



## *Is Fire Important in the West?*

**Biomass Burning Activity & Emissions Data + Regional Air Quality Analysis and Planning Support in the WRAP region**

Tom Moore, Air Quality Program Manager  
WRAP/Western Governors' Association

NCAR Early Career Scientists Assembly – Junior Faculty Forum  
Boulder, Colorado, USA – July 15, 2010



- **Mission**

- The Western Governors’ Association is an independent, nonprofit organization representing the governors of 19 states and three U.S.-Flag islands in the Pacific. Through their Association, Western governors identify and address key policy and governance issues for the West.

- **Purpose**

- Develop and Communicate Regional Policy
- Serve as a Leadership Forum
- Build Regional Capacity
- Conduct Research and Distribute Findings
- Form Coalitions and *Partnerships* to Advance Regional Interests
- Build Public Understanding and Support for Regional Issues and Policy Positions



Home

Ozone

Regional Haze

PM, Nitrogen & Mercury

Membership



## Welcome to the WRAP [www.wrapair2.org](http://www.wrapair2.org)

The Western Regional Air Partnership (WRAP) is a voluntary partnership of states, tribes, federal land managers, local air agencies and the US EPA whose purpose is to understand current and evolving regional air quality issues in the West.

These issues include but are not limited to:

- Implementation and future planning for the Regional Haze Rule;
- Air quality issues related to ozone, particulate matter, nitrogen deposition and critical loads, mercury, and other pollutants;
- Emissions sources from all sectors, both domestic and international;
- Effects of air pollution transport; and
- Effects of climate change on regional air quality.

To accomplish this, WRAP develops, maintains, and shares databases, supports technical analyses, and provides access to data and results from various information sources to produce consistent, comparable, and complete results for use by individual WRAP member jurisdictions and agencies.

[➔ MORE ABOUT WRAP](#)

[View Full Screen Map](#)



## CALENDAR

Tuesday, August 10, 2010 10:00 AM  
[WRAP O & G Workgroup Call](#)

## LINKS



[Other Links](#)

Where have we been, what have we been doing?

# Air Quality Analysis & Planning Support for the West

- WRAP's first task 2000-09 was to provide technical and policy tools needed by western states to implement the EPA Regional Haze Rule, a 50+ year program
  - More than 75% (118) of the nation's visibility-protected areas are in WRAP region
  - Foundational visibility protection plans largely completed
  - Next Regional Haze Plan source-receptor and control analysis plan due 2018
- WRAP's current Tasks:
  - **August 31, 2010** - revised Ozone National Ambient Air Quality Standard (NAAQS) primary health = range of 0.060 to 0.070 ppm 8-hour average (4<sup>th</sup> highest monitored site value averaged over 3 consecutive years) – large regions and numerous national parks of the Western U.S. are expected to violate NAAQS, interstate transport and pollution control plans due 2013
    - Possible secondary welfare/ecosystem Ozone NAAQS as well, [W126]
  - PM<sub>2.5</sub> and PM<sub>10</sub> NAAQS = revised standards in Fall 2011
  - Limited Regional Haze check-in progress analysis 2012-13
  - Nitrogen monitoring, deposition and role in ozone/PM/haze formation
  - Mercury monitoring and deposition
  - 400+ tribes in WRAP region are not required, but may submit TIPs (Tribal Implementation Plans) as they deem appropriate – none currently planned – EPA as backstop

## Regional Planning Organizations

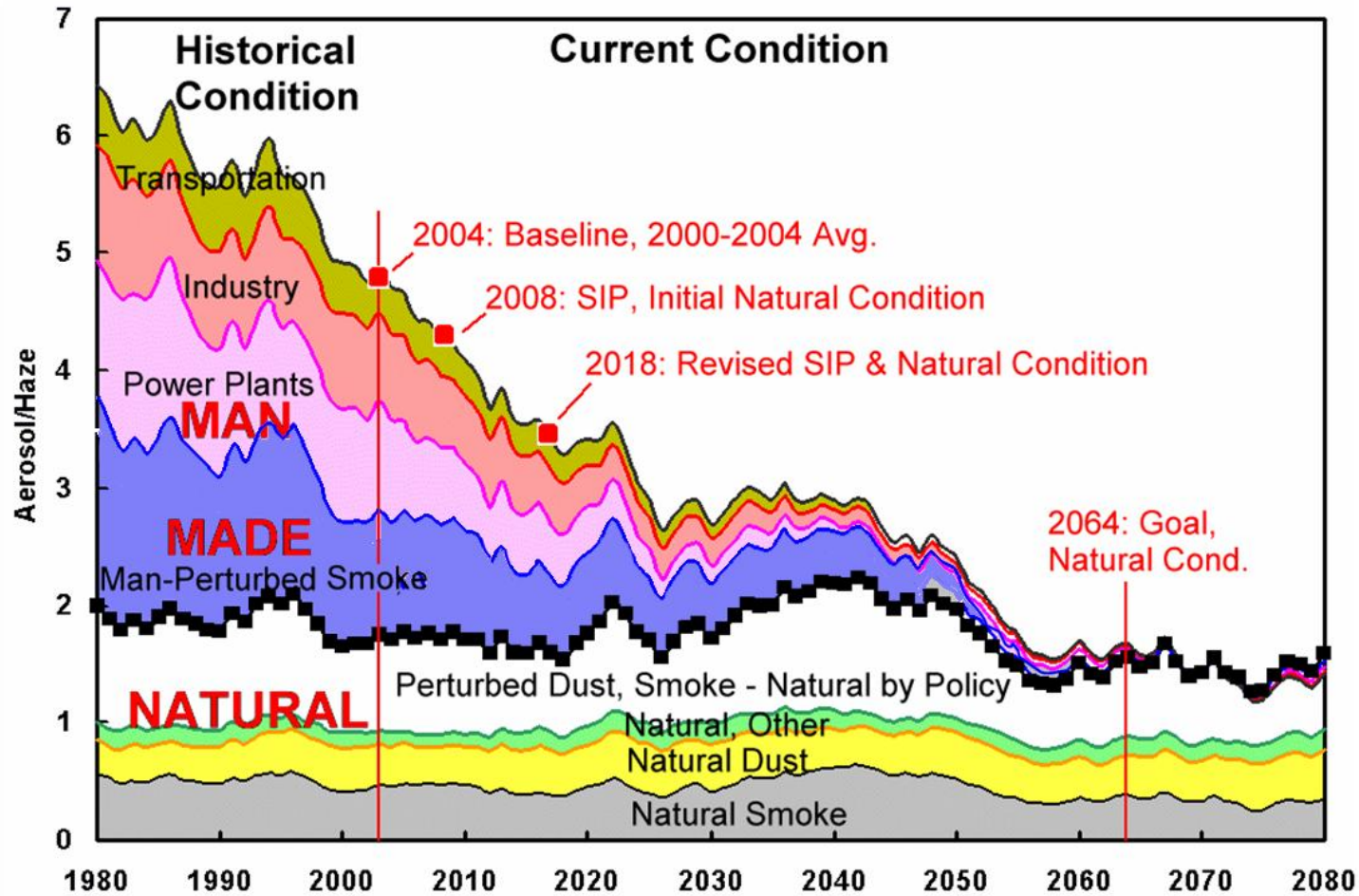


For 2000-04 baseline and 2018 projection periods, large effort completed to:

- Characterize visibility-impairing aerosols (particles) in national parks and wilderness areas (75% of areas protected by Clean Air Act are in WRAP region)
- Comprehensively inventory all emissions sources and project future “growth and control” scenarios
- Apply continental-scale air quality modeling and source apportionment methods with GEOS-Chem boundary conditions

# The Regional Haze Rule:

Return visibility in national parks and wilderness areas to “natural visibility” conditions by 2064

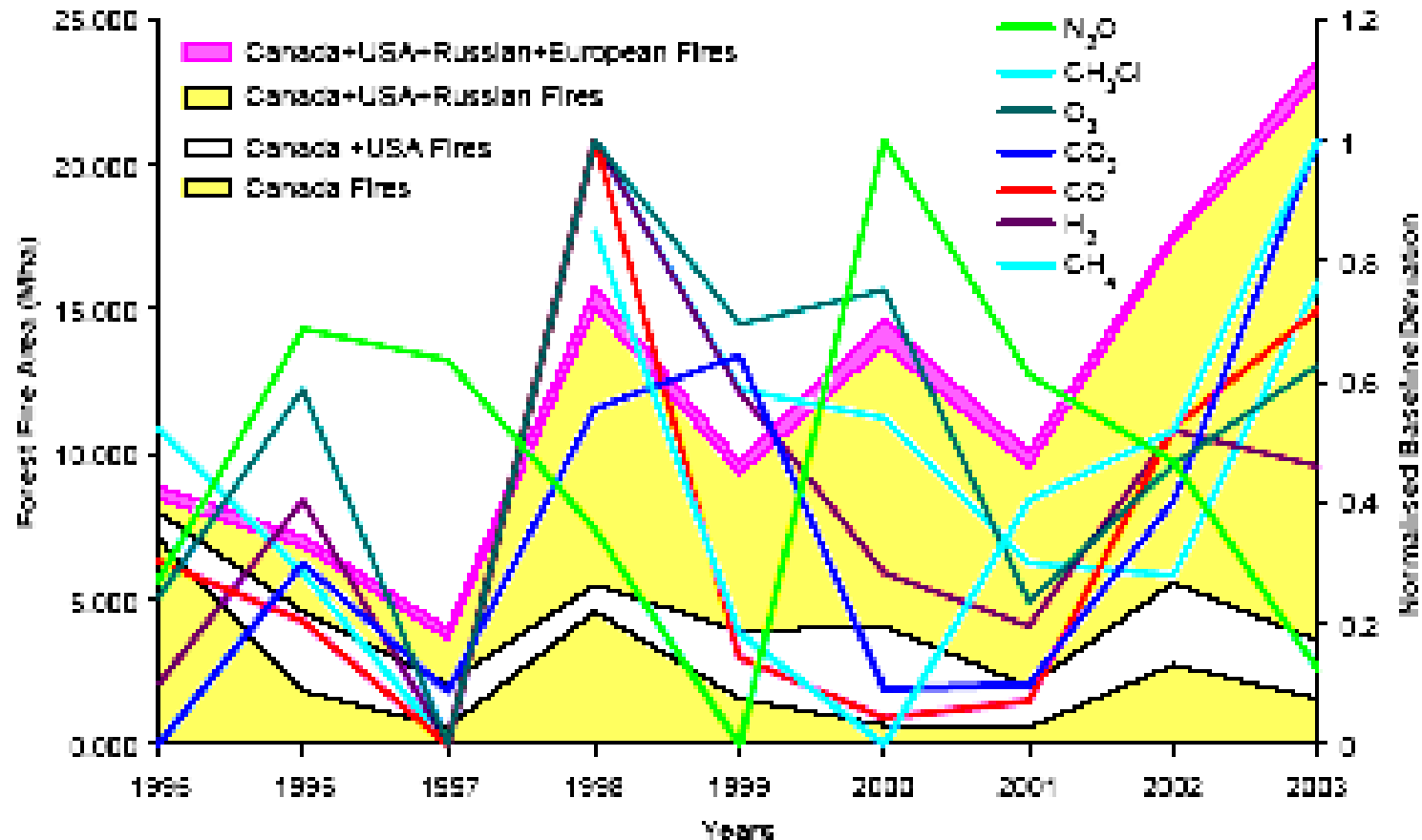


Husar

- Progress is tracked using the 20% worst haze days

# Fire influences the global atmosphere

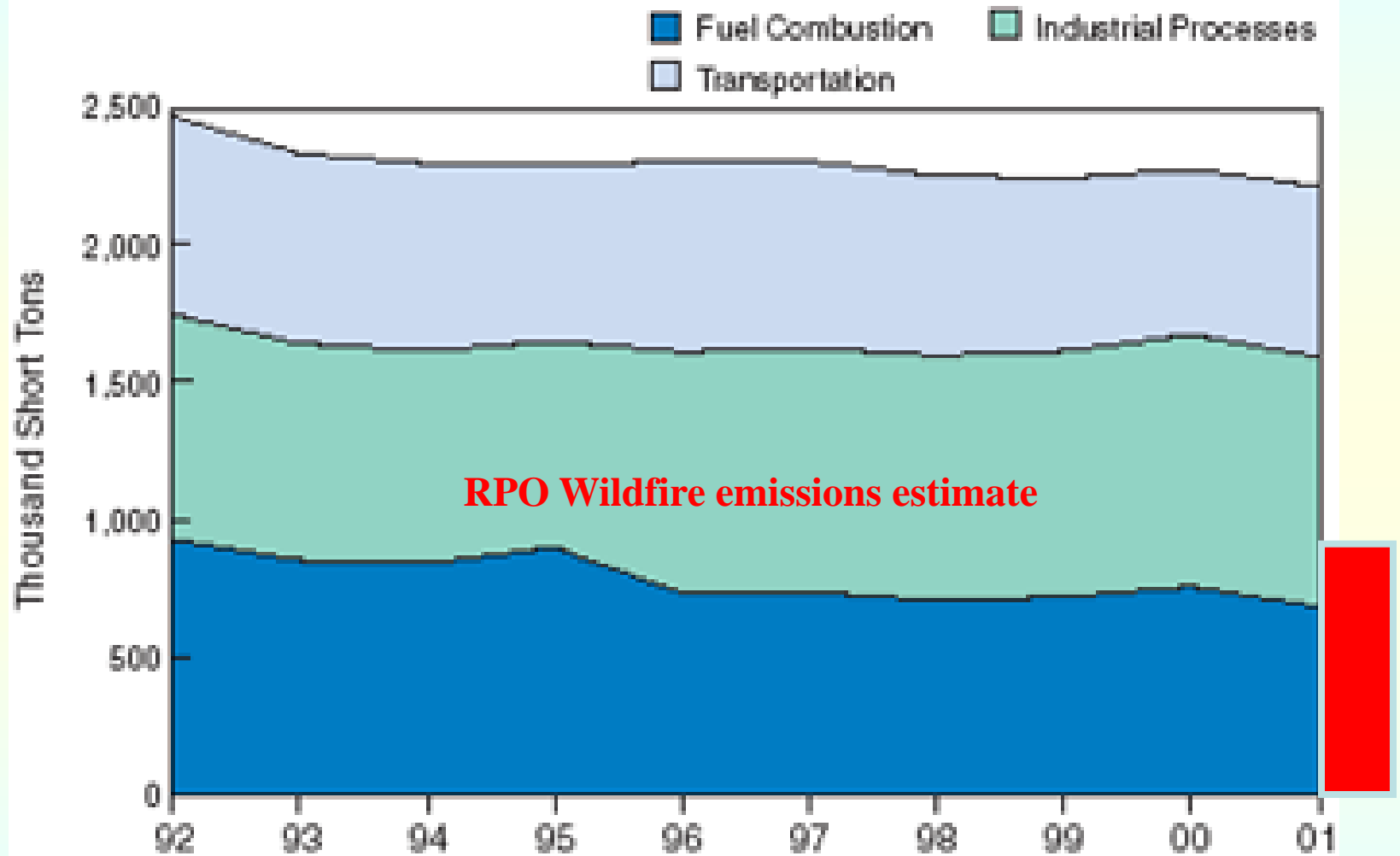
*P.G. Simmonds et al / Atmospheric Environment 39 (2005) 2513–2517*



**Normalized concentration deviations during fire season vs. fire acreage**  
Simmonds, et. al. (2005) Atmos Environ 39 2513–2517

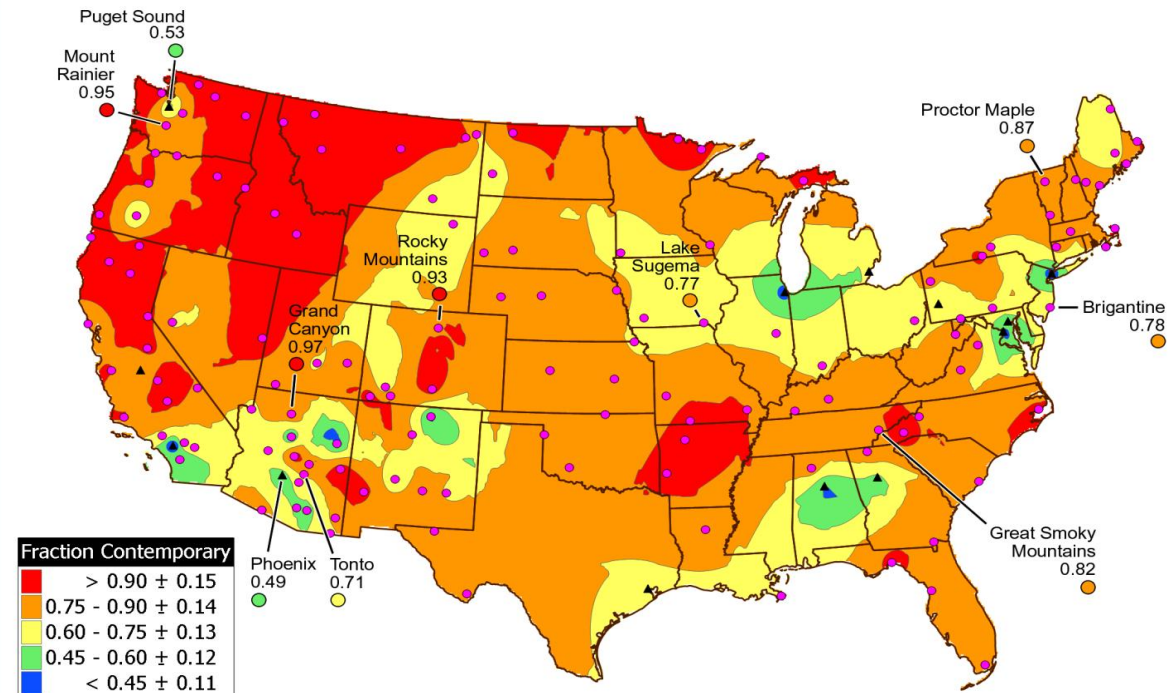
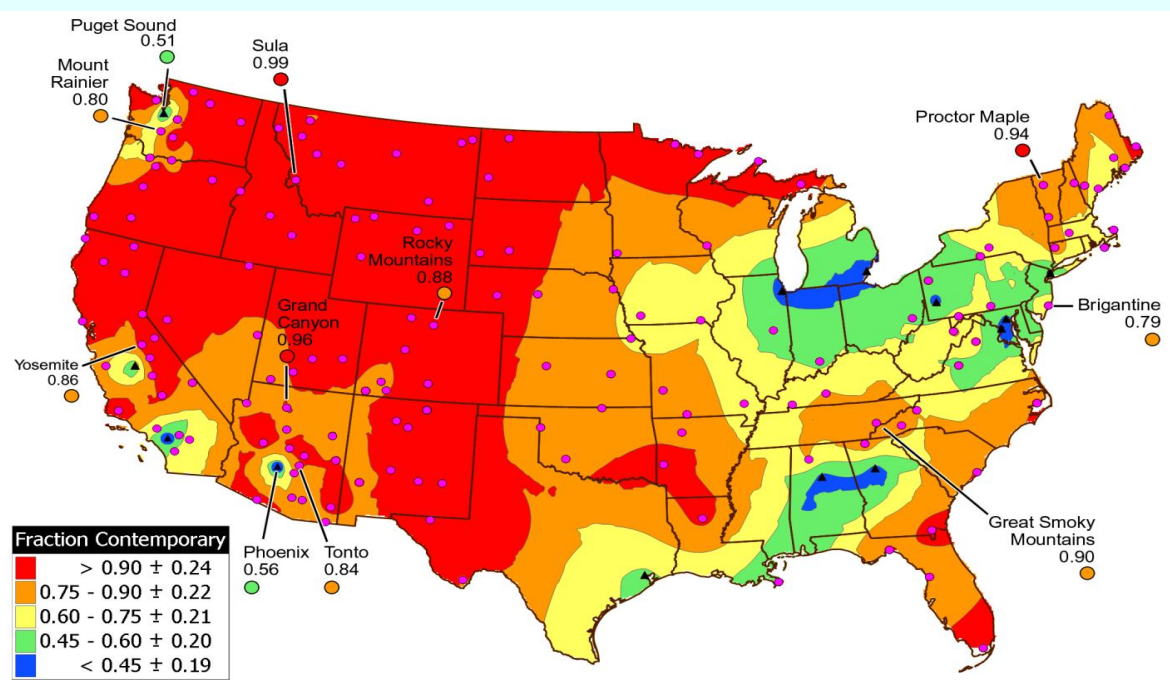


# Direct PM<sub>2.5</sub> Emissions, 1992–2001



1992–01: 10% decrease

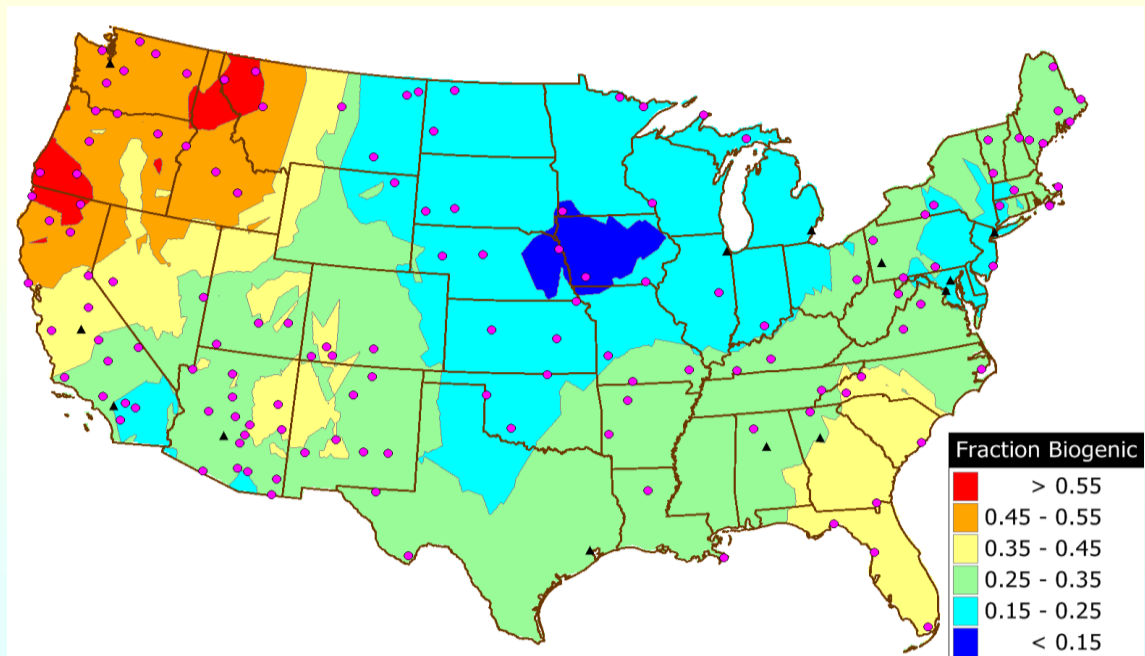
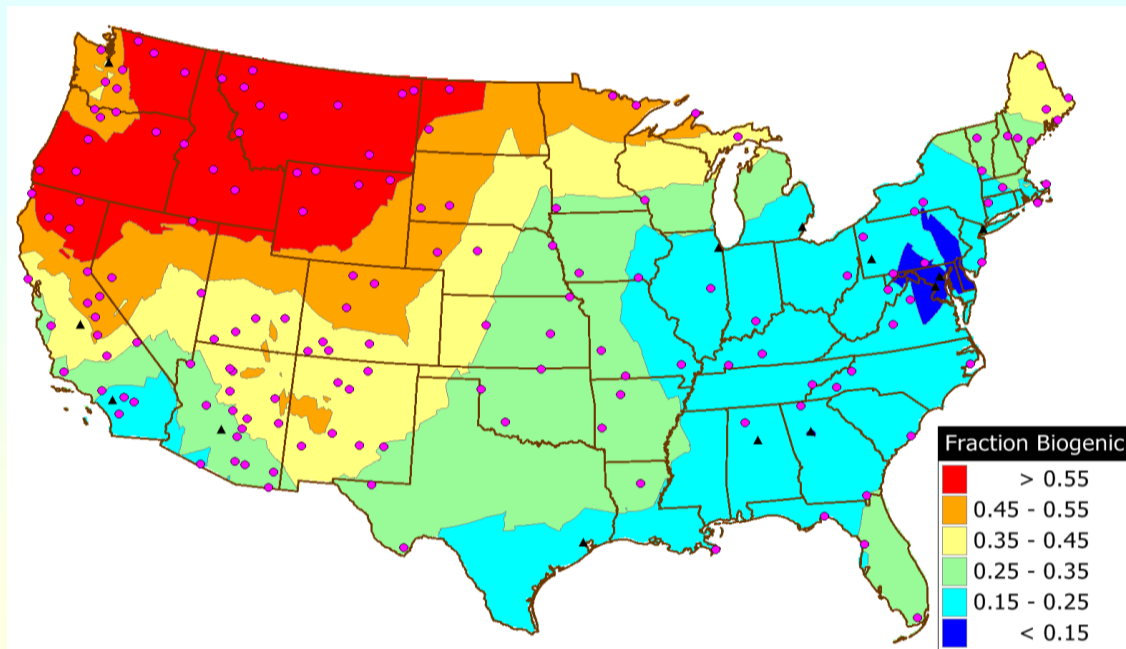
# Average contemporary fraction of PM<sub>2.5</sub> carbon for the summer (top) and winter (bottom) estimated from the December 2004 to February 2006 IMPROVE carbon data.



The circles are rural IMPROVE sites and triangles urban IMPROVE sites. The measured contemporary fraction of PM<sub>2.5</sub> carbon at the 12 sites used in this study is also indicated on the maps. The data are spatially interpolated using a Kriging algorithm to help visualize spatial patterns in the data. (Schichtel, et. al., JGR)

**Contribution of biogenic sources including biomass burning to fine particulate matter during the summer (top) and winter (bottom)**

Schichtel, et. al.,  
JFSP report, in  
press



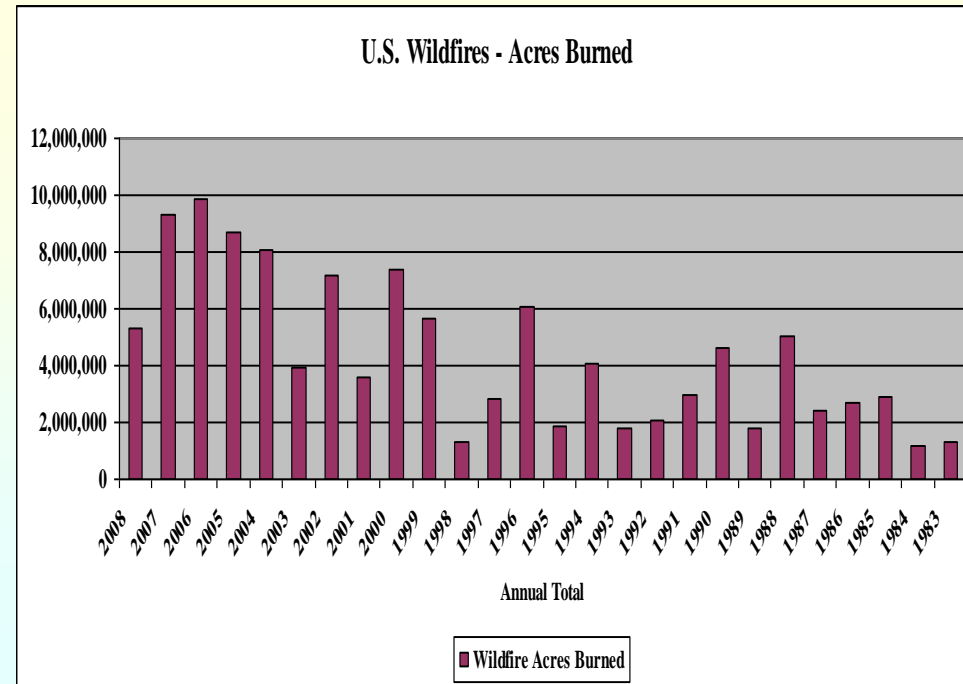
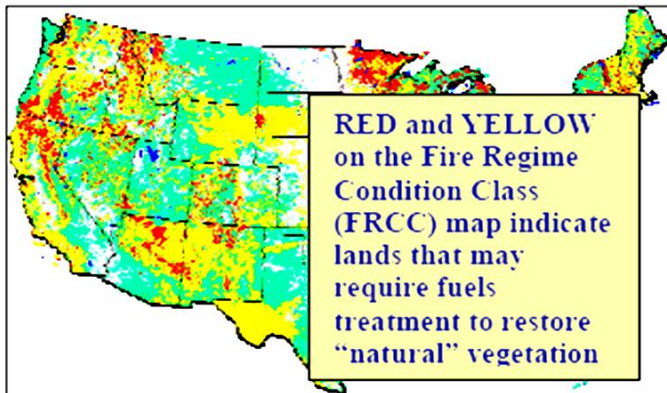
Smoke/Fire & the Ozone and PM  
NAAQS, Regional Haze Rule  
(or other AQ program)

# *The Big Picture*

Technical Products for air  
quality planning &  
management as required by  
the Clean Air Act

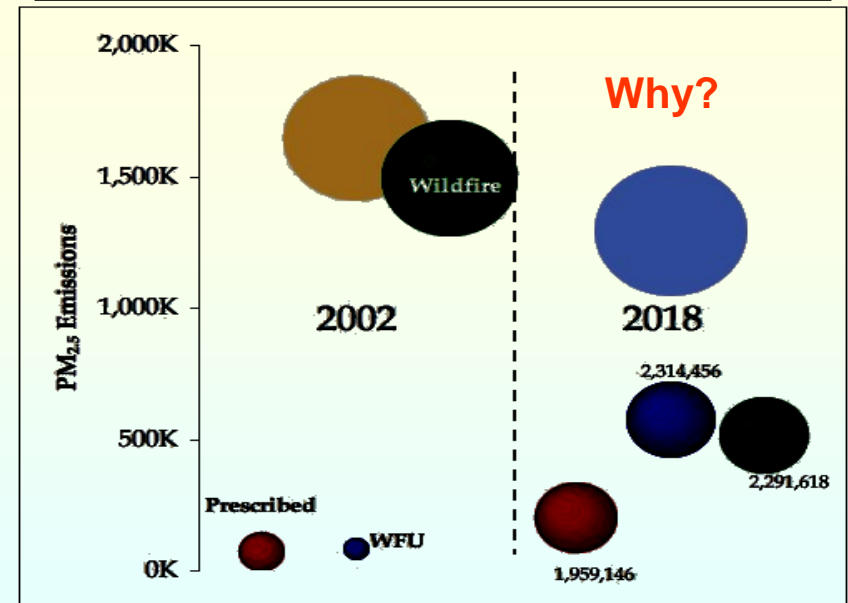
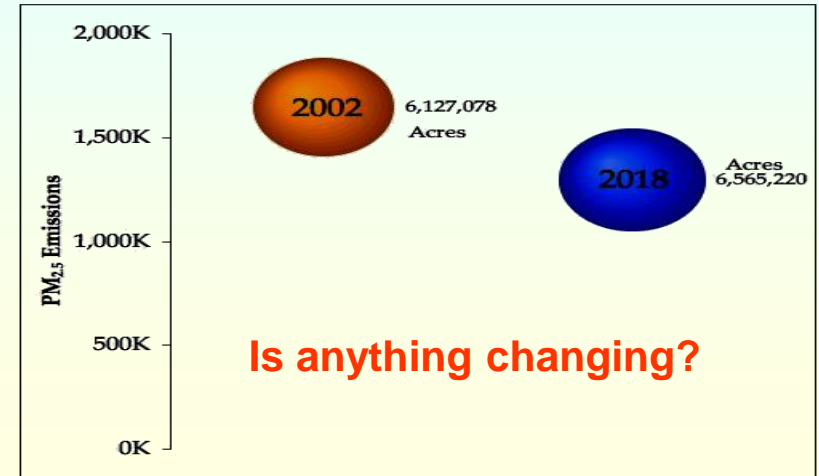
Future emissions, efforts to  
avert emissions &  
health/visibility impacts, &  
adapt to a changing/varying  
climate

The quantity of forest fuels and composition of vegetation in the wildlands of the Western U. S. motivate the land managers to increase the application of prescribed fire to the landscape (from 650,000 acres in 2002 to a projection of up to 3.6 MM acres in 2018).



# Desire by Federal Land Managers for dramatic shift in fire source type

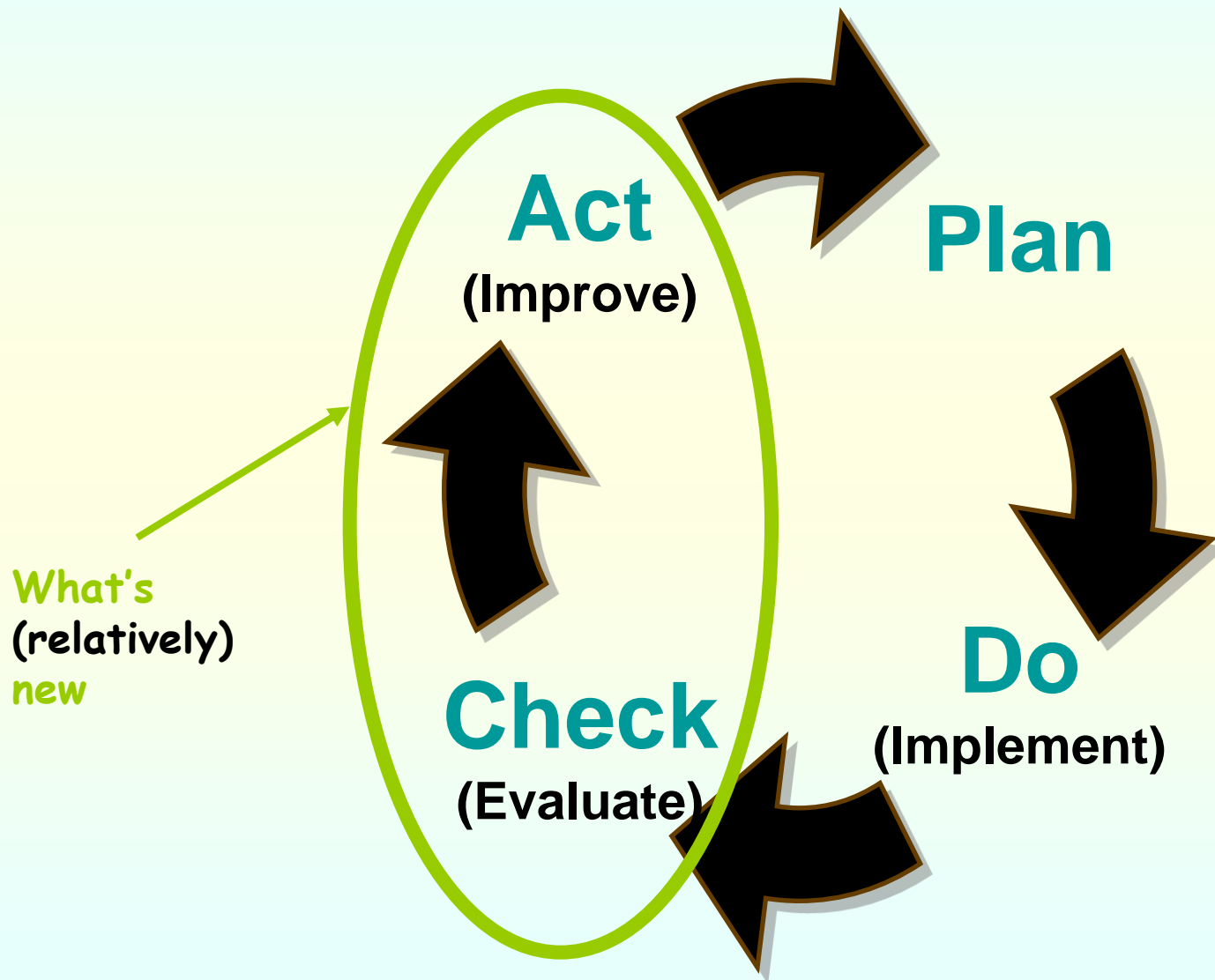
- Prescribed fire activity in the West increases due to a change in land management practices
  - For decades, FLMs had focused on fire suppression.
  - The resulting build-up of fuels cause catastrophic wildfire, danger to humans, and declining forest ecosystem health.
  - Executing more aggressive treatments more frequently restores ecosystems and protects human interests.
  - ...AND air quality impacts must be addressed.

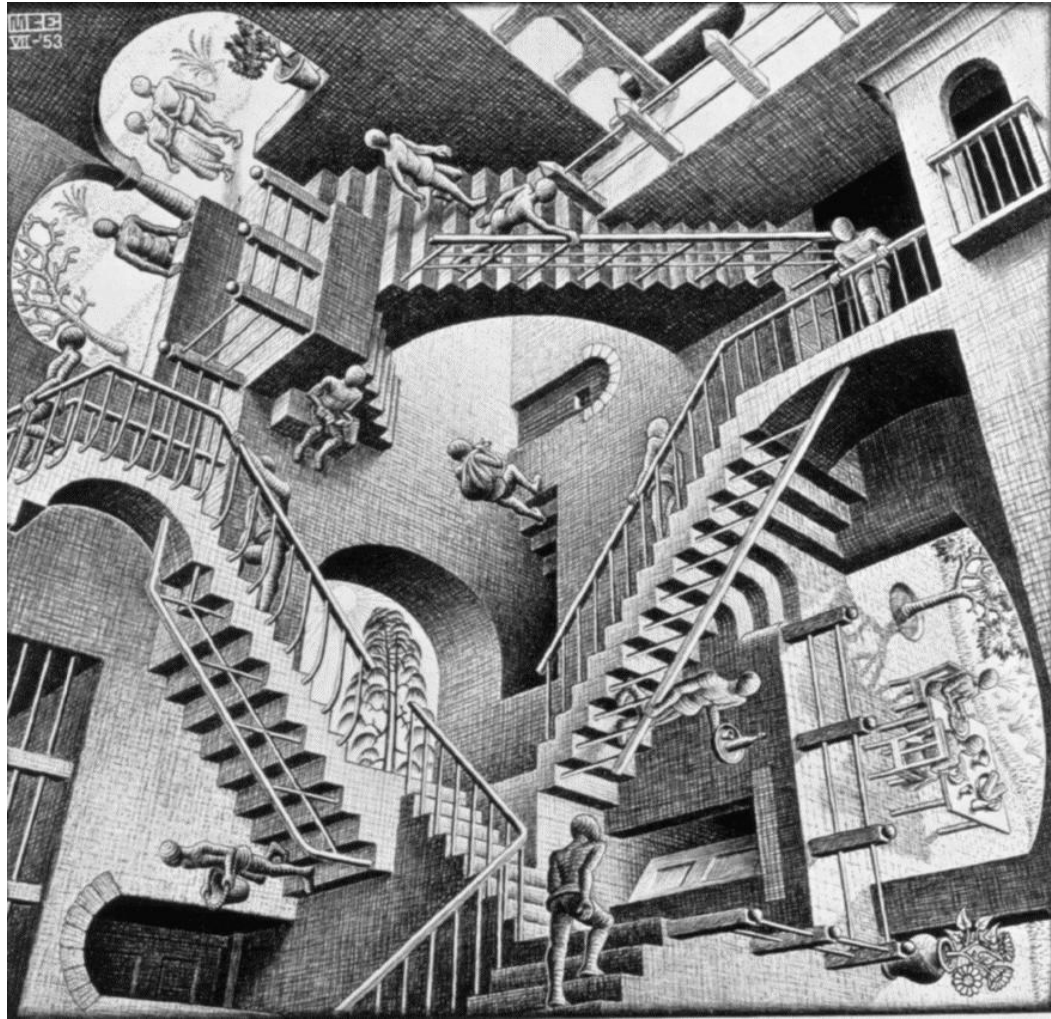


# **FLM responsibilities are Strategic, Tactical & Operational ....**

- **Clean Air Act:**
  - **NAAQS air quality management and planning**
    - **Ozone**
    - **PM2.5**
    - **Sulfur and Nitrogen Deposition**
  - **Regional Haze**
    - **Natural Background determinations**
    - **Reductions in controllable Regional Haze sources**
- **Smoke Management Programs (SMP)**
  - **Tracking fire activity and managing emissions**
  - **Anticipating air-shed loadings**
  - **Documenting plans & accomplishments**

# FLMs partner with individual States for Smoke - Air Quality Management System





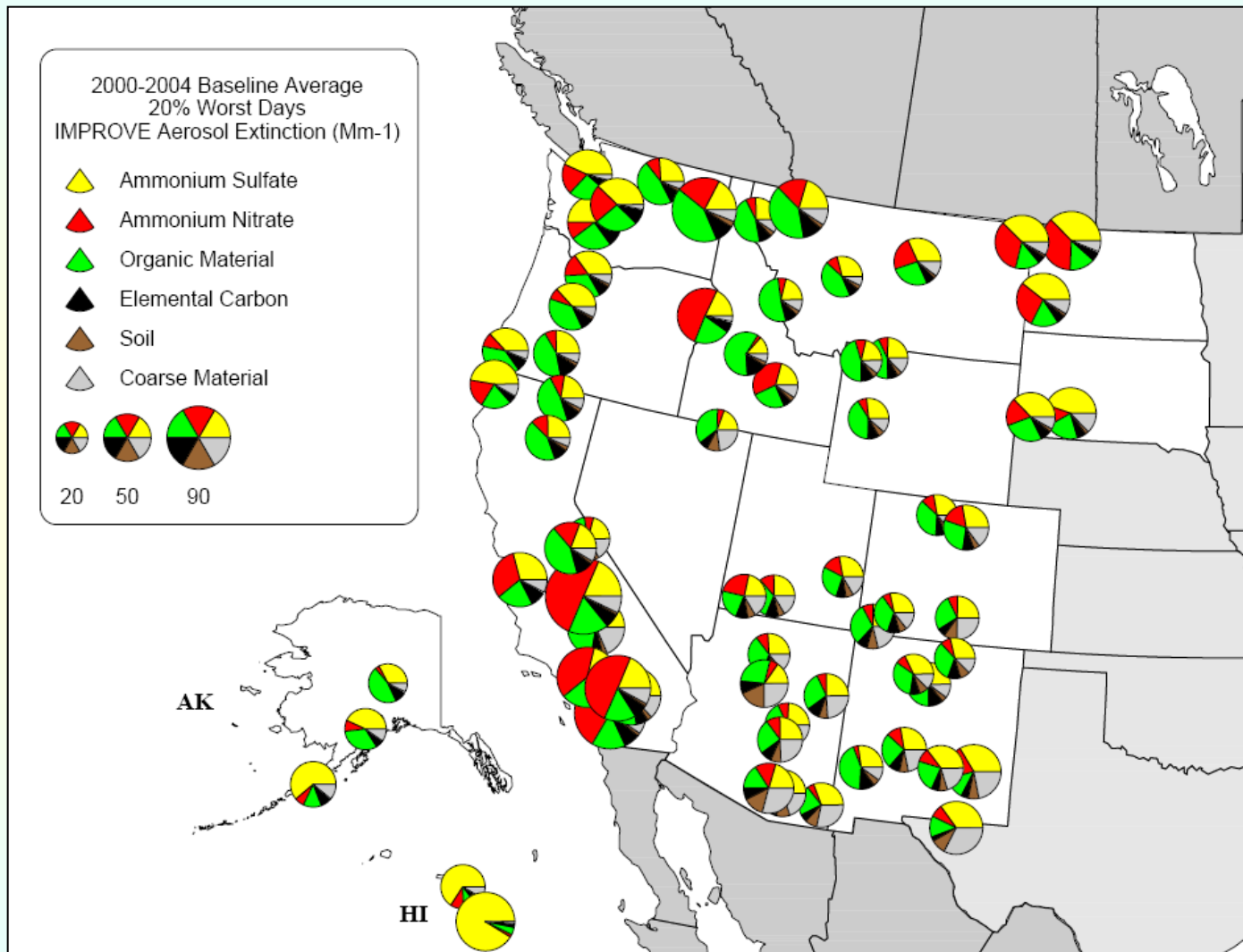
M.C. Escher, "Relativity"

Fire activity data users are going up and down all at once.  
*A comfortable place to rest for some may mean that others will have to defy gravity.*



Why is the West different?

# IMPROVE Monitored Baseline Extinction for 20% Worst Days





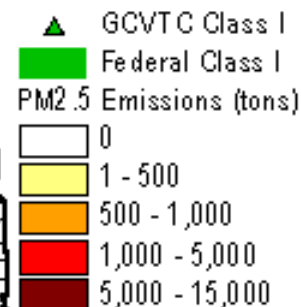
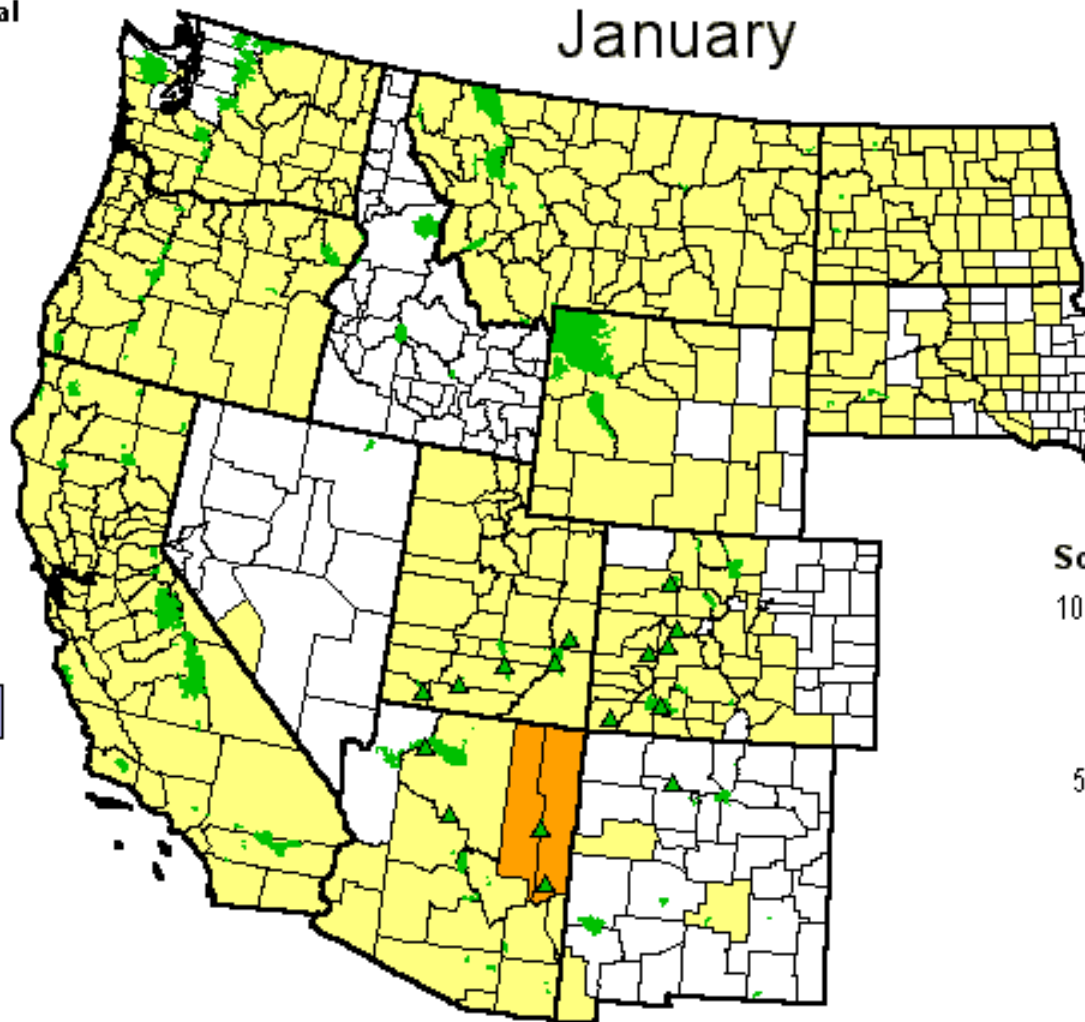
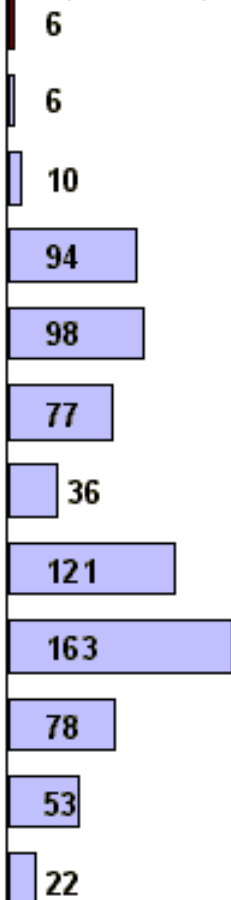
M.C. Escher, "Eight Heads"

*Spaces between data may be just as important as the data points themselves.*

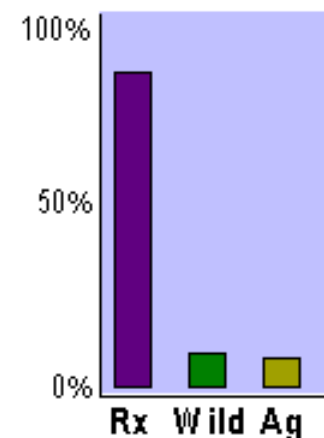
## 2018 Projected Emission Inventory Total Fire Emissions

### January

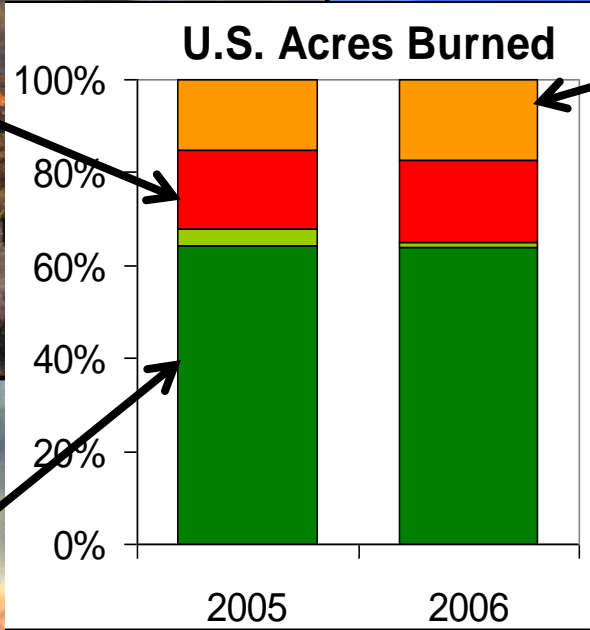
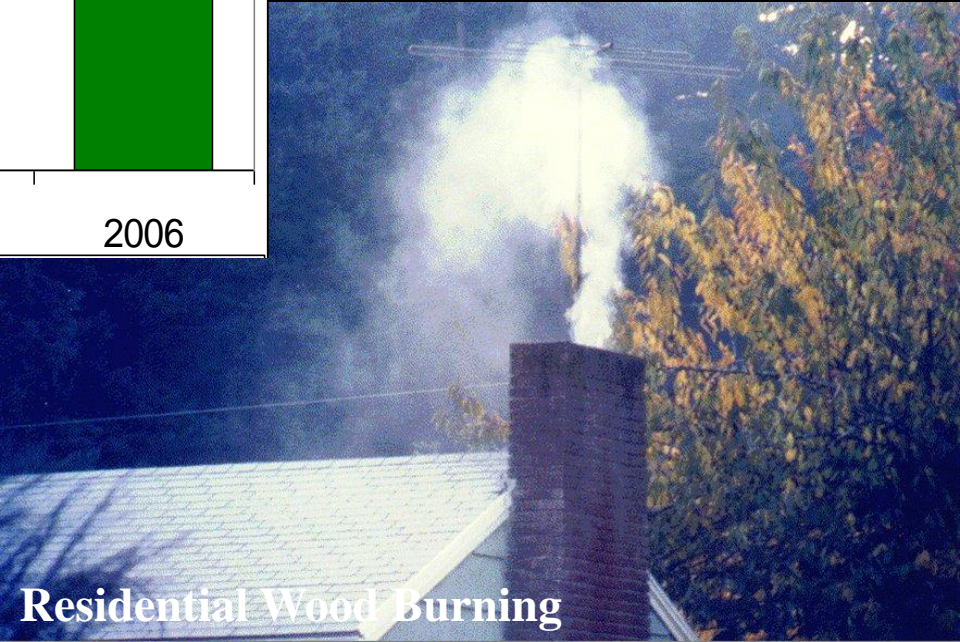
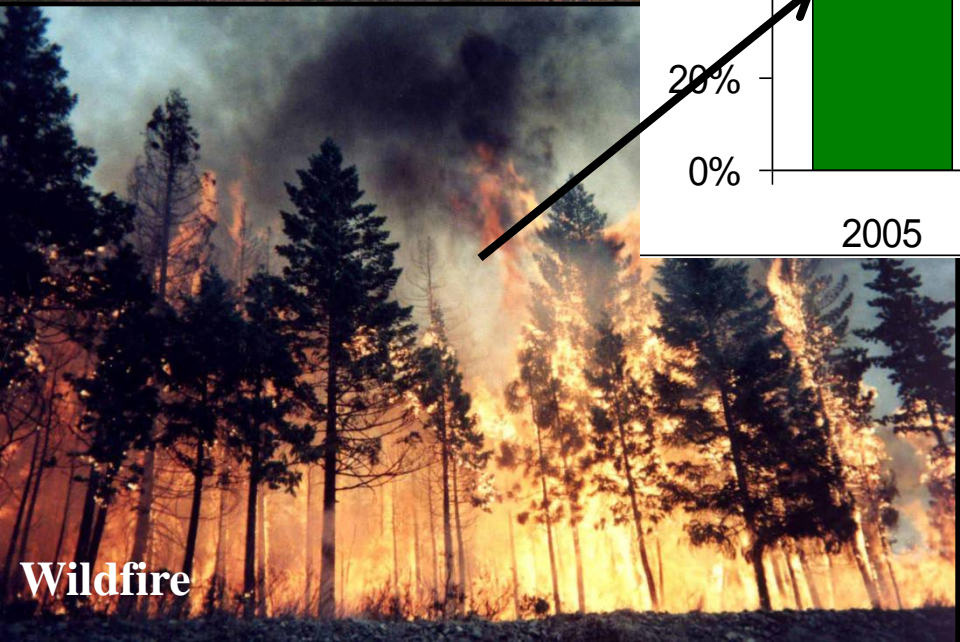
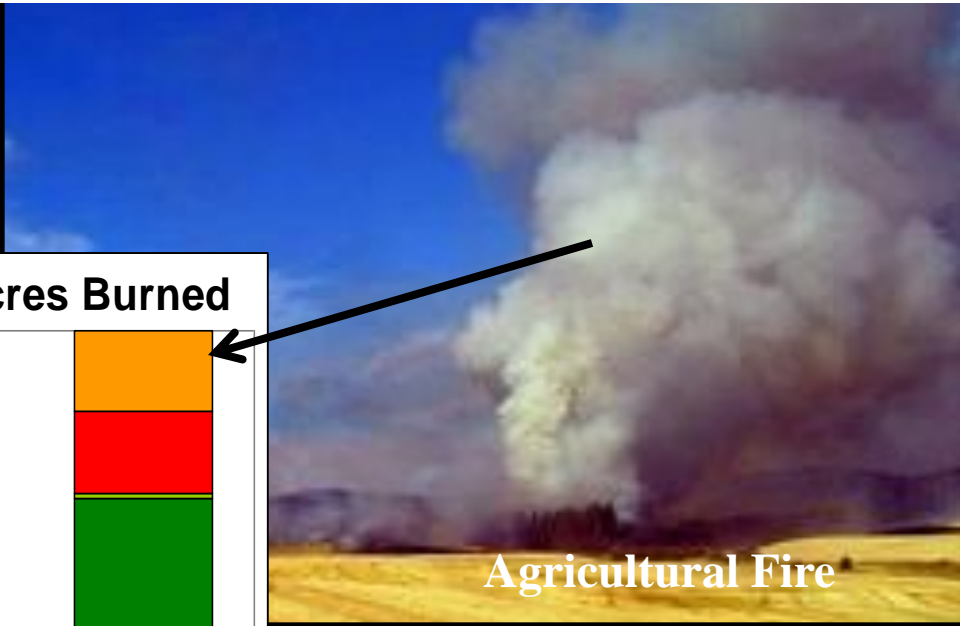
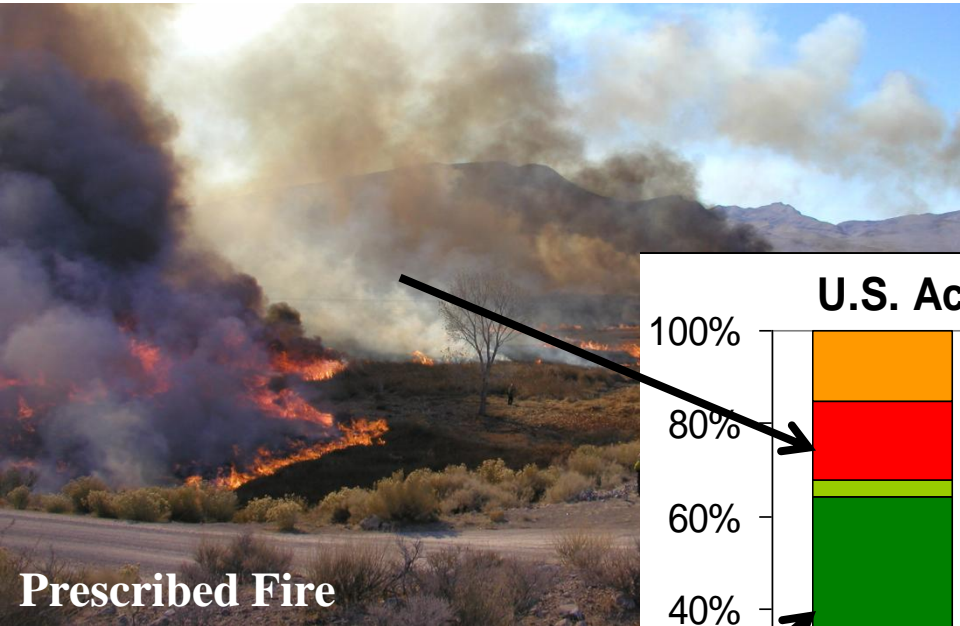
WRAP-wide Total  
(1000 Tons)



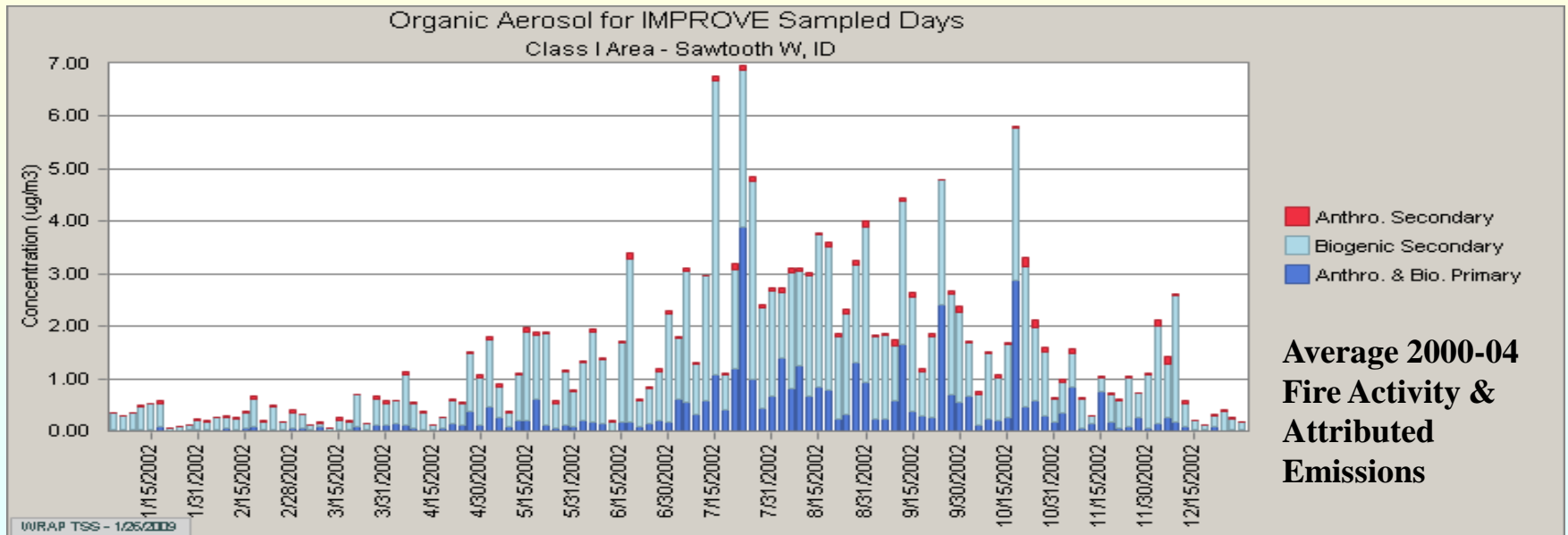
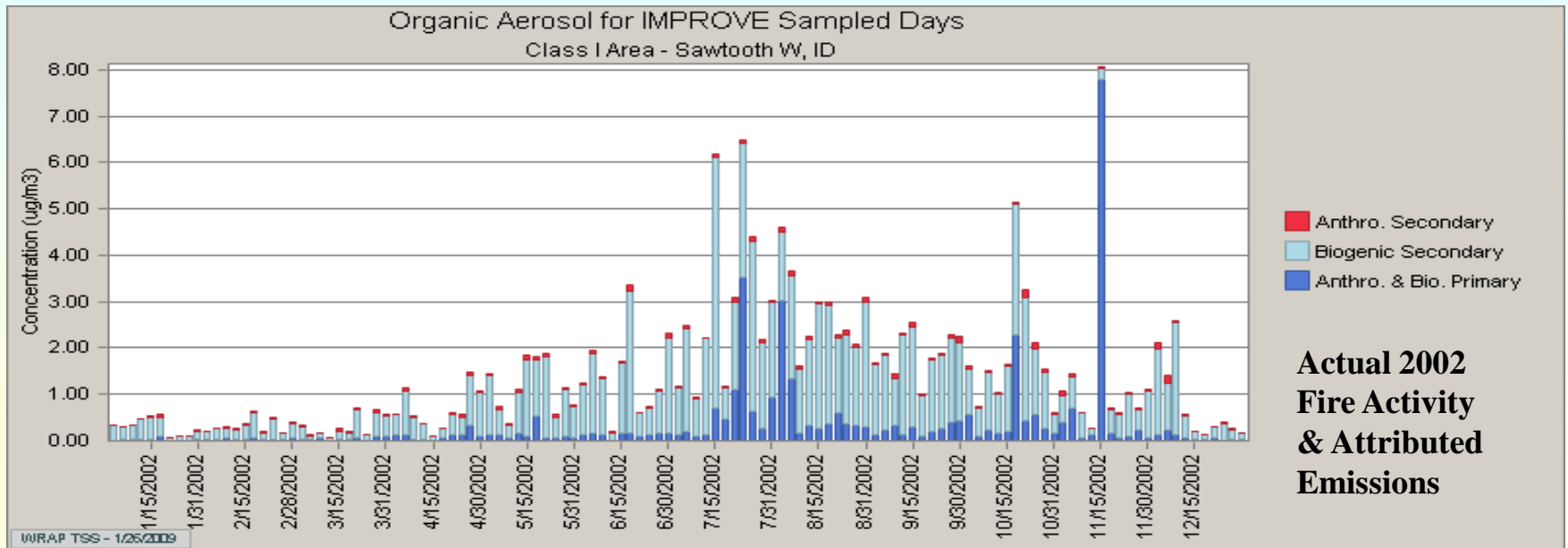
### Source Contribution



# Contribution of Fires to Particulate Carbon emissions



# WRAP Modeling Data – Organic Aerosol Tracer



# Small (Prescribed) Fires

59% of July events	91% of November events
2% of July fire PM2.5	38% of November fire PM2.5

Emissions from Large Wildfires were analyzed separately with from Small Prescribed Fires with 12km CMAQ model

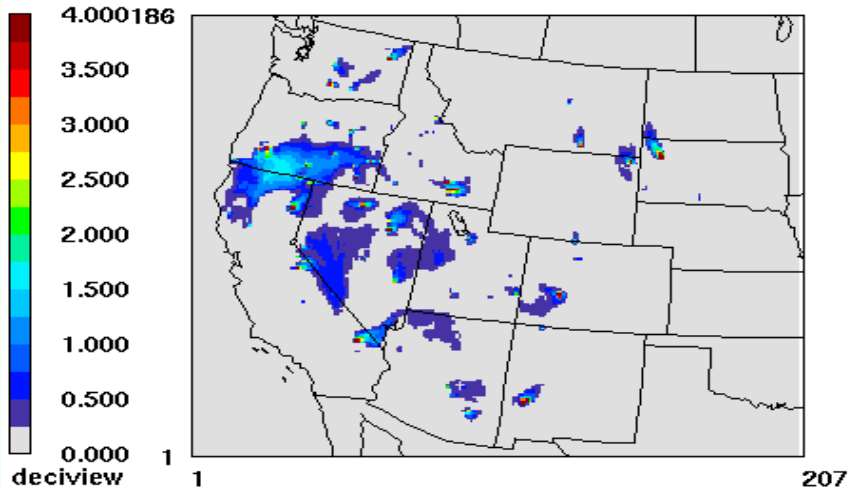
- No fires less than 100 acres in timber, 300 acres in grass/brush were in database
- Large wildfires removed were generally 10,000+ acres

## Resulting Modeled Visibility Impairment by Fires in 2002

### Large Wildfires

Delta DCV\_Recon

Base02a - Base02a Fire  
Daily average concentration

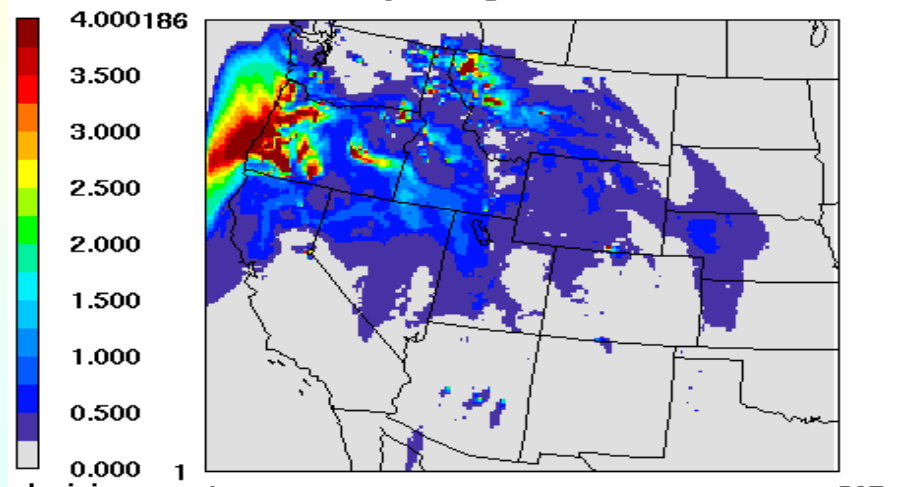


July 14, 2002 0:00:00  
Min= -0.304 at (27,132), Max= 13.052 at (113,23)

### Small (Prescribed) Fires

Delta DCV\_Recon

Base02a - Base02a Fire  
Daily average concentration



November 15, 2002 0:00:00  
Min= -0.337 at (160,144), Max= 12.492 at (65,146)

[Home](#) | [View My Projects](#) | [Enter Project](#) | [View My Burn Days](#) | [Enter Burn Day](#) | [Map](#) | [Reports](#)  
[Contact](#) | [FTP](#)

Welcome to the WRAP Fire Emissions Tracking System (FETS).



- [Map of Current Fire Activity in WRAP Region](#)
- [Resources](#)
- [Methods](#)
- [State and Tribal Smoke Manager Contacts](#)

The WRAP's Fire Emissions Tracking System (FETS) is a web-enabled database for planned and unplanned fire events. It is intended as a planning tool for daily smoke management coordination, and retrospective analyses such as emission inventories and regional haze air quality planning tasks.

#### News and Events

May 2010 FETS Project call. [Details...](#)

March 2010 FETS Project call. [Details...](#)

December 2009 FETS Status Report for [December 17th FETS Project call](#). [Agenda \(PDF\)](#)

October 2009 FETS Status Report for [October 13th FETS Project call](#). [Agenda \(PDF\)](#)

[2009-2010 FETS Scope and Budget \(October 1, 2009\)](#)

[Fire Emissions Tracking System \(FETS\) Project Meeting \(August 31-September 1, 2009\)](#)

FETS 2009 Webinar Series - *View a summary of topics, attendees and outcomes* [here](#)

[older events...](#)

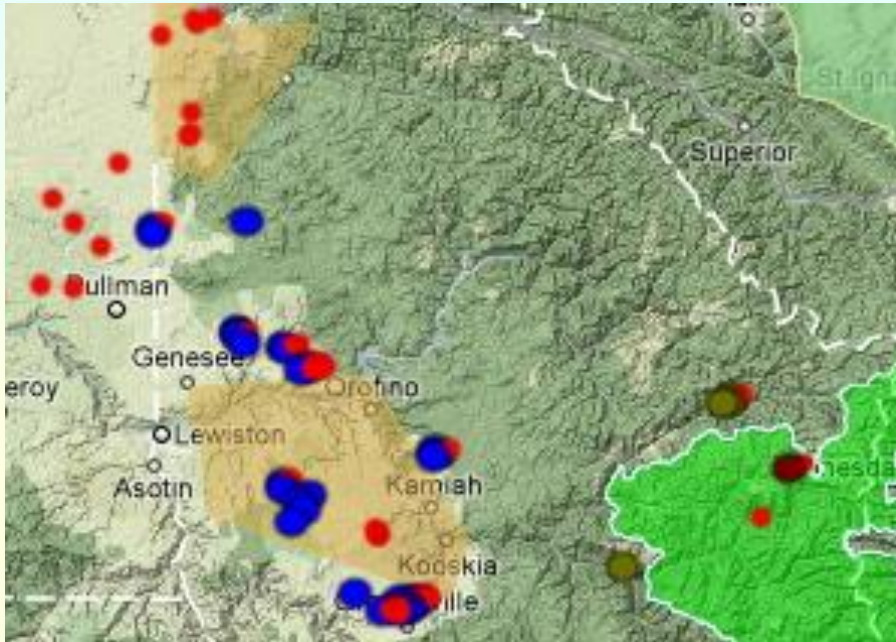
Copyright 2007-2010, Western Regional Air Partnership.



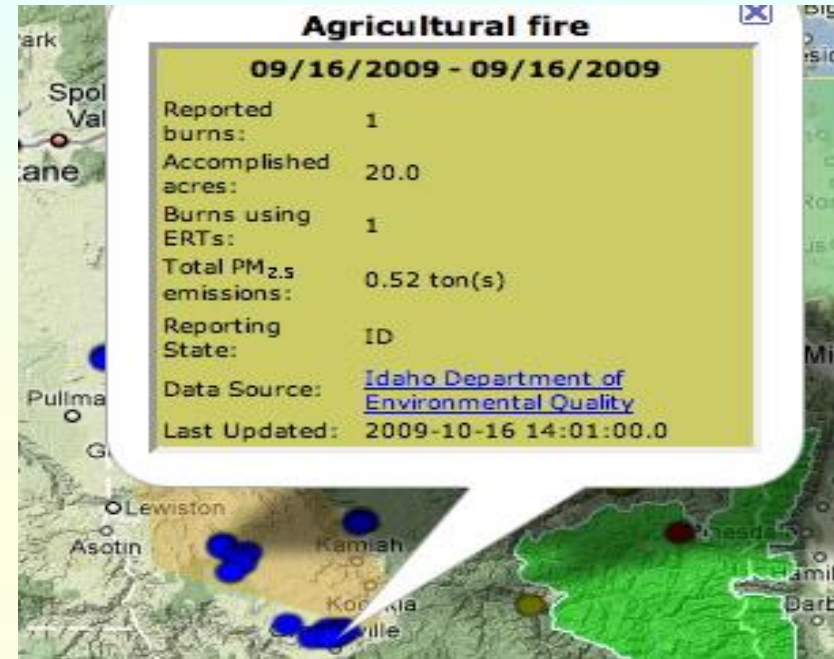
# FETS Users

System Users	Purpose	Frequency
<i>State &amp; Tribe</i>		
Smoke Management Programs	Regional Coordination; Burn decisions	Daily
Air Quality Planners	Emission Inventories; Regional Haze Plans; Air Quality episodes	Periodic
<i>Land Managers</i>	Regional Coordination; Burn plans	Daily
<i>Public</i>	Interest; Air Quality advisories	Periodic

# FETS Map Tool



**Satellite fire detections** (red shapes in figure) are displayed only as a visual tool on the FETS map. **Agricultural burns** (blue circles) often occur concurrently with **Prescribed** (green) and **wildland** (dark red) fires. The lower right depicts a Class I area (light green). Fire detections in the upper left show areas where data are not sent to the FETS.



**Click on a burn to see associated metadata. Acres burned, Emission Reduction Techniques (ERTs) used, and a link to the reporting agency are included.**

# Fires and Ozone

(contributor to urban and rural impacts, direct formation from fire event(s), precursor transport?)



**Wildfire**



**Agricultural Fire**

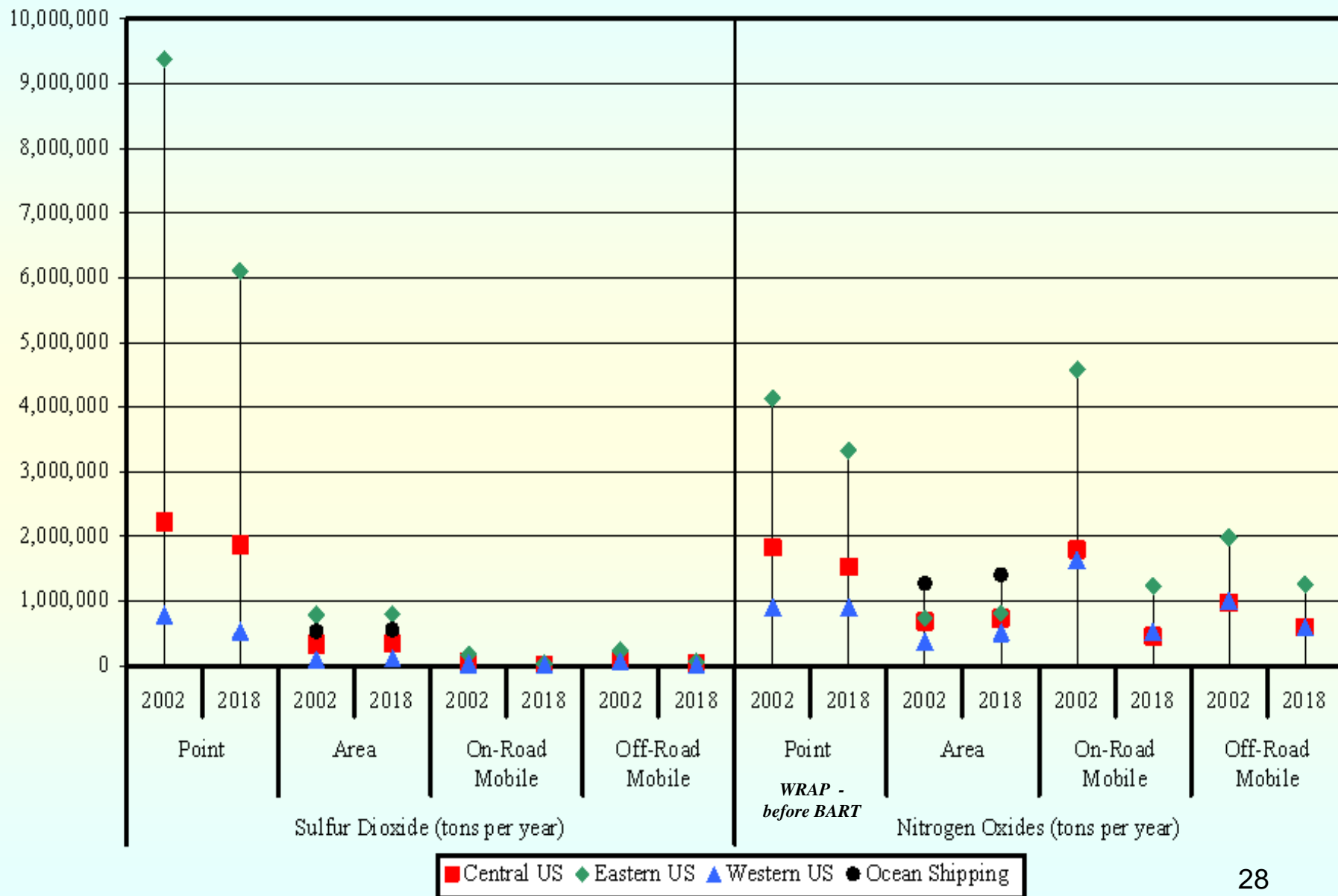


**Prescribed Fire**



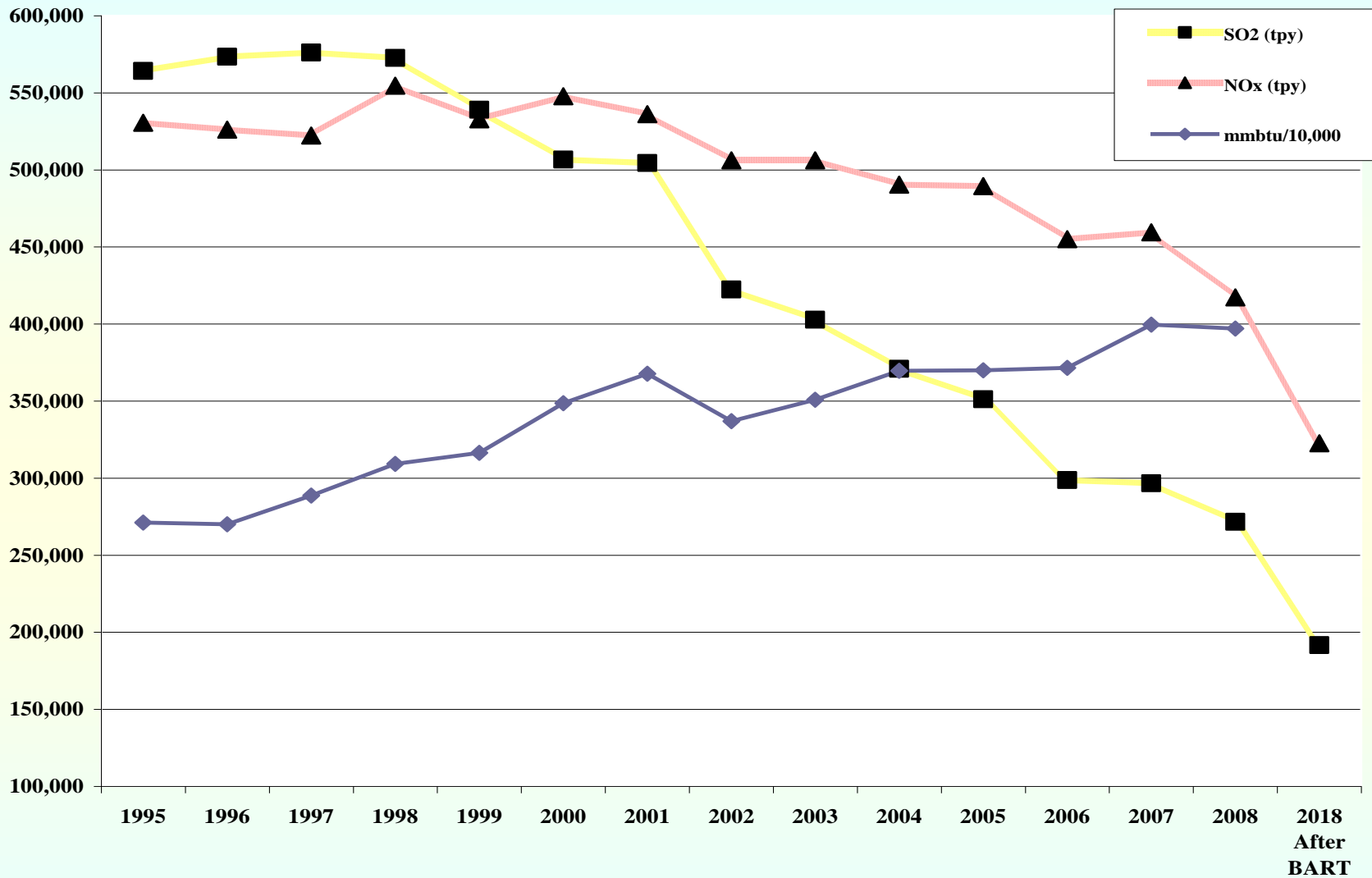
**Residential Wood Burning**

## U.S. Regional Emissions Changes 2002-18





## Western State Power Plant Emissions\* (1995-2008) and After BART\*\*

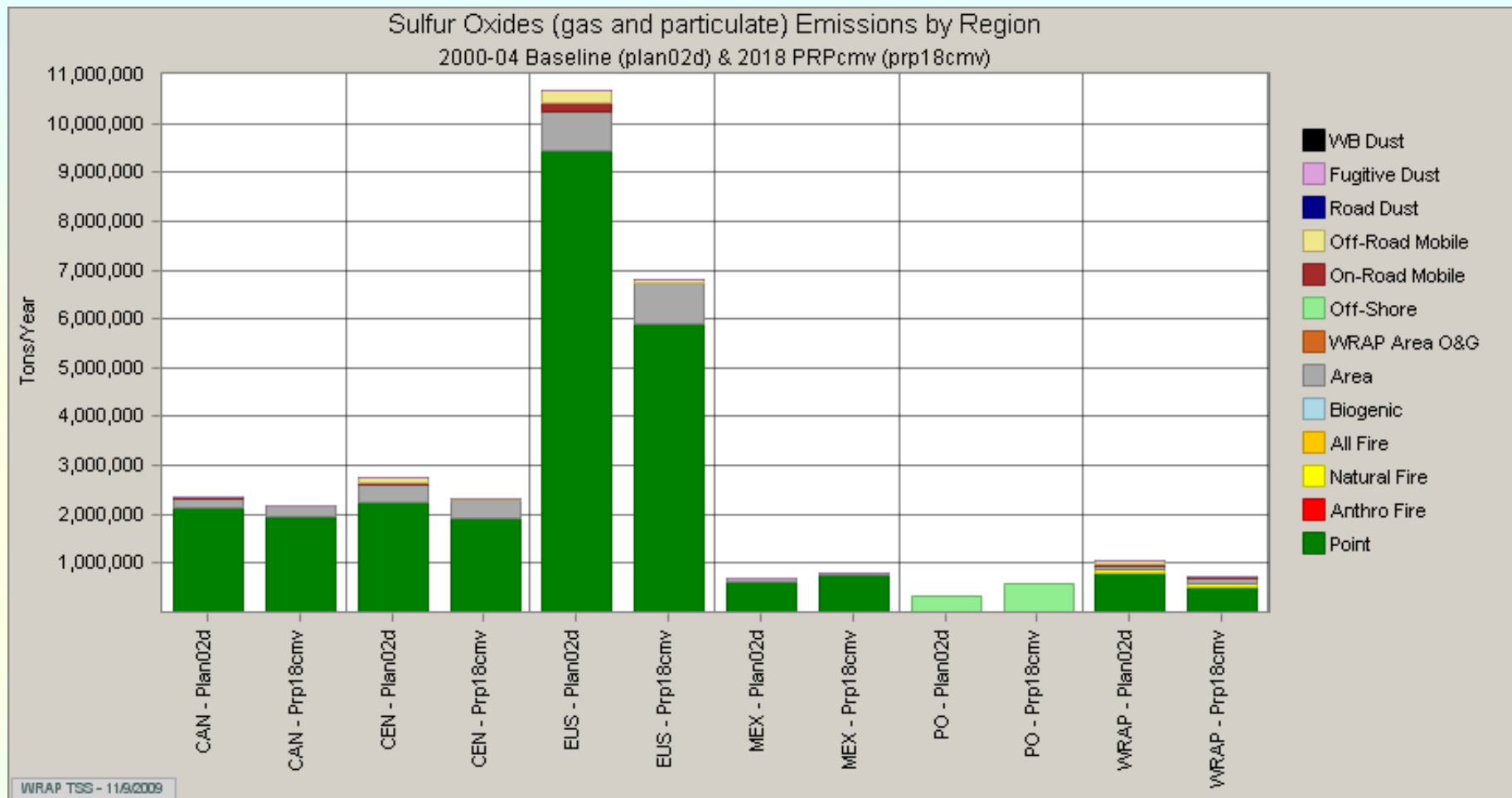


\* Currently operating coal, gas, and fuel oil-fired plants in the 11-state Western Interconnection

\*\* Estimates for BART controls are from WRAP PRP18b emissions analysis (as of Spring 2009) at:

<http://www.wrapair.org/forums/ssjf/pivot.html>

# Change in SO2 Emissions (tpy) 2002 to 2018 across North America



## All SO<sub>2</sub> Sources 2002 to 2018

Tons/year

%

Canada

-159,003

-7%

CENRAP

-445,526

-16%

Eastern US

-3,856,861

-36%

Mexico

+99,105

+14%

Pacific Off-Shore

+273,413

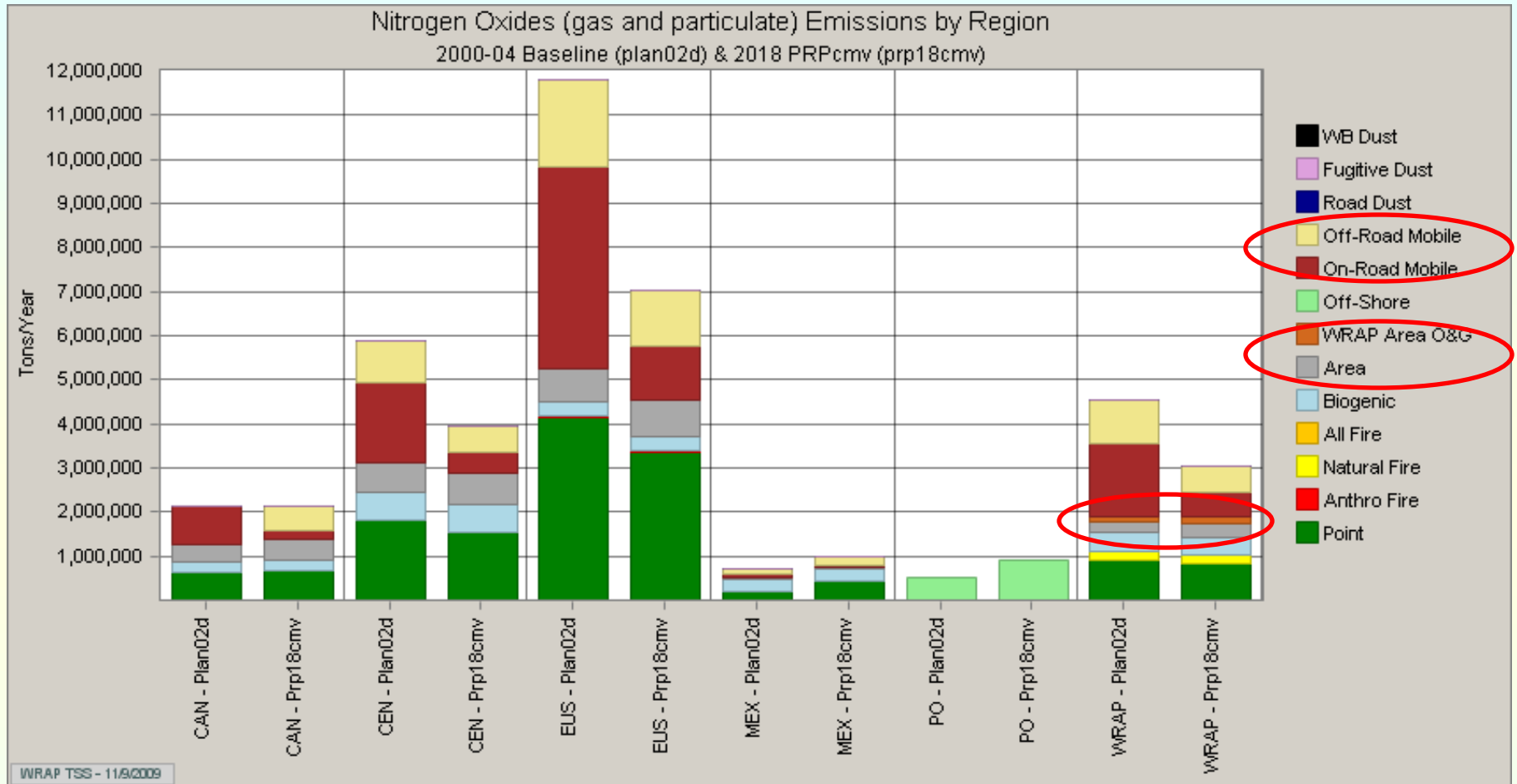
+88%

WRAP

-341,348

-32%

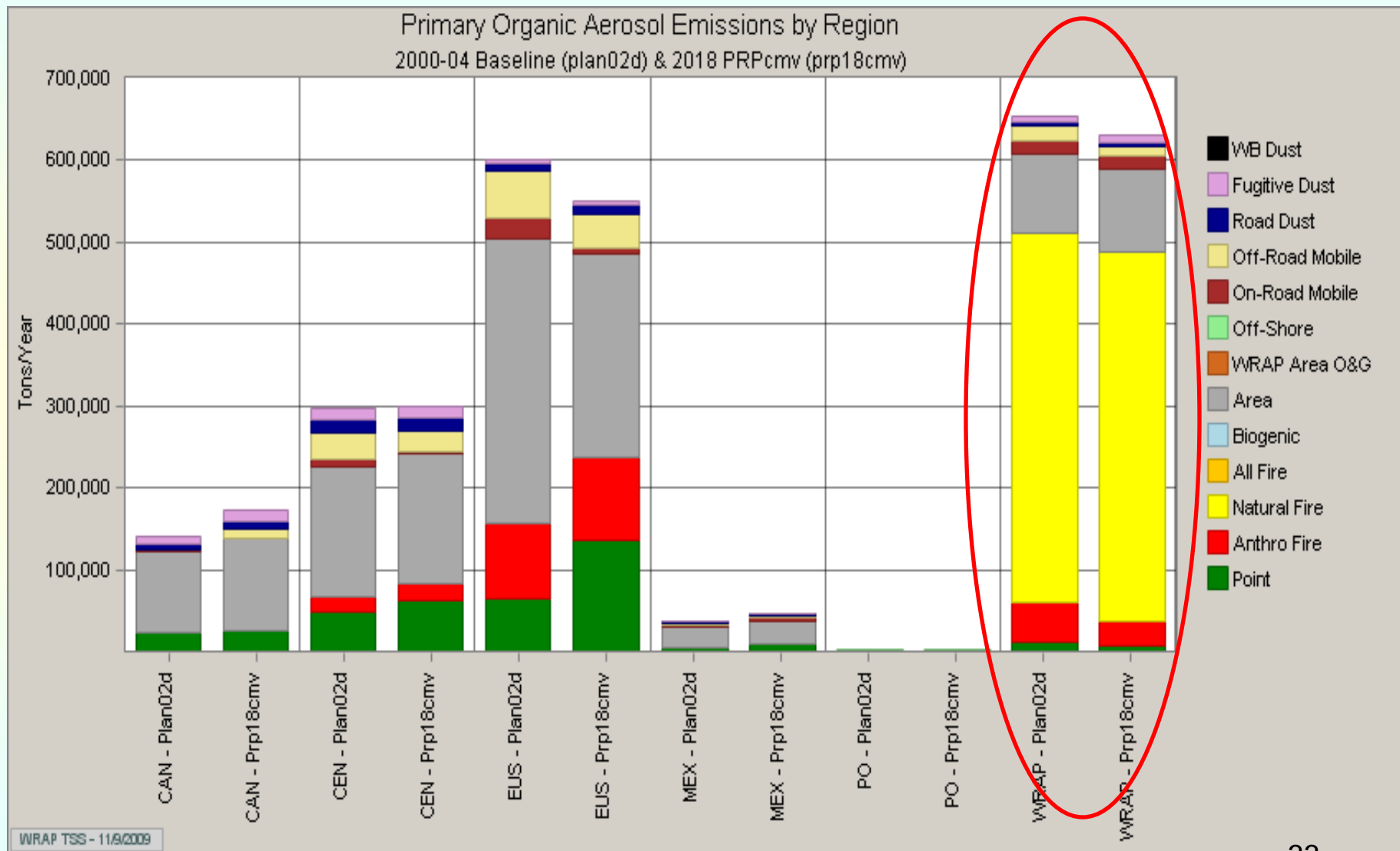
# Change in NO<sub>x</sub> Emissions (tpy) 2002 to 2018 across North America



All NO <sub>x</sub> Sources 2002 to 2018	Canada	CENRAP	Eastern US	Mexico	Pacific Off-Shore	WRAP
Tons/year	-17,043	-1,947,438	-4,765,494	+280,697	+391,972	-1,518,746
%	-1%	-33%	-40%	+39%	+76%	-33%



# Change in Primary Organic PM2.5 Emissions (tpy) 2002 to 2018 across North America

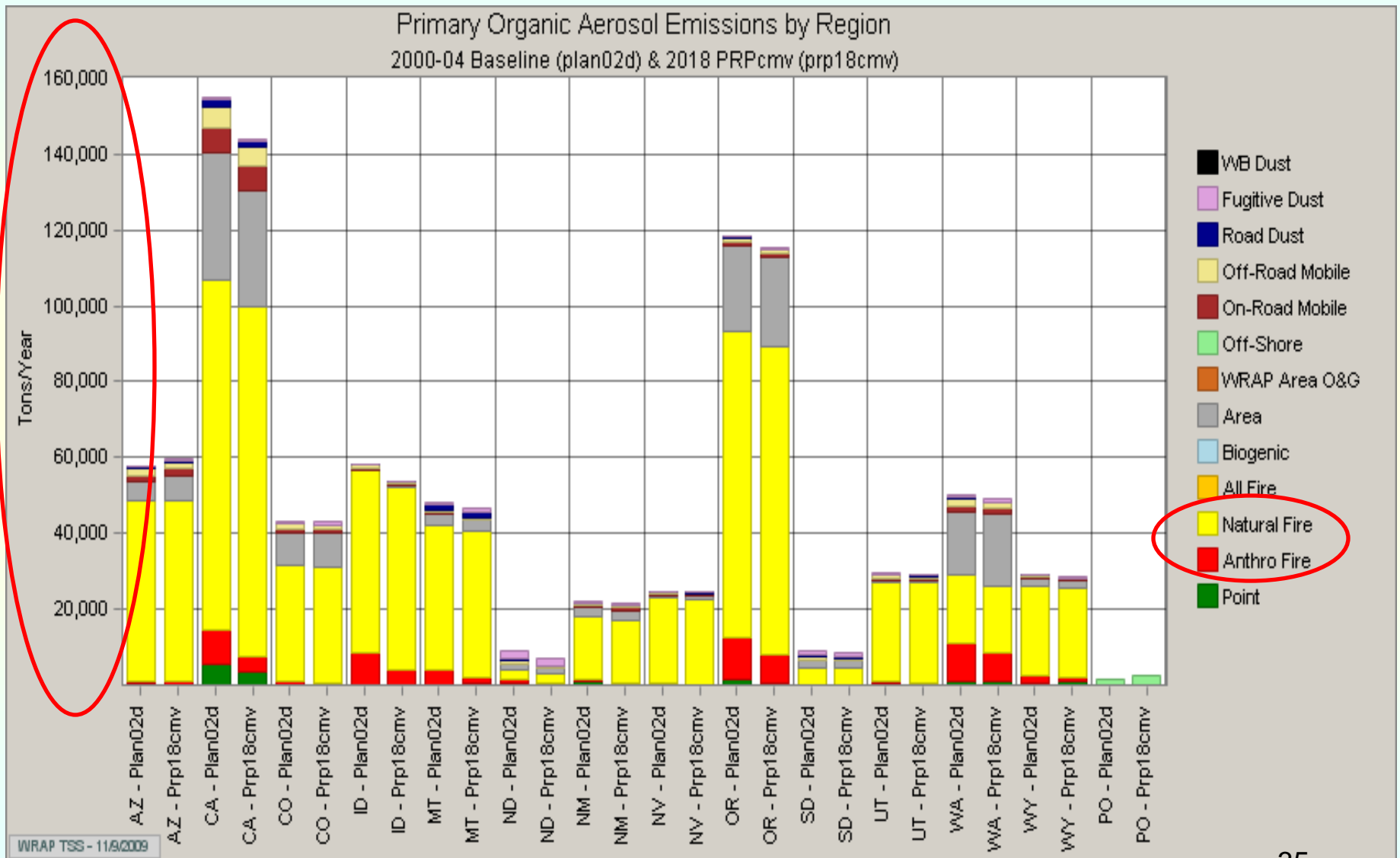


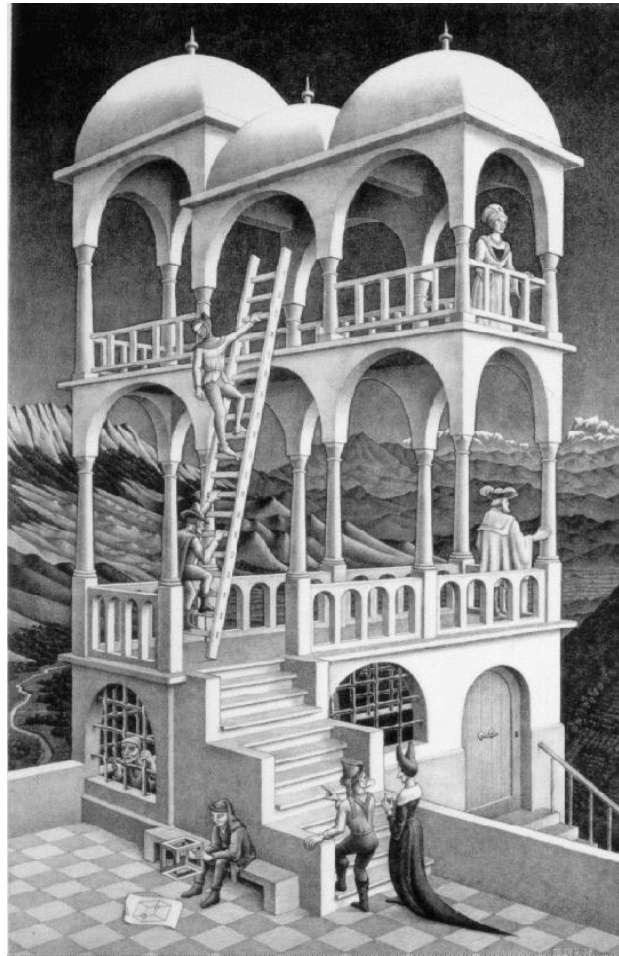
# Western U.S. Emissions

- Down ↓
  - Power plants & other industrial point sources
  - Mobile
  - Prescribed Fire
- Up ↑
  - Pacific Off-Shore Shipping
  - Dairy Farms
    - 1970 (national average of 19 cows/farm)
    - By 2007, the average Western dairy has 550 cows (about 5 times the 2007 national average)
    - About 80 Western dairies now each have at least 5,000 cows
  - Oil & Gas
- 2002 WRAP region emissions inventories used as starting point for many sub-regional studies

# Change in WRAP region Primary Organic PM2.5 Emissions (tpy) 2002 to 2018

*Point sources down 3,181 tons (-30%), Mobile down 5,669 tons (-17%), Rx Fire down 19,945 tons (-17%)*





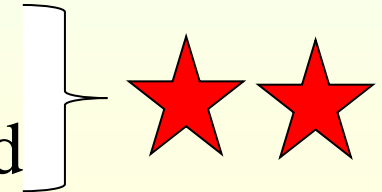
M.C. Escher, "Belvedere"

The ladder starts inside the building on first floor and we're outside the building by the time we ascend to the second.  
*Comparing, processing, or combining data in any number of ways may appear reasonable, but is it?*

What's on the way -

# Key issues from WRAP Santa Fe (11/09) & Denver (03/10) meetings

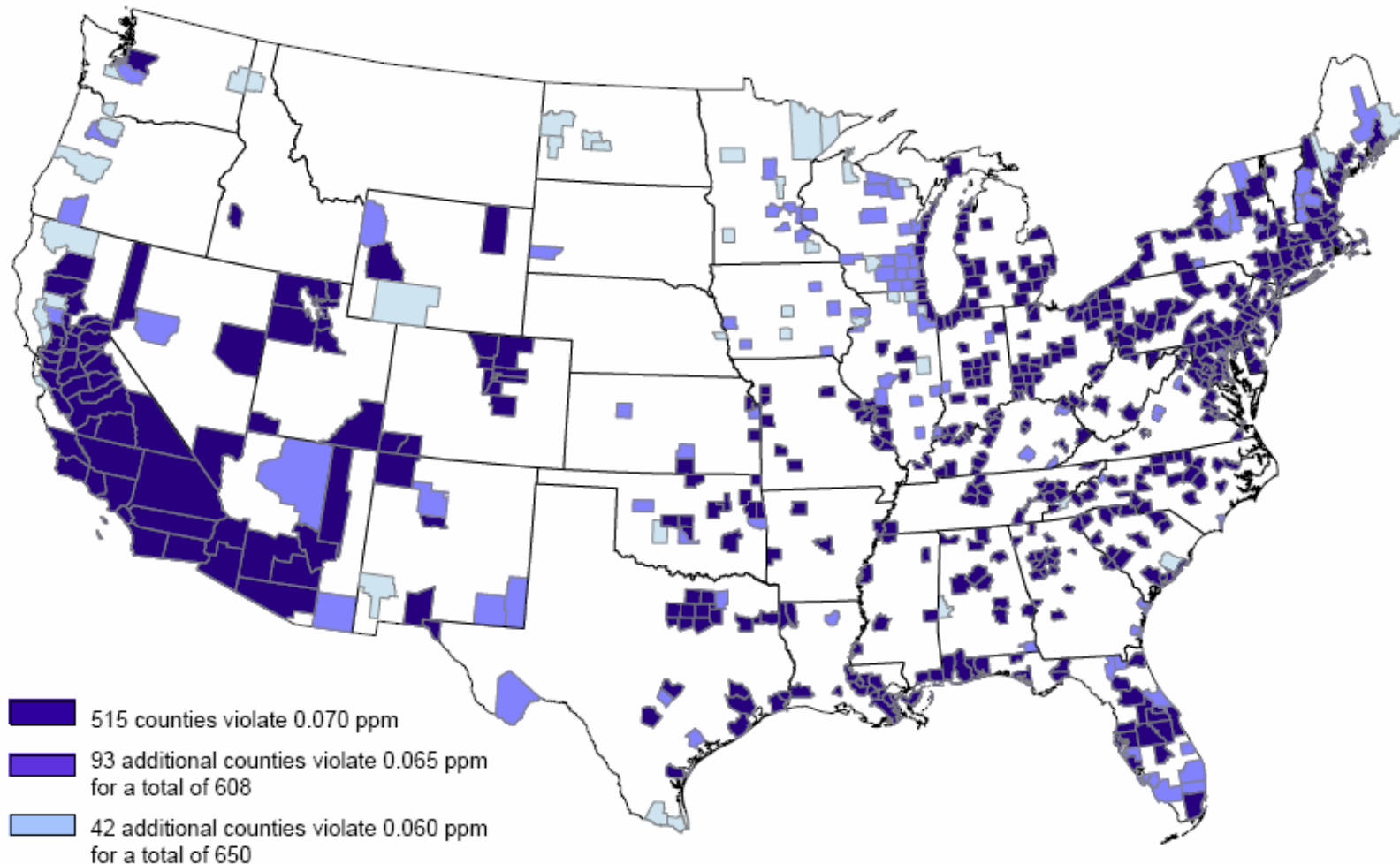
- Multiple EPA standards in review, most likely to change or be added:
  - Ozone health standard level
  - Separate Ozone secondary welfare standard
  - 1-hour NO<sub>2</sub> health added
  - NO<sub>x</sub>/SO<sub>2</sub> combined secondary welfare (deposition)
  - PM<sub>2.5</sub> and PM<sub>10</sub> health
  - Separate PM welfare (light extinction)
  - SO<sub>2</sub> health



# Counties With Monitors Violating Proposed Primary 8-hour Ground-level Ozone Standards 0.060 - 0.070 parts per million

(Based on 2006 – 2008 Air Quality Data)

EPA will not designate areas as nonattainment on these data, but likely on 2008 – 2010 data which are expected to show improved air quality.



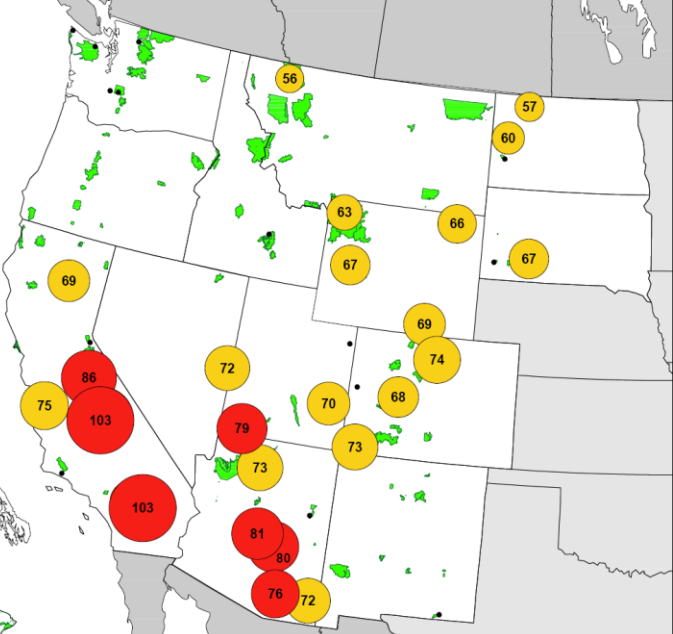
## Notes:

1. No monitored counties outside the continental U.S. violate.
2. EPA is proposing to determine compliance with a revised primary ozone standard by rounding the 3-year average to three decimal places.

# Class I area & rural Ozone monitoring data

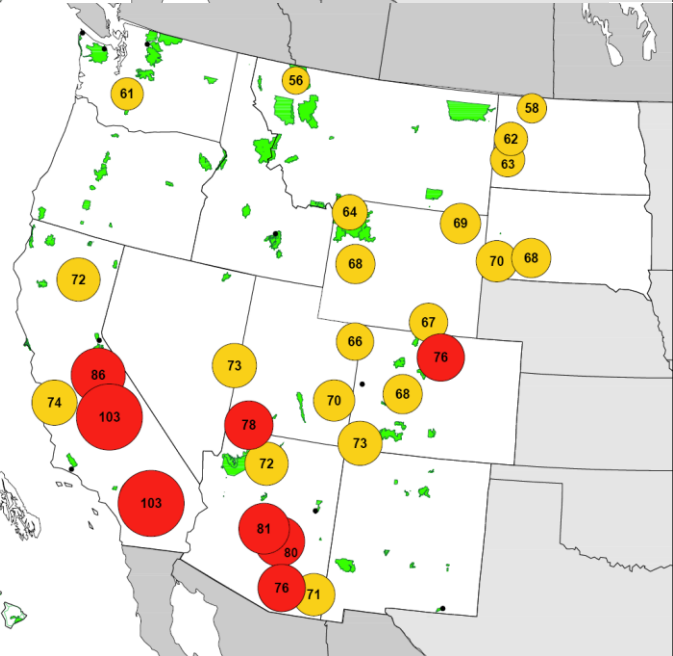
3-Year Average of 4th highest 8-hour Ozone (ppb) 2004-2006

- > 75 ppb
- ≤ 75 ppb
- Incomplete Data



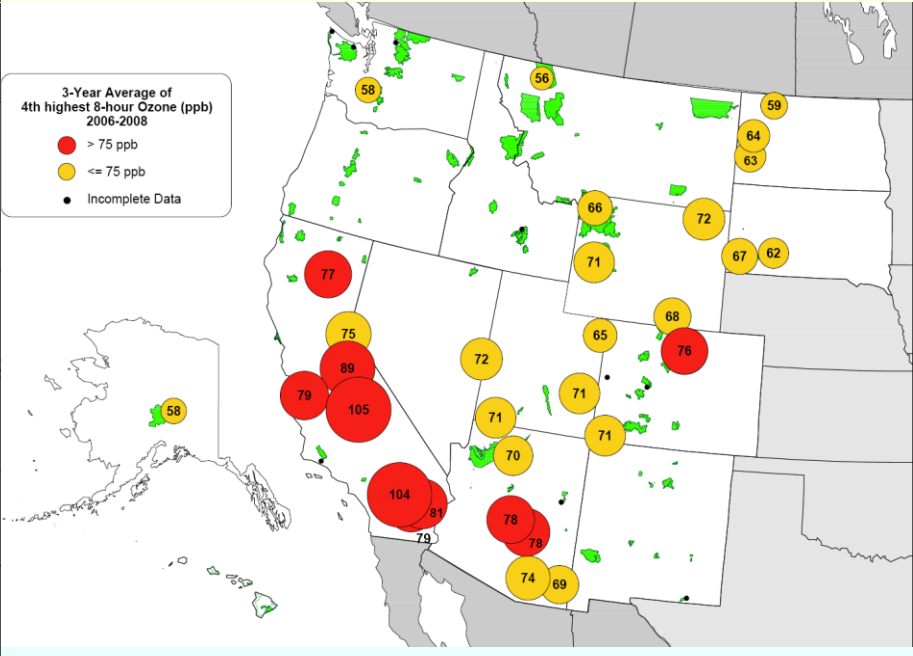
3-Year Average of 4th highest 8-hour Ozone (ppb) 2005-2007

- > 75 ppb
- ≤ 75 ppb
- Incomplete Data



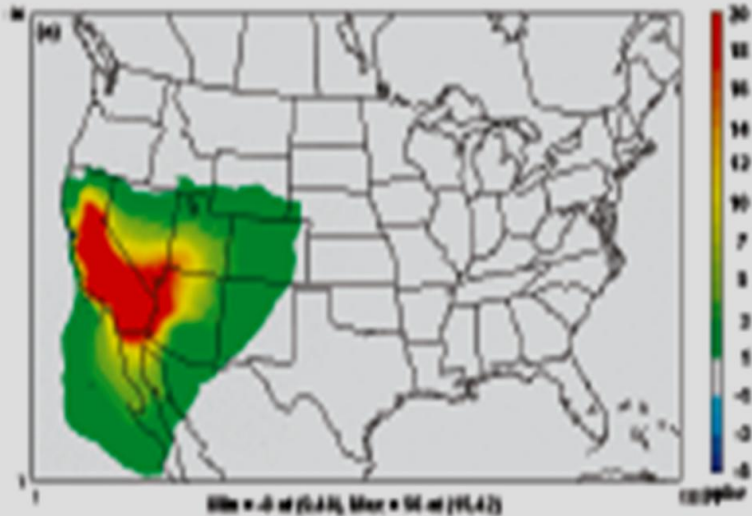
3-Year Average of 4th highest 8-hour Ozone (ppb) 2006-2008

- > 75 ppb
- ≤ 75 ppb
- Incomplete Data





# California Ozone Transport - Source Apportionment Study Results



Ozone Source Apportionment Monthly Mean Results (WRAP region states highlighted) Tong, D. Q. and Mauzerall, D. L. Summertime State-Level Source-Receptor Relationships between Nitrogen Oxides Emissions and Surface Ozone Concentrations over the Continental United States.

*Environmental Science & Technology, Volume 42, Number 21, 2008.*

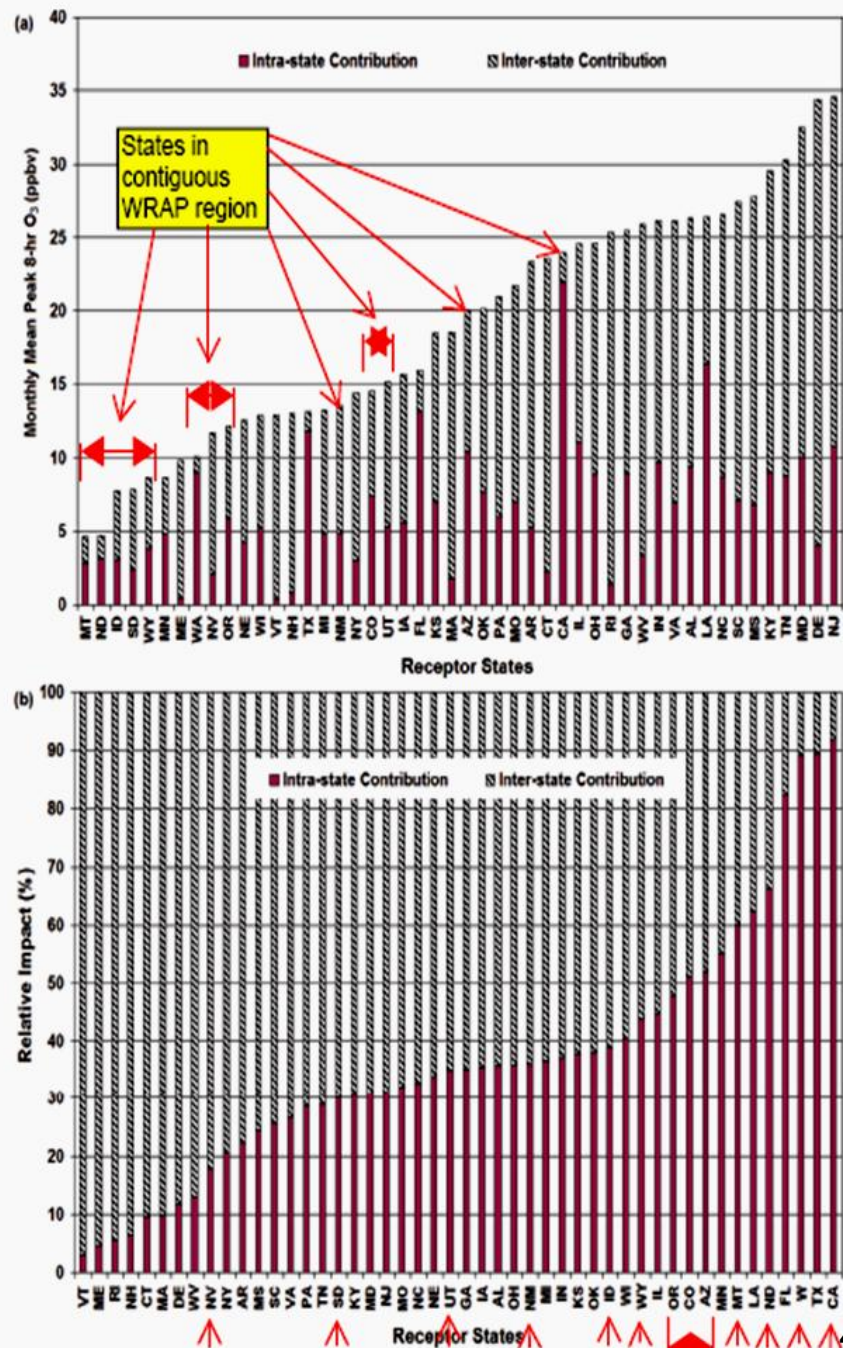
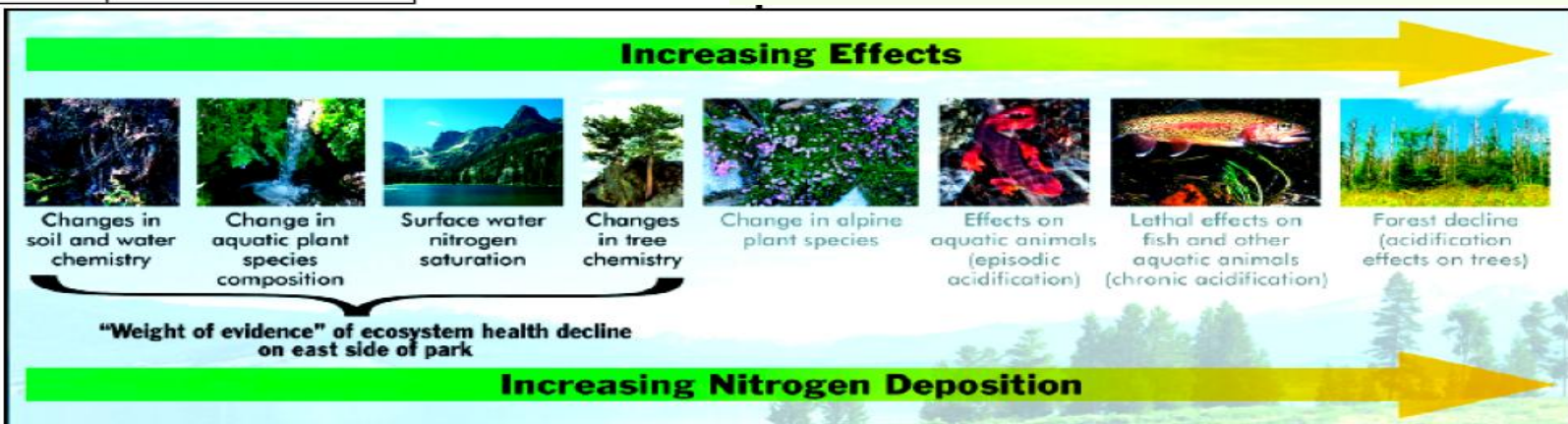
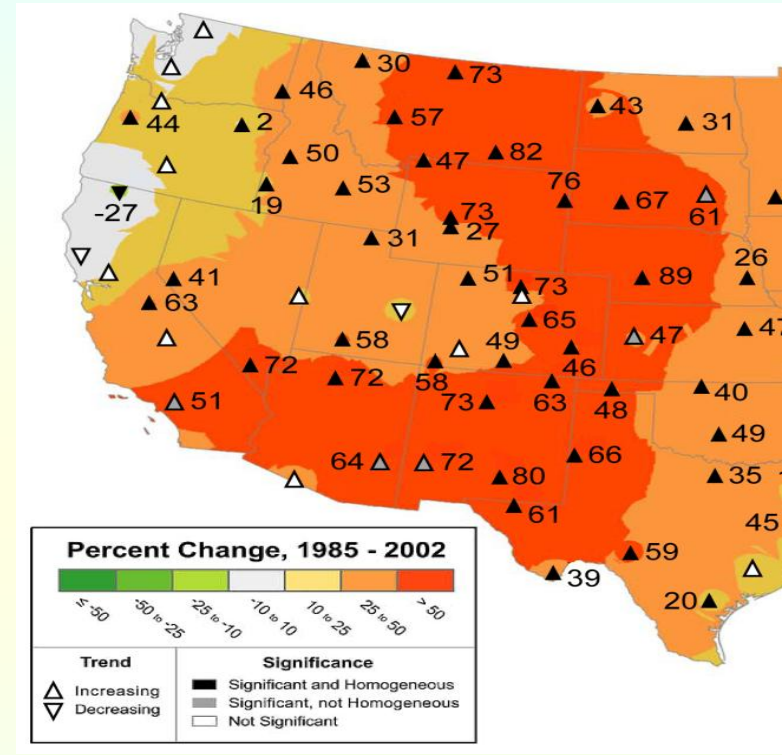
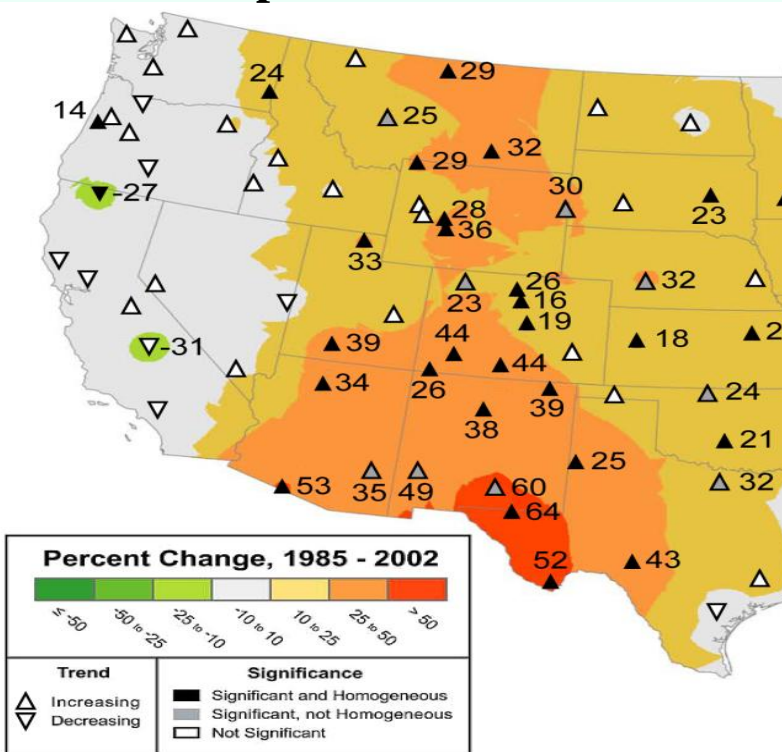


FIGURE 4. Contributions from intrastate and interstate NO<sub>x</sub> emissions to monthly mean peak 8 h surface O<sub>3</sub> concentrations in (a) ppbv; (b) percent.

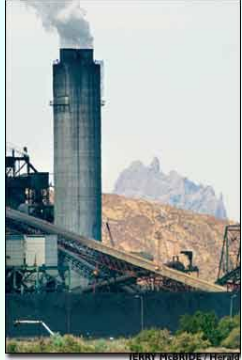
# Regional precipitation N trends

## Wet nitrate concentration deposition trends

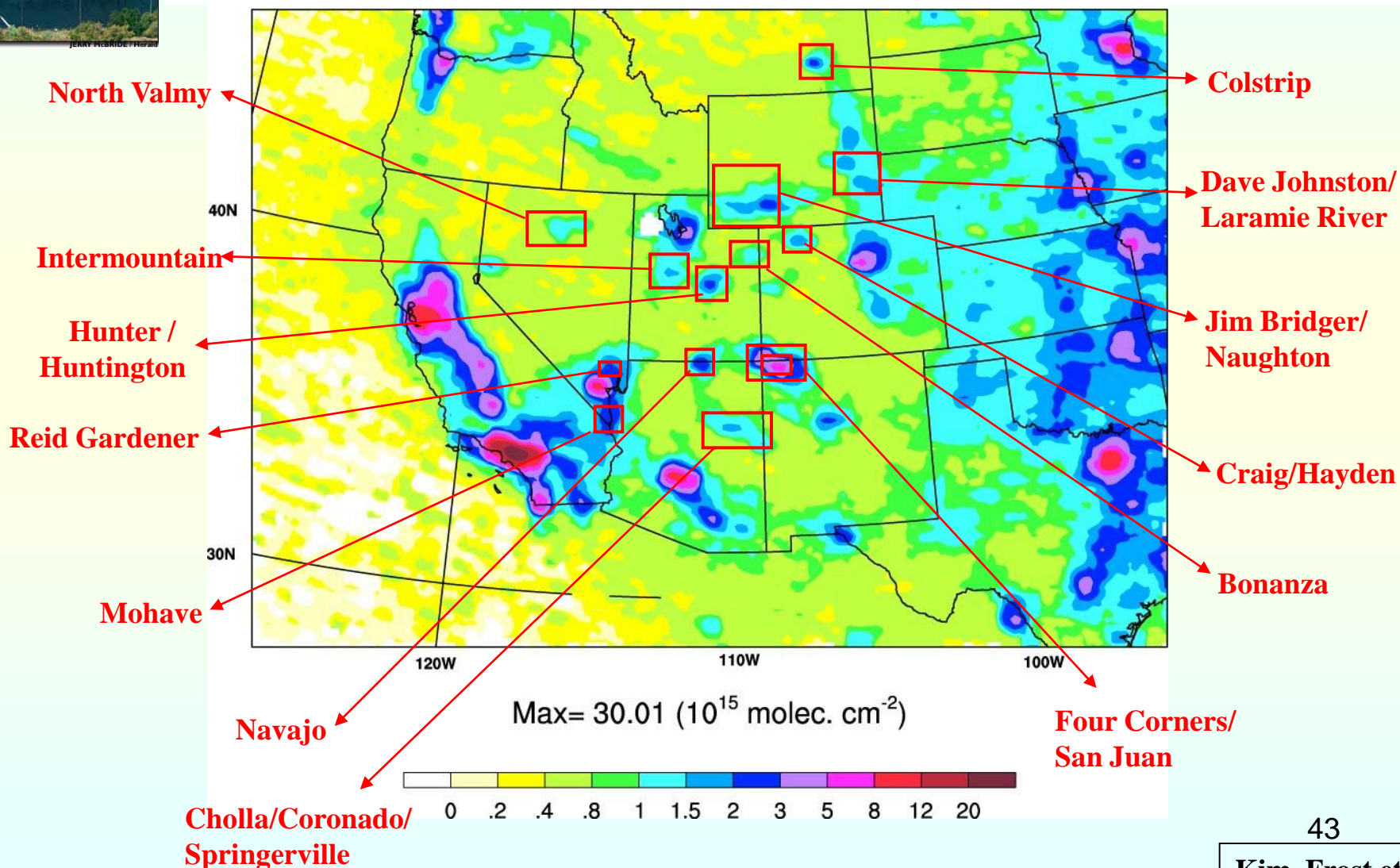
## Wet ammonium concentration deposition trends



# NO<sub>x</sub> Emissions from Western US Power Plants



- *Isolated plants have discrete signatures in satellite retrievals*
  - *Power plant emissions are measured continuously at each stack*
  - *Currently no post-combustion NO<sub>x</sub> controls on large coal-burning plants (some proposed)*
- *“Calibration” for satellite-model comparison*



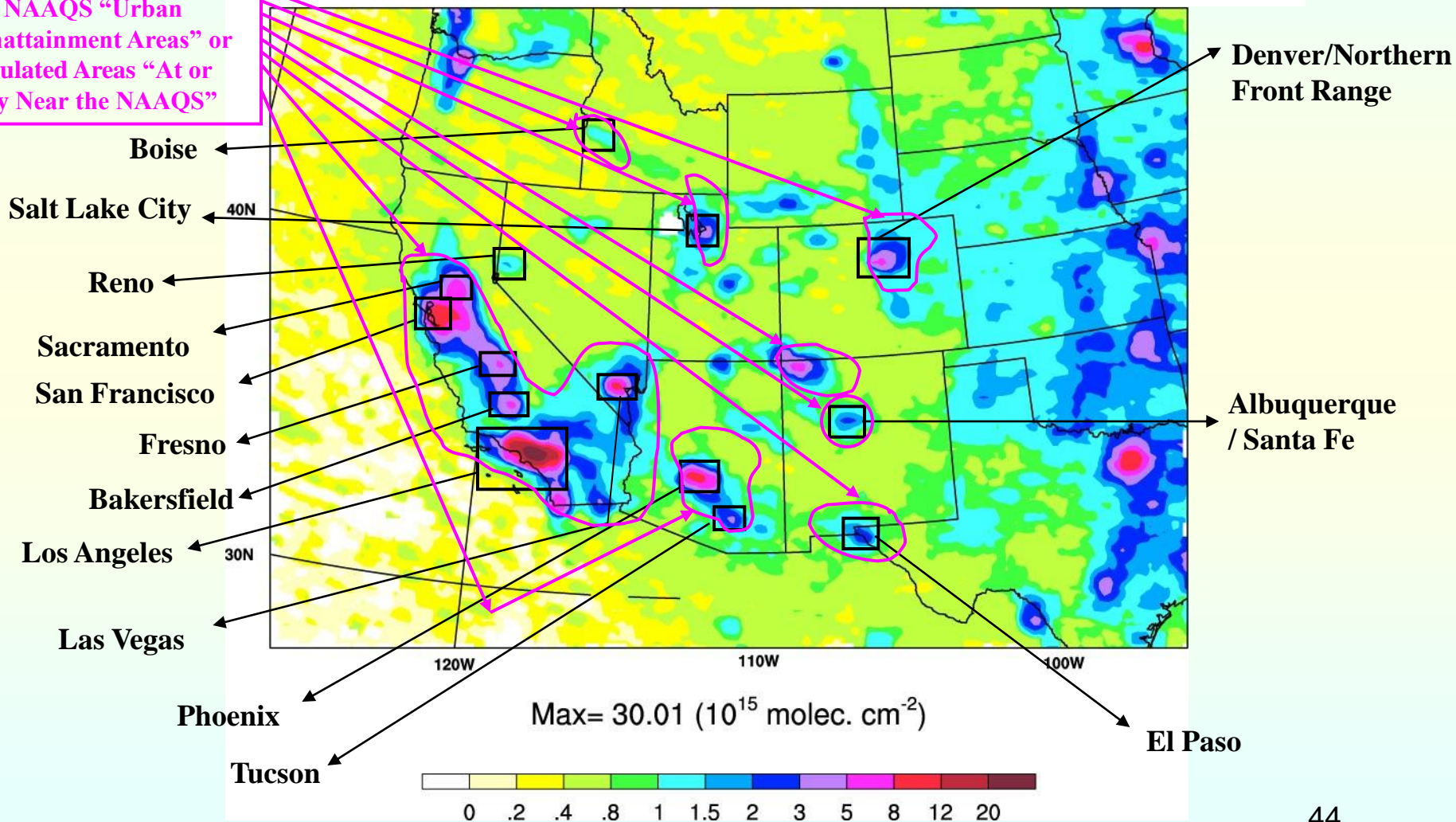


# NO<sub>x</sub> Emissions from Western US Urban Areas + O<sub>3</sub>/PM Urban and/or High Ambient Concentration Areas

*Build on satellite-model comparisons for power plants*

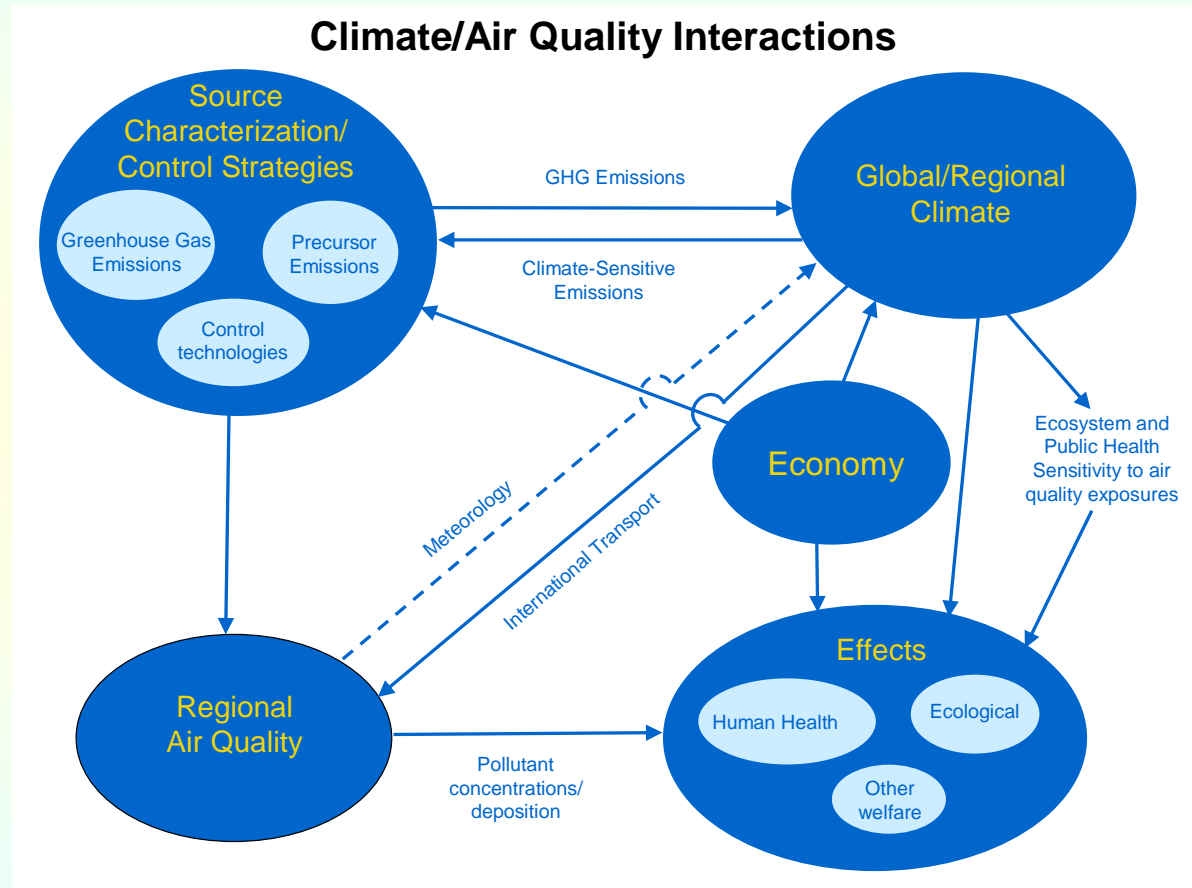
➤ *Evaluate urban area emission inventories and monitor changes*

Example Ozone and/or PM NAAQS "Urban Nonattainment Areas" or Populated Areas "At or Very Near the NAAQS"



# Climate Change and Air Quality

- Links between climate and air quality from emissions sources, atmospheric chemistry, mitigation strategies, and health and environmental outcomes
- From a policy perspective, essential to consider how actions in either arena will affect the other, and whether there are integrated, efficient strategies that can achieve climate and air quality goals simultaneously



**What is needed – a partial list**

# Research needs: Climate Change and Air Quality

- How does climate impact air quality?
- How does air pollution impact regional and global climate?
- What are the optimal strategies to adapt air quality management systems to changes in climate? For example:
  - Which air pollution control scenarios are worth pursuing in a changing climate regardless of the uncertainties associated with various future scenarios?
  - What additional air pollution mitigation efforts may be necessary as people alter behavior in response to future climate conditions?
  - What are the opportunities to devise and implement strategies that reduce air pollutants and climate pollutants simultaneously and cost-effectively (e.g., methane and black carbon)?

# Regional technical Analyses for new/revised NAAQS

Western air quality agencies will need to address:

- Effects of new/revised NAAQS(s)
  - Nonattainment findings for one or more NAAQS, and the required AQ planning will be closely spaced in time (*the historical and current California experience?!)*
  - More stringent NAAQS suggest greater regional contribution
  - Likely to be many new Western nonattainment areas, a significant number of which will be Class I areas and large rural counties/CMSAs
    - **More frequent and numerous air quality events thought to be “exceptional”**



# Regional technical Analyses for new/revised NAAQS

Western air quality agencies will need to address:

- Analyses for CAA Planning requirements
  - Timing of planning/control strategy development for multiple standards
  - Defining the various time/space/emissions scales of the impacts to the standards and contributing sources  
*(opportunity for multi-pollutant and multi-jurisdictional analysis and planning!)*
    - **Sources and regions will combine in many different regional transport contributions**
  - Needs for local, sub-regional, and West-wide technical support

# Smoke Management Needs for Air Quality Regulations

- Develop an unambiguous routine and cost effective methodology for apportioning primary and secondary carbonaceous compounds in PM<sub>2.5</sub> retrospectively to prescribed, wildfire, agricultural fire, and residential wood burning activities
  - Daily contributions needed for Haze Rule to properly estimate natural contribution and contribution to worst 20% haze days
  - Annual and daily contributions needed for PM<sub>2.5</sub> and PM<sub>10</sub> NAAQS
  - Long term data and contribution analyses needed to assess successes of smoke management policies
- Similar needs for ozone and reactive nitrogen deposition issues

# Ideal Biomass Burning Emission Inventory

- Spatial Scale – 3d inventory
  - North American coverage at 36 km or less
  - \* Plumes vertically resolved (plume rise)
- Temporal scale
  - Sub-daily duration for all seasons
  - A new inventory every year
- Species
  - Speciated PM<sub>2.5</sub> and PM Coarse
    - e.g. OC, EC, S species, N species
  - VOCs
    - \* Combustion by-products
    - \* Enhanced biogenic VOC emissions
- Activity tracked by fire type, e.g. wild, prescribed, agricultural, residential - a pressing and near-term tangible issue

**\* research activity**

**Thanks –**

**Tom Moore  
970.491.8837**

**[mooret@cira.colostate.edu](mailto:mooret@cira.colostate.edu)**





**FETS Data Status table on the Map page** – provides details on who, what, when, and where for all fires submitted to the FETS. The last column provides details on the quality and expected frequency of data submittals.

### Incoming Data Status

Source	WF	WFU	RX	AG	NFR	Last Submit	Domain	Disclaimers / Comments
ICS-209	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	-	-	-	10/21/09	WRAP CONUS	Latest data available are from yesterday. Updated at 02:00 every morning.
AK	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	N.D.	N.D.	10/20/09	State/Federal > 40 ac	Data are submitted manually by the agency, with a 1-3 day lag.
AZ	-	-	<input checked="" type="checkbox"/>	N.D.	N.D.	02/21/09	State-Wide	Data are submitted manually by the agency and are currently sporadic.
CA - PFIRS	-	-	N.D.	N.D.	N.D.	No Data	State-Wide	
CO	-	-	<input checked="" type="checkbox"/>	N.D.	N.D.	09/02/09	State-Wide	Data are submitted manually by the agency and are currently limited to accomplished burns. Prescribed fires only.

# Fire Emissions Tracking System (October 23-28, 2008)

