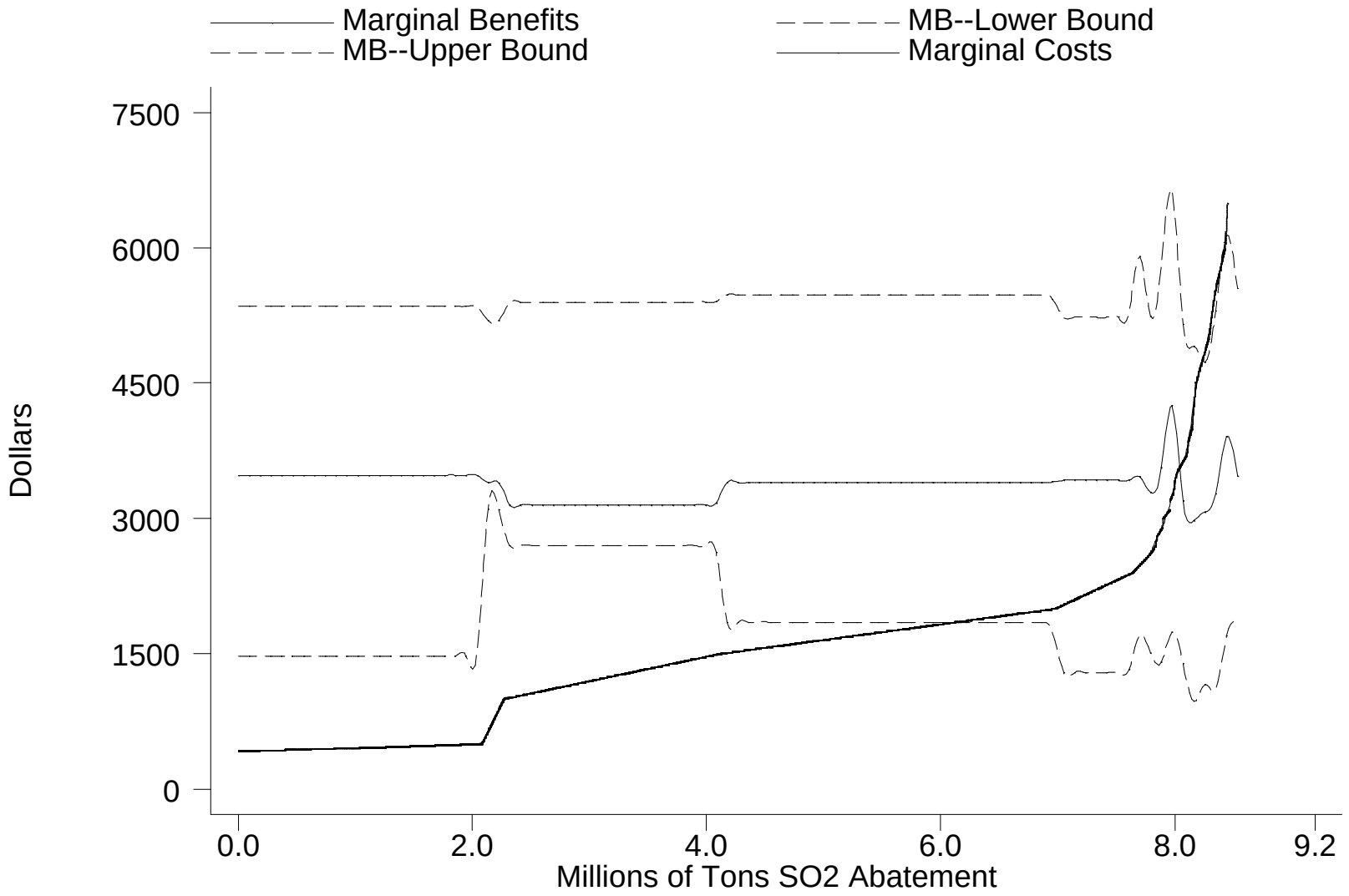
Legislative Proposal	S. 366 Jeffords (108th)	S. 485 Clear Skies (108th)	S. 3135 Carper (107th)
National Annual Allowance Allocation Caps			
Sulfur Dioxide (SO_2) Million Tons	2.25 in 2009. Two regions.[1]	4.5 in 2010. 3.0 in 2018.	4.5 in 2008. 3.5 in 2012. 2.25 in 2015.
Nitrogen Oxides (NO_x) Million Tons	1.51 in 2009.	2.1 in 2008. 1.7 in 2018. Two regions.[2]	1.87 in 2008. 1.7 in 2012.
Mercury (Hg) Tons	5 in 2008. Facility specific. Non-tradable.	26 in 2010. 15 in 2018.	24 in 2008. 5 to 16 in 2012.[3] Facility specific.[4]
Carbon Dioxide (CO_2) Billion Tons	2.05 in 2009.[5]	No CO_2 policy.	2.59 in 2008.[6] 2.47 in 2012.[7] Sequestration increases CO_2 cap.

Efficient Emission Levels for SO2 and NOx

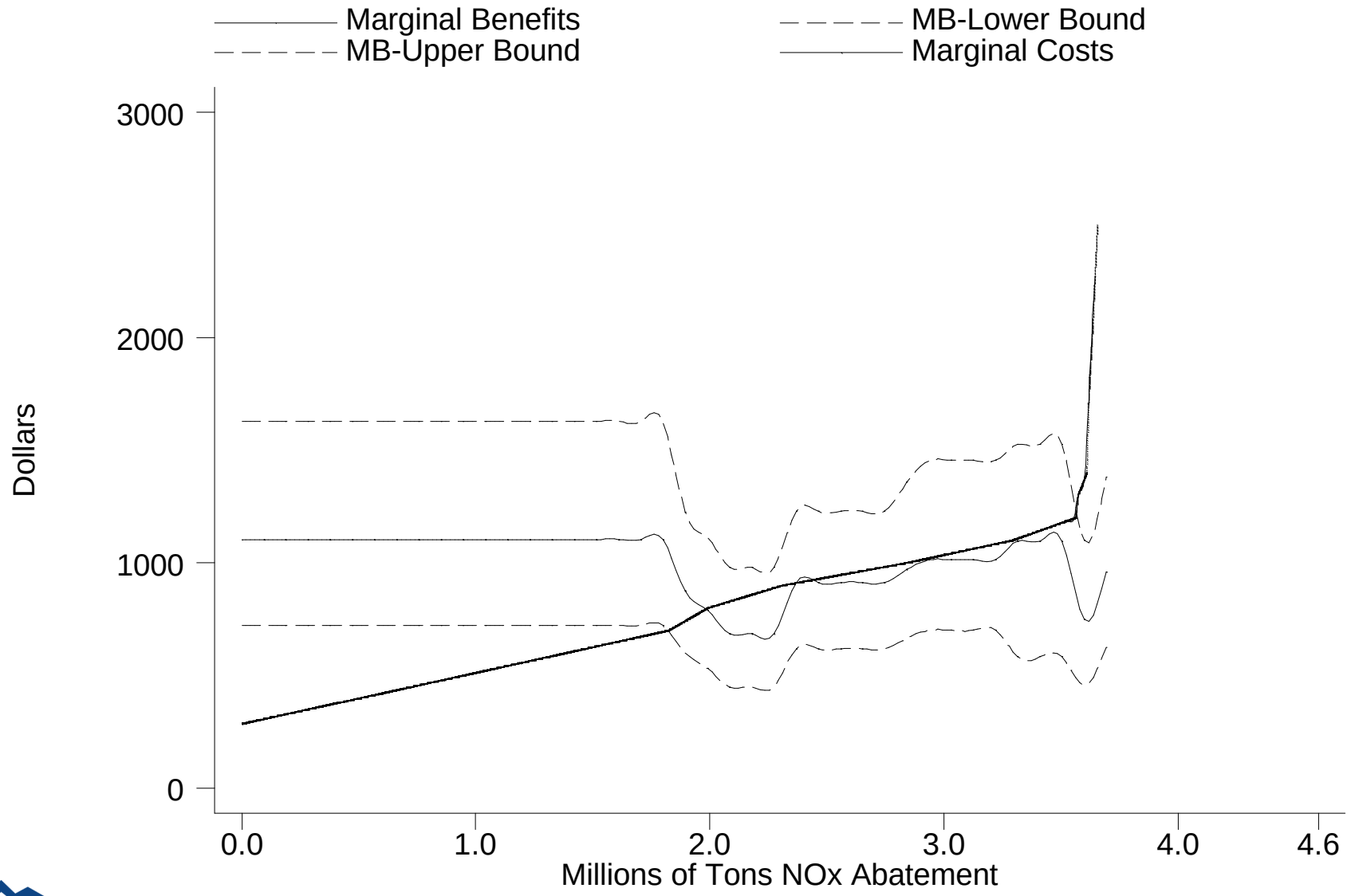
Scenario and Key Assumptions

- PM-health modeled only; no ozone benefits
- Examine SO2 and NOx emission fees
- No CO2 or mercury requirements
- Results for 2010
- Title IV SO2, SIP Call NOx baseline
- Pope et al. (1995) for sulfates
- Nitrates as ordinary PM_{10}
- VSL=$2.25 million (Mrozek and Taylor, 2001)

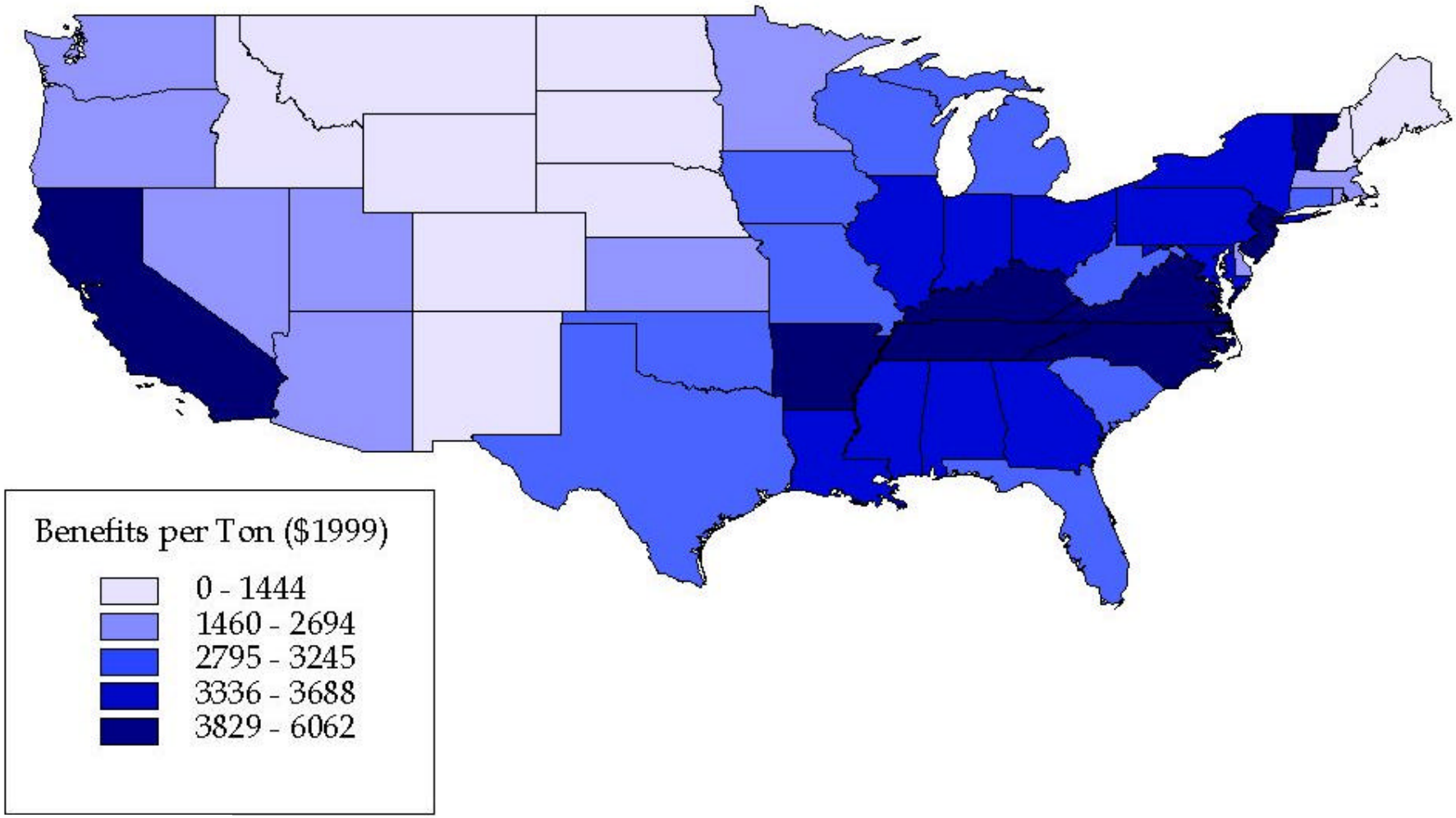
Marginal Benefits and Costs: SO_2



Marginal Benefits and Costs: NO_X

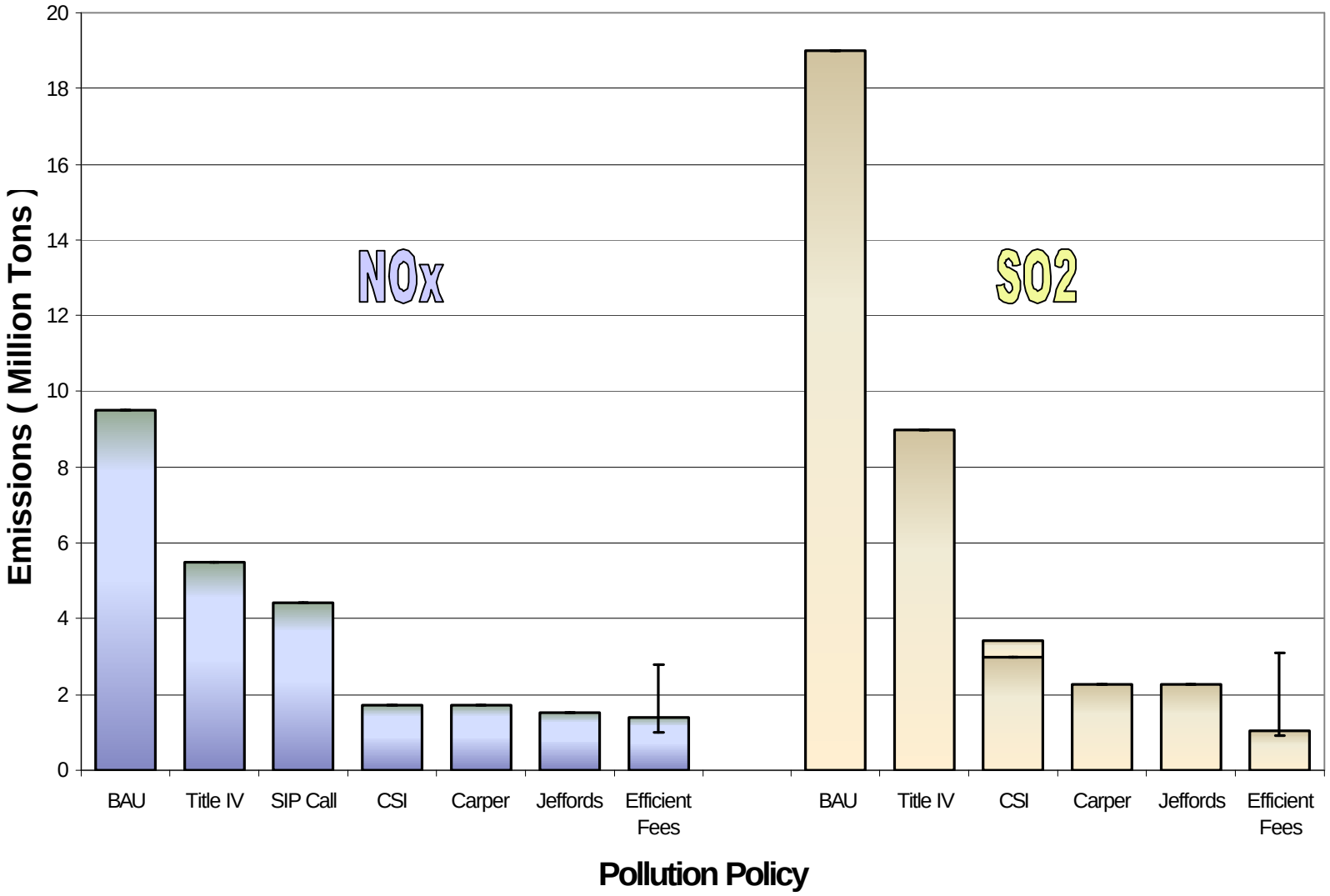


Value of SO_2 Emission Reductions by State



RESOURCES FOR THE FUTURE

NO_X & SO_2 Electricity Sector Emissions in 2020



Source: Banzhaf, Burtraw and Palmer, 2002. *Public Utilities Fortnightly*

Main Points on Criteria Pollutants

- SO2 and NOx caps for all of the proposals appear justified... there is room for more SO_2 reductions; NO_x reductions about right.
  - Efficient SO_2 fee ($4,700 - $1,800 per ton) would yield 0.9 – 3.1 million tons.
  - Efficient NO_X fee ($1,200 - $700 per ton) would yield 1.0 – 2.8 million tons.
- Evidence supporting regional caps.
- Ancillary CO_2 reductions.

Mercury

Target:

What does benefit literature say?

MACT~7.4 tons/yr to Ancillary~28 tons/yr

(current levels in coal burned: ~75 tons/yr)

Timetable:

Help states

Design:

Trading enables tougher goals. Perhaps with…

- Maximum emission rate constraint

(not minimum emission rate reduction), and

- State opt out of trading for local protection

Architecture for Carbon

Principles:

1. The fundamental divide: voluntary or binding
2. More important to start early than to start large
3. More important to end economy-wide than to start there
4. Compensation through allocation
5. Efficiency is essential if constraints tighten

Annual Asset Value of Emission Allowances

NO_X
$1.7 Billion

SO_2
$2.7 Billion

Carbon 34%
Reduction (Kyoto)
Economy Wide
$450 Billion

Carbon 6%
Reduction
in Electricity
$15-$24 Billion

Key Ingredients to Multipollutant Policy

- **SO_2 and NO_X caps** are justified on benefit-cost.
- **Mercury trading,** with constraints, can lower costs; benefits not well quantified.
- Architecture is very important for **carbon** policy.
  - ✓ Start soon rather than start large.
  - ✓ Auction is **less costly** to society, and preserves **asset values** better than output-based allocation.
  - ✓ The auction institution is **expandable** beyond electricity.
  - ✓ A hybrid allocation approach to balance **compensation** and **efficiency**.

Final Thoughts on Integrated Assessment, in Any Domain

- **Embrace and understand uncertainty** to assess confidence in your knowledge and in the policy implications of your assessment
- **Progressively refine model scope**, and **model components**, to improve credibility and relevance of your analysis to policy
- **Maintain an open architecture** to support easy model expansion, as well as adoption of the model by others