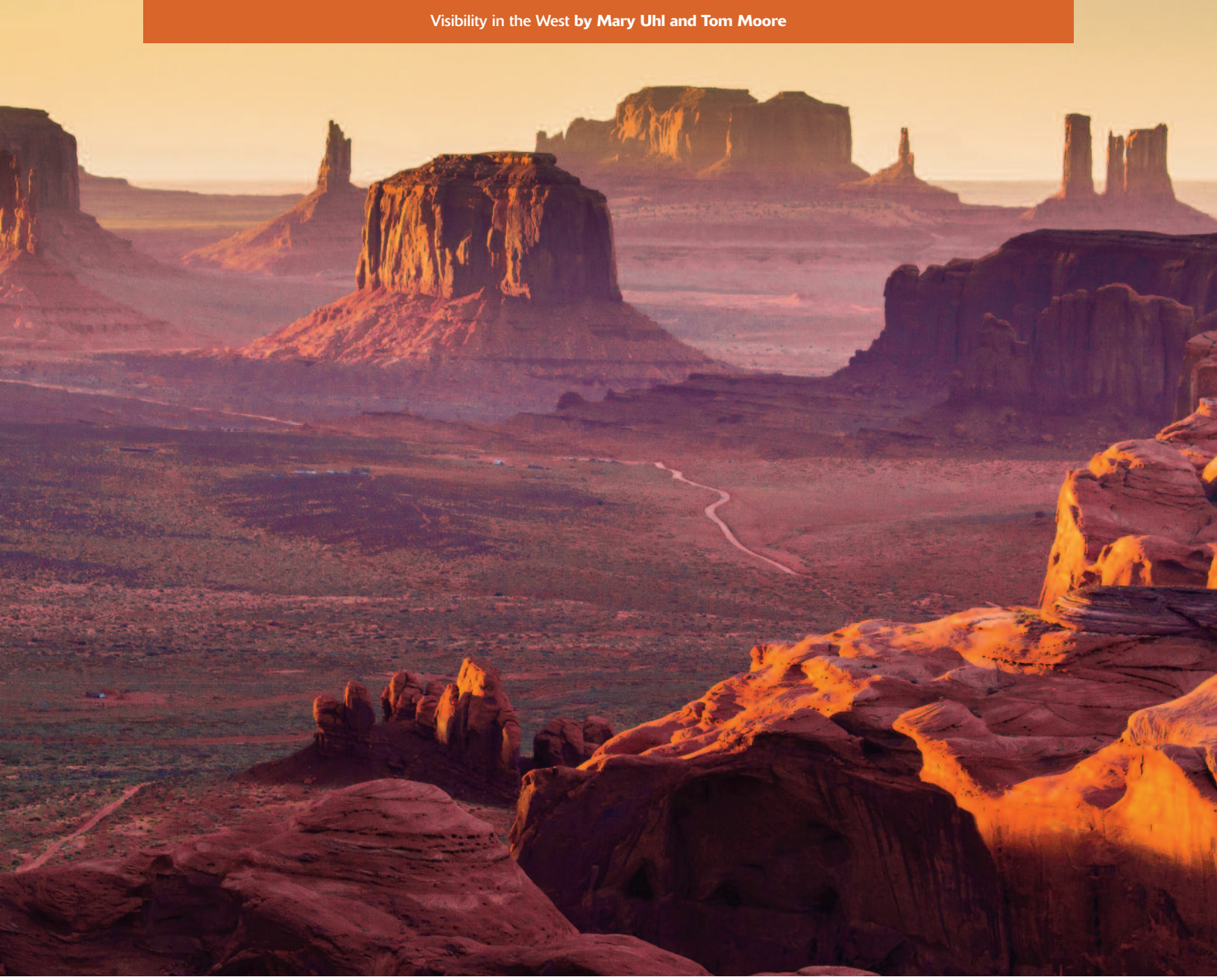

Visibility, Haze, and Background Air Pollution in the West

An overview of visibility issues in the Western United States.

Unimpeded visibility in the Western United States is strongly valued because of the many wilderness areas and national parks. When western vistas and scenic viewpoints are obscured by pollution or haze, visitors and residents are robbed of a unique western experience to see landmarks that are over 100 miles away. Visitors to western parks and wilderness areas will often remark and remember the view from a well-known scenic point as a highlight of a long-planned trip. Western states have significant interest in protecting visibility to ensure that visitor numbers and tourism continue to play a positive role in local, state, and regional economies. With 118 of the 156 congressionally-mandated Class I areas located in the West, this 15-state region hosts more parks and wilderness areas than any other region of the United States.

Western states, tribes, industry, and environmental interests first began organizing as a group focused on visibility issues in 1991 with the advent of the Grand Canyon Visibility Transport Commission. Five years later, the commission issued recommendations to the U.S. Environmental Protection Agency (EPA) to improve visibility in western states. The recommendations were the foundation for further work to determine the causes of regional haze in the West and for states to eventually develop State Implementation Plans for federal visibility rules first mandated for development by EPA in the 1977 U.S. Clean Air Act amendments. Western states and tribes organized the follow-up work to the commission under the Western Regional Air Partnership (WRAP), which was integrated into the Western States Air Resources Council (WESTAR) in 2014 to become WESTAR–WRAP. A map of the WESTAR–WRAP region is shown in Figure 1.

Figure 1. WESTAR–WRAP region.

EPA's 1999 Regional Haze Rule required western states and tribes to work together through the WRAP to develop plans to improve visibility on days with the worst visibility and ensure that best visibility days were maintained. The first set of plans were due in 2007, and subsequent plans are due at 10-year intervals. The West has unique challenges and issues for improving visibility, including the prevalence and increasing trend in wildfires, international transport, stratospheric ozone intrusions, winter ozone formation, population growth and national park visitation, as well as increases in oil and gas production and accelerating climate change impacts resulting in longer seasons of photochemical reactivity and ozone production. Despite these challenges, the West has seen average visibility improve at all western Class I areas (see Figure 2).

Sources of Pollution

Sources of pollutants that affect haze in the West include controllable anthropogenic emissions, which are trending downward due to market forces and regulatory programs. Many coal-fired electrical generating units (EGUs) in the West, for example, have either been retired or retrofitted with control technologies that significantly reduce pollution. Mobile source emissions have been reduced as a result of federal controls, but could rise due to population increases. Oil and gas production emissions are declining on a per-unit basis due to regulations, the desire of industry to recover product and market forces, but an increase in commodity prices could see increased production that could lead to increases in emissions from this sector. Overall, anthropogenic emissions that can be controlled are declining as suggested in the reasonable control requirements under the Regional Haze Rule.

The picture for background sources, including international transport, and natural sources affecting visibility appears hazier (see sidebar "Background Sources in the West"). The West has seen significant increases in areas burned by wildfire over the last decade, resulting in weeklong smoke events that affect local communities and transport the components of haze over long distances. A western state now commonly sees several days to several weeks of hazy conditions in the summer due to wildfires, with many of these smoky days attributable to smoke from hundreds or thousands of miles away. International transport emissions are also increasing due to increasing world population and increase in electricity demand from rapidly-modernizing regions of the world. Natural emissions from dust and sea salt that contribute to haze are increasing and will continue to increase with exacerbation of western drought, the scarcity of water in the west and evaporation from warmer oceans due to climate change.

These trends in emissions affect rural and urban areas of the west in strikingly different patterns related to haze. Urban

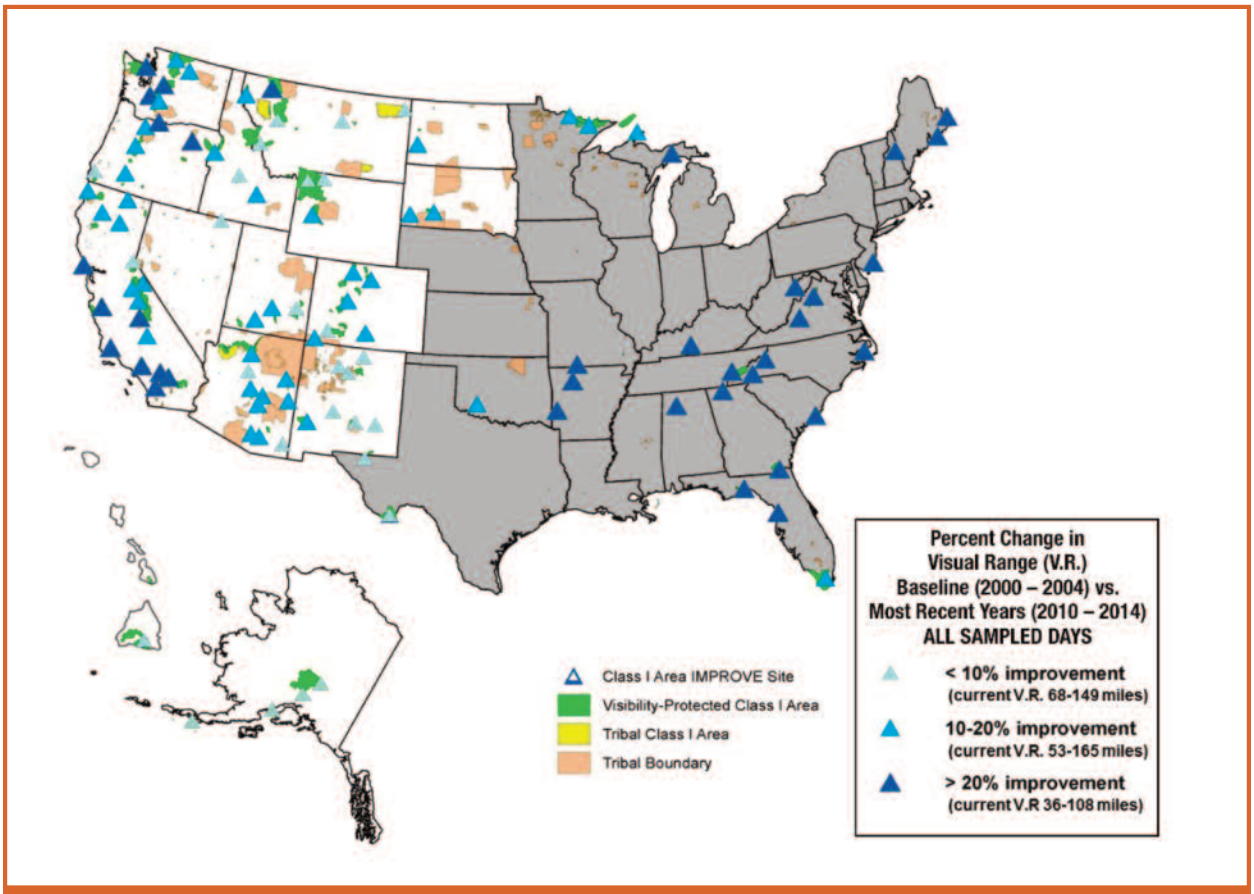

Figure 2. Percent change in five-year average visual range between baseline period and most recent progress period (C. Suarez-Murias and T. Moore, 2016).

area visibility, which is strongly influenced by anthropogenic emissions from mobile and industrial sources, including EGUs, has seen more dramatic visibility improvements due to significant emissions reductions in anthropogenic sources. Visibility in rural areas, on the other hand, is overwhelmed by background source emissions, which are uncontrollable, and, more recently, to a smaller degree from increased oil and gas production emissions. The oil and gas production emissions are significantly less than emissions from EGUs and mobile sources, and while newer regulations for oil and gas production have reduced emissions, these regulations affect cumulatively smaller total emissions than the effect of regulations and market forces on coal-fired EGUs.

Figure 3 shows this greater improvement in visibility in miles at Class I areas nearer to urban areas and lesser improvement in visibility at Class I areas further from urban areas. Figure 3 also presents the greater emissions decreases at Class I areas nearer to urban areas. Red and yellow blocks are nitrate and sulfate, which represent primarily controllable anthropogenic emissions. Green and gray blocks are organic carbon and coarse mass, which are generally of uncontrollable, natural origin. It is important to remember, however, that the West has seen improvement at all western Class I areas, which highlights the successes of the Regional Haze Rule implementation over the past decade.

Moving Forward

Looking to the future, the West must continue to improve visibility at Class I areas in accordance with the requirements of the Regional Haze Rule. EPA has proposed significant changes to the rule, which will allow the west to focus on a brand new definition of the visibility planning metric; "anthropogenically-impaired days," where state and federal regulations focus on improvements on hazy days where natural sources are not the main contributor to the haze. Since wildfire can result in overwhelming haze that is largely uncontrollable by state and federal programs, this shift in focus is welcomed in the West. That said, it is a significant challenge for western air agencies to reconcile smoke impacts on health and visibility in both urban and rural areas, while also completing air quality planning to further reduce anthropogenic sources.

Yet, with many of the largest anthropogenic sources controlled and significant visibility improvements already realized, the low-hanging fruit of western emissions that can easily be

Background Sources in the West

Why Background Ozone Is So Important

EPA ozone source apportionment modeling for the 2017 75-parts per billion (ppb) national ambient air quality standards (NAAQS) initial compliance year and retrospective 2007 EPA CMAQ and CAMx modeling of seasonal mean background ozone, as well as the WRAP WestJumpAQMS retrospective CAMx 2008 source apportionment modeling studies, all show that western ozone concentrations are particularly influenced by the natural fraction of ozone, as shown in Figure S1.

In some parts of the Intermountain West, modeling predicts that the manmade fraction is less than 30 percent and seasonal mean background ozone is above 40 ppb, as well as modeled background ozone exceeding 80 percent on the highest ozone days used for compliance. Seven rural monitors in the Intermountain West have design values at or near the 70-ppb NAAQS for ozone and the manmade fraction is estimated to be less than 15 percent. The West's higher elevations are ripe for natural events like stratospheric intrusion, where the ozone-rich stratosphere intrudes into the troposphere due to meteorological conditions.

As western states begin work to resolve ozone nonattainment areas and visibility impairment, background ozone will be important to understand and define. WESTAR–WRAP has identified several western needs for background ozone, including modeling tools and routine assessment of hourly and daily background ozone concentrations. WESTAR–WRAP provided comment on EPA's background ozone white paper and continues to dialogue with EPA and other researchers to further refine the scientific understanding of background ozone in the West.

Exceptional Events

Smoke, dust, volcanic eruptions, stratospheric intrusion of ozone, and international transport of pollutants to western

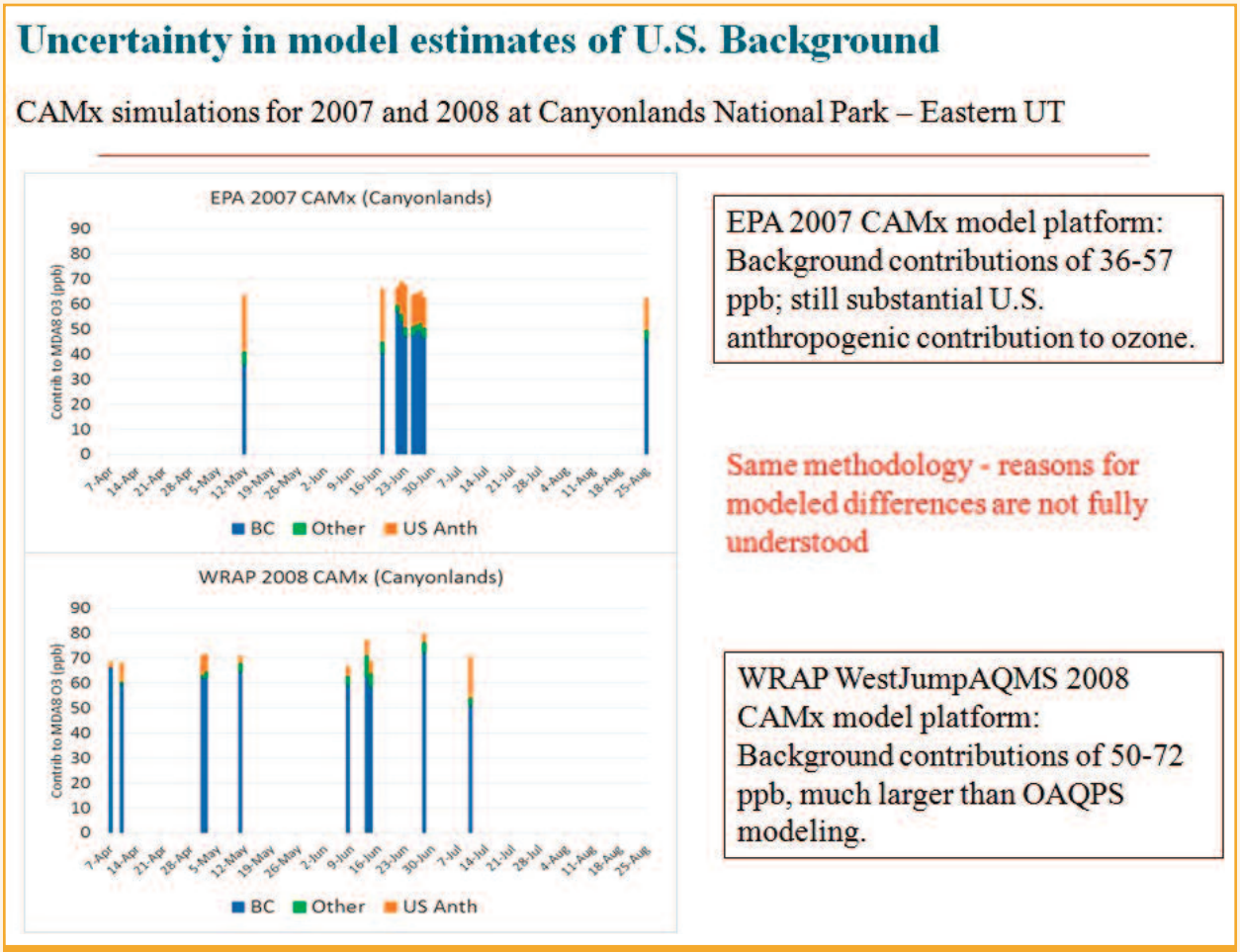

Figure S1. A comparison of modeled U.S. background ozone.

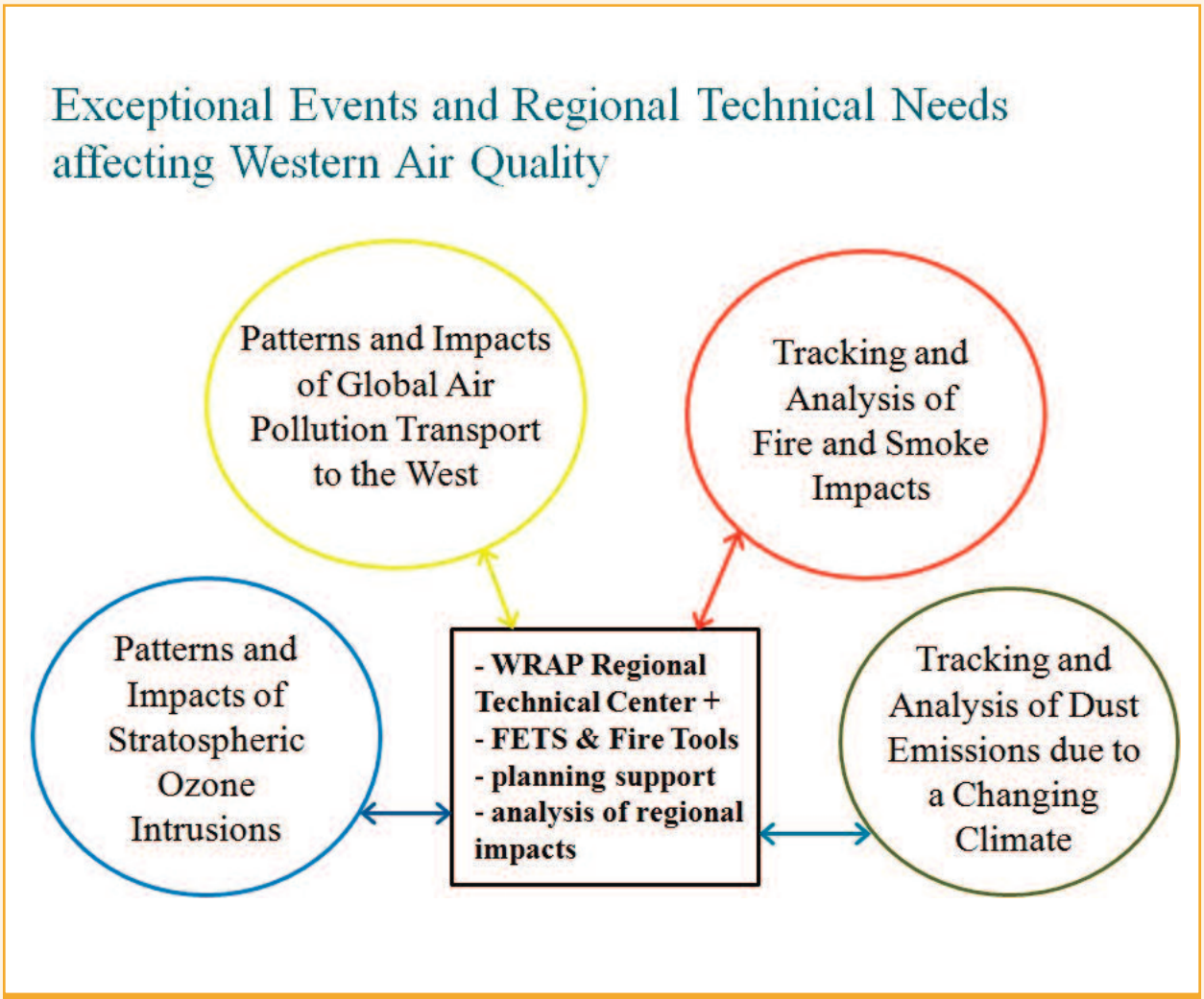

Figure S2. Exceptional events and western regional technical needs.

states all may push western air monitors to exceedances of NAAQS. With climate change, these events may occur more frequently in the future as western wildfire intensity, duration, and season increase and extended droughts result in drier soils where dust can be more easily entrained into the atmosphere.

In September 2016, EPA revised the Exceptional Events Rule to address these unusual and/or naturally-occurring events that cannot be reasonably controlled by air regulatory agencies. States, tribes, and local governments can identify monitoring data influenced by these events and then document why the event qualifies as an exceptional event. Since many of these events are regional in nature, there is a need for regional technical tools and collaboration to track and analyze the impacts of exceptional events (see Figure S2). WESTAR–WRAP has already developed a fire emissions tracking tool. Further modeling for ozone and haze will provide tools for dust, ozone, and global transport exceptional events.

Oil and Gas Development

The rapid development of oil and gas resources in the West has resulted in increasing emissions from this industrial sector. While EPA has issued rules that will substantially reduce emissions for new oil and gas production sources as development of shale oil and gas continues, the sheer number of existing oil and gas production sites from both shale and conventional resources challenges states, tribes, and local air regulatory agencies (see Table S1 and Figures S3 and S4). As technology has rapidly advanced to allow industry to recover more product that in the past might have been vented, oil and gas emissions inventories have quickly become dated. The oil and gas

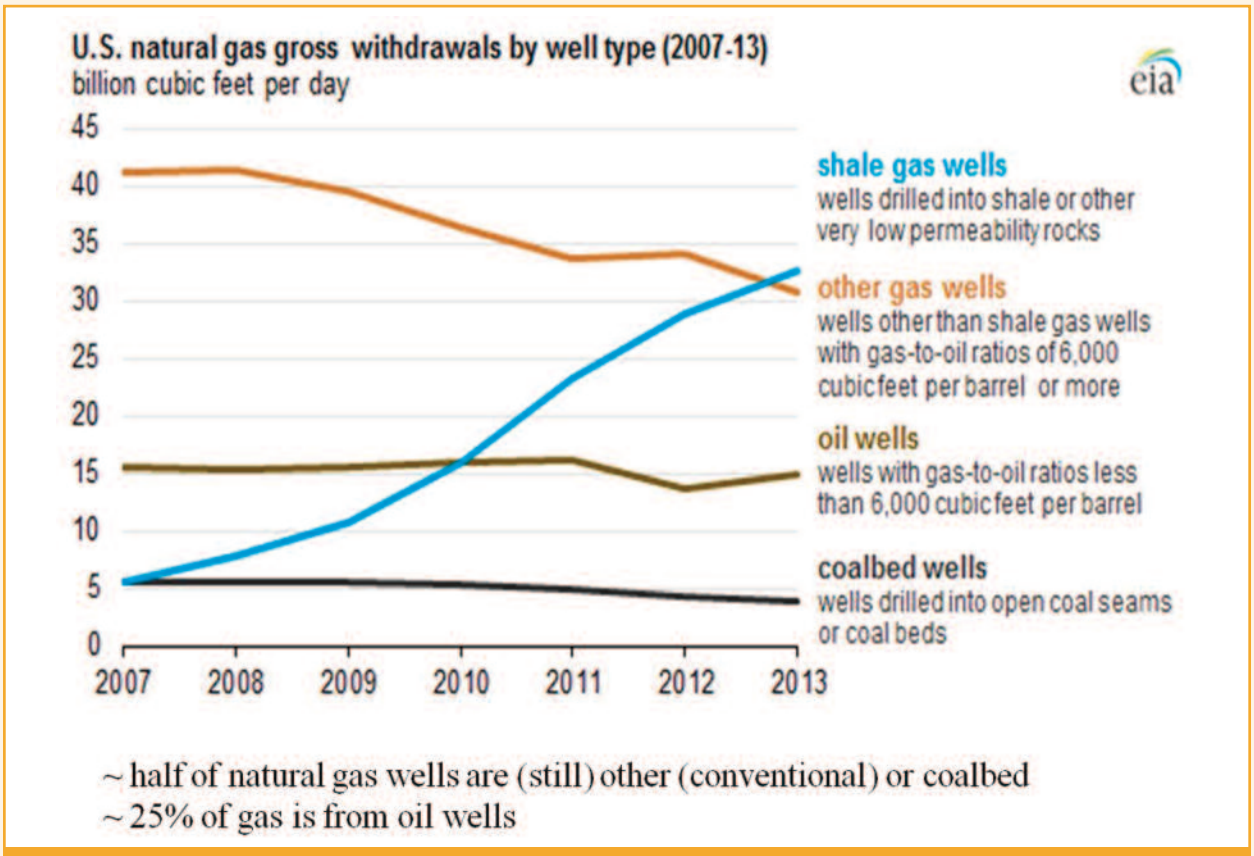

Figure S3. U.S. natural gas withdrawals by well type (2007–2013).

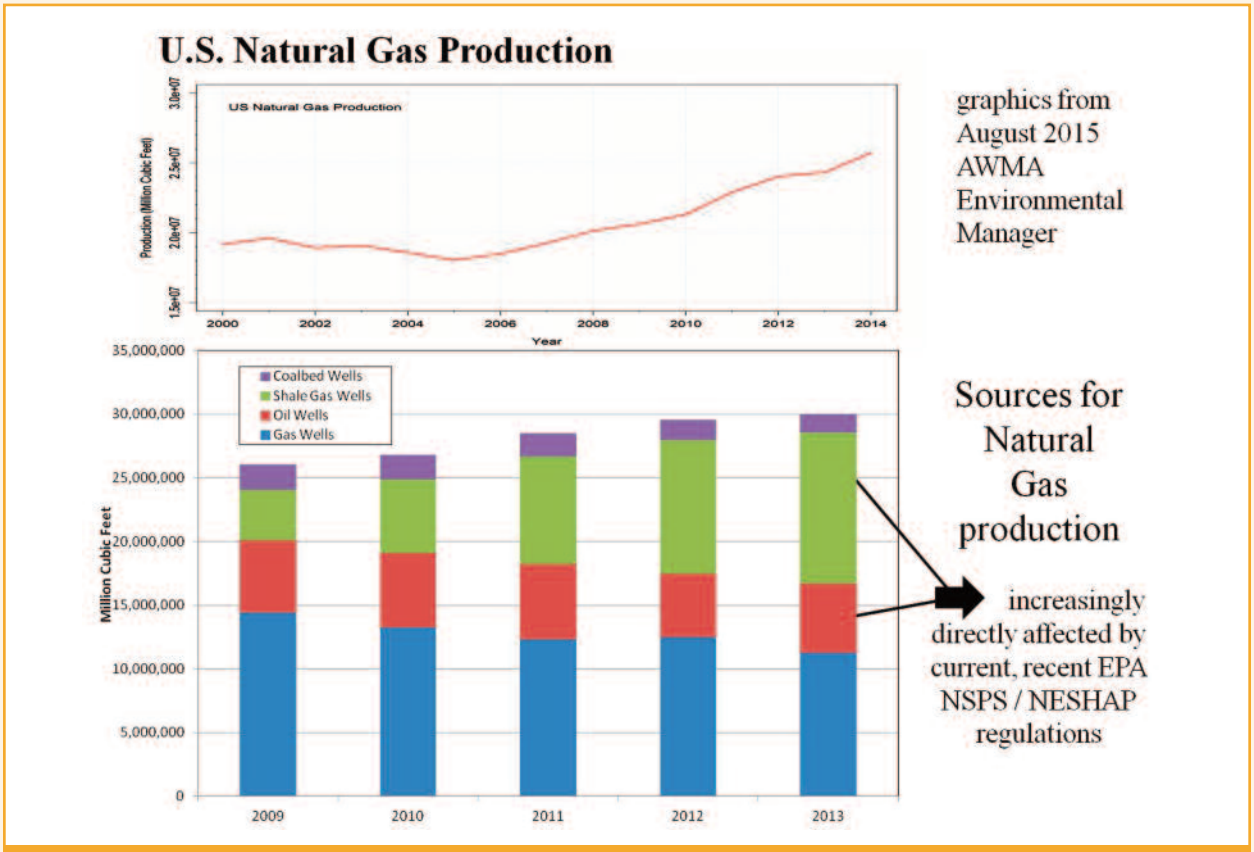

Figure S4. Sources for natural gas production (2000–2014).

Table S1. Oil and gas production in the United States (top 15 states).

Rankings: Crude Oil Production, August 2016

Rank	State	Crude Oil Production (thousand barrels)
1	Texas	97,850
2	**North Dakota**	30,216
3	**California**	15,873
4	**Alaska**	14,226
5	Oklahoma	13,061
6	**New Mexico**	12,241
7	**Colorado**	10,017
8	**Wyoming**	5,744
9	Louisiana	4,708
10	Kansas	3,016
11	**Utah**	2,572
12	**Montana**	1,888
13	Mississippi	1,827
14	Ohio	1,706
15	Illinois	741

Rankings: 2015 Natural Gas Marketed Production

Rank	State	Natural Gas Marketed Production (million cu ft)
1	Texas	7,880,530
2	Pennsylvania	4,812,983
3	Oklahoma	2,499,599
4	**Wyoming**	1,793,716
5	Louisiana	1,776,800
6	**Colorado**	1,704,836
7	West Virginia	1,318,822
8	**New Mexico**	1,244,811
9	Ohio	1,014,848
10	Arkansas	1,010,274
11	**North Dakota**	471,504
12	**Utah**	423,300
13	**Alaska**	343,534
14	Kansas	285,236
15	**California**	231,060

Note: WESTAR–WRAP region states in bold.
Source: U.S. Energy Information Administration (EIA)

sector emissions are important to states working to resolve nonattainment areas with the federal standards and regional haze. Oil and gas development in the West occurs near larger metropolitan areas and in rural areas, including areas near national parks and wilderness areas. Accuracy of the oil and gas inventory is the one of the obstacles to determining the impact from the source sector and the potential effect of additional controls.

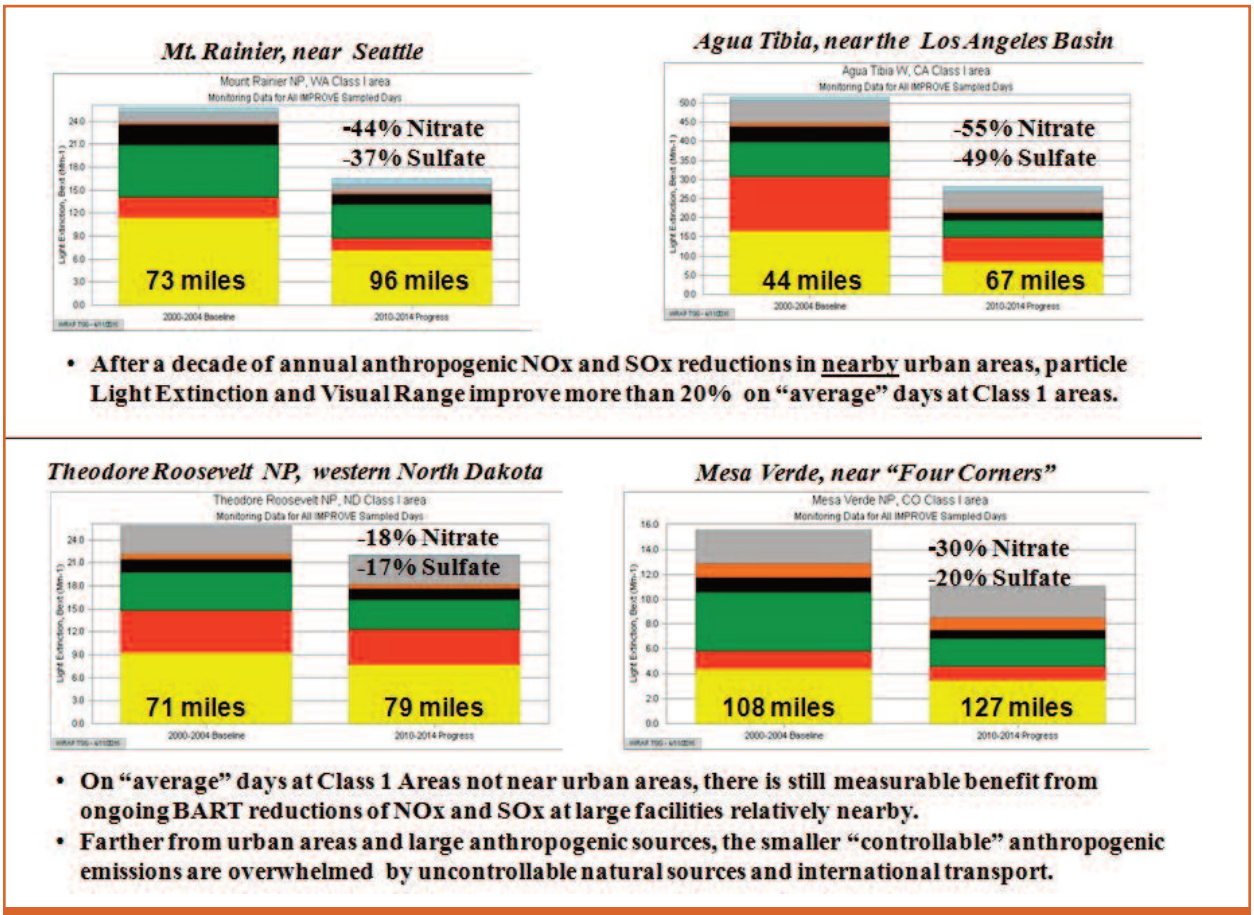

Figure 3. Reductions in emissions of nitrogen oxides and sulfur dioxide and improvements in visibility at selected near-urban and rural Class I areas (C. Suarez-Murias, 2015).

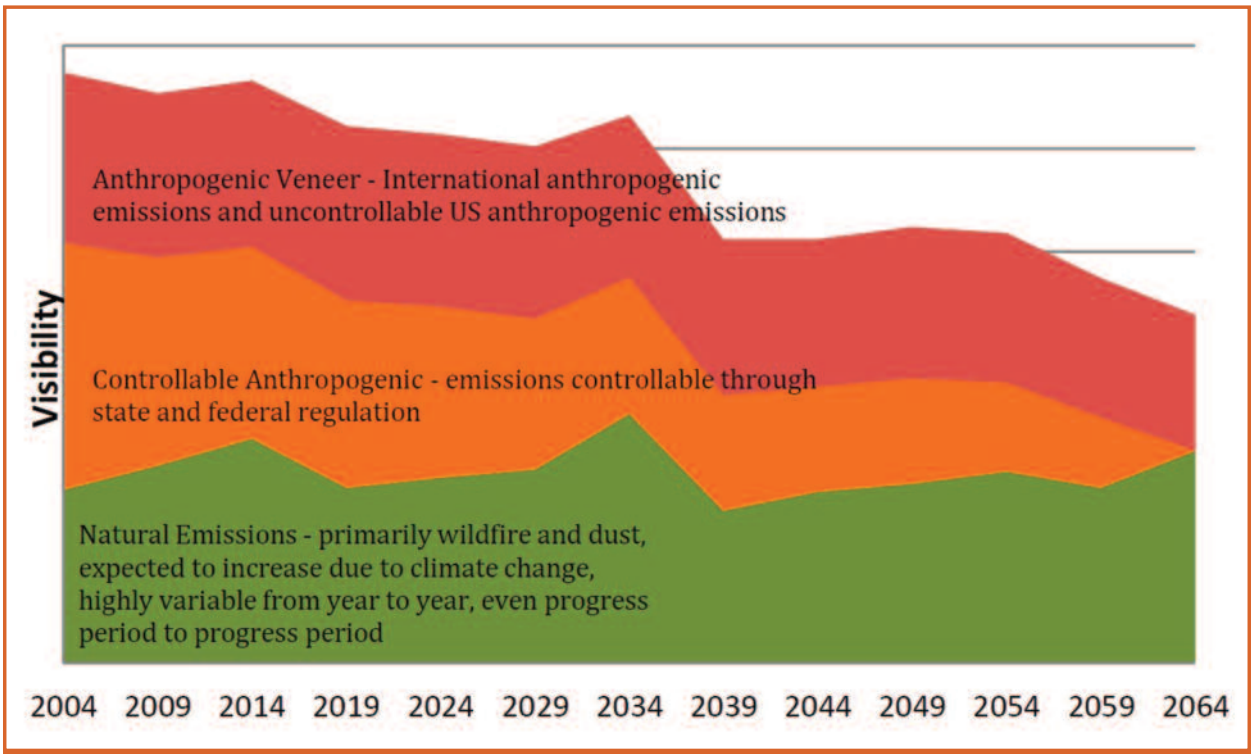

Figure 4. Conceptual progress in reducing visibility impairment (C. Suarez-Murias, 2015).

	Source	Controllability	Trend	Variability
Anthropogenic	US Anthropogenic	Some emissions are controllable	Downward as sources are controlled	Relatively stable
		Some emissions will remain after all reasonable controls implemented	Could rise because of population increases	Relatively stable
	International Anthropogenic	Not controllable by state or federal regulations	Likely increasing due to increased development worldwide and rising population	Relatively stable
Natural	Fire, Dust, Sea Salt	Natural, not controllable	Increases due to climate change	Highly variable
	Volcanic	Natural, not controllable	Unpredictable	Highly variable
	Other Natural Sources	Not controllable	Potentially affected by climate change, e.g., changes in temperature	Relatively stable

Table Note: Shaded areas represent emissions that states cannot control.

Figure 5. Typical source types affecting visibility (C. Suarez-Murias and T. Moore, 2016).

further controlled has all but disappeared. The next rounds of emissions reductions and visibility improvements will require significant effort to analyze which and whether smaller anthropogenic emissions can be controlled to improve visibility in western Class I areas. Figure 4 illustrates the conceptual progress in reducing visibility impairment in terms of the relative contributions of anthropogenic sources, which can be further controlled and the remaining anthropogenic emissions, relative to each other and to the ongoing natural emissions, all impacting regional haze. Figure 5 further illustrates typical source types affecting visibility that must be analyzed in the regional haze planning process.

The western air agencies, led by the state air programs, have the advantage of the experience and expertise of a successful decades-long collaboration; however, because there has been no congressional appropriation of funds toward the effort, the next round may prove more difficult despite the complexity of the task ahead. Western states need clarity and resources for collaborative analyses from federal land managers and EPA to balance and reduce the substantial uncertainties in background ozone and transport, quantitatively assess and anticipate growth in U.S. natural and uncontrollable sources for haze and ozone, many of which come from federal lands and allowed activities, and better project the growth, control, and ongoing management and additional reasonable emissions reduction efforts for oil and gas emissions and other local anthropogenic sources—as our climate and atmospheric composition and chemistry continue to change. Efforts are already underway to discuss these issues through WESTAR–WRAP workgroups, including state, tribal, local and federal agencies. The continuity of these efforts will be key to continued western visibility improvement. **em**

Mary Uhl and **Tom Moore** are both with the Western States Air Resources Council–Western Regional Air Partnership (WESTAR–WRAP). E-mail: **maryuhl@westar.org; tmoore@westar.org**.