



Emission Sources, Observations/Trends/Management, Modeled Deposition Results, & Future WRAP Activities

USFS Air Resource Program - Western Lakes Monitoring
Workshop

March 3, 2010

Stevenson, WA

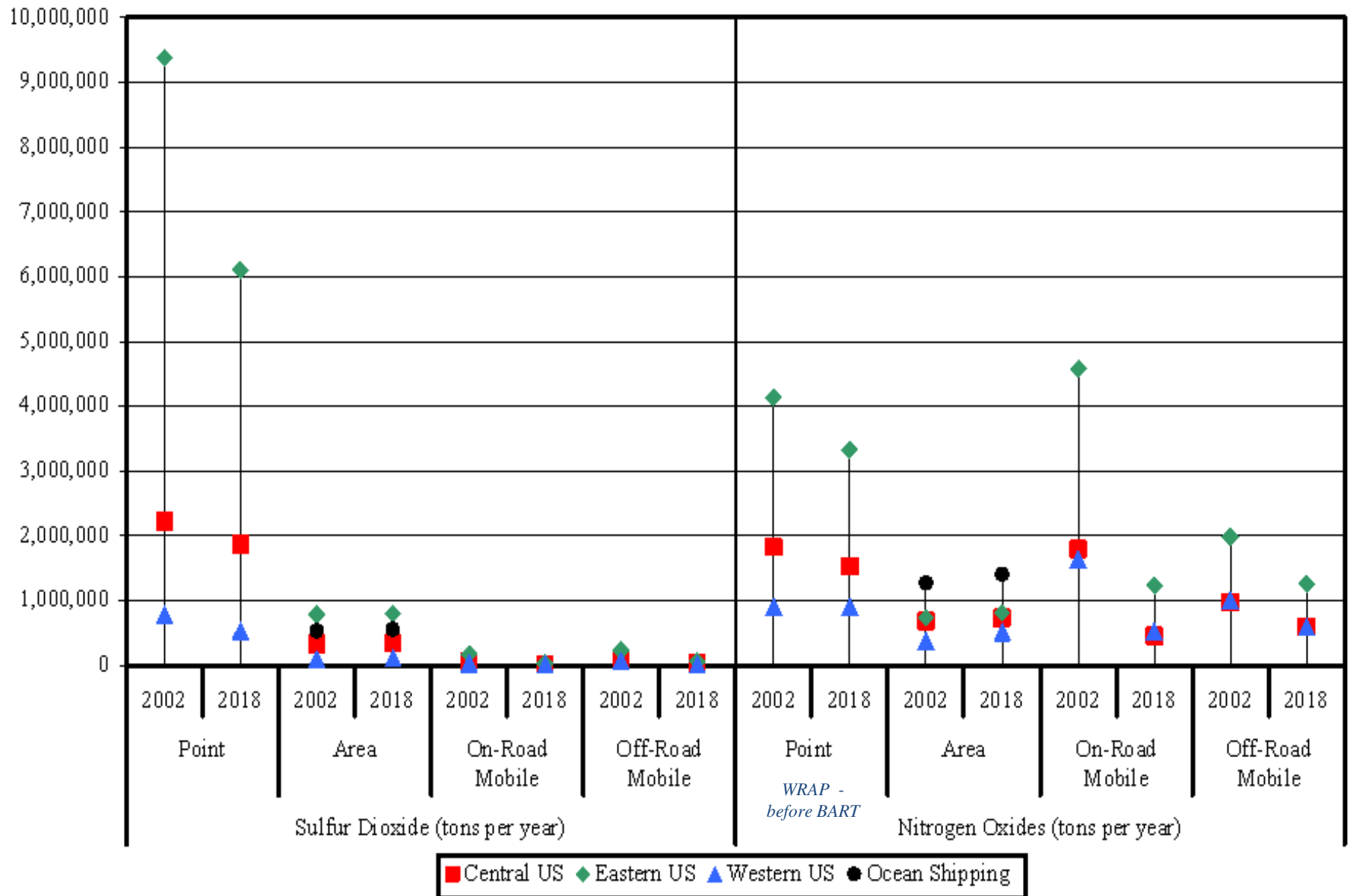
Tom Moore

Western Governors' Association – Air Quality Program
Manager & WRAP Coordinator

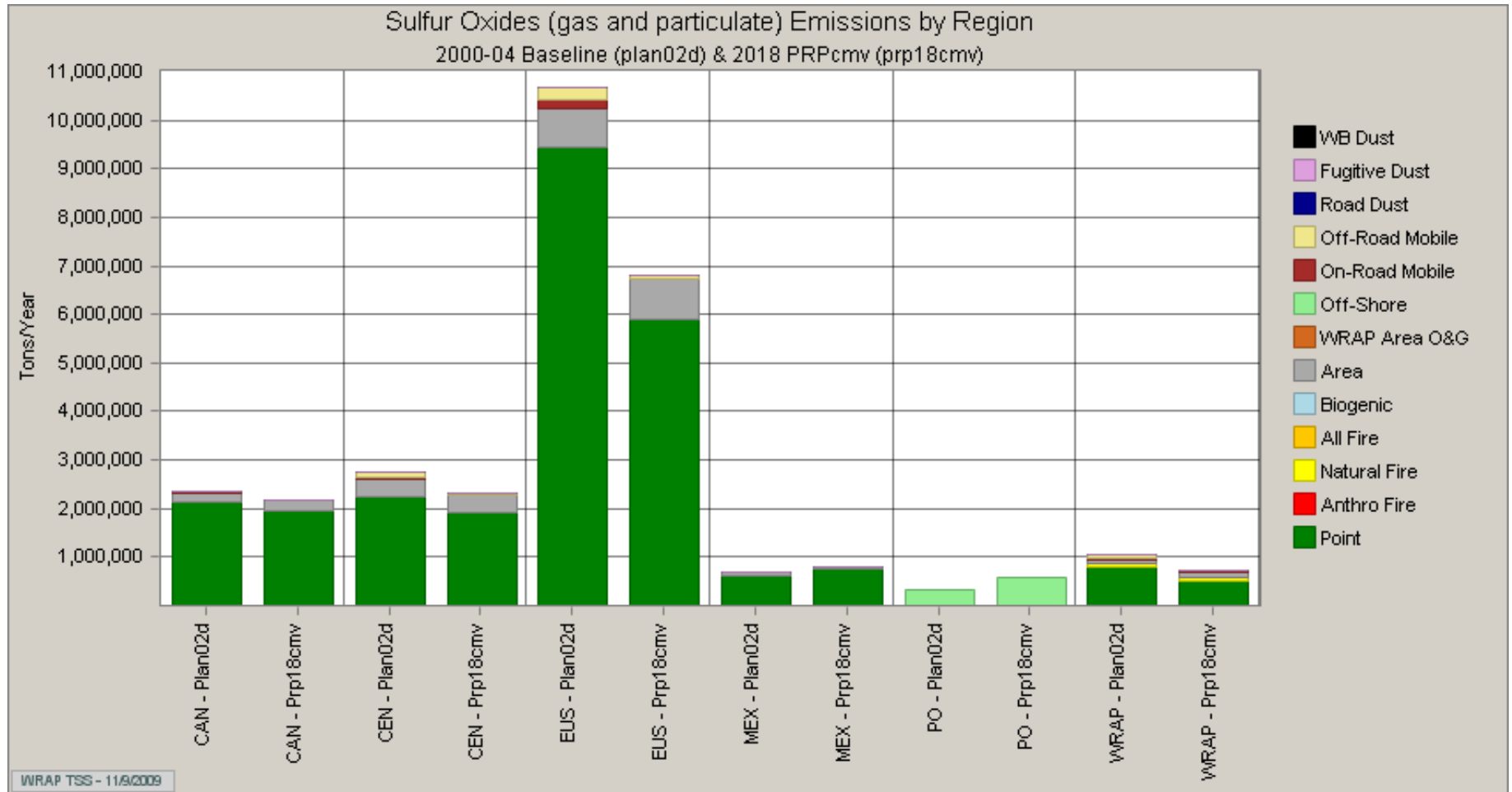
**Big Picture - North American Emissions Inventory Regions:
WRAP, CENRAP, Eastern US, Canada, Mexico, and Pacific
Off-Shore Shipping (base year 2002, projection year 2018)**



U.S. Regional Emissions Changes 2002-18

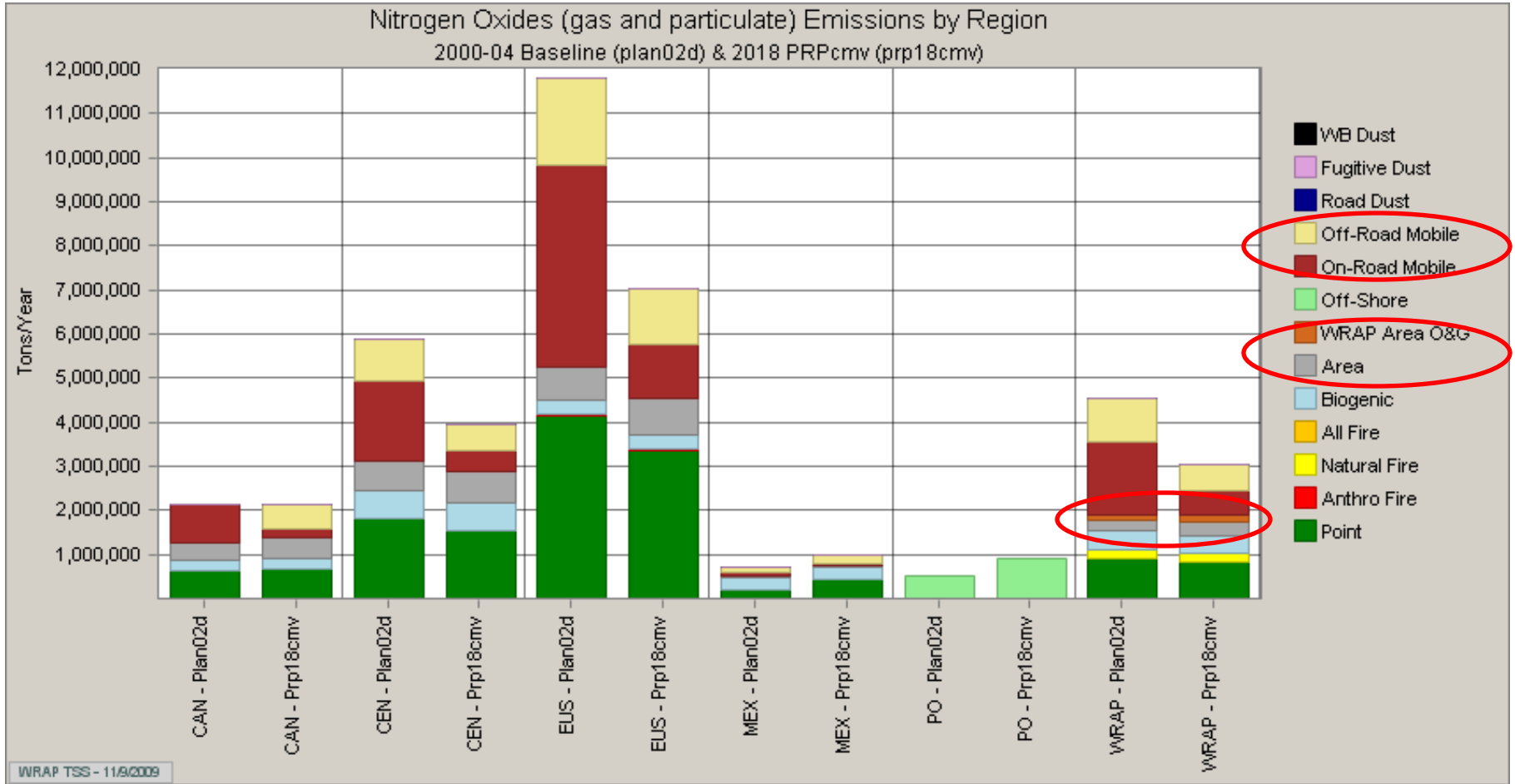


Change in SO2 Emissions (tpy) 2002 to 2018 across North America



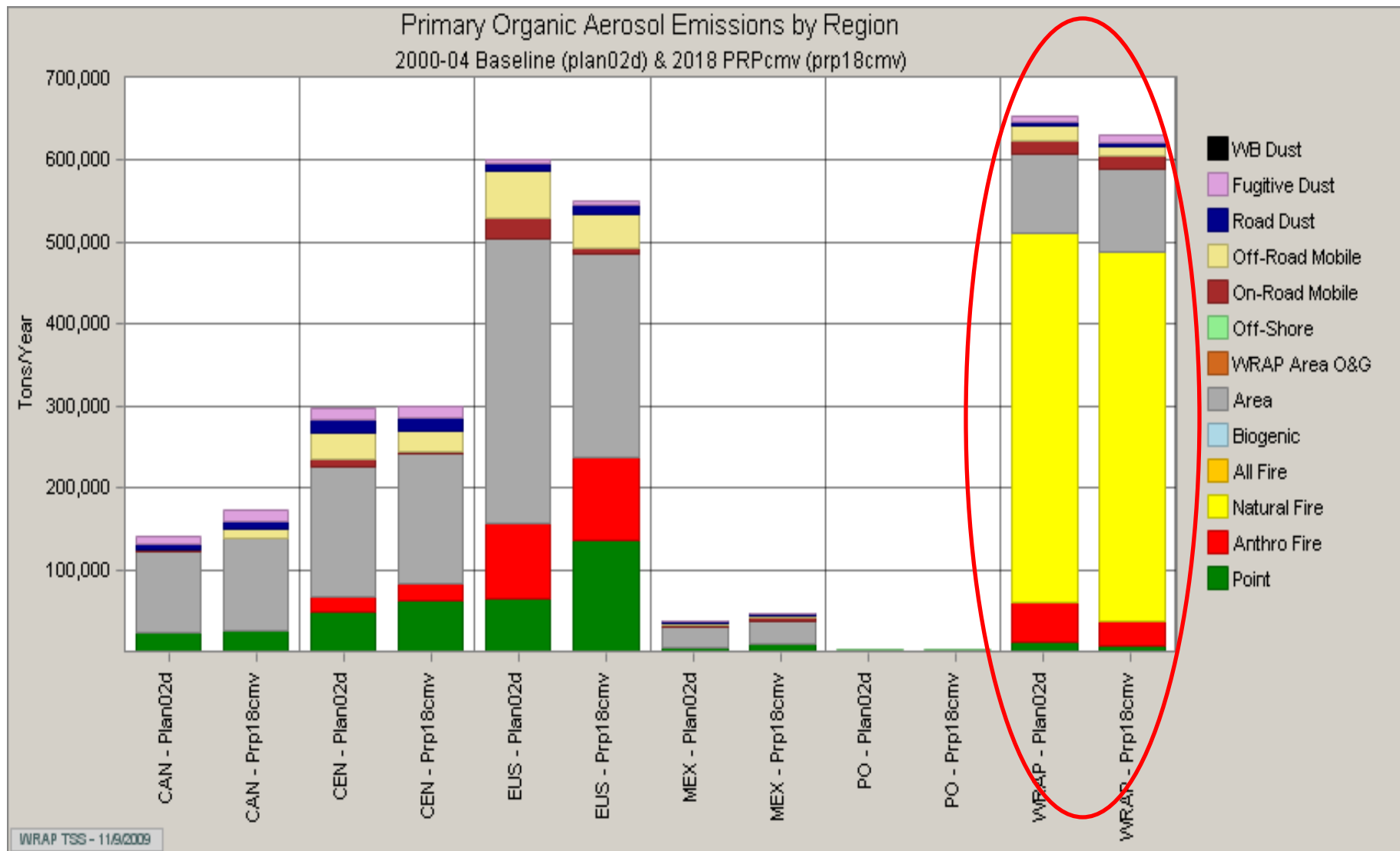
All SO ₂ Sources 2002 to 2018	Canada	CENRAP	Eastern US	Mexico	Pacific Off-Shore	WRAP
Tons/year	-159,003	-445,526	-3,856,861	+99,105	+273,413	-341,348
%	-7%	-16%	-36%	+14%	+88%	-32%

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



All NO _x 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%

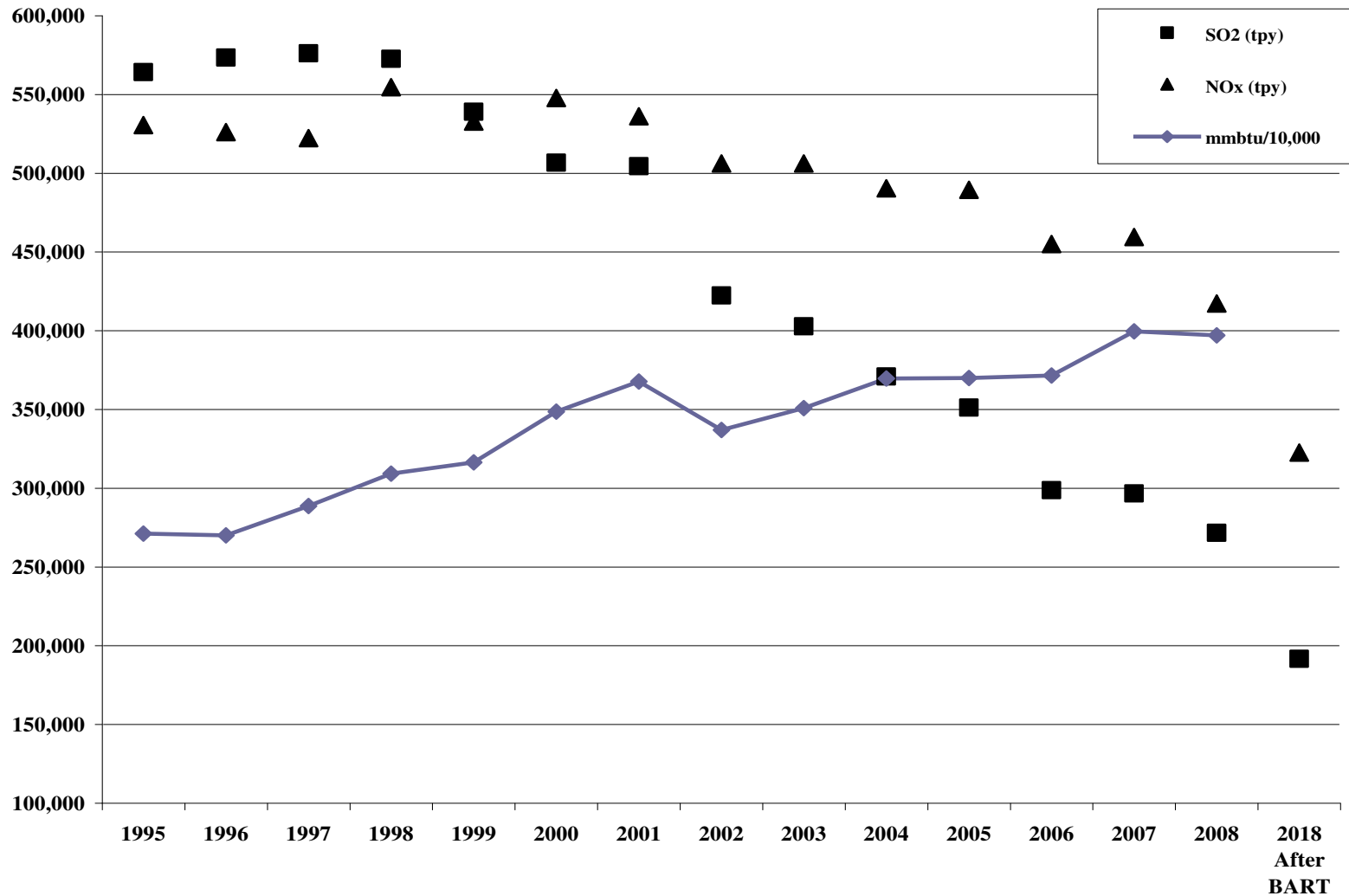
Change in Primary Organic PM2.5 Emissions (tpy) 2002 to 2018 across North America



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

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



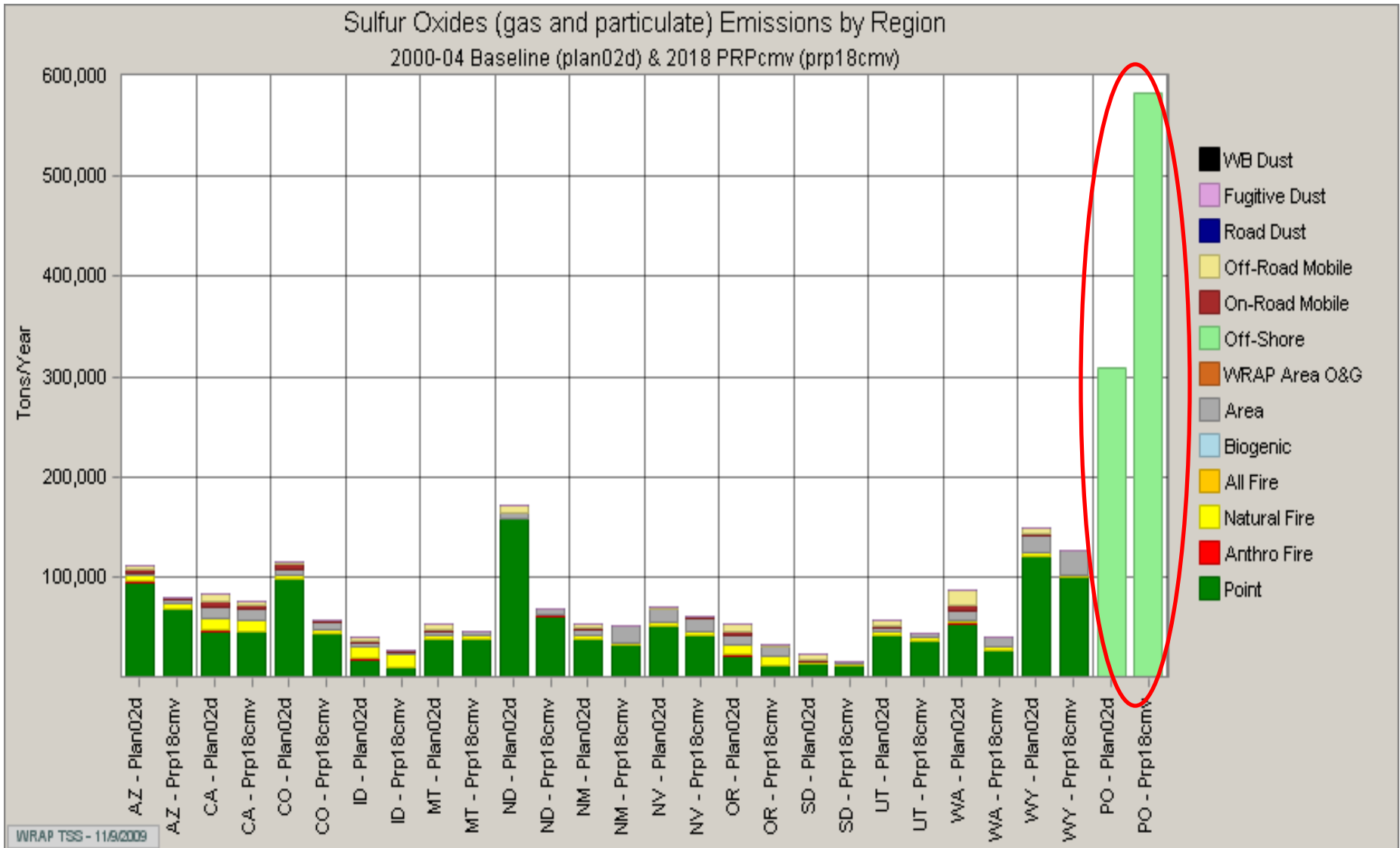
* Currently operating coal, gas, and fuel oil-fired plants in the 11-state Western Interconnection

** Estimates for BART controls are from WRAP PRP18b emissions analysis at:

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

Change in WRAP region SO2 Emissions (tpy) 2002 to 2018

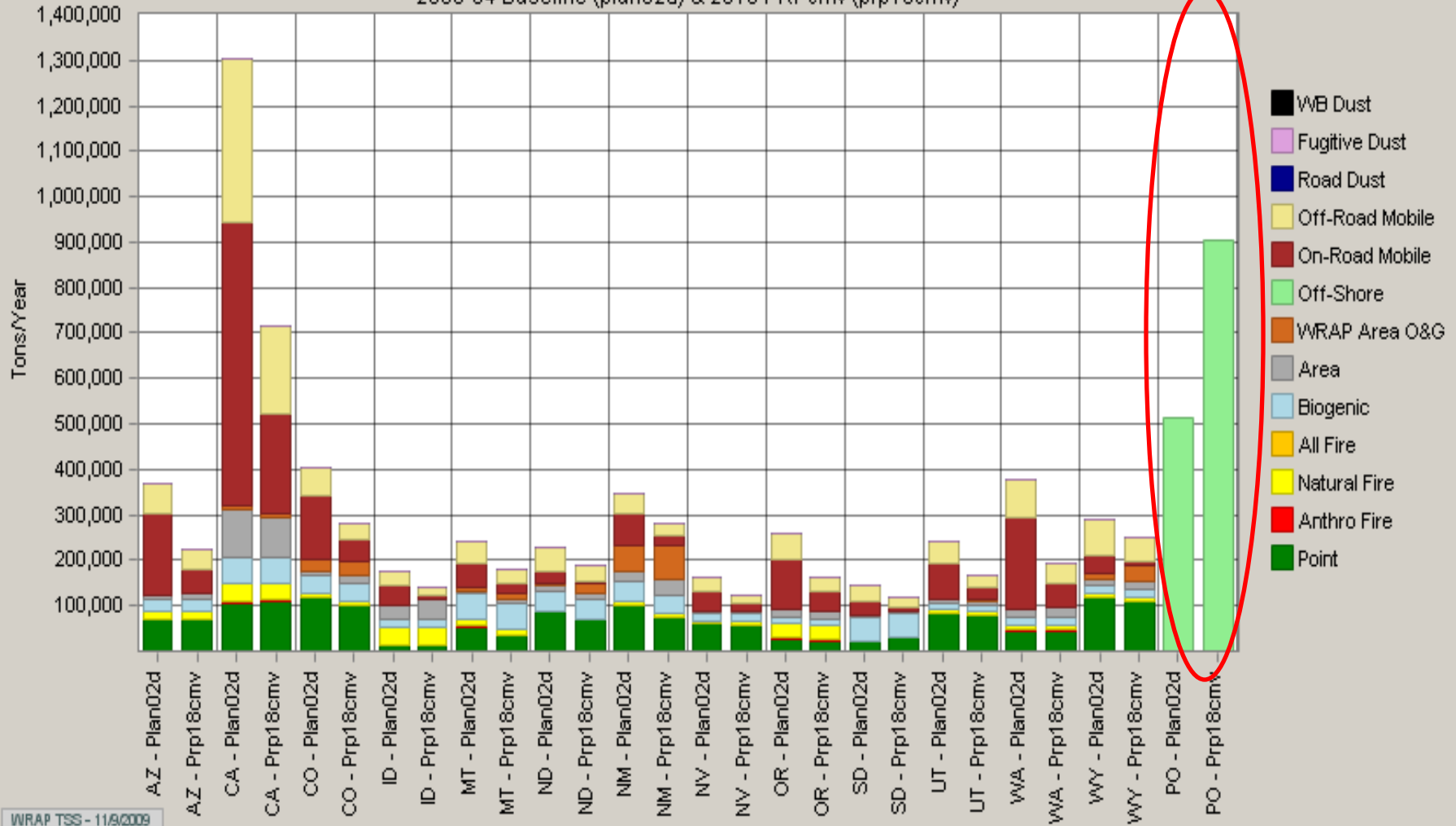
Point sources down 269,675 tons (-34%), Mobile down 91,147 tons (-83%)



Change in WRAP region NOx Emissions (tpy) 2002 to 2018

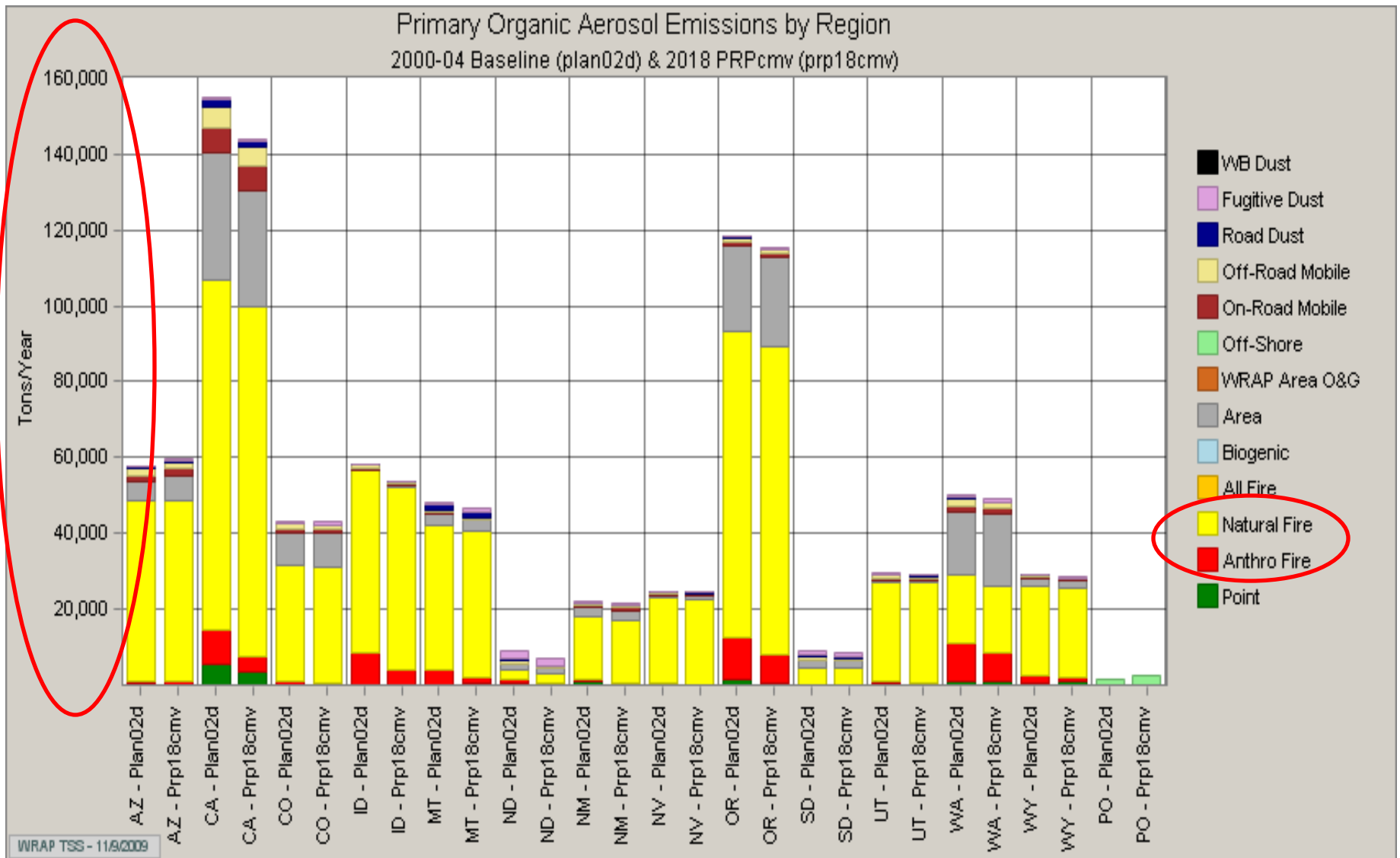
Point sources down 87,157 tons (-10%), Mobile down 1,524,975 tons (-58%)

Nitrogen Oxides (gas and particulate) Emissions by Region
2000-04 Baseline (plan02d) & 2018 PRPcmv (prp18cmv)



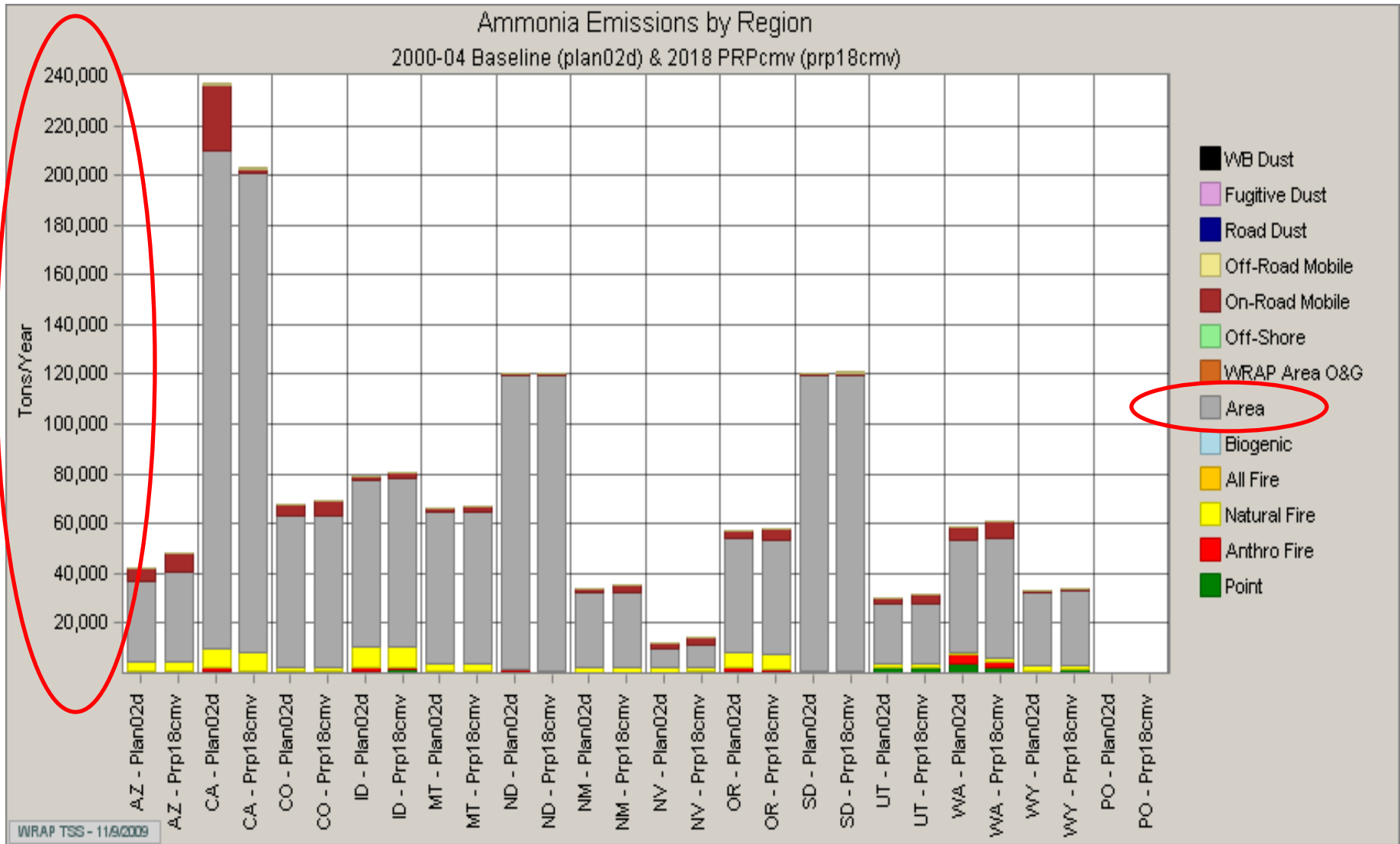
Change in WRAP region Primary Organic PM2.5 Emissions (tpy) 2002 to 2018

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



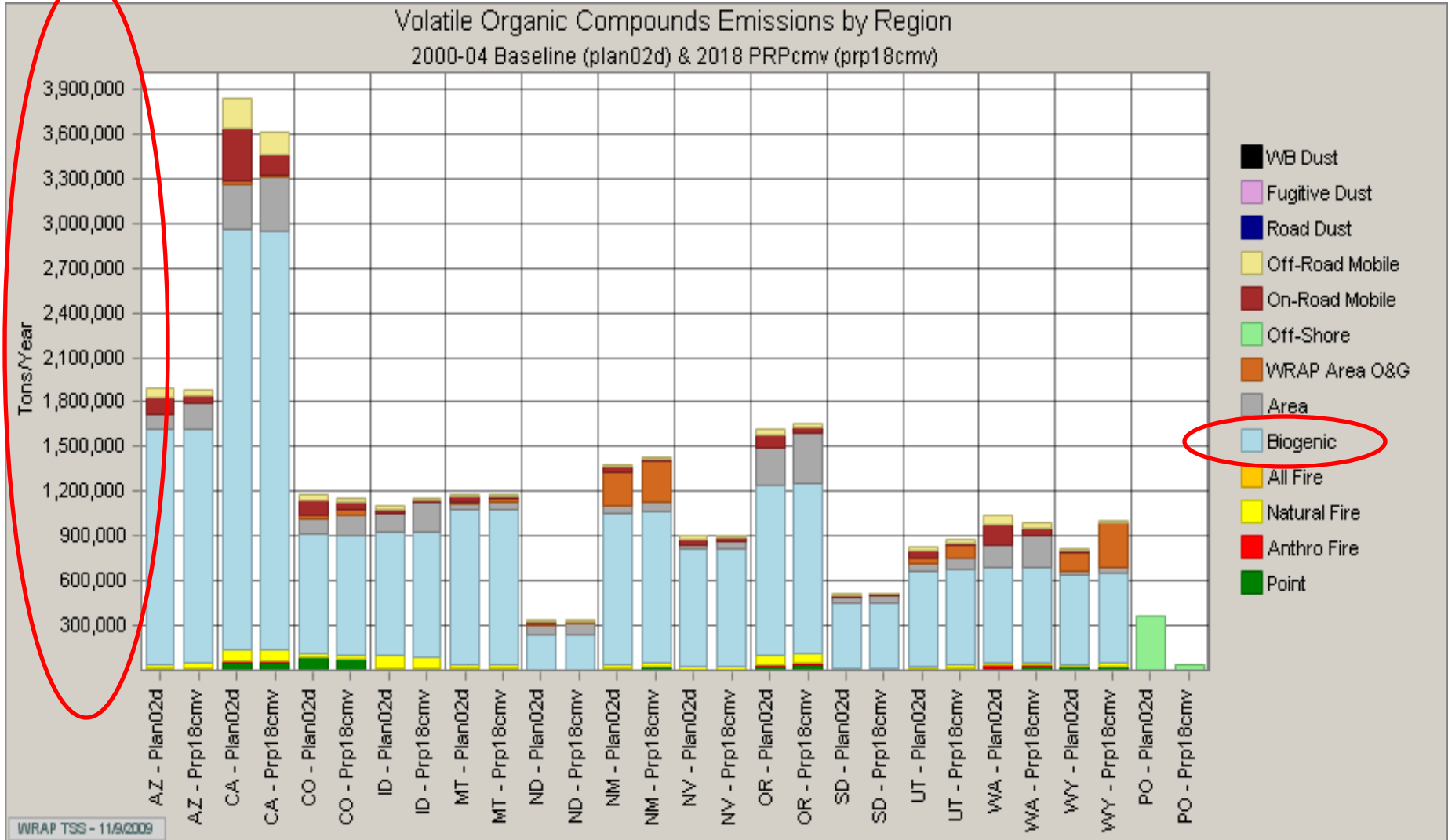
Change in WRAP region Ammonia Emissions (tpy) 2002 to 2018

Mobile down 12,098 tons (-21%), Rx Fire down 3,943 tons (-43%)



Change in WRAP region Gaseous Volatile Organic Compound Emissions

(tpy) 2002 to 2018 - Mobile down 785,779 tons (-50%), Point up 40,176 tons (+15%), Area up 499,144 tons (+38%), WRAP O&G Area up 310,648 tons (+71%)



Questions & more work needed on methane, speciation, spatial/temporal/source type allocation

Rocky Mountain U.S. Oil & Gas Phase III Emissions Inventory Results To Date (2006 Baseline Emissions)

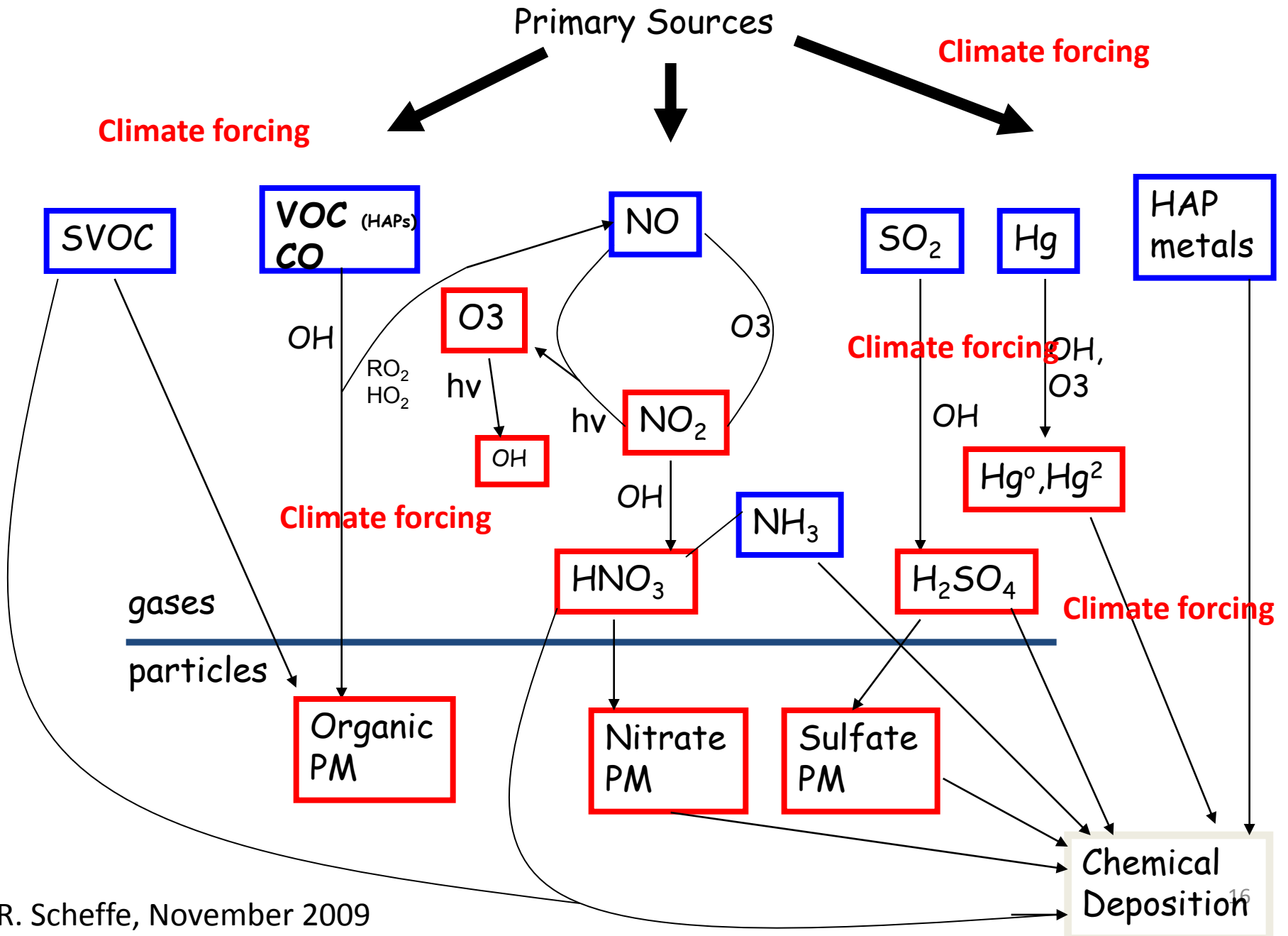
Work products at: http://www.wrapair.org/forums/ogwg/PhaseIII_Inventory.html

Basin	Well Count			Oil Production (bbl)			Gas Production (MCF)			Spud Counts
	total	CONV	CBM	Total	Oil Well Oil	Gas Well Condensate	Total	CONV	CBM	Total
Denver-Julesburg	19,841	19,841	0	14,242,088	0	14,242,088	234,630,779	234,630,779	0	1500
Uinta	6,881	6,018	863	11,528,121	9,758,247	1,769,874	331,844,336	254,219,432	77,624,904	1069
Piceance	6,315	6,255	60	7,158,305	5,755,076	1,403,229	421,358,666	420,165,237	1,193,429	1186
North San Juan	2,676	1,009	1,667	32,529	27,962	4,567	443,828,500	28,642,418	415,186,082	127
South San Juan	20,649	16,486	4,163	2,636,811	1,002,060	1,634,751	1,020,014,851	520,060,869	499,953,982	919

Basin	Emissions (tons/year)				
	NOx	VOC	CO	SOx	PM
Denver-Julesberg	20,783	81,758	12,941	226	636
Uinta	13,093	71,546	8,727	396	623
Piceance	12,390	27,464	7,921	314	992
North San Juan	835	69	321	1	10
South San Juan	42,075	60,697	23,471	305	574

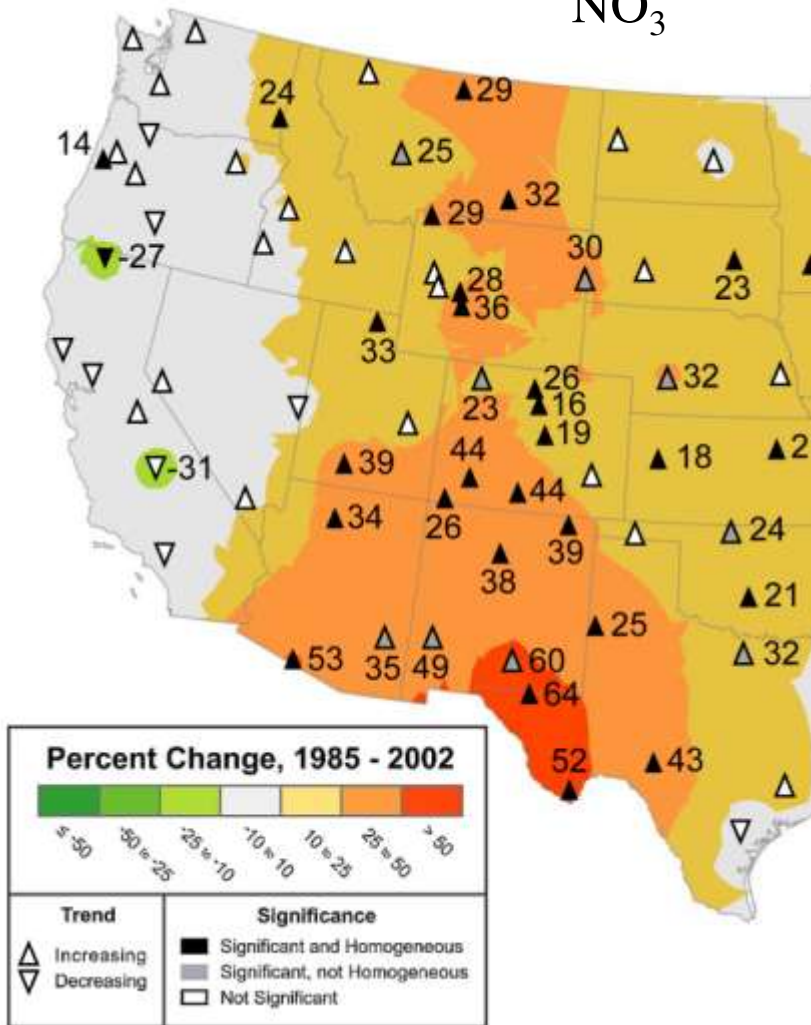
Observations, Trends, & Management

Integration across pollutants, climate and media: tradeoffs and optimum strategies?

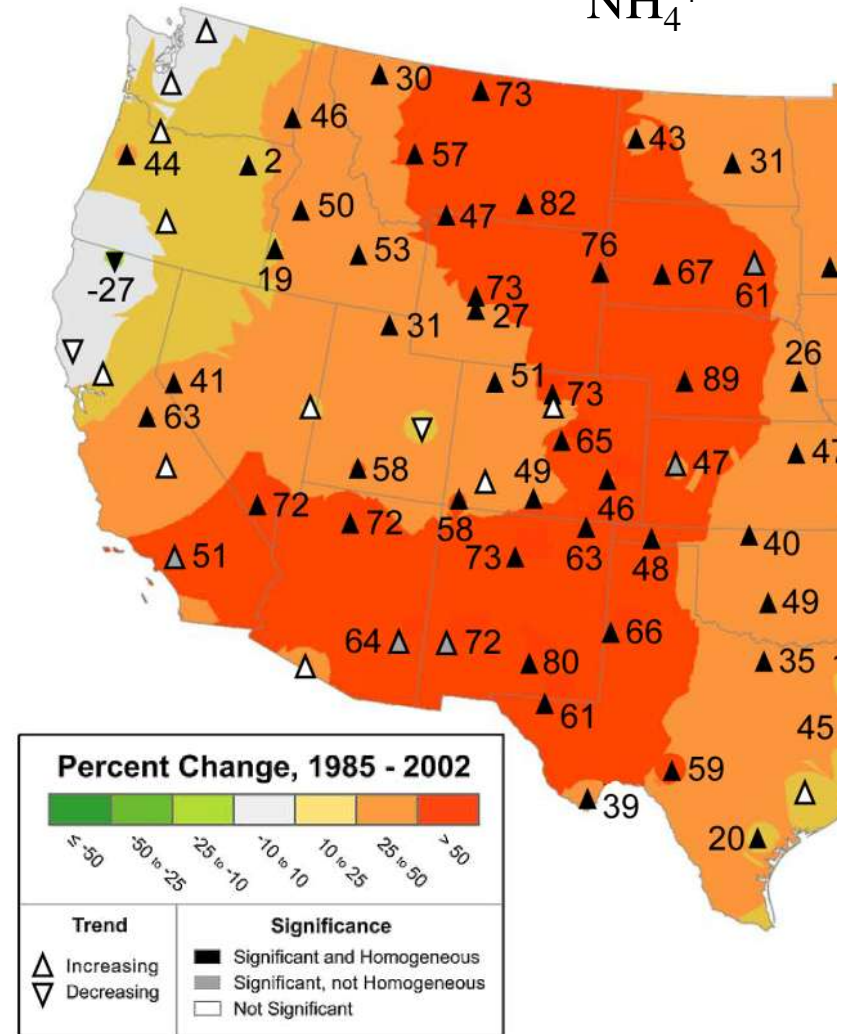


Regional precipitation N trends

NO_3^-

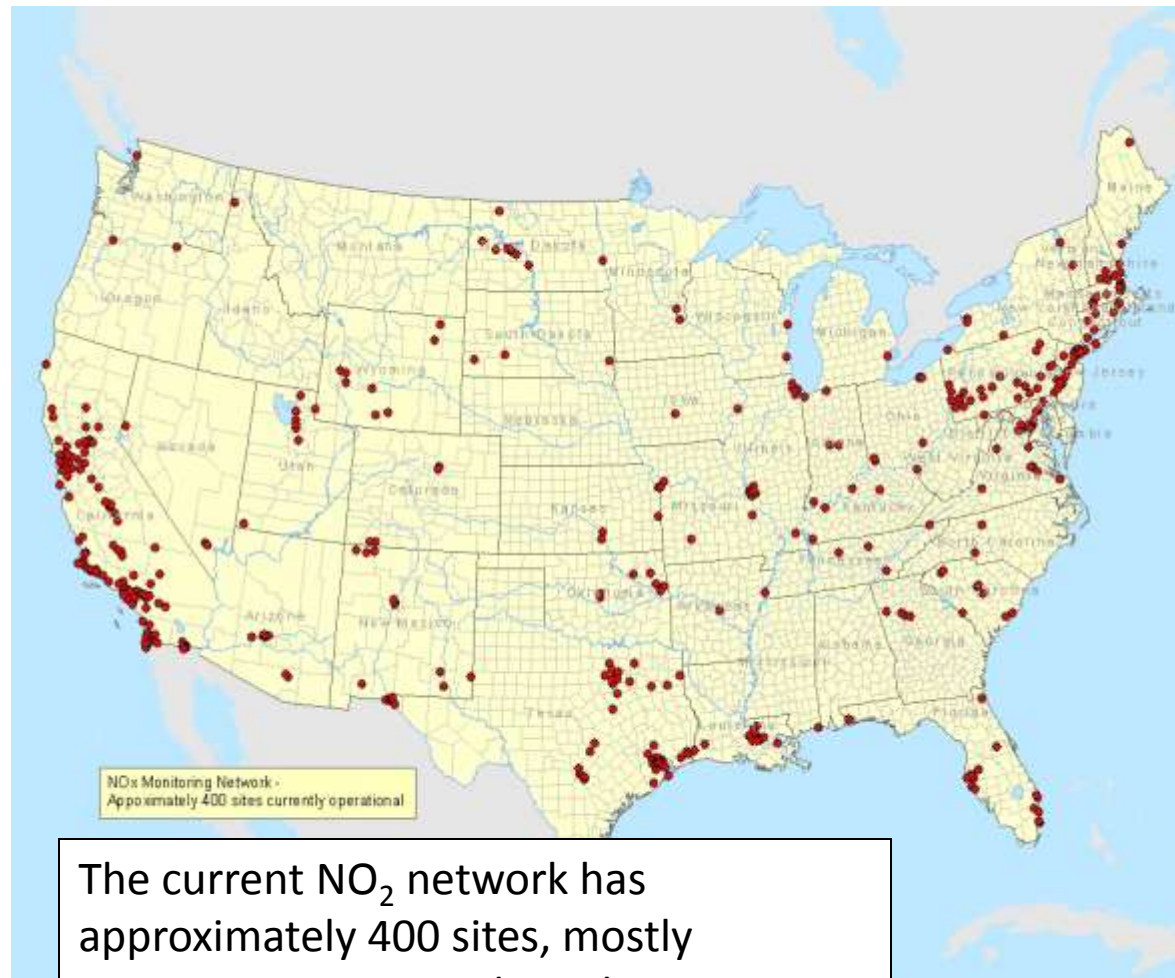


NH_4^+



Current NO₂ (?) Monitoring Network

- The current network was implemented to support an annual standard
- The existing sites are satisfying multiple objectives including:
 - NAAQS compliance
 - assessment of ozone formation and transport
 - health study support
 - Prevention of Significant Deterioration (PSD)



Rethinking Nitrogen/ozone monitoring in rural/regional scales

- Nitrogen is universal across environmental issues/media, atmospheric chemistry and physics, and national control scenarios *[many have said this -]*
- Population weighted approach inadequate to characterize regional scale air quality – exacerbated in the West
- NAAQS by itself can not drive adequate network design

National Nitrogen Observation Networks

Also SEARCH, NPS



SLAMS



NADP



CASTNET

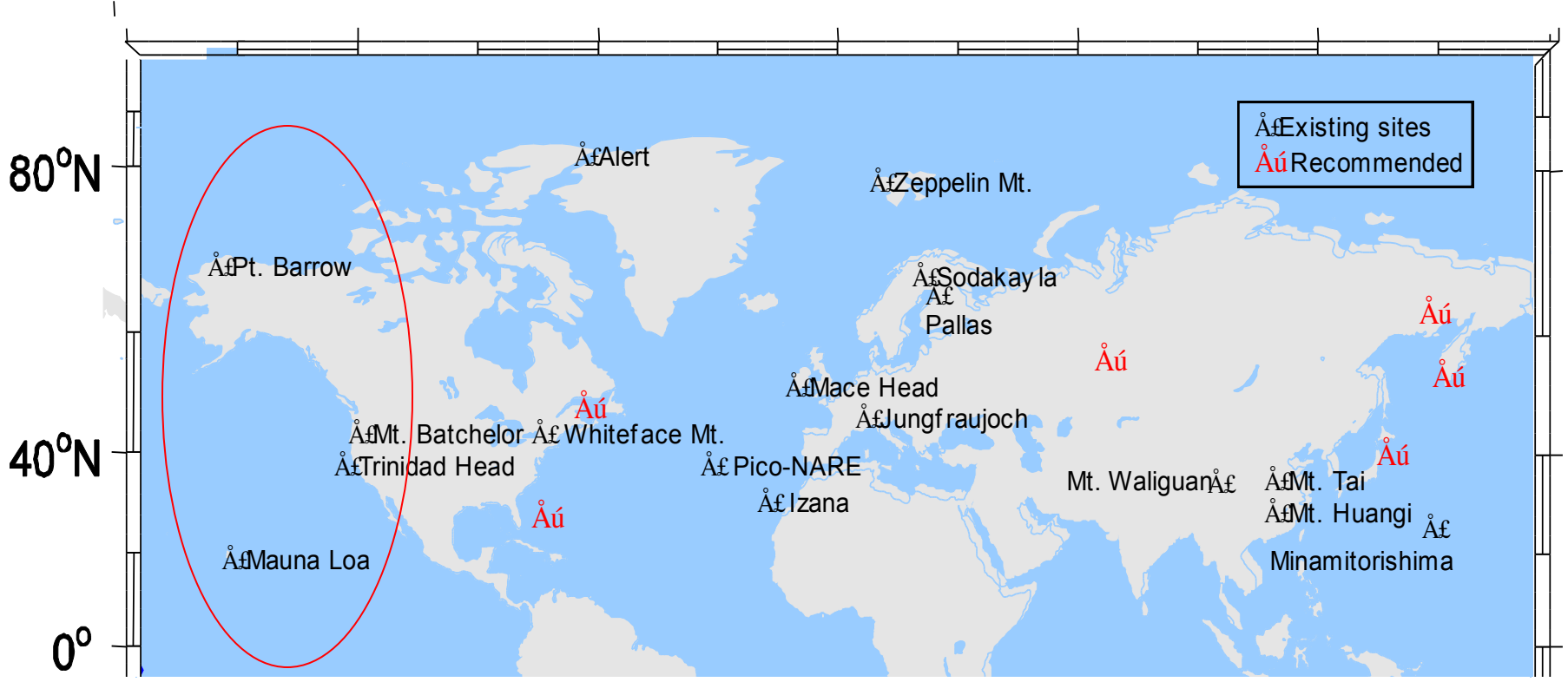


PM speciation



NCORE

Existing and proposed sentinel sites – LRTAP 2007 assessment



What's missing

- 1st...what is adequate (relative terms)
 - Great NO network
 - wet and dry nitrate
- But,
- Rural coverage in general...especially Western States
- Virtually no true NO₂ observations
- Skeleton NO_y network
- Missing routine and sustained vertical profile and aloft data
 - Sentinel transport sites
 - Reliance on occasional intensive studies (2010 CALNEX)

Rethinking Nitrogen/ozone monitoring in rural/regional scales

- Opportunities
 - NAAQS
 - New NO₂ standard
 - Lead to molecule specific observations
 - N/S secondary standards review
 - Possible growth of NO_y observations
 - Increased attention to NH₃
 - catalyze blending models and obs (spatial scarcity and wet-dry anomalies)
 - Tighter primary ozone standards & secondary ozone standard
 - Spread to regional/Western locations
 - Greater influence of hemispherical transport
 - Collaborations across agencies, remote sensing
 - Blending models and observations

Satellites provide best source of ambient NO₂: Accountability and Trends

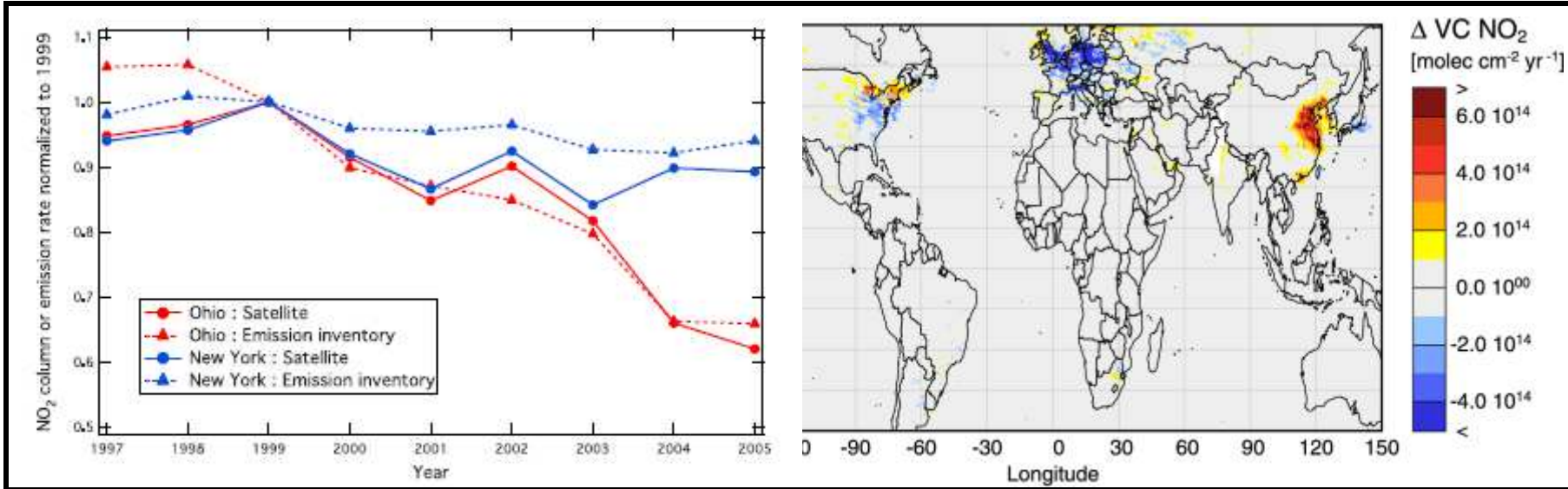


Figure 20. Left - superimposed Eastern U.S. emission and combined GOME and SCIAMACHY NO₂ 1997-2002 trends (Kim et al., 2006); right - GOME NO₂ trends from 1995 – 2002 (after Richter, 2005). Clear evidence of reductions in midwest U.S. and European NO_x emissions, and increased NO_x generated in Eastern Asia.

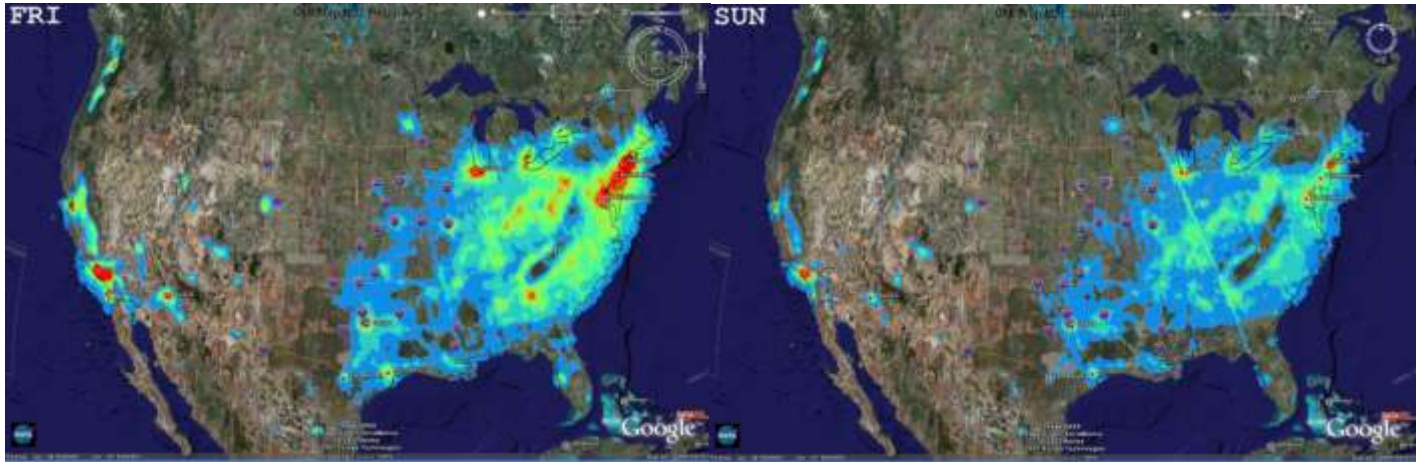
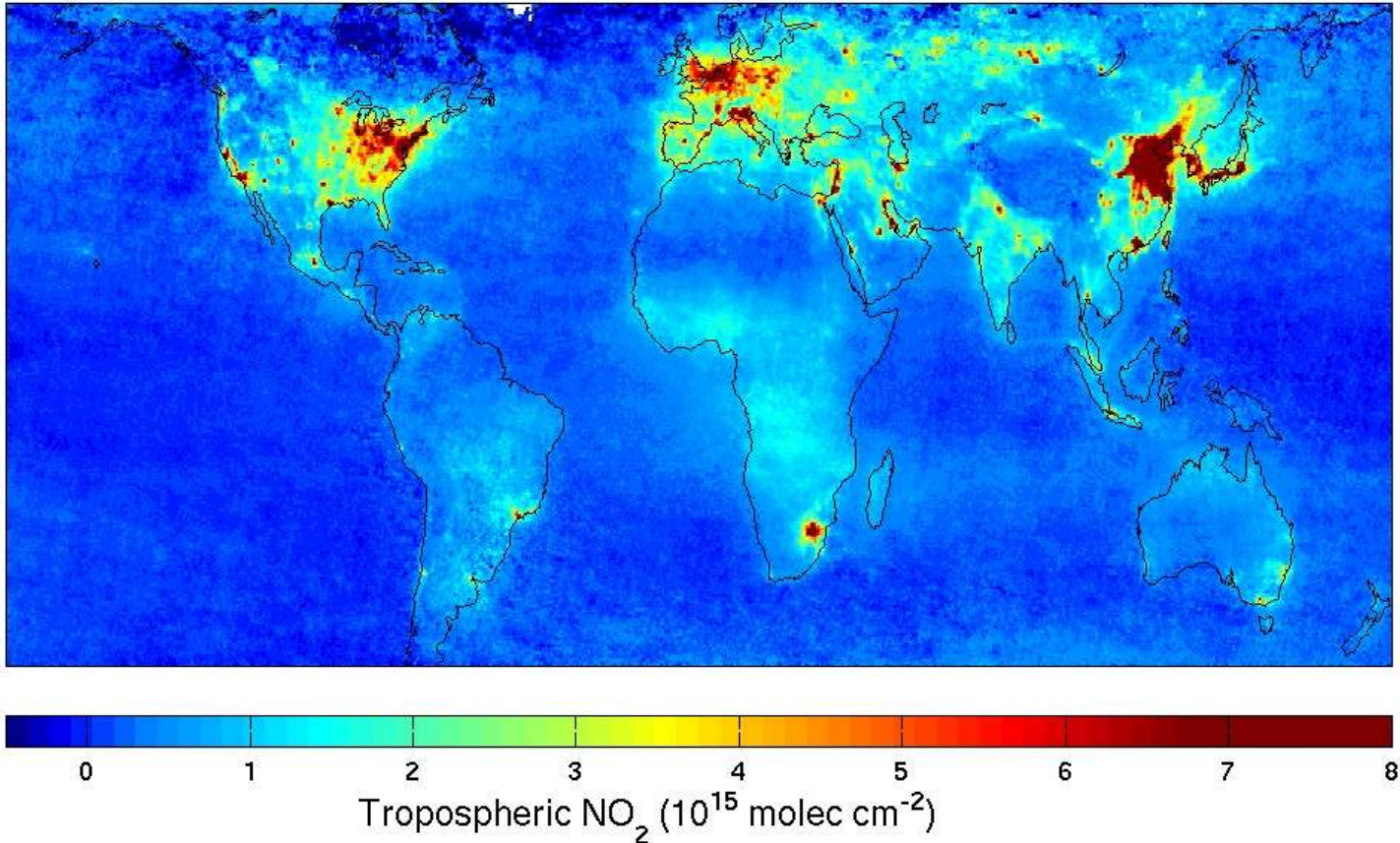


Figure 21. 2004 OMI NO₂ column images aggregated for all Fridays (left) and Sundays (right) indicating weekend/weekday patterns associated with reduced Sunday emissions (source, Husar).

Global Distribution of Nitrogen Dioxide: Precursors to Ozone Formation (Fishman)



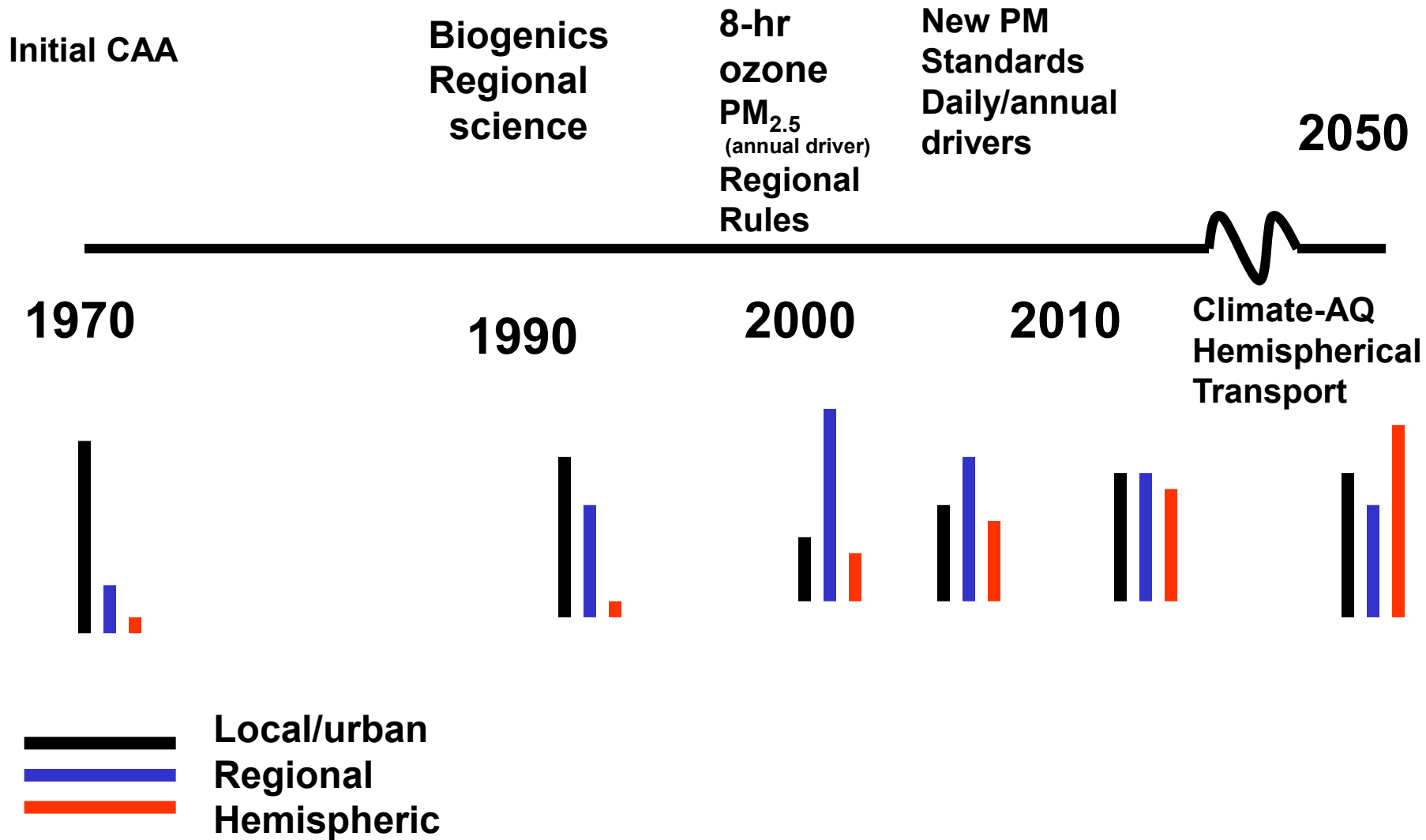
Tropospheric NO₂ columns retrieved from the SCIAMACHY satellite instrument for 2004 –2005 (after Martin et al., 2002)

National Ambient Air Quality (Secondary) Standards (NAAQS) for NO_x and SO_x

**[from presentation by: Lydia Wegman, Director,
Health and Environmental Impacts Division, EPA OAQPS - November 11, 2009]**

- First separate review for secondary standards; first consideration of multi-pollutant standards – focus on deposition-related effects
- Challenging policy and technical issues
 - Reconciling diverse deposition-related effects with a national standard
 - Translating deposition effects into ambient concentration-based standard
 - Assessing the role of reduced nitrogen (ammonia)
 - Developing a monitoring system for remote ecosystems
- CASAC's view: sufficient information to set separate secondary standards; necessary to protect against acidification and nutrient enrichment effects
- Just agreed to extend schedule by ~ 2 years
- Policy assessment will be released February 2010

Evolutional change in National Air Pollution Management



Impacts of NO_x/SO_x in the West

- Western locations are dominated by NO_x and NH₃ deposition, reflecting greater NO_x and NH₃ emissions in the West compared with SO₂
- Some western locations, e.g. high-elevation lakes, are highly sensitive to atmospheric nitrogen deposition
- Terrestrial systems in the west are also sensitive to nitrogen deposition. Lichens are especially sensitive indicator species

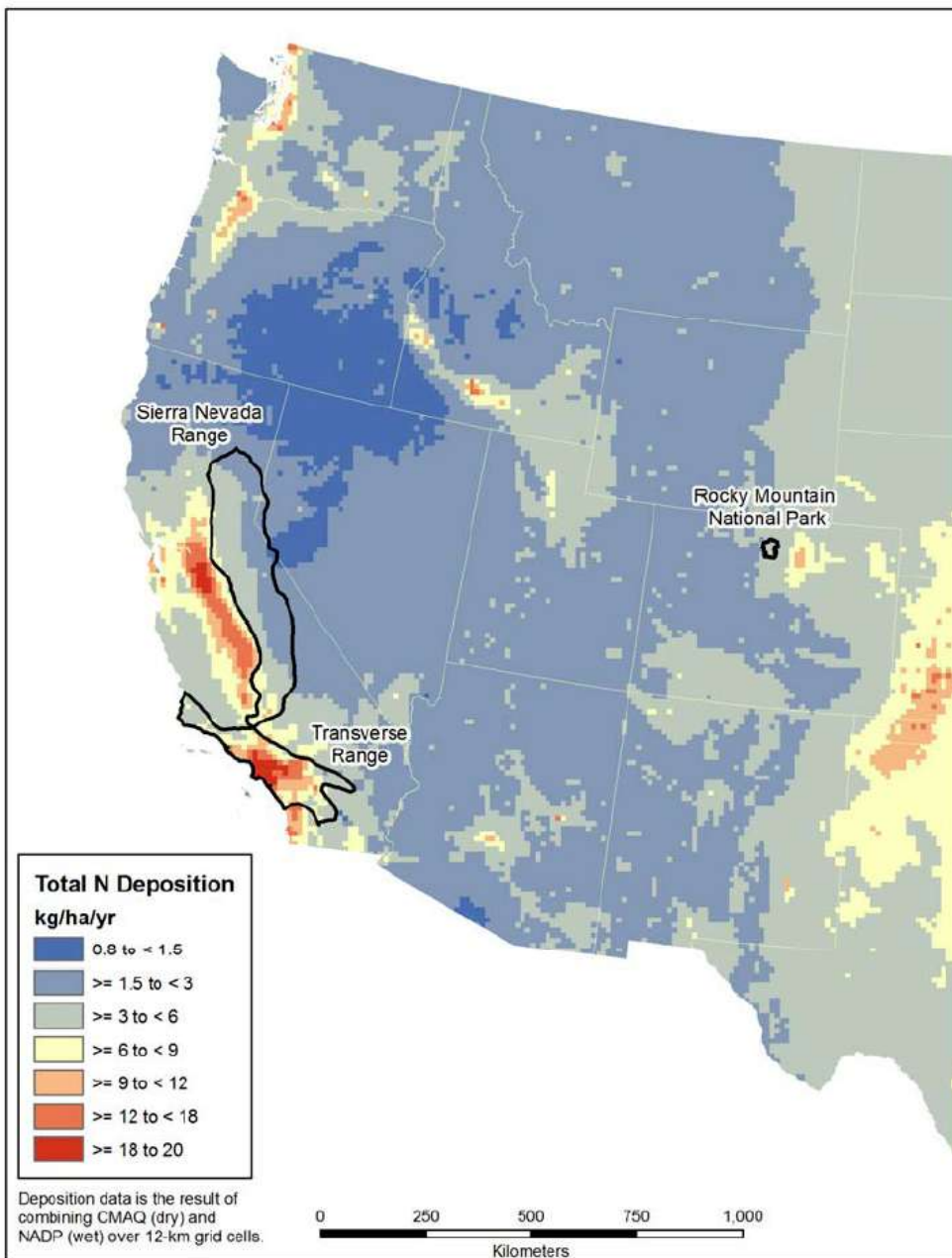


Figure 5.3-8. CMAQ 2002 modeling results and NADP monitoring data for deposition of total nitrogen in the western United States.

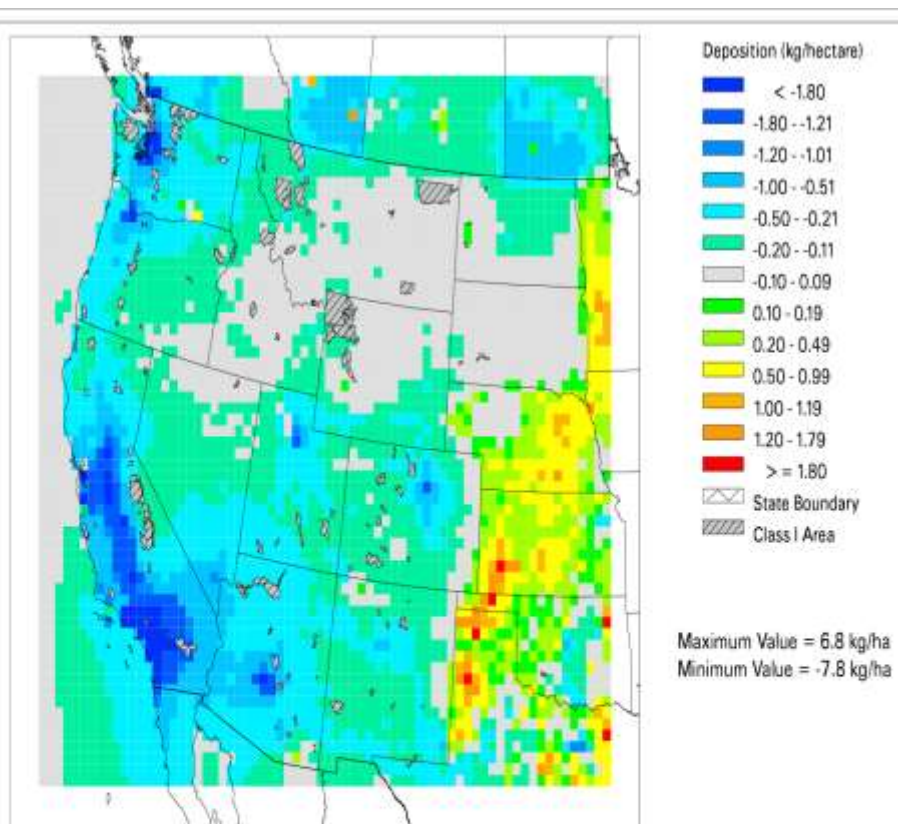
- EPA included three western areas in the NO_x/SO_x secondary standards risk and exposure assessment
- Western case study areas were selected to address observed effects of nitrogen deposition on Alpine lakes and meadows, and effects of nitrogen saturation in California forests
- These effects can include impacts on both aquatic and terrestrial ecosystems, including community level changes in plants and lichens, such as coastal sage scrub, mixed conifer forest in California, and alpine ecosystems in the Rocky Mountains

Role of National Assessment Tools in support of Western U.S. Air Quality

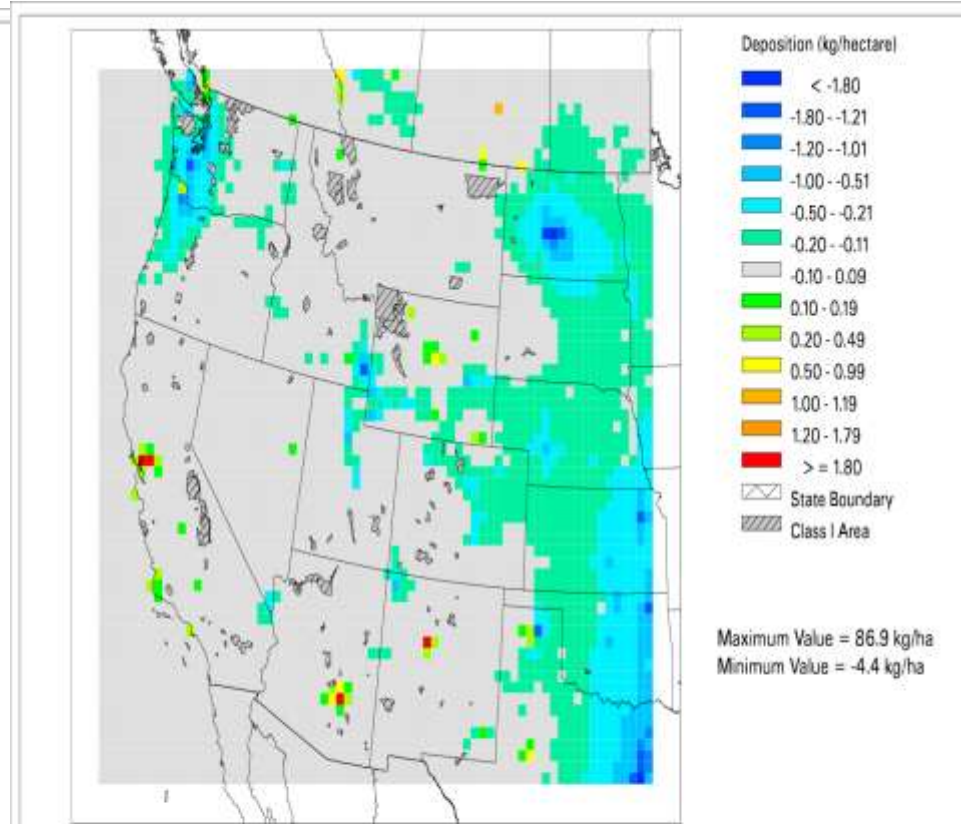
- Historical emphasis on Eastern US applications
 - Original RADM NAPAP modeling, ROM
 - The West is challenging relative to softer gradations in Eastern U.S. topography
- Further confounded by:
 - Challenging emissions characterizations, e.g.,
 - dominant role of fires
 - New dispersed oil/gas operations
 - Meteorology
 - Precursor Concentration enhancing (mtn-valley inversions)
 - Exacerbated photochemical stimulation (bright surfaces/snow)
 - Intercontinental transport
- continued Western Modeling Center?
- Monitoring network design tethered to population surrogate approaches
 - Natural conflict with Western heterogeneity

Modeling Results

Modeled Difference for Dry Deposition of N and S (2002-2018)



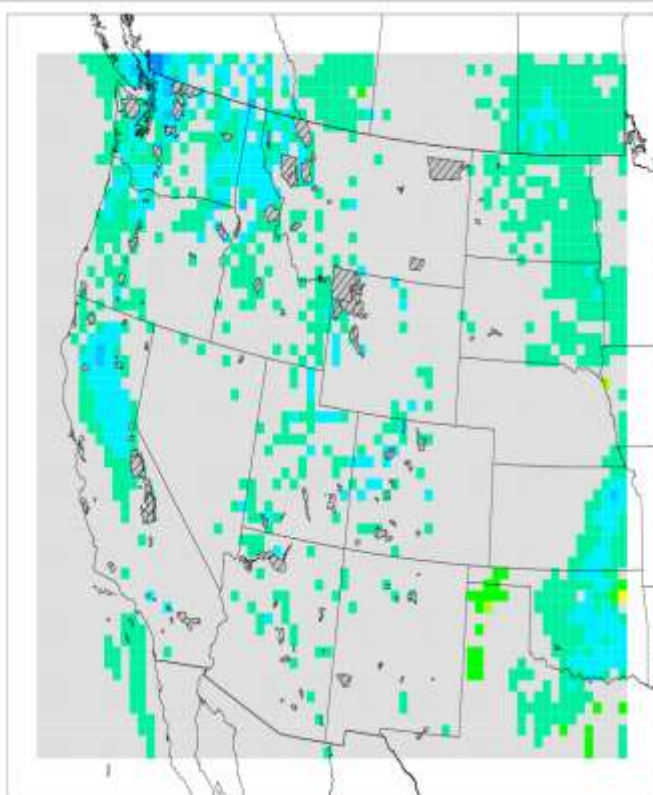
Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Dry Deposition of Nitrogen



Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Dry Deposition of Sulfur

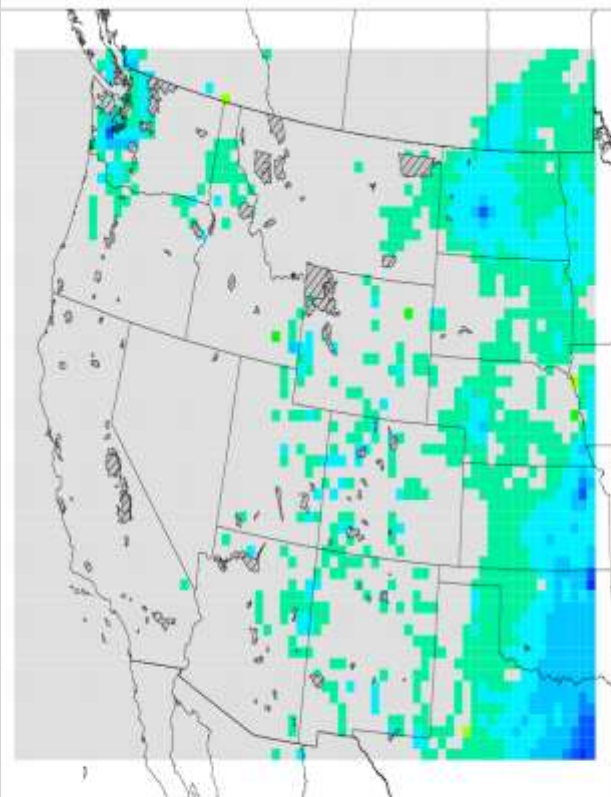


Modeled Difference for Wet Deposition of N and S (2002-2018)



Maximum Value = 0.8 kg/ha
Minimum Value = -1.1 kg/ha

Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Wet Deposition of Nitrogen

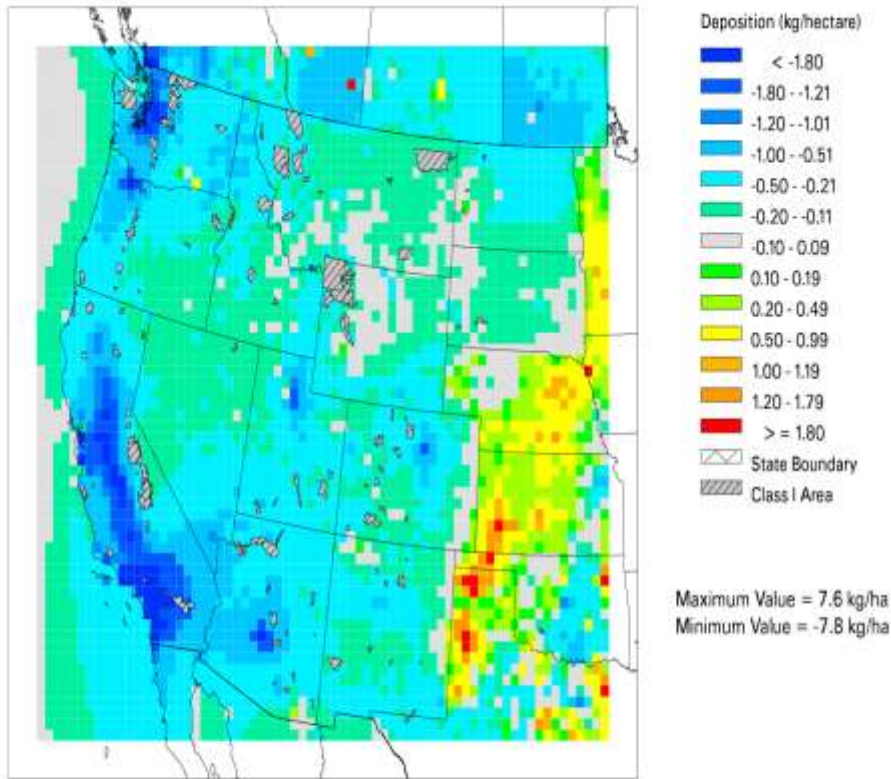


Maximum Value = 0.6 kg/ha
Minimum Value = -4.0 kg/ha

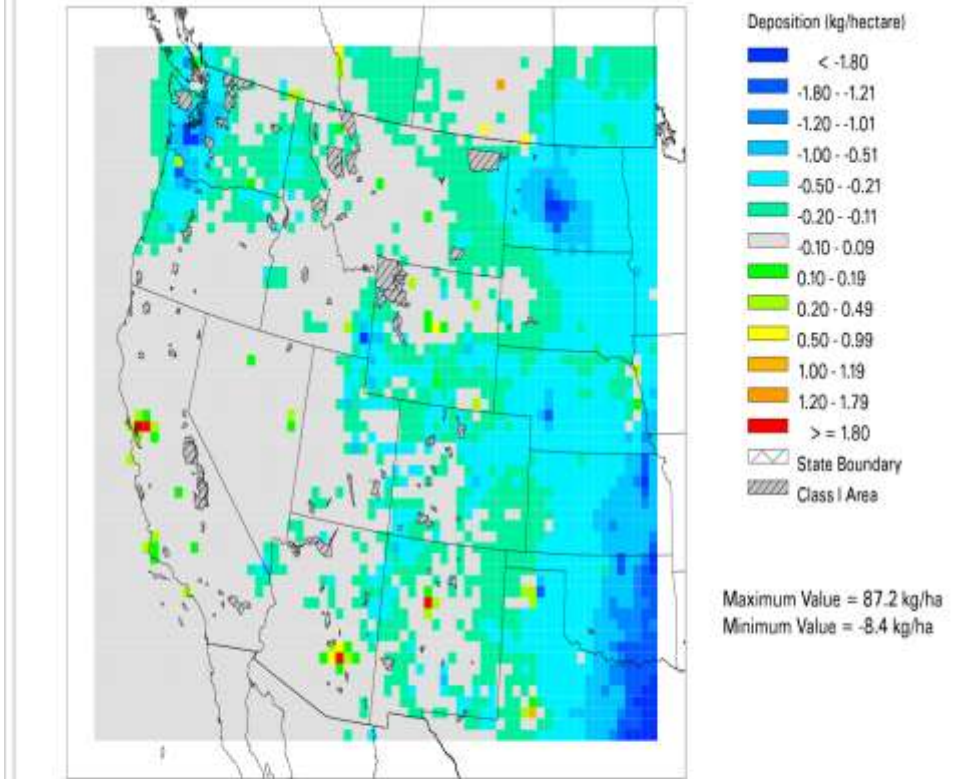
Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Wet Deposition of Sulfur



Modeled Difference for Total (D+W) Deposition of N and S (2002-2018)



Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Total Deposition of Nitrogen



Difference in Annual CMAQ Modeled Deposition -- PRP18a - Plan02d
Total Deposition of Sulfur



WRAP Regional Modeling Center Specification Sheets

<http://pah.cert.ucr.edu/aqm/308/cmaq.shtml>

Simulation Name (Spec Sheet)	Emission Inputs	AQ/Visibility Results
CMAQ 2002 36km base B MPE Case (Base02b)	Base02b Emissions	<ul style="list-style-type: none">•CMAQ 36km base B MPE results and its comparison to Base A MPE
2002 36km Plan B (Plan02b)	Plan02b Emissions	<ul style="list-style-type: none">•2002 36km Plan B Results and Comparison to Plan A
2018 36km Base B (Base18b)	Base18b Emissions	<ul style="list-style-type: none">•Base18b model results (spatial plots)•Comparison of base18b to plan02b (spatial difference plots)•Comparison of base18b to plan02c (spatial difference plots)•Visibility projection results can be downloaded here (excel spreadsheets and zip files)•Visibility projection results based on worst 20% BEXT,SO4 and NO3 days using new and old IMPROVE algorithms (excel spreadsheets in zip files).
2002 36km Planning C (Plan02c)	Plan02c Emissions	<ul style="list-style-type: none">•Comparison of plan02c to plan02b (spatial difference plots for QA purpose)•Comparison of plan02c to base02b (spatial difference plots)
CMAQ 12km MPE and Comparison to 36km 2002 Base A		<ul style="list-style-type: none">•CMAQ 12km versus 36km MPE comparisons using 2002 Base Case A
2018 36km Base C (Base18c) summer seasons	Base18c Emissions	<ul style="list-style-type: none">•Comparison of base18c to base18b (spatial difference plots)
2018 36km PRP18a (PRP18a)	PRP18a Emissions	<ul style="list-style-type: none">•Comparison of prp18a to base18b (spatial difference plots)•Comparison of prp18a to plan02c (spatial difference plots)•Comparison of prp18a to plan02d (spatial difference plots)
2002 36km Planning D (Plan02d)	Plan02d Emissions	<ul style="list-style-type: none">•Comparison of prp18a to plan02d (spatial difference plots)•Comparison of plan02d to plan02c (spatial difference plots)
2018 36km PRP18b (PRP18b)	PRP18b Emissions	<ul style="list-style-type: none">•Comparison of prp18b to prp18a(spatial difference plots)•Comparison of prp18b to plan02d (spatial difference plots)
2018 36km PRP18cmv (PRP18cmv)	PRP18cmv Emissions	<ul style="list-style-type: none">•Comparison of prp18cmv to prp18b(spatial difference plots)

WRAP Status

WRAP Charter & Board Structure

- **“Old WRAP”** - chartered in 1997
 - Focus primarily on regional haze, including implementation of Grand Canyon Visibility Transport Commission recommendations
 - Other air quality issues “as requested by the membership”
 - Large, high-level Board – up to 31 members
 - Governors, Tribal Leaders, Agriculture/Interior Secretaries – EPA ex officio
 - 14 states, up to 14 tribes
 - USFS, NPS, FWS, EPA
 - Highly structured Technical and Policy oversight with members from state, tribal, federal, industry, and environmental communities
 - Most committees have completed work and are inactive
 - *Time for a change* –
- **“New WRAP” Charter & Board Structure**
 - Review & approval by former WRAP Board completed December 2009
 - http://www.wrapair.org/forums/amc/meetings/091111_Nox/Revised_WRAP_Charter_October_2009.pdf
 - New Board seated last week
 - First “New WRAP” Board & Membership meeting – Denver – March 31st

New WRAP Charter - Purpose

The WRAP provides a venue for Western states, tribes, local governments, federal land managers and the USEPA to:

- 1) Maintain and update the regional haze work that WRAP has developed and continue to make the data and tools available for states and tribes to use as they implement their regional haze SIPs;
- 2) *Develop a common understanding of current and evolving regional air quality issues in the West, such as regional haze, ozone, fine and coarse particulate matter, nitrogen deposition and critical loads, and mercury and other hazardous air pollutants;*
- 3) *Examine and discuss Western regional air quality issues from a multi-pollutant perspective;*
- 4) develop and maintain regional databases that support regional and sub-regional technical analyses. This includes collection and analysis of data from various sources to produce regionally consistent, comparable, complete, and transparent results, able to be utilized and relied upon by individual jurisdictions and agencies;

New WRAP Charter Purpose, continued

- 5) collaborate with USEPA to ensure that, to the maximum extent possible, WRAP data and analyses are compatible with and leverage work conducted at the national level. This could include WRAP work to compile data and analyses related to international, off-shore, and other sources of air pollution affecting Western air quality;
- 6) evaluate the air quality impacts associated with regionally significant emission sources, such as mobile sources, fire, traditional and alternative energy development/extraction, windblown dust, and electricity generation, and, as warranted, to discuss regional and cross-jurisdictional strategies to improve air quality and mitigate the impacts from such sources;
- 7) consult with air quality agencies in other regions to prevent duplication of effort and enhance efficiency and consistency of databases and analyses;
- 8) evaluate how the impacts of climate change may affect air quality in the West; and
- 9) as requested by the membership, formulate and advance Western regional air quality policy positions on air quality.

New WRAP Charter - Membership

- Membership in the WRAP is open to all states, federally recognized tribes, and local air agencies located in the geographical region encompassed by the states of: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.
- Membership in the WRAP is also open to the US Forest Service, National Park Service, Bureau of Land Management, Fish and Wildlife Service, and US EPA.
- In order to become a recognized member of the WRAP, eligible states, tribes, local agencies, and federal agencies shall submit an official letter to the WRAP requesting membership and designating primary and secondary contacts for the jurisdiction or agency.

New WRAP Charter - Board of Directors

- The WRAP Board of Directors shall consist of *five state, five tribal, five federal, and two local government representatives*. The state, tribal, and local directors shall be elected by their respective delegations to staggered two-year terms, with the option of extension based upon respective caucus discussion and approval. The directors representing eligible federal agencies shall be appointed by their agencies to staggered two-year terms.
- *Officers*
 - The officers of WRAP shall consist of a state and tribal Co-Chairperson, and a Treasurer and a Secretary elected from the membership of the Board of Directors.
- *Powers of WRAP Board*
 - In directing the activities of the WRAP, the Board of Directors may:
 - Solicit and accept funding;
 - Hire staff, or arrange for the provision of staff support, to carry out its activities;
 - Approve work plans;
 - Approve contracts for support from outside experts and consultants;
 - *Establish a Technical Steering Committee from the membership to oversee and direct the technical and analytical work of WRAP staff, contractors, and work groups;*
 - *Establish Work Groups from the membership to manage specific elements of the work plan;*
 - Call membership meetings.

Thanks –

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