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ACRONYMS

ACHEX - Aerosol Characterization Experiment

ARCTAS-CARB – California portion of the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites conducted in 2008

BEARPEX – Biosphere Effects on Aerosols and Photochemistry Experiment in 2007 and 2009

CABERNET – California Airborne BVOC Emission Research in Natural Ecosystem Transects in 2011

CalNex – Research at the Nexus of Air Quality and Climate Change conducted in 2010

CARB – California Air Resources Board

CARES – Carbonaceous Aerosols and Radiative Effects Study in 2010

CCOS - Central California Ozone Study

CIRPAS - Center for Interdisciplinary Remotely-Piloted Aircraft Studies

CRPAQS - California Regional PM_{10}/$PM_{2.5}$ Air Quality Study

DISCOVER-AQ - Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality

DV – Design Value

IMS-95 – Integrated Monitoring Study of 1995

IONS – Intercontinental transport experiment Ozonesonde Network Study)

LIDAR – Light Detection And Ranging

MCAB – Mountain Counties Air Basin

MDA – Maximum Daily Average

NASA – National Aeronautics and Space Administration

NOAA - National Oceanic and Atmospheric Administration

NO_x – Oxides of nitrogen

PAMS – Photochemical Assessment Monitoring Stations

PAN – Peroxy Acetyl Nitrate

$PM_{2.5}$ – Particulate Matter with aerodynamic diameter less than 2.5 micrometers

PM_{10} – Particulate Matter with aerodynamic diameter less than 10 micrometers

ROG – Reactive Organic Gases

SAOS – Sacramento Area Ozone Study

SARMAP – SJVAQS/AUSPEX Regional Modeling Adaptation Project

SFNA – Sacramento Federal Non-attainment Area

SIP – State Implementation Plan

SJV – San Joaquin Valley

SJVAB – San Joaquin Valley Air Basin (SJVAB)

SJVAQS/AUSPEX – San Joaquin Valley Air Quality Study/Atmospheric Utilities Signatures Predictions and Experiments

SVAB – Sacramento Valley Air Basin (SJVAB)

SOA – Secondary Organic Aerosol

SoCAB – Southern California Air Basin

U.S. EPA – United States Environmental Protection Agency

VOC – Volatile Organic Compounds

WNNA – Western Nevada county Non-attainment Area

WRF Model – Weather and Research Forecast Model

1. TIMELINE OF THE PLAN

Table 11 Timeline for Completion of the Plan (update)

Timeline	Action
Early 2018	Emission Inventory Completed
Late spring 2018	Modeling Completed
Fall 2018	District Hearing to consider the Draft Plan
Late fall 2018	ARB Board Hearing to consider Adopted Plan
Early winter 2018	Plan to be submitted to U.S. EPA

2. DESCRIPTION OF THE CONCEPTUAL MODEL FOR THE NONATTAINMENT AREA

2.1. History of Field Studies in the Region

The Western Nevada county Non-attainment Area (WNNA) for the 2008 8-hour ozone National Ambient Air Quality Standards (NAAQS) or standard is a region of highly complex terrain, with elevations ranging from a few hundred feet above sea level to over 9,000 feet. It extends from the foothills of the Sierra Nevada mountain range into the Tahoe National Forest to the east. WNNA is located in the western part of Nevada County within the Mountain Counties Air Basin (MCAB). The Northern Sierra Air Quality Management District (NSAQMD) has jurisdiction over Nevada County with an estimated area of ~ 978 square miles and an estimated population of 136,484 in 2010 (Fig. 2-1).

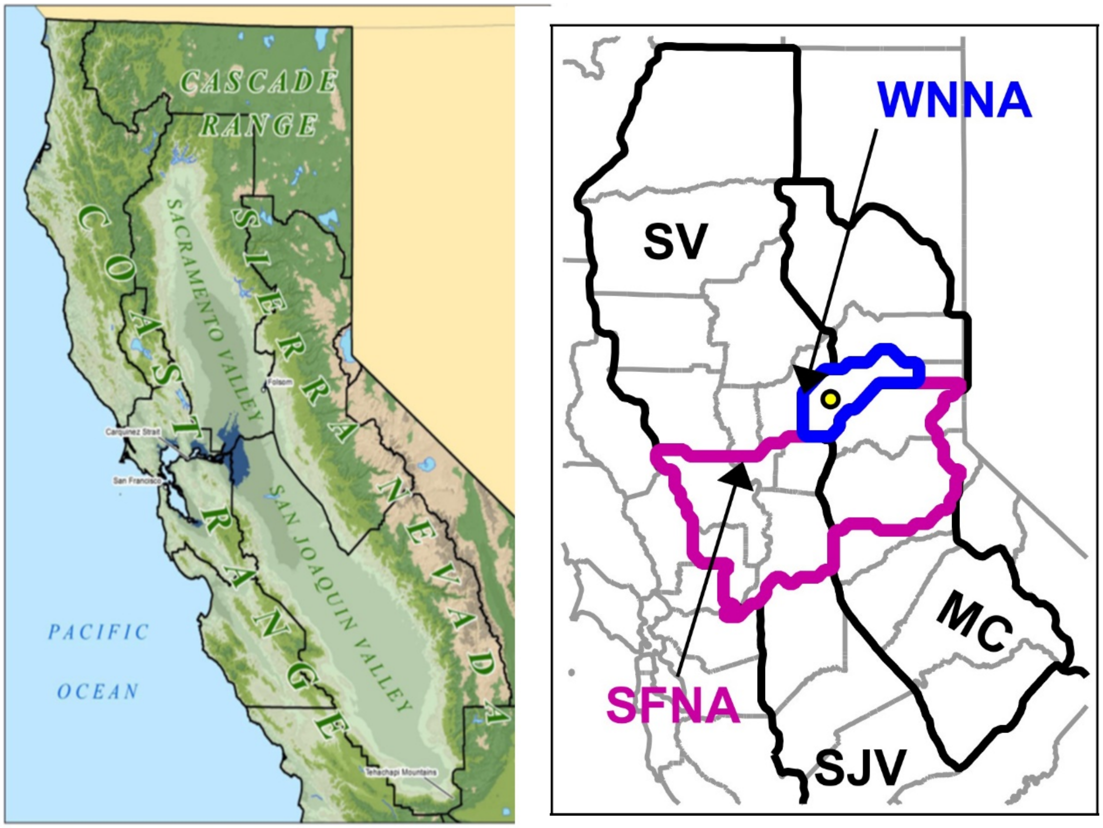

Figure 21. Map of California's central valley (left) along with the location of Western Nevada county 8-hour ozone Non-attainment Area (WNNA) in blue and Sacramento Federal 8-hour ozone Non-attainment Area (SFNA) in magenta. SV, MC and SJV denote Sacramento Valley, Mountain Counties (MC) and San Joaquin Valley (SJV) air basins.

The WNNA is located to the east of California's central valley in the north central portion of the Mountain Counties Air Basin (MCAB). The Central Valley is a 500 mile long northwest-southeast oriented valley encompassing two of the most polluted air basins in the nation – San Joaquin Valley Air Basin (SJVAB) and Sacramento Valley Air Basin (SVAB). As a result, the Central Valley is one of the most studied regions in the world, in terms of the number of publications in peer-reviewed international scientific/technical journals and other major reports. The major field studies conducted within the surrounding regions including the Central Valley (listed in Table 2–1) have provided the essential knowledge base and contributed significantly to our understanding of the underlying factors (including complex terrain, meteorological conditions, chemical processes and inter-basin transport of pollutants) that typically lead to high ozone concentrations violating the 8-hour ozone standard in the WNNA.

The WNNA is located downwind of the Sacramento Federal 8–hour ozone Non-attainment Area (SFNA). An observational field study was carried out in August, 1980 to investigate the transport of ozone and its precursors from Sacramento Valley and its impact on the surrounding areas (Smith et al., 1981). The sulfur hexafluoride (SF_6) tracer results of this field study indicated that emissions from the Bay area could significantly impact the Sacramento area and downwind regions, while the emissions from Sacramento impacted the northern Sacramento Valley and downwind Sierra foothills (located to the east/northeast). The Smith et al., (1981) study also concluded that ozone and its precursors from the Bay area and Sacramento can also be transported and entrapped in the elevated layers over the valley resulting in surface level impacts on the following day.

The California Air Resources Board performed a series of transport assessments (CARB 1989; 1990; 1993; 1996; 2001) to better understand the fundamental transport relationships between different regions in California that lead to ozone exceedances. These assessments determined that from an ozone perspective, the contribution of transport from SFNA into Western Nevada was "overwhelming" (i.e. ozone exceedances were solely caused by upwind emissions) on all days.

Table 21. Major Field Studies in Central California and surrounding areas.

Year	Study	Significance
1970	Project Lo-Jet	Identified summertime low-level jet and Fresno eddy

1972	Aerosol Characterization Experiment (ACHEX)	First TSP chemical composition and size distributions
1979-1980	Inhalable Particulate Network	First long-term PM2.5 and PM10 mass and elemental measurements in Bay Area, Five Points
1978	Central California Aerosol and Meteorological Study	Seasonal TSP elemental composition, seasonal transport patterns
1979-1982	Westside Operators	First TSP sulfate and nitrate compositions in western Kern County
August 1980	A Study of the Origin and Fate of Air Pollutants in California's Sacramento Valley	SF-6 tracer release study to investigate the transport of ozone and precursors into, within and out of Sacramento Valley
1984	Southern SJV Ozone Study	First major characterization of O3 and meteorology in Kern County
1986-1988	California Source Characterization Study	Quantified chemical composition of source emissions
1988-1989	Valley Air Quality Study	First spatially diverse, chemical characterized, annual and 24-hour PM2.5 and PM10
July and August 1990	Sacramento Area Ozone Study	Intensive ozone measurements in the Sacramento Area
Summer 1990	San Joaquin Valley Air Quality Study/ Atmospheric Utilities Signatures Predictions and Experiments (SJVAQS/AUSPEX) – Also known as SARMAP (SJVAQS/AUSPEX Regional Modeling Adaptation Project)	First central California regional study of O3 and PM2.5

July – September 1990	Upper Sacramento Valley Transport Study	Measurements to study the transport of pollutants from the lower to upper Sacramento Valley
July and August 1991	California Ozone Deposition Experiment	Measurements of dry deposition velocities of O3 using the eddy correlation technique made over a cotton field and senescent grass near Fresno
Winter 1995	Integrated Monitoring Study (IMS-95, the CRPAQS Pilot Study)	First sub-regional winter study
December 1999– February 2001	California Regional PM10/PM2.5 Air Quality Study (CRPAQS) and Central California Ozone Study	First year-long, regional-scale effort to measure both O_3 and $PM_{2.5}$
December 1999 to present	Fresno Supersite	First multi-year experiment with advanced monitoring technology
July 2003	NASA high-resolution lidar flights	First high-resolution airborne lidar application in SJV in the summer
February 2007	U.S. EPA Advanced Monitoring Initiative	First high-resolution airborne lidar application in SJV in the winter
August-October 2007; June-July 2009	BEARPEX (Biosphere Effects on Aerosols and Photochemistry Experiment)	Research-grade measurements to study the interaction of the Sacramento urban plume with downwind biogenic emissions
June 2008	ARCTAS - CARB	First measurement of high-time resolution (1-10s) measurements of organics and free radicals in SJV
May-July 2010	CalNex 2010 (Research at the Nexus of Air Quality and Climate Change)	Expansion of ARCTAS-CARB type research-grade measurements to multi-platform and expanded geographical area including the ocean.

June 2010	CARES (Carbonaceous Aerosols and Radiative Effects Study)	Research-grade measurements of trace gases and aerosols within the Sacramento urban plume to investigate SOA formation
May – June 2010	IONS (Intercontinental transport experiment Ozonesonde Network Study)	Daily Ozonesonde measurements from four coastal and two inland sites in California to improve the characterization of western U.S. baseline ozone
June 2011	CABERNET (California Airborne BVOC Emission Research in Natural Ecosystem Transects)	Provided the first ever airborne flux measurements of isoprene in California
January- February 2013	DISCOVER-AQ (Deriving Information of Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality)	Research-grade measurements of trace gases and aerosols during two $PM_{2.5}$ pollution episodes in the SJV

The impact of transported pollutants on ozone air quality in a downwind region like the WNNA is governed by various factors, including complex terrain and topographic features, precursor emissions in the upwind source regions (SFNA and Bay Area), local emissions from anthropogenic and naturally occurring biogenic ROG sources, as well as the prevailing meteorological conditions that facilitate transport of ozone and its precursors. In addition, the formation of ozone and the associated chemistry along the transport pathways, as well as the prevailing ozone chemistry regimes both locally and in the upwind source regions, play an important role in determining ozone levels in the region. These factors are discussed in the following sections.

2.2. Local Topography and Climate

Nevada County is located in the foothills and mountains of the Sierra Nevada mountain range with elevations increasing from roughly 300 feet above mean sea level (MSL) in the west to over 9,000 feet in the east, at the Sierra crest (CAPCOA, 2015). It encompasses an area of 978 square miles and is home to ~136,000 residents. Nevada County is characterized by river valleys running roughly east-northeast to west-southwest, separated by mountain ridges. This tends to inhibit north-south air flow, but allows east-west upslope and downslope flow. The western portions of the county slope relatively gradually with deep river canyons running from southwest to northeast toward the crest of the Sierra Nevada range. East of the divide, the slope of the Sierra is steeper, but river canyons are relatively shallow. The warmest areas in Nevada County are found at the lower elevations along the county's west side, while the coldest average temperatures are found at the highest elevations.

The region has a Mediterranean climate type, with seasonal variation in temperature and precipitation. Summers are hot and dry, while winters are cool and wet occurring from late October to early May. The prevailing wind direction over the county is westerly. However, the terrain of the area has a great influence on local winds, so that a wide variability in wind direction can be expected. Afternoon winds are generally channeled up-canyon, while nighttime winds generally flow down-canyon. Winds are, in general, stronger in spring and summer and weaker in fall and winter. Periods of calm winds and clear skies in fall and winter often result in strong, ground based inversions forming in mountain valleys. These layers of very stable air restrict the dispersal of pollutants, trapping these pollutants near the ground, representing the worst conditions for local air pollution occurring in the county (https://www.mynevadacounty.com/DocumentCenter/View/11228/50-Air-Quality-PDF?bidId=).

Regional airflow patterns have an effect on air quality patterns by directing pollutants downwind of sources. Localized meteorological conditions, such as light winds and shallow vertical mixing, and topographical features, such as the surrounding mountain ranges, can create areas of high pollutant concentrations by hindering dispersal. The local sources of pollution along with polluted air masses from the nearby regions (SFNA and Bay Area) that are frequently transported into this area tend to stagnate over Western Nevada under unfavorable meteorological conditions, resulting in high ozone levels which exceed the 8-hour ozone NAAQS.

2.3. Meteorological Conditions Conducive to Ozone Exceedances

California's proximity to the ocean, its complex terrain, and diverse climate produces unique synoptic and mesoscale meteorological features that lead to pollution episodes. In the summertime, the majority of the storm tracks are far to the north of the state and a semi-permanent Pacific high typically sits off the California coast. Interactions between this eastern Pacific subtropical high pressure system and the thermal low pressure further inland over the Central Valley lead to conditions conducive to pollution buildup over large portions of the state (Fosberg and Schroeder, 1966; Bao et al., 2008).

The WNNA is located in the highly complex terrain region to the east of California's Central Valley (See Figure 2-1). Elevations in the Central Valley extend from a few feet to almost 500 feet above sea level. This long valley is surrounded by the Coastal Mountain Range on the west, the Cascade Range to the northeast, the Sierra Nevada Mountains on the east, and the Tehachapi Mountains to the south. The Coastal Range is actually a series of north/south mountain ranges that extend 800 miles from the northwest corner of Del Norte County south to the Mexican border. The San Francisco Bay Area divides the Coastal Mountain Range into northern and southern ranges. The Coastal Mountains generally form a barrier between the Pacific Ocean and the Central Valley, with occasional breaks created by low elevation passes and the small gap between the northern and southern ranges in the San Francisco Bay area known as the Carquinez Strait. Elevations in the Coastal Range generally vary between 2,000 and 4,000 feet, but can reach heights above 7,000 feet. In contrast, elevations in the Cascade Range and Sierra Mountains in northern California are typically above 5,000 feet and can exceed 10,000 feet.

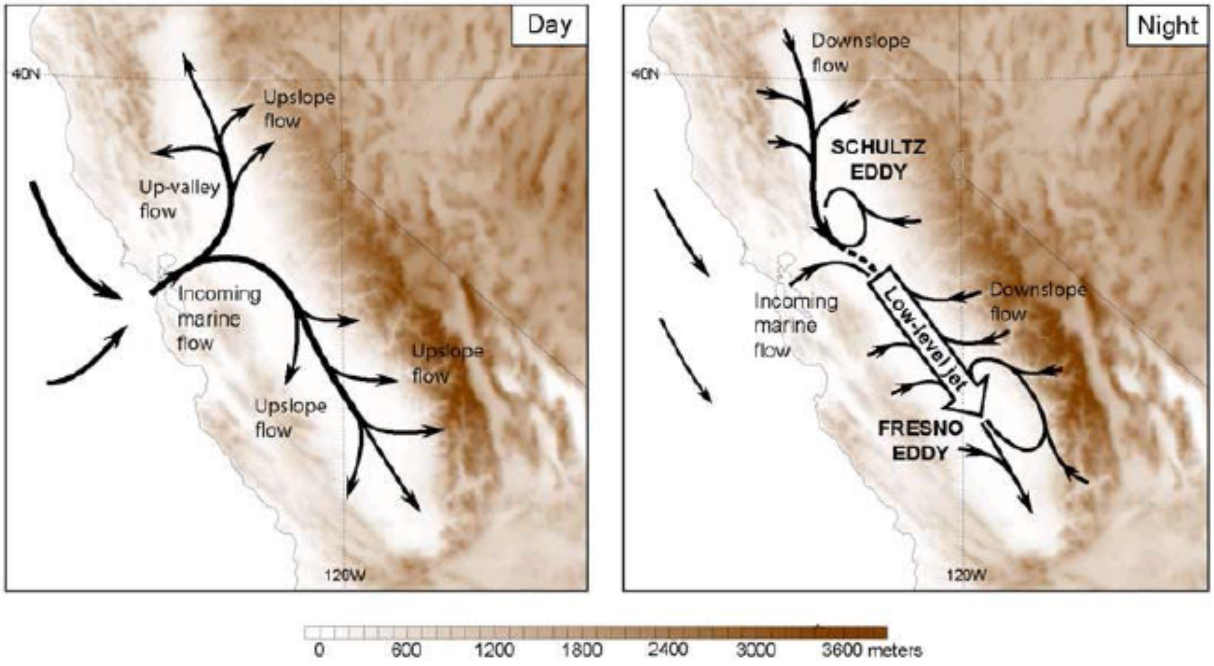

Figure 22 Conceptual low-level wind patterns in Central California during the day (left panel) and night (right panel) for typical ozone episode conditions (adapted from Bao et al., 2008).

Weather conditions during much of the summer ozone season are dominated by an area of high pressure, known as the East Pacific Ridge, which creates a broad region of warm, descending air over Central California. Studies have shown that the strength and positioning of this ridge has a strong influence on the prevailing weather conditions and summertime ozone levels in Central California (Lehrman et al., 2004; Pun et al., 2008). Synoptic forcing under the East Pacific Ridge is typically weak, with wind flows above the planetary boundary layer from the northwest, resulting in wind flows in Central California that are primarily thermally driven and strongly influenced by orographic effects (Zhong et al., 2004). Thermal gradients between the eastern Pacific Ocean and inland in the Valley result in a strong daytime sea breeze which follows the terrain and can extend well inland through the Carquinez Strait and to a lesser extent the Altamont, Pacheco, and Cholame Passes. When meteorological conditions are favorable, polluted air masses from the Bay Area travel through the Carquinez Strait and bifurcate over the Delta region, with one branch flowing to the northeast into the southern Sacramento Valley and the other branch flowing southeast into the northern San Joaquin Valley (Figure 2-2).

At night, the sea breeze gradually weakens and can even reverse in some cases, but up-valley flow off of the Delta usually persists. Nighttime surface wind flow in the Central Valley is dominated by downslope flows, known as nocturnal drainage, off of the mountain ranges on all sides (Figure 2-2) and when combined with the continued up-valley flows from the Delta, result in low-level eddies such as the Schultz eddy in the southern Sacramento Valley and the Fresno eddy in the SJV (Lehrman et al., 2004). The dynamical conditions favorable for the formation of both the Fresno and Shultz eddies are investigated and discussed by Lin and Jao (1995).

Clustering and classification techniques have been utilized on both observed meteorology (Lehrman et al., 2001; Blanchard et al., 2008; Beaver and Palazoglu, 2009) and observed and modeled ozone (Fujita et al., 1999; Jin et al., 2011) in the Valley and the surrounding region to better understand the relationship between meteorology and elevated ozone. These various studies reveal that the position and strength of the Pacific High has a dominant influence on ozone levels throughout the Central Valley, along with the height of the marine inversion and strength of the low-level on-shore flow. Synoptic flows that weaken or break down the Pacific High result in lower ozone throughout the Central Valley, while a strong sea breeze with a deep marine boundary layer results in lower ozone levels within the Bay Area, but also an enhanced transport of polluted air masses into the Delta region. Under such conditions, elevated ozone can occur in the Sacramento and its downwind regions if the synoptic forcing is sufficiently weak so that vertical mixing is reduced and recirculation is enhanced. The highest ozone levels occur as the thermal gradient between off-shore and inland weakens and the high pressure system strengthens. The ozone levels remain elevated until a synoptic system moves through the area and breaks down the Pacific High.

The WNNA borders the SFNA in the southwest. The SFNA is located in the northern portion of the California's Central Valley and is home to more than 2 million residents encompassing an area of 5600 square miles and occupies the southern portion of the Sacramento Valley It extends southward to the Sacramento Delta Region and northward to include the southern portion of Sutter County. The northern branch of the flow through the Carquinez Strait and the recirculation pattern in the southern Sacramento Valley as depicted in Figure 2-2 lead to the transport of elevated ozone and its precursors from the SFNA and the Bay Area into the WNNA. As these air masses move downwind, ozone is continuously formed along the way through photochemical reactions resulting even high ambient ozone concentrations. The Nevada County air flow is most frequently from the south-southwest, which coincides with the transport path (U.S. EPA, 2012). This transport pattern was also observed and documented in the past field studies (Smith et al., 1981). Ozone and its precursors from the Bay Area and the SFNA can also be directly transported and carried aloft, which could also impact the surface ozone values in the WNNA.

2.4. .Ozone Formation and Associated Chemistry

The ozone levels in the WNNA are not only influenced by ozone transported out of the SFNA and the Bay Area, but also by ozone that is formed along the transport pathways that bring polluted air masses from the upwind source regions into Western Nevada. As the air masses laden with ozone and its precursors including NO_x and ROG move downwind, ozone is continuously formed through photochemical reactions in the presence of sunlight along the way, which leads to enhanced ozone levels by the time the air masses reach the WNNA.

The role of biogenic ROG precursors also becomes increasingly important during this downwind transport process. The WNNA, a region of highly complex terrain (with elevations ranging from a few hundred feet above sea level to over 9,000 feet), has diverse vegetation coverage. It lies in close proximity and directly downwind of SFNA, and has large amounts of reactive biogenic ROG precursors, which can react with the transported NO_x from the upwind source region to produce enhanced ozone levels along the transport pathway.

As the air masses are transported downwind, NO_x is removed more rapidly than ROG and the lack of fresh NO_x emissions along the transport path can prevent the scavenging of ozone by NO, which causes ozone levels to remain high during the transport process. The nighttime ozone levels also have a significant impact on ozone air quality in areas impacted by transported pollutants such as the WNNA. Typically, the nighttime ozone levels are lower in areas with the continuous influx of fresh NO_x emissions (e.g. Metropolitan areas), due to removal of ozone through reaction with NO in the absence of photolysis (i.e., no sunlight). However, in regions like the WNNA the absence of large sources of fresh NO_x emissions at night prevents the removal of ozone through the NO_x titration process, and allows the nighttime ozone levels to remain elevated. This can facilitate pollutant carryover the following morning, and can contribute to elevated ozone levels on the following day.

2.5. Description of the Ambient Monitoring Network

As discussed above, the WNNA, is largely mountainous and is located downwind of the heavily polluted SFNA and Bay Area, which pose many issues to the region's ozone air quality. The transport of pollutants from the SFNA are generally thought to significantly contribute to the exceedances of the ozone NAAQS in the WNNA.

The region's air quality planning is led by the Northern Sierra Air Quality Management District (NSAQMD). The NSAQMD also operates the Grass Valley monitoring station, located at 200 Litton Dr., Suite 230 (Figure 2-3). The Grass Valley monitor is at an elevation of 865 m, and has been in operation since June 1993 (see Table 2-2 for longitude/latitude information). The monitor was located to capture the highest ozone mixing ratios and assess regional transport patterns in the WNNA. The air quality monitoring data aids in determining compliance with the NAAQS and for improving regional air quality and protecting public health. A detailed discussion about the monitoring network and its adequacy can be found in the 2018 Air Monitoring Network and Assessment Plan (https://www.arb.ca.gov/aqd/amnr/amnr.htm).

Table 22. Ozone monitoring site in the WNNA

Site ID (AQS/ARB)	Site (County, Air Basin)	Ozone	$PM_{2.5}$	Latitude	Longitude	Elevation (m)
060570005 (29800)	Grass Valley-Litton Building (Nevada, MCAB)	X	X	39.23352	-121.05567	865

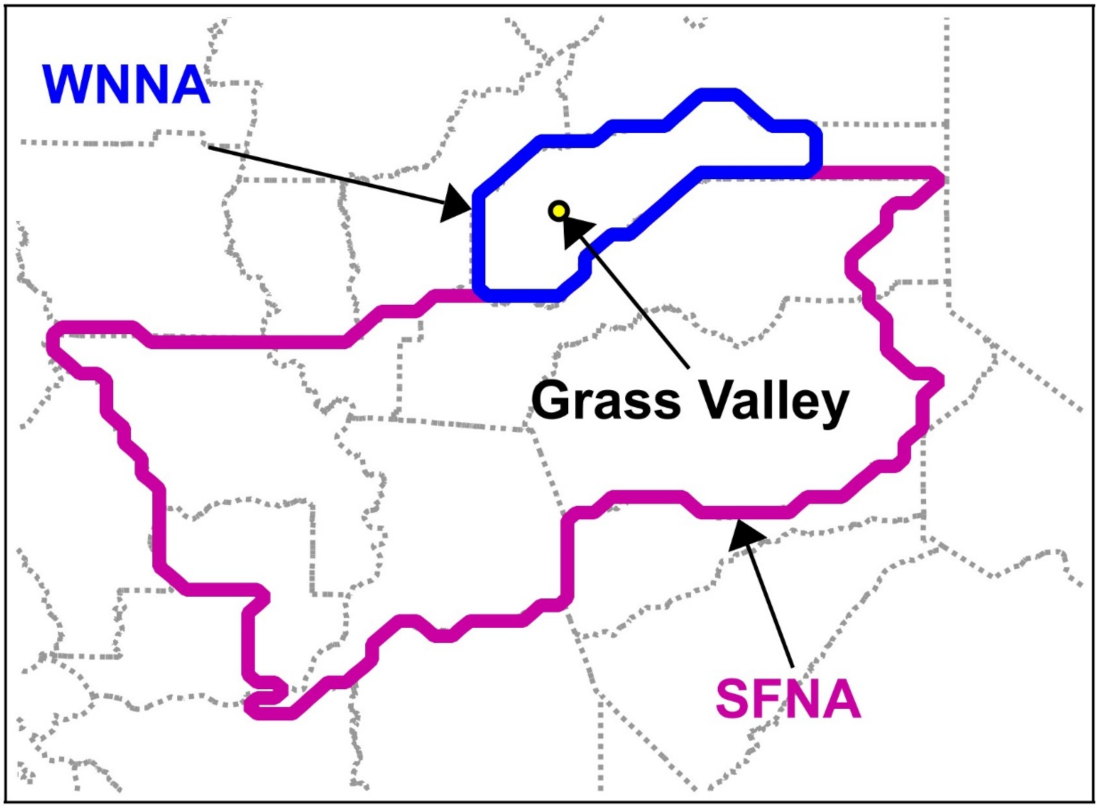

Figure 23. Map of the Grass Valley Ozone Monitoring Site in the Western Nevada County 8-hour ozone Non-attainment Area (WNNA) along with the location of Sacramento Federal Non-attainment Area (SFNA).

2.6. Ozone Trends and Sensitivity to Emissions Reductions

The Western Nevada county 8–hour ozone Non-attainment Area (WNNA) is designated as a moderate ozone nonattainment area for the U.S. EPA 2008 0.075 ppm 8-hour ozone standard. The major precursors that lead to ozone formation in this region are the emissions of anthropogenic NO_x and ROG (both local and transported), as well as natural biogenic ROG emissions. There is a relatively lower contribution from local emissions, which are dominated by stationary and mobile sources. Since the 1980's, California's emission control programs have substantially reduced the amounts of both anthropogenic NO_x and ROG throughout the region (https://www.arb.ca.gov/aqd/almanac/almanac.htm). As these control programs have led to changes in the relative levels of NO_x and ROG over time, the control programs have also adapted so as to reduce ozone levels as rapidly as possible. This adaptation within the control programs is necessary because ozone formation responds differently to NO_x and ROG controls as the relative levels of NO_x and ROG in the atmosphere change.

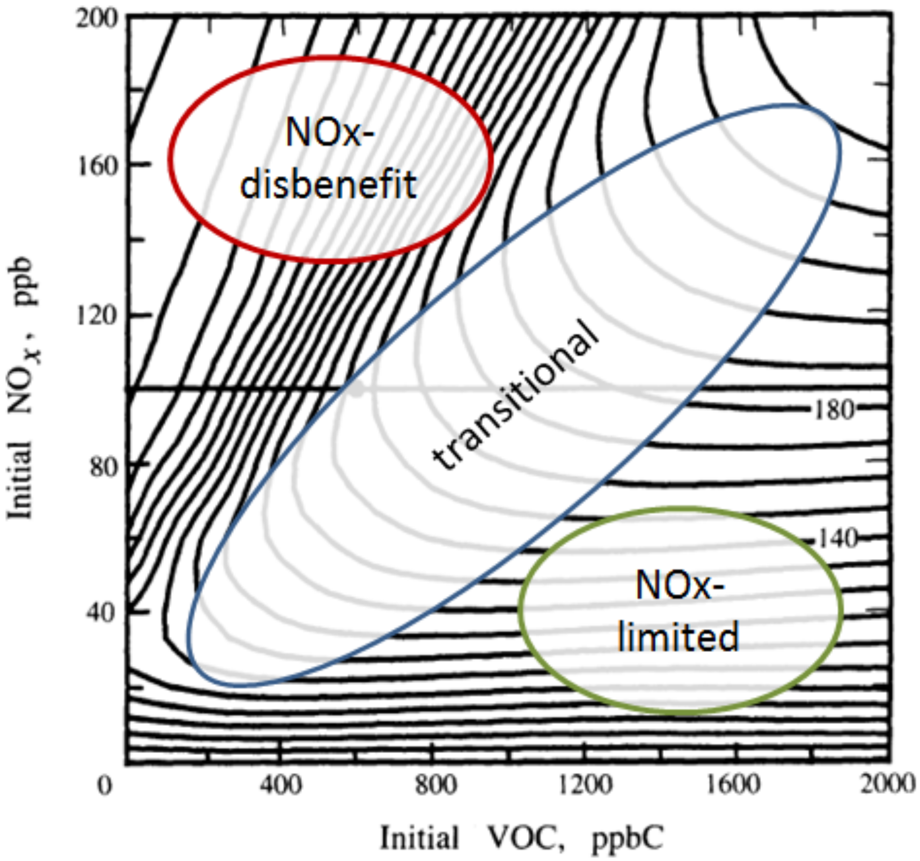

Figure 24. Illustrates a typical ozone isopleth plot, where each line represents ozone mixing ratio, in 10 ppb increments, as a function of initial NO_x and VOC (or ROG) mixing ratio (adapted from Seinfeld and Pandis, 1998, Figure 5.15). General chemical regimes for ozone formation are shown as NO_x-disbenefit (red circle), transitional (blue circle), and NO_x-limited (green circle).

Specifically, ozone formation exhibits a nonlinear dependence to NO_x and ROG precursors in the atmosphere. In general terms, under ambient conditions of high-NO_x and low-ROG (NO_x-disbenefit region in Figure 2-4), ozone formation tends to exhibit a disbenefit to reductions in NO_x emissions (i.e., ozone increases with decreases in NO_x) and a benefit to reductions in ROG emissions (i.e., ozone decreases with decreases in ROG). In contrast, under ambient conditions of low-NO_x and high-ROG (NO_x-limited region in Figure 2-4), ozone formation shows a benefit to reductions in NOx emissions, while changes in ROG emissions result in only minor decreases in ozone. These two distinct “ozone chemical regimes” are illustrated in Figure 2-4 along with a transitional regime that can exhibit characteristics of both the NO_x-disbenefit and NO_x-limited regimes. Note that Figure 2-4 is shown for illustrative purposes only, and does not represent the actual ozone sensitivity within the WNNA for a given combination of NO_x and VOC (ROG) emissions.

The prevailing chemical regime for ozone formation and the associated trend can be analyzed through the year-to-year variability in biogenic ROG emissions, which during the summer ozone season can be many times greater than anthropogenic ROG emissions in the WNNA, as well as through the so called "weekend effect" which shows an increase in ozone on the weekend under NO_x -disbenefit conditions (and a decrease under NO_x-limited conditions).

2.6.1. Trend in Emissions

Area-wide summer emission trends from 2000 to 2015 in the WNNA are shown in Figure 2-5 for anthropogenic NO_x and ROG, as well as biogenic ROG. Figure 2-5 clearly shows a significant decrease in both local anthropogenic NO_x (from 9.6 tpd to 5.2 tpd) and ROG (from 8.2 tpd to 5.2 tpd) emissions from 2000 to 2012. The anthropogenic NO_x and ROG emissions continued to decline from 2012 to 2015.

The transport of pollutants from the SFNA can significantly contribute to the exceedances of the federal ozone NAAQS in the WNNA. As such, it is useful to look at the emissions trend in SFNA since emissions from this regions are readily transported into the WNNA. The anthropogenic NO_x and ROG emissions trends for SFNA is also displayed in Figure 2-5 and shows large decreases in both anthropogenic NO_x (from 184 tpd to 103.6 tpd) and ROG (from 173 tpd to 110 tpd) emissions from 2000 to 2012. However, the SFNA emissions are much higher when compared to local sources, and specifically for 2012, the SFNA anthropogenic NO_x and ROG emissions are ~20 times higher than the corresponding local emissions in WNNA for 2012. It can be clearly seen from Figure 2-5 that the upwind source region has emissions that are an order of magnitude or higher than the local emissions, and when aided by conducive meteorological conditions (that facilitate pollutant transport), can be the dominant contributor to ozone levels in this region.

Over the same time period, the biogenic ROG emissions in WNNA exhibited large year-to-year variability, ranging from ~179 tpd in 2005 to ~303 tpd in 2006. However, even at its lowest levels, biogenic ROG is estimated to be ~25 times as high as the anthropogenic ROG inventory in 2005 and upwards of 45 times as high during peak biogenic years. The biogenic emissions for the upwind SNFA vary year-by-year but are estimated to be ~5 times higher than the corresponding anthropogenic emissions.

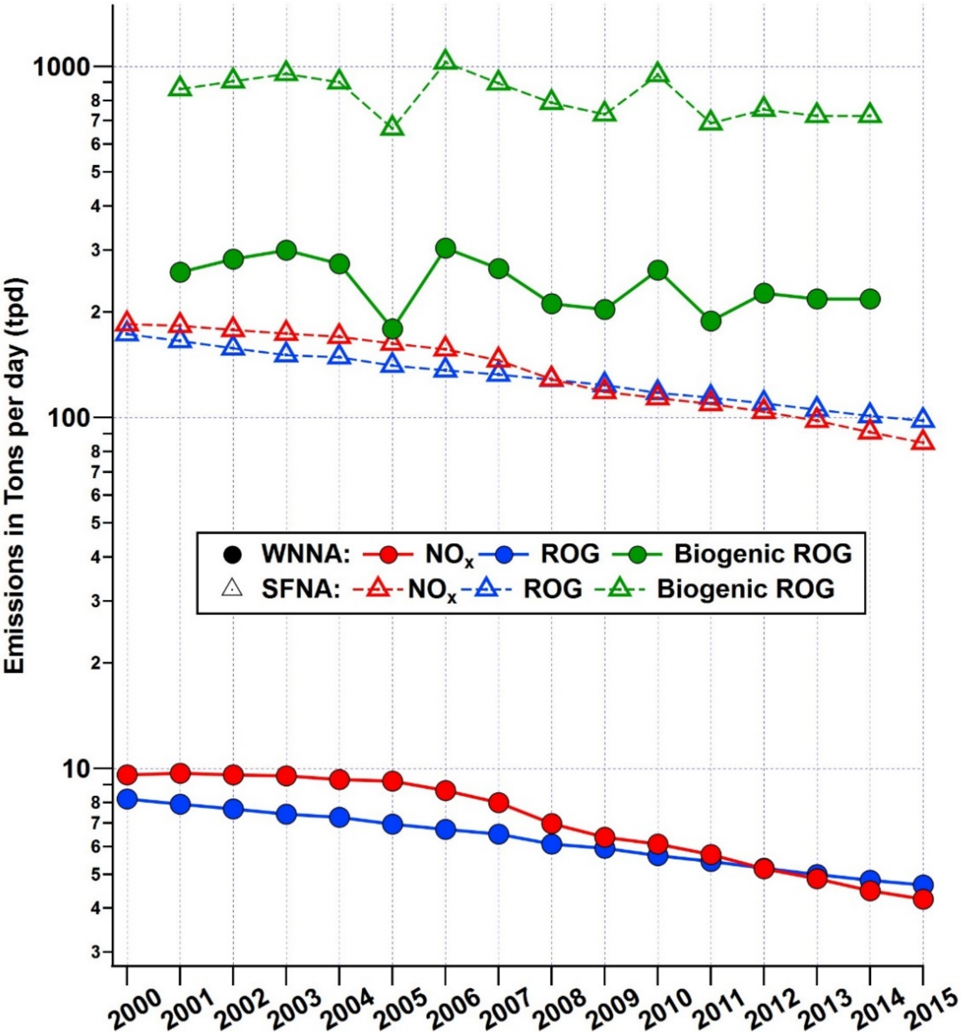

Figure 25. Trends in Anthropogenic NO_x and ROG along with biogenic ROG emissions of WNNA (Western Nevada county Non-attainment Area) and SFNA (Sacramento Federal 8-hour ozone Non-attainment Area) between 2000 and 2015.

2.6.2. Trend in 8-hour Ozone Design Values (DV)

Over the same 2000 to 2015 time period, the 8-hour ozone design values (DVs) and 4th highest values (used to calculate the DVs) within the WNNA declined steadily (Figure 2-6), but also exhibited a fair amount of variability due to year-to-year differences in meteorology, which impacts the transport of pollutants from upwind sources and the associated changes in biogenic emissions. Overall, the area-wide design values have declined by ~15 ppb from 96 ppb in 2000 to 81 ppb in 2015, albeit with fluctuations due to the year-to-year meteorological variability. However, these DVs are still substantially higher than the 2008 8-hour ozone standard of 75 ppb.

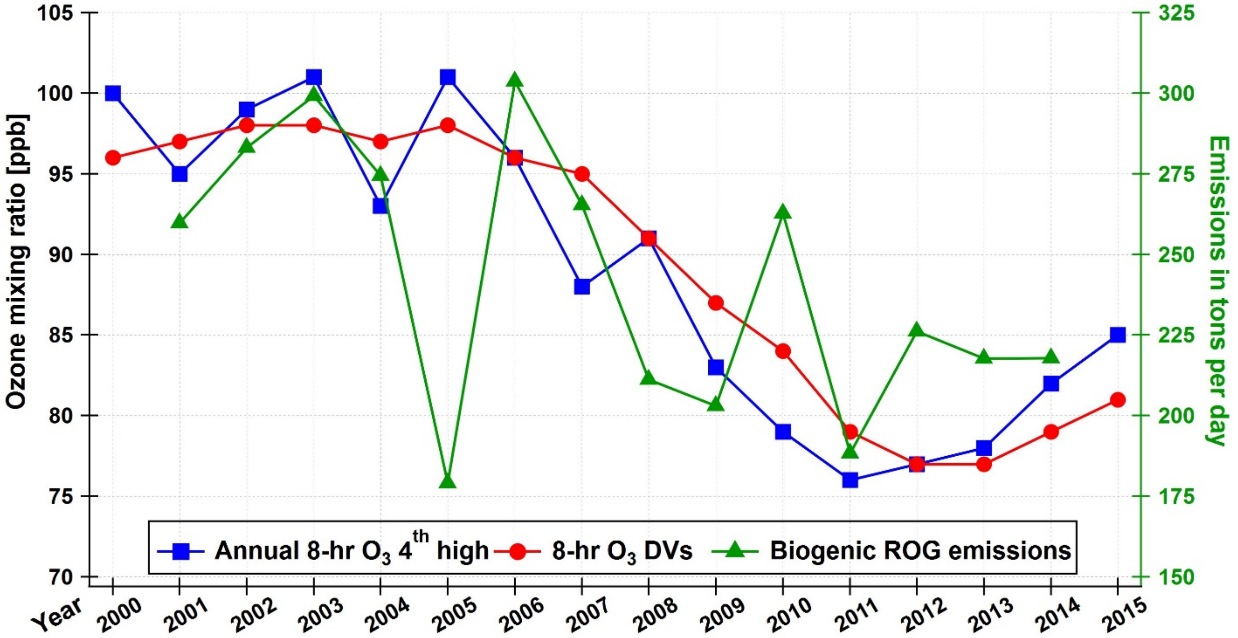

Figure 26. Trends in Western Nevada annual 4th high 8-hour ozone, 8-hour ozone design value, and biogenic ROG emissions between 2000 and 2015.

Comparing the year-to-year variability in ozone DVs and annual 4th highest values to similar variability in the biogenic ROG emissions, can sometimes provide evidence regarding the ozone chemistry regime for a region. For example, in areas that exhibit a strong NO_x-disbenefit, year-to-year variability in peak ozone will often be correlated to changes in biogenic ROG emissions (i.e., when biogenic ROG emissions increase, peak ozone will also increase). In WNNA, this correlation between biogenic ROG emissions and peak ozone was present from 2000 to 2004 (Figure 2-6), but after 2004 the two were generally anticorrelated, suggesting that the region is likely NO_x-limited and that other factors beyond chemistry, such as meteorology and wildfires, play a large role in the year-to-year variability in ozone.

2.6.3. Ozone Weekend Effect

Investigating the “weekend effect” and how it has changed over time is also a useful metric for evaluating the ozone chemistry regime in the WNNA. The weekend effect is a well-known phenomenon in some major urbanized areas where emissions of ozone precursors (in particular NO_x) are substantially lower on weekends than on weekdays, but the corresponding ozone levels are higher on weekends than on weekdays. Under these conditions, the region is considered to be in a NO_x-disbenefit (or VOC-limited) chemistry regime for ozone, where ozone increases with decreasing NO_x emissions. The excess NO_x in this regime not only titrates the O_3 but also mutes the VOC reactivity by using Peroxy radicals to terminate NO_2 as NO_3 radicals and subsequently HNO_3. The reduction of NO_x during the weekend (mainly due to the reduced motor vehicle and diesel truck activity) would lessen the titration and increase the VOC reactivity. The final result is elevated O_3 mixing ratios occurring disproportionally on weekends. When the opposite is true (i.e., higher ozone on weekdays than on weekends), the region is considered to be in a NO_x-limited chemistry regime (Heuss et al., 2003). A lack of a weekend effect (i.e., no pronounced high O_3 occurrences during weekends) would suggest that the region is transitioning from a NO_x-disbenefit to a NO_x-limited regime.

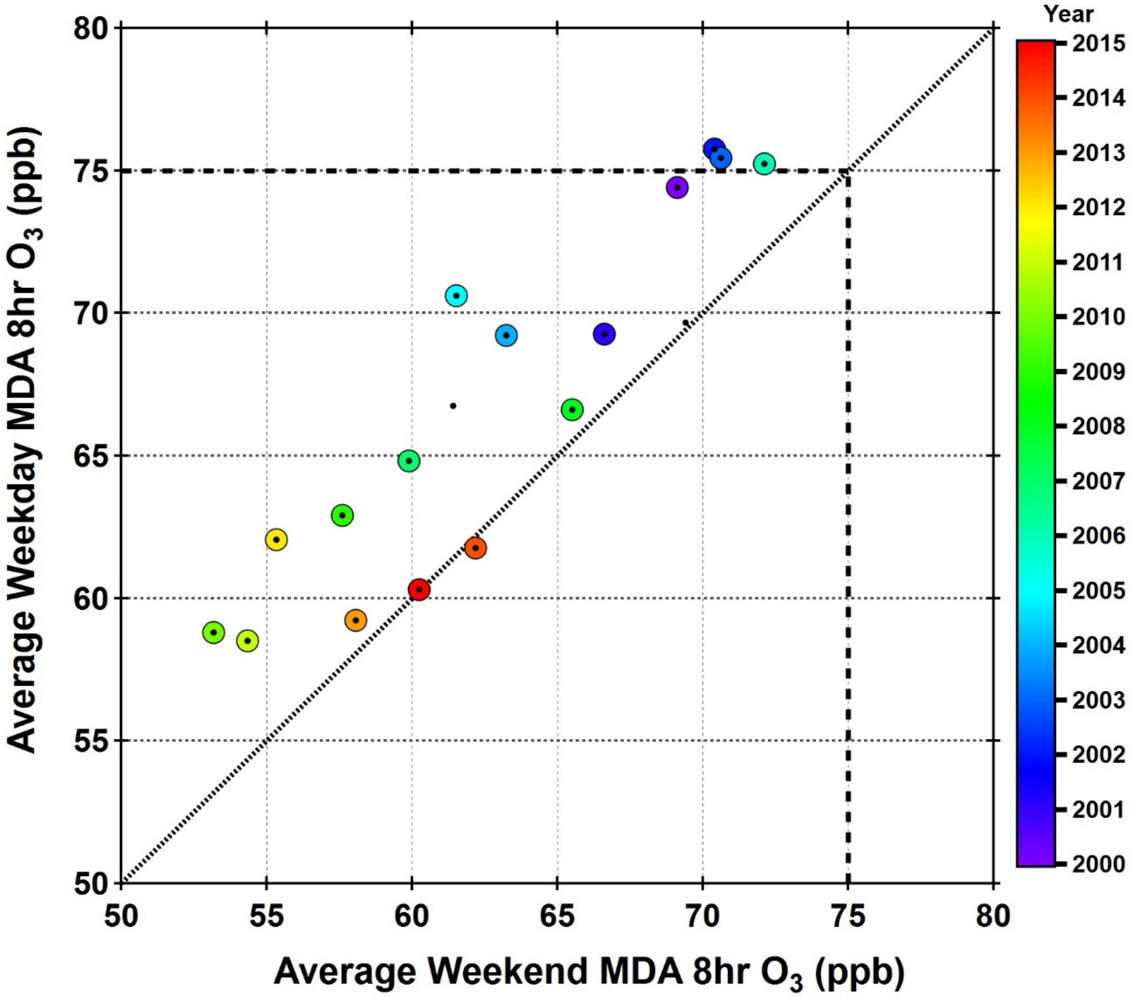

Figure 27. Average weekday and weekend maximum daily average (MDA) 8-hour ozone for each year from 2000 to 2015 for the Mojave ozone monitoring site in the

WNNA. Points falling below the 1:1 dashed line represent a NO_x-disbenefit regime, those on the 1:1 dashed line represent a transitional regime, and those above the 1:1 dashed line represent a NO_x-limited regime.

The trend in day-of-week dependence in the WNNA was analyzed using the ozone observations between 2000 and 2015 and the average site-specific weekday (Wednesday and Thursday) and weekend (Sunday) summertime (June through September) maximum daily average (MDA) 8-hr ozone value (Figure 2-7). Different definitions of weekday and weekend days were also investigated and did not show appreciable differences from the Wednesday/Thursday and Sunday definitions. A key observation in Figure 2-7 is that the summertime average weekday and weekend ozone levels have steadily declined between 2000 and 2015, which is consistent with the decline in the area-wide DVs and 4th high ozone values shown in Figure 2-6.
Along with the declining ozone levels, it can be seen that the WNNA has generally been in a NO_x limited regime, represented as greater peak weekday ozone when compared to weekend ozone. This region is in close proximity to biogenic ROG emissions sources and farther away from the large anthropogenic NO_x sources in the SFNA, such that low NO_x and high ROG conditions are prevalent, which is consistent with a NO_x-limited regime. The occasional shift in weekday/weekend ozone levels closer to the 1:1 dashed line (and in some years crossing over the line) is likely due to interannual variability in meteorological conditions and its impact on the regional transport patterns and local biogenic ROG emissions.

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