Air Quality Management –
From Then to Now…

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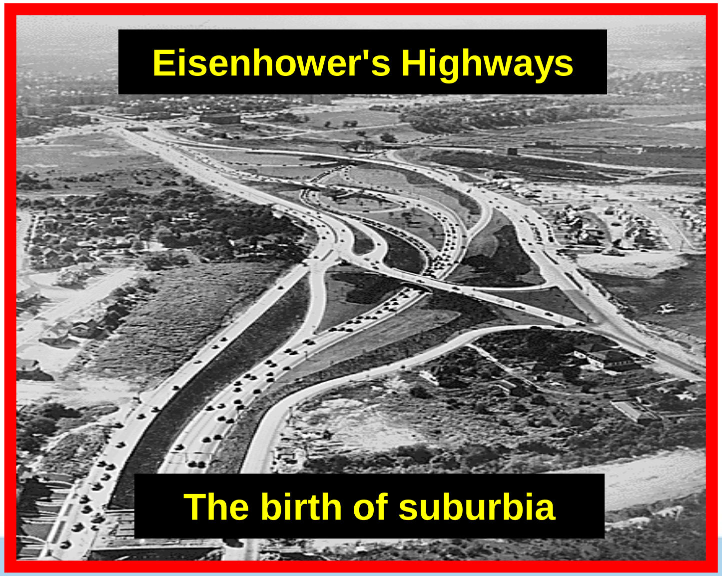
This presentation does not necessarily represent EPA policy

Today's Mind map

- A short journey through air pollution history…
  - Clearing the air
  - The public and legal drivers
  - The early days of the Clean Air Act

- A Framework for Air Quality Management
  - Implementing a cohesive process
  - Monitoring is the heart of the AQM
- Measures of success
  - Evidence we can measure in the air
  - Environmental and public health evidence
- Addressing what's left to be done
  - Disproportionate impacts
  - The sensor revolution
  - Systematic approaches to environmental and public health
  - National issues and environmental futures

A Compelling History: Post-War Industrialization and Growth



A Compelling History: Public Distress with Health Consequences


Donora – 1948

London –1952


New York City – 1966

Events of health consequence and growing health adversities


Birmingham – 1972


Los Angeles – 1988


Atlanta – 1996

A Compelling History: Public and Private Efforts Yield Marked Recovery


Donora

London


New York City

A new era for cities – places to live, work and play


Birmingham


Los Angeles


Atlanta

How did the US federal government transition from largely ignoring a highly polluted environment to one that today, is much cleaner and as a result of concerted effort… is much healthier?

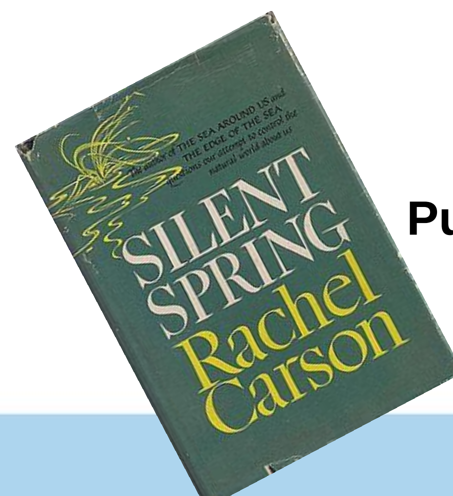
US Air Pollution Programs in 1950s-60s

- Cities were largely responsible for dealing with air pollution
  - Regulations were based on the opacity of smoke
  - California dominated resources (60% of all city/state spending)

- Federal involvement was very limited and disjointed
  - National Air Sampling Network 60 urban, 20 nonurban particle (TSP)
  - New PHS Division of Air Pollution: 251 employees, $4 million

Nascent federal efforts were scattered across many agencies

1907 - 1964



Published 1962

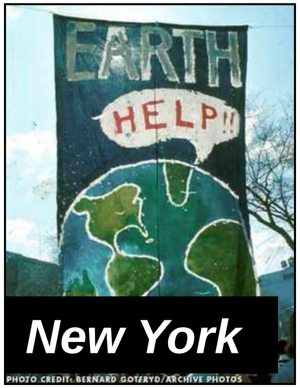
Earth Day – April 22, 1970

20 million people participated in a national teach-in

DC

Chicago

New Orleans



New York

Miami

Boston

Philadelphia

The Evolution of "The" Clean Air Act

Title	Overview of Major Provisions
The Air Pollution Control Act 1955	Authorized HEW to do research and assist states. Little happened.
The Clean Air Act of 1963	PHS expanded research, grants to states.– First Federal role – HEW to develop pollution criteria.
Motor Vehicle Act 1965	Authorized 'practicable' emissions stds for new cars
The Clean Air Act Amendments of 1966	Extended the 1963 law. Added authority for grants to maintain (not just develop) state and local programs.
The Air Quality Act of 1967	Established an air quality management (AQM) system with required actions by states and increased Federal role HEW criteria for ambient state standards, review of state standards and control plans, and authority to step in Preempted state regulation of new automobile emissions except for California.

Believe it or Not: Things Can Move Quickly…

The Birth of the US EPA

- 1969 - Nixon created the *Environmental Quality Council* "to coordinate governmental action against environmental decay…"
- April 1970 - Advisory Council on Executive Organization ("Ash Council") advised Nixon to form the EPA
- Dec 4, 1970 - Presidential Executive Order - formally established the EPA

President
Richard M. Nixon

Senator
Edmund S. Muskie

The 1970 Clean Air Act Amendments

The 1970 CAA Amendments signed on New Years Eve; the first NAAQS were proposed January 31, 1971

- Identified air quality as a major public health problem*
- Introduced quantitative air quality management across the nation
- Defined a partnership between Federal Government and States

Designated 7 ubiquitous air pollutants (now 6) for the establishment of primary health based stds to protect public health - NAAQS

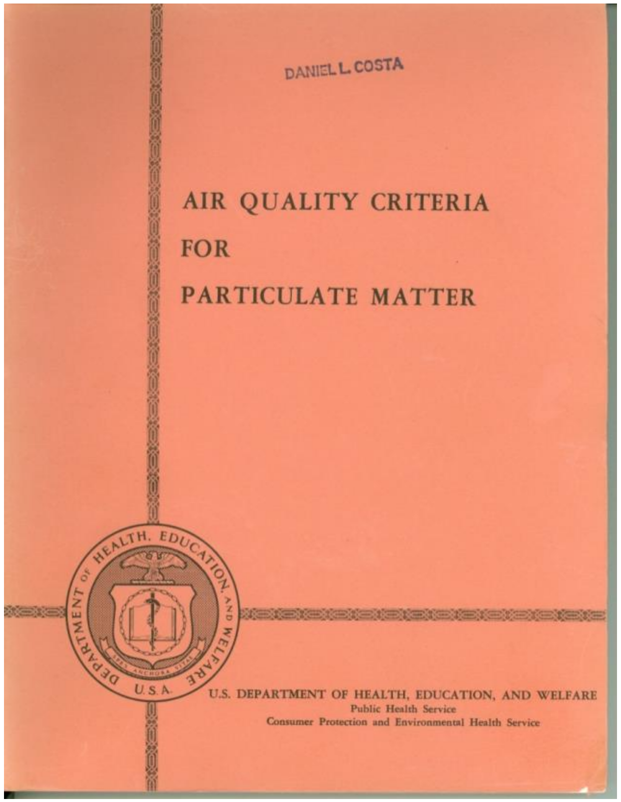
- **Particulate Matter – PM**
- **Photochemical Oxidants – O_3 (mostly)**
- **Carbon Monoxide – CO**
- **Lead –Pb**
- **Nitrogen Dioxide – NO2**
- **Sulfur Dioxide – SO2**
- **Hydrocarbons – THC**

Hazardous Air Pollutants (HAPs) were identified as risk-based – later in 1990, 189 HAPs (or Air Toxics) were identified - to be controlled emission technologies

***Cost could not be a consideration in standard setting; costs only during implementation**

PM NAAQS – The Early Days

AQ Criteria Document for PM



William D. Ruckelshaus

Text – 284 pgs

(Released Feb 1969 HEW)

No Staff Paper for Policy

(not until 1987 for PM)

Staff Options were Developed

Public Comment period

EPA Administrator decision

NAAQS Proposed: Jan 1971

Finalized: Apr 1971

All 6 NAAQS completed by May!

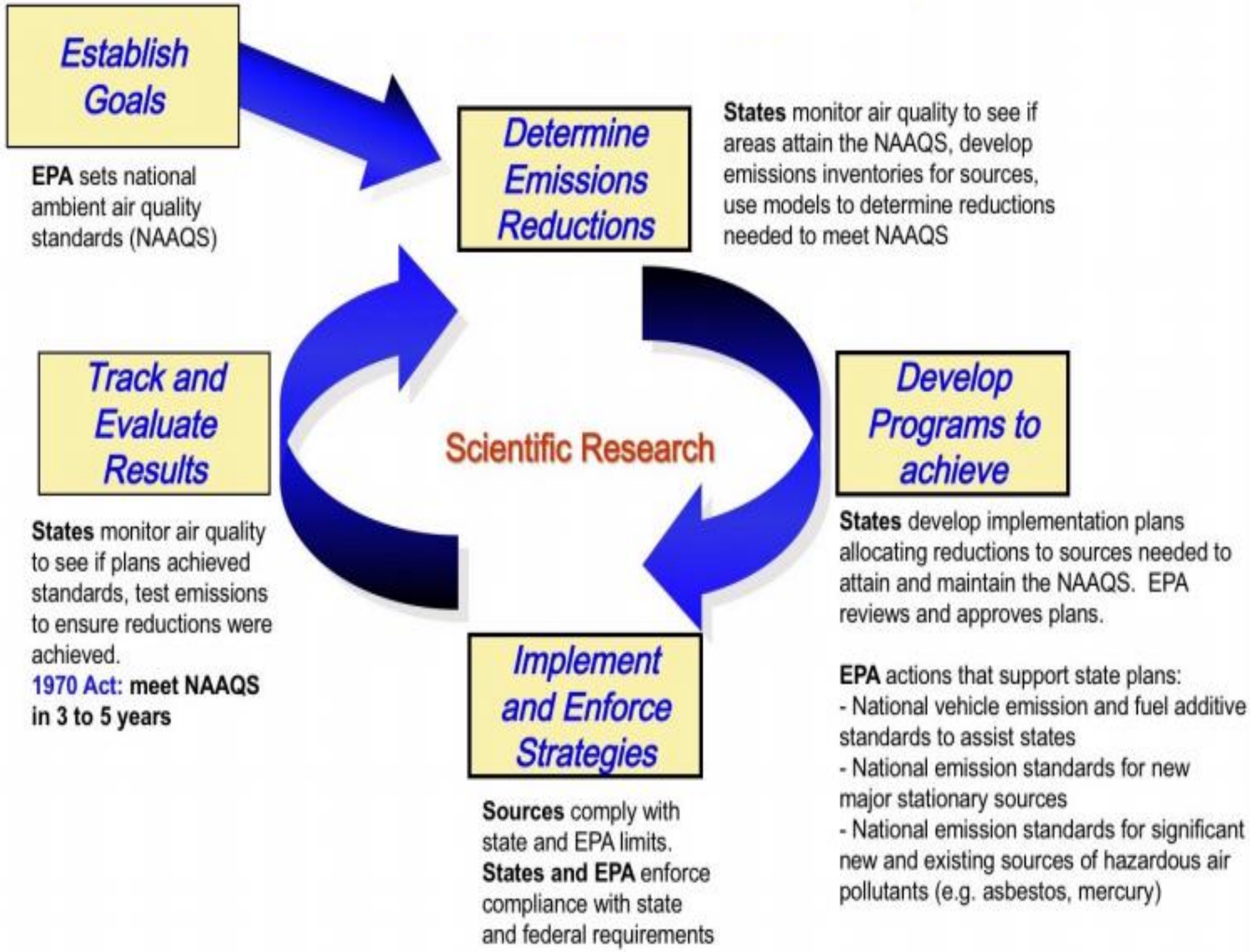
No Clean Air Science Advisory Committee (CASAC) reviews of any NAAQS until 1977

https://www.epa.gov/naaqs

So that was then…

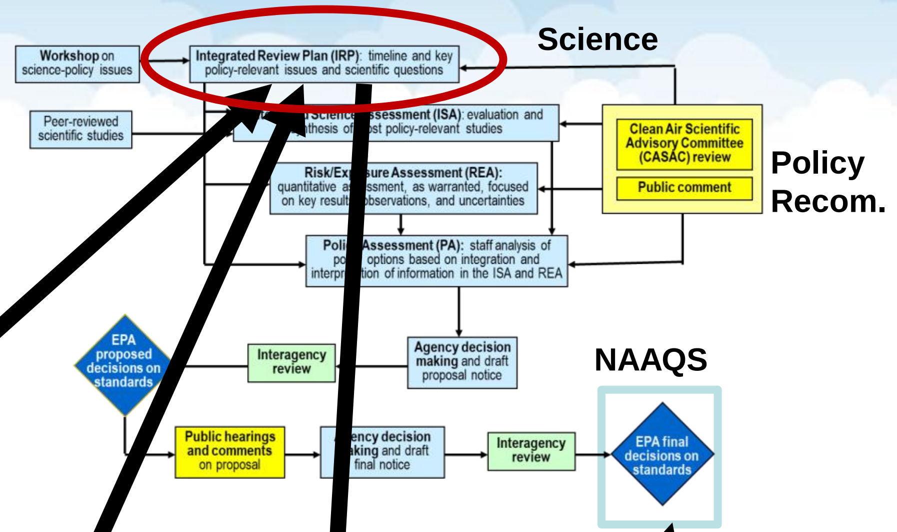
A process, however loosely structured, was functioning. But challenges by industry and Congress for accountability pushed for a more codified process?

A Framework for US Air Quality Management

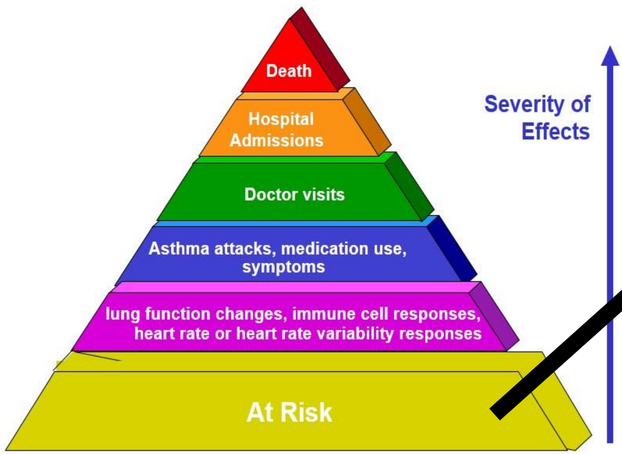


Translating the Science into Regulation

NAAQS Review Process

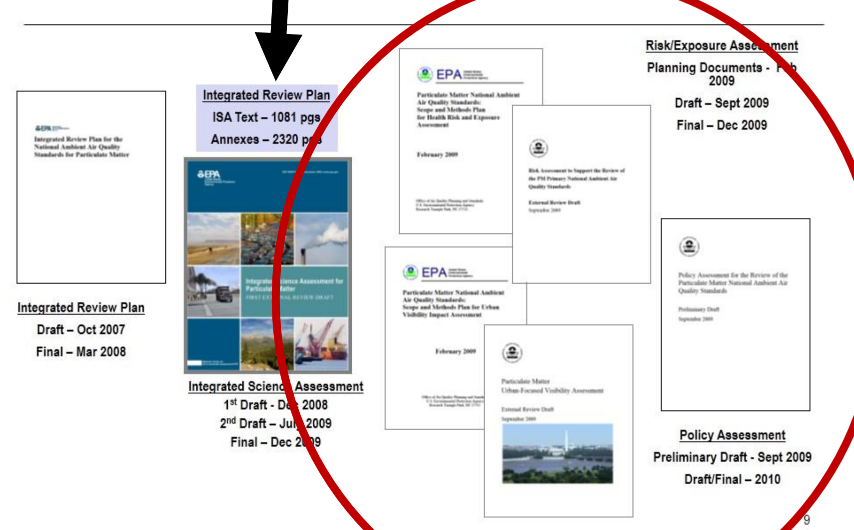


Pyramid of Health Effects for NAAQS

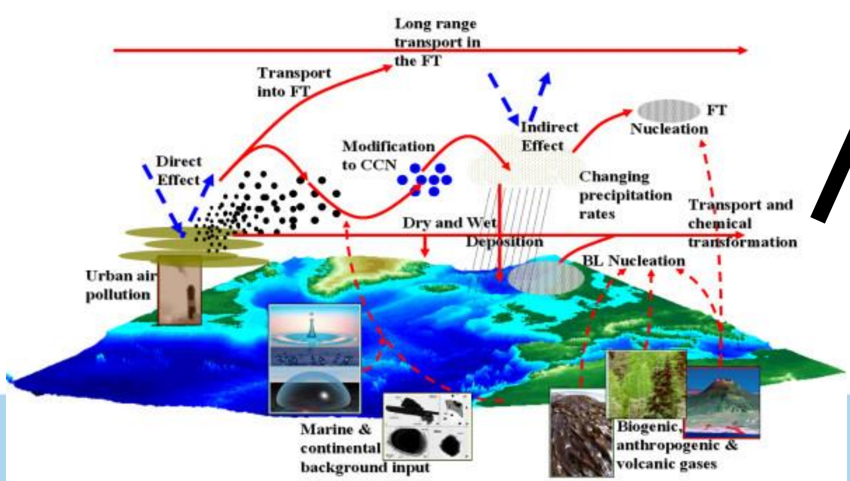


Population Impacted

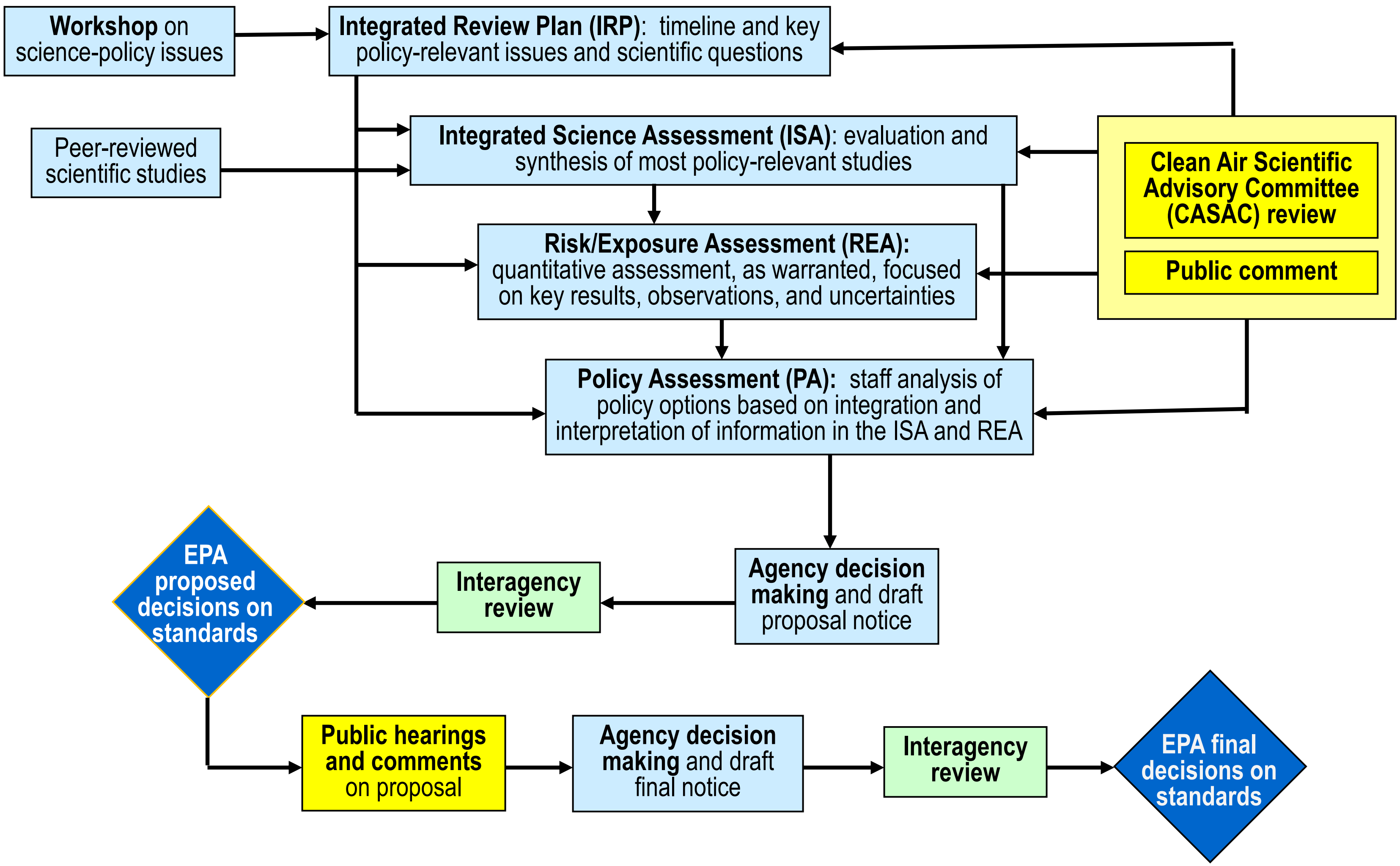
Current PM NAAQS Review Documents



Atmospheric Sciences



NAAQS Review Process



Anatomy of Air Quality Standards

- Sections 107 /108 /109: establish "criteria" and process for setting the NAAQS and designations of attainment
  - Based on the latest scientific criteria….
    - Primary standards - *requisite* to *protect public health* with an *adequate margin of safety**

**Cost is not a consideration in setting the NAAQS and Congressional intent to protect a representative sample of the most sensitive groups, not the most sensitive individuals*

    - Secondary standards - *protect public welfare* (the environment, materials, visibility, ecosystems….) from known or anticipated adverse effects

- Section 110: State Implementation Plans (SIPs) for meeting the NAAQS if not in attainment
- Section 112: Hazardous Air Pollutants

Anatomy of Air Quality Standards

The four major components of air quality standards

- **Indicator** - i.e. *what* is measured (O_3, NO_2, TSP, $PM_{2.5}$) *& how (*Federal Ref. Method - FRM)
- **Averaging time** - 1-hr, 8-hr, 24-hr, annual
- **Form** - statistic – e.g. exceedance, concentration based
- **Level** – e.g. 12.0 $\mu g/m^3$ (for $PM_{2.5}$),
  0.070 ppm O_3 (a gas)

Summary of the U.S. EPA NAAQS* *(as of Oct 2017)*

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3-month average	0.15 µg/m^3	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb	Annual Mean
Ozone (O_3)		primary and secondary	8-hour	0.070 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particulate Matter (PM)	$PM_{2.5}$	primary	Annual	12.0 µg/m^3	Annual mean, averaged over 3 years
		secondary	Annual	15.0 µg/m^3	Annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

*For more information, visit https://www.epa.gov/criteria-air-pollutants/naaqs-table

AQM / SIP Components - Data

Establish Goals

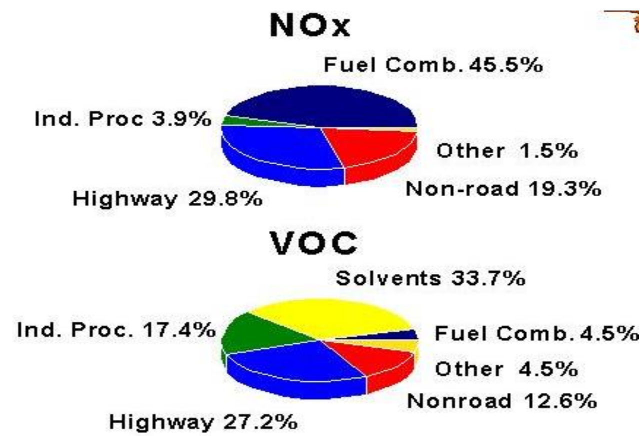
--Air Quality

Determine Emissions Reductions

-- Monitoring
-- Inventories
-- Data Analysis & Modeling

Track and Evaluate Results

--Monitoring sources, air
-- Performance benchmarks



Air Quality and emissions data are critical for planning and evaluating strategies. Both are required in SIPs

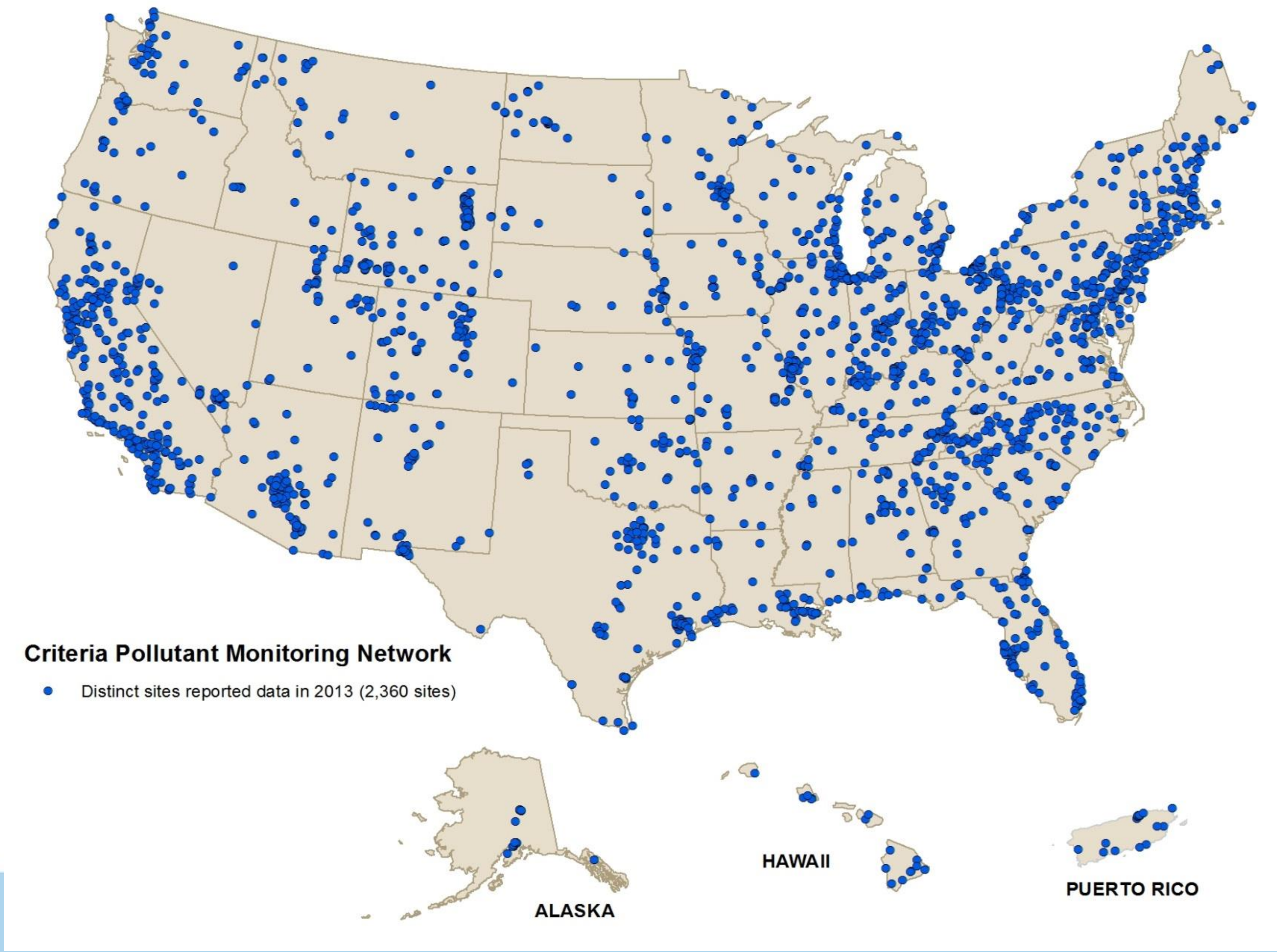
SLAMS: State or Local Air Monitoring Stations

- The SLAMS make up the ambient air quality monitoring sites attainment of the NAAQS

- The SLAMS network also includes the following networks:
  - NCore: National Core
  - CSN: Current Speciation Network
  - Near-road: NO_2; select CO/$PM_{2.5}$
  - PAMS: Photochem. Assessment Monitoring Station

- Other key networks include IMPROVE and NATTS (air toxics)

Criteria Pollutants are Generally Associated with Large National Networks



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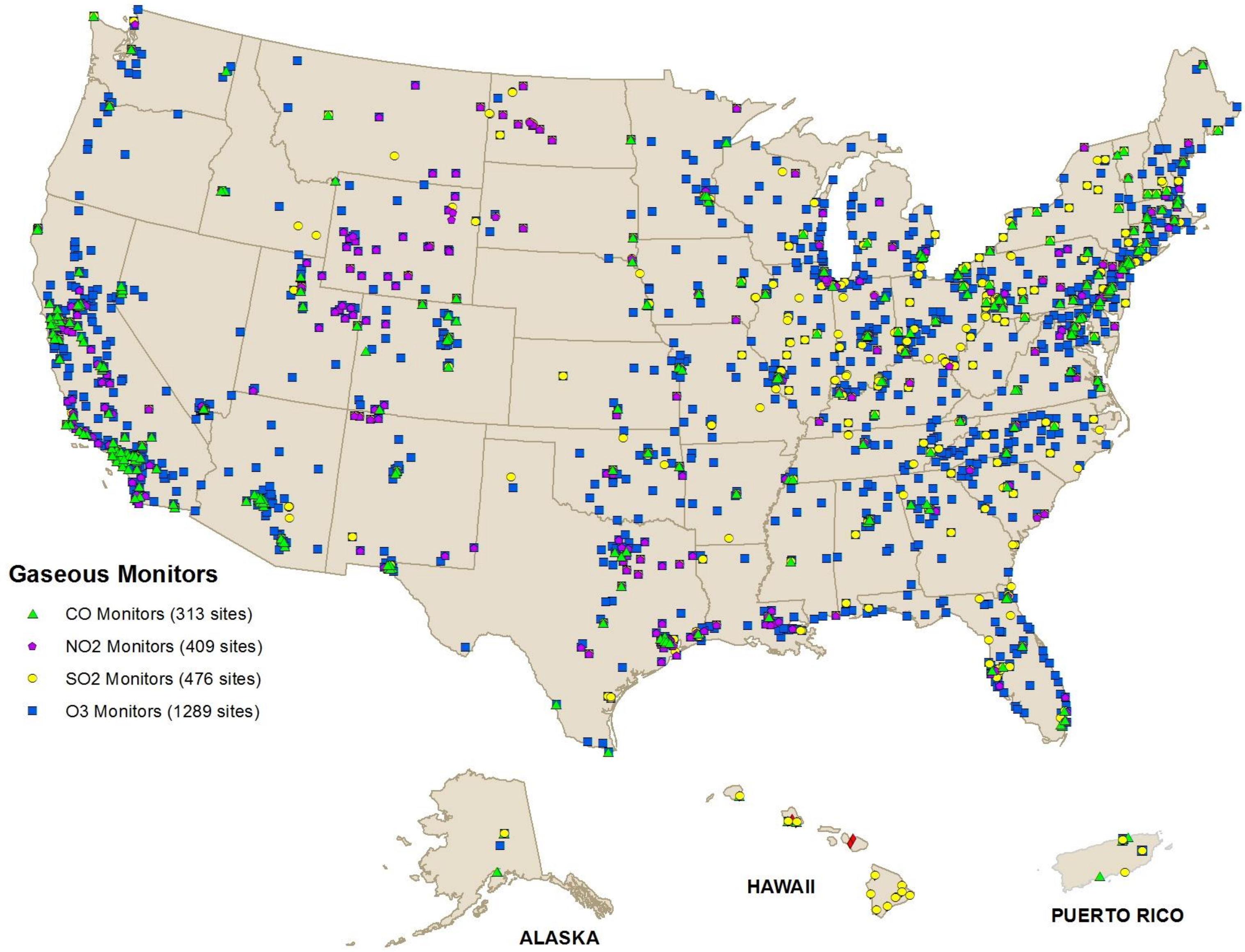

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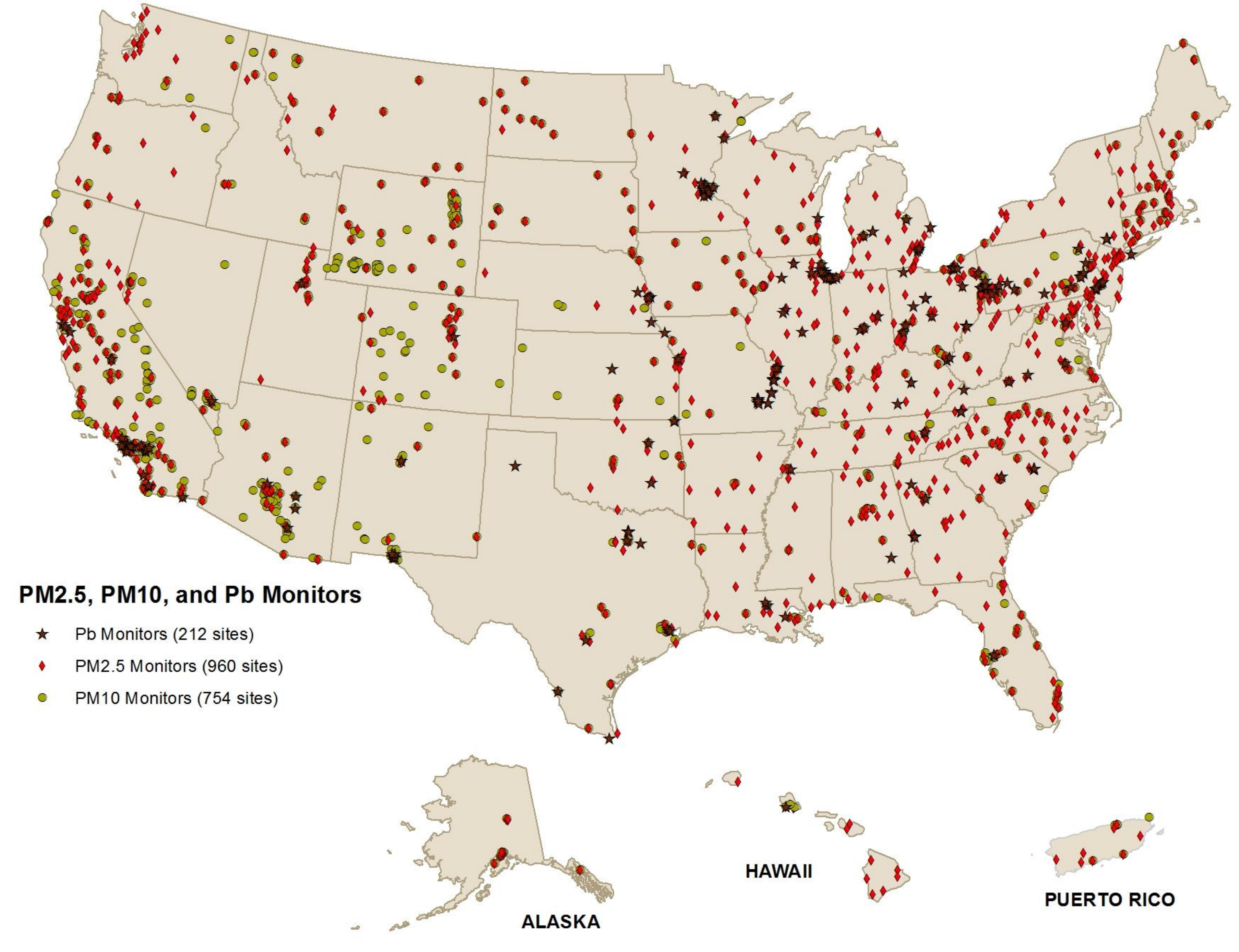
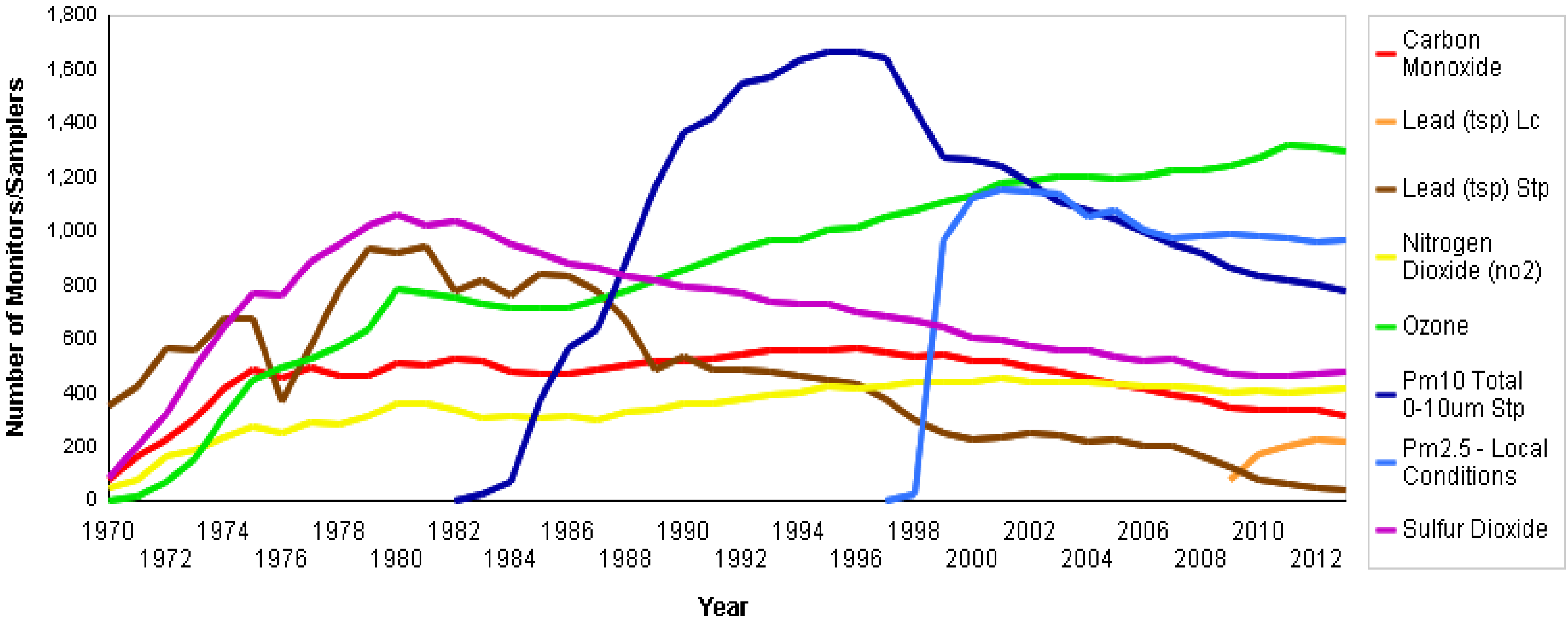


Number of Air Monitors by Pollutant 1970-2013



National Core (NCore) Network

<u>Pollutants Measured:</u>

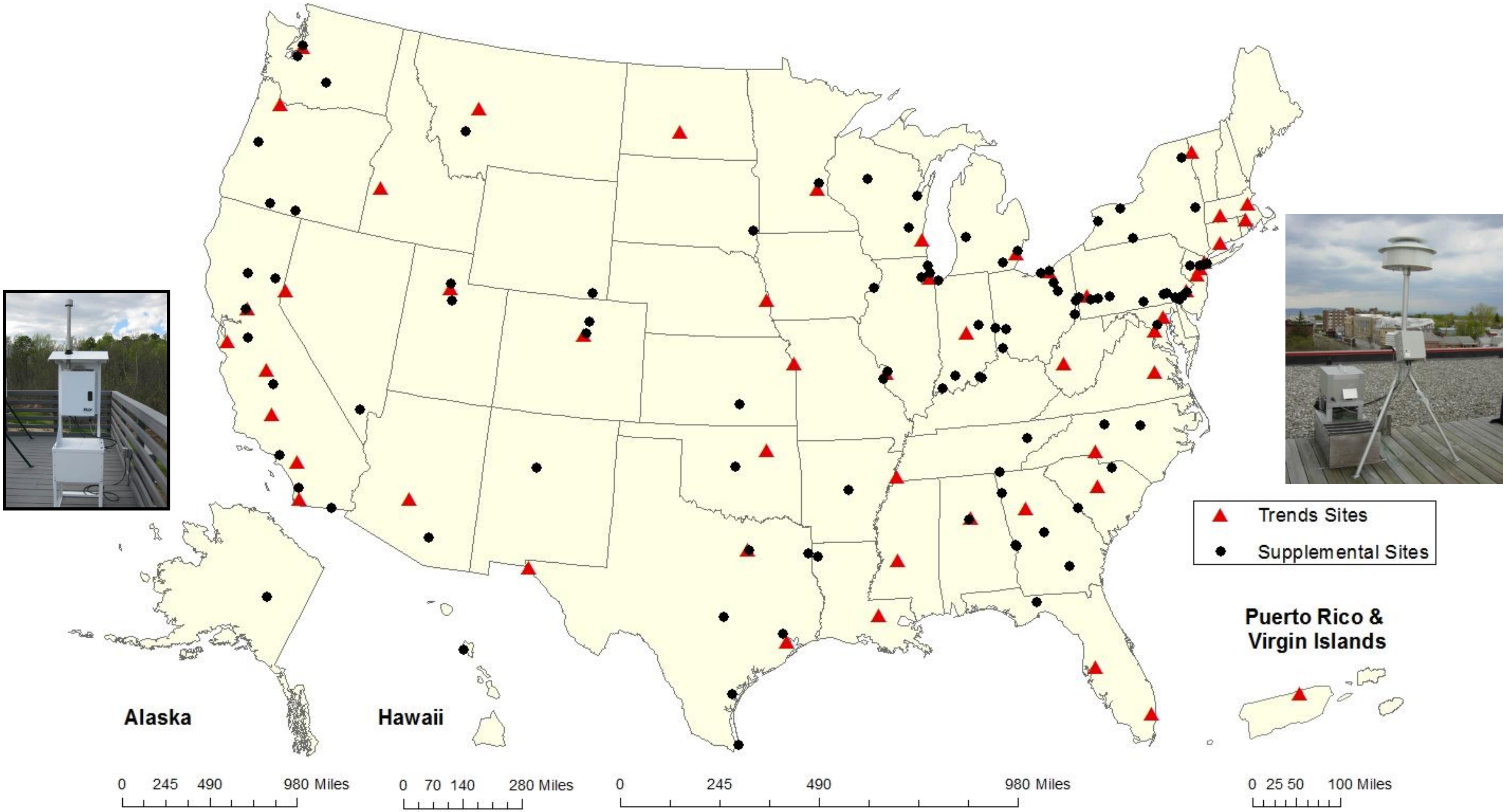
Gases – CO, SO_2, NO and NOy, and O_3,

Particles - $PM_{2.5}$, (continuous mass, filter mass, speciation), $PM_{10-2.5}$, (mass)

Meteorology - basic meteorological parameters (Temperature, Wind Speed, Wind Direction, Relative Humidity)

Current Speciation Network

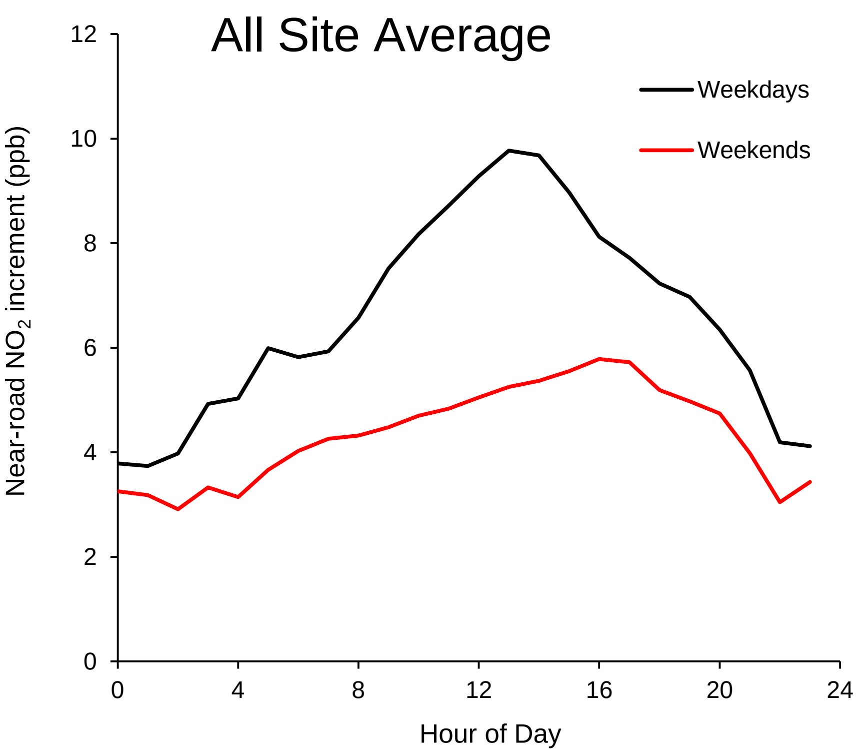
(Measures major $PM_{2.5}$ anions, carbonaceous material, cations, trace elements)



https://www.sdas.battelle.org/CSNAssessment/html/Default.html

Hourly NO_2 Interpolation at NR sites

(100 days minimum)



Phased network (2010-pres): one near-road NO_2 site in all CBSAs with pop. > 500K and a second site in CBSAs with +2.5M

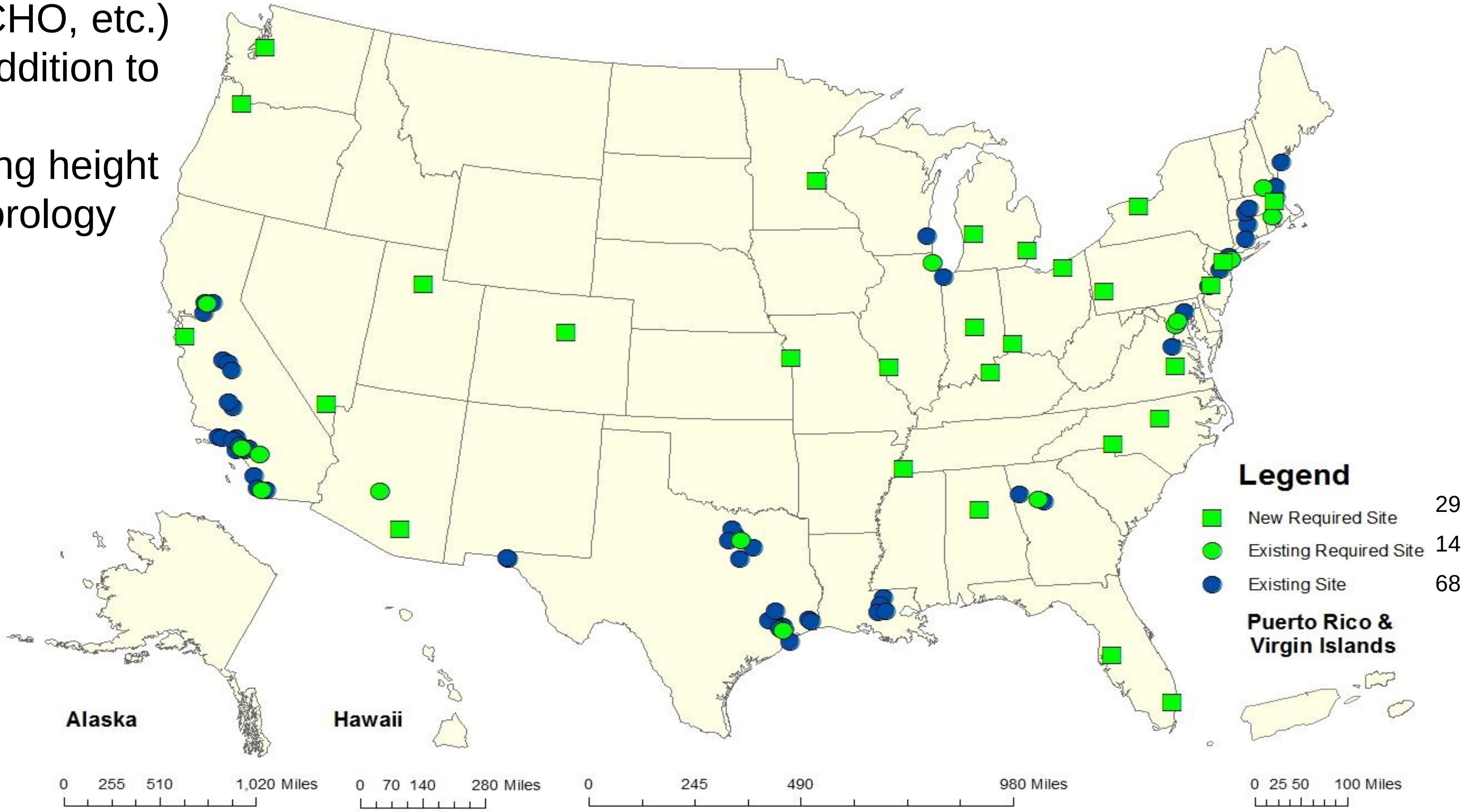
NR sites have always been envisioned to be multipollutant

- In addition to NO_2 :
  - 39 sites instrumented for $PM_{2.5}$
    - 22 with continuous methods only
    - 11 with FRM methods only
    - 6 with both FRM and continuous methods
  - 51 sites with CO instrumentation
  - 23 sites with BC instruments
- For a complete listing of NR site metadata, http://www.epa.gov/ttnamti1/nearroad.html

Updated PAMS Map

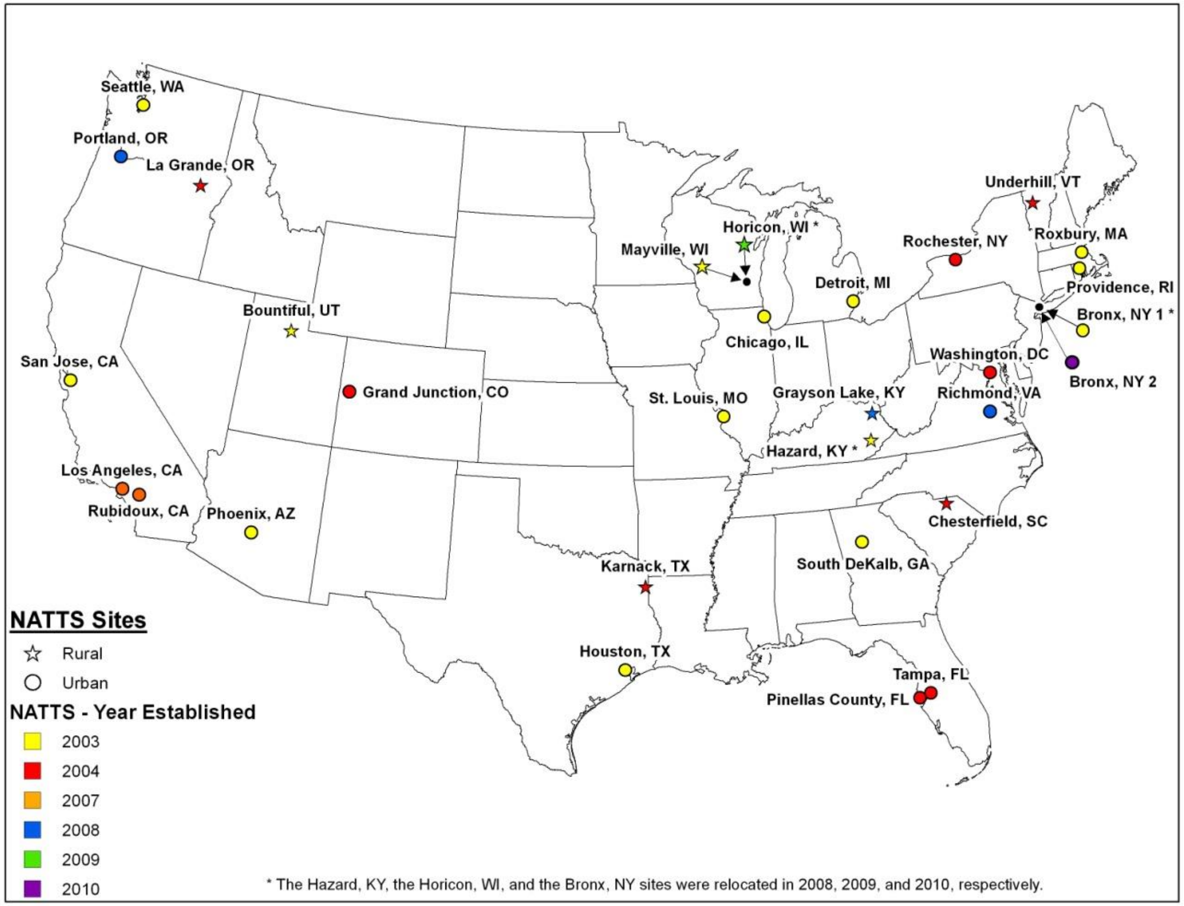
(To improve understanding of ozone formation)

- Ozone
- Hourly VOC
- Carbonyls (HCHO, etc.)
- True NO2 in addition to current NOy
- Upper air/mixing height
- Surface meteorology



Photochemical Assessment Monitoring Stations

National Air Toxics Trends Sites



TSP Hexavalent Chromium - No longer required

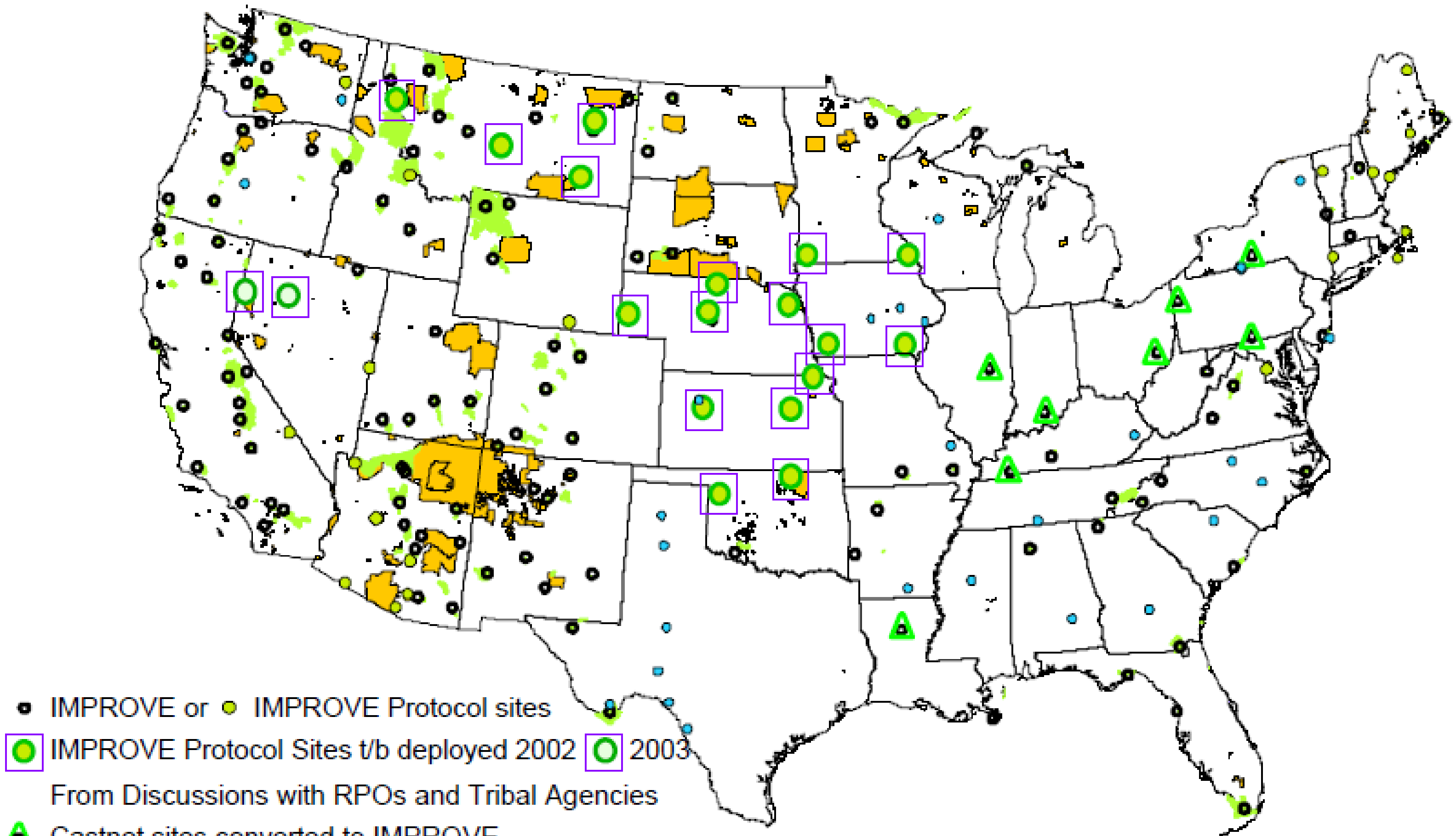
VOCs
Acrolein
Benzene
Chloroform
1,3-butadiene
Vinyl Chloride
Perchloroethylene
Carbon Tetrachloride
Trichloroethylene

Carbonyls
Formaldehyde
Acetaldehyde

PM_{10} Metals
Nickel compounds
Arsenic compounds
Cadmium compounds
Manganese compounds
Beryllium compounds
Lead compounds

PAHs
Benzo(a)pyrene
Naphthalene

Current/Planned IMPROVE, IMPROVE Protocol & Rural Supplemental $PM_{2.5}$ Speciation Sites



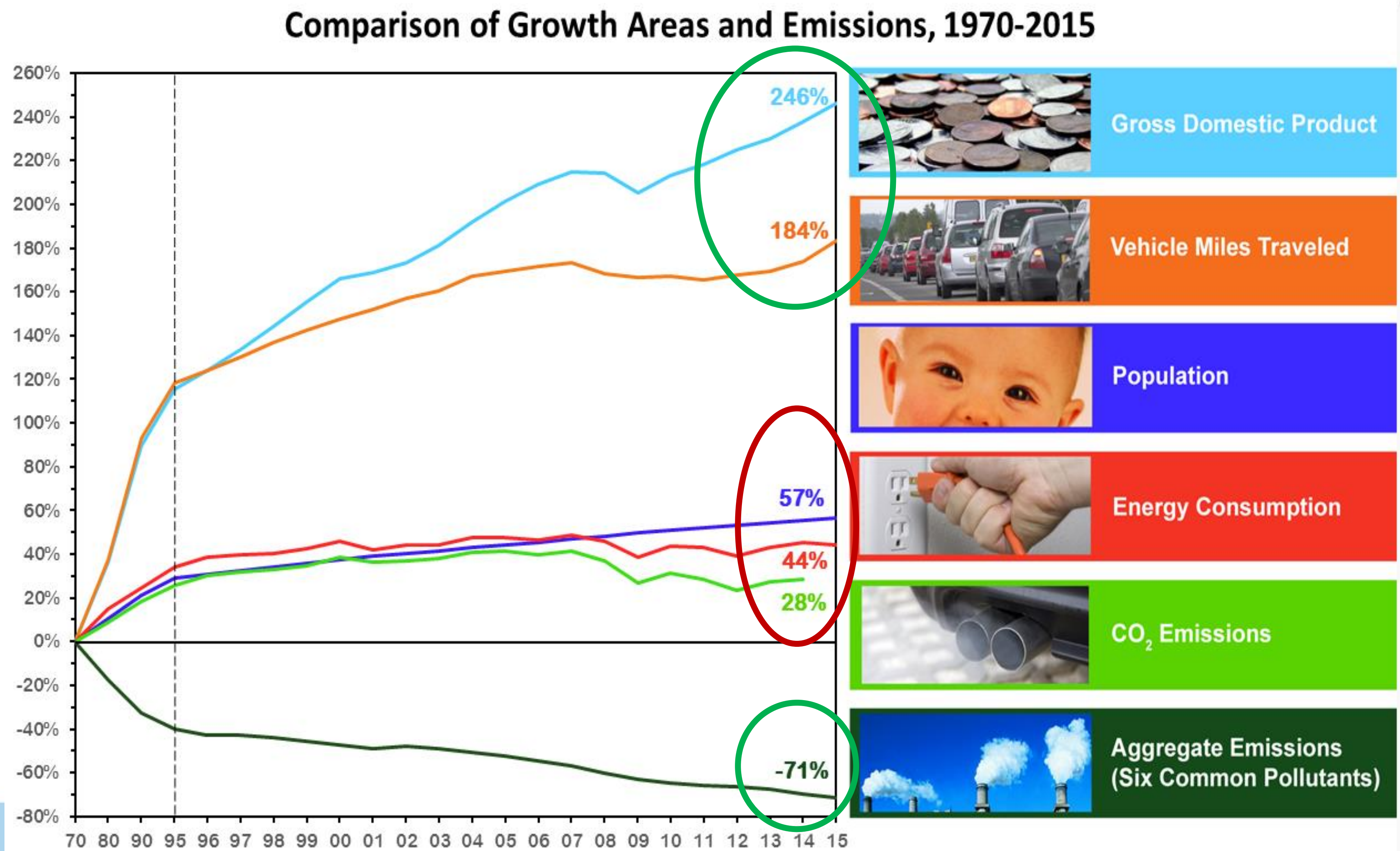
The IMPROVE Network

(Focus on less populated areas – visibility and haze)

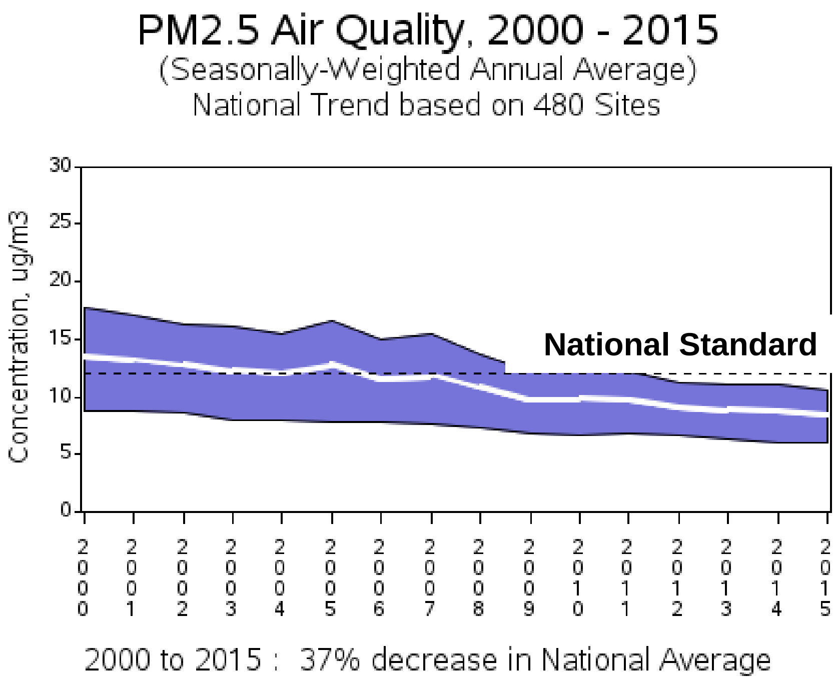
https://www3.epa.gov/ttnamti1/visdata.html

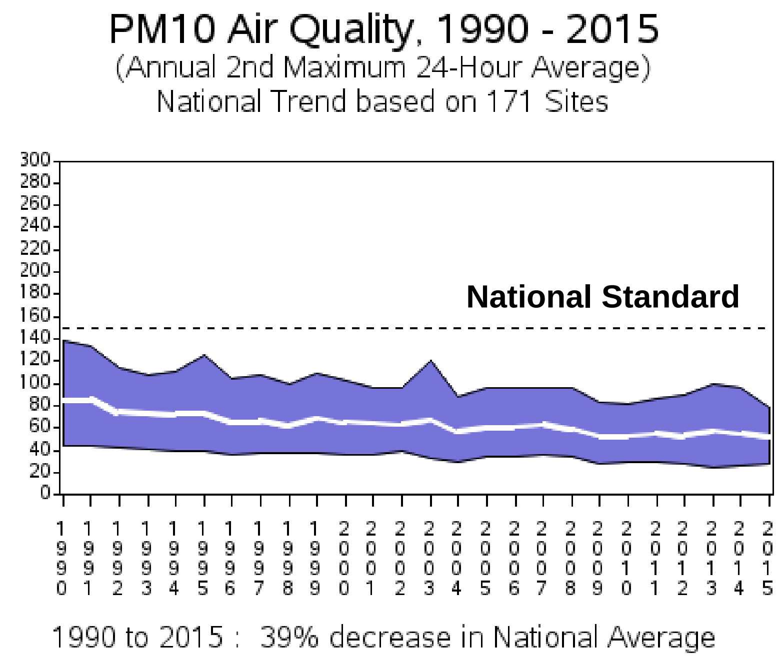
What have these networks told us?

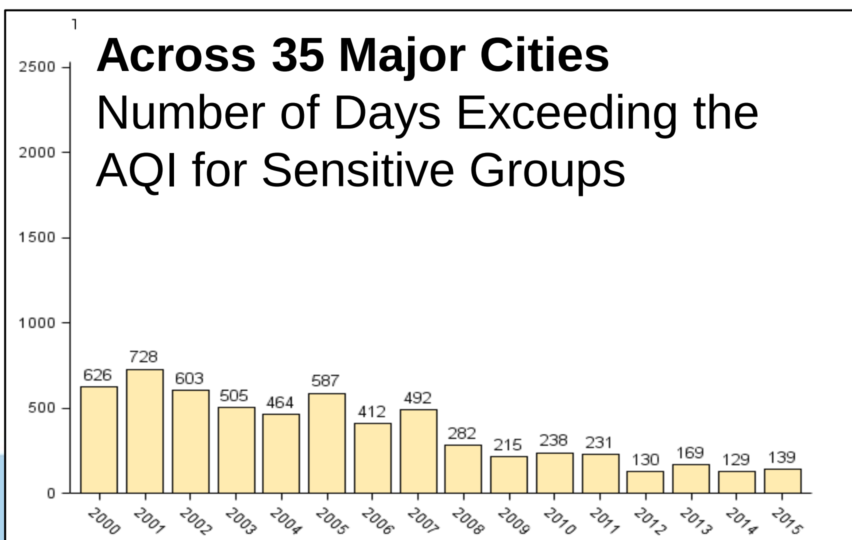
Emissions: A Good News Story…

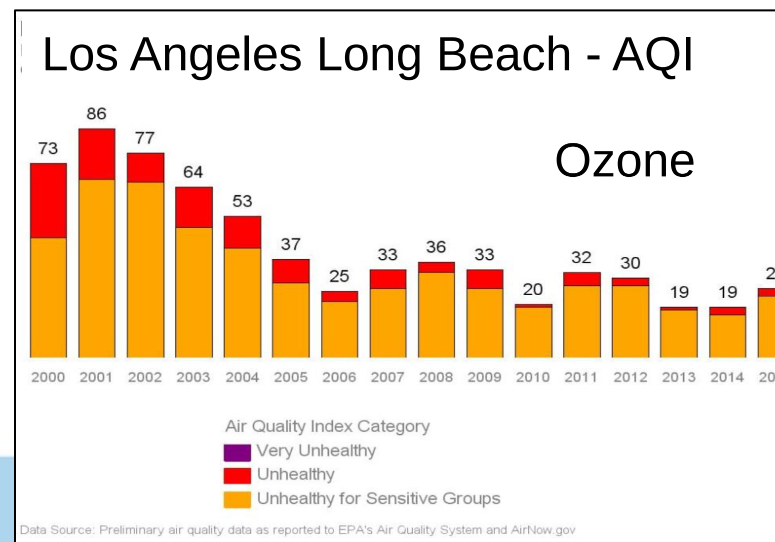


Emissions Reductions Impact Ambient Levels

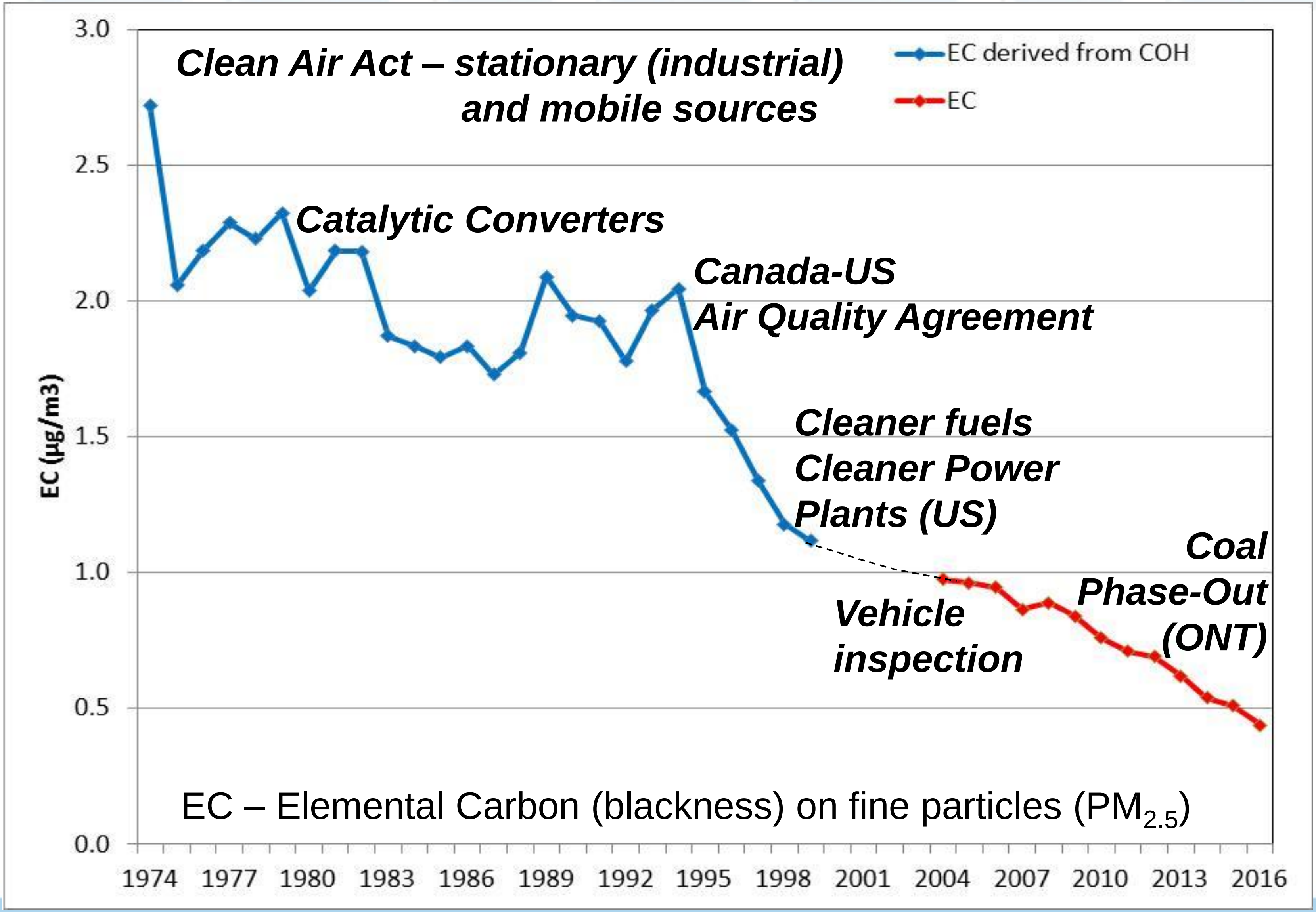






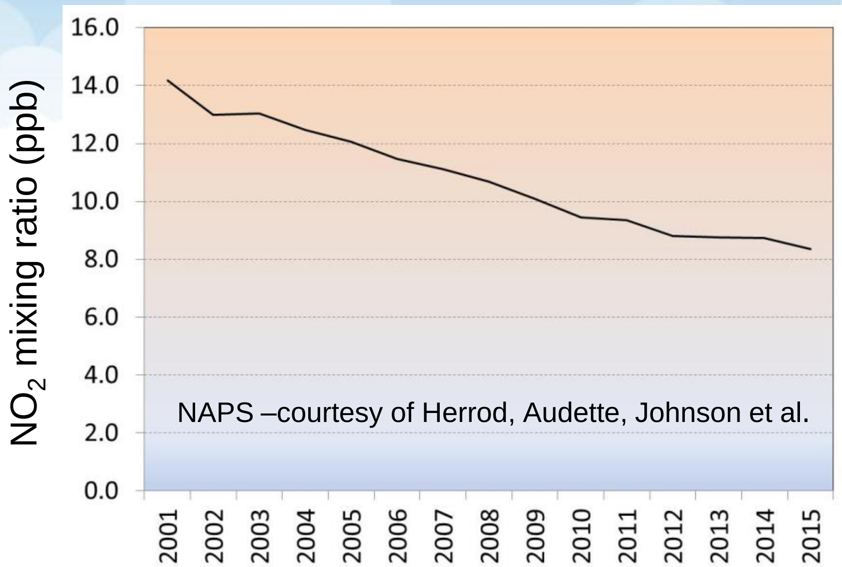


Long-Term Trend in Black Carbon in Canadian Cities

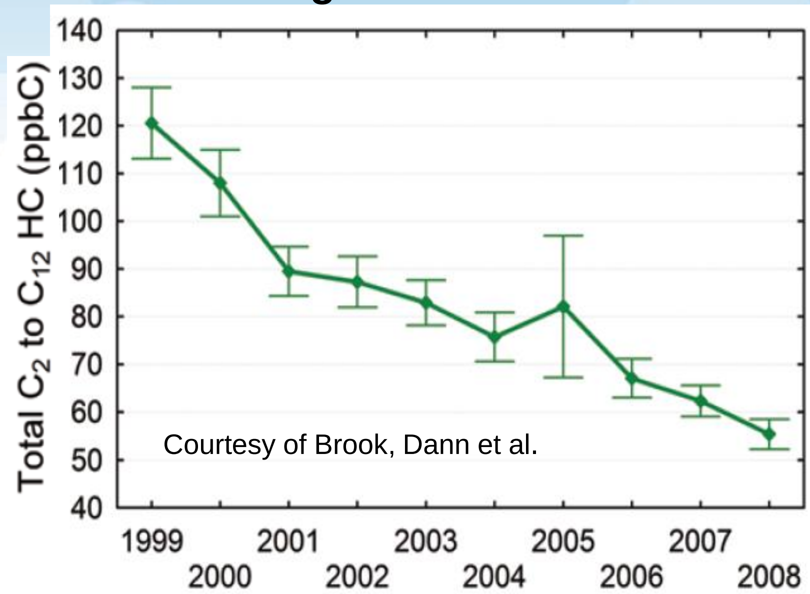


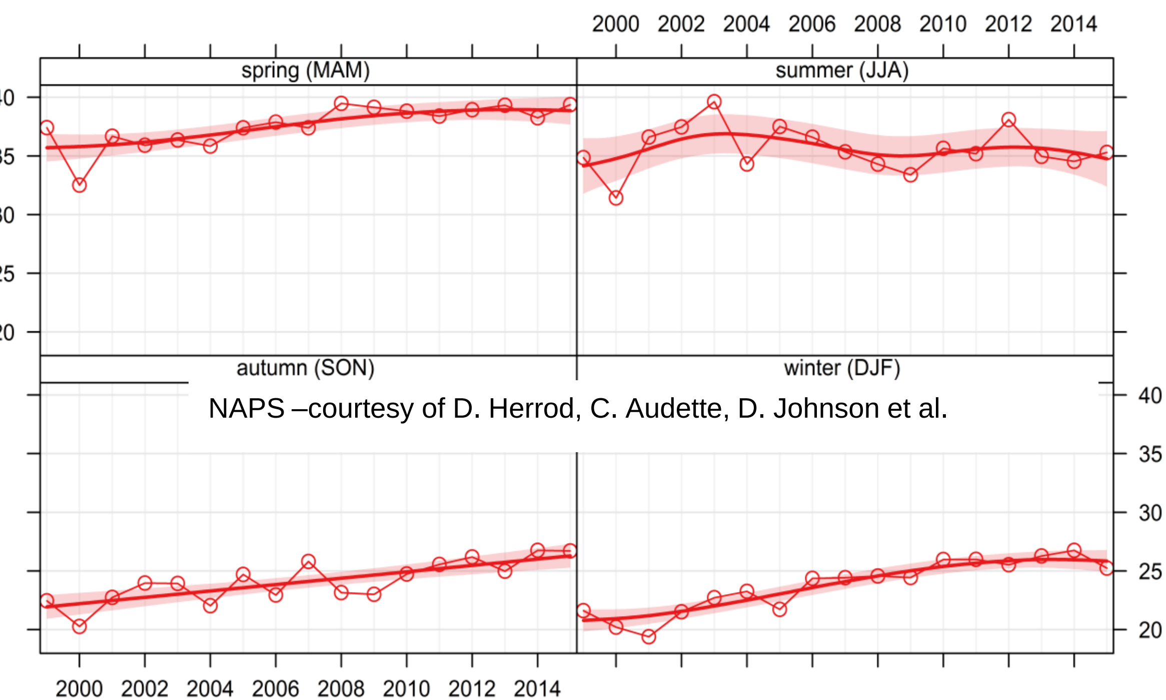
Courtesy of Environment and Climate Change Canada

Decreasing NO_2 across Canada



Decreasing VOCs across Canada



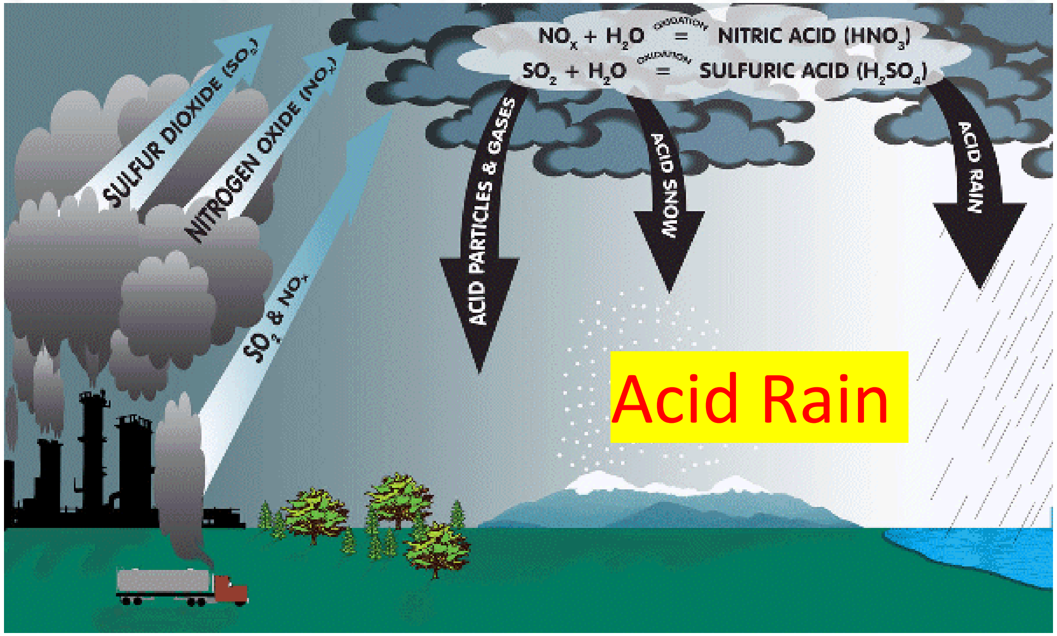


Large Urban Population Centers seem to show a rising mean level for O_3

So what do these reductions mean for the average adult?

A couple good news stories

The PM Issue of the '70s/80s was Acid Aerosols – Driven by Sulfur



Acid (H_2SO_4) was thought to be a major pulmonary irritant, but:

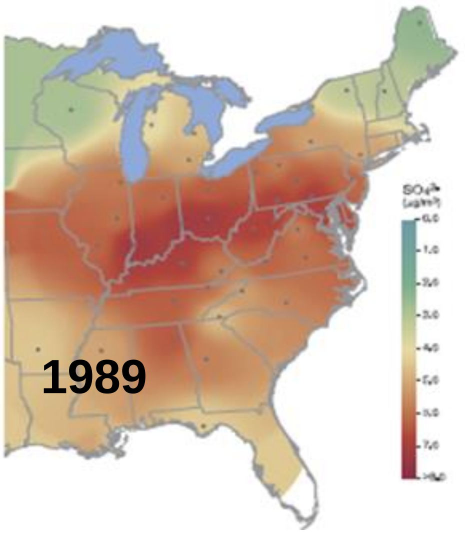
- By itself was not as potent as thought - except in asthmatics
- Conventional epidemiology not very revealing

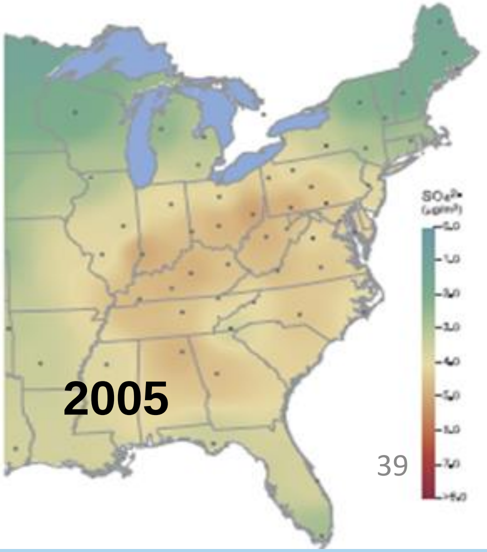
The Clean Air Act Amendments of 1990

- Targeted smoke reduction & lower sulfur coal and oil
- CAP & TRADE on sulfur had a dramatic effect

Ozone seemed to be the looming problem

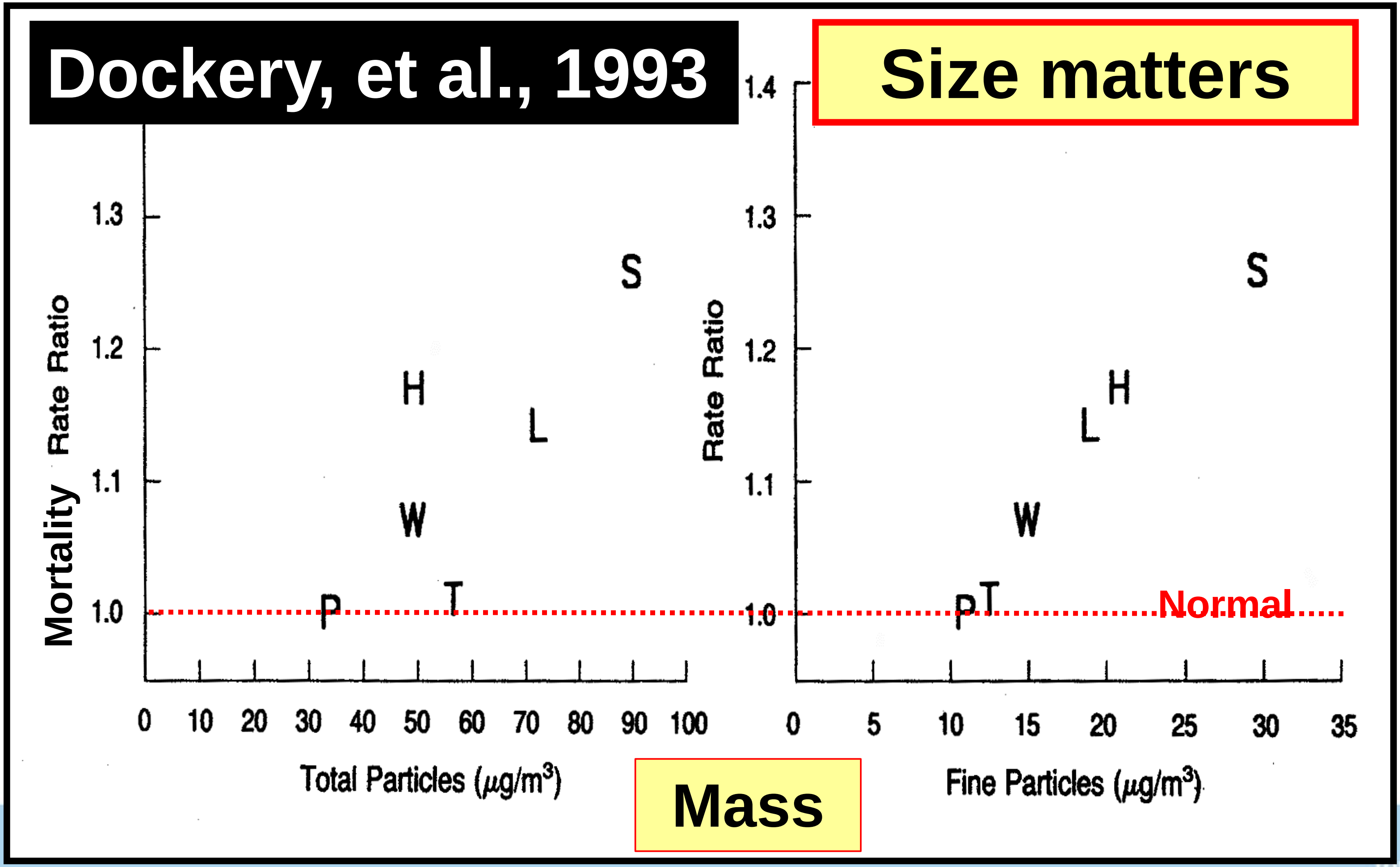
PM Problem was thought… Solved!



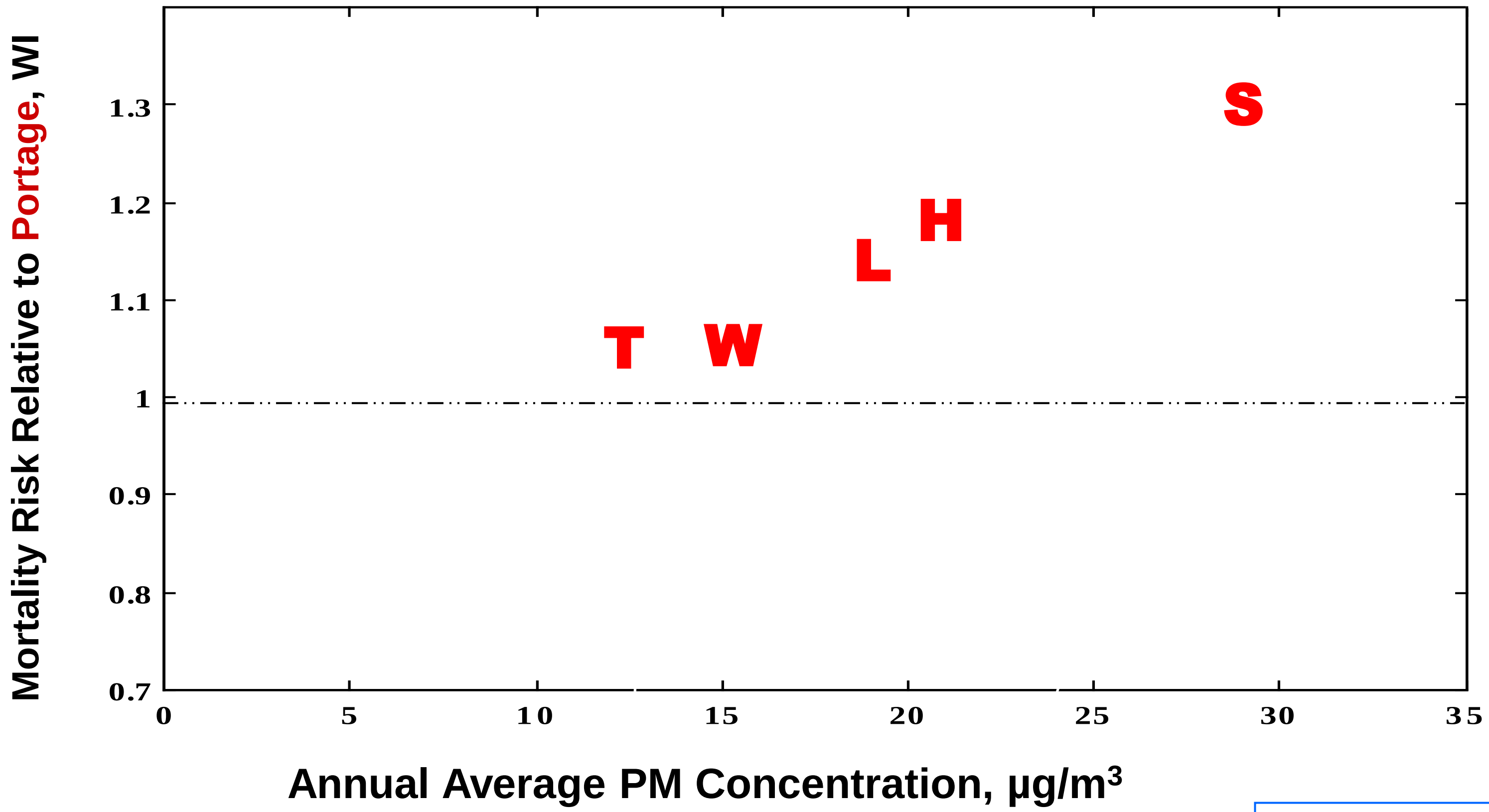


Foundry along Ohio River near Stubenville, OH.
Photo: J. Spengler or D. Dockery

The Harvard Six-Cities Studies began in the 1970's looking for a health impact of acid particles



Follow-up to the Harvard Six Cities Study Indicates Reduced Air Pollution Results in Lowered Health Risks.



Laden et al, 2006

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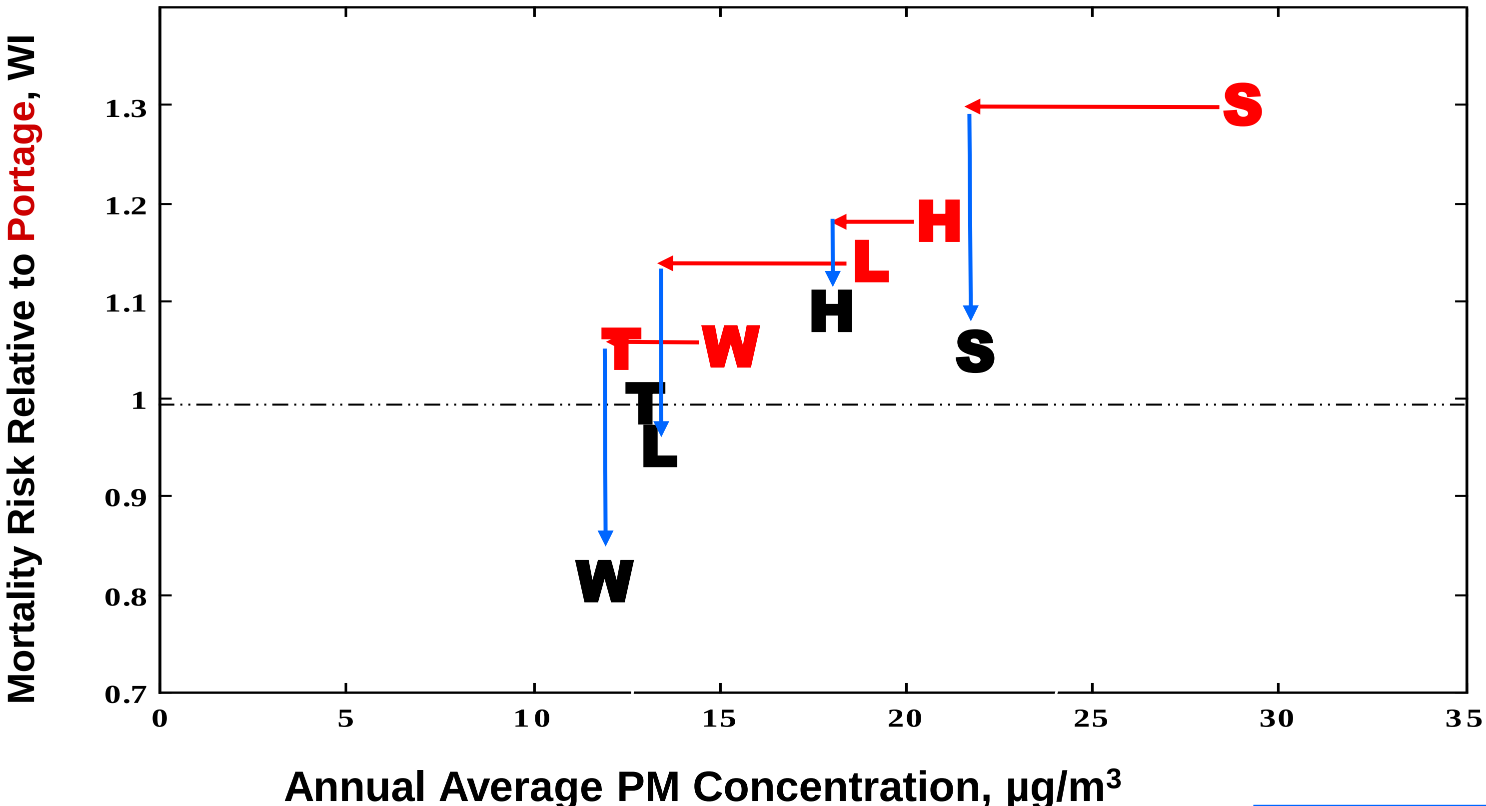
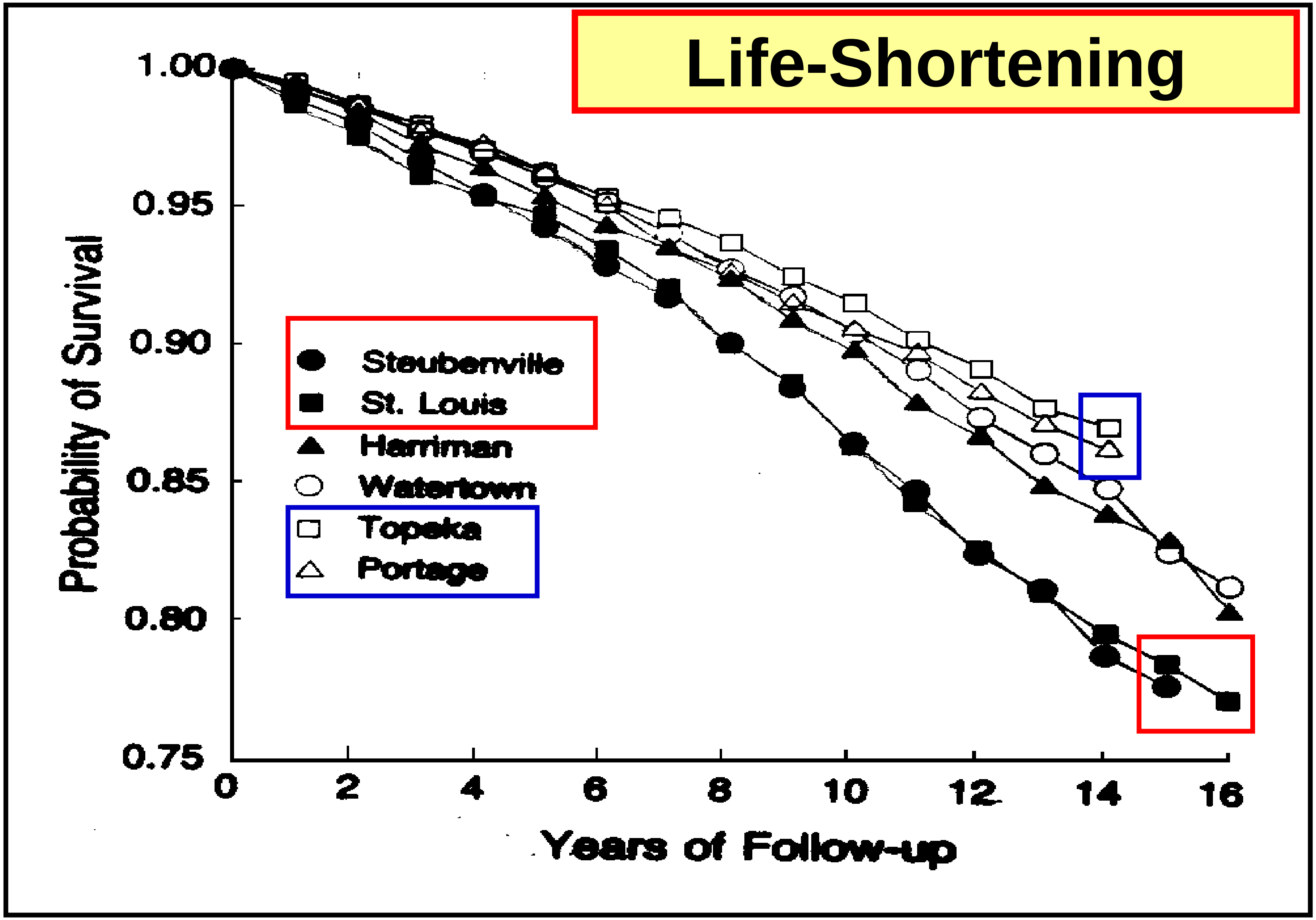


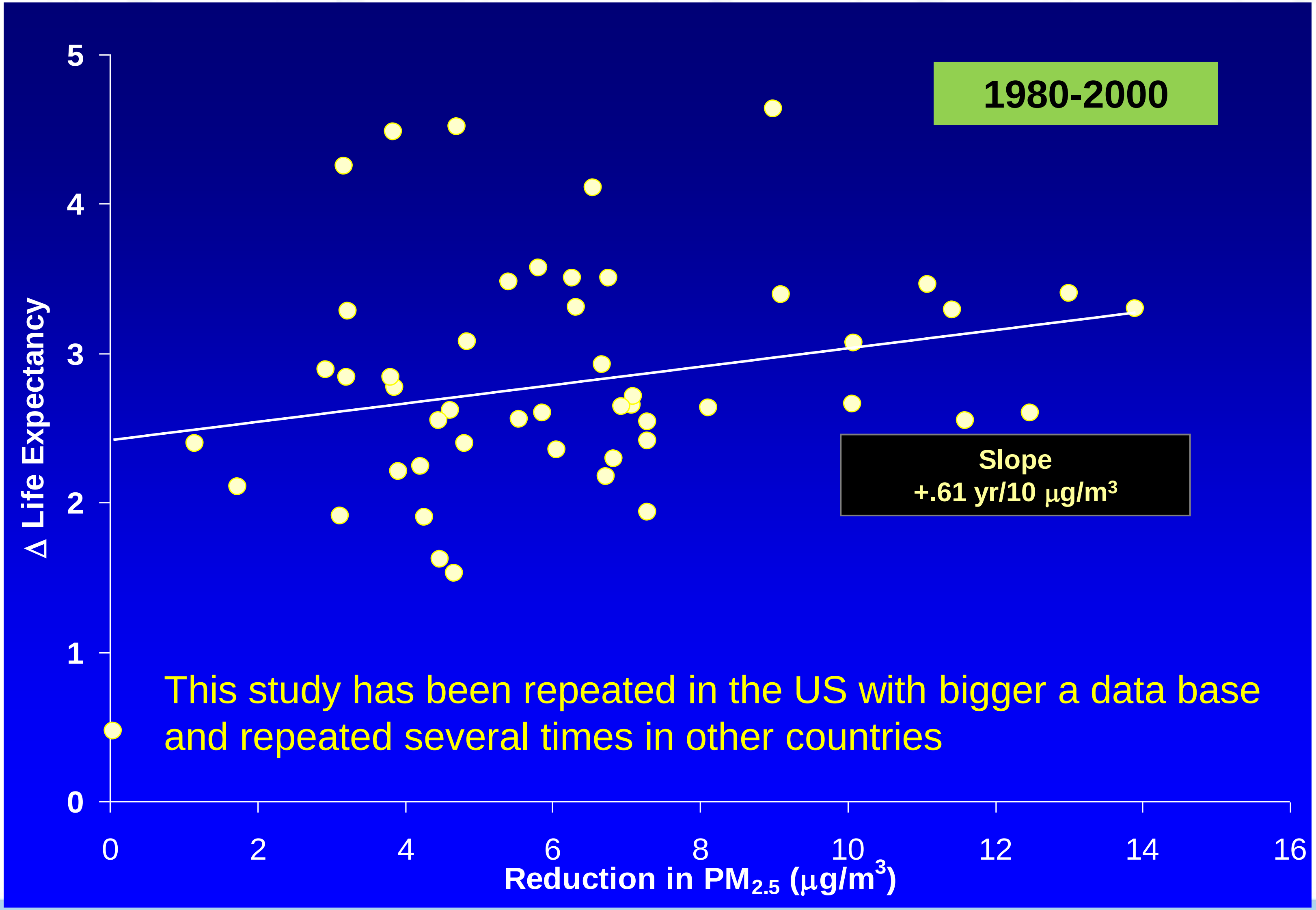
Laden et al, 2006

The PM Epidemiology Was Compelling

(But with many uncertainties)

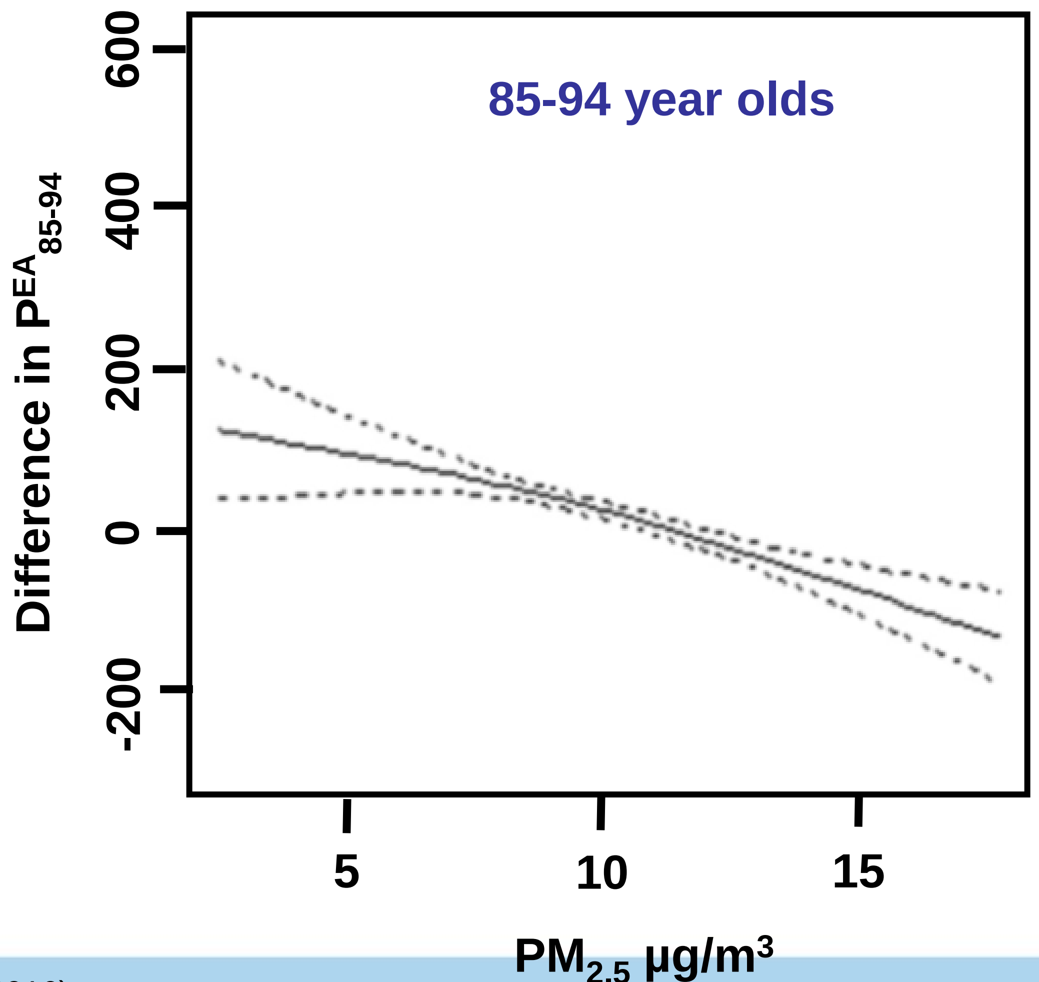


Life Expectancy Increased as $PM_{2.5}$ Went Down



Impact of $PM_{2.5}$ on Numbers of Individuals of "Exceptional Age"

*A*fter adjustments, older people live longer in areas with cleaner air



Baccarelli et al. Env Hlth Persp 124(11):1744 (2016)

The U.S. Office of Management and Budget estimated in 2006 that the EPA's air pollution regulations save between $63 and 430 billion annually. (Costs $25-28 billion)*

Reality Check…

In 2016, Americans spent roughly $1.2 trillion for energy.

EPA's investment from 1998-2017 in air pollution research amounts to less 1/1,000 of that energy expenditure.

*No longer available on the OMB website

“The interest in air pollution is inversely proportional to its concentration.”

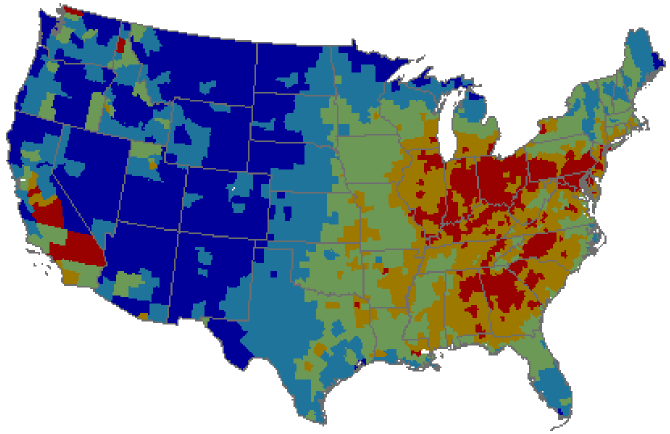
Sir Patrick Lawther, (~1981)

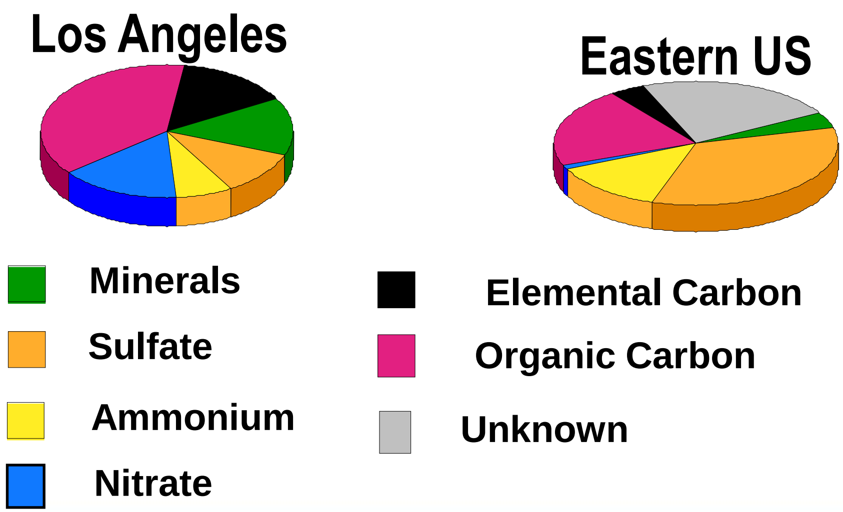
What lies ahead?

Many Issues Remain Unresolved and New Emerging Issues Appear Even More Complex

A $PM_{2.5}$ Public Health Burden Remains

Percentage of $PM_{2.5}$ related deaths due to 2005 air quality levels by county





Summary of National $PM_{2.5}$ impacts due to 2005 air quality	
Excess mortalities (adults)[A]	130 to 320,000
Percentage of all deaths due to $PM_{2.5}$[B]	5.4%
Impacts among Children	
ER visits for asthma (<18 yr)	110,000
Acute bronchitis (age 8-12)	200,000
Exacerbation of asthma (age 6-18)	2,500,000

[A] Range reflects use of alternate PM mortality estimates
[B] Population-weighted value using Krewski et al. (2009) PM mortality estimates

(Fann et al., 2011)

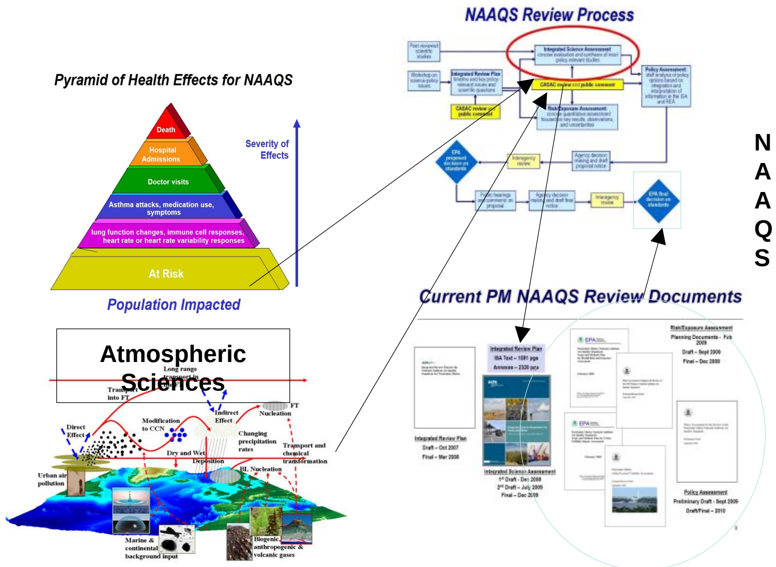
On the surface things look great…

BUT….

Not all problems are solved nor adequately addressed

Are We Getting the Answers We Need?

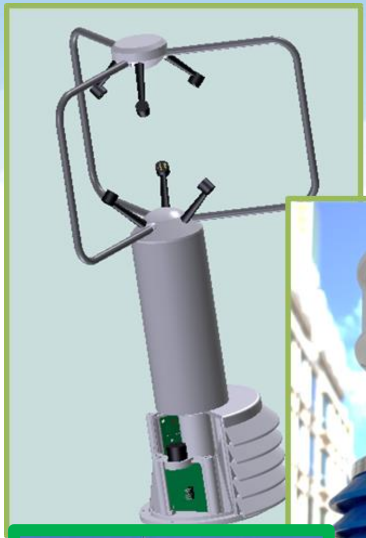
Do we stick with the traditional pollutant-by-pollutant Regulatory Science?



Or… can we get what we need from systems-based science targeting the broader tenets of public health?

Next Generation of Air Monitoring

- Currently, major monitoring networks can measure the major pollutants
  - The technology is aging and expensive
- There is need for more continuous, fast responding and compact sensor capability
- A major technological boom in sensor development – great potential for both site monitoring and personal use
- The potential of Citizens' Science



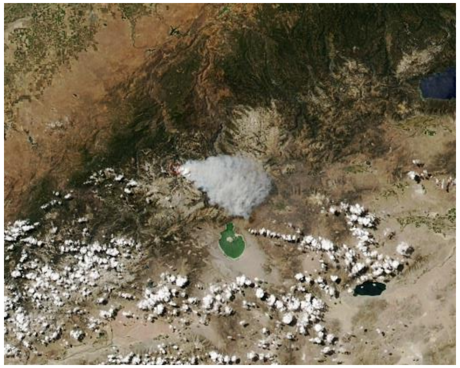


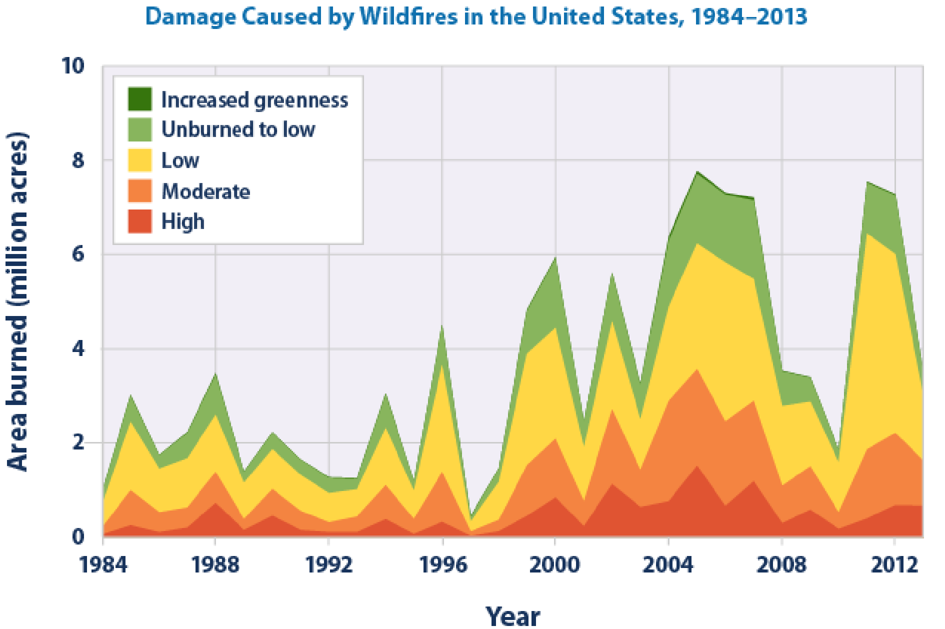




So are there issues looming in the 21st century?

Addressing National Issues Offers Opportunities





- The United States spends more than $1 billion every year to fight wildfires
- According to National Interagency Fire Center data, of the 10 years with the largest acreage burned, nine have occurred since 2000 (as of 2012)
- NEI: ~38% of the 2014 $PM_{2.5}$ annual avg. resulted from wildland fires

Climate Impacted Public Health in our Future

AIR

Air quality in China

HEAT

Wildfire & heatwave everywhere

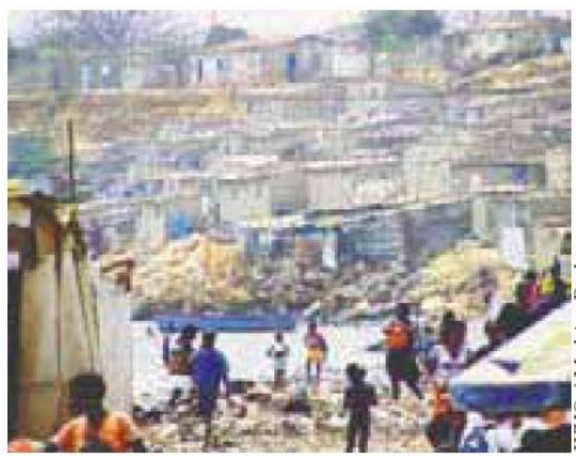
FOOD

Food availability in Mali

WATER

Fresh water in Bangladesh

SHELTER



Shelter in Angola

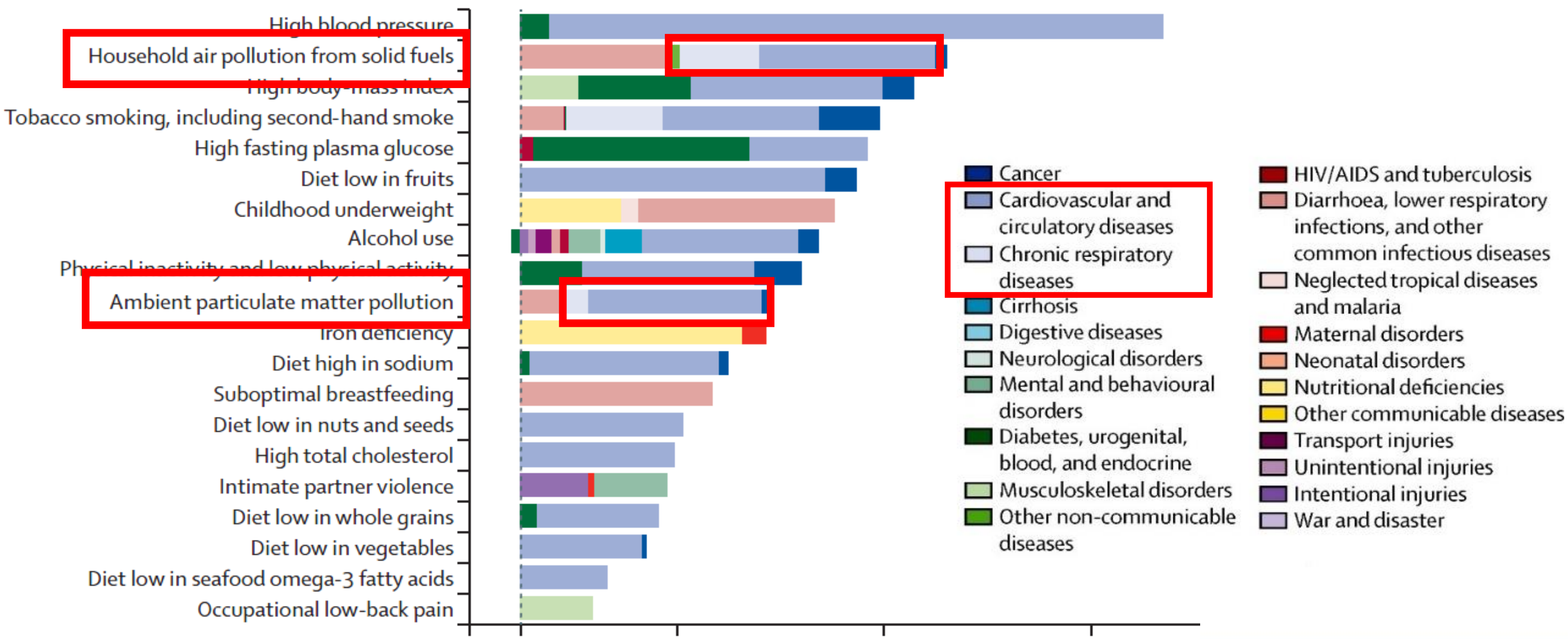
FREEDOM FROM DISEASE

Infection in Cambodia

WHO (2009). Protecting health from climate change: connecting science, policy and people. – J Samet 2010

Global Issues Already Exist

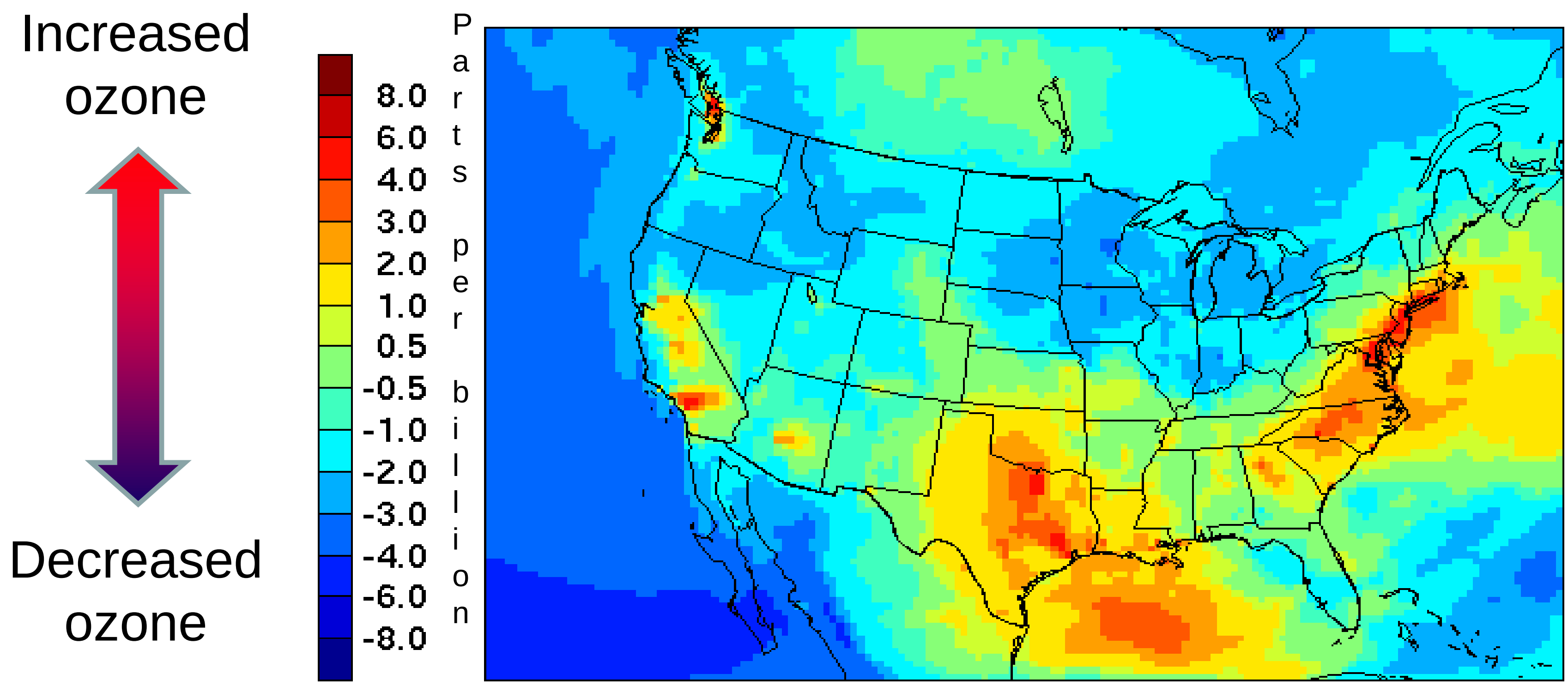
Global Burden of Disease – 2010 (chronic disease)



Lim et al. Lancet 2012; 380: 2224–60
Fann et al, Risk Anal. 2012 Jan;32(1):81-95.

Climate Models Predict More Summertime O_3 with Global Change [Climate Penalty]

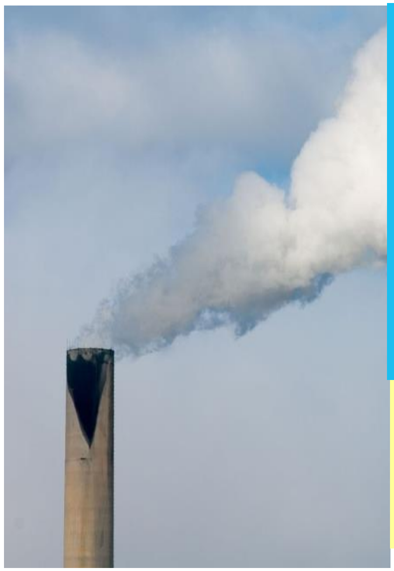
Model Prediction for year 2050 relative to 2000 using constant emissions



Used in the EPA Administrator's CAA "Endangerment finding" for greenhouse gases

Bloomer et al., Geophysical Letters 36(9): 2009





Future environmental policies would do well to embrace systems-based science as the foundation of effective air quality management

Policy should be a fabric woven with the threads of science


Thank
You