TRANSBOUNDARY OZONE POLLUTION CONFERENCE

at TENAYA LODGE

Tuesday, March 31 - Thursday, April 2, 2015

at YOSEMITE NATIONAL PARK

Western Regional Analysis for Ozone Standard Planning

April 2, 2015

Tom Moore

WRAP Air Quality Program Manager

WESTAR Council

Fish Camp, CA

WESTERN REGIONAL AIR PARTNERSHIP

WESTAR

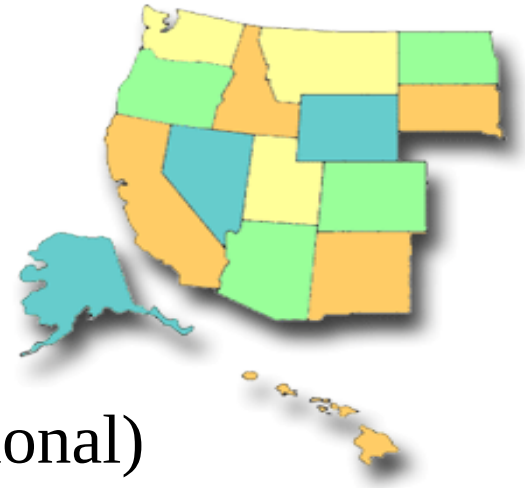
Western States Air Resources Council

Topics

- Overview of WESTAR and WRAP regional organizations
- Key issues and areas of focus
- Ozone analysis: Results from recent projects and studies

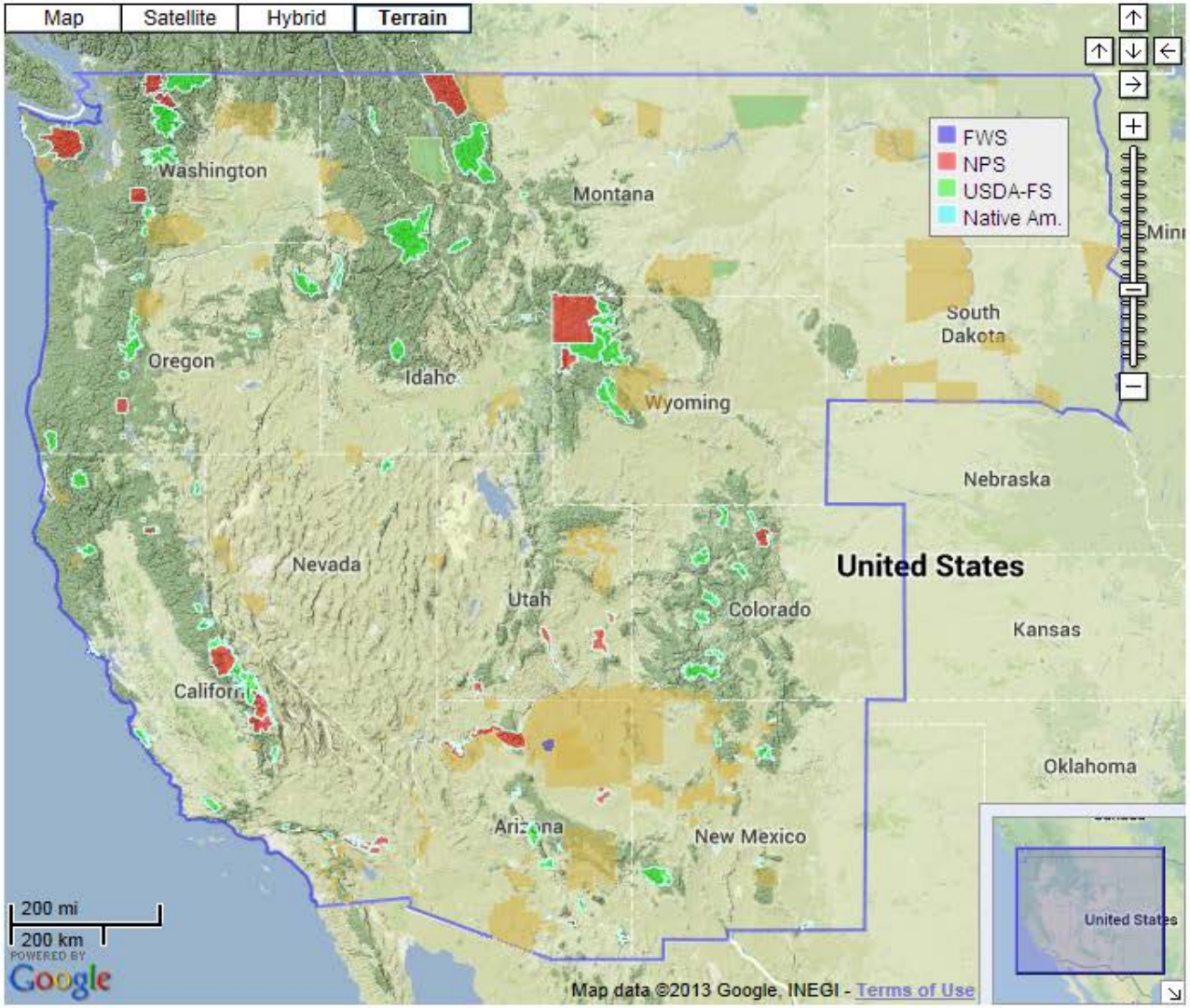
Overview of WESTAR and WRAP

- Purpose
  - Service organizations
  - Assist members in achieving their air quality management goals
- WESTAR
  - Training
  - Provide a forum for discussion
  - Inform policy-related discussions
  - www.westar.org



- WRAP - provides technical support (esp. regional)
  - Virtual organization, not incorporated
  - 65+ member agencies include 15 state air agencies, NPS, FWS, BLM, USFS, EPA, and interested tribes and local air agencies/districts in the WRAP region
  - Board has representatives across states, tribes, federal, and local agencies.
  - www.wrapair2.org

About WESTAR and WRAP

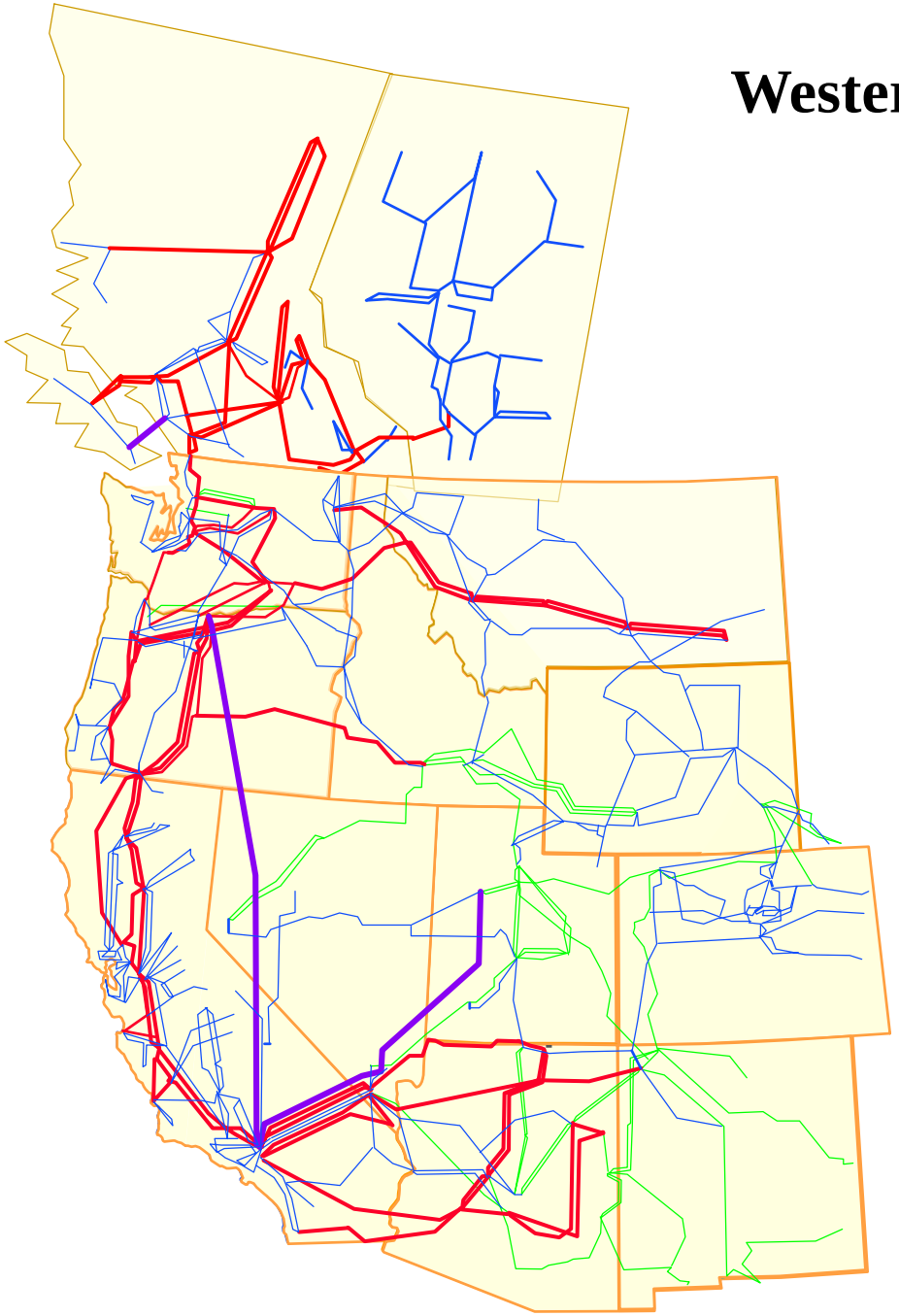


- 15 states, federal land managers and EPA, tribes, and local air districts
- Regional analyses for Western sources and air quality impacts

Overview of WRAP

- Since 2010, WRAP working as regional technical center to support and coordinate Regional Analysis and Planning
- Develop and facilitate use of western air quality data:
  - Make improvements, ensure consistency and comparability
  - Increase transparency and access
  - Track trends for better, reproducible analyses
  - Regional emissions and modeling studies
- National Ozone and PM Ambient Air Standards Implementation and Maintenance – transport and background
- Exceptional Events
- Implementation of Regional Haze SIPs
- Needs of sub-regional groups of states
  - Currently oil and gas, fire
  - Similar efforts in past – dust, BART, other topics

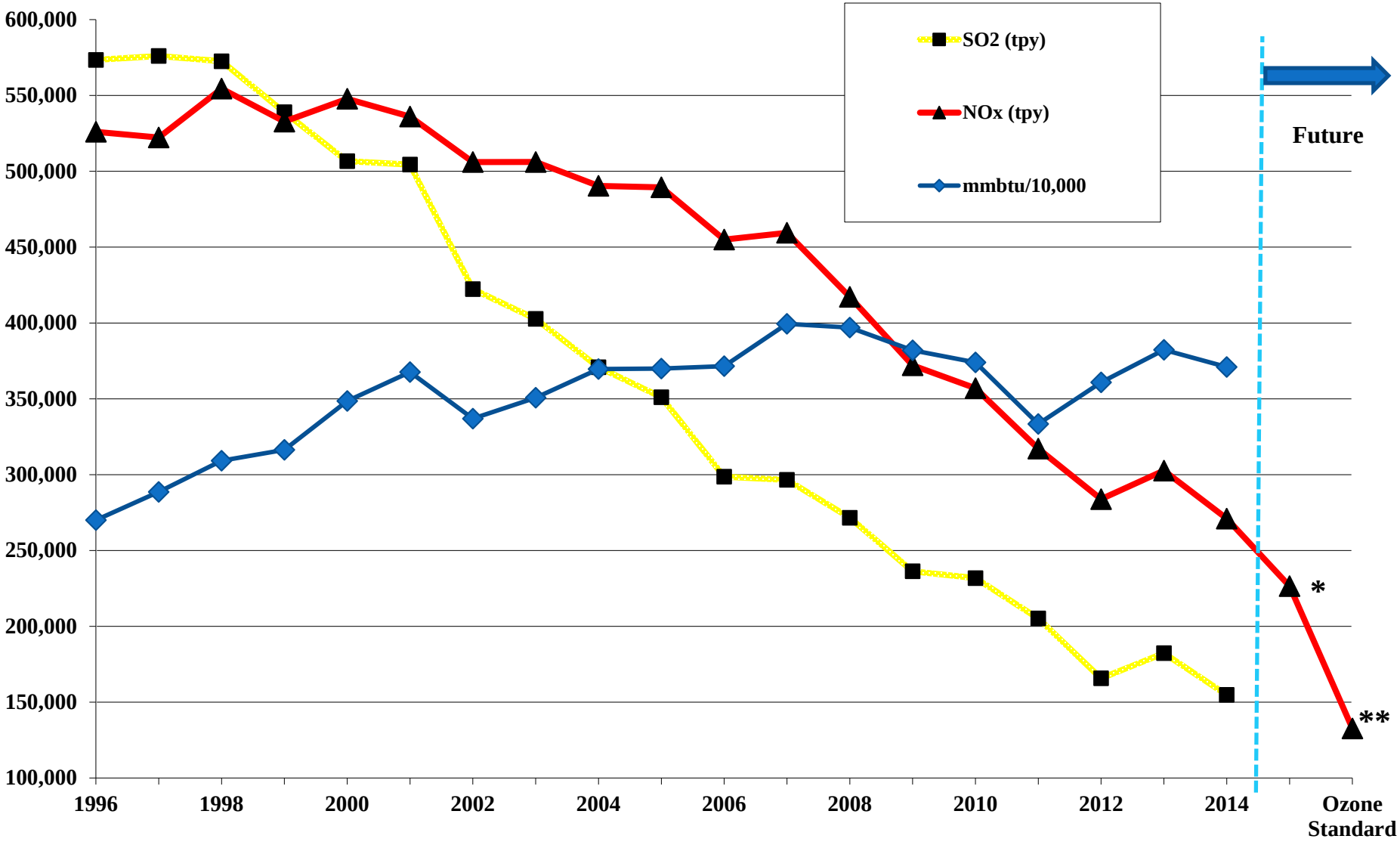
Western Electrical Interconnect



WECC
Existing Transmission System

	230 kV HVAC
	345 kV HVAC
	500 kV HVAC
	± 500 kV HVDC

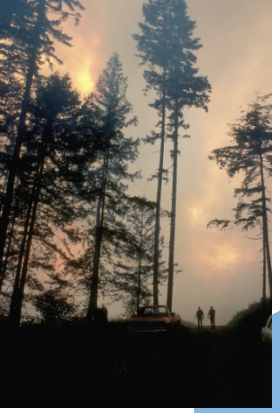
Western Interconnect Fossil Fuel Power Plant Emissions



1996 through 2014 data from EPA data for fossil fuel-fired electrical generating units in the 11-state Western Interconnect

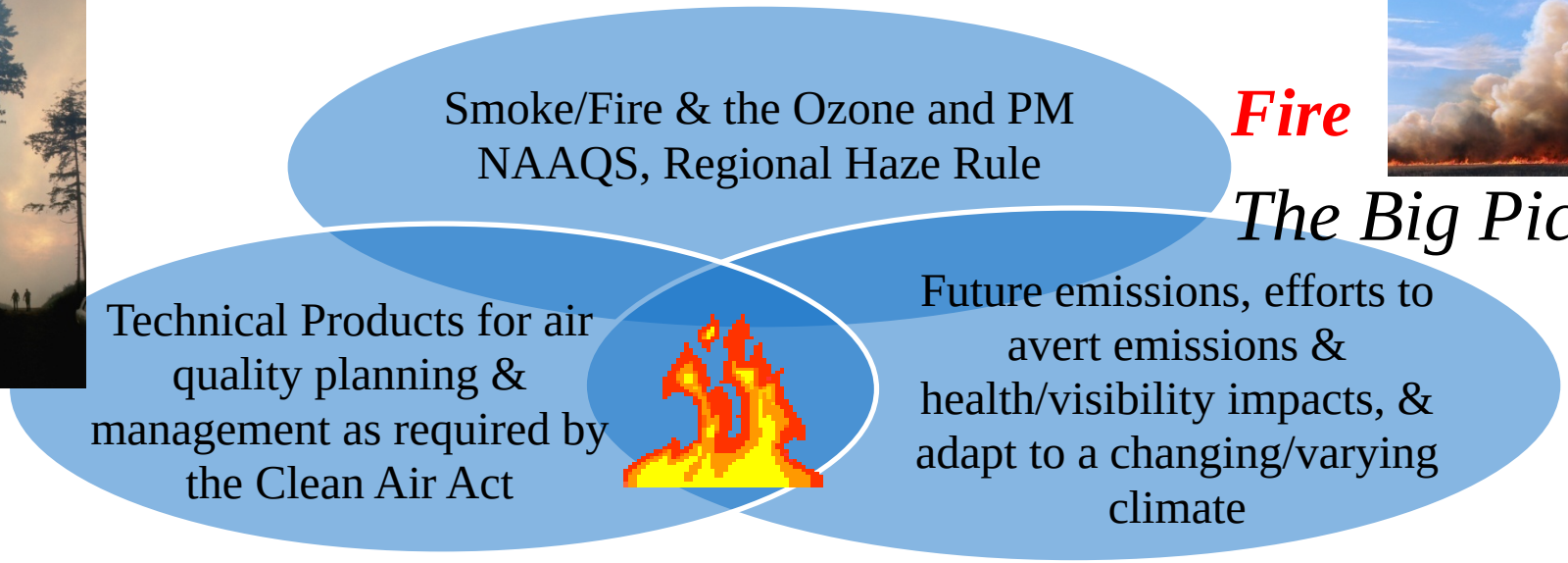
* Additional NOx reductions estimate - BART controls from Regional Haze baseline planning

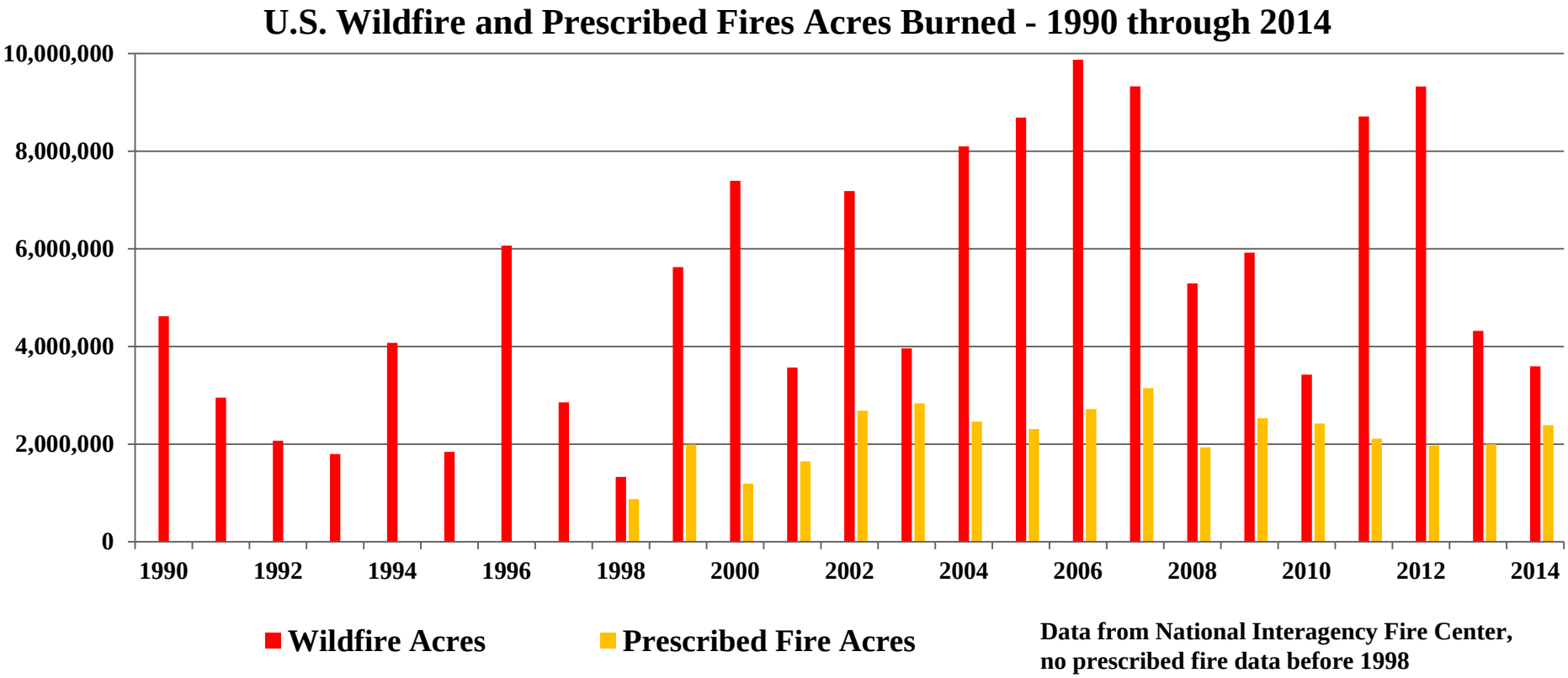
** Further NOx reductions from applying maximum post-combustion controls to all remaining units



Fire

The Big Picture

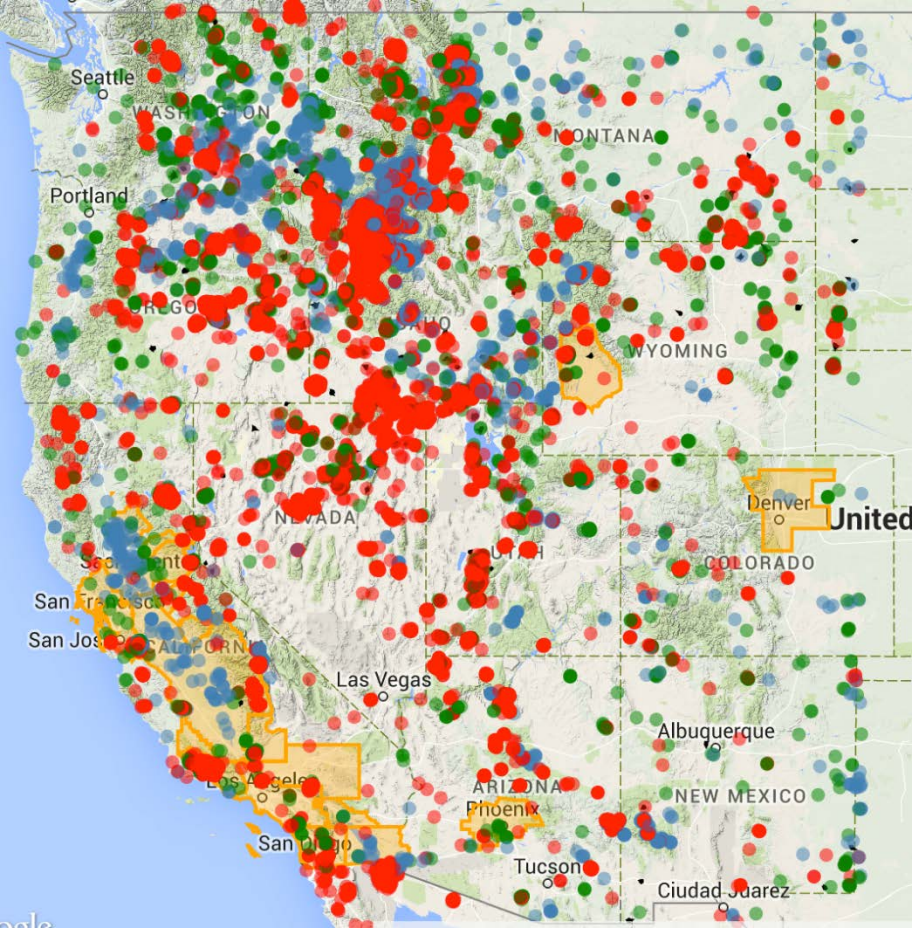




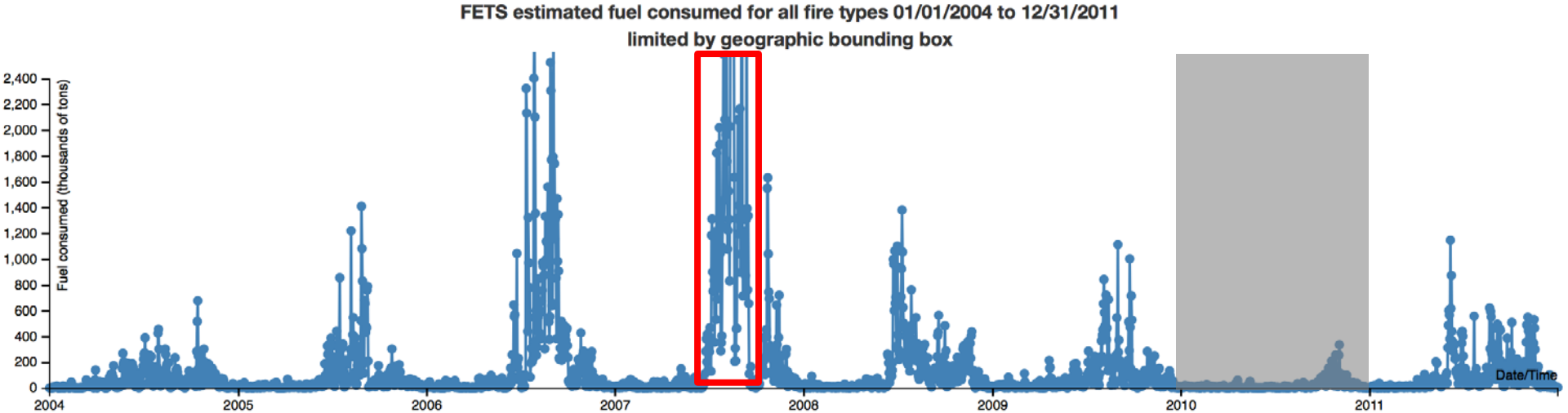
2007

6/21 – 9/21
Limited by bounding box

Source: WRAP Fire Tools



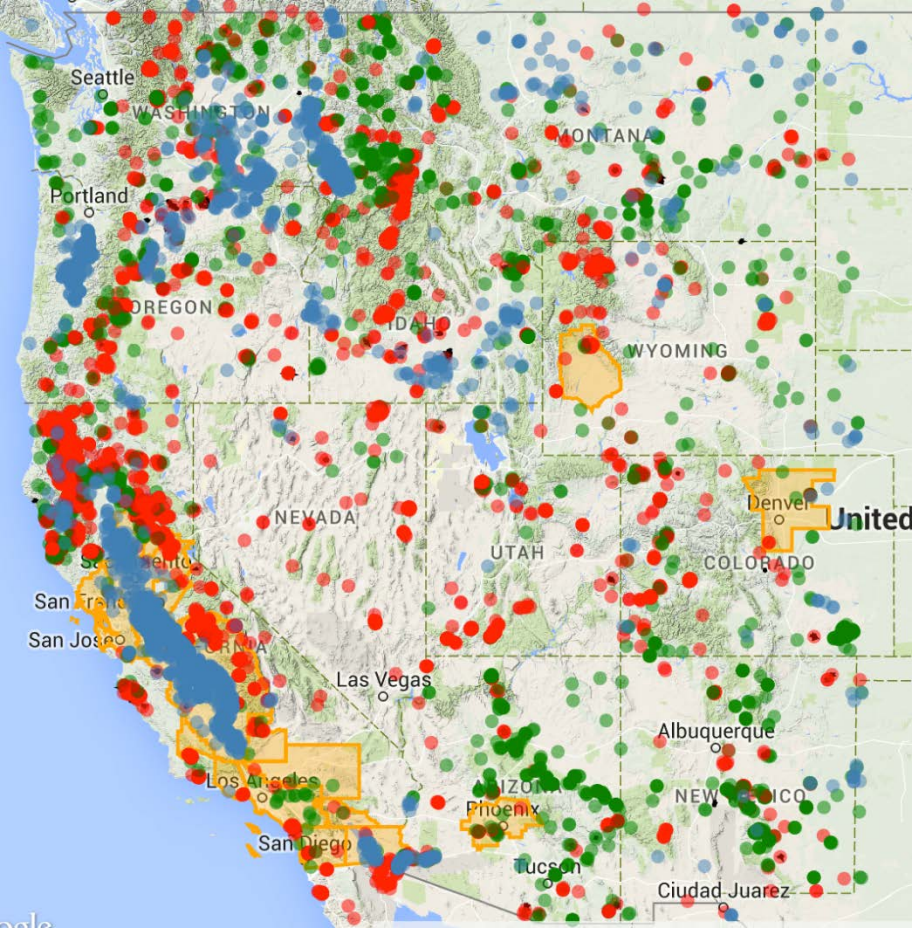
Agriculture
Prescribed
Wildfires



2008

6/21 – 9/21
Limited by bounding box

Source: WRAP Fire Tools



Agriculture
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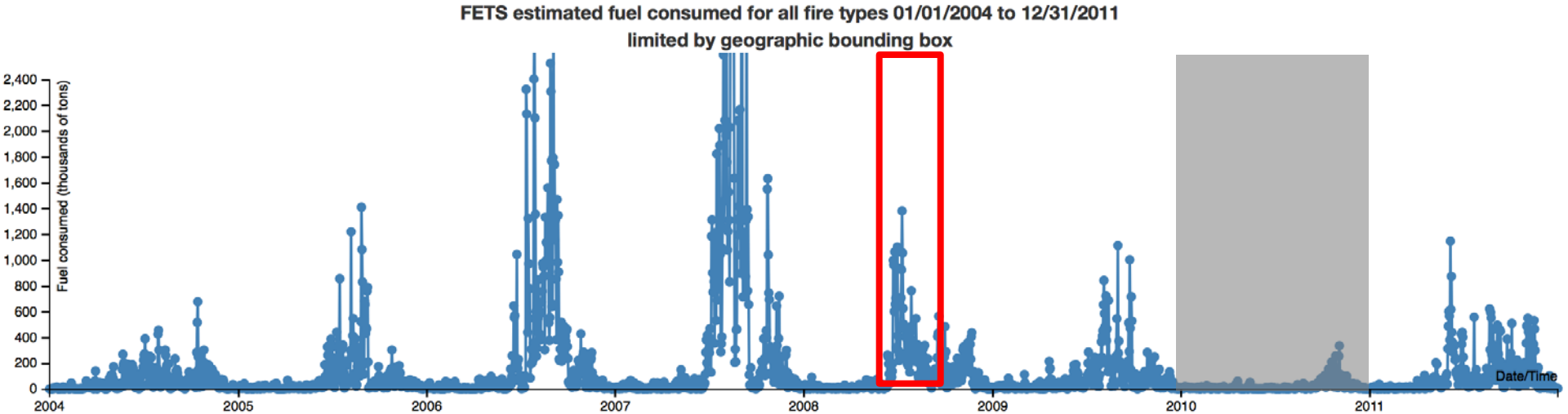
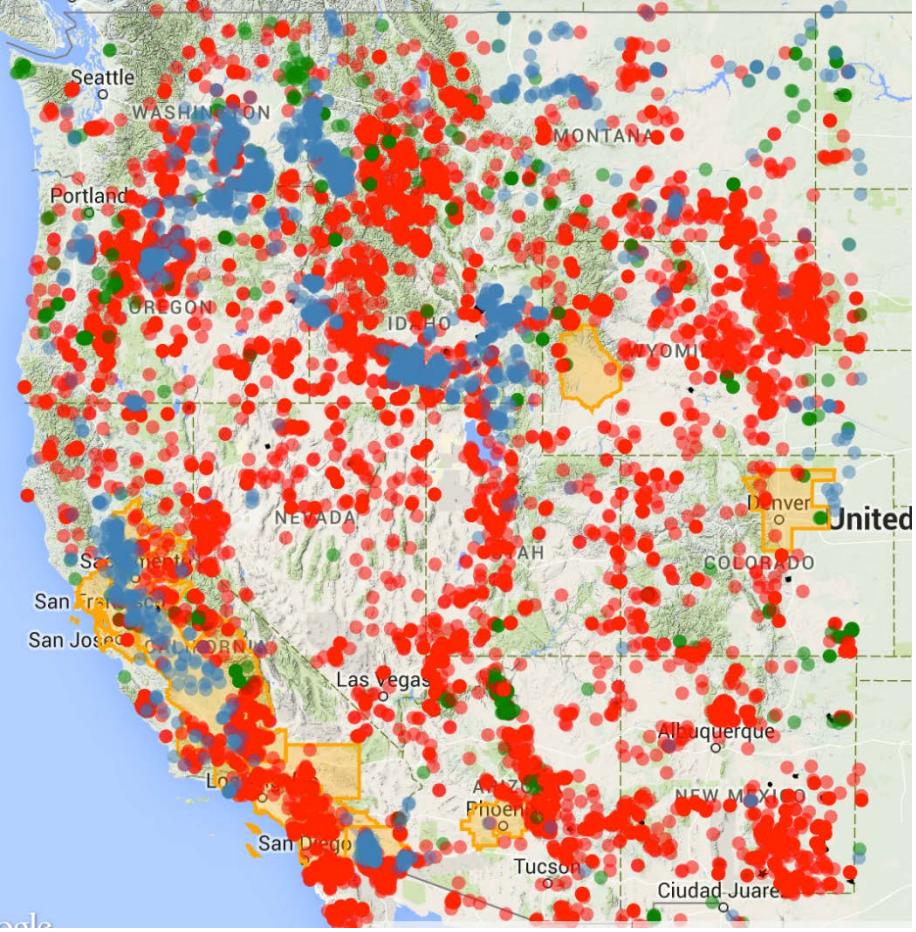




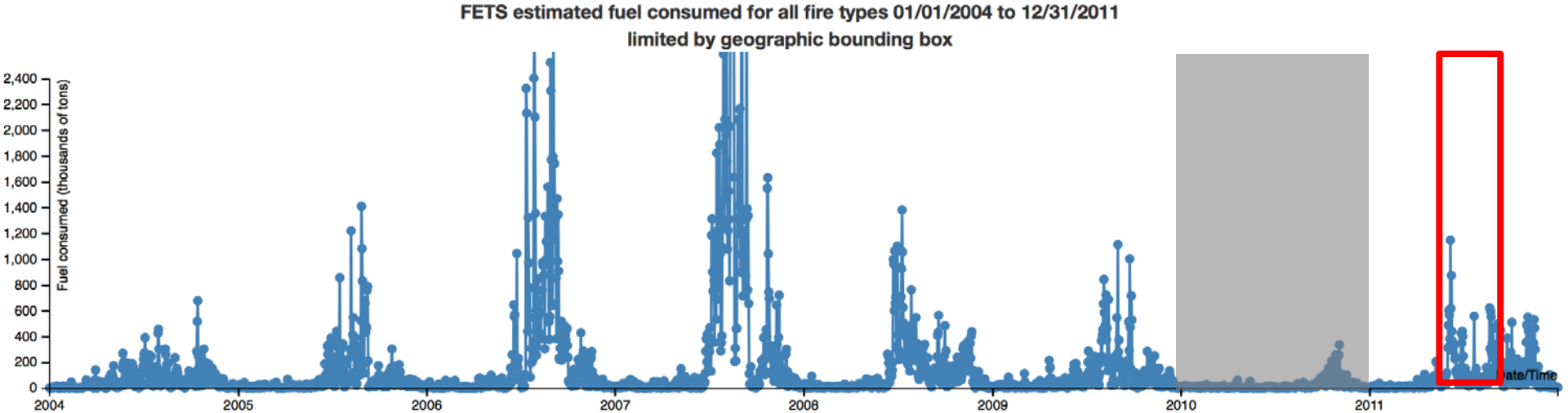
2011

6/21 – 9/21
Limited by bounding box

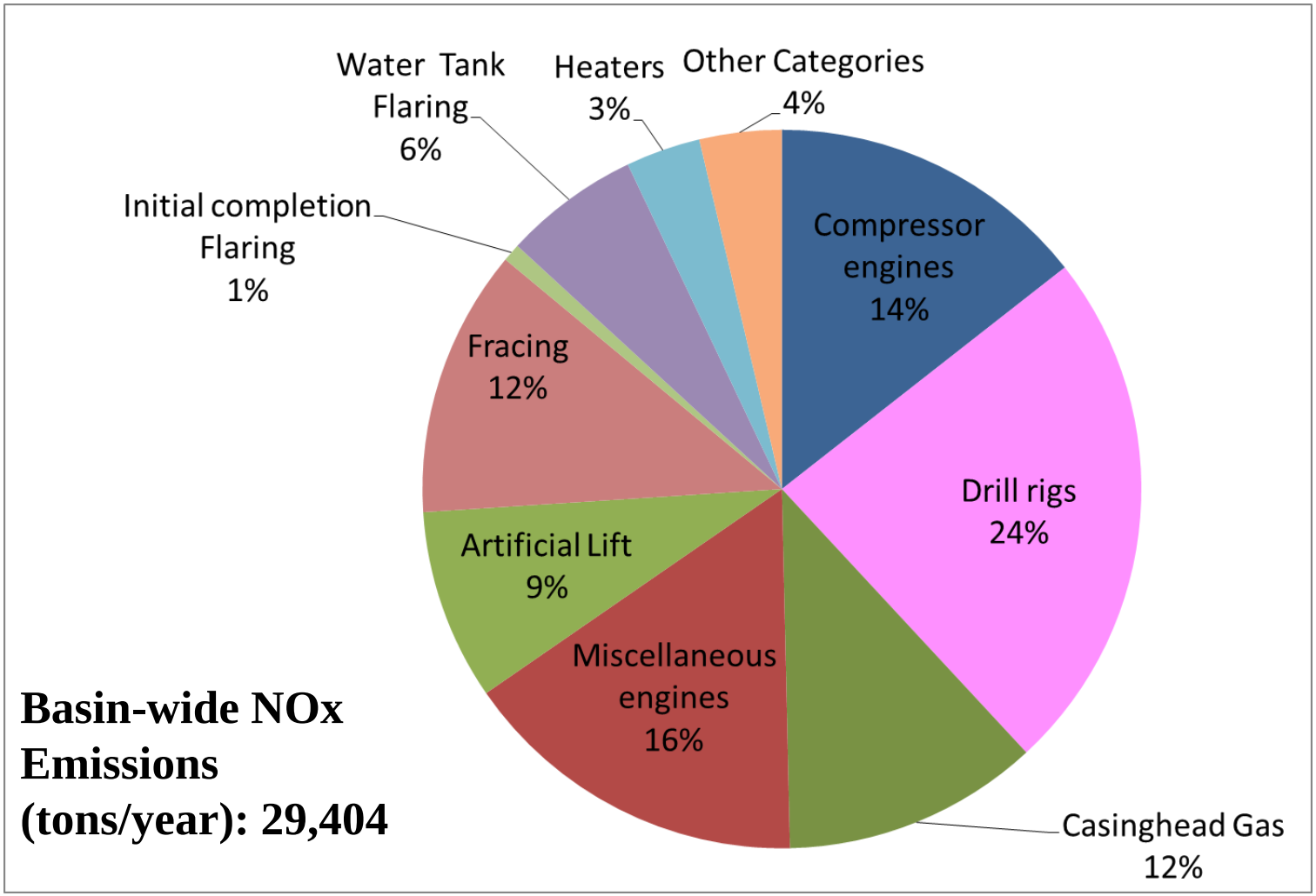
*Obtained additional small wildfire data for this inventory

Source: WRAP Fire Tools

Agriculture
Prescribed
Wildfires



Example Oil & Gas Study: Williston Basin 2011 Baseline Results NOx Emissions By Source Category



Source: BLM/WRAP Oil and Gas Inventory project

Numerous U.S. sources will continue to contribute to air quality impacts across the West

Some are further controllable

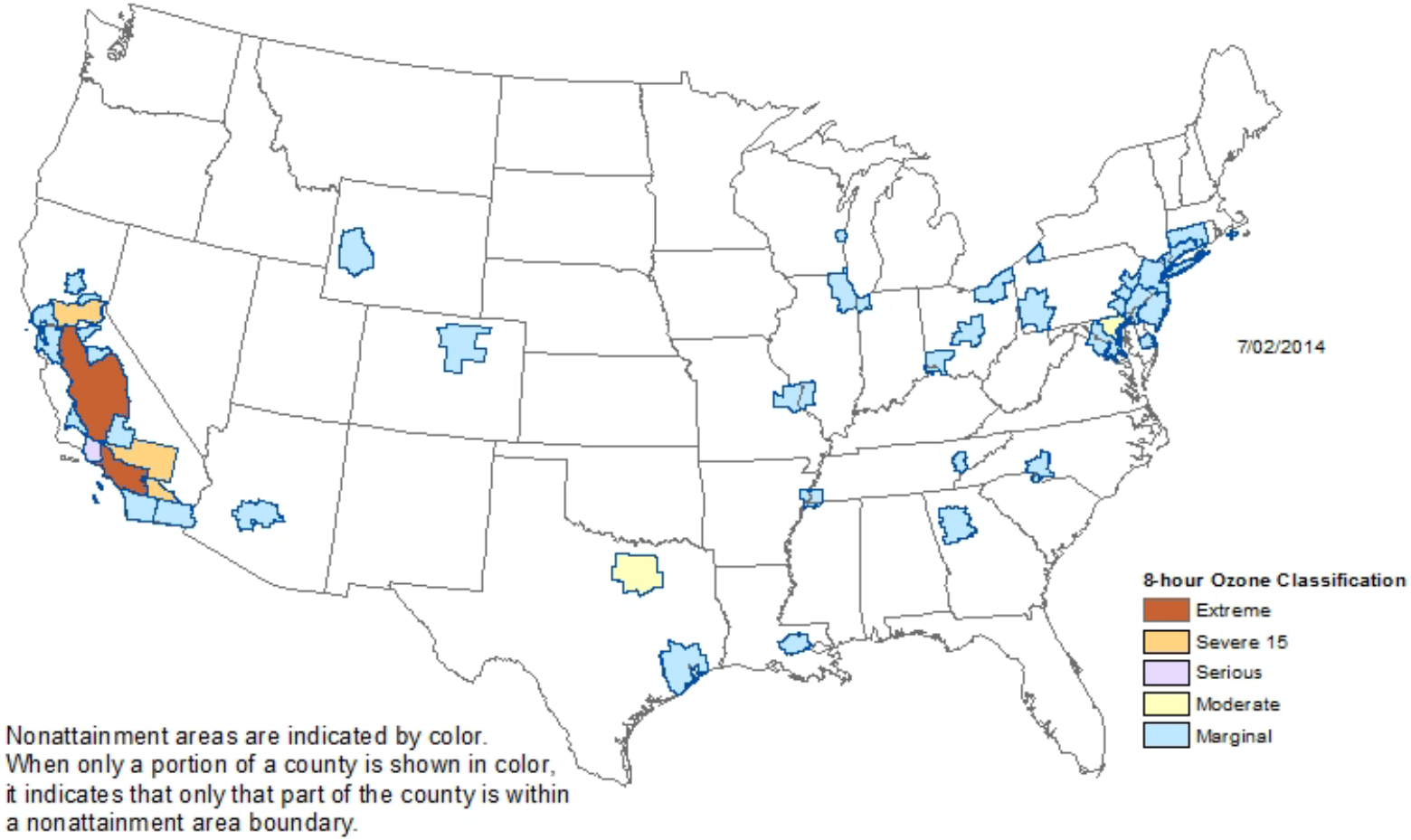
Others are less controllable, quasi-natural, and/or less well-understood - these may grow within the CAA planning timeframes

EPA national Ozone Standard

- Measured at ground station sites, highest 8-hour average each day
- 4th highest values each year are averaged over specific 3-year periods to determine compliance (e.g., 2007-09, 2008-10)
  - Statistic is called a "Design Value" for that site for that time period
- Current Ozone health standard level is 75 ppb
- EPA proposed a revised Ozone health standard in a range of 65 to 70 ppb
- EPA proposed a secondary Ozone standard for ecosystem protection at the same range
  - Proxy for a growing season / daylight hours-weighted cumulative metric

Counties with Monitors Violating Primary 8-Hour Ground-Level Ozone Standard (0.075 ppb)

(Based on 2011-2013 Air Quality Data)

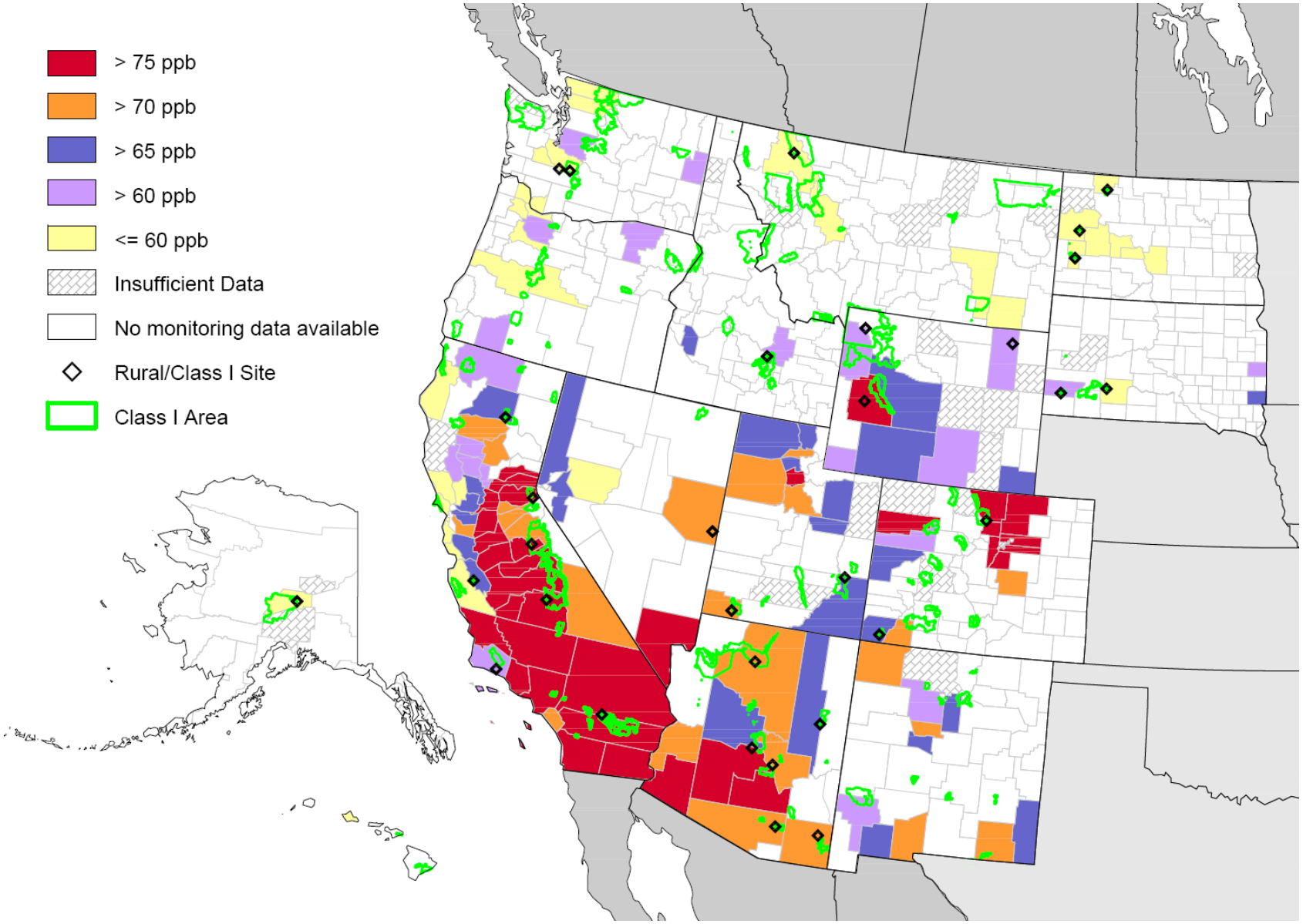


http://www.epa.gov/airquality/greenbook/map8hr_2008.html

What are (some of) the sources and control issues in the West related to new Ozone standard(s)?

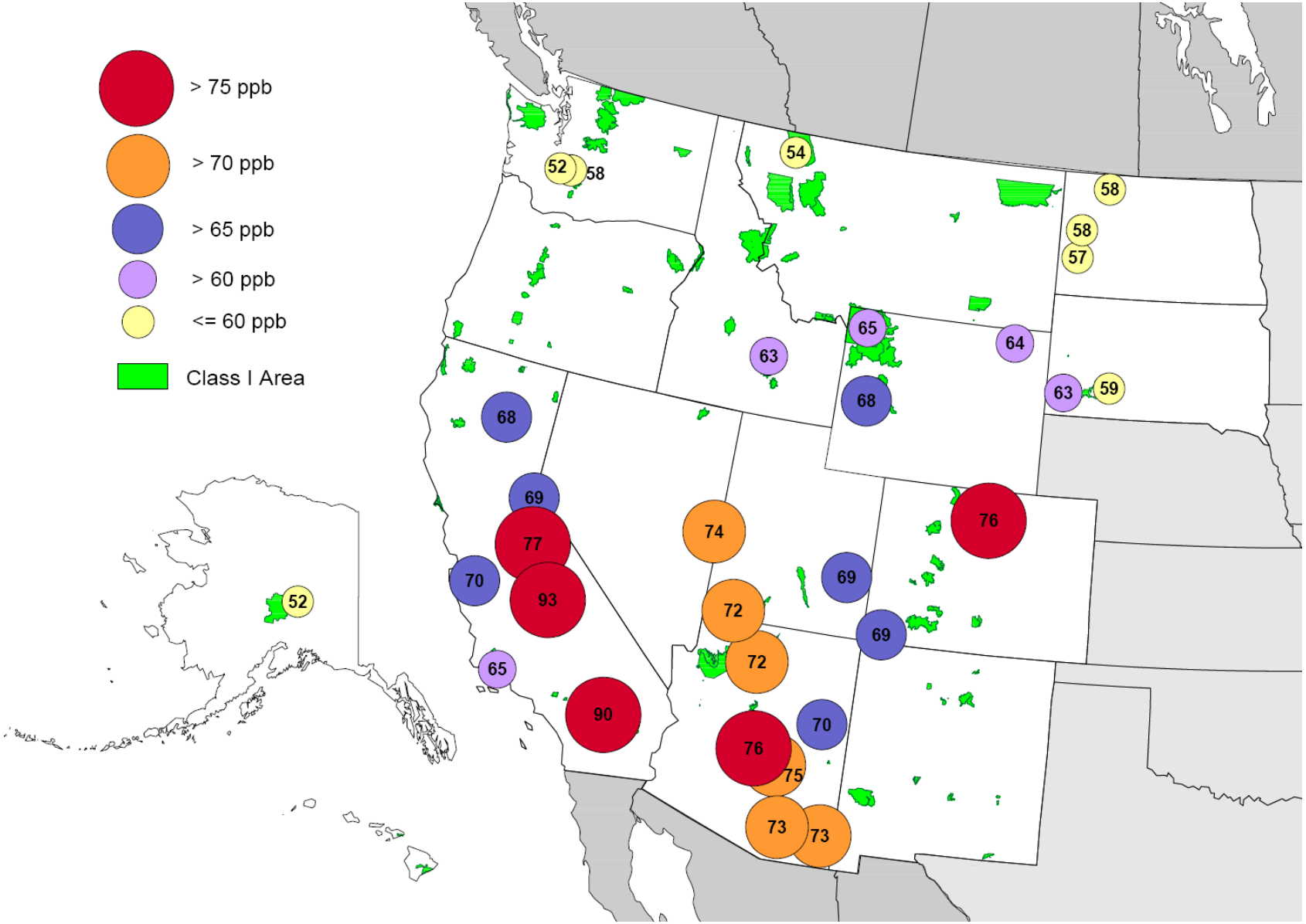
- Urban and rural reactivity
- Transport and formation – how much / how important?
- Public lands with large biogenic emissions and fire activity
  - How to characterize for effects of drought and climate variation ?
- Federal and state mobile fuel and tailpipe controls
- Upstream Gas NSPS rules in place in 2015
  - Industry practices changing rapidly, e.g., green completions
- Point sources (dominated by EGUs for SO_2, NO_x)
  - Significant NO_x BART by ~2018
  - Less coal-fired electricity supply due to climate change rule?
  - 17+ million acres of public lands leased in last 5 years for O&G exploration and production

3-year Average 4th Highest 8-Hour Ozone value by County 2011-2013



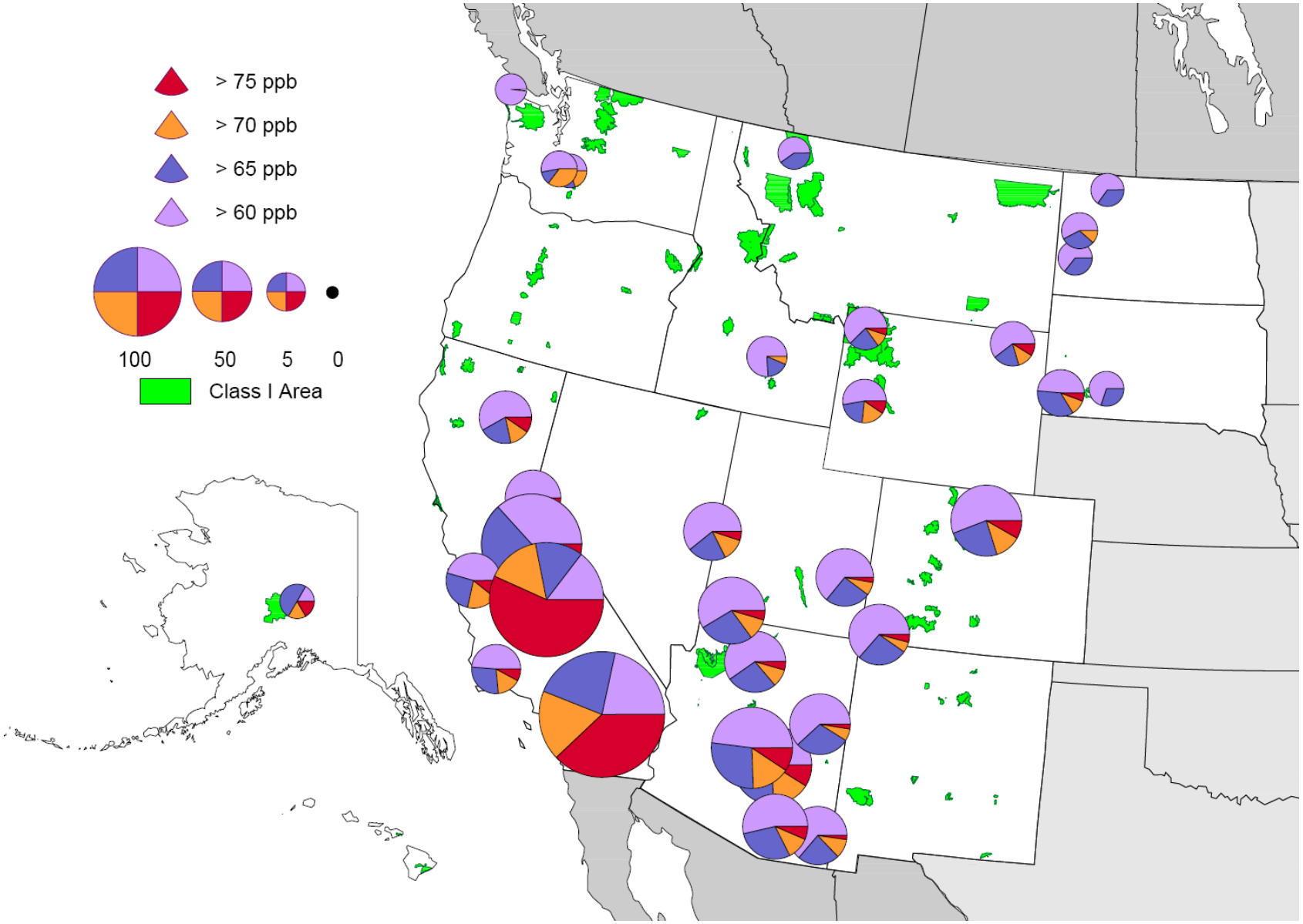
AQS Federal Reference Method data from the monitoring site in each County with the highest Ozone values

3-year Average 4th Highest 8-Hour Ozone value for Rural/Class I Sites 2011-2013



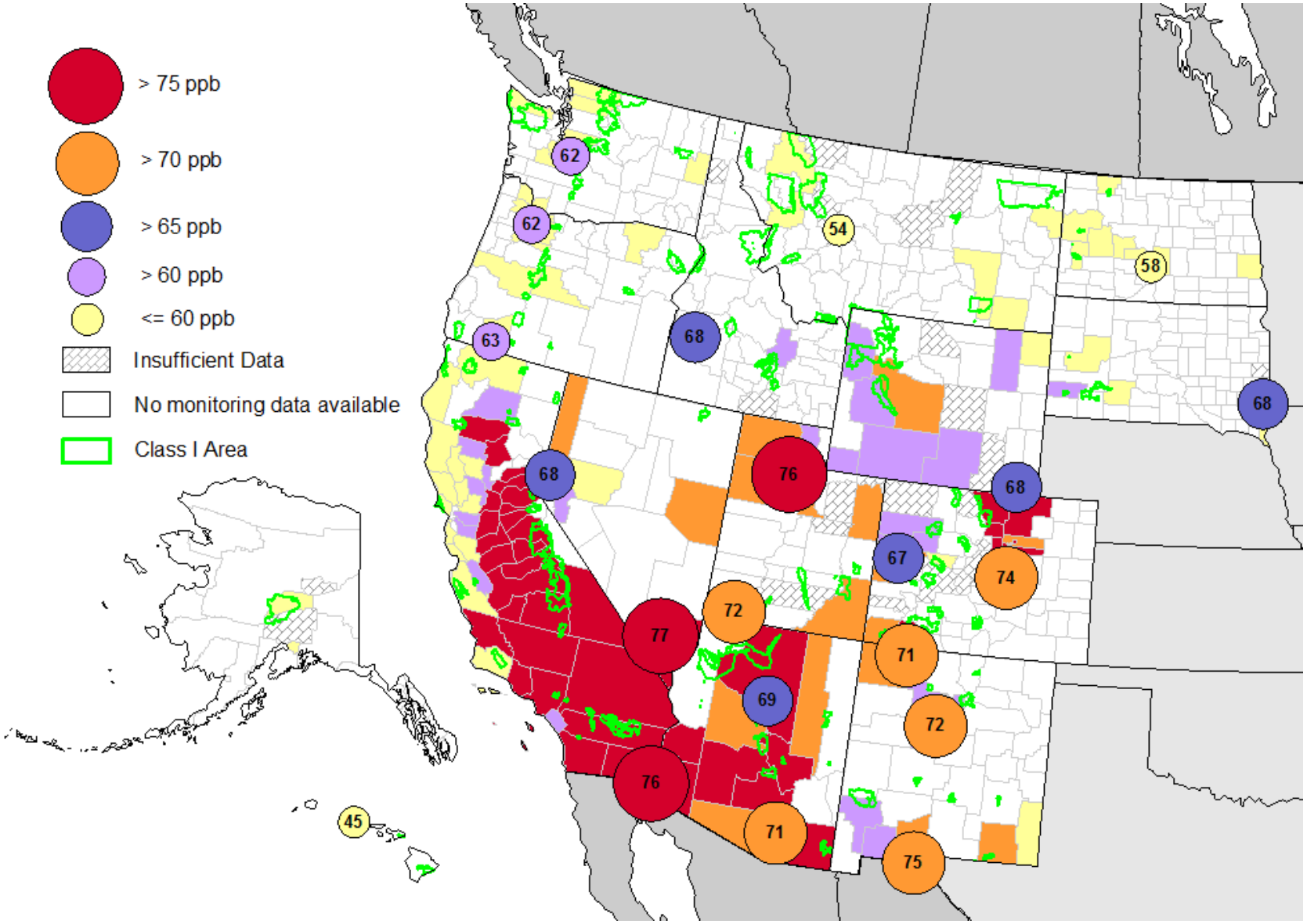
AQS Federal Reference Method data from rural or Class I area monitoring sites

Average Annual Count of Days with 8-Hour Ozone Averages >60 ppb for Rural/Class I Monitoring Sites – 2004 through 2013



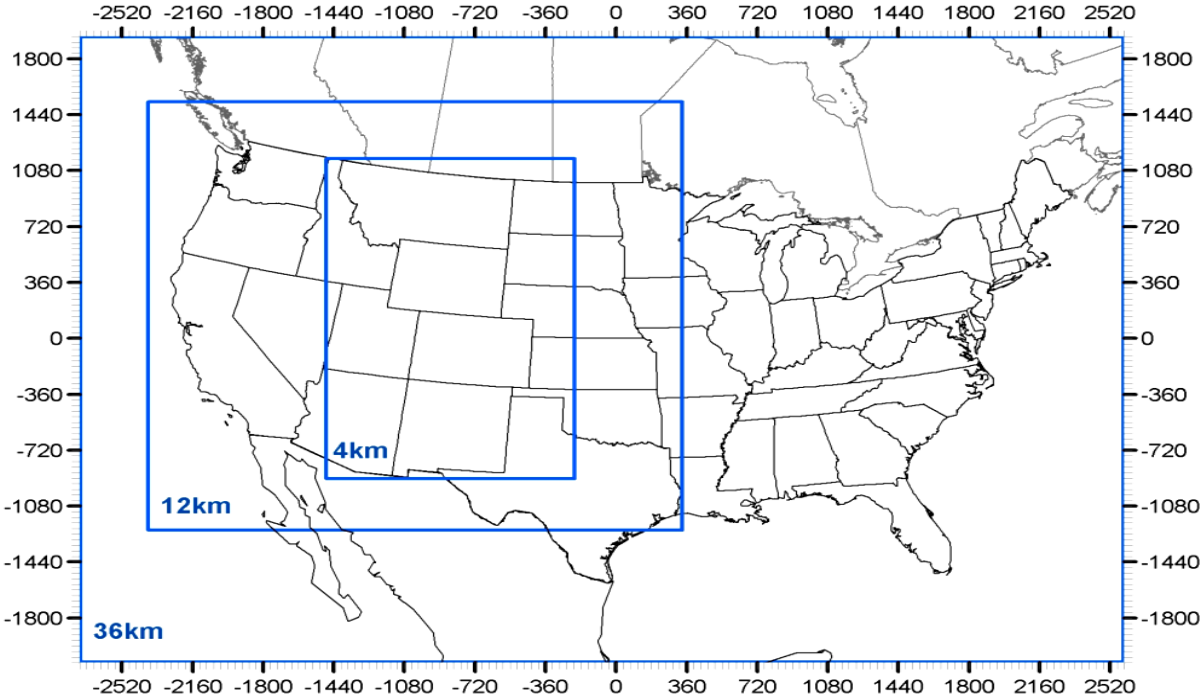
AQS Federal Reference Method data from rural or Class I area monitoring sites

3-year Average 4th Highest 8-Hour Ozone Design Value for Selected Urban Counties currently in Attainment – 2011 through 2013



AQS Federal Reference Method data from the monitoring site in each County with the highest Ozone values

WestJumpAQMS Area

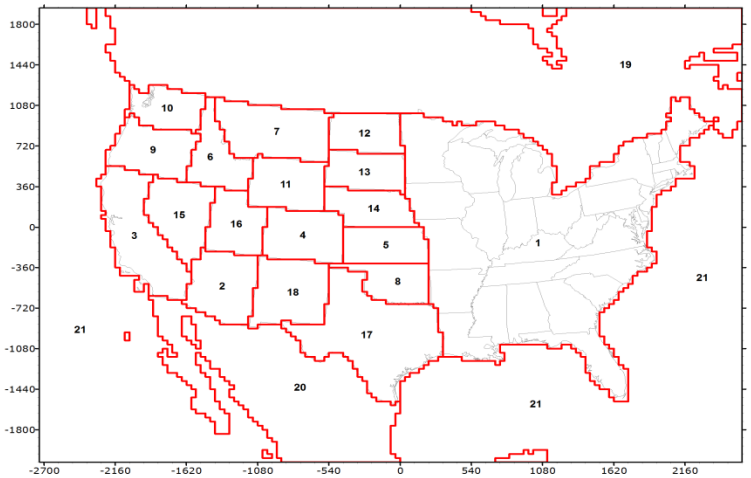


Modeling Domain

36km: 148 x 112 (-2736, -2088) to (2592, 1944)
12km*: 227 x 230 (-2388, -1236) to (336, 1542)
04km*: 317 x 515 (-1480, -904) to (-212, 1156)

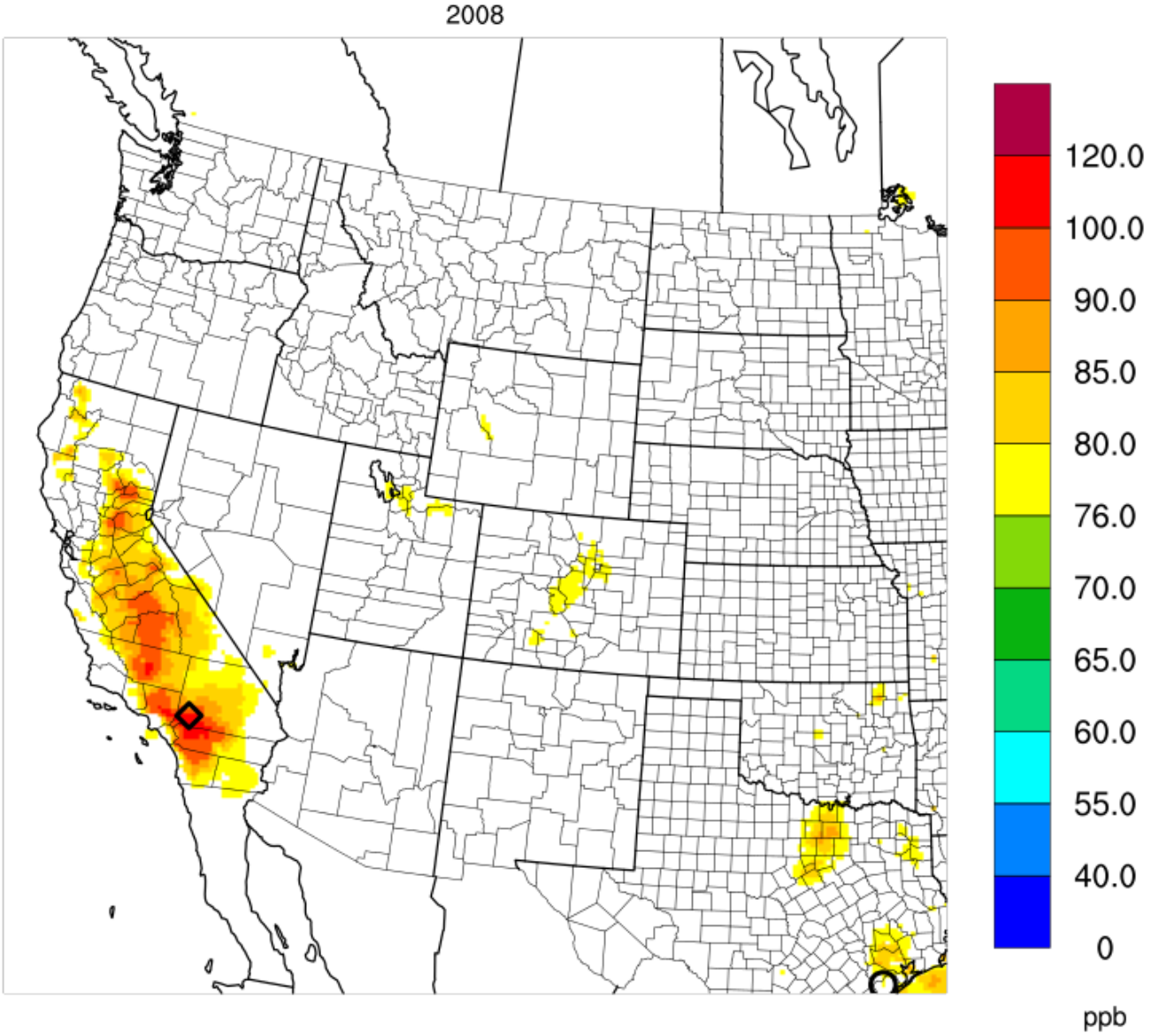
* includes buffer cells

Source Regions used in the State-Specific APCA ozone and PSAT particulate matter 2008 source apportionment modeling for WestJumpAQMS.



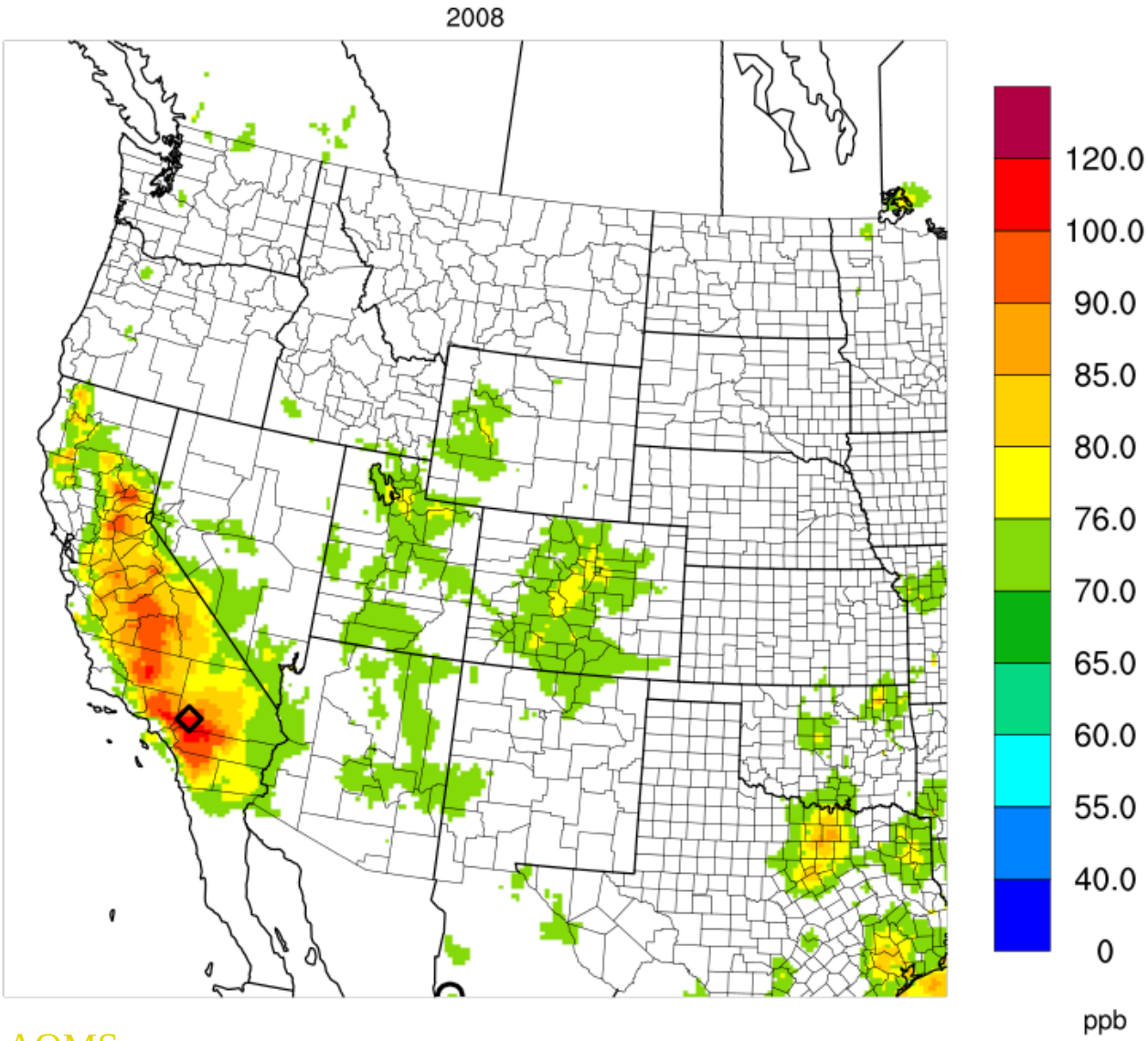
Source: WestJumpAQMS

Ozone Modeled Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 76 ppb



Source: WestJumpAQMS

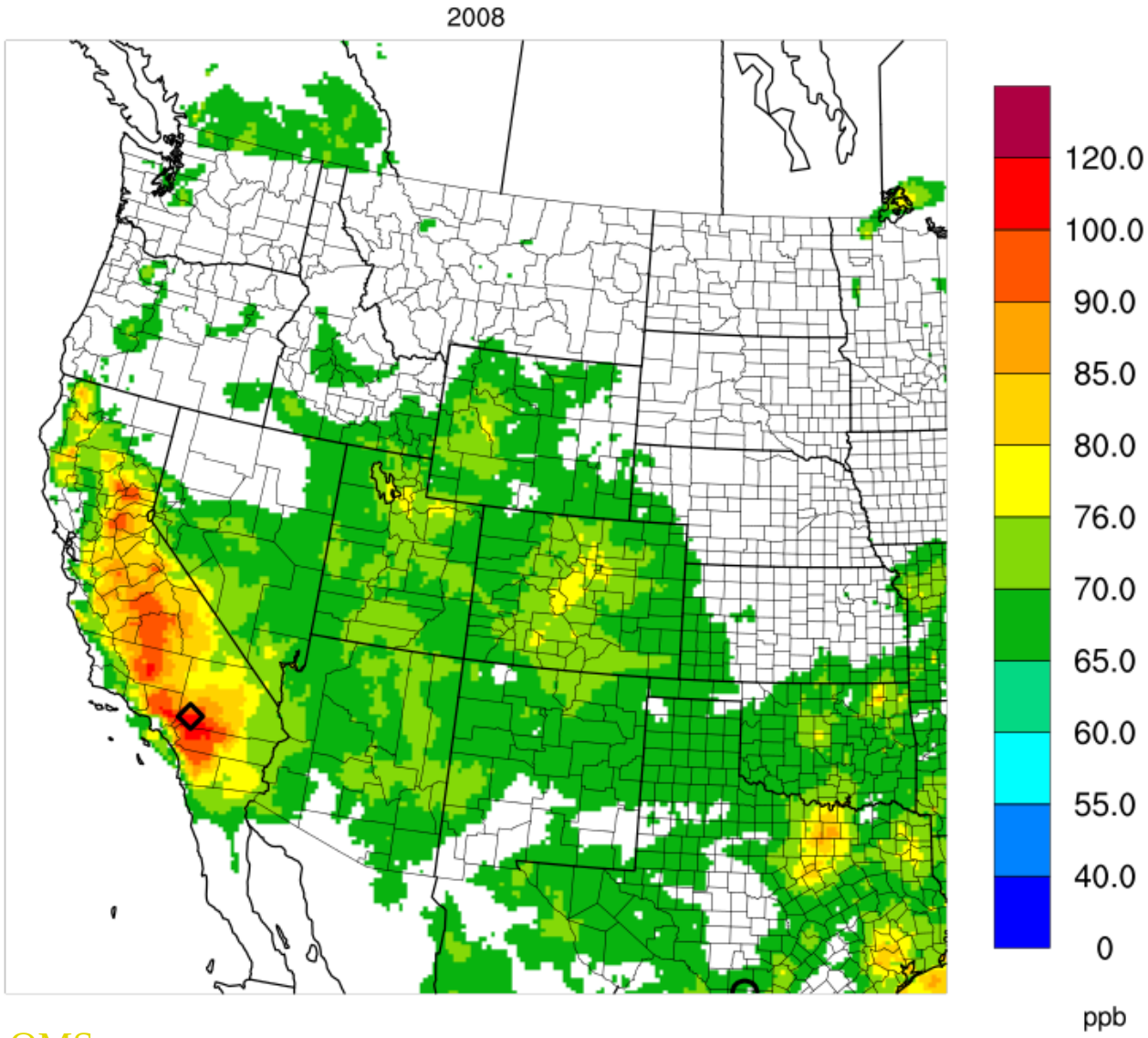
Ozone Modeled Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 70 ppb



Source: WestJumpAQMS

○ Min(107,1) = 70.00, ◇ Max(45,67) = 113.30

Ozone Modeled Attainment Test Software – Unmonitored Area Analysis with Design Value (2006-2010) ≥ 65 ppb



Source: WestJumpAQMS

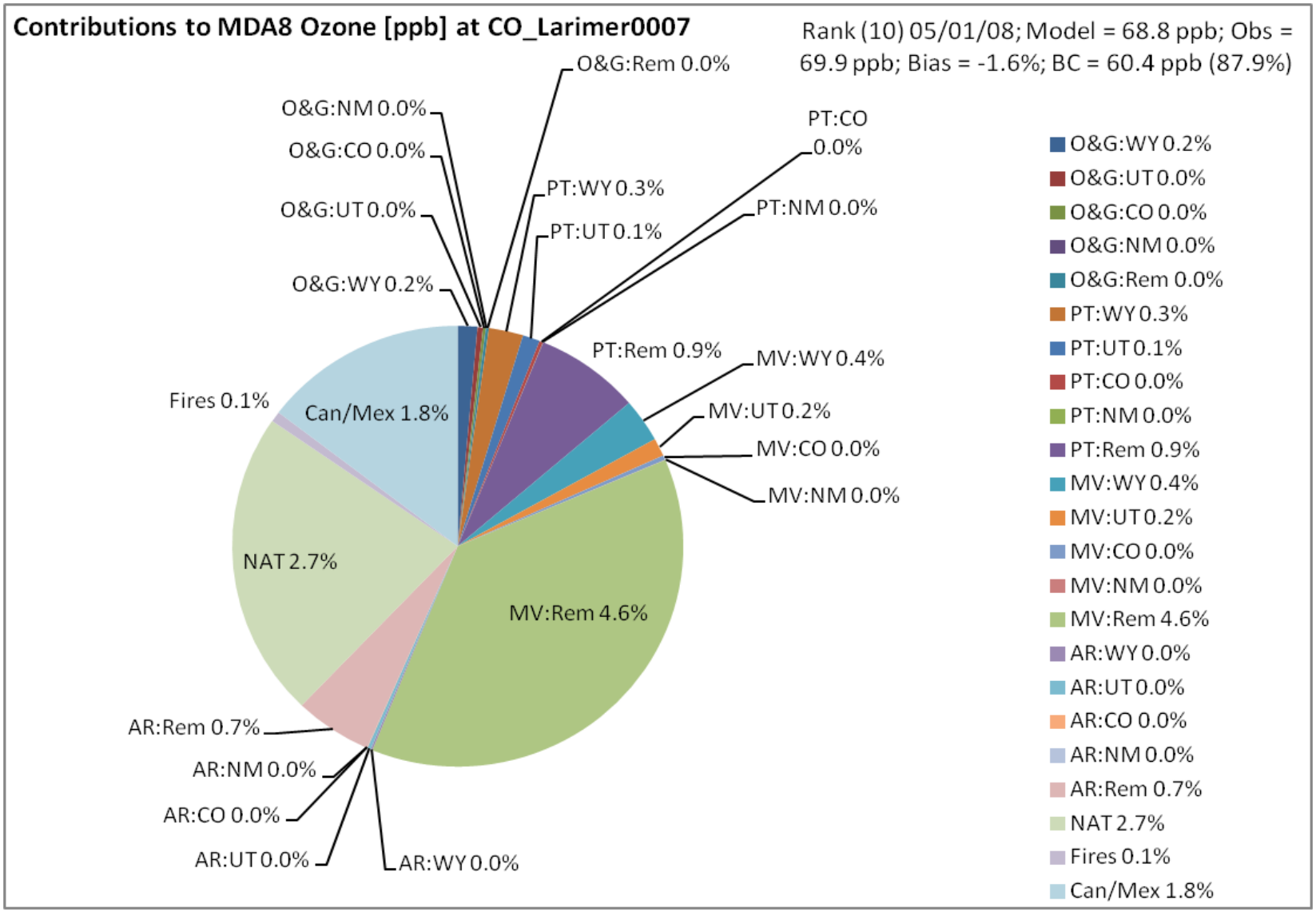
○ Min(177,1) = 65.00, ◇ Max(45,67) = 113.30

Regional modeling of U.S. sources for air quality planning, to identify sources and assess controls for contributing sources, will continue within the West

Inter-jurisdictional transport contributions are more important with more stringent standards and air quality goals

The process for analyzing emissions controls is well-established, practiced by all air regulatory agencies, and EPA will need to work with western air agencies to develop methodologies and a system for this round of analysis

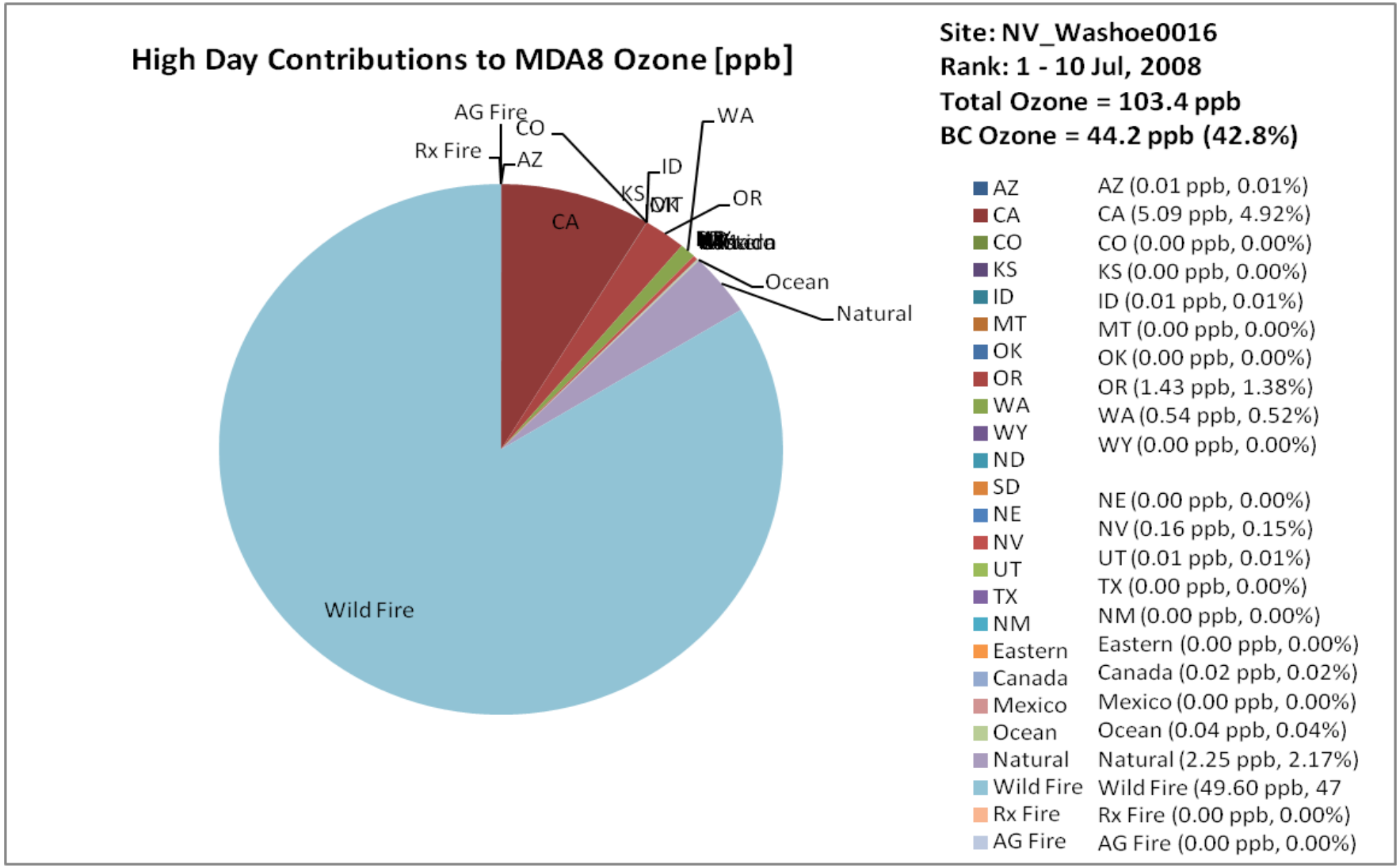
Contributions to Ozone at Rocky Mountain National Park



Source: WestJumpAQMS

State Contributions to Modeled DMAX8 Ozone Days

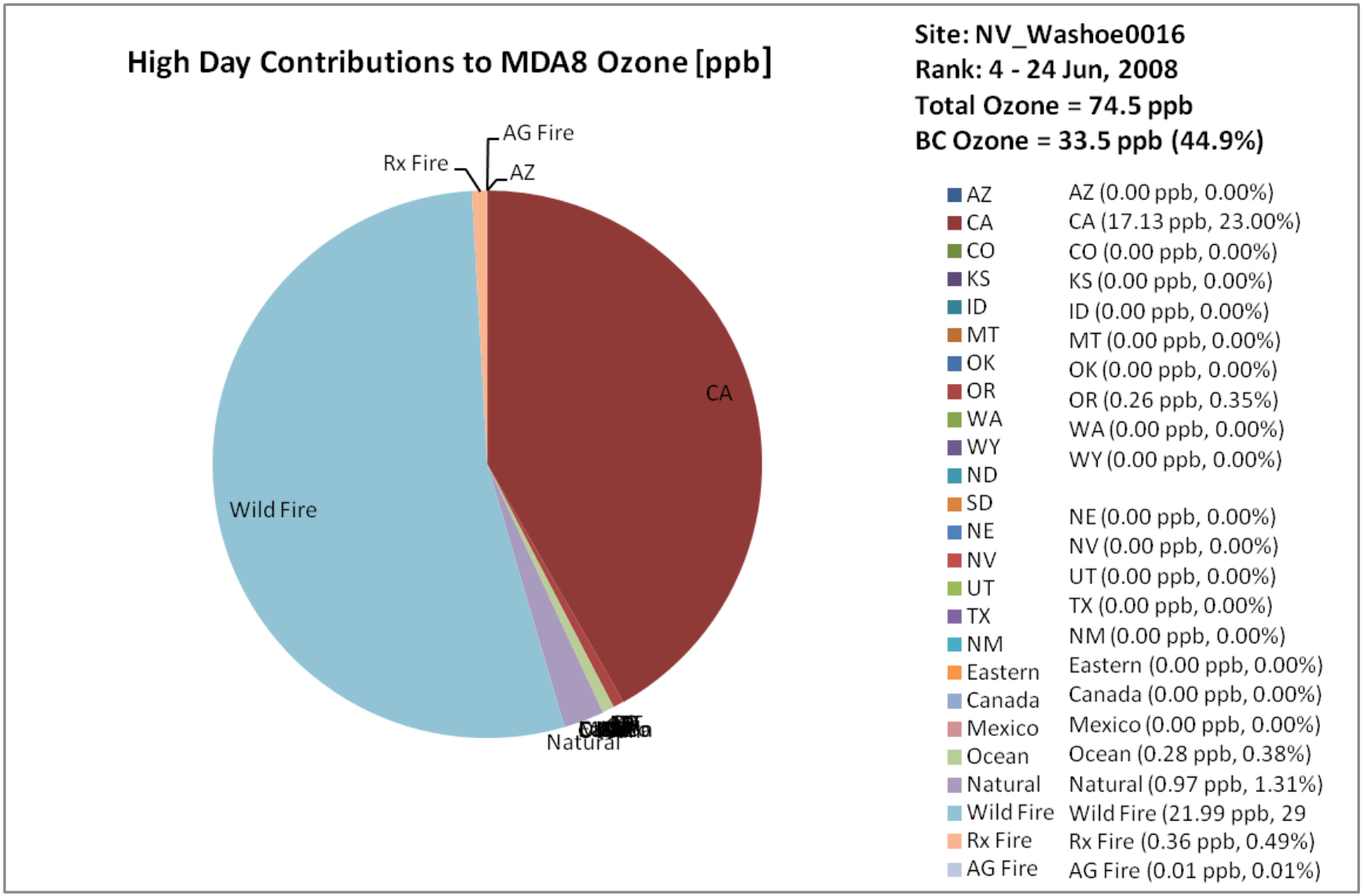
Highest Modeled DMAX8 Day at "Reno3" on State Street, Reno



Source: WestJumpAQMS

State Contributions to Modeled DMAX8 Ozone Days

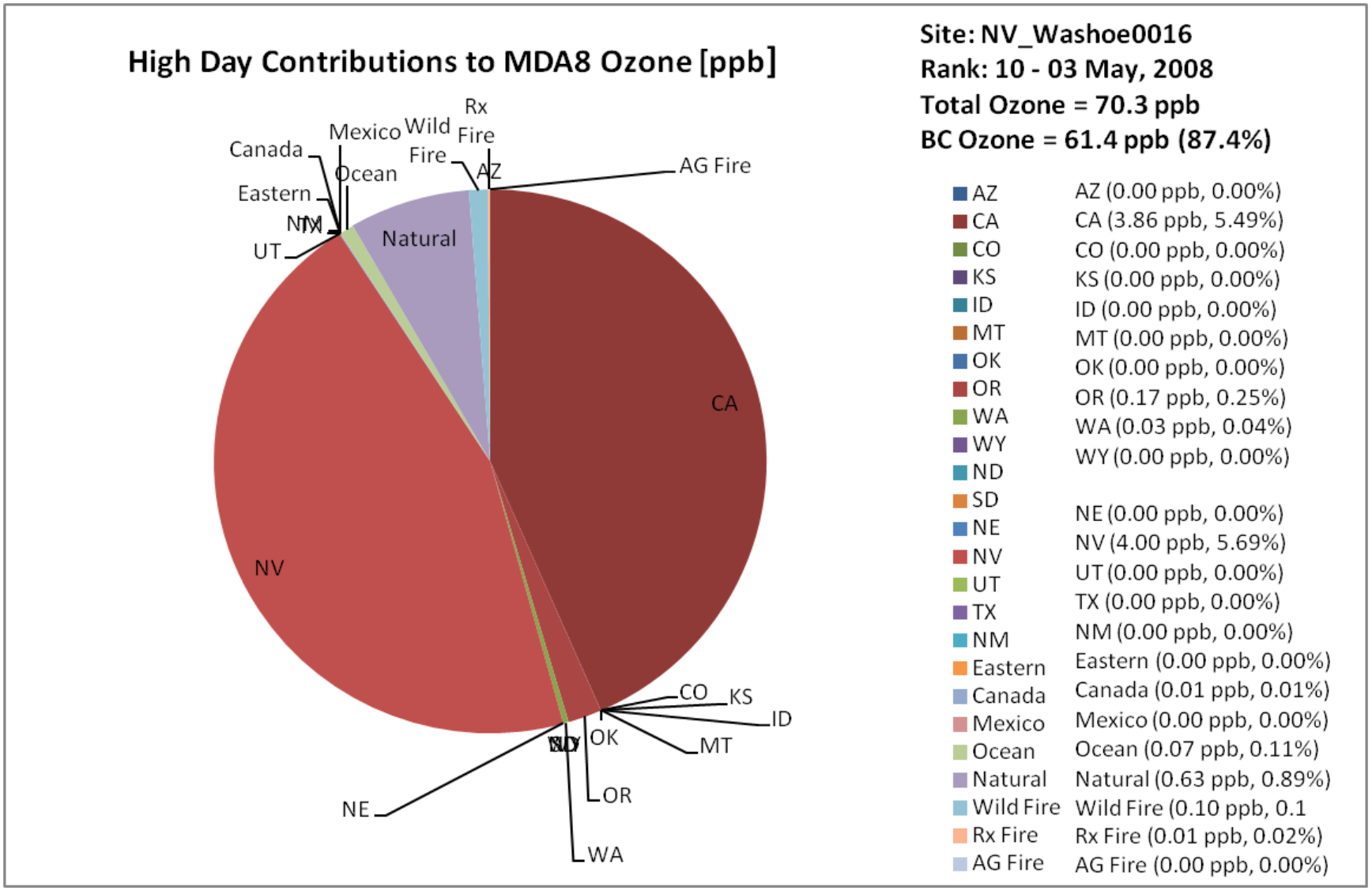
4th Highest Modeled DMAX8 Day at "Reno3" on State Street, Reno



Source: WestJumpAQMS

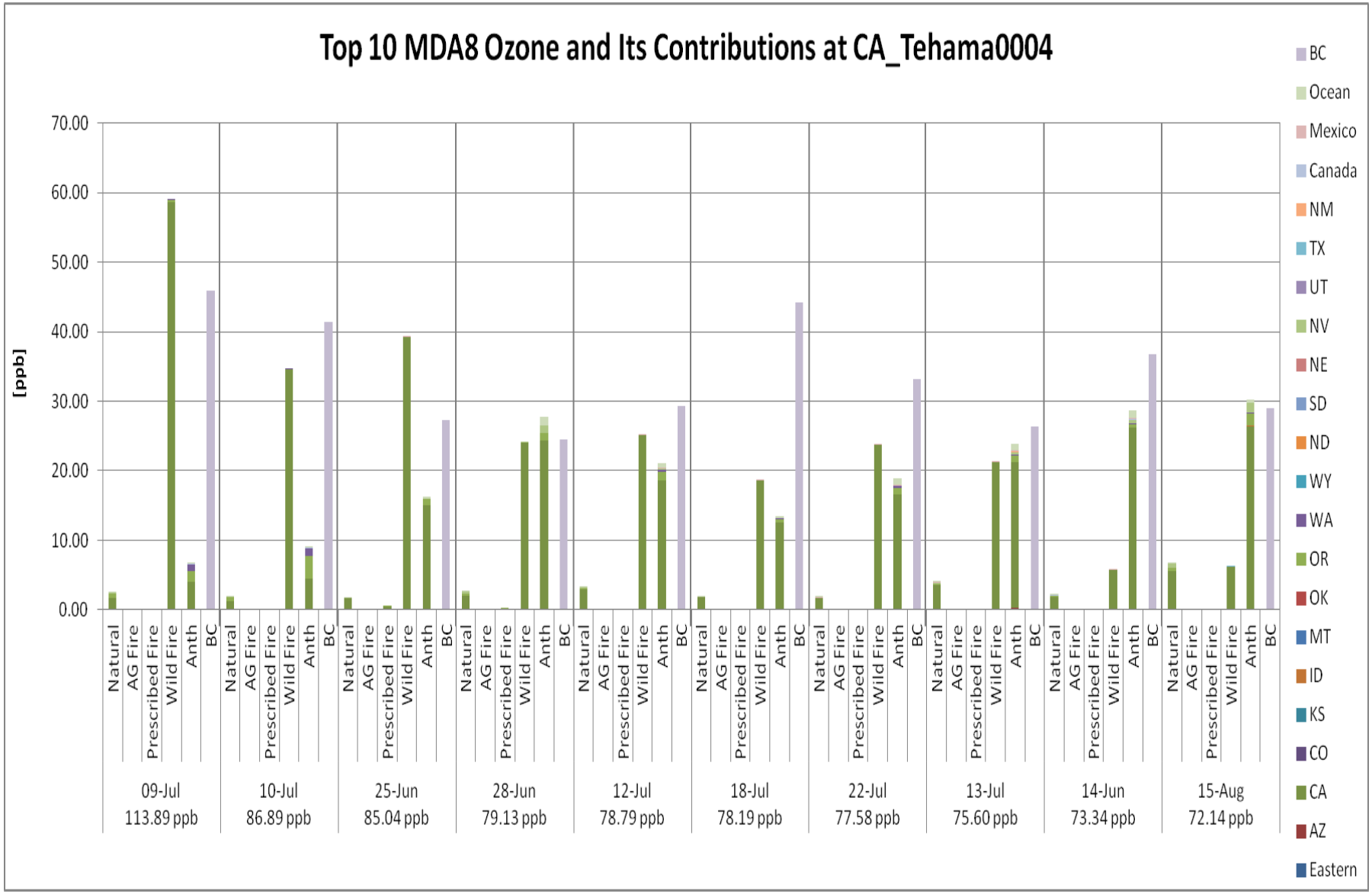
State Contributions to Modeled DMAX8 Ozone Days

10th Highest Modeled DMAX8 Day at "Reno3" on State Street, Reno



Source: WestJumpAQMS

Contributions to 2008 Ozone at Tuscan Buttes



Source: WestJumpAQMS

Five Ozone Planning Needs

1. Ozone NAAQS planning – requires photochemical modeling for SIP attainment demonstrations for nonattainment areas.
2. Ozone transport SIPs –photochemical source apportionment modeling can be used to quantify U.S. Ozone transport between states and jurisdictions.
3. Identification of Ozone exceptional events caused by stratospheric intrusion and wildfires – requires observations & data analysis, supplemented with global/regional scale photochemical models and regression models.
4. Identification of international transport of Ozone for §179B demonstrations: requires nested global and regional scale photochemical modeling to evaluate international transport of Ozone.
5. Identification of §182 Rural Transport Areas – combination of data analysis and photochemical modeling.

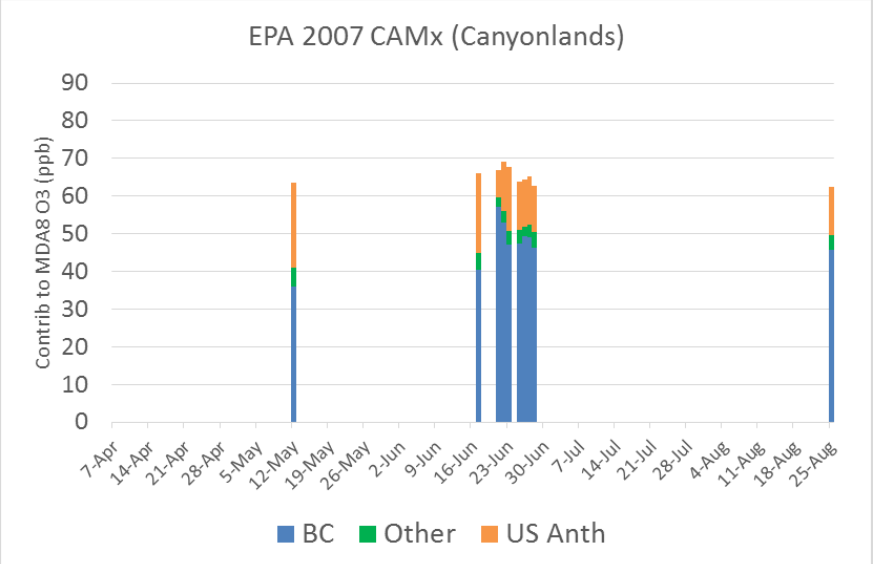
In the West under CAA, whom to do which ?

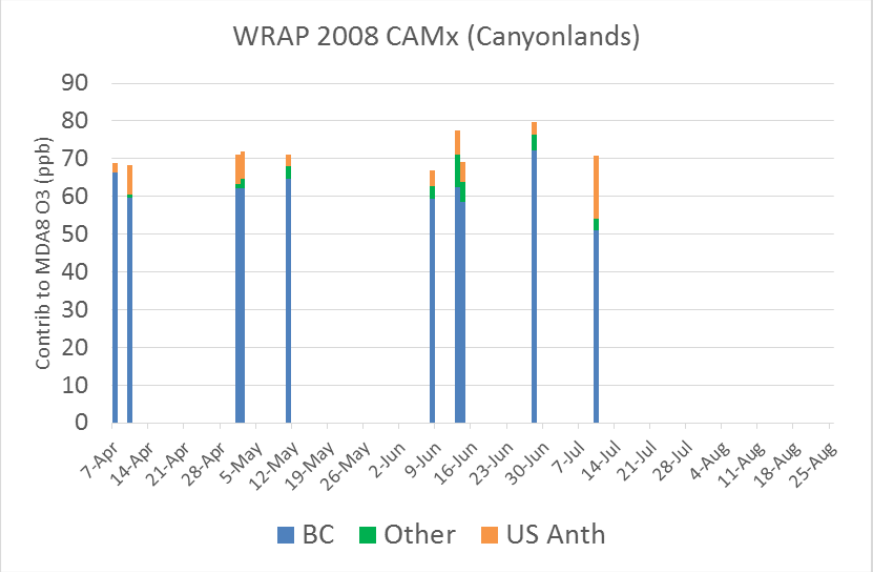
Alone or together ?

- States/Locals
- Regional
- Federal

Uncertainty in model estimates of U.S. Background

CAMx simulations for 2007 and 2008 at Canyonlands National Park – Eastern UT





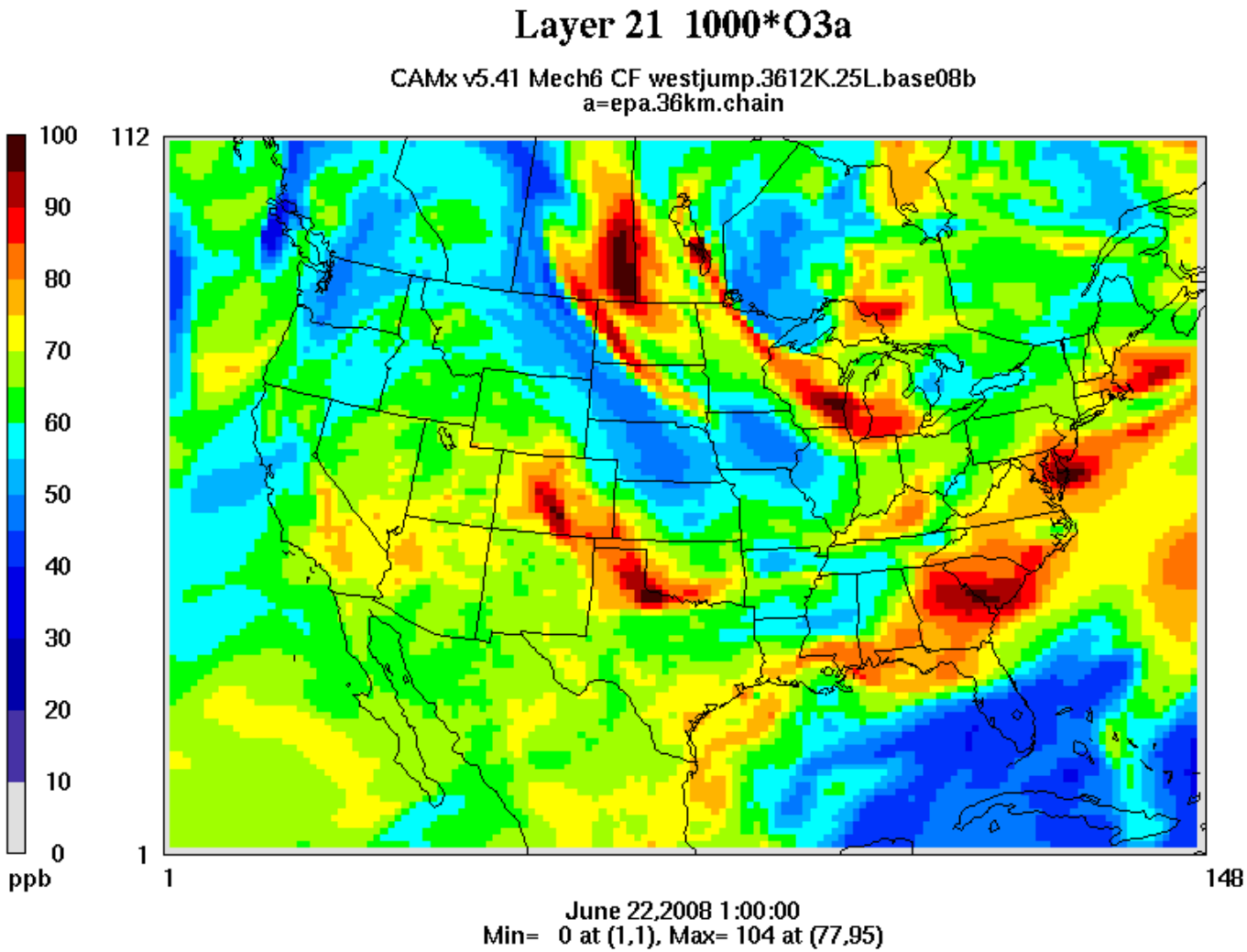
EPA 2007 CAMx model:
BC contributions of 36-57 ppb; still substantial U.S. anthropogenic contribution to O3.

WRAP 2008 CAMx model:
BC contributions of 50-72 ppb, much larger than OAQPS modeling.

Same methodology - reasons for modeled differences are not fully understood

O_3 in upper free troposphere is determined primarily by transport from boundaries

O_3 animation in Layer 21 (6-7 km) June 22 through July 4, 2008



http://views.cira.colostate.edu/tsdw/

Background / Boundary Conditions evaluations:

MOZART
GEOS-Chem
(now adding AM3)

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Observations vs. Boundary Condition / Background Monthly Mean MDA8 Ozone

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Animations of Modeled Daily Max Concentrations

Background contribution
Difference plots for background minus U.S. sources

O3, NO_x, CO, $PM_{2.5}$

++

Animations of Daily Max Concentrations for O3 and Dust Boundary Tracers

Boundary conditions plots:

O3, Ox (O3+NO+NO2+PAN)
Coarse Dust (CCRS), Fine PM (FPRM+FCRS)

Applications of global model data as regional modeling boundary conditions need to codified between the science and regulatory communities

Current, clear, and unambiguous scientific findings are needed about uncertainty, assessment methods, and applications of global modeling products as boundary conditions and to clarify transport within the U.S.

Resources and usable tools for applying data and knowledge from global models and observational studies across the West are likely beyond the scope of most/many air regulatory agencies – how will that work be done and when, and whom will be responsible for communicating those results?

WRF Meteorological Model					CAMx/CMAQ Air Quality Model		
WRF Layer	Sigma	Pressure (mb)	Height (m)	Thickness (m)	CAMx Layer	Height (m)	Thickness (m)
37	0.0000	50.00	19260	2055	25	19260.0	3904.9
36	0.0270	75.65	17205	1850			
35	0.0600	107.00	15355	1725	24	15355.1	3425.4
34	0.1000	145.00	13630	1701			
33	0.1500	192.50	11930	1389	23	11929.7	2569.6
32	0.2000	240.00	10541	1181			
31	0.2500	287.50	9360	1032	22	9360.1	1952.2
30	0.3000	335.00	8328	920			
29	0.3500	382.50	7408	832	21	7407.9	1591.8
28	0.4000	430.00	6576	760			
27	0.4500	477.50	5816	701	20	5816.1	1352.9
26	0.5000	525.00	5115	652			
25	0.5500	572.50	4463	609	19	4463.3	609.2
24	0.6000	620.00	3854	461	18	3854.1	460.7
23	0.6400	658.00	3393	440	17	3393.4	439.6
22	0.6800	696.00	2954	421	16	2953.7	420.6
21	0.7200	734.00	2533	403	15	2533.1	403.3
20	0.7600	772.00	2130	388	14	2129.7	387.6
19	0.8000	810.00	1742	373	13	1742.2	373.1
18	0.8400	848.00	1369	271	12	1369.1	271.1
17	0.8700	876.50	1098	177	11	1098.0	176.8
16	0.8900	895.50	921	174	10	921.2	173.8
15	0.9100	914.50	747	171	9	747.5	170.9
14	0.9300	933.50	577	84	8	576.6	168.1
13	0.9400	943.00	492	84			
12	0.9500	952.50	409	83	7	408.6	83.0
11	0.9600	962.00	326	82	6	325.6	82.4
10	0.9700	971.50	243	82	5	243.2	81.7
9	0.9800	981.00	162	41	4	161.5	64.9
8	0.9850	985.75	121	24			
7	0.9880	988.60	97	24	3	96.6	40.4
6	0.9910	991.45	72	16			
5	0.9930	993.35	56	16	2	56.2	32.2
4	0.9950	995.25	40	16			
3	0.9970	997.15	24	12	1	24.1	24.1
2	0.9985	998.58	12	12			
1	1.0000	1000	0			0	

37 Vertical layer interface definition for WRF simulations (left most columns), and approach for reducing to 25 vertical layers for CAMx/CMAQ by collapsing multiple WRF layers (right columns).

CAMx (Version 5.41) and CMAQ (Version 5.0.1) model configurations for WestJumpAQMS

Science Options	Configuration	Details
Model Codes	CAMx V5.41 – November 2012 Release CMAQ V5.0.1 – July 2012 Release	CAMx V6.00 was released in May 2013 CMAQ V5.0.1 is latest version
Horizontal Grid Mesh	36/12/4 km	Many CAMx runs done using just 36/12 km grids
36 km grid	148 x 112 cells	36 km CONUS domain
12 km grid	239 x 206 cells	12 km WESTUS domain
4 km grid	DSAD 4-km domain	Also set up 4 km IAD as a one-way nest
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 thickness ~24- m. Model top at ~19-km above MSL
Grid Interaction	36/12/4 km two-way nesting for CAMx	One-way grid nesting for CMAQ
Initial Conditions	10 day spin-up on 36 km grid	Clean initial conditions
Boundary Conditions	36 km from global chemistry model	MOZART GCM used, GEOS-Chem GCM BCs used in sensitivity test.
Emissions		
Baseline Emissions Processing	SMOKE, MOVES and MEGAN	
Sub-grid-scale Plumes	Plume-in-Grid not used, waiting for improvements in CAMx V6.1	CMAQ has no subgrid-scale Plume-in-Grid module
Chemistry		
Gas Phase Chemistry	CB05	CB6 sensitivity test
Meteorological Processor	WRFCAMx and MCIP 4.1	Compatible with CAMx V5.4 and CMAQ V5.0.1
Horizontal Diffusion	Spatially varying	K-theory with Kh grid size dependence
Vertical Diffusion	CMAQ-like in WRF2CAMx	ACM2 for CMAQ V5.0.1
Diffusivity Lower Limit	Kz_min = 0.1 to 1.0 m^2/s or 2.0 m^2/s	
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme (CAMx) M3Dry Pleim dry deposition (CMAQ)	Zhang 2003
Wet Deposition	CAMx and CMAQ-specific formulation	rain/snow/graupel/virga
Numerics		
Gas Phase Chemistry Solver	Euler Backward Iterative (EBI) -- Fast Solver	EBI implemented in both CAMx and CMAQ
Vertical Advection Scheme	Implicit scheme w/ vertical velocity update (CAMx) New vertical velocity scheme (CMAQ)	
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	PPM in both CAMx and CMAQ
Integration Time Step	Wind speed dependent	~0.1-1 min (4 km), 1-5 min (1 -km), 5-15 min (36 km)