# California's Regional Haze Plan

## For the Second Implementation Period

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The Class I areas in the photographs shown on the page 1 are listed below from left to right.

**Top Row**
Desolation Wilderness Area, photograph courtesy of Nicole Dolney
Lassen Volcanic National Park, photograph courtesy of Jeff Kessler
Ansel Adams Wilderness Area, photograph courtesy of Rebekka Fine
Emigrant Wilderness Area, photograph courtesy of Jeff Kessler

**Middle Row**
Hoover Wilderness Area, photograph courtesy of Nicole Dolney
Kings Canyon National Park, photograph courtesy of Rebecca Garcia
Point Reyes National Seashore, photograph courtesy of Jeff Kessler

**Bottom Row**
San Jacinto Wilderness Area, photograph courtesy of Jeff Kessler
Sequoia National Park, photograph courtesy of Jeff Kessler
Ventana Wilderness Area, photograph courtesy of Jeff Kessler

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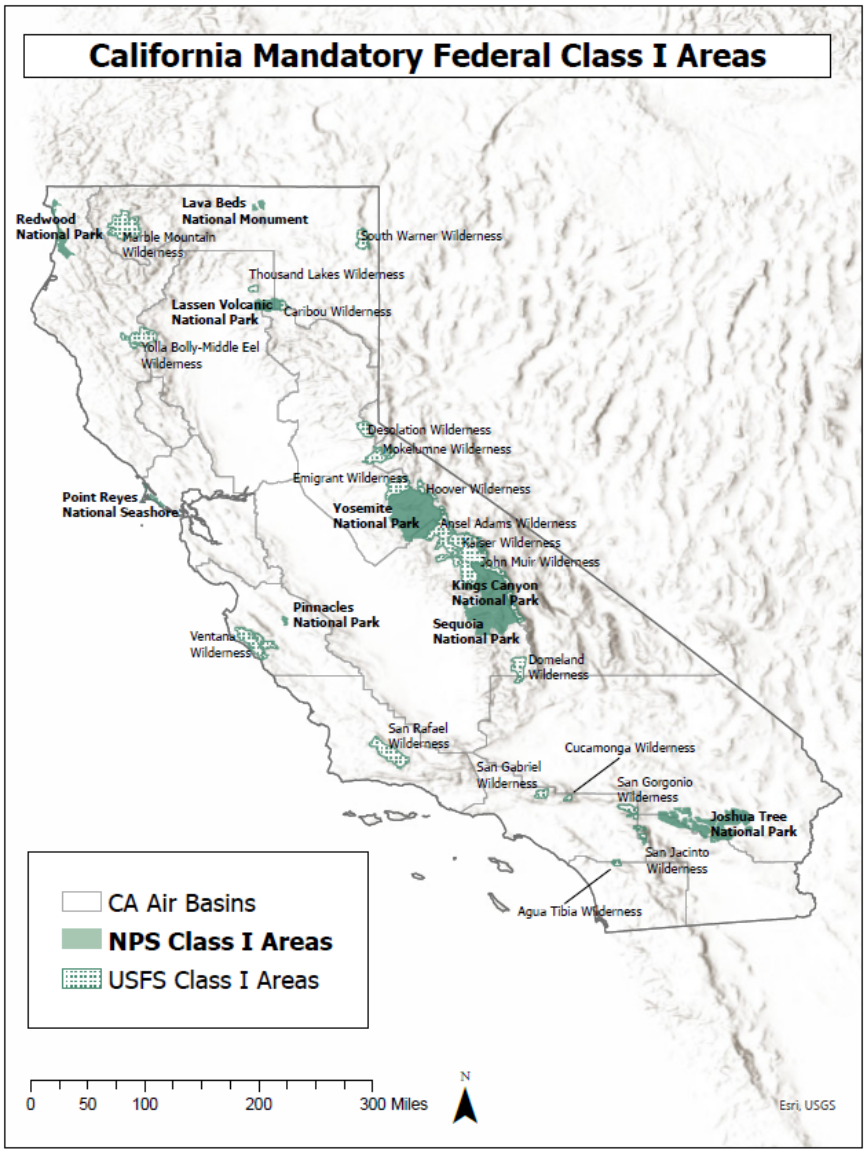
## Executive Summary

National parks and wilderness areas in California are known for their extensive vistas and striking views of the natural landscape. Views of these natural landscapes are diminished when pollutants from man-made and natural sources scatter and absorb light, reducing clarity, color, and overall visibility. The same man-made pollutants that contribute to diminished visibility across the State also impact air quality in communities, affecting the health outcomes of California's residents. Reducing emissions of man-made pollutants not only improves views of natural landscapes in parks and wilderness areas, but also improves visibility and air quality in communities throughout California.

In 1977, the U.S. Congress amended the federal Clean Air Act (Act) to include a national goal to remedy any existing visibility impairment and prevent any future visibility degradation in large national parks and federal wilderness areas. These wilderness areas and national parks that were afforded visibility protection under the Act are known as mandatory federal Class I areas (Class I areas). California has 29 Class I areas ranging from Yosemite National Park with its iconic alpine valley vistas to Joshua Tree National Park, known for its dramatic desert landscapes (Figure ES-1).

*Figure ES-1: California Class I Areas*




To ensure progress towards meeting the national goal, the U.S. Environmental Protection Agency (U.S. EPA) promulgated visibility protection rules that established state implementation plan (SIP) requirements for states to

address sources of visibility impairment and improve visibility to natural conditions by 2064. Under these rules, the California Air Resources Board (CARB) is required to develop a Regional Haze Plan every 10 years. The Regional Haze Plan must address visibility in California's 29 Class I areas along with impacts of California emissions on visibility in Class I areas located in other states.

This Regional Haze Plan builds on California's first plan, which was adopted by the CARB's governing board in 2009 and approved by U.S. EPA in 2011. As required by federal rule, this Regional Haze Plan includes a summary of visibility conditions in California's Class I areas, an assessment as to whether California is on track to restoring natural visibility conditions, a long-term strategy to ensure visibility continues to improve, and reasonable progress goals for visibility conditions in 2028. Consultation with neighboring states and federal land management agencies is also a required and critical part of developing the Regional Haze Plan.

In addition to numerous wilderness areas and national parks in California, the State is home to nearly 40 million people and has the fifth largest economy in the world. Weather, topography, and emissions from mobile sources drive significant air quality challenges in California, including the designation of the only two extreme ozone nonattainment areas (San Joaquin Valley, South Coast Air Basin) in the nation. As a result of these significant air quality challenges, the U.S. Congress provided California authority in the Clean Air Act to control mobile sources beyond the limits set by the federal government. California has been exercising this authority for over 50 years and emissions in the State have been reduced despite substantial population growth.

California also has some of the strictest controls on stationary sources in the nation as a result of strategies developed in response to the State's significant air quality challenges. With these mobile and stationary source controls, California has made significant strides in improving air quality.

The San Joaquin Valley and the South Coast Air Basins, the only two designated extreme ozone nonattainment areas in the country, have the most challenging ozone air quality problems in the nation. Implementation of controls has markedly reduced emissions of oxides of nitrogen (NOx), a pollutant that drives the formation of ozone and fine particulate matter. Since 1980, the number of days over the 70 parts per billion (ppb) 8-hour ozone standard has been reduced by about 25 percent in the San Joaquin Valley and South Coast Air Basins. Further, between 2000 and 2018, the first regional haze planning period, statewide NOx emissions decreased by more than 60 percent.

Alongside these emission reductions and air quality improvements, visibility conditions have improved in Class I areas throughout California. For regional haze planning purposes, visibility conditions are described using a metric called the deciview (dv) where visual perception is translated into a trackable number. A decrease in the dv metric indicates a

decrease in visibility impairment and an improvement in visibility. Thus, as visibility improves, impairment decreases, and the dv metric decreases. The dv metric is calculated using air quality data from monitoring sites in and around Class I areas.

Figure ES-2 shows the NOx emission reductions corresponding to an improved visibility at the SEQU1 visibility monitoring site, located in Sequoia National Park adjacent to the population centers and transportation corridors of the San Joaquin Valley, and the SAGO1 visibility monitoring site, which is located in the San Gorgonio Wilderness Area adjacent to the population centers of the South Coast Air Basin. Visibility impairment on the most impaired days at the SEQU1 monitor has decreased by more than 20 percent since 2000. At the SAGO1 monitor, visibility impairment has decreased by more than 30 percent since 2000. The figure is illustrative of the improvements measured in all of California's Class I areas and shows that CARB's emission control strategies focused on criteria air pollutants like ozone and fine particulate matter (PM2.5) are fundamental to improving visibility in California's parks and wilderness areas.

*Figure ES-2: Statewide Annual NOx Emissions and Average Annual Visibility Impairment on the Most Impaired Days at the SEQU1 and SAGO1 Monitoring Sites*

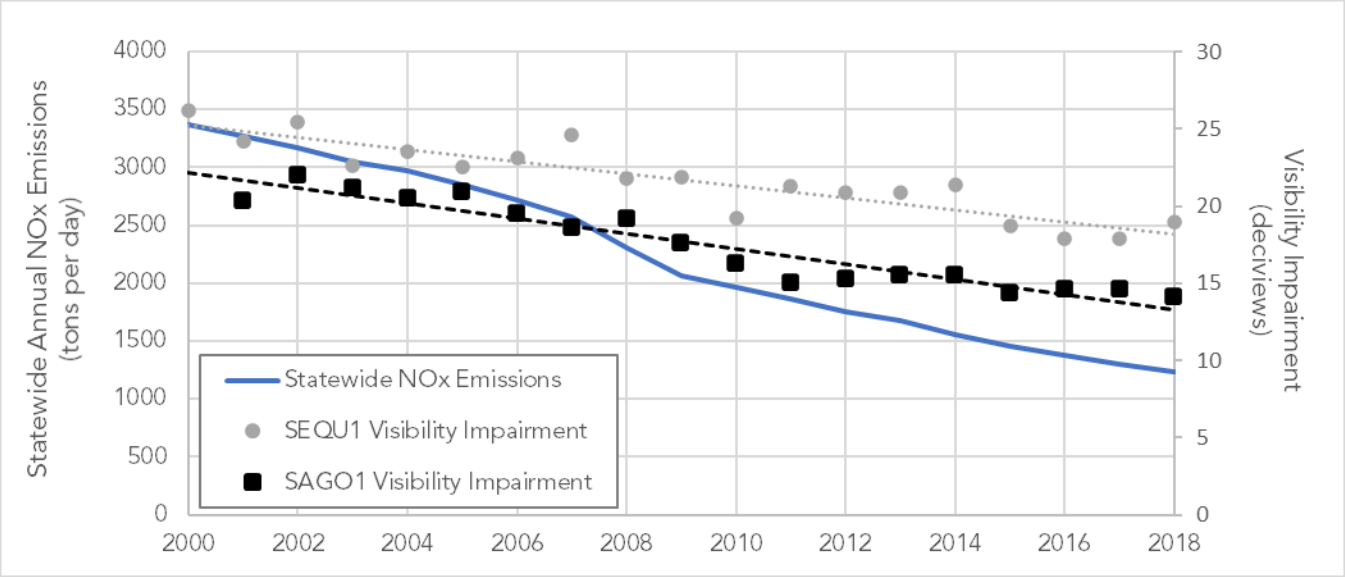



*Figure Notes: Linear trend lines shown for SEQU1 (dotted) and SAGO1 (dashed) visibility impairment; Emissions Data from CEPAM 2019 Ozone SIP Tool v1.03, 2017 Base Year*

California's first Regional Haze Plan addressed the 2008 to 2018 implementation period. The Plan included interim reasonable progress goals for visibility conditions in 2018 and a long-term strategy to meet those interim goals. The long-term strategy detailed in California's first Regional Haze Plan focused on emission reductions associated with mobile source control programs; specifically, NOx reductions from a suite of mobile source measures and oxides of sulfur (SOx) reductions from implementation of low-sulfur diesel fuel measures. Key to the strategy were the requirements to accelerate turnover of heavy-duty trucks and off-road

equipment. The long-term strategy yielded substantial reductions. Between the 2002 baseline inventory used for preparation of California's first Regional Haze Plan and 2017:

- Volatile organic compound emissions were reduced by 42 percent,
- NOx emissions were reduced by 57 percent,
- SOx emissions were reduced by 63 percent, and
- PM2.5 emissions were reduced by 29 percent.

Those emission reductions resulted in visibility improvement across the State. Table ES-1 compares visibility metrics calculated using baseline and current air quality data. Visibility conditions at all Class I areas in California have improved since the baseline period with the largest improvements measured in areas located in southern California.

*Table ES-1: Visibility on the Most Impaired Days at Monitoring Sites Representing Conditions in California's Class I areas*

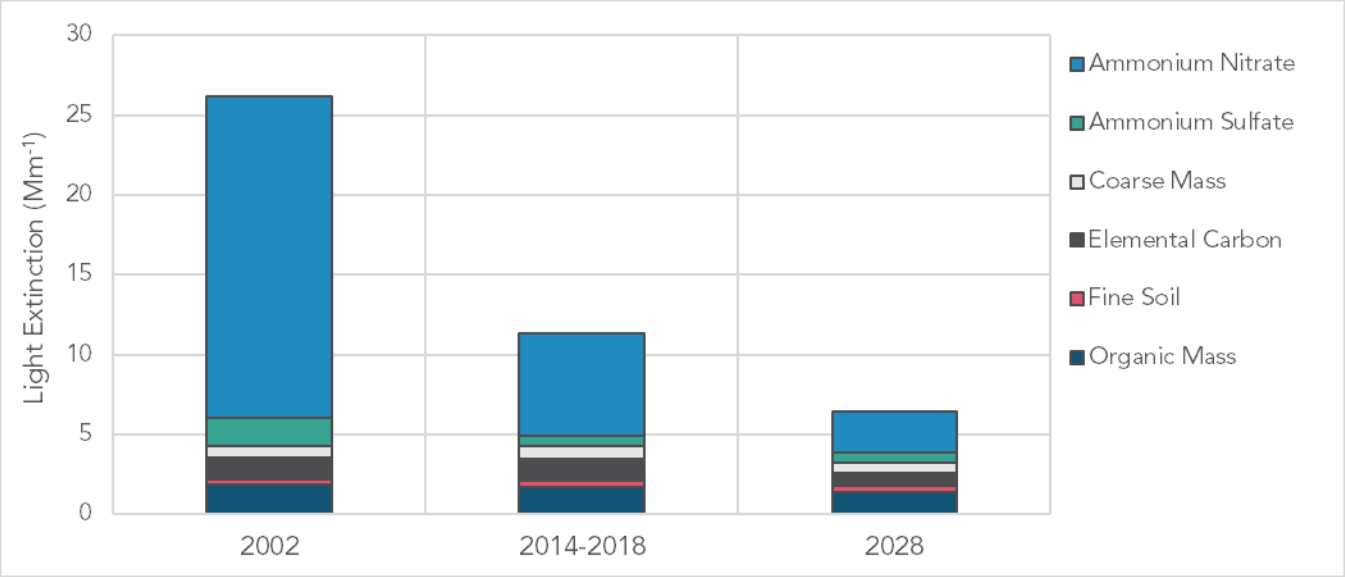
| California Region | Visibility Monitoring Site | Baseline 2000-2004 (dv) | Current 2014-2018 (dv) | Visibility Improvement (dv) |
|---|---|---|---|---|
| Northern | LABE1 | 11.3 | 9.7 | 1.6 |
| Northern | REDW1 | 13.7 | 12.6 | 1.1 |
| Northern | TRIN1 | 11.9 | 10.4 | 1.5 |
| Northern | LAVO1 | 11.5 | 10.2 | 1.3 |
| Northern | BLIS1 | 10.1 | 9.3 | 0.8 |
| Northern | PORE1 | 19.4 | 15.3 | 4.1 |
| Northern | YOSE1 | 13.5 | 11.6 | 1.9 |
| Central | HOOV1 | 8.9 | 7.8 | 1.1 |
| Central | KAIS1 | 12.9 | 11.0 | 1.9 |
| Central | PINN1 | 17.0 | 14.1 | 2.9 |
| Central | SEQU1 | 23.2 | 18.4 | 4.8 |
| Central | RAFA1 | 17.3 | 14.1 | 3.2 |
| Southern | DOME1 | 17.2 | 15.1 | 2.1 |
| Southern | SAGA1 | 17.9 | 13.2 | 4.7 |
| Southern | SAGO1 | 20.4 | 14.4 | 6.0 |
| Southern | JOSH1 | 17.7 | 12.9 | 4.8 |
| Southern | AGTI1 | 21.6 | 16.3 | 5.3 |

As shown in the above table, CARB's mobile source control strategy was effective at improving visibility in the first planning period. The strategy targeted NOx and SOx emissions, which serve as precursors to the haze pollutants ammonium nitrate and ammonium sulfate, respectively. Figure ES-3 shows the components of haze attributable to

man-made pollution at the SEQU1 monitoring site, which represents visibility conditions in Sequoia and Kings Canyon National Parks. These Class I areas have the highest levels of visibility impairment among all Class I areas in California. In Figure ES-3, ammonium nitrate is shown in blue and ammonium sulfate is shown in green. As shown, ammonium nitrate and ammonium sulfate levels decreased significantly in response to emissions reductions associated with the implementation of the control strategy between 2002 to 2018.

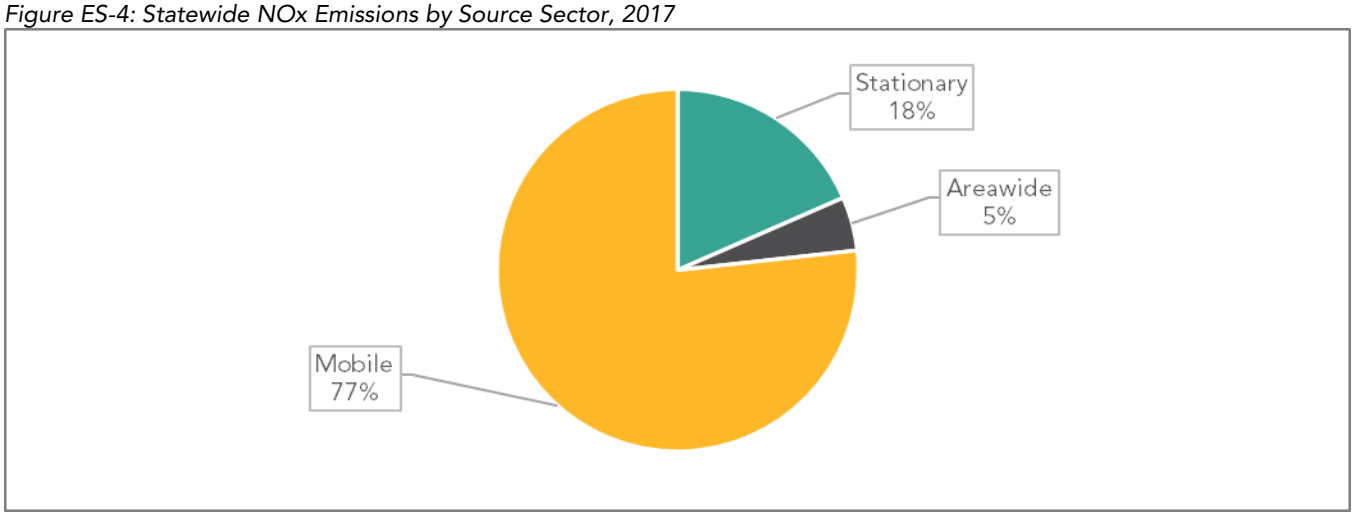
For this Regional Haze Plan, the 2014-2018 period is considered the current period and 2028 is the next milestone. Figure ES-3 shows that ammonium nitrate remains an important component of haze in this planning period and focused efforts to reduce NOx emissions will lead to further visibility improvements. As a result of the implementation of CARB's on-the-books controls, between the current period and 2028, statewide NOx emissions are forecast to decrease by 43 percent. Projections for California Class I areas, like those in Figure ES-3, show that ammonium nitrate will decrease in response to these NOx reductions. Thus, CARB is continuing to focus on NOx controls for this planning period.

*Figure ES-3: U.S. Source Apportionment for 2002, 2014-2018, and 2028 Emissions Scenarios at SEQU1*




Mobile sources operating in California account for nearly 80 percent of the State's NOx emissions (Figure ES-4). While just three percent of the on-road vehicle population, heavy-duty trucks account for 40 percent of mobile source NOx emissions and 31 percent of the total NOx emissions. In addition to the almost 400 tons per day (tpd) of NOx reductions projected to results from implementation of the existing mobile source control program across the State, CARB is committing to achieve additional emission reductions from the heavy-duty truck and light-duty vehicle sector as part of California's integrated long-term strategy to meet health-based air quality standards, reduce air toxics, and improve air quality in the most impacted communities.

*Figure ES-4: Statewide NOx Emissions by Source Sector, 2017*



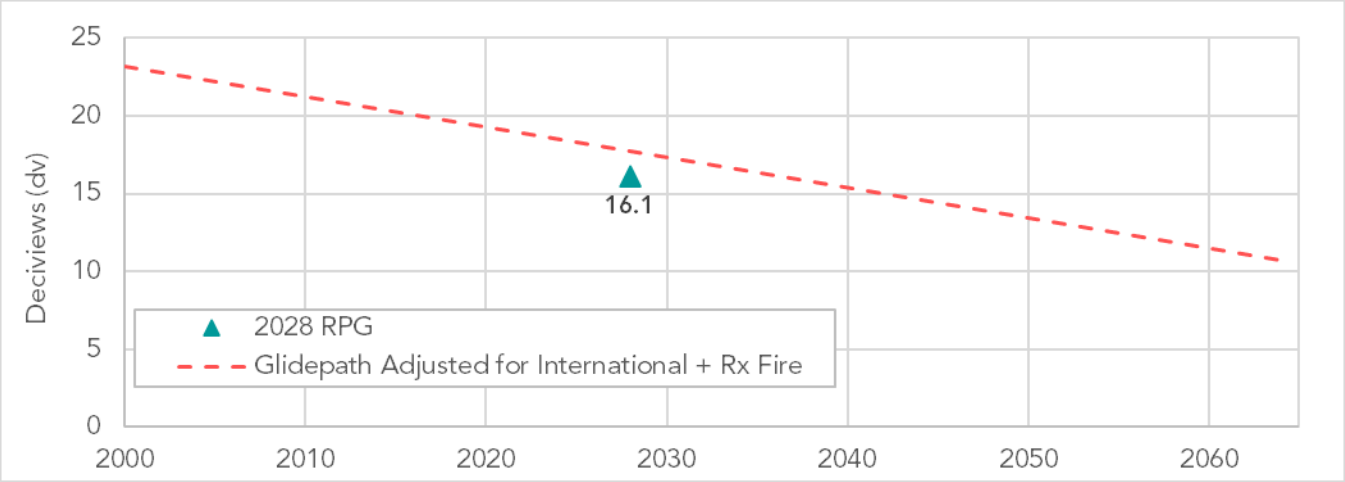

The State's commitment in this Regional Haze Plan (Table ES-2) is to achieve an aggregate emissions reduction of 40 tpd of NOx by 2028 through the adoption and implementation of four mobile source control measures. These emission reductions, coupled with the additional emission reductions from existing control programs will reduce haze pollutants and improve visibility at the Class I areas throughout the State.

*Table ES-2: Expected Statewide Emissions Reductions From 2016 State SIP Strategy Measures*

| **Regulatory Measure** | **NOx Reductions 2028 (tpd)** |
|---|---|
| Heavy-Duty Omnibus Regulation | 9 |
| Advanced Clean Trucks (Last Mile Delivery Measure) | 2 |
| Heavy Duty Vehicle Inspection and Maintenance Program | 28 |
| Advanced Clean Cars II | 1 |
| **Total Aggregate Commitment** | **40** |

The long-term strategy will provide for the achievement of reasonable progress in California's Class I areas. Figure ES-5 shows that the projected reasonable progress goal (RPG) for Kings Canyon and Sequoia National Parks is below the glidepath to achieve natural conditions by 2064. The 2028 RPGs show that visibility is on track to reach natural conditions by 2064 not only in Kings Canyon and Sequoia National Parks, but at all California Class I areas.

*Figure ES-5: Comparison of 2028 RPG and Adjusted Glidepath for Kings Canyon and Sequoia National Parks*



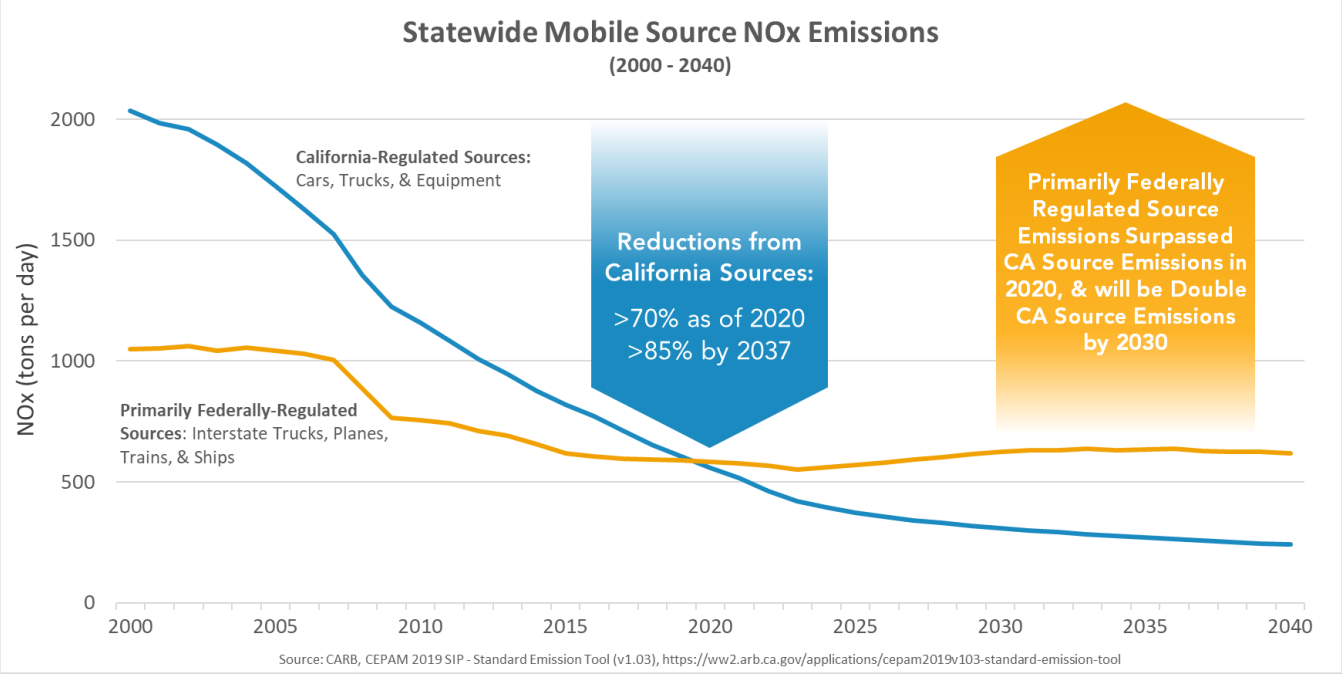

The projections are conservative because the new emission reduction strategies CARB is pursuing to reach attainment of the most recent 70 ppb 8-hour ozone national ambient air quality standard (NAAQS), specified in California's 2022 State SIP Strategy, are not accounted for in CARB's emission reduction commitment or the modeled visibility projections. The 2022 State SIP Strategy includes measures that further transition the state to zero emission technology over the next twenty to thirty years. This strategy will be critical for California to continue to make progress in future planning periods and for Class I areas like Kings Canyon National Park, shown below in Figure ES-6, to meet the 2064 natural conditions visibility goal.

*Figure ES-6: Photograph of Kings Canyon National Park*

*Photograph courtesy of Jeff Kessler*

Control strategies developed to meet health protective federal standards provide visibility benefits because the pollutants that diminish air quality and cause exceedances of health protective standards are the same pollutants that diminish visibility. Adoption of increasingly stringent health protective federal standards will continue to drive the need for additional control strategies and concerted efforts by regulatory agencies, including the U.S. EPA. As shown in Figure ES-6, absent federal action, NOx emissions from primarily federally-regulated mobile sources will be double California-regulated mobile sources by 2030. Federal action is critical for efforts aimed at meeting health-based standards and improving visibility in California's Class I areas in future planning periods.

*Figure ES-6: Statewide Mobile Source NOx Emissions, 2000 to 2040*




Regional haze planning is an iterative process. Every ten years, states assess current visibility across Class I areas to evaluate whether they are on track to return to natural visibility conditions in 2064. As control strategies improve visibility on the worst days relative to the previous planning period, new types of worst days come to the forefront. In other words, as California continues to reduce emissions from mobile sources and the resulting visibility impact of ammonium nitrate, other regional haze pollutants may become more prominent.

For this Regional Haze Plan, multiple lines of evidence indicate that reducing NOx emissions from mobile sources will be the most effective strategy for improving visibility across California Class I areas and ensure iconic vistas are preserved. For the next planning period, the State will consider actual 2024-2028 air quality data and again assess the pollutants and sources that are most effective to control. In alignment with the iterative planning process for

regional haze, following future assessments, California will make any needed adjustments to the State's long-term strategy to ensure visibility continues to improve.

# 1. Overview of the Regional Haze Rule

National parks and wilderness areas in California and throughout the U.S. are known for their extensive vistas and striking views of the natural landscape. Yosemite National Park, replete with some of California's most iconic vistas, is shown below in Figure 1-1. Views of these natural landscapes are diminished when pollutants from human-made and natural sources scatter and absorb light, reducing clarity, color, and overall visibility. Congress recognized the importance of these natural landscapes as specified in Section 169A of the Act by declaring "as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from man-made pollution." Pollutants that diminish visibility are known as haze and this Regional Haze State Implementation Plan (SIP) focuses on remedying visibility impairment.

*Figure 1-1: Photograph of Yosemite National Park, November 2021*
*Smoke Visible in the Photograph is from Prescribed Fire Operations*

*Photo Courtesy of Josh Berghouse*

Air pollutants that contribute to regional haze come from natural and human-made sources. Natural sources that contribute to haze include oceans, wildfires, plants, windblown dust, and volcanoes. Human-made sources that contribute to haze include stationary sources, mobile

sources, and areawide source. Stationary sources are emission sources in a fixed location like industrial and manufacturing facilities. Mobile sources include motor vehicles, aircraft, ocean-going vessels, and locomotives. Areawide sources are those where the emissions are spread over a wide area like residential wood burning, solvent evaporation, and prescribed fires.

As stated earlier, in 1977, Congress set a national goal to remedy any existing visibility impairment and prevent any future visibility degradation in mandatory federal Class I areas (Class I areas) that results from human-made air pollution. Section 162(a) of the Act designates Class I areas as those national parks greater than 6,000 acres in size, national wilderness area and national memorial parks greater than 5,000 acres in size, and international parks that were in existence on August 7, 1977. In 1979, U.S. EPA promulgated a list of the 156 Class I areas[1] where visibility is identified as an important value. Twenty-nine Class I areas are located in California.

Programs to protect visibility in Class I areas have been implemented as the result of rules promulgated by U.S. EPA. The Visibility Protection Rule promulgated in 1980 was intended to address visibility impairment that was reasonably attributable to a single source or small group of sources.[2] The Regional Haze Rule,[3] promulgated in 1999, laid out more comprehensive requirements for visibility protection in Class I areas. The Emigrant Wilderness Area, shown below in Figure 1-2, is one of California's Class I areas where visibility is protected under the Regional Haze Rule.

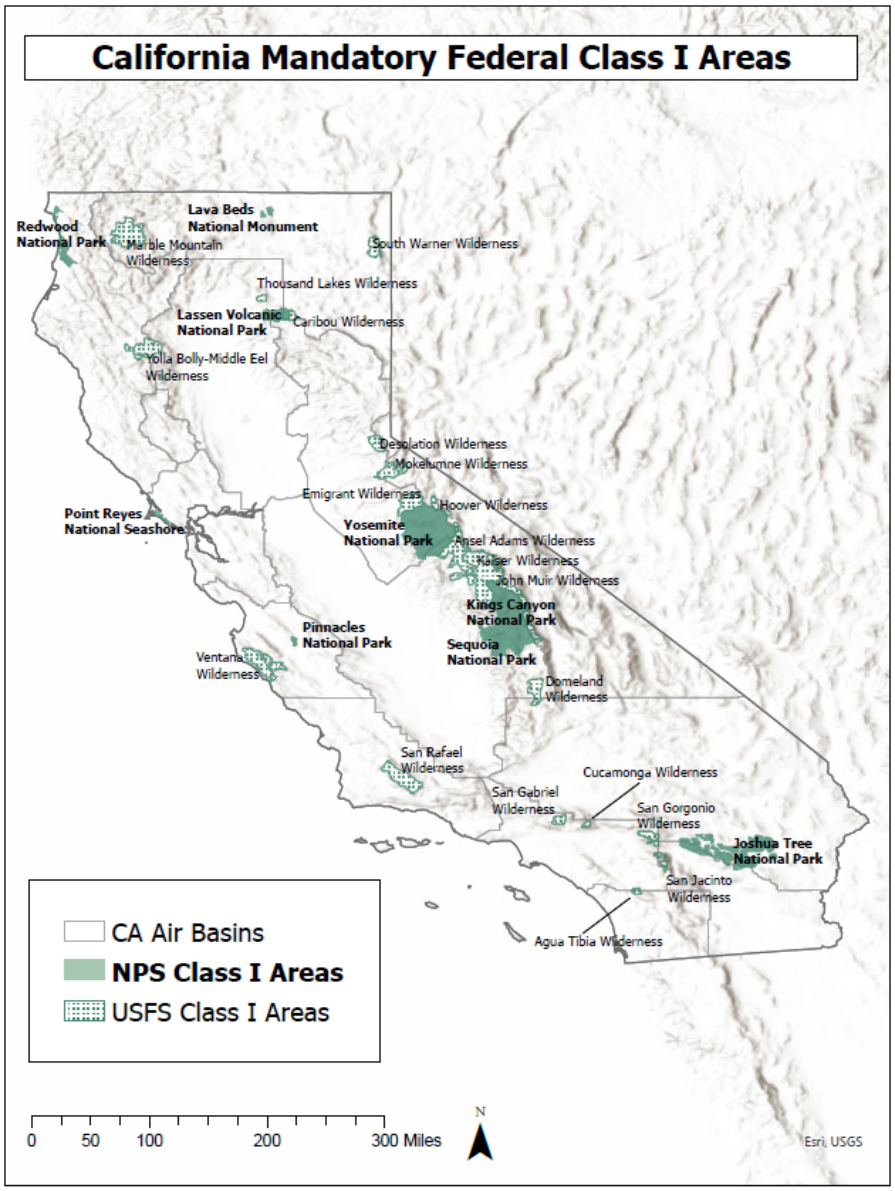
*Figure 1-2: Photograph of the Emigrant Wilderness Area*

*Photograph courtesy of Jeff Kessler*

[1] 44 FR 69122; November 30, 1979
[2] 45 FR 80084; December 2, 1980
[3] 64 FR 35714; July 1, 1999

The Regional Haze Rule lays out specific requirements intended to reduce emissions that contribute to visibility impairment in Class I areas, with the long-term goal of returning to natural visibility conditions in these areas by 2064. The 29 Class I areas in California are shown in Figure 1-3. The National Park Service (NPS) and the U.S. Forest Service (USFS) are the federal land managers with primary responsibility for management of the Class I areas in California.

*Figure 1-3: California's Mandatory Federal Class I Areas and Managing Agencies*




Unlike SIPs developed for NAAQS compliance that require specific targets and attainment dates, the Regional Haze Rule requires states to self-select a series of interim goals and strategies to demonstrate they are making "reasonable progress" towards the 2064 goal.

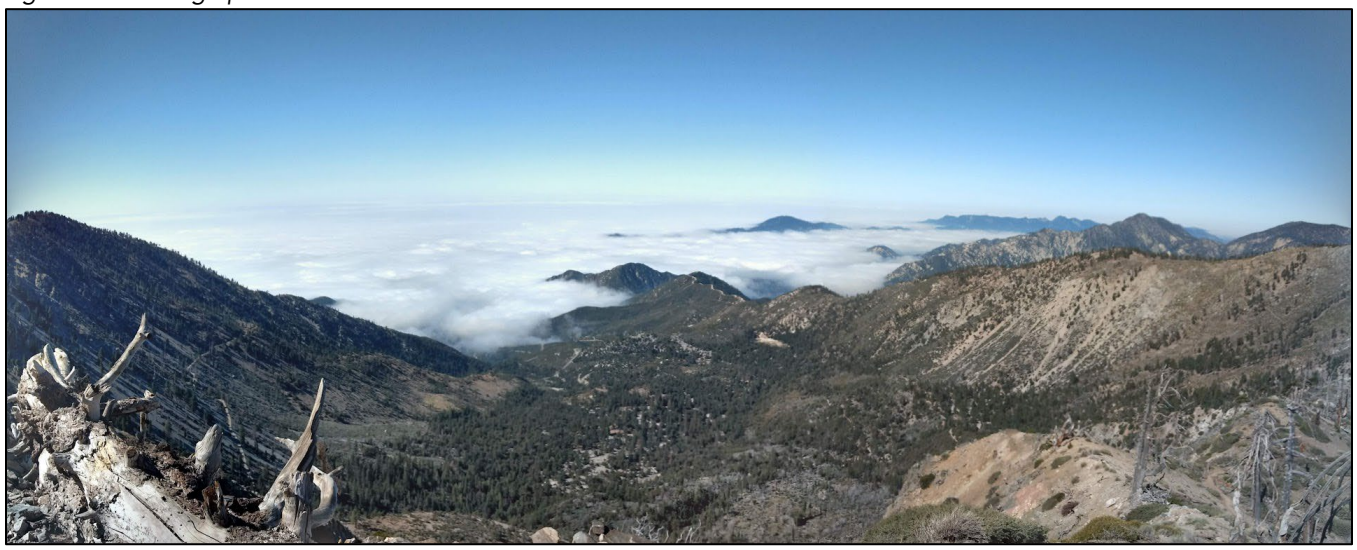
Given the regional nature of haze pollution, multi-state planning organizations were established to facilitate the coordinated technical analyses and consultation necessary for effective regional haze planning.

For western states, including California, the Western Regional Air Partnership (WRAP)[4] is the regional planning organization established to facilitate regional haze planning efforts. California works closely with the WRAP to develop regional haze SIPs that meet the requirements laid out by the Regional Haze Rule and provide meaningful progress towards improving visibility in California's Class I areas.

California's first Regional Haze Plan was adopted by CARB in December 2009 and approved by U.S. EPA in June 2011. This first Regional Haze Plan addressed the 2008 to 2018 implementation period, included interim reasonable progress goals for 2018, and a long-term strategy to meet those interim goals.

The long-term strategy detailed in California's first Regional Haze Plan focused on emission reductions associated with mobile source control programs. Emission reductions from CARB's mobile source programs were expected to reduce visibility impairment and prevent future visibility degradation in Class I areas impacted by emissions from California, including the San Gabriel Wilderness Area, shown below in Figure 1-4. Natural emission sources, particularly wildfire emissions, were expected to have an ongoing impact on visibility conditions in California's Class I areas.

*Figure 1-4: Photograph of the San Gabriel Wilderness Area*



*Photograph courtesy of Jeff Kessler*

[4] More information about the WRAP and its work is available online at *https://www.wrapair2.org/*.

U.S. EPA promulgated amendments to the Regional Haze Rule in 2017[5] and included changes to the content required in the second round of Regional Haze SIPs. The key changes included a revised metric to track progress and a provision to allow for the accounting of impacts from certain types of prescribed fire and international sources. The amendments also extended the due date for the second round of Regional Haze SIPs from July 31, 2018 to July 31, 2021.

This Regional Haze Plan is the required periodic SIP revision covering the second implementation period, 2018 to 2028. The key content required for this Regional Haze Plan includes:

- Calculation of baseline, current, and natural visibility conditions,
- Progress made for the most impaired and clearest days,
- Uniform rate of progress to achieve natural visibility conditions by 2064,
- Long-term strategy to reduce regional haze pollutants,
- Evaluation of emission reduction measures necessary to make reasonable progress as determined by consideration of the four statutory reasonable progress factors,
- Consideration of ongoing air pollution control programs, measures to mitigate construction activities, source retirement and replacement schedules, basic smoke management practices, and anticipated net effect on visibility due to projected changes in emissions,
- Technical basis for long-term strategy,
- 2028 reasonable progress goals, and
- Consultation with neighboring states and federal land management agencies.

This Regional Haze Plan is being submitted to fulfill the requirements for the second implementation period. The next periodic update is due in 2028, and every ten years thereafter.

To fulfill the requirements in the Regional Haze Rule for development of progress reports in the interim between periodic SIP revisions, this submittal also includes an embedded progress report. California commits to submitting the next interim progress report by its due date of January 31, 2025. Subsequent interim progress reports are due every ten years thereafter.

[5] 82 FR 3078; January 10, 2017

# 2. Visibility Conditions in California's Mandatory Federal Class I Areas

California's Class I areas span more than four million acres, ranging in size from the Cucamonga Wilderness Area, which includes just under 13,000 acres, to Yosemite National Park, which covers more than 750,000 acres. Nine of California's Class I areas are managed by the NPS and twenty are managed by the USFS. This chapter provides an overview of the visibility monitoring network, describes visibility conditions on the clearest and most impaired days, and summarizes progress towards natural conditions.

## Visibility Monitoring

California relies on data from 17 monitoring sites operated by the Interagency Monitoring of PROtected Visual Environments (IMPROVE) Network to track visibility conditions in California's Class I areas. Operation of monitors in the IMPROVE Network requires reliable power and year-round site access. As result, there are limitations to where monitoring sites can be established. IMPROVE monitoring sites in California are located in or near Class I areas and some monitoring sites are representative of conditions in more than one Class I area. The IMPROVE monitoring site in the Agua Tibia Wilderness Area is shown in Figure 2-1.

*Figure 2-1: Photograph of the AGTI1 Monitoring Site in Agua Tibia Wilderness Area*

Source: http://vista.cira.colostate.edu/Improve/monitoring-site-browser/

Each IMPROVE monitoring site includes four independent sampler modules. The data collected by each module is summarized in Table 2-1. The modules collect 24-hour samples, midnight to midnight, every three days. Filters from each of the sampler modules are then manually collected and shipped to laboratories for analyses. Data are then compiled and reported to publicly available databases.

*Table 2-1: Description of IMPROVE Sampler Modules*

| Module | Filter Type | Inlet Type | Data Type |
|---|---|---|---|
| A | Teflon | PM2.5 | PM2.5 mass and elements |
| B | Nylon | PM2.5 | Sulfate, nitrate, nitrite, and chloride |
| C | Quartz | PM2.5 | Organic and elemental carbon |
| D | Teflon | PM10 | PM10 mass |

Filter analysis from each of the IMPROVE sampler modules yields a large amount of data, including mass of visibility reducing PM species (measured in units of micrograms per cubic meter, or ug/$m^3$), that are used in determining visibility conditions. Visibility reducing PM species include ammonium nitrate, ammonium sulfate, coarse mass, elemental carbon, fine soil, organic mass, and sea salt. The contribution to visibility impairment from each of these key species varies from site to site and is influenced by proximity to sources, land use patterns, climate, and meteorological conditions. Common human-made and natural sources of these visibility reducing PM species are shown in Table 2-2.

*Table 2-2: Common Sources of Visibility Reducing PM Species*

| PM Species | Human-made Sources | Natural Sources |
|---|---|---|
| Ammonium Nitrate | Motor vehicles, industrial boilers, other combustion processes, agriculture | Soil, lightning, fire |
| Ammonium Sulfate | Coal-fired power plants, diesel engines, industrial boilers | Volcanoes, fire, oceanic emissions, geothermal activity |
| Coarse Mass | Construction, roads, residential wood burning | Wind-blown dust, fire |
| Elemental Carbon | Residential wood burning, motor vehicles | Fire |
| Organic Mass | Motor vehicles, commercial cooking, commercial solvents, incineration, residential heating | Vegetation, fire |
| Sea Salt | -- | Ocean spray, dry lakebeds |
| Fine Soil | Off-road vehicles, agriculture, deforestation, unpaved roads | Soil resuspension, dust storms |

The procedures for collecting data, analyzing samples, and reporting monitoring results are established by the IMPROVE Steering Committee. Operating procedures for all aspects of the program are routinely reviewed by the IMPROVE Steering Committee. Raw data, the algorithms used to calculate visibility impairment metrics, standard operating procedures, and other network documents are available on the IMPROVE website.[6]

California will continue to participate in the IMPROVE program, follow the monitoring strategy developed by the Steering Committee, and rely on data collected by the network to track visibility conditions for Class I areas in the state. California's interests are represented by WRAP's participation on the IMPROVE Steering Committee.

[6] *http://vista.cira.colostate.edu/Improve/*

## Visibility Metrics

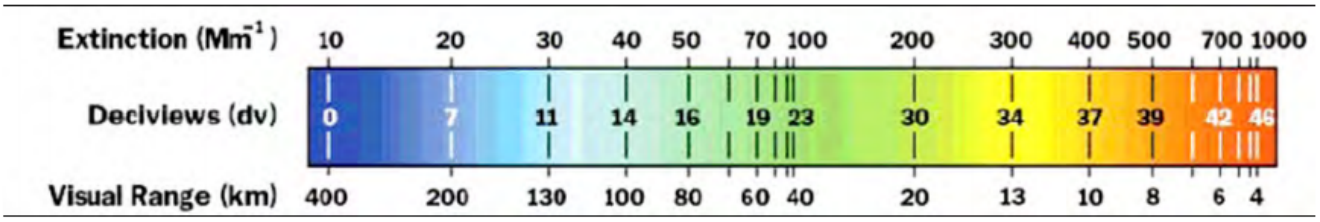
The link between visibility reducing PM species and visibility impairment is key to understanding regional haze. Visibility reducing PM species scatter and absorb light in the atmosphere. The quantity of light scattered and absorbed affects visibility, that is the clarity of objects viewed at a distance by the human eye.

The amount of light scattered or absorbed varies by PM species. After the concentration of each PM species is determined by laboratory analyses, the IMPROVE algorithm is used to calculate the magnitude of light extinction, in units of inverse megameters ($Mm^{-1}$), attributable to each PM species. The sum of the calculated amount of light extinction for a given day is then converted to deciviews (dv) using the equation below:

*$DV = 10 * ln (b_{ext}/10)$, where $b_{ext}$ is light extinction expressed in $Mm^{-1}$*

Deciviews are the specific units of measurement used to report visibility conditions for areas subject to the Regional Haze Rule. The relationship between inverse megameters and deciviews is shown in Figure 2-2. Visual range increases as deciviews and light extinction decrease. A change of one dv, equivalent to 10 $Mm^{-1}$, is generally considered perceptible to the human eye.

*Figure 2-2: Relationship Between Units Used to Describe Visibility Conditions*




The main benefit of using the deciview index as the standard reporting metric is that it allows for a quantitative measure of visibility impairment. A drawback to its use is that the deciview index is not easily relatable to ambient PM concentrations. Rather, deciviews are proportional to the natural logarithm of atmospheric light extinction. While atmospheric light extinction can be directly related to PM concentrations, light extinction is non-linearly related to a person's perception of visual range.

To illustrate what these indicators represent, two images of the Ansel Adams Wilderness Area are shown in Figure 2-3. The image on the left is representative of visibility conditions on the clearest days during the 2014 to 2018 time-period when the average visibility impairment was 1.5 dv, which is comparable to a visual range of 336 km (209 miles). The image on the right is representative of visibility conditions on the most impaired days during the 2014 to 2018 time-period when the average visibility impairment was 11.0 dv, which is comparable to a visual range of 130 km (81 miles).

*Figure 2-3: Simulated Images of Ansel Adams Wilderness Area Representative of Average Visibility Conditions on the Clearest (left) and Most Impaired (right) days during 2014-2018*

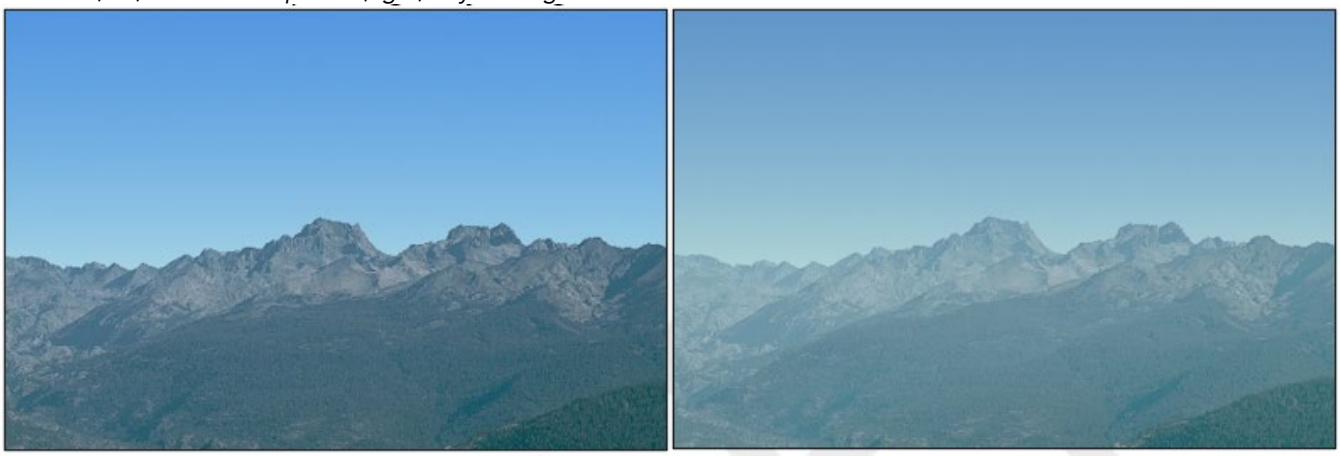


*Image Source: WinHaze Visual Air Quality Modeler from http://vista.cira.colostate.edu/Improve/winhaze/*

## Overview of Baseline, Current, and Natural Visibility Conditions

Visibility conditions represent the degree of visibility impairment in a particular area over a certain set of days. The Regional Haze Rule requires states to report visibility conditions during the baseline and current periods for the clearest and most impaired days.

The baseline period is the 2000 to 2004 time-period. The current period is the 2014 to 2018 time-period, for purposes of this Regional Haze Plan. The clearest days means the 20 percent of monitored days in a calendar year with the lowest amounts of visibility impairment. Conversely, the most impaired days means the 20 percent of monitored days in a calendar year with the highest amounts of human-made visibility impairment.

The baseline visibility metrics are determined using monitoring data from the five-year baseline period to calculate the average of annual values for the clearest days and the most impaired days. Calculation of the current visibility metrics follow the same convention as the baseline visibility metrics, except monitoring data from the 2014 to 2018 period are used.

Baseline visibility conditions at California's Class I areas ranged from 1.4 to 10.5 dv on the clearest days and 8.9 to 23.2 dv on the most impaired days. Since implementation of California's first Regional Haze Plan, visibility has improved when compared to the baseline period. Visibility conditions for the current period now range from 1.0 to 8.2 dv on the clearest days and 7.8 to 18.4 dv on the most impaired days.

For each Class I area, the goal set forth by the Regional Haze Rule is to return visibility to natural conditions by the end of 2064. Natural conditions are visibility conditions expected to exist in the absence of impairment resulting from human-made pollutants. Natural events including dust storms, volcanic activity, and wildfires can contribute to visibility impairment at Class I areas, with some episodic events leading to elevated short-term impairment.

Estimates of natural conditions attempt to provide a statistical normalization of routine and episodic natural conditions over time. Natural condition estimates were calculated as part of the technical analyses conducted by the WRAP and are based on 2000 to 2014 average natural condition values for the clearest and most impaired days following U.S. EPA's December 2018 guidance.

Additional research is needed to improve our understanding and quantify the role of natural emissions on regional haze. As our understanding improves, the revisions to the equations used to develop natural condition estimates are expected to be revised. For this Regional Haze Plan, natural conditions at California's Class I areas are estimated to range from 0.0 to 4.8 dv on the clearest days and 4.9 to 9.7 dv on the most impaired days.

### Progress Metrics

The Regional Haze Rule requires states to quantify progress towards estimated natural conditions. The amount of progress made is quantified by reporting the difference between visibility conditions during the baseline and current periods. The amount of progress that still needs to be made is quantified by reporting the difference between visibility conditions during the current period and estimated natural conditions.

Comparison of data from the baseline and current time periods, indicates that no degradation in visibility conditions occurred at any of California's Class I areas. Between the baseline and current periods, visibility conditions on the clearest days improved by 0.3 to 2.6 dv. Visibility conditions on the most impaired days improved by 0.8 to 6.0 dv.

For each Class I area, the following section will provide the baseline, current, and natural visibility conditions along with progress made and the progress that still needs to be made for the most impaired and clearest days.

## Discussion of Visibility Conditions and Progress

### California Air Basins

For air quality planning purposes, California is divided geographically into 15 air basins (Figure 2-4). An air basin generally has similar meteorological and geographic conditions throughout. To facilitate the discussion and presentation of information in this Regional Haze Plan, the 29 Class I areas in California are organized into three groups: Northern California, Central California, and Southern California, based upon the geographic location of the air basin where the representative IMPROVE monitor is located.

*Figure 2-4: Air Basins in Northern California, Central California, and Southern California*


## Northern California – Visibility Conditions and Progress Metrics

The Northern California region includes the Lake County, Lake Tahoe, Mountain Counties, North Coast, Northeast Plateau, Sacramento Valley, and San Francisco Bay Air Basins. The terrain is varied with numerous mountains surrounding the expansive Sacramento Valley. The Klamath Mountains and the southern end of the Cascade Range lie north of the Sacramento Valley. The Coast Ranges are situated between the Pacific Ocean and the Sacramento Valley forming the western border, while the Sierra Nevada Mountains border the Sacramento Valley to the east.

The terrain of this region plays a critical role in the transport of emissions. The sea breeze circulation promotes transport of offshore emissions, from sources such as ocean-going

vessels (OGV), while the mountains that border the Sacramento Valley provide a physical barrier that directs circulation patterns. Under typical sea breeze circulation patterns, air enters the valley through the San Francisco Bay and then is funneled both north and south by the Sierra Nevada Mountains. Local-scale circulations also influence pollutant formation and transport in this area. Mountain-valley circulations are driven by the temperature gradients between the valleys and adjacent mountains. Areas adjacent to waterbodies can be influenced by sea breeze or lake breeze circulations, which are driven by the temperature gradients between the surface of the water and the surface of the adjacent land.

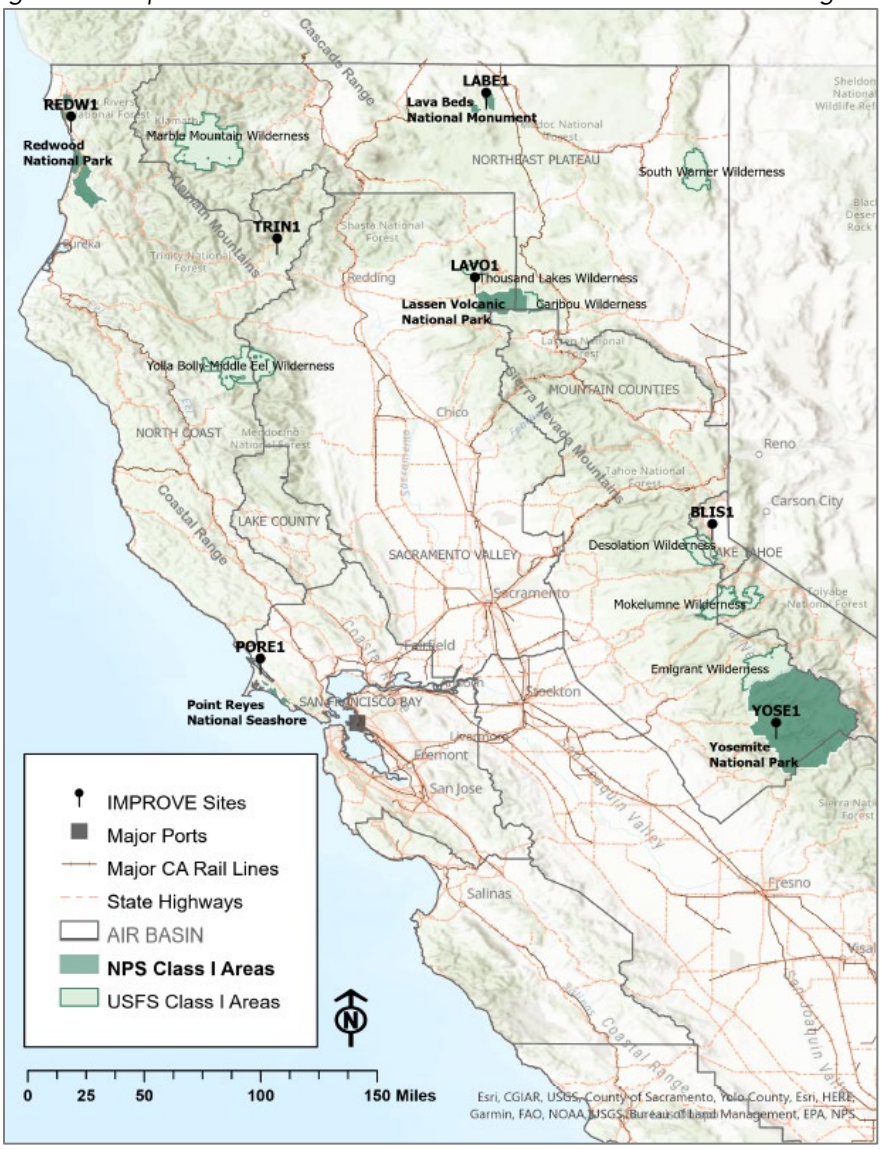
Most of the Northern California region is sparsely populated. Portions of the Sacramento Valley and San Francisco Bay Air Basins are an exception. The capital city of Sacramento, with a population of nearly 500,000 people, is in the southern part of the Sacramento Valley Air Basin. The cities of Oakland, San Francisco, and San Jose, located within the San Francisco Air Basin, are home to more than two million people. When outlying suburban areas are considered, the population is more than five million. Emissions from these urban areas contribute to visibility impairment at Class I areas in this region. The landscape of most of the rural areas in this region is densely forested and fire emissions routinely contribute to visibility impairment. The forested landscape west of the IMPROVE monitoring site in the Trinity National Forest (TRIN1) is shown below in Figure 2-5.

*Figure 2-5: Photograph Looking West from the Trinity National Forest IMPROVE Site (TRIN1)*

*Image Source: http://vista.cira.colostate.edu/Improve/monitoring-site-browser/*

As shown in Figure 2-6, seven IMPROVE monitoring sites are in the Northern California region. From north to south, the monitoring sites in Northern California are located at Lava Beds National Monument (LABE1), Redwood National Park (REDW1), Trinity National Forest (TRIN1), Lassen Volcanic National Park (LAVO1), DL Bliss State Park (BLIS1), Point Reyes National Seashore (PORE1), and Yosemite National Park (YOSE1). Data collected at these monitoring sites represent visibility conditions at 13 Class I areas.

*Figure 2-6: Map of Northern California Class I Areas and IMPROVE Monitoring Sites*




Visibility conditions for the clearest and most impaired days in the Class I areas characterized by these Northern California monitors are summarized in Table 2-3. For these areas, visibility impairment on the clearest days ranged from 2.5 to 10.5 dv during the baseline period and 1.8 to 8.2 dv during the current period. On the most impaired days, visibility impairment ranged from 10.1 to 19.4 dv during the baseline period and 9.3 to 15.3 dv during the current period. For the current period, these visibility conditions are comparable to a visual range of 172 to 326 km (107 to 202 miles) on the clearest days and a visual range of 84 to 154 km (52 to 96 miles) on the most impaired days.

*Table 2-3: Visibility Conditions at Class I Areas in Northern California*

| IMPROVE Site | Class I Area(s) | Clearest Days Baseline (dv) | Clearest Days Current (dv) | Most Impaired Days Baseline (dv) | Most Impaired Days Current (dv) |
|---|---|---|---|---|---|
| LABE1 | Lava Beds National Monument South Warner Wilderness Area | 3.2 | 2.5 | 11.3 | 9.7 |
| REDW1 | Redwood National Park | 6.1 | 5.3 | 13.7 | 12.6 |
| TRIN1 | Marble Mountain Wilderness Yolla Bolly-Middle Eel Wild. Area | 3.4 | 3.1 | 11.9 | 10.4 |
| LAVO1 | Caribou Wilderness Area Lassen Volcanic National Park Thousand Lakes Wilderness | 2.7 | 2.2 | 11.5 | 10.2 |
| BLIS1 | Desolation Wilderness Area Mokelumne Wilderness Area | 2.5 | 1.8 | 10.1 | 9.3 |
| PORE1 | Point Reyes National Seashore | 10.5 | 8.2 | 19.4 | 15.3 |
| YOSE1 | Emigrant Wilderness Area Yosemite National Park | 3.4 | 2.9 | 13.5 | 11.6 |

The least amount of impairment on both the clearest and most impaired days was measured at the BLIS1 monitor, which represents visibility conditions in Desolation Wilderness Area and Mokelumne Wilderness Area (shown below in Figure 2-7). The BLIS1 monitor is in the Lake Tahoe Air Basin. The steep terrain surrounding Lake Tahoe provides a physical barrier which typically isolates the air basin from routine transport of emissions from urban areas. However, the steep terrain can facilitate the formation of strong inversions that can promote the accumulate of pollutants and limit dispersion. Motor vehicle emissions, road dust, and residential wood burning are the largest emission source sectors in the Lake Tahoe Air Basin.

*Figure 2-7: Photograph of the Mokelumne Wilderness Area*

*Photograph courtesy of Jeff Kessler*

The most impairment on the clearest and most impaired days was measured at the PORE1 monitor, representing visibility conditions at the Point Reyes National Seashore, shown below in Figure 2-8. The PORE1 monitor is in the San Francisco Bay Air Basin, which includes one of the largest and most populous metropolitan areas in California as well as one of the largest

natural harbors in the world. Urban emissions from these areas contribute to visibility impairment measured at PORE1.

*Figure 2-8: Point Reyes National Seashore*

*Public domain photograph, courtesy of NPS*

A comparison of baseline, current, and natural conditions for Class I areas in Northern California is provided in Tables 2-4 and 2-5 for the clearest and most impaired days, respectively. On the clearest days, estimated natural visibility conditions in Northern California range from 0.4 to 4.8 dv. Oceanic emissions routinely contribute to visibility impairment at Class I areas situated along the coast, including Point Reyes National Seashore and Redwood National Park. Estimates of natural conditions at Class I areas situated along the coast are generally higher than Class I areas situated farther inland. Visibility has not degraded on the clearest days in any of California's Class I areas. In Northern California, between the baseline and current periods visibility impairment has decreased by 9 to 28 percent on the clearest days.

*Table 2-4: Natural Conditions, Progress Made, and Progress Needed for Clearest Days in Northern California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| LABE1 | Lava Beds National Monument<br>South Warner Wilderness Area | 1.3 | 0.7 | 1.2 |
| REDW1 | Redwood National Park | 3.5 | 0.8 | 1.8 |
| TRIN1 | Marble Mountain Wilderness<br>Yolla Bolly-Middle Eel Wild. Area | 1.2 | 0.3 | 1.9 |
| LAVO1 | Caribou Wilderness Area<br>Lassen Volcanic National Park<br>Thousand Lakes Wilderness | 1.0 | 0.5 | 1.2 |
| BLIS1 | Desolation Wilderness Area<br>Mokelumne Wilderness Area | 0.4 | 0.7 | 1.4 |
| PORE1 | Point Reyes National Seashore | 4.8 | 2.3 | 3.4 |
| YOSE1 | Emigrant Wilderness Area<br>Yosemite National Park | 1.0 | 0.5 | 1.9 |

As shown in Table 2-5, estimated natural visibility conditions on the most impaired days range from 4.9 to 9.7 dv in Northern California. Like the clearest days, the routine contribution of oceanic emissions yields higher estimated natural conditions for Class I areas situated on the coast. Visibility impairment on the most impaired days decreased by a range of 8 to 21 percent between the baseline and current periods.

*Table 2-5: Natural Conditions, Progress Made, and Progress Needed for Most Impaired Days in Northern California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| LABE1 | Lava Beds National Monument<br>South Warner Wilderness Area | 6.2 | 1.6 | 3.5 |
| REDW1 | Redwood National Park | 8.6 | 1.1 | 4.0 |
| TRIN1 | Marble Mountain Wilderness<br>Yolla Bolly-Middle Eel Wild. Area | 6.5 | 1.5 | 3.9 |
| LAVO1 | Caribou Wilderness Area<br>Lassen Volcanic National Park<br>Thousand Lakes Wilderness Area | 6.1 | 1.3 | 4.1 |
| BLIS1 | Desolation Wilderness Area<br>Mokelumne Wilderness Area | 4.9 | 0.8 | 4.4 |
| PORE1 | Point Reyes National Seashore | 9.7 | 4.1 | 5.6 |
| YOSE1 | Emigrant Wilderness Area<br>Yosemite National Park | 6.3 | 1.9 | 5.3 |

The greatest improvement among the areas in Northern California was measured at Point Reyes National Seashore, reflecting the efficacy of strategies targeting mobile sources, which are concentrated in urban and portside areas. Class I areas further removed from urban areas also benefited from the implementation of emission reduction strategies between the baseline and current periods, however the reductions were more modest.

## Central California – Visibility Conditions and Progress Metrics

The Central California region includes the Great Basin Valleys, North Central Coast, San Joaquin Valley, and South Central Coast Air Basins. The terrain is varied with the Coast Ranges framing the western and southern portion of this region. The long and flat San Joaquin Valley lies in the central portion of the region, and the central and southern extent of the Sierra Nevada Mountains frame the east side of the region.

The Great Basin Valleys Air Basin is the least populated among the air basins in Central California. The total population of the air basin was less than 35,000 people in 2018. The landscape is characterized by steep rugged mountain terrain and arid desert. Emissions sources are limited.

The North Central Coast Air Basin is located south of the San Francisco Bay Air Basin. The largest cities include Salinas, Santa Cruz, and Watsonville which are located along the coast.

Agriculture is a major economic sector. Lettuce and strawberries are among the top crops produced.

The South Central Coast Air Basin includes several moderate to large coastal cities including Oxnard and Camarillo. There also numerous agricultural areas in this air basin including areas devoted to cultivating vegetables, flowers, and wine grapes. Port Hueneme is located in the southern portion of the South Central Coast Air Basin. Port Hueneme is the only deep-water commercial port between San Francisco and Los Angeles and consistently ranks among the top ten busiest ports in the country. Automobiles and fresh produce are the among the largest commodity categories handled at the port. The port's on-dock cold storage facility is the largest on the west coast of the United States.

Central California's population is concentrated in the San Joaquin Valley Air Basin and emissions from this air basin dominate for the Central California region. The landscape of the San Joaquin Valley Air Basin is primarily devoted to agriculture. Urban and industrial development has increased substantially over the last few decades. The San Joaquin Valley Air Basin includes numerous metropolitan cities that rank among Central California's most populous including Fresno, Bakersfield, Stockton, and Modesto, which are distributed along U.S. Interstate 5 and CA State Highway 99, the major transportation thoroughfares for the western states. The differential heating between the valleys and the surrounding mountains, particularly during the hot and dry months of the year, leads to terrain forced flow that disperses pollutants from metropolitan areas in the San Joaquin Valley Air Basin into the surrounding foothill and mountain regions. In cooler months, the terrain limits circulation and strong inversions are established that limit dispersion and effectively trap emissions in the valley and lower foothills.

As shown in Figure 2-9, five IMPROVE monitoring sites are in the Central California region. From north to south, the monitoring sites in Central California are in the Hoover Wilderness Area (HOOV1), Kaiser Wilderness Area (KAIS1), Pinnacles National Park (PINN1), Sequoia National Park (SEQU1), and San Rafael Wilderness Area (RAFA1). Visibility conditions for nine Class I areas are characterized by these Central California monitors.

*Figure 2-9: Map of Central California Class I Areas and IMPROVE Monitoring Sites*


As shown in Table 2-6, visibility impairment on the clearest days in Central California ranged from 1.4 to 8.9 dv during the baseline period and 1.0 to 7.7 dv during the current period. Visibility impairment on the most impaired days ranged from 8.9 to 23.2 dv during the baseline period and 7.8 to 18.4 dv during the current period. For the current period, these visibility conditions are comparable to a visual range of 181 to 353 km (112 to 219 miles) on the clearest days and 62 to 179 km (38 to 111 miles) on the most impaired days.

*Table 2-6: Visibility Conditions at Class I Areas in Central California*

| IMPROVE Site | Class I Area(s) | Clearest Days Baseline (dv) | Clearest Days Current (dv) | Most Impaired Days Baseline (dv) | Most Impaired Days Current (dv) |
|---|---|---|---|---|---|
| HOOV1 | Hoover Wilderness Area | 1.4 | 1.0 | 8.9 | 7.8 |
| KAIS1 | Ansel Adams Wilderness Area<br>John Muir Wilderness Area<br>Kaiser Wilderness Area | 2.3 | 1.5 | 12.9 | 11.0 |
| PINN1 | Pinnacles National Park<br>Ventana Wilderness Area | 8.9 | 7.7 | 17.0 | 14.1 |
| SEQU1 | Kings Canyon National Park<br>Sequoia National Park | 8.8 | 7.0 | 23.2 | 18.4 |
| RAFA1 | San Rafael Wilderness Area | 6.5 | 4.9 | 17.3 | 14.1 |

The best visibility in this region was measured at the HOOV1 monitor, representing visibility conditions in the Hoover Wilderness Area (shown below in Figure 2-10). The HOOV1 monitor is in the Great Basin Valleys Air Basin, which encompasses the steeply rugged eastern side of the Sierra Nevada Mountains, the sparsely populated desert valleys, and remote mountain ranges situated between the Sierra Nevada Mountains and the Nevada border. The steep terrain limits transport from metropolitan areas.

*Figure 2-10: Photograph of the Hoover Wilderness Area*

*Photograph Courtesy of Nicole Dolney*

The differential heating between the mountain slopes and the desert valleys facilitates mountain-valley circulations promoting boundary layer growth and dispersion in the warmer months and strong inversions capping valley areas during the cold months. Population

density in the Great Basin Valleys Air Basin is around two persons per square mile. Thus, emissions are limited.

On the clearest days, the most impairment was measured at the PINN1 monitor, which represents visibility conditions in Pinnacles National Park. The PINN1 monitor is in the North Central Coast Air Basin directly south of the San Francisco Bay Air Basin and one of the most populous metropolitan areas in California. Urban emissions from this metropolitan area contribute to visibility impairment measured at PINN1, as do oceanic emissions.

On the most impaired days, the most impairment was measured at the SEQU1 monitor, which represents visibility conditions in Kings Canyon and Sequoia National Parks. Sequoia National Park is shown below in Figure 2-11. The SEQU1 monitor is in the San Joaquin Valley Air Basin. The San Joaquin Valley Air Basin is one of only two areas in the country designated as an extreme ozone nonattainment area and is also designated as nonattainment for PM2.5 NAAQS. Emissions driving nonattainment with health-based standards also contribute to impairment in the adjacent Class I areas.

*Figure 2-11: Photograph of Sequoia National Park*

*Photograph courtesy of Jeff Kessler*

As shown in Table 2-7, estimated natural visibility conditions for the clearest days in 2064 at Central California Class I areas range from 0.0 to 3.5 dv. The contribution of oceanic emissions leads to higher estimates for natural conditions at areas near the coast compared

to areas situated farther inland. Visibility has not degraded on the clearest days, rather improvements of 13 to 35 percent occurred between the baseline and current periods.

*Table 2-7: Natural Conditions, Progress Made, and Progress Needed for Clearest Days in Central California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| HOOV1 | Hoover Wilderness Area | 0.1 | 0.4 | 0.9 |
| KAIS1 | Ansel Adams Wilderness Area<br>John Muir Wilderness Area<br>Kaiser Wilderness Area | 0.0 | 0.8 | 1.5 |
| PINN1 | Pinnacles National Park<br>Ventana Wilderness Area | 3.5 | 1.2 | 4.2 |
| SEQU1 | Kings Canyon National Park<br>Sequoia National Park | 2.3 | 1.8 | 4.7 |
| RAFA1 | San Rafael Wilderness Area | 1.8 | 1.6 | 3.1 |

As shown in Table 2-8, estimated natural visibility conditions for the most impaired days in 2064 range from 4.9 to 6.9 dv. Like the clearest days, the routine contribution of oceanic emissions leads to higher estimated natural visibility impairment at the Class I areas near the coast. Between the baseline and current periods, visibility impairment decreased by 2 to 21 percent on the most impaired days. The greatest decrease in visibility impairment was measured at SEQU1, reflecting the efficacy of strategies targeting sources concentrated in metropolitan areas and transportation hubs. Class I areas further removed from these areas also benefited from the implementation of emission reduction strategies between the baseline and current periods, however the reductions were more modest.

*Table 2-8: Natural Conditions, Progress Made, and Progress Needed for Most Impaired Days in Central California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| HOOV1 | Hoover Wilderness Area | 4.9 | 1.1 | 2.9 |
| KAIS1 | Ansel Adams Wilderness Area<br>John Muir Wilderness Area<br>Kaiser Wilderness Area | 6.1 | 1.9 | 4.9 |
| PINN1 | Pinnacles National Park<br>Ventana Wilderness Area | 6.9 | 2.9 | 7.2 |
| SEQU1 | Kings Canyon National Park<br>Sequoia National Park | 6.3 | 4.8 | 12.1 |
| RAFA1 | San Rafael Wilderness Area | 6.8 | 3.2 | 7.3 |

## Southern California – Visibility Conditions and Progress Metrics

The Southern California region, detailed in Figure 2-12, includes the Mojave Desert, Salton Sea, San Diego County, and South Coast Air Basins. Emissions from human-made and natural

sources contribute to numerous air quality challenges in the region. Meteorology, terrain, and land use patterns vary widely throughout the region.

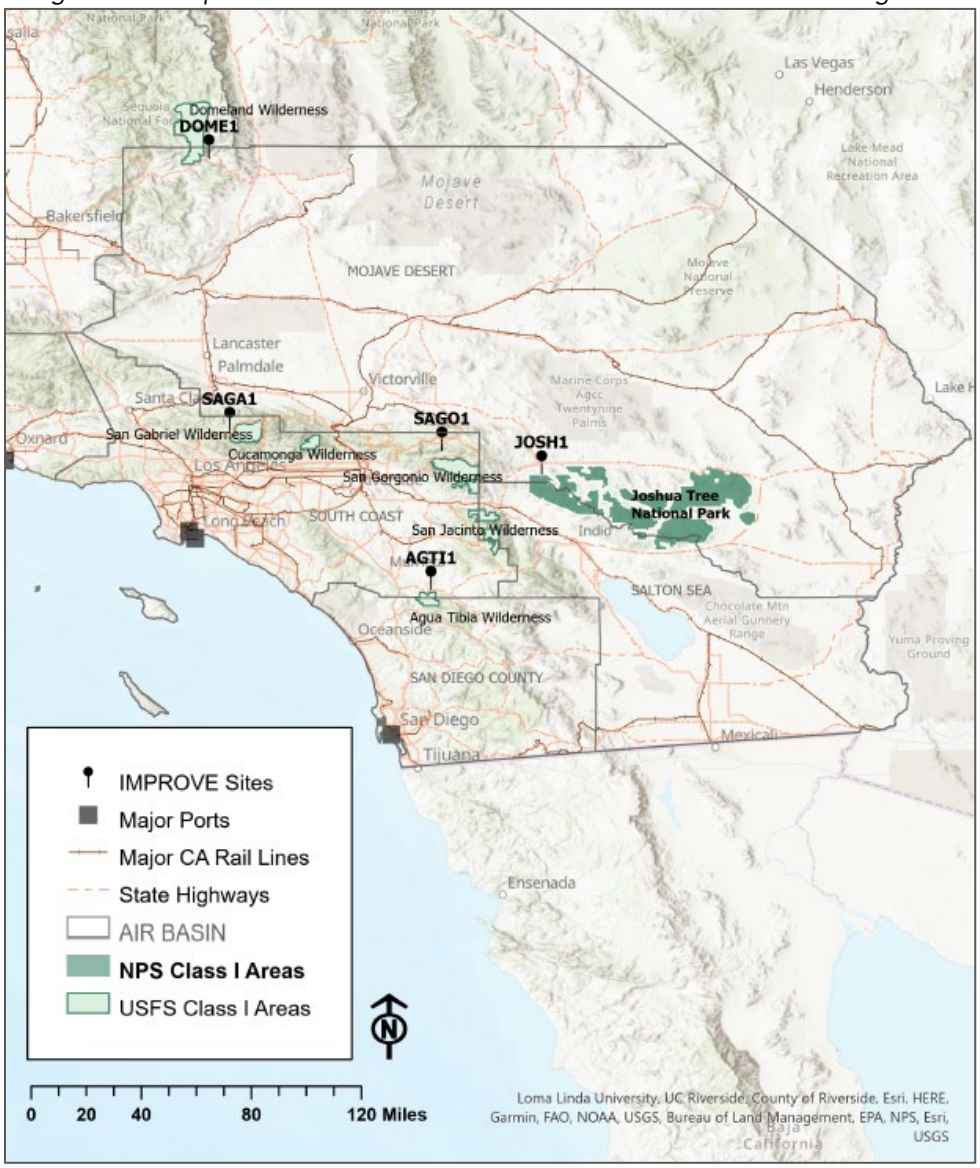
The Mojave Desert Air Basin is California's largest air basin, covering over 27,000 square miles (69,930 $km^2$). The sparsely populated desert landscape is bound by the Colorado River Valley on the south and the east and by mountains to the west and north. Elevations range from below sea level to more than 7,000 feet (2,134 m) asl. Population is concentrated in the south-central portion of the air basin. The cities of Lancaster, Palmdale, Victorville, and Hesperia are collectively home to nearly 500,000 people. These communities have grown rapidly in the last few decades, developing into bustling suburban areas with many residents making a daily commute into the greater Los Angeles area via CA State Highway 14 or U.S. Interstate 15, which serve as major transportation thoroughfares in southern California.

The South Coast Air Basin is a lowland coastal plain bounded by the Pacific Ocean on the west, and mountains on the other three sides. It is California's most populated air basin and includes the Los Angeles-Long Beach-Anaheim Metropolitan Statistical Area, which had an estimated population of 13.2 million people in 2019. The population of this single metropolitan area is home to more than 25 percent of California's population. More people live in this single metropolitan area than the states of Arizona, Hawaii, and Nevada combined. Emissions from the metropolitan area contribute to visibility impairment at adjacent Class I areas.

The terrain of the San Diego County Air Basin is similar to the South Coast Air Basin, with low lying areas along the coast bounded by mountain ranges to the east. The San Diego County Air Basin includes the San Diego-Chula Vista-Carlsbad Metropolitan Statistical Area, which had an estimated population of 3.3 million people in 2019. Emissions from the metropolitan area contribute to visibility impairment at adjacent Class I areas.

The Salton Sea Air Basin encompasses the southeastern corner of California. Mountain areas traverse the high desert landscape, and form the northern, western, and eastern borders of the air basin. The state's largest lake, the Salton Sea, is a central feature in the air basin. The Salton Sea is shallow, saline, and landlocked. Decades of historical water diversions and drought have lowered the lake level and exposed acres of lakebed. Emissive dust from the lakebed can impact air quality throughout the region and has been the focus of restoration efforts in recent years. Farmland, established on alluvial deposits from the Colorado River, is located throughout much of the low-lying areas in the southern portion of the air basin. Mexico borders the Salton Sea Air Basin to the south. International anthropogenic emissions are routinely transported across the border and contribute to persistent air quality challenges in the Salton Sea Air Basin.

*Figure 2-12: Map of Southern California Class I Areas and IMPROVE Monitoring Sites*




In the coastal areas of Southern California, airflow is influenced by differential heating between the land and the ocean which promotes development of a diurnal land-sea breeze that routinely transports urban and offshore emissions inland. In addition to the major metropolitan areas in the coastal areas, there are also three major shipping ports: Port of Los Angeles, Port of Long Beach, and the Port of San Diego. These three ports account for more than half of the tonnage moved by ports on the west coast. Mountain passes serve as a conduit for pollution from the urban coastal areas to move inland.

Five IMPROVE monitoring sites are in the Southern California region. From north to south, the monitoring sites in Southern California are in the Domeland Wilderness Area (DOME1), San Gabriel Wilderness Area (SAGA1), San Gorgonia Wilderness Area (SAGO1), Joshua Tree

National Park (JOSH1), and Agua Tibia Wilderness Area (AGTI1). Visibility conditions for the clearest and most impaired days in the seven Class I areas characterized by these monitors are summarized in Table 2-9.

Visibility impairment on the clearest days in Southern California's Class I areas ranged from 5.1 to 9.6 dv during the baseline period and 2.8 to 7.0 dv during the current period. Visibility impairment on the most impaired days ranged from 17.2 to 21.6 dv during the baseline period and 12.9 to 16.3 dv during the current period. For the current period, these visibility conditions are comparable to a visual range of 194 to 295 km (120 to 183 miles) on the clearest days and 76 to 107 km (47 to 67 miles) on the most impaired days.

*Table 2-9: Visibility Conditions at Class I Areas in Southern California*

| IMPROVE Site | Class I Area(s) | Clearest Days Baseline (dv) | Clearest Days Current (dv) | Most Impaired Days Baseline (dv) | Most Impaired Days Current (dv) |
|---|---|---|---|---|---|
| DOME1 | Domeland Wilderness Area | 5.1 | 4.4 | 17.2 | 15.1 |
| SAGA1 | Cucamonga Wilderness Area<br>San Gabriel Wilderness Area | 4.8 | 2.8 | 17.9 | 13.2 |
| SAGO1 | San Gorgonio Wilderness Area<br>San Jacinto Wilderness Area | 5.4 | 3.3 | 20.4 | 14.4 |
| JOSH1 | Joshua Tree National Park | 6.1 | 4.7 | 17.7 | 12.9 |
| AGTI1 | Agua Tibia Wilderness Area | 9.6 | 7.0 | 21.6 | 16.3 |

For the current period, the best visibility was measured at the SAGA1 and JOSH1 monitors on the clearest and most impaired days, respectively. SAGA1 is in the northwest portion of the South Coast Air Basin and is among the Southern California sites in closest proximity to the Pacific Ocean. On the clearest days, impacts from the greater Los Angeles metropolitan area are likely buffered by onshore flow. On the most impaired days, Class I areas in Southern California are heavily impacted by mobile source emissions originating in the South Coast Air Basin, concentrated in the greater Los Angeles metropolitan area.

JOSH1 is located adjacent to the south-central edge of the Mojave Desert Air Basin. While metropolitan emissions do make a significant contribution to visibility impairment in Joshua Tree National Park, the JOSH1 monitor is the furthest removed from Southern California's metropolitan areas, relative to the other Southern California monitoring sites. The view at sunrise near Quail Mountain in Joshua Tree National Park is shown in Figure 2-13.

*Figure 2-13: Photograph of Joshua Tree National Park*

*Public domain photograph, courtesy of NPS/Brad Sutton*

The most impairment on the clearest and most impaired days in both the baseline and current periods was measured at the AGTI1 monitor, which represents visibility conditions in the Agua Tibia Wilderness Area. The AGTI1 monitor is in the South Coast Air Basin, just north of the border with the San Diego County Air Basin. Urban emissions from adjacent metropolitan areas routinely contribute to poor visibility at AGTI1. Depending on the meteorological patterns, emissions transported to the site can originate in the Los Angeles or San Diego metropolitan areas or the nearby I-15 transportation corridor. Periods of stagnation can yield combined impacts from both metropolitan areas and the nearby transportation corridor.

As shown in Table 2-10, estimated natural visibility conditions for 2064 on the clearest days in Southern California range from 0.4 to 2.9 dv. Oceanic emissions, windblown dust, and vegetation are among the predominant natural sources that contribute to visibility impairment at Class I areas in Southern California. Between the baseline and current period, visibility has not degraded on the clearest days at Class I areas in Southern California. Rather, visibility on the clearest days improved by 14 to 48 percent in the current period relative to the baseline period.

*Table 2-10: Natural Visibility Conditions, Progress Made, and Progress Needed for Clearest Days in Southern California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| DOME1 | Domeland Wilderness Area | 1.2 | 0.7 | 3.2 |
| SAGA1 | Cucamonga Wilderness Area<br>San Gabriel Wilderness Area | 0.4 | 2.0 | 2.4 |
| SAGO1 | San Gorgonio Wilderness Area<br>San Jacinto Wilderness Area | 1.2 | 2.1 | 2.1 |
| JOSH1 | Joshua Tree National Park | 1.7 | 1.4 | 3.0 |
| AGTI1 | Agua Tibia Wilderness Area | 2.9 | 2.6 | 4.1 |

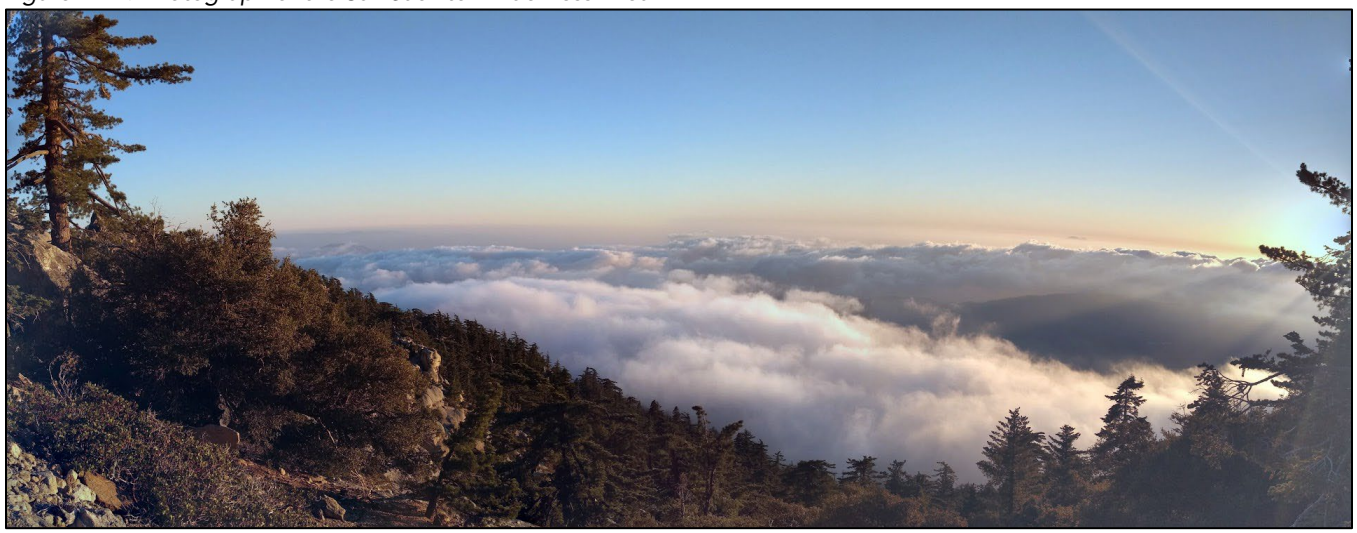
As shown in Table 2-11, estimated natural visibility conditions for 2064 on the most impaired days ranges from 6.1 to 7.7 dv. Visibility impairment decreased by 12 to 29 percent on the most impaired days between the baseline and current periods.

*Table 2-11: Natural Conditions, Progress Made, and Progress Needed for Most Impaired Days in Southern California*

| IMPROVE Site | Class I Area(s) | 2064 Natural Conditions (dv) | Progress Made 2000 to 2018 (dv) | Progress Needed 2018 to 2064 (dv) |
|---|---|---|---|---|
| DOME1 | Domeland Wilderness Area | 6.2 | 2.1 | 8.9 |
| SAGA1 | Cucamonga Wilderness Area<br>San Gabriel Wilderness Area | 6.1 | 4.7 | 7.1 |
| SAGO1 | San Gorgonio Wilderness Area<br>San Jacinto Wilderness Area | 6.2 | 6.0 | 8.2 |
| JOSH1 | Joshua Tree National Park | 6.1 | 4.8 | 6.8 |
| AGTI1 | Agua Tibia Wilderness Area | 7.7 | 5.3 | 8.6 |

The greatest improvement was measured at SAGO1, the site in closest proximity and most often directly downwind of the Los Angeles metropolitan area. The San Jacinto Wilderness Area, which is represented by data collected at the SAGO1, is shown below in Figure 2-14. This improvement likely reflects emission control strategies targeting sources concentrated in metropolitan areas and transportation hubs. Class I areas further removed from these areas also benefited from the implementation of emission reduction strategies between the baseline and current periods as the visibility metrics for the most impaired days at other sites routinely downwind of the Los Angeles metropolitan area improved by 25 percent or more during this timeframe.

*Figure 2-14: Photograph of the San Jacinto Wilderness Area*



*Photograph courtesy of Jeff Kessler*

As a result of statewide emission control efforts detailed in California's first Regional Haze Plan, visibility conditions in all of California's Class I areas improved between the baseline and current periods. This widespread and marked improvement in visibility conditions indicates that the strategies developed and implemented in California are effective for reducing haze pollutants and making progress towards restoring natural conditions in California's Class I areas.

# 3. Emissions Inventory

Emission inventories are a critical input for the technical analyses used to develop regional haze plans. CARB, in cooperation with local air pollution control and air quality management districts (districts), develops and maintains a statewide emissions inventory. For this Regional Haze Plan, the WRAP prepared the technical analyses for 15 western states, including California. California provided WRAP with the emissions inventories for human-made sources. WRAP developed estimates for natural sources such as biogenic (plant) emissions, wildfires, and natural windblown dust as these sources occur similarly throughout the western region.

Additional information about the emission inventory development for this Regional Haze Plan is provided in Appendix D.

## Pollutants Assessed

The emissions inventory used for this Regional Haze Plan began with the same inventory of pollutants used in planning efforts to meet the NAAQS. Emissions that impact NAAQS attainment also contribute to visibility impairment. Pollutants assessed for this Regional Haze Plan are the pollutants reasonably anticipated to cause or contribute to visibility impairment and include nitrogen oxides (NOx), particulate matter (PM) - both PM10 and PM2.5, sulfur oxides (SOx), ammonia ($NH_3$), and volatile organic compounds (VOC). California's emissions inventory substitutes VOC with reactive organic gases (ROG), which represents a slightly broader group of compounds than those in U.S. EPA's list of VOCs. Not all these pollutants contribute directly to the development of haze, but they may undergo chemical reactions in the atmosphere to contribute to the impairment of visibility.

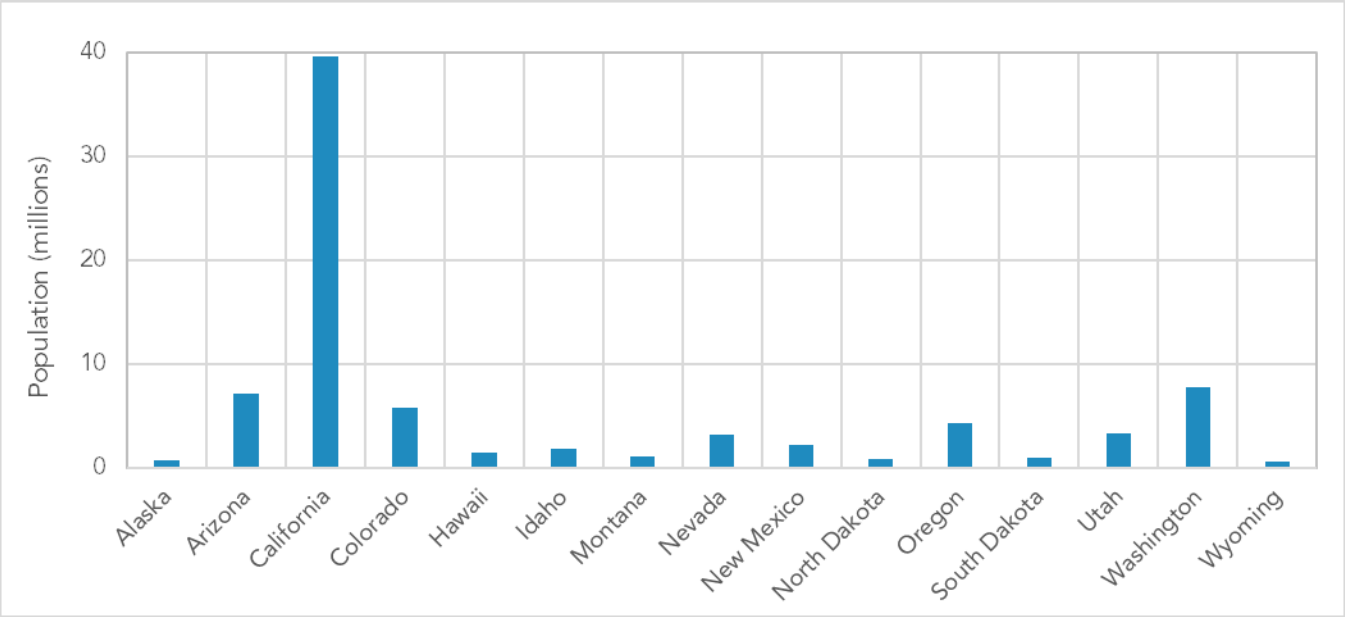
Stationary, areawide, and mobile sources contribute to emissions of pollutants assessed for this Regional Haze Plan. Mobile sources are the largest source of human-made NOx and ROG emissions. Areawide sources, specifically fugitive dust and residential fuel combustion, are the largest sources of directly emitted PM2.5. Fugitive dust, unpaved roads, and paved roads are the largest sources of PM10. Industrial facilities involved in mineral processing and petroleum refining are the largest sources of SOx. Farming and solvent evaporation, which are categorized as areawide sources, are the largest sources of ammonia.

The relative importance of each haze component varies. Technical analyses indicate that ammonium nitrate, formed in the atmosphere from NOx and ammonia, is generally the predominant haze pollutant in California's Class I areas attributable to human-made emissions. NOx emissions are the primary precursor to ammonium nitrate formation and California's long-term strategy for regional haze will focus on efforts to reduce NOx emissions.

## Statewide Emissions

California is a large state in terms of geographic area and population. The State encompasses more than 163,000 square miles, making it the third largest state in the country. Results of the 2020 Census show that with a population of nearly 40 million people, California is the most populous state in the country. As shown in Figure 3-1, the number of people living in California is more than four times greater than any other state in the WRAP Region.

*Figure 3-1: 2020 Census Populations of States in the Western Regional Air Partnership (WRAP) Region*




The movement of goods and people account for a significant share of emissions within California. Large fleets of aircraft, locomotives, ocean-going vessels, and on-road vehicles operate within the State. Combined, there are more than 100 million air carrier enplanements annually at the State's 30 major airports. Los Angeles International and San Francisco International rank among the busiest airports in the country. California ranks second in the U.S. in terms of freight carloads, with more than three million carloads originating and terminating along its 4,828 miles of freight rail lines. International shipping activity is concentrated in and around the State's 10 major water ports. The Ports of Los Angeles and Long Beach in southern California rank among the busiest ports in the world. Fleets of smaller sized vessels move goods and people through 290 miles of inland waterways.

California has more than 175,000 miles of public roads, 248.8 billion vehicle miles traveled (VMT) annually, and more than 30 million registered vehicles. Seven ports of entry are located along the State's southern border with Mexico, including three of the busiest in the country. The port of entry at San Ysidro was the busiest border crossing in the U.S. in 2020 with 11.8 million entries.

California has authority under the Clean Air Act to regulate certain mobile sources and establish stricter than federal emission limits for these sources. The implementation of California's mobile source control strategy has led to substantial reductions in mobile source emissions despite significant growth in the mobile source population. NOx emissions from California-regulated mobile sources declined by more than 70% between 2000 and 2020. Emissions from primarily-federally regulated sources are now comparable to emissions from California-regulated sources. Federal action to address and reduce emissions from primarily-federally regulated sources including interstate trucks, planes, trains, and ocean-going vessels, would accelerate emission reductions and yield benefits for not only visibility but public health as well.

Statewide emissions inventories provide a basis for regional haze planning efforts. The resultant analyses allow agencies to focus planning efforts on the pollutants and sources that make the most significant contribution to visibility impairment in Class I areas.

Table 3-1 provides a summary of the statewide average daily emissions for directly emitted PM and PM precursors for the stationary, areawide, and mobile sources. More detailed inventories of emissions from each of these source sectors are provided in Appendix E. Data in Table 3-1 are summarized for 2014 and 2028. Data for 2014 are shown because this was the base year used for this round of regional haze planning. Data for 2028 are shown because reasonable progress goals included in this Regional Haze Plan were set for the year 2028. The 2028 projections account for adopted controls and forecasted growth.

*Table 3-1: Statewide Emission Inventories in tons per day (tpd) for PM and PM Precursors*

| Pollutant | 2014 Stationary | 2014 Areawide | 2014 Mobile | 2014 Total | 2028 Stationary | 2028 Areawide | 2028 Mobile | 2028 Total |
|---|---|---|---|---|---|---|---|---|
| **Ammonia** | 70 | 532 | 40 | **642** | 79 | 517 | 29 | **625** |
| **NOx** | 249 | 68 | 1290 | **1605** | 257 | 61 | 597 | **914** |
| **PM2.5** | 61 | 244 | 67 | **371** | 70 | 245 | 48 | **363** |
| **PM10** | 118 | 1198 | 103 | **1419** | 142 | 1239 | 87 | **1468** |
| **ROG** | 372 | 567 | 616 | **1555** | 396 | 581 | 340 | **1317** |
| **SOx** | 47 | 4 | 12 | **63** | 52 | 4 | 13 | **69** |

The mobile source sector is the largest source of NOx emissions in California. In 2014, the mobile source sector accounted for 80 percent of NOx emissions. Heavy-duty on-road vehicles and off-road mobile sources, including equipment, trains, aircraft, and ocean-going vessels, were the largest mobile source categories for NOx emissions in 2014. Considering

growth and controls, NOx emissions are forecast to decrease by 43 percent between 2014 and 2028, owing largely to mobile source control strategies being implemented in the State.

Areawide sources account for the largest share of the PM2.5 emissions inventory. Fugitive windblown dust and residential fuel combustion were the largest areawide source categories in 2014. PM2.5 emissions are projected to remain stable through 2028. Given the unprecedented increase in wildfire activity throughout California in recent years, it is also noteworthy that wildfires are a natural source of PM2.5 emissions. Wildfires emit more than twice the amount of PM2.5 from all anthropogenic sectors combined.

Like PM2.5, areawide sources account for the largest share of the PM10 emissions inventory. In 2014, areawide sources accounted for 84 percent of PM10 emissions. Fugitive windblown dust, unpaved road dust, and paved road dust were the largest areawide source categories. PM10 emissions are projected to remain stable through 2028.

Stationary sources account for the largest share of the SOx emissions inventory. In 2014, stationary sources accounted for 80 percent of SOx emissions. Within the stationary source sector, industrial facilities involved in mineral processing and petroleum refining were the top sources of SOx emissions. SOx emissions are projected to remain stable through 2028.

Mobile sources are the largest source of ROG emissions in California. In 2014, mobile sources accounted for 40 percent of ROG emissions. Within the mobile source sector, light duty passenger vehicles, off-road equipment, and recreational boats are the top sources of ROG emissions. ROG emissions are projected to decrease by 15 percent between 2014 and 2028, largely due to the implementation of mobile source control strategies.

The areawide source sector accounts for 83 percent of statewide ammonia emissions. Farming operations and solvent evaporation from pesticides and fertilizers were the largest areawide source categories of ammonia emissions. Ammonia emissions are forecast to remain stable through 2028.

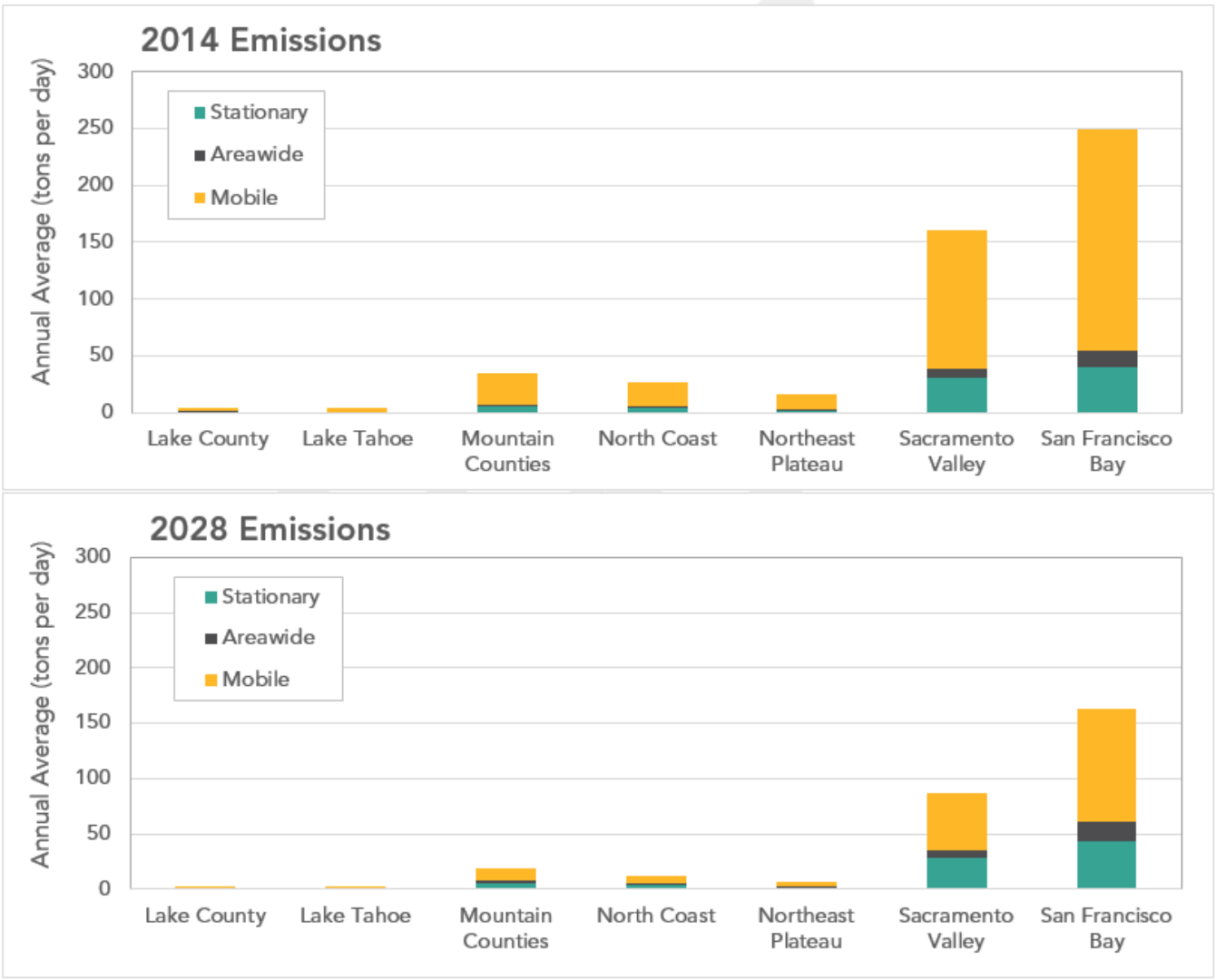
## Regional NOx Emissions

Mobile sources are the predominant source of emissions in California and drive air quality challenges throughout the State, including the formation of haze in Class I areas. Reducing emissions from mobile sources was effective at reducing haze pollutants during the first implementation period. For the second implementation period, the additional emission reductions that will result from mobile source NOx reductions will be effective at reducing haze pollutants and improving visibility in Class I areas. Thus, California's long-term strategy for regional haze is focused on NOx emissions for this implementation period. Regional summaries that provide a comparison of NOx emissions for source groups within each air basin are discussed in this section. Basin scale summaries for other pollutants in the emission inventory are provided in Appendix E.

## Northern California

As shown in Figure 3-2, emissions from the San Francisco Bay and Sacramento Valley Air Basins dominate the NOx emissions inventory for Northern California, accounting for 47 percent and 31 percent of NOx emissions in 2014, respectively. Mobile sources account for the largest portion of NOx emissions in all Northern California air basins.

*Figure 3-2: NOx Emissions for Air Basins in Northern California*




The portion of NOx emissions attributable to mobile sources ranged from 76 percent in the Sacramento Valley Air Basin to 89 percent in the Lake Tahoe Air Basin for the 2014 emissions inventory. The majority of Lassen Volcanic National Park, shown below in Figure 3-3, is located in the Sacramento Valley Air Basin. Projections indicate that significant reductions in NOx emissions are expected by 2028; however, mobile sources will continue to be the dominant source of NOx emissions in this region.

*Figure 3-3: Photograph of Lassen Volcanic National Park*

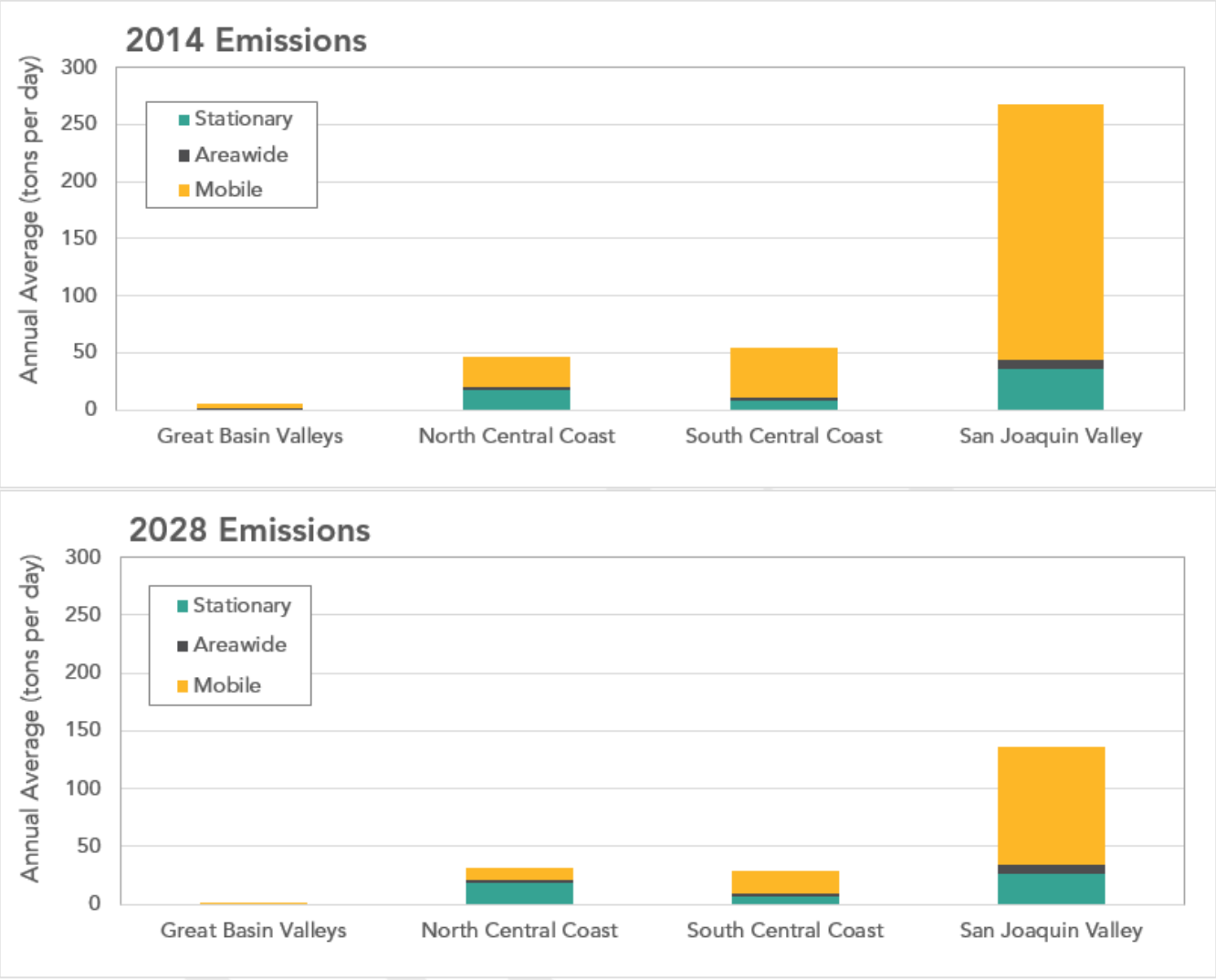
*Photograph courtesy of Michele Houghton*

## Central California

NOx emissions for air basins in Central California are shown in Figure 3-4. Emissions from the San Joaquin Valley Air Basin dominate the NOx emissions inventory for this region, accounting for 72 percent of NOx emissions in the 2014 emissions inventory. Like Northern California, mobile sources account for the largest portion of NOx emissions in Central California air basins.

The portion of NOx emissions attributable to mobile sources in the 2014 emissions inventory ranged from 57 percent in the North Central Coast Air Basin to 84 percent in the San Joaquin Valley Air Basin. Projections for 2028 indicate that NOx emissions will decrease markedly in each air basin in the region. Despite these reductions, additional work will be needed, particularly in areas like the San Joaquin Air Basin that have the greatest air quality challenges, and mobile source controls will continue to be an important focus for integrated planning in California.

*Figure 3-4: NOx Emissions for Air Basins in Central California*

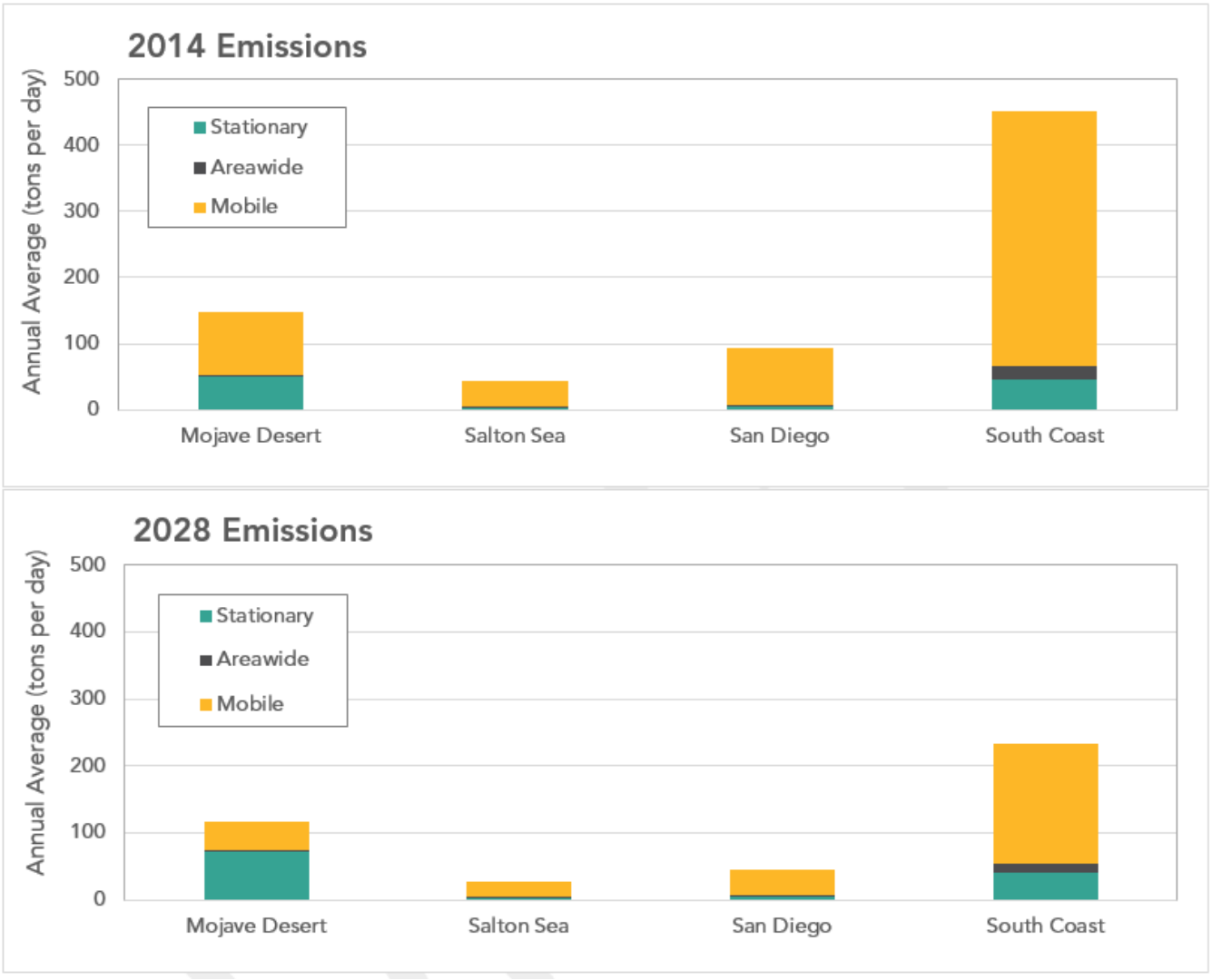



## Southern California

NOx emissions for air basins in Southern California are shown in Figure 3-5. Emissions from the South Coast Air Basin dominate the NOx emissions inventory for Southern California, accounting for 61 percent of NOx emissions in the 2014 emissions inventory, with mobile sources accounting for 85 percent of these emissions.

The portion of NOx emissions attributable to mobile sources in the 2014 inventory for this region ranged from 64 percent in the Mojave Desert Air Basin to 92 percent in the San Diego Air Basin. Similar to other areas in California, marked reductions by 2028 are projected for mobile source NOx emissions but mobile source controls will continue to be an important focus for integrated planning aimed at meeting myriad air quality, climate, and public health goals.

*Figure 3-5: NOx Emissions for Air Basins in Southern California*




The visibility metrics summarized in Chapter 2 indicate that visibility is improving in California's Class I areas. The improvement in visibility conditions between the baseline and current periods is the result of the implementation of statewide measures aimed at reducing emissions from mobile sources, which were the focus of California's long-term strategy for the first implementation period and remains the focus of the long-term strategy for the second implementation period.

This focus for California's long-term strategy is supported by multiple lines of evidence. Light extinction budgets for PM attributable to human-made sources indicate that ammonium nitrate is a dominant visibility reducing PM species in Class I areas in California. NOx emissions generally drive the formation of ammonium nitrate. Emission inventories show that mobile sources are the dominant source of NOx emissions in air basins throughout the State. While significant progress has been made in reducing NOx emissions and subsequently

improving visibility in protected areas, additional work remains. The following chapters will continue to describe the basis for California's long-term strategy to improve visibility in Class I areas, including Lava Beds National Monument, which is shown below in Figure 3-6.

Emission inventories are integral to efficient and effective regional haze planning efforts. California remains committed to routinely updating the emissions inventories for pollutants relevant to regional haze planning efforts.

*Figure 3-6: Photograph of Lava Beds National Monument*

*Photograph courtesy of Kathy Leuterio*

# 4. Source Apportionment Modeling

The technical analyses, including source apportionment modeling for this Regional Haze Plan, were coordinated by the WRAP, the partnership among states, tribes, federal land managers, local air agencies, and U.S. EPA focused on understanding regional air quality issues in the western states. The results were made available to stakeholders through the web-based Technical Support System (TSS).[7]

Source apportionment is the process of using air quality modeling analyses to identify sources that contribute to haze pollutants that impair visibility in Class I areas. The air quality model used for this Regional Haze Plan is called CAMx, which is an acronym that stands for Comprehensive Air Quality Model with eXtensions. CAMx combines regional emissions inventory information with information on atmospheric chemistry and meteorology to determine the amount of haze pollution that was or will be formed in a particular location on a particular day.

Two sets of emission inputs were developed for use in the air quality modeling efforts for this regional haze implementation period. The RepBase2 emissions input used information about emissions during the 2014 to 2018 time period and was intended to be representative of emissions during the current period. The 2028OTBa2 emissions input was intended to be representative of emissions in 2028 and accounted for adopted emission controls and projected growth. Emissions inventory information provided by CARB that was used to help construct these two sets of emission inputs are detailed in Chapter 3 and Appendix D. Resources for accessing detailed technical specifications for the RepBase2 and 2028OTBa2 CAMx modeling simulations are provided in Appendix F.

To identify sources that contribute to haze measured in Class I areas, high-level and low-level source apportionment modeling analyses were completed. The high-level source apportionment modeling was used to estimate how much of each haze pollutant was attributable to six broad source categories. The results of high-level source apportionment help in understanding how much haze comes from U.S. sources (which are controllable) and how much haze comes from international sources, prescribed fires, wildfires, and other natural sources (which are not directly controllable). High-level source apportionment was completed for the beginning of this implementation period (2014-2018) and the end of this implementation period (2028). Low-level source apportionment modeling was used to estimate how much ammonium nitrate and ammonium sulfate is attributable to regional human-made sources. Low-level source apportionment modeling was completed for the end of this implementation period (2028). The results of low-level source apportionment modeling help in understanding which types of U.S. sources are expected to make the largest contributions to haze and where efforts to improve visibility can be focused. The

[7] *http://views.cira.colostate.edu/tssv2/*

results of high-level and low-level source apportionment analyses are summarized in the following sections.

## High-Level Source Apportionment

High-level source apportionment analyses were completed to estimate the portion of each haze pollutant attributable to six broad source categories: U.S. human-made, international, natural, U.S. wildfire, U.S. prescribed fire, and Canada/Mexico fire. High-level source apportionment modeling used the RepBase2 and 2028OTBa2 emission inputs.

### High-Level Source Apportionment for Most Impaired Days in 2014-2018

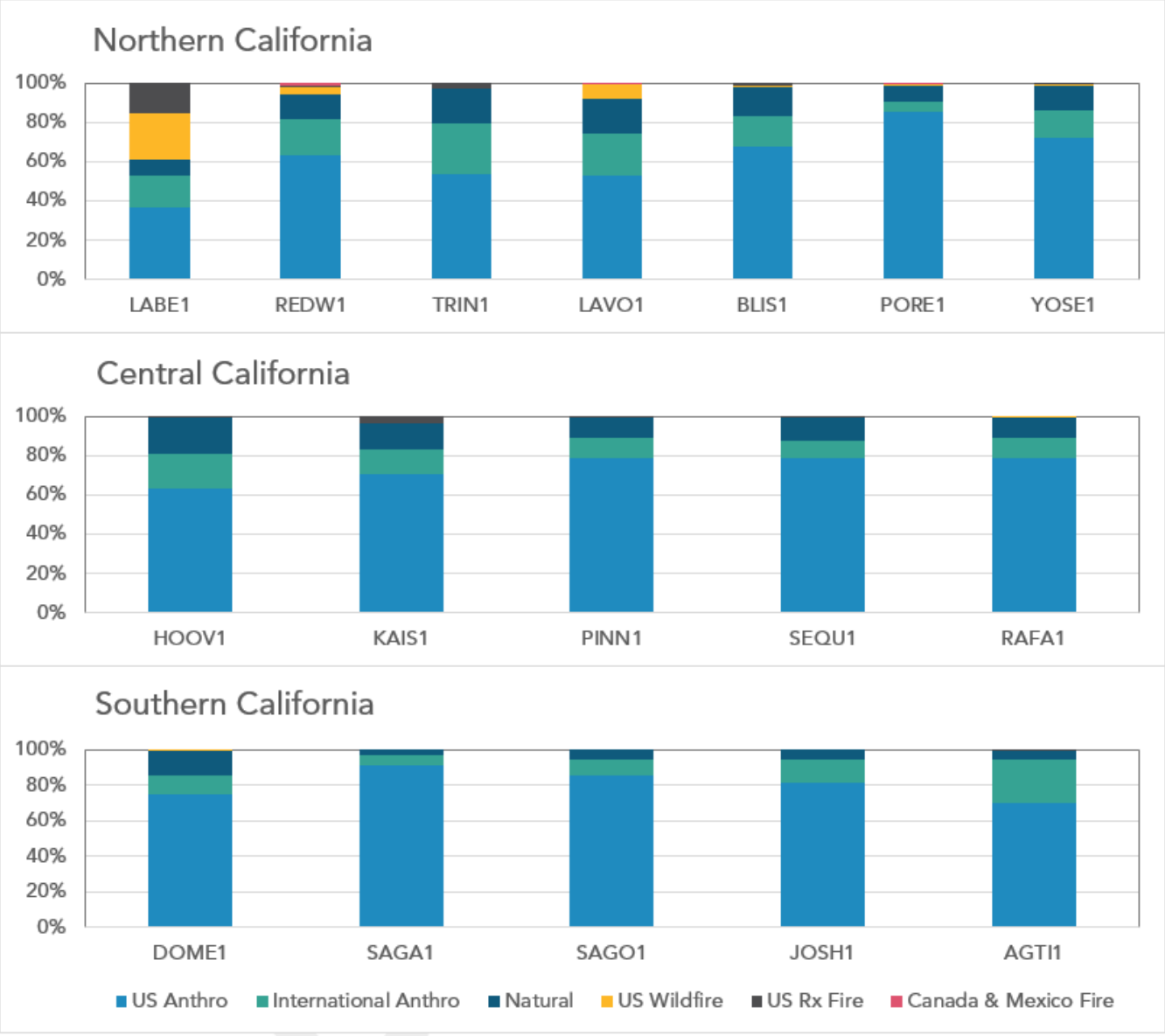
High-level source apportionment results for ammonium nitrate, organic mass, and ammonium sulfate on the most impaired days in the 2014 to 2018 period at California IMPROVE monitoring sites are shown in Figures 4-1 to 4-3. The source categories shown in these figures correspond to the six broad source categories selected by the modeling team. Source apportionment results are shown for these specific haze pollutants because they accounted for most of the light extinction in California's Class I areas for the current period.

#### Ammonium Nitrate

As shown in Figure 4-1, U.S. emissions (US Anthro), international emissions (International Anthro), and natural emissions were the most dominant sources of ammonium nitrate on the most impaired days in Northern California. An average of 62 percent of ammonium nitrate was attributable to U.S. sources, with the site-specific average ranging from 37 percent at LABE1, representative of visibility conditions in Lava Beds National Monument and South Warner Wilderness Area, to 85 percent at PORE1, representing visibility conditions in Point Reyes National Seashore. Point Reyes National Seashore is near the densely populated San Francisco metropolitan area and is the most impaired Class I area in the Northern California region. Measures that target NOx emissions, which drive the formation of ammonium nitrate, are needed to improve visibility and are the focus of California's long-term strategy for this implementation period.

Combined, international and natural sources accounted for an average of 30 percent of ammonium nitrate at sites in Northern California. Despite significant efforts to exclude wildfire impacted days, wildfire emissions also made a notable contribution to light extinction at LABE1, accounting for 23 percent of light extinction attributable to ammonium nitrate on the most impaired days. Continued efforts to improve our understanding of natural sources, cooperative efforts to reduce international emissions, and investment of resources to mitigate the risks of catastrophic wildfire will be needed as we move forward in the iterative regional haze planning process.

*Figure 4-1: Ammonium Nitrate Source Apportionment for the 2014-2018 Most Impaired Days*




In Central California, U.S. emissions were also the dominant source of ammonium nitrate on the most impaired days. This source category accounted for an average of 74 percent of light extinction from ammonium nitrate at Central California monitoring sites, with site-specific averages ranging from 63 percent at HOOV1 to 79 percent at PINN1, SEQU1, and RAFA1. International and natural source categories accounted for nearly all the remainder of light extinction attributable to ammonium nitrate at these sites. Targeting U.S. emissions that drive the formation of ammonium nitrate is the most effective strategy to improve visibility in this region.

Like other areas of California, U.S. emissions are the dominant source of ammonium nitrate on the most impaired days in Southern California. This source category accounts for an average of 81 percent of light extinction attributable to ammonium nitrate across sites in this region. On a site-specific basis, the portion of ammonium nitrate attributed to the U.S. source category ranges from 70 percent at AGTI1 to 91 percent at SAGA1, highlighting the significance of emissions from the adjacent urban areas. International emissions and natural sources account for the remainder of ammonium nitrate at sites in this region. Reducing U.S. emissions that drive the formation of ammonium nitrate will lead to visibility improvements in Class I areas throughout the region.

### Ammonium Sulfate

On the most impaired days in California's Class I areas, the majority of ammonium sulfate is attributable to international and natural sources. In Northern California, the portion of ammonium sulfate attributable to international emissions ranges from 12 percent at REDW1, representing visibility conditions in Redwood National Park which is shown below in Figure 4-2, to 53 percent at TRIN1, representing visibility conditions in the Marble Mountain and Yolla Bolly-Middle Eel Wilderness Areas. The areas with the largest portion of international emissions are generally those with a relatively smaller amount of light extinction attributable to ammonium sulfate, highlighting the pervasive role of transport of international sulfate emissions.

*Figure 4-2: Photograph of Redwood National Park*

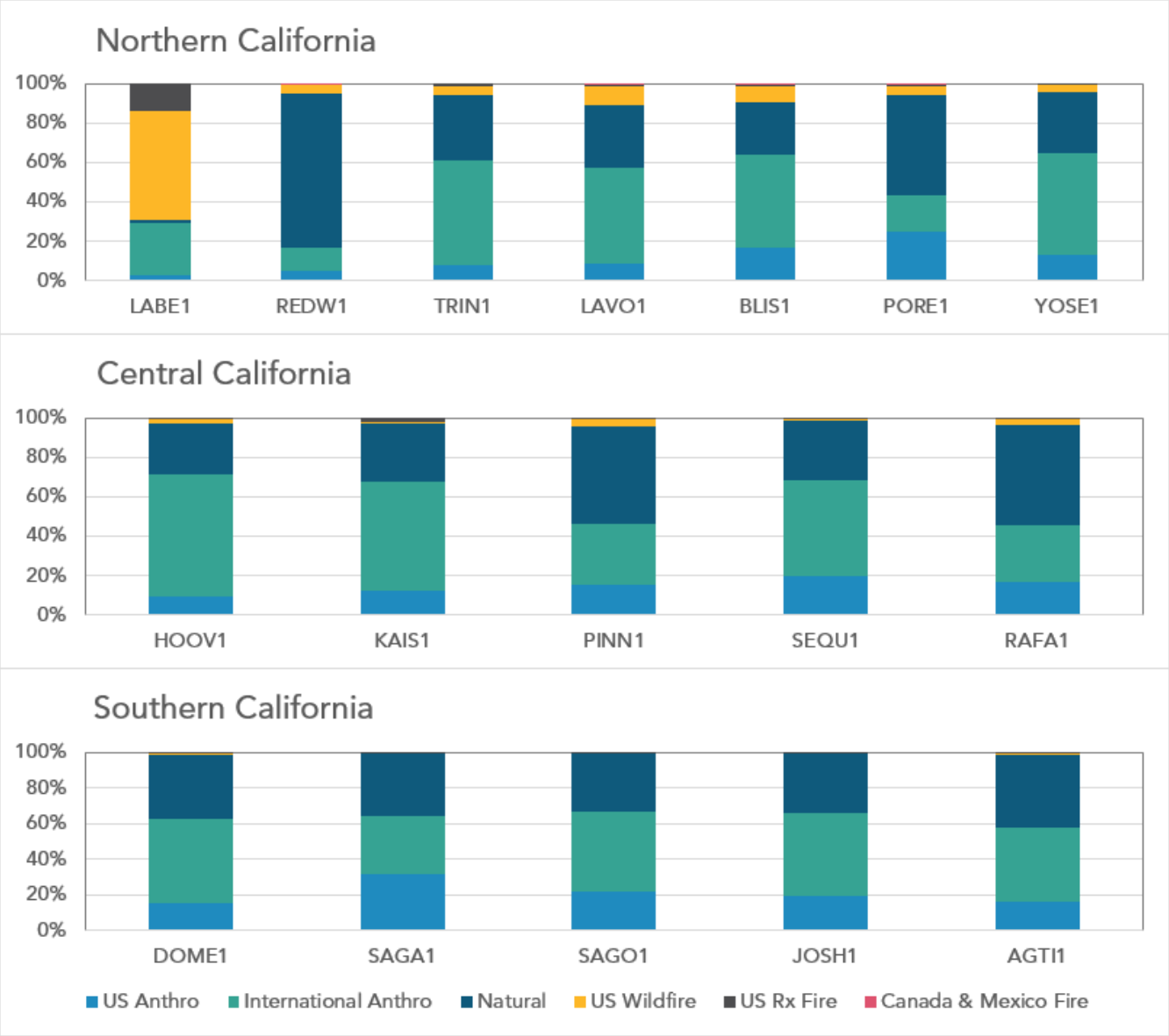
*Photograph courtesy of Jeff Kessler*

As shown in Figure 4-3, among monitoring sites in Northern California, natural emissions accounted for an average of 36 percent of light extinction attributable to ammonium sulfate on the most impaired days. Natural sources make the largest contribution to ammonium sulfate in Redwood National Park and Point Reyes National Seashore, areas near the coast.

At LABE1, 70 percent of ammonium sulfate was attributable to emissions from wildfires and prescribed burning. This area of Northern California has been heavily impacted by fire in recent years. U.S. emissions accounted for an average of 11 percent of ammonium sulfate across monitoring sites in Northern California, ranging from 3 percent at LABE1 to 25 percent at PORE1. Generally, the areas with the largest portion of ammonium sulfate

attributed to U.S. sources were areas in the southern portion of the Northern California region and in closer proximity to Northern California's more urbanized areas.

*Figure 4-3: Ammonium Sulfate Source Apportionment for the 2014-2018 Most Impaired Days*




In Central California, emissions from natural and international sources collectively accounted for more than 80 percent of ammonium sulfate. Across the region, natural sources accounted for an average of 37 percent of ammonium sulfate. On a site-specific basis, light extinction from ammonium sulfate ranged from 26 percent at HOOV1 to 51 percent at RAFA1. The share attributable to natural sources was larger at sites located closer to the coast. International sources accounted for an average of 45 percent of ammonium sulfate, ranging from 29 percent at RAFA1 to 62 percent at HOOV1. The Hoover Wilderness Area,

represented by data collected at HOOV1, is shown below in Figure 4-4. To reduce emissions from international sources, coordinated efforts with other countries will be necessary in future planning periods.

*Figure 4-4: Rainbow in the Hoover Wilderness Area*

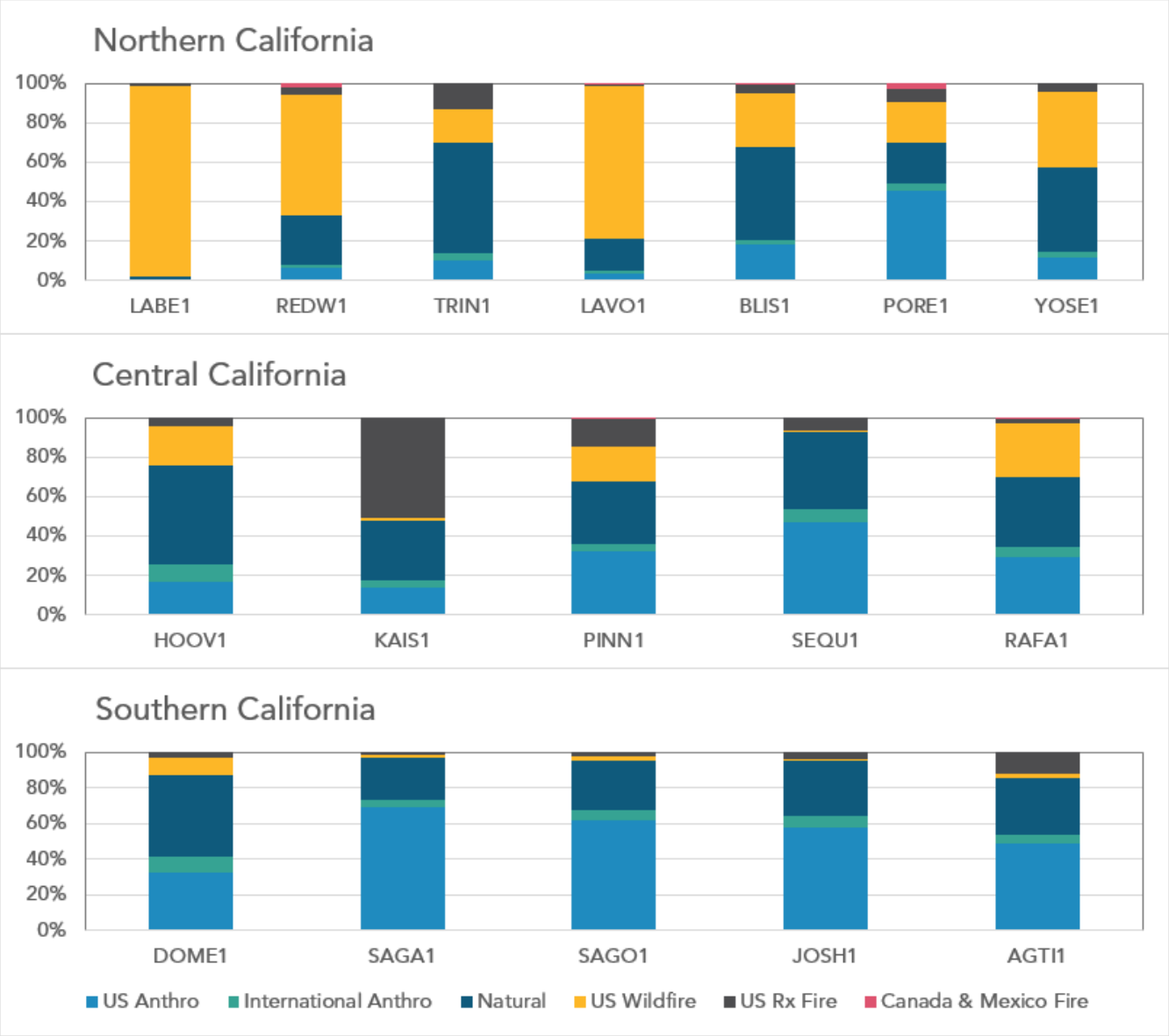
*Photograph courtesy of Jeff Kessler*

In Southern California, the dominant sources of ammonium sulfate on the most impaired days were international emissions and natural emissions. Combined, these source group categories accounted for an average of 78 percent of ammonium sulfate on the most impaired days. SAGA1, representing visibility conditions in the Cucamonga and San Gabriel Wilderness Areas, had the largest portion ammonium sulfate attributable to U.S. sources. These areas are in close proximity to the urban areas in the South Coast Air Basin, which includes the greater Los Angeles metropolitan area and the San Pedro Bay Ports Complex where the Ports of Los Angeles and Long Beach are located. The largest source categories for SOx emissions in the South Coast Air Basin are industrial fuel combustion, aircraft, and commercial marine vessels.

### Organic Mass

As shown in Figure 4-5, source categories contributing to organic mass are variable. In Northern California, the dominant source categories are U.S. wildfire and natural emissions. Wildfire activity has been particularly high in the northern portion of this region and, consequently, the U.S. wildfire source category generally accounts for larger portions of organic mass at sites representing visibility conditions in this portion of the region.

*Figure 4-5: Organic Mass Source Apportionment for the 2014-2018 Most Impaired Days*




Regarding natural emissions, biogenic emissions are significant throughout the year but notably increase during the spring and summer months when vegetation is in the most active growth phase. This period generally coincides with the portion of the year when the largest number of most impaired days occur. Data collected at PORE1, representing visibility conditions in Point Reyes National Seashore, show a smaller relative contribution from natural sources and a larger relative contribution from U.S. sources. In contrast to most other Class I areas, the most impaired days occur most frequently during the winter months in Point Reyes National Seashore, which coincides with a time when biogenic emissions are comparatively lower than other seasons. In the San Francisco Air Basin, where PORE1 is located, mobile

sources, consumer products, and residential wood combustion are among the largest sources of ROG emissions, which are precursors to organic mass.

For areas in Central California, the dominant sources of organic mass on the most impaired days are in the U.S., U.S. wildfire, U.S. prescribed fire, and natural source categories. At Class I areas closer to more populated areas, including Pinnacles National Park, Kings Canyon and Sequoia National Parks, and the San Rafael Wilderness Area, the portion of organic mass attributable to U.S. emission sources is comparable to the portion attributable to natural sources. The Ventana Wilderness Area, represented by data collected at PINN1, is shown below in Figure 4-6. Across the region, organic mass attributable to natural sources ranged from 30 percent at KAIS1 to 51 percent at HOOV1. With the increasing intensity and duration of wildfires, emissions from wildfire and prescribed fire will be an ongoing consideration for regional haze planning.

*Figure 4-6: Photograph of the Ventana Wilderness Area*

*Photograph courtesy of Jeff Kessler*

In Southern California, emissions from U.S. and natural source categories were the dominant sources of organic mass on most impaired days in the 2014 to 2018 period. Combined, these two source groups accounted for 79 to 94 percent of light extinction attributable to organic mass. The portion of organic mass attributable to U.S. sources is noticeably larger in Southern California than in other California regions. This difference is largely due to the higher density of development and expanse of urban areas located in Southern California, relative to other regions of the state.

Mobile sources account for the largest share of ROG emissions in the South Coast Air Basin. Emissions from the South Coast Air Basin are transported throughout Southern California and measurably impact Class I areas throughout this region. Natural emission sources are also a significant factor. The highest number of most impaired days occurred in spring and summer

at Class I areas in Southern California. Processes driving biogenic emissions are the most active during these seasons.

Atmospheric chemistry involving organic species is complex. Lower-level source apportionment of organic mass in future planning periods will be necessary to identify the key sources driving the formation of organic mass that contributes to visibility impairment in Class I areas. Identification of these key sources will be necessary to focus future planning efforts on the sources that matter the most.

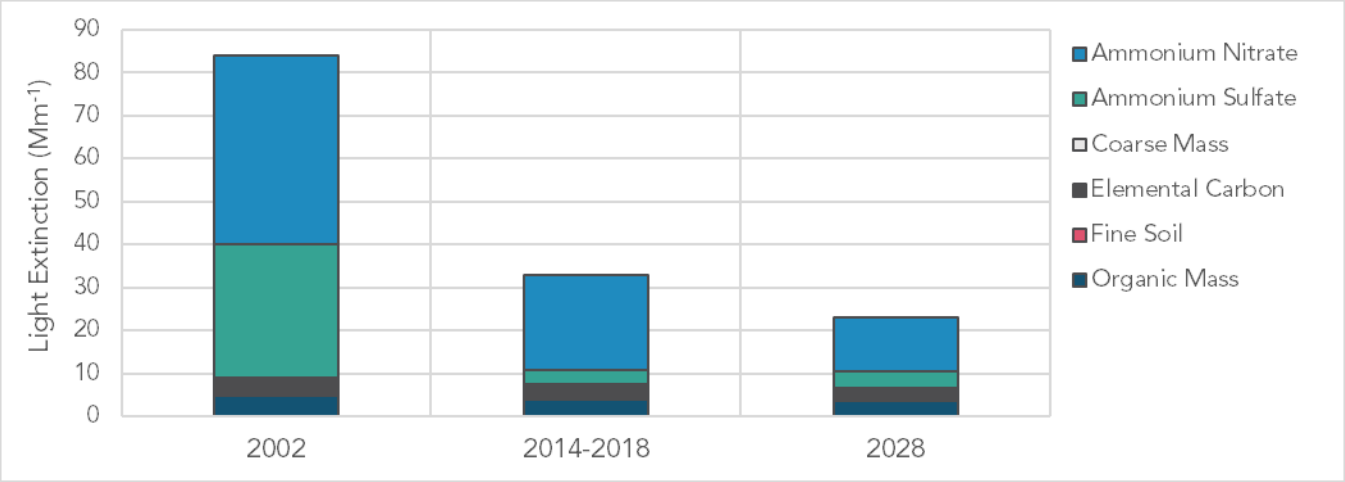
## U.S. Source Contributions

Comparing the portion of haze attributed to U.S. human-made sources at different points in time offers insight into how control strategies have affected visibility conditions in the past and will affect visibility conditions in the future. The results of source apportionment modeling initially conducted for this Regional Haze Plan provide two time frames for comparison, the 2014-2018 period and 2028. To bolster this comparison, the WRAP modeling team also estimated U.S. emissions for the year 2002 to represent the baseline (2000-2004) period. To demonstrate the utility of this work, a comparison of light extinction for haze pollutants attributable to U.S. sources for these three emissions scenarios are provided in this section for the most impaired Class I areas in each region. Comparisons for the remaining Class I areas are available in Appendix C.

### Northern California

During the current period, Point Reyes National Seashore (PORE1) was the most impaired Class I area in Northern California. As shown in Figure 4-7, significant reductions in ammonium nitrate and ammonium sulfate occurred between the baseline and current period on the most impaired days. Between these periods, estimated light extinction attributable to ammonium nitrate decreased by 50 percent and ammonium sulfate decreased by 90 percent.

*Figure 4-7: U.S. Source Apportionment for 2002, 2014-2018, and 2028 Emissions Scenarios at PORE1*



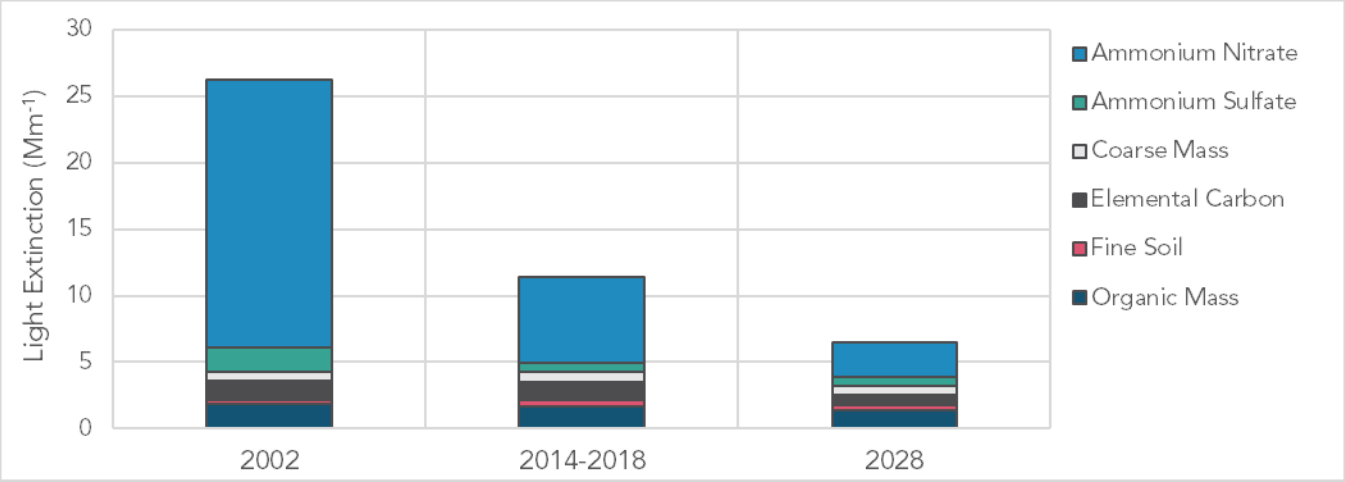
The reduction in ammonium sulfate was the result of a combination of regulatory actions. In 2006, California implemented standards to lower the maximum sulfur content in diesel fuels from 500 parts per million by weight (ppmw) to 15 ppmw. Enforcement of California's Ocean-Going Vessel Fuel Regulation began in 2009, requiring the use of low sulfur marine distillate fuels with a maximum of 0.1 percent sulfur by weight in main engines, diesel-electric engines, auxiliary engines, and auxiliary boilers for vessels operated within 24 nautical miles of the California coastline. Emission reductions at several large stationary sources in the San Francisco Bay Area also contributed to the ammonium sulfate reductions.

The reductions in ammonium nitrate resulted from the implementation of the State's mobile source control program. Adopted measures targeting NOx emissions from mobile sources are projected to reduce light extinction attributable to ammonium nitrate by an additional 42 percent on the most impaired days in 2028. These reductions will make a measurable impact on visibility at Point Reyes National Seashore in 2028. While additional work remains, these results suggest that measures being implemented to meet health standards and climate targets in California are also effective at reducing visibility impairment in Class I areas.

### Central California

Kings Canyon and Sequoia National Parks (SEQU1), located in the Central California region, had the highest level of visibility impairment in this region during the current period as well as all Class I areas in California. As shown in Figure 4-8, reductions in ammonium nitrate and ammonium sulfate occurred between the baseline and the current periods.

*Figure 4-8: U.S. Source Apportionment for 2002, 2014-2018, and 2028 Emissions Scenarios at SEQU1*



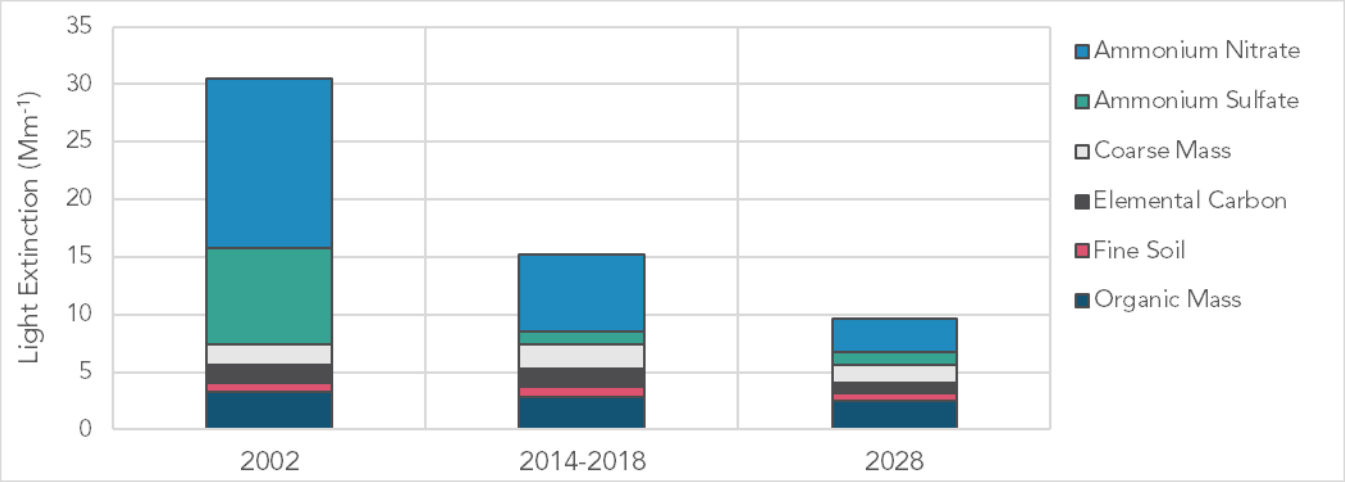

Light extinction attributable to ammonium nitrate was reduced by 68 percent and light extinction attributable to ammonium sulfate was reduced by 63 percent. Additional reductions of nearly 60 percent in light extinction attributable to ammonium nitrate are projected for 2028. The past and projected ammonium nitrate reductions are largely due to

statewide implementation of mobile source control measures. Reductions in ammonium sulfate were largely due to implementation of measures limiting the sulfur content in fuel.

### Southern California

The Agua Tibia Wilderness Area (AGTI1) had the highest level of visibility impairment on the most impaired days for the 2014-2018 period among Class I areas in Southern California. As shown in Figure 4-9, source apportionment results for this area indicate that light extinction attributable to ammonium nitrate and ammonium sulfate decreased between the baseline and current periods. Light extinction attributable to ammonium nitrate was reduced by 54 percent and light extinction attributable to ammonium sulfate was reduced by 87 percent. Similar reductions have occurred at Class I areas throughout California following the implementation of statewide mobile source control measures and enforcement of low sulfur fuels limits. Implementation of addition mobile source controls during the 2018 to 2028 implementation period is projected to yield an addition 57 percent reduction in light extinction attributable to ammonium nitrate in the Agua Tibia Wilderness by 2028.

*Figure 4-9: U.S. Source Apportionment for 2002, 2014-2018, and 2028 Emissions Scenarios at AGTI1*




While additional work remains, the reductions in visibility impairment attributable to the sources highlighted above are occurring at Class I areas throughout California. This progress indicates that California is making meaningful strides towards 2064 visibility goals. The integrated planning process utilized in California to develop, adopt, and implement measures to meet air quality, climate, and community health goals has been effective at reducing visibility impairment in Class I areas.

## Low-Level Source Apportionment

The low-level source apportionment modeling used the 2028 emissions inputs to identify U.S. sources projected to contribute to ammonium nitrate and ammonium sulfate at Class I areas in the western states. Sources were divided into five groups for each of the individual 13 continental states in the WRAP region as well as an "other US" source group that includes

offshore U.S. waters. The five emission source groups considered in the low-level source apportionment modeling are listed below:

- EGU (Electric Generating Units) Point
- Non-EGU Point
- Oil and Gas (Point and Non-Point)
- Mobile (On-Road and Off-Road)
- Other (all remaining anthropogenic nonpoint sources including residential wood combustion, fugitive dust, and agriculture)

Due to time and budget constraints, low-level source apportionment work was limited to ammonium nitrate and ammonium sulfate. Resources for accessing additional technical information about the source apportionment modeling strategies are available in Appendix F. These low-level source apportionment results provide insight into the sectors contributing to two of the main haze pollutants impacting visibility in Class I areas across the western U.S. and provide a means to identify potential impacts on or from neighboring states.

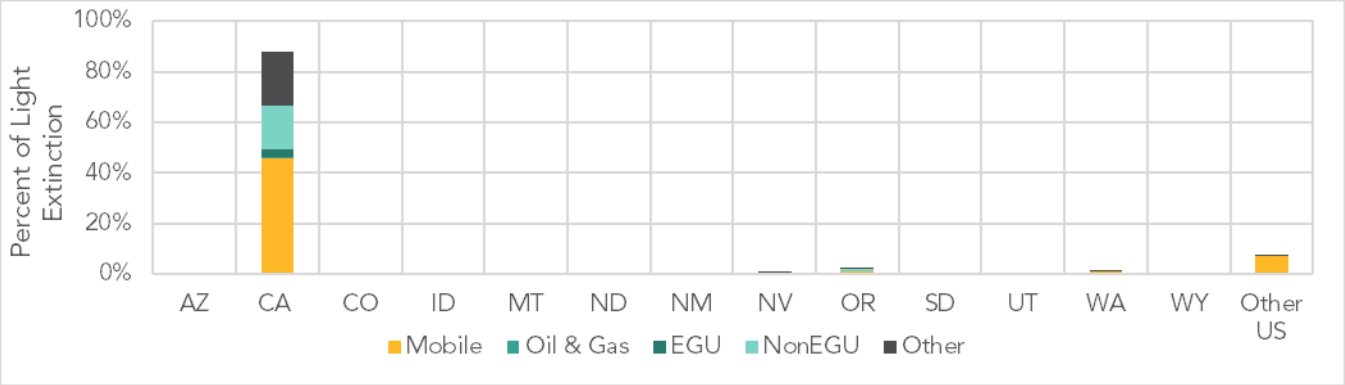
## Low-Level Source Apportionment Projections for Most Impaired Days in 2028

In California, ammonium nitrate is largely attributed to U.S. sources. As a result, the focus of California's regional haze planning efforts is on emission sources contributing to ammonium nitrate. Low-level source apportionment results for ammonium nitrate in Point Reyes National Seashore (PORE1), Kings Canyon and Sequoia National Parks (SEQU1), and the Agua Tibia Wilderness Area (AGTI1), which are the most impaired Class I areas in each of the three regions in California, are provided in this section to demonstrate the utility of this work. Additional results, including low-level source apportionment for ammonium sulfate at these sites and low-level source apportionment for other Class I areas in California, are provided in Appendix C.

### Northern California

As shown in Figure 4-10, low-level source apportionment projections for visibility conditions at Point Reyes National Seashore (PORE1) in 2028 indicate that mobile sources will be the dominant source sector contributing to ammonium nitrate at Point Reyes National Seashore. The projections for the most impaired days indicate that 56 percent of ammonium nitrate from will be attributable to mobile sources, with mobile sources operating in California accounting for most of this portion.

*Figure 4-10: 2028 U.S. Anthropogenic Source Apportionment for Ammonium Nitrate on the Most Impaired Days at PORE1*

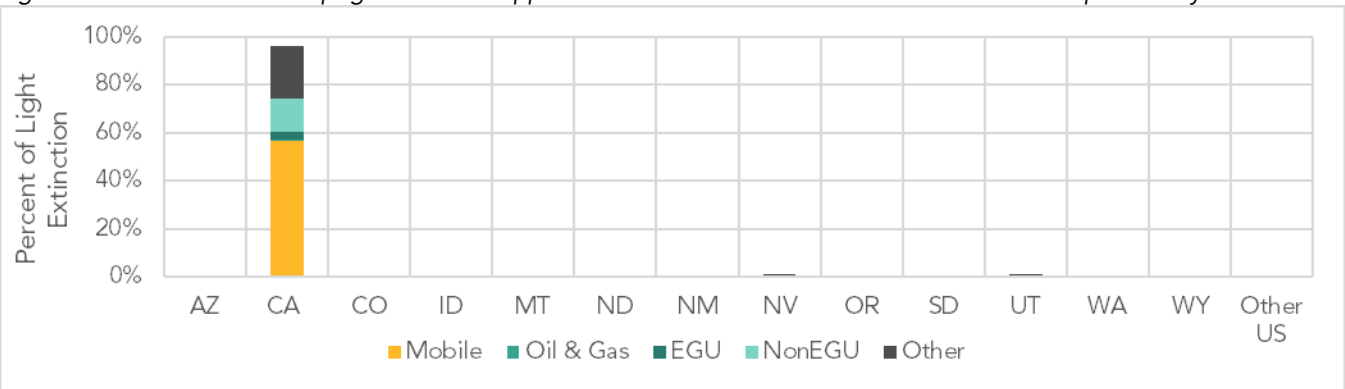



California's long-term strategy for regional haze is focused on emission reductions from mobile sources, which is supported by data and technical analysis for this implementation period. As California moves closer to a zero-emission transportation sector and mobile source impacts are further reduced, the iterative planning process laid out by the Regional Haze Rule provides an opportunity for California to pivot its focus in future planning periods to other sources that data and technical analyses may indicate are the predominantly important to regional haze planning.

### Central California

As shown in Figure 4-11, source apportionment projections for visibility conditions at Kings Canyon and Sequoia National Parks (SEQU1) in 2028 indicate that mobile sources will be a significant contributor to ammonium nitrate. The projections show that 59 percent of ammonium nitrate attributable to U.S. sources will be from mobile sources. Specifically, mobile sources operating in California will account for 57 percent the light extinction attributable to ammonium nitrate in 2028. Integrated planning efforts to develop strategies to reduce mobile source emissions throughout California and within the San Joaquin Valley Air Basin will be essential for California to improve visibility and meet its many air quality, climate, and community health goals.

*Figure 4-11: 2028 U.S. Anthropogenic Source Apportionment for Ammonium Nitrate on the Most Impaired Days at SEQU1*

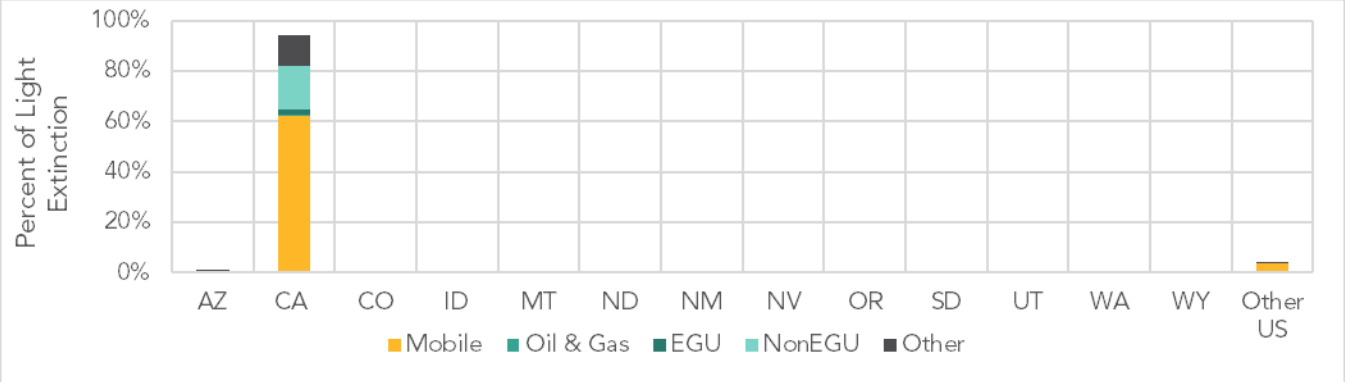


### Southern California

Consistent with the results for Point Reyes National Seashore and Kings Canyon and Sequoia National Parks, source apportionment projections for 2028 visibility conditions in the Agua Tibia Wilderness Area (AGTI1) indicate that mobile sources will be the dominant U.S. source group for light extinction attributed to ammonium nitrate. As shown in Figure 4-12, mobile sources are projected to account for 67 percent of ammonium nitrate attributable to U.S. sources in 2028.

Most of the mobile sources are those operating in California. Integrated planning efforts to develop strategies to reduce mobile source emissions throughout California and hasten the transition to low and zero-emissions technologies in mobile sectors within the South Coast Air Basin will be essential for California to meet its many air quality, climate, and community health goals.

*Figure 4-12: 2028 U.S. Anthropogenic Source Apportionment for Ammonium Nitrate on the Most Impaired Days at AGTI1*




As described in Chapter 2 and earlier in this chapter, ammonium nitrate is generally the dominant visibility reducing PM species in the U.S. light extinction budget for California's Class I areas. As described in Chapter 3, mobile sources account for nearly 80 percent of NOx emissions statewide. A strategy focused on emission reductions from mobile sources will be effective at reducing ammonium nitrate and improving visibility at California's Class I areas including the Domeland Wilderness Area, shown below in Figure 4-13.

California's authority to set emission standards for mobile sources allows for the implementation of measures that will achieve emission reductions well-beyond those that could be achieved by only relying on implementation of federal rules. Additional federal support to control mobile sources that are registered out of state as well as emissions from off-road sources like locomotives, ocean-going vessels, and aircraft will be needed in future planning periods. Emissions from international sources also make measurable contributions to visibility impairment at monitoring sites in California. Additional federal support to address the contribution from international emission sources will be needed in future planning periods.

*Figure 4-13: Photograph of the Domeland Wilderness Area*

*Photograph courtesy of Jeff Kessler*

## Neighboring States

Source apportionment results were also used to assess California's contribution to haze in neighboring states and ensure that the long-term strategy for regional haze is adequate for addressing California's contribution to visibility impairment at Class I areas in neighboring states. California's first Regional Haze Plan included an assessment of California's contribution to visibility impairment at Class I areas in Oregon, Nevada, and Arizona. The scope of the neighboring states assessment will remain consistent in this Regional Haze Plan.

The projected contributions of ammonium nitrate and ammonium sulfate to total light extinction on the most impaired days in 2028 in Class I areas located in neighboring states are shown in Table 4-1 through 4-6. The share of ammonium nitrate and ammonium sulfate attributable to California sources is also shown in these tables. The projections and regional apportionment are from the low-level source apportionment modeling scenarios.

The contribution to light extinction in Class I areas in neighboring states from sources in California is small. The projected share of ammonium nitrate attributable to California sources ranges from 0.1 to 1.7 percent of the total light extinction budgets at Class I areas in neighboring states. The projected share of ammonium sulfate attributable to California sources ranges from 0.1 to 1.0 percent of the total light extinction budgets at Class I areas in neighboring states. Consultation with neighboring states is a requirement of the Regional Haze Rule. The details of California's consultation with Oregon, Nevada, and Arizona are provided in Chapter 9.

## Oregon

Twelve Class I areas are in Oregon (Figure 4-14). Visibility conditions for these 12 areas are determined based on data collected at six IMPROVE monitoring sites. At Oregon Class I areas, ammonium nitrate is expected to account for 6 to 24 percent of total light extinction in 2028 (Table 4-1). Source apportionment modeling shows that ammonium nitrate attributable to California sources is projected to account for 0.2 to 1.1 percent of total light extinction on the most impaired days at Class I areas in Oregon.

*Table 4-1: 2028 Source Apportionment for Ammonium Nitrate (AN) on the Most Impaired Days in Oregon Class I Areas*

| IMPROVE Site | Class I Area(s) | AN in Total Light Extinction Budget | AN Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| STAR1 | Eagle Cap Wilderness Area<br>Strawberry Mountain Wilderness Area | 14% | 0.3% |
| HECA1 | Hells Canyon Wilderness Area | 7% | 0.2% |
| THSI1 | Three Sisters Wilderness Area<br>Mount Jefferson Wilderness Area<br>Mount Washington Wilderness Area | 10% | 0.2% |
| MOHO1 | Mount Hood Wilderness Area | 24% | 0.3% |
| CRLA1 | Crater Lake National Park<br>Diamond Peak Wilderness Area<br>Mountain Lakes Wilderness Area<br>Gearhart Mountain Wilderness Area | 11% | 1.1% |
| KALM1 | Kalmiopsis Wilderness Area | 6% | 0.2% |

As shown in Table 4-2, ammonium sulfate is projected to account for 8 to 43 percent of total light extinction at Class I areas in Oregon in 2028. Modeling shows that ammonium sulfate attributable to California sources is expected to account for 0.1 to 0.5 percent of total light extinction for Class I areas in Oregon.

*Table 4-2: 2028 Source Apportionment for Ammonium Sulfate (AS) on the Most Impaired Days in Oregon Class I Areas*

| IMPROVE Site | Class I Area(s) | AS in Total Light Extinction Budget | AS Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| STAR1 | Eagle Cap Wilderness Area<br>Strawberry Mountain Wilderness Area | 39% | 0.3% |
| HECA1 | Hells Canyon Wilderness Area | 8% | 0.1% |
| THSI1 | Three Sisters Wilderness Area<br>Mount Jefferson Wilderness Area<br>Mount Washington Wilderness Area | 33% | 0.2% |
| MOHO1 | Mount Hood Wilderness Area | 43% | 0.1% |
| CRLA1 | Crater Lake National Park<br>Diamond Peak Wilderness Area<br>Mountain Lakes Wilderness Area<br>Gearhart Mountain Wilderness Area | 39% | 0.5% |
| KALM1 | Kalmiopsis Wilderness Area | 23% | 0.1% |

Overall, mobiles sources are projected to account for 31 to 42 percent of the portion of light extinction from California sources. The long-term strategy for regional haze in California will focus on emission reductions from mobile source sectors. This focus will have the co-benefit of reducing California's contribution to visibility impairment in Oregon's Class I areas.

## Nevada

The Jarbidge Wilderness Area is the only Class I area in Nevada (Figure 4-14). Visibility conditions for this area are determined from data collected at the JARB1 IMPROVE monitoring site. As shown in Table 4-3, ammonium nitrate is projected to account for 10 percent of total light extinction under the 2028 emissions scenario in the Jarbidge Wilderness Area. Modeling shows that ammonium nitrate attributable to California sources accounts for 0.6 percent of total light extinction.

*Table 4-3: 2028 Source Apportionment for Ammonium Nitrate (AN) on the Most Impaired Days in Nevada's Class I Area*

| IMPROVE Site | Class I Area(s) | AN in Total Light Extinction Budget | AN Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| JARB1 | Jarbidge Wilderness Area | 10% | 0.6% |

In the Jarbidge Wilderness Area, ammonium sulfate is projected to account for 50 percent of total light extinction (Table 4-4). Modeling shows that ammonium sulfate attributable to sources in California will account for 0.6 percent of total light extinction for the Jarbidge Wilderness Area.

*Table 4-4: 2028 Source Apportionment for Ammonium Sulfate (AS) on the Most Impaired Days in Nevada's Class I Area*

| IMPROVE Site | Class I Area(s) | AS in Total Light Extinction Budget | AS Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| JARB1 | Jarbidge Wilderness Area | 50% | 0.6% |

Overall, mobiles sources are projected to account for 32 percent of the portion of light extinction in Nevada's Class I area attributed to California sources. The long-term strategy for regional haze in California will focus on emission reductions from mobile source sectors. This focus will have the co-benefit of reducing California's contribution to visibility impairment in Nevada's Class I area.

## Arizona

Twelve Class I areas are in Arizona (Figure 4-14). Visibility conditions in these 12 areas are determined based on monitoring data collected at nine IMPROVE monitoring sites. At Arizona's Class I areas, ammonium nitrate is projected to account for 4 to 13 percent of total light extinction under the 2028 emissions scenario (Table 4-5). Modeling shows that ammonium nitrate attributable to sources in California will account for 0.1 to 1.7 percent of light extinction at Class I areas in Arizona.

*Table 4-5: 2028 Source Apportionment for Ammonium Nitrate (AN) on the Most Impaired Days in Arizona Class I Areas*

| IMPROVE Site | Class I Area(s) | AN in Total Light Extinction Budget | AN Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| CHIR1 | Chiricahua National Monument<br>Chiricahua Wilderness Area<br>Galiuro Wilderness Area | 5% | 0.1% |
| SAGU1 | Saguaro National Monument | 7% | 0.4% |
| PEFO1 | Petrified Forest National Park | 9% | 0.6% |
| BALD1 | Mount Baldy Wilderness Area | 13% | 1.6% |
| TONT1 | Superstition Wilderness Area | 6% | 0.5% |
| SIAN1 | Sierra Ancha Wilderness Area | 4% | 0.6% |
| IKBA1 | Mazatzal Wilderness Area<br>Pine Mountain Wilderness Area | 6% | 1.0% |
| GRCA2 | Grand Canyon National Park | 8% | 1.7% |
| SYCA | Sycamore Canyon Wilderness Area | 7% | 0.5% |

As shown in Table 4-6, ammonium sulfate is projected to account for 13 to 37 percent of total light extinction in 2028 at Class I areas in Arizona. Modeling shows that ammonium sulfate from anthropogenic sources in California are projected to account for 0.2 to 1.0 percent of total light extinction for Class I areas in Arizona.

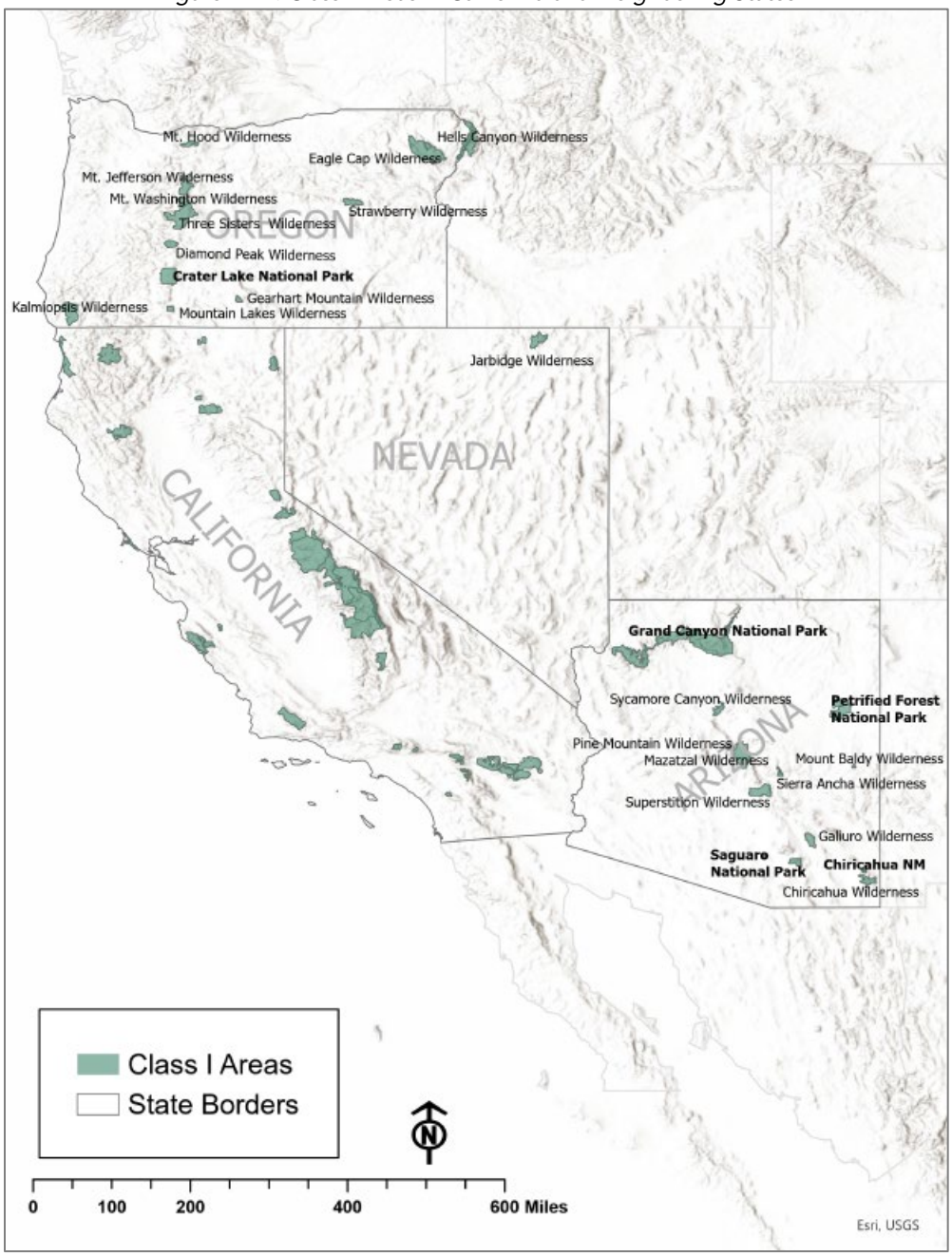
*Table 4-6: 2028 Source Apportionment for Ammonium Sulfate (AS) on the Most Impaired Days in Arizona Class I Areas*

| IMPROVE Site | Class I Area(s) | AS in Total Light Extinction Budget | AS Attributable to CA Sources in Total Light Extinction Budget |
|---|---|---|---|
| CHIR1 | Chiricahua National Monument<br>Chiricahua Wilderness Area<br>Galiuro Wilderness Area | 35% | 0.4% |
| SAGU1 | Saguaro National Monument | 13% | 0.2% |
| PEFO1 | Petrified Forest National Park | 27% | 0.5% |
| BALD1 | Mount Baldy Wilderness Area | 37% | 0.5% |
| TONT1 | Superstition Wilderness Area | 25% | 0.5% |
| SIAN1 | Sierra Ancha Wilderness Area | 15% | 0.3% |
| IKBA1 | Mazatzal Wilderness Area<br>Pine Mountain Wilderness Area | 27% | 0.8% |
| GRCA2 | Grand Canyon National Park | 28% | 1.0% |
| SYCA | Sycamore Canyon Wilderness Area | 22% | 0.6% |

Overall, mobiles sources account for 22 to 47 percent of the portion of light extinction attributed to California sources. The long-term strategy for regional haze in California will

focus on emission reductions from mobile source sectors. This focus will have the co-benefit of reducing California's contribution to visibility impairment in Arizona Class I areas.

*Figure 4-14: Class I Areas in California and Neighboring States*



# 5. Selection of Sources for Reasonable Progress Analysis

California evaluated monitoring and modeling data to develop a consistent source selection process that focuses planning efforts on reducing pollutants that drive visibility impairment in California's Class I areas. The source selection process maintains efficiency in the planning process and provides a foundation for the development of a Regional Haze Plan that will lead to visibility improvement at the Class I areas like Kings Canyon National Park, shown below in Figure 5-1, which are impacted by emissions from California.

*Figure 5-1: Kings Canyon National Park*

*Photo courtesy of Rebecca Garcia*

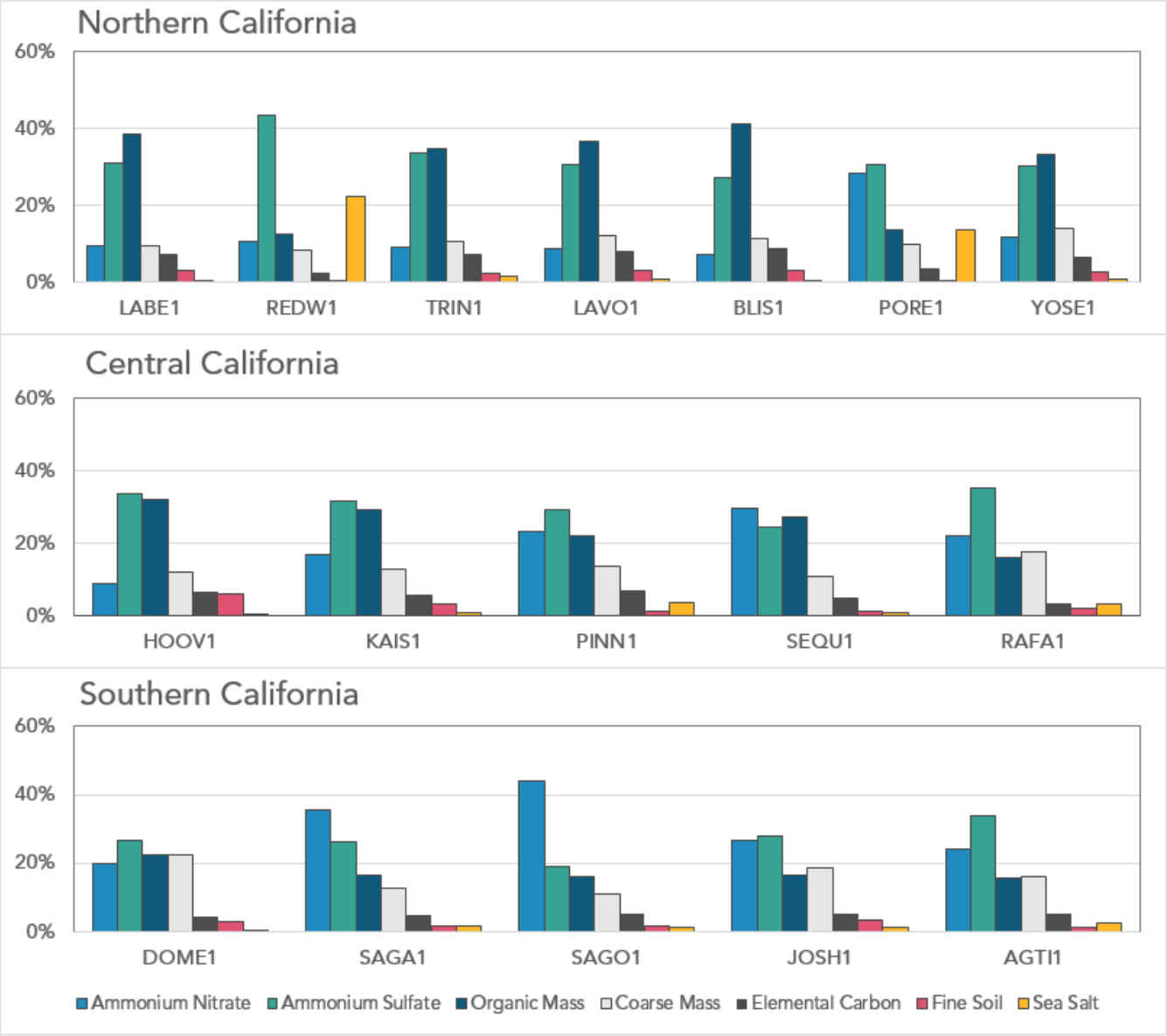
## Technical Basis

The extent to which each haze pollutant affects visibility differs among sites. To understand which pollutants had the largest impact at California Class I areas, light extinction budgets were developed. The light extinction budget shows the relative contribution from each haze pollutant measured at each monitoring site. Light extinction from U.S. sources and non-U.S. sources was also considered to ensure California's strategy was focused on emission sources that are controllable.

Total light extinction budgets developed with monitoring data from the IMPROVE network indicate that light extinction on the most impaired days at Class I areas in California is predominantly attributable to ammonium nitrate, ammonium sulfate, and organic mass (Figure 5-2). Ammonium nitrate and ammonium sulfate account for the largest portion of the

light extinction budgets at sites in closer proximity to urban areas, whereas ammonium sulfate and organic mass account for the largest portion of light extinction budgets at sites more removed from urban areas. These budgets include both U.S. and non-U.S. sources.

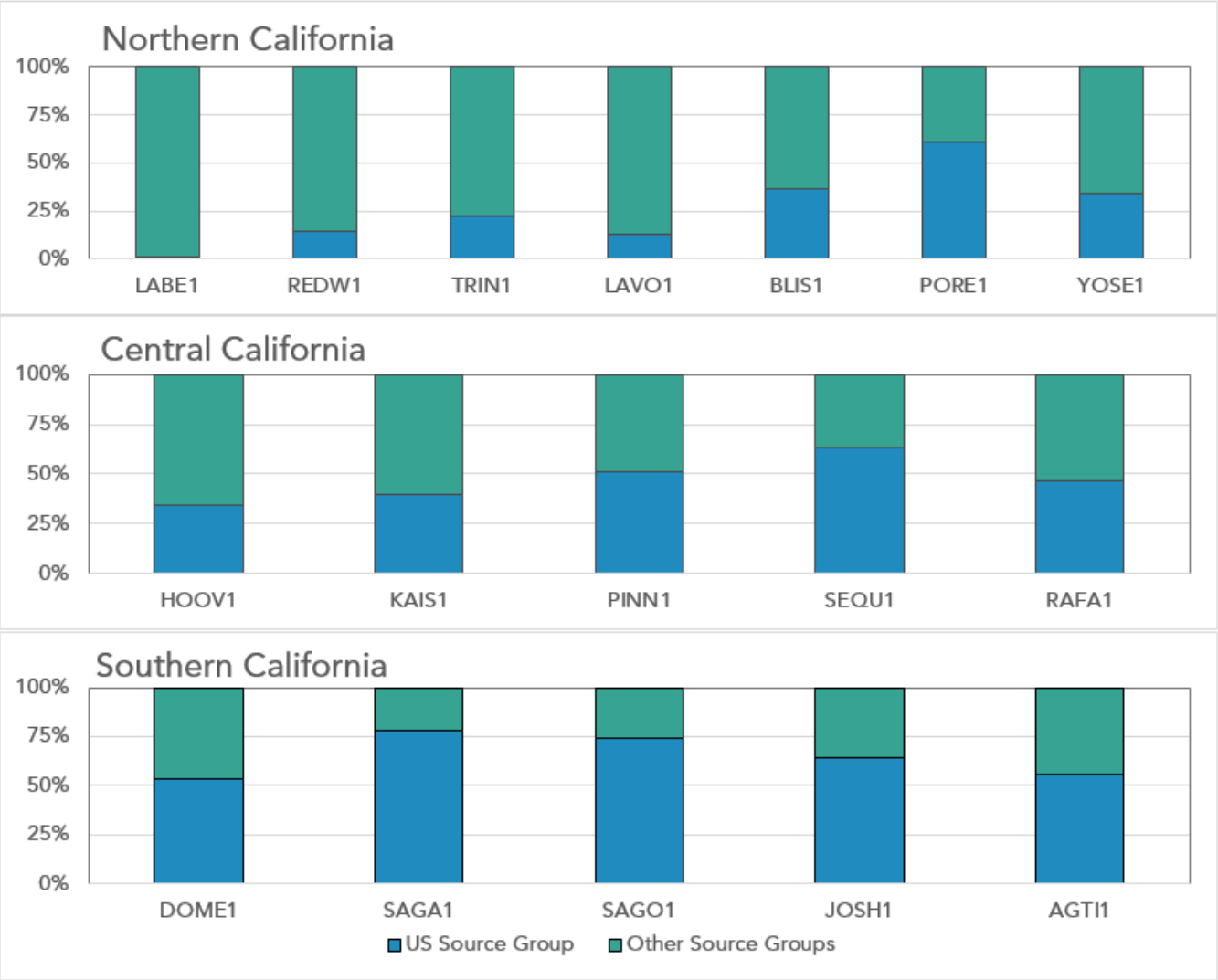
*Figure 5-2: Total Light Extinction Budgets for the 2014-2018 Most Impaired Days at California IMPROVE monitoring sites*




As shown in Figure 5-3, the contributions from non-U.S. sources were greater than the contributions from U.S. sources at most Class I areas on the most impaired days in the 2014 to 2018 period. Emissions from U.S. sources accounted for an average of 26 percent of light extinction on the most impaired days at sites in Northern California, 47 percent at sites in Central California, and 65 percent at sites in Southern California. Light extinction budgets for the portion of visibility impairment attributable to U.S. sources provide the basis to focus

planning efforts on the emissions from sources that make the largest contribution to visibility reducing PM species and are within the regulatory jurisdiction of agencies responsible for developing plans for regional haze.

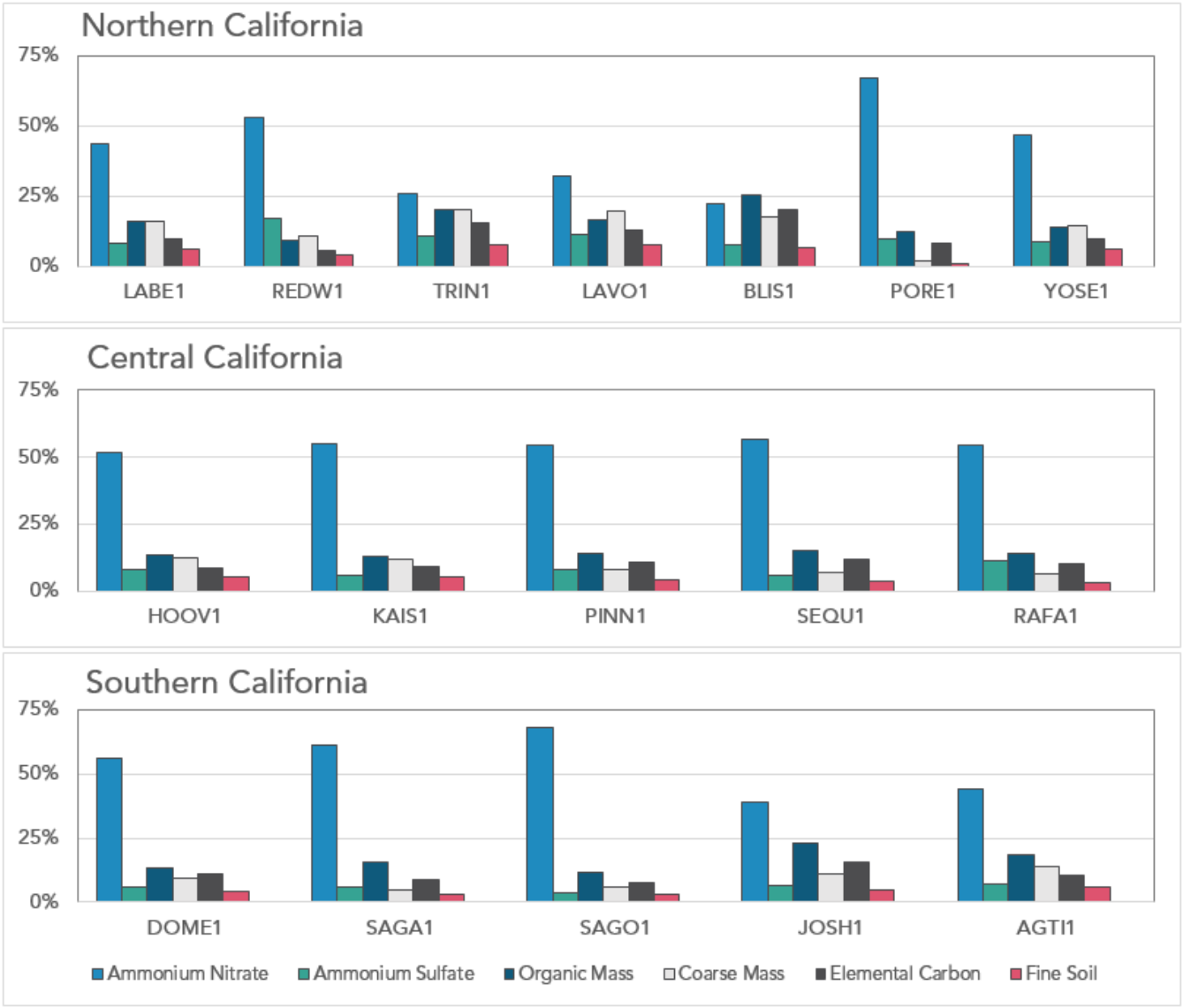
*Figure 5-3: Share of Light Extinction Attributable to U.S. Human-Made Sources vs. Other Source Groups at California IMPROVE sites on the Most Impaired Days in 2014-2018*




U.S. wildland prescribed fire impacts are considered their own source group for the purposes of source apportionment modeling and were not included in the subset of data shown in Figures 5-2 and 5-3. Like wildfire emissions, emissions from wildland prescribed fire are dominated by organic mass and do contribute to visibility impairment at Class I areas. Wildland prescribed fires are a necessary tool used to reduce the risk of catastrophic wildfires. The application of wildland prescribed fires, particularly in the western states, is expected to increase over the next decade and is discussed in detail in Chapter 7.

Parsing out non-U.S. sources, light extinction attributable to U.S. sources on the most impaired days indicates that ammonium nitrate is generally the dominant visibility reducing PM species, accounting for an average of 49 percent of light extinction at Class I areas in California (Figure 5-4). At monitoring sites in the closest proximity to major urban centers, including PORE1, SAGA1, and SAGO1, ammonium nitrate accounted for 61 to 68 percent light extinction attributable to U.S. sources.

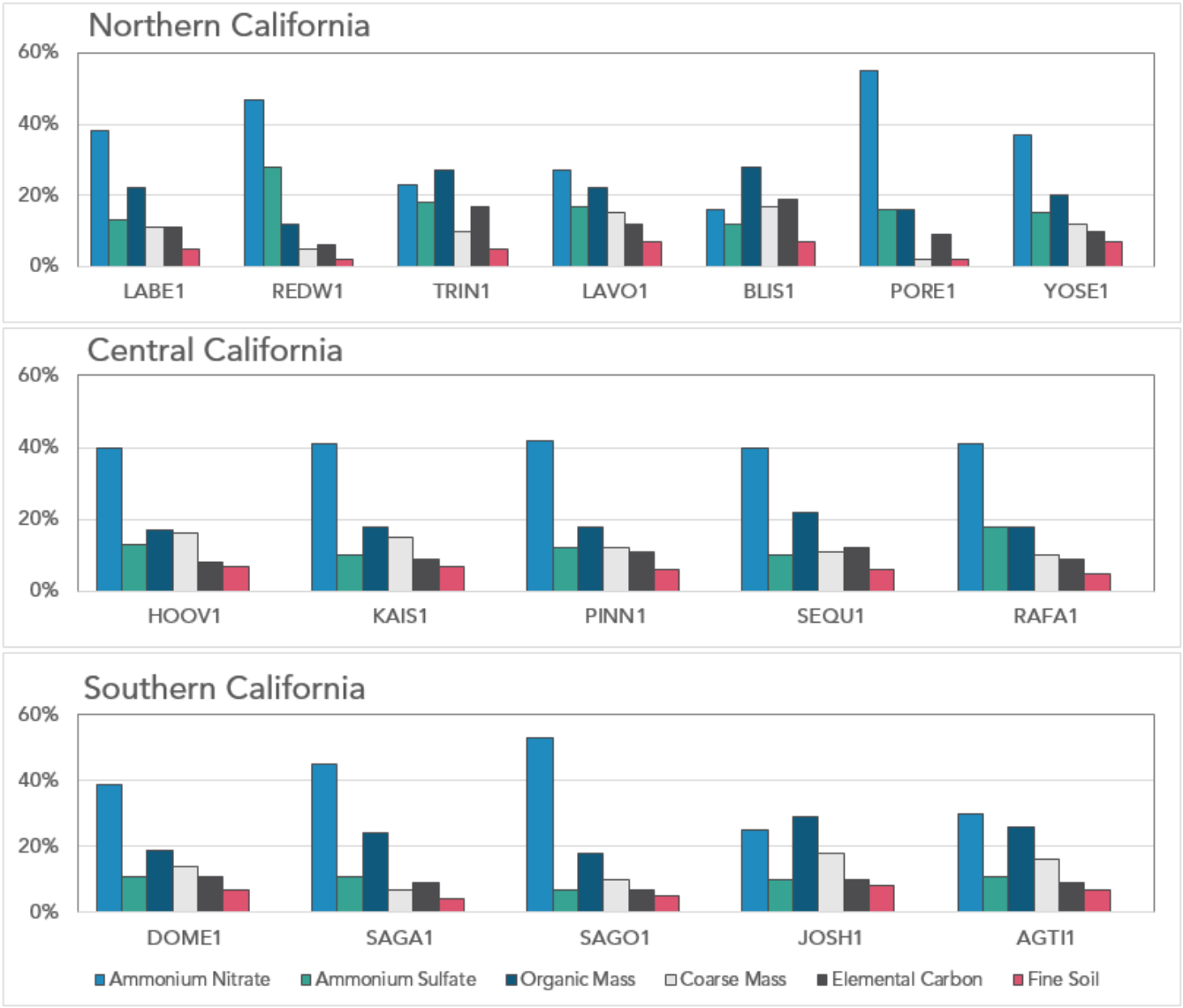
*Figure 5-4: Modeled PM Species Contribution to Light Extinction on the 2014-2018 Most Impaired Days Attributable to U.S. Human-Made Sources*




Prospective U.S. light extinction budgets for 2028, shown in Figure 5-5, indicate that ammonium nitrate continues to be an important contributor, accounting for an average of 38 percent of light extinction at Class I areas in California. At monitoring sites in the closest proximity to major urban centers, this share ranges from 45 to 55 percent, highlighting the

importance of a long-term strategy focused on continuing to reduce emissions that contribute to the formation of ammonium nitrate.

*Figure 5-5: Prospective 2028 PM Species Contributions to Light Extinction on the Most Impaired Days Attributable to U.S. Human-Made Sources*




Emissions from U.S., international, and natural sources contribute to visibility impairment in Class I areas. Visibility impairing PM species do not make equal contributions to light extinction. Regional haze strategies, by rule, are focused on human-made sources. The technical analyses for this planning period indicate that ammonium nitrate is generally the dominant visibility impairing PM species attributable to U.S. sources in California Class I areas and is the focus of our regional haze planning efforts. Visibility improvement and modeling indicate that NOx reductions are effective at reducing ammonium nitrate and is considered the limiting precursor rather than ammonia. California will focus its long-term strategy for this

Regional Haze Plan on ensuring that reasonable controls are in place for the major sectors that emit NOx emissions.

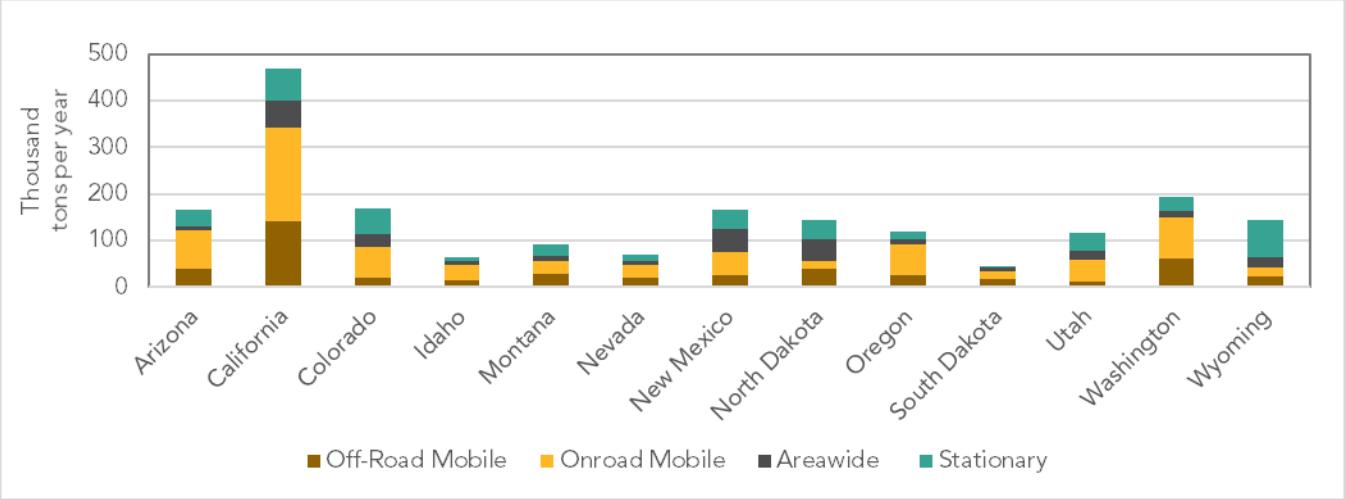
While the focus of this planning period will be on reducing ammonium nitrate through NOx controls, regional haze planning is an iterative process. Additional technical analyses will be completed during future regional haze planning periods. To ensure that regional haze strategies will continue to improve visibility in Class I areas, the results of future technical analyses will continue to provide the basis for future regional haze planning efforts.

## Source Selection

Integrated planning efforts to meet air quality, climate, and community health goals are ongoing in California. Emission reductions achieved through integrated planning efforts have measurable impacts on visibility metrics in Class I areas. California's source selection goal for this regional haze planning effort was to consider sources that accounted for at least 50 percent of the NOx emissions in the inventory to ensure reasonable controls were in place. Emission inventories from 2014 were initially considered. Following delays associated with the revision of the Regional Haze Rule and the one-time due date extension for this Regional Haze Plan, emission data for 2017 became available and were also considered in the source selection process.

The breakdown of NOx emissions from the 2017 National Emissions Inventory (NEI) for continental states in the WRAP region are shown in Figure 5-6. Emissions from the mobile source sector dominate the NOx emissions inventory in California. On-road mobile emissions in California alone are greater than NOx emissions from all sectors combined in the other WRAP states.

*Figure 5-6: 2017 NEI NOx Emissions by Source Sector for WRAP States in the Continental U.S.*



## Mobile Sources

Mobile sources operating in California account for nearly 80 percent of the State's NOx emissions. Mobile sources include the on-road and off-road sectors. Light and medium-duty vehicles are among the most numerous on-road sources operating in California. Collectively, emissions from these source groups accounted for 13 percent of NOx emissions in the 2017 inventory. While just 3 percent of the on-road vehicle population, heavy-duty trucks account for 40 percent of mobile source NOx emissions and 31 percent of the total NOx emissions. NOx emissions from all off-road sources combined are nearly equivalent to emissions from heavy-duty trucks.

Off-road equipment, trains, aircraft, and ocean-going vessels were the largest sources in the off-road mobile source sector. In the absence of additional controls, emissions are expected to increase in future years for aircraft and ocean-going vessels, which are federally and internationally regulated source groups. While emissions from aircraft represent a dominant source of NOx emissions in California, strategies to reduce emissions from aircraft will require federal action and were removed from consideration for reasonable progress analysis. As shown in Figure 5-1, emissions from mobile source sectors that California does have regulatory authority to control are projected to decrease significantly over the course of this implementation period as a result of the implementation of adopted control measures.

*Table 5-1: 2017 Mobile Source Sector Emissions in tons per day (tpd), Detailed by Source Groups*

| Sector Description | 2017 Emissions (tpd) | Projected 2028 Emissions (tpd) |
|---|---|---|
| On-Road: Heavy-Duty Trucks | 409 | 227 |
| On-Road: Light & Medium-Duty Trucks | 111 | 31 |
| On-Road: Light-Duty Passenger | 70 | 26 |
| On-Road: Other (Buses, Motorcycles, Motorhomes) | 29 | 18 |
| Off-Road: Off-Road Equipment | 222 | 132 |
| Off-Road: Trains | 78 | 37 |
| Off-Road: Aircraft | 46 | 59 |
| Off-Road: Ocean-Going Vessels | 28 | 37 |
| Off-Road: Commercial Harbor Craft | 19 | 18 |
| Off-Road: Recreational Boats | 16 | 13 |
| Off-Road: Recreational Vehicles | 1 | 1 |

During the development of this Regional Haze Plan, strategies to control emissions from light and medium-duty vehicles, heavy-duty trucks, off-road equipment, trains, and ocean-going

vessels are among those being considered through California's integrated planning process. Combined, emissions from these five source groups account for 60 percent of NOx emissions in the 2017 inventory and are projected to account for 50 percent of NOx emissions in 2028. Thus, consideration of control strategies for these five sources meets California's source selection goal. Consideration of the four statutory reasonable progress factors for controlling emissions from these sources is presented in Chapter 6.

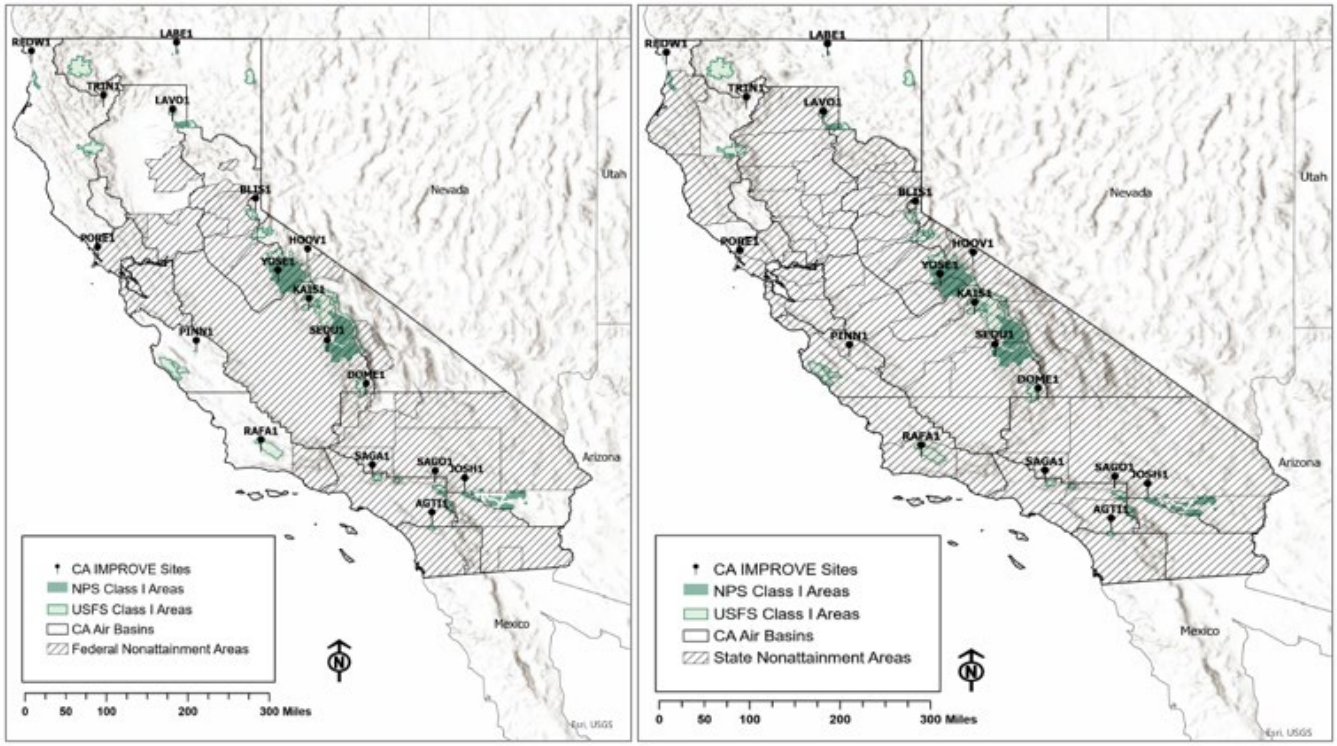
With a gross domestic product of over $2.5 trillion, California has the fifth largest economy in the world. People and transportation form the backbone for this economy. California's population has increased nearly four-fold since 1950 when the transportation infrastructure was constructed. Within the State, there are more than 175,000 centerline miles of roadway, over 300 airports, twelve seaports including the busiest port complex in the nation, and an extensive rail system that includes more the 10,000 miles of passenger and freight railroad. The collective scale of California's transportation network is unmatched by any other U.S. state. While transportation is fundamental to California's economy, it is also the root of most of the State's air pollution challenges. Integrated planning efforts focusing on emissions from mobile sources are fundamental to improving air quality, meeting climate and community health goals, and reducing visibility impairment in Class I areas in California.

### Stationary Sources

Although California's focus on mobile sources for this implementation planning period is different than most other WRAP states, it is warranted given the significant role of mobile source emissions in California and the State's authority to establish stricter than federal emissions standards for certain mobile sources. Nonetheless, California also assessed stationary sources. California's consideration of stationary sources for this implementation period is focused on ensuring that reasonable NOx controls will be in place at major stationary sources that are in operation during this implementation period.

In California, stationary sources accounted for 15 percent of NOx emissions in the 2017 NEI. Most major stationary sources are within areas designated as nonattainment for a State or federal air quality standard. Nonattainment designations trigger planning requirements for local air districts, including emission controls for stationary sources. As shown in Figure 5-7, the geographic extent of nonattainment areas in California is considerable. As a result, stationary source control programs are in place throughout California, and many are among the most stringent in the country.

*Figure 5-7: Areas in California Designated as Nonattainment for Federal (left) and State (right) Air Quality Standards*




To ensure that reasonable controls are in place at major stationary NOx sources, California developed a stationary source screening and selection process. The stationary source screening and selection process followed by California consisted of the four steps detailed below.

### Step 1: Calculate NOx Q/d as a Surrogate for Visibility Impacts

Consistent with many other states in the WRAP region, an initial stationary source screening list was developed by calculating a Q/d for each stationary source. The Q/d metric was calculated using a source's annual emissions (Q) in tons divided by distance (d) in km between the source and a Class I area. The Q/d metric serves as a surrogate for visibility impacts. The Q/d metric does not consider transport direction or pathways, dispersion and photochemical processes, or the particular days that have the most anthropogenic impairment. Due to these limitations, the Q/d metric was used solely to develop an initial list of stationary sources for further consideration.

Calculation of the surrogate metric for visibility impacts was initially completed using 2014 NEI NOx emission data and the distance between a stationary source and Class I areas as determined by Ramboll, the contractor for the WRAP analyses. Emissions were updated when the 2017 NEI was released. Facilities with a NOx Q/d greater than five were moved forward for further consideration.

As shown in Table G-1 in Appendix G, 42 stationary sources in ten local air districts were identified in the first stationary source screening step. These stationary sources included petroleum refining facilities, airports, cement plants, biomass energy or cogeneration facilities, steel mills, a paper plant, a generator station, a materials facility, and a mineral extraction facility. Collectively, emissions from these stationary sources accounted for 62 percent of stationary source NOx emissions reported in the 2017 NEI for the California.

Of the stationary sources on this initial screening list, airports account for the largest share of NOx emissions. The twelve airports account for 46 percent of emissions from sources on the screening list and represent four out of the top ten NOx emission sources on the screening list. The next largest source sectors represented on the initial screening list are cement plants and petroleum refineries, which account for 28 percent and 18 percent of NOx emissions, respectively.

Following the development of the initial screening list in the first step of the screening process, the next steps focused on detailed source information. Detailed source information was considered to determine if a full four factor analysis should be completed or if it was reasonable to conclude that a full four factor analysis would likely result in the conclusion that reasonable controls were in place and no further controls were reasonable at this time.

**Step 2: Review Device Level Emission Inventories**

For the 42 stationary sources with a Q/d over five, device level inventories were reviewed. Device level inventories provide details on the quantity of emissions from each type of emission point or process at a stationary source. Review of this information provides insight into the types of equipment or processes generating emissions at each stationary source location.

In California, authority for permitting of stationary sources is delegated to local air districts. Local air district staff were consulted to confirm actual emissions. Seventeen stationary sources were excluded from further consideration at this screening step, leaving 25 to be evaluated under the next step. A description of the sources excluded from further consideration are detailed in Appendix G.

**Step 3: Review Existing Controls, Planned Controls, and Proposed Operational Changes**

California's air quality challenges have required aggressive efforts to reduce emissions and drive development of new emission control technologies. These efforts have led to a stringent stationary source control program. The California Clean Air Act (CCAA) of 1988 established requirements for local air districts to incorporate Best Available Retrofit Control Technologies (BARCT). BARCT is defined in California Health and Safety Code Section 40406:

> …as *an air emission limit that applies to existing sources and is the maximum degree reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source.*

BARCT is a State version of the federal Reasonable Available Control Technologies (RACT) requirement, but the stringency is generally more akin to the that of the federal Best Available Control Technologies (BACT) requirement. Implementation of BARCT at stationary sources is required under certain conditions in California districts designated as having moderate, serious, severe, or extreme air pollution.[8]

State Assembly Bill (AB) 617 was signed into law in 2017 and expanded the scope of BARCT requirements. Specifically, AB 617 required air districts to review emission control technologies installed at industrial facilities subject to the State's Cap-and-Trade Program for greenhouse gas emissions. Air districts were required to adopt an expedited BARCT implementation schedule by January 1, 2019 detailing the rules or rule revisions that will be developed for any source categories for which BARCT is not in place. Industrial facilities subject to this AB 617 requirement must have BARCT in place by December 31, 2023.

Local districts are in the process of developing rules and rule revisions to meet the expedited BARCT requirements of AB 617. California views the implementation of BARCT level controls as equivalent to reasonable controls for regional haze planning purposes. Implementation of additional controls measures due to AB 617 will have a measurable impact on reducing air pollution, including reduction of particulate matter and particulate matter precursors that impair visibility. Stationary facilities implementing new control measures to meet the expedited BARCT requirements of AB 617 will have measures in place prior to 2028, the end of the second implementation period for regional haze purposes, and measures will be enforceable under State law and local rules.

For each of the facilities moved forward to this third screening step, operating permits were reviewed as well as plans for additional emission controls or proposed operational changes. Facilities were excluded at this step if the information about existing controls, planned controls, or planned operational changes indicated that a full four factor analysis would likely result in the conclusion that reasonable controls are in place.

Twenty-four stationary sources were excluded from further consideration at this screening step. A description of the sources excluded from further consideration at this step are detailed in Appendix G.

[8] Section 40921.5, Chapter 10, Part 1, Division 26 of the California Health and Safety Code

### Step 4: Proceed with Consideration and Evaluation of Four Statutory Factors

One stationary source remained on the list for consideration following the first three stationary source screening steps. A description of the remaining facility is below. CARB staff worked with the local air district and the facility to evaluate potential NOx control opportunities. A discussion of the consideration of the four statutory reasonable progress factors for NOx control strategies at this source is provided in Chapter 6.

**Collins Pine Co.**
Facility ID: 3270311
Nearest Mandatory Federal Class I Area: Caribou Wilderness Area
2017 NEI: 129 tons per year (tpy) NOx
2017 NOx Q/d: 10.4

Collins Pine Co. operates a sawmill with a cogeneration plant in Plumas County in the jurisdiction of the Northern Sierra Air Quality Management District. Sawmill operations began at this location in 1943. Feedstock includes Ponderosa pine, Sugar pine, White fir, Incense cedar, and Douglas fir. The facility has the capacity to process 120 million board feet of timber (MMBF) annually. All NOx emissions come from one wood-fired boiler. The boiler provides heat to kilns for drying lumber and for electric power cogeneration. Per district staff, no NOx emission controls are in place at the facility. The facility is located outside the boundaries of the Portola PM2.5 Nonattainment Area and is not subject to the expedited BARCT requirements of AB 617.

Potential opportunities for controlling NOx emissions from this facility are discussed in Chapter 6. Feasible controls were evaluated based on information collected on the four statutory reasonable progress factors, which are discussed in Appendix H.

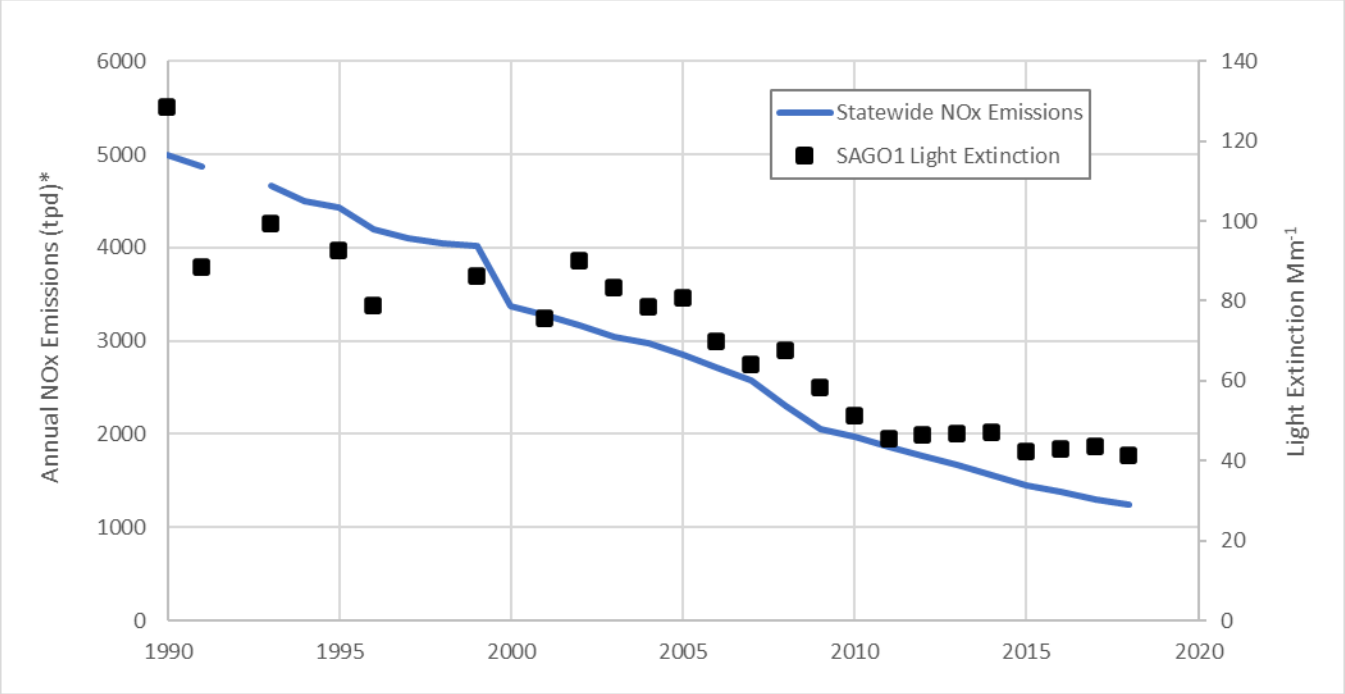
# 6. Consideration of Control Measures for Selected Sources

In developing the long-term strategy for this Regional Haze Plan, California's focus is on NOx emissions from mobile sources. Mobile sources account for nearly 80 percent of NOx emissions in the State. NOx emissions contribute to the formation of regional haze, ozone, and PM. NOx emission reductions are the focus of integrated planning efforts to meet NAAQS, combat climate change, and address community health concerns.

California has over 50 years of experience with developing and implementing emission control programs including authority under the Clean Air Act to establish stricter than federal emission limits for some types of mobile sources. Significant improvements in air quality have been realized through these efforts, and California is a recognized leader in pioneering efforts to improve air quality.

At Class I areas in the State, visibility impairment has decreased in concert with decreases in statewide NOx emissions. The SAGO1 monitoring site, representing visibility conditions in the San Gorgonio and San Jacinto Wilderness Areas, has one of the longest records of visibility monitoring data in California. Figure 6-1 shows average light extinction measured at the SAGO1 monitoring site on the most impaired days in 1990 through 2018 and the annual statewide NOx emissions for this period.

*Figure 6-1: Statewide Annual NOx Emissions and Average Annual Light Extinction on the Most Impaired Days at the SAGO1 Monitoring Site*




**Emissions Data Sources:*
*1990-1999 NOx Emissions: CEPAM 2007 Ozone SIP Tool v1.06, 2002 Base Year*
*2000-2020 NOx Emissions: CEPAM 2019 Ozone SIP Tool v1.03, 2017 Base Year*

Despite these emission reductions, California still has work to do in overcoming the significant air quality challenges that persist. Many areas in the State are nonattainment for at least one NAAQS. Five areas are nonattainment for multiple criteria pollutants. The San Joaquin Valley and the South Coast are the only two areas in the country designated as extreme ozone nonattainment areas. Combined, these two areas include more than 30,000 square miles and are located upwind from most of California's Class I areas. Integrated planning efforts focused on reducing emissions and improving air quality to meet California's air quality, climate, and community health goals will yield meaningful progress in reducing visibility impairing PM.

The Regional Haze Rule requires states to set reasonable progress goals based on consideration of four statutory factors:

1. the cost of compliance,
2. the time necessary for compliance,
3. the energy and non-air quality impacts of compliance, and
4. the remaining useful life of potentially affected sources.

The rule-making process employed by CARB and local air districts has embodied the consideration of these four factors for decades. Rules adopted through State and local efforts have effectively reduced emissions that contribute to haze in Class I areas. An integrated planning effort, one that leverages the resources and reductions from priority programs focused on human health objectives, will yield greater improvements than isolated efforts focused on secondary, welfare objectives alone.

The mobile source control measures detailed in this section were first articulated in California's 2016 Mobile Source Strategy,[9] which identified the suite of technology trajectories and programmatic concepts necessary to meet the State's air quality objectives. The 2016 Mobile Source Strategy was used to inform the development of the 2016 State SIP Strategy[10] and other air quality planning efforts undertaken by State and local agencies.

Five mobile source groups were selected for consideration for this Regional Haze Plan: heavy-duty trucks, light and medium-duty passenger vehicles, off-road equipment, trains, and ocean-going vessels. Combined, these mobile source groups accounted for 60 percent of NOx emissions in 2017. A summary of each of the most feasible control measures for each of these source groups follows.

Further, information on each of the four reasonable progress factors was obtained from publicly available documentation prepared or compiled by CARB staff for the development

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[9] Mobile Source Strategy: *https://ww3.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf*

[10] State SIP Strategy: *https://ww3.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf*

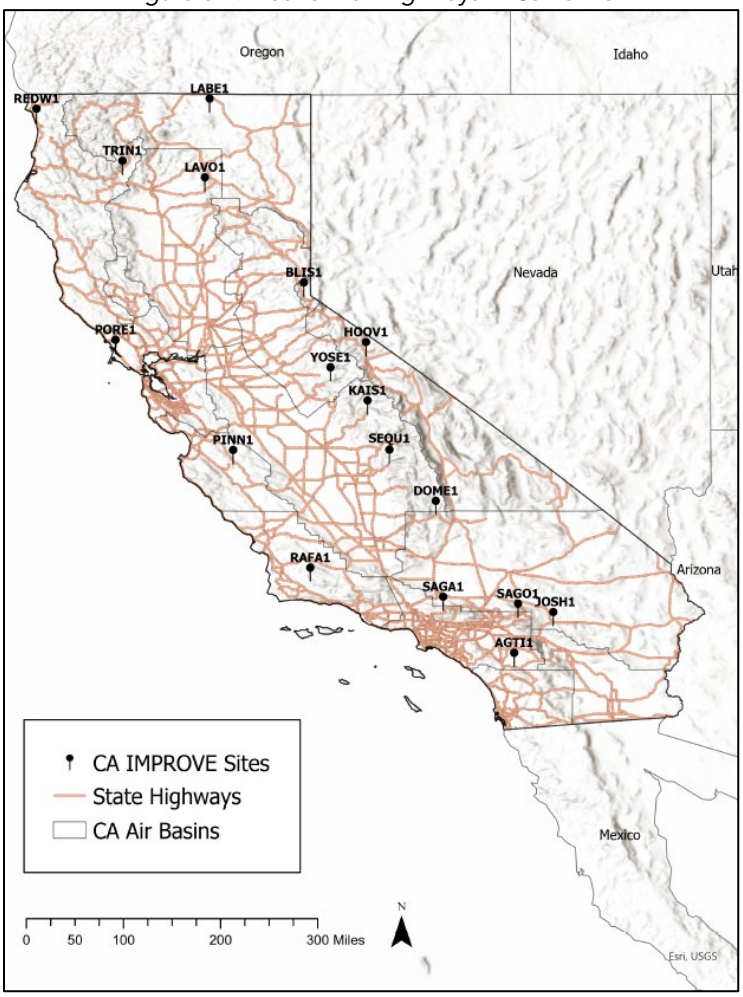
of regulatory measures for these source groups. A discussion of the four reasonable progress factors for each of the most feasible control options is in provided in Appendix H.

## On-Road Mobile Sources

### Heavy-Duty Trucks

Nearly a million heavy-duty trucks operated on California roadways in 2017. The 2017 California Public Road Data publication[11] prepared by the California Department of Transportation reports that more than 175,000 miles of public roadway are maintained by local, State, and federal agencies in California and the annual vehicle miles traveled on these public roadways amounted to more than 300 billion in 2017. As shown in Figure 6-2, the network of major highways spans the entire State.

*Figure 6-2: Network of Highways in California*




[11] https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system

On-road heavy-duty vehicle fleets are an essential part of California's economy but are a significant source of NOx, PM, and greenhouse gas emissions. On-road heavy-duty vehicles are the largest NOx emission source category and, subsequently, the focus of integrated planning efforts to meet air quality, climate, and community health goals.

Three key regulatory measures were developed through the integrated planning process during this regional haze planning period and are intended to reduce emissions from on-road heavy-duty vehicles. The Heavy-Duty Omnibus Regulation aims to reduce emissions by implementing more stringent emission standards. The Heavy-Duty Inspection and Maintenance (Heavy-Duty I/M) Program Regulation aims to reduce emissions by implementing a comprehensive enforcement program to ensure that emission standards are met for the operational life of the vehicle. The Advanced Clean Trucks (ACT) Regulation aims to reduce emissions by accelerating the transition to zero-emission vehicle technologies. Implementation of these measures is projected to lead to significant NOx emission reductions that will foster progress towards meeting air quality, climate, and community health goals in California. A detailed discussion of these measures follows.

### Heavy-Duty Omnibus

The first heavy-duty engine emissions standards were adopted by CARB in 1970 and targeted emissions of carbon monoxide, hydrocarbons, and NOx. These engine emission standards were adopted at the federal level in 1974. As our understanding of the detrimental impacts of vehicle emissions has improved, engine emission standards have become increasingly stringent and emission control technologies have advanced.

Implementation of the NOx emission standard of 0.2 grams per brake horsepower hour (g/bhp-hr) was phased in for on-road heavy-duty vehicles beginning in 2007 and was fully implemented in 2010. On-road heavy-duty vehicles in California are currently subject to the 0.2 g/bhp-hr NOx emission standard. The 0.2 g/bhp-hr NOx emission standard represents a 97 percent reduction from the NOx emission standard of 6.0 g/bhp-hr that was in place in 1998. Most engine manufacturers employ urea-based selective catalytic reduction (SCR) aftertreatment control technologies to meet the 0.2 g/bhp-hr NOx standard. California also requires certification that vehicles meet a 30 grams per hour (g/hr) NOx idling emission standard.

Despite significant emission reductions associated with the adoption of increasingly stringent engine emission standards, additional reductions are necessary to meet air quality, climate, and community health goals. To pave the way for more stringent NOx emission standards, California established optional low NOx standards in 2013. The most aggressive optional standard was 0.02 g/bhp-hr. For the 2018 model year, more than ten engines were certified as having met this optional low NOx standard.

To complement the optional low NOx standard, California initiated the Low NOx Demonstration Program in 2013 to investigate potential approaches for achieving the low NOx emission standard. Work on the Low NOx Demonstration Program was contracted to the Southwest Research Institute and funded by a collaborative group of stakeholders that included Manufacturers of Emission Controls Association, U.S. EPA, South Coast Air Quality Management District (AQMD), and individual engine manufacturers. The Program focused on the evaluation of aftertreatment technologies and engine calibration work. The Low NOx Demonstration Program provided a springboard for practical advancement of emission control technologies that can be utilized to meet more stringent NOx emission standards.

To legally sell new engines, manufacturers must certify that their engines will comply with applicable emission standards throughout a specified period termed the regulatory useful life. The current regulatory useful life period ranges from 110,000 miles or 10 years for Otto-cycle engines and Class 4-5 diesel-cycle engines to 435,000 miles or 10 years or 22,000 hours for Class 8 diesel-cycle engines. Manufacturers must also warranty emission-related components. Manufacturers are required to report component failure data to CARB. If failure rates are high enough, manufacturers are required to implement corrective actions that may include recall of faulty components.

The Heavy-Duty Omnibus Regulation includes a broad suite of measures that range from more stringent heavy-duty engine NOx standards to revised in-use testing procedures and changes to warranty periods. The goal of the regulation is to achieve the greatest degree of real-world NOx emission reductions that are technologically feasible and cost-effective. The regulation applies to diesel-cycle or otto-cycle engines in vehicles with a gross vehicle weight greater than 10,000 lbs (Class 3-8).

The engine NOx standards in the Heavy-Duty Omnibus Regulation are shown in Table 6-1. NOx emissions from heavy-duty trucks certified to the in-use engine standards in this regulation will be 90 percent lower in model year 2027 and later than those engines certified to meet the current NOx standards. The Heavy-Duty Omnibus Regulation is one piece of the broader strategy to reduce mobile source emissions to meet air quality, climate, and public health protection goals.

*Table 6-1: Heavy-Duty Engine NOx Standards in the Heavy-Duty Omnibus Regulation*

| Model Years | In-Use Standard | Idling Standard |
|---|---|---|
| 2024 - 2026 | 0.05 g/bhp-hr* and 0.20 g/bhp-hr** | 10 g/hr |
| 2027 and later | 0.02 g/bhp-hr* and 0.05 g/bhp-hr** | 5 g/hr |

* Standard for Federal Test Procedure (FTP) and Ramped Modal Cycles (RMC)
**Standard for low load cycle (LLC)

## Heavy-Duty Inspection and Maintenance

While engine and vehicle standards for new heavy-duty vehicles have become increasingly stringent, emissions from the heavy-duty sector remain the largest source of NOx emissions in California. When emission control systems malfunction, in-use emissions can increase significantly. The Heavy-Duty Vehicle Inspection Program (HDVIP) and the Periodic Smoke Inspection Program (PSIP) are CARB's heavy-duty in-use vehicle inspection programs that were developed to help ensure vehicle emission control systems are operating properly.

HDVIP requires inspection of heavy-duty vehicles for excessive smoke, tampering, and compliance with emission control label requirements. Inspections are conducted by CARB enforcement personnel at border crossings, weigh stations, fleet facilities, and random roadside locations. Inspections may be conducted on any heavy-duty vehicle traveling in California, including vehicles registered in other states and foreign countries. Owners of vehicles found in violation of operating standards are subject to penalties starting at $300 per violation. Penalty payments and proof of correction must be submitted to clear violations cited by inspection staff.

PSIP requires fleet owners to conduct annual smoke opacity inspections of their fleets and make repairs to vehicles with excessive smoke emissions. CARB enforcement staff conduct random fleet audits, review inspection and maintenance records submitted by fleet owners, and test a representative sample of fleets. Vehicles must be repaired and retested if they fail annual inspection and testing.

More information about HDVIP and PSIP is available online: *https://ww2.arb.ca.gov/our-work/programs/heavy-duty-diesel-inspection-periodic-smoke-inspection-program*

CARB research suggests that in-use vehicle NOx emissions may be substantially higher than expected based on current engine and vehicle standards. A feasibility study by the University of California at Riverside under CARB Contract #15R0D22 reported NOx reductions ranging from 50 percent to over 75 percent were achieved following maintenance repairs.

California Senate Bill (SB) 210 was signed into law in 2019 to strengthen California's heavy-duty inspection program. SB 210 directs CARB to work with the California Department of Motor Vehicles (CA DMV) and the Bureau of Automotive Repair to develop a heavy-duty inspection and maintenance program. SB 210 requires implementation of the heavy-duty inspection and maintenance program within two years of completion of a pilot program to test technologies that show potential for bringing heavy-duty vehicles into compliance. Following implementation of the heavy-duty inspection and maintenance program, SB 210 also requires the CA DMV to confirm that a heavy-duty vehicle is compliant prior to initial registration, transfer of ownership, or renewal of registration.

CARB initiated a primary pilot program in 2020. The pilot program included assessment of on-board diagnostic (OBD) testing, development of automated license plate recognition (ALPR) cameras, and field testing of roadside emission monitoring devices. During the pilot program, OBD testing technologies reliably collected parameters of interest and were capable of diagnosing emission related vehicle issues. More than 50,000 heavy-duty vehicles were scanned by the ALPR cameras during the primary pilot period. The successful license plate capture rate was greater than 70 percent. More than 16,000 vehicles were screened using attended roadside emission monitoring devices and over 230,000 vehicles were screened using unattended devices. The combination of technologies tested during the primary pilot program were well-suited for a future statewide program. Repairs for identified emissions related issues were found to be feasible and effective at reducing vehicle emissions.

The Heavy-Duty I/M regulation includes a suite of measures aimed at ensuring emission control systems on heavy-duty vehicles are maintained for the operational life of the vehicle. The regulation will apply to on-road non-gasoline vehicles with a gross vehicle weight rating greater than 14,000 lbs operating in California. As shown in Table 6-2, the regulation will affect more than a million heavy-duty vehicles that operate in California each year.

*Table 6-2: Projected Annual Heavy-Duty Vehicle Population Operating in California*

| Year | In-State Heavy-Duty OBD-Equipped | In-State Heavy-Duty Non-OBD-Equipped | Out of State Heavy-Duty OBD-Equipped | Out of State Heavy-Duty Non-OBD-Equipped | Total |
|---|---|---|---|---|---|
| 2023 | 415,157 | 193,508 | 502,953 | 40,087 | 1,151,704 |
| 2024 | 443,008 | 181,014 | 523,800 | 31,948 | 1,179,770 |
| 2025 | 470,176 | 168,952 | 541,623 | 25,476 | 1,206,227 |
| 2026 | 494,842 | 157,363 | 557,470 | 20,301 | 1,229,976 |
| 2027 | 517,284 | 145,602 | 571,953 | 16,136 | 1,250,975 |
| 2028 | 536,780 | 133,628 | 585,389 | 27,788 | 1,268,586 |
| 2029 | 552,448 | 122,014 | 598,106 | 10,060 | 1,282,628 |
| 2030 | 563,559 | 111,190 | 610,446 | 7,923 | 1,293,119 |

## Advanced Clean Trucks

The ACT Regulation aims to accelerate the adoption of zero-emission technologies in the medium and heavy-duty vehicle sector. The regulation has two main elements: a requirement that zero-emission capable vehicles make up an increasing share of manufacturer's medium and heavy-duty vehicles sales and a requirement that large entities report information that can be used to develop strategies to further accelerate transition to zero-emission

technologies. The sales requirement will apply to manufacturers with a California sales volume of 500 vehicles or more. One-time reporting will be required for large entities.

Large entities are those public or private organizations with more than $50 million in total annual gross revenue or that own/dispatch 100 or more Class 2b or larger vehicles. Large entities include a wide range of businesses and agencies including hotels, drayage terminal operators, utility providers, and government agencies. Large entities will be required to report information about contracting practices for services that require the use of trucks or shuttles and usage of existing trucks and buses.

The ACT Regulation will help foster the increased commercialization and acceptance of clean transportation technologies in a wide range of applications. As shown in Table 6-3, the projected number of vehicles in Classes 2b through 8 that will be sold each year in California is more than 70,000. Significant NOx reductions are expected to result from implementation of the proposed regulation. Emission reductions from implementation will promote progress towards air quality, climate, and community health goals.

*Table 6-3: Projected Annual Sales in California by Vehicle Class*

| Model Year | Class 2B-3 | Class 4-5 | Class 6-7 (excluding tractors) | Class 8 (excluding tractors) | Class 7-8 Tractor | Total |
|---|---|---|---|---|---|---|
| 2024 | 53,761 | 6,856 | 7,136 | 1,119 | 4,686 | 73,559 |
| 2025 | 54,217 | 6,957 | 7,241 | 1,137 | 4,769 | 74,321 |
| 2026 | 54,753 | 7,083 | 7,372 | 1,177 | 4,918 | 75,302 |
| 2027 | 55,152 | 7,228 | 7,523 | 1,194 | 4,993 | 76,091 |
| 2028 | 55,765 | 7,354 | 7,654 | 1,216 | 5,075 | 78,041 |

## Light-Duty Vehicles

The light-duty vehicle population in California is sizeable. At the end of 2020, there were more than 28 million light-duty vehicles registered in California.[12] Pollutants emitted from light-duty vehicles include hydrocarbons and NOx, which contribute to the formation of smog and particulate pollution. Light-duty vehicles account for more than 10 percent of statewide NOx emissions and have been the focus of California emission control programs for decades.

Evaporative emission control measures were established by California in 1969, requiring tighter-fitting fuel caps and the redesign of fuel lines to reduce leakage of gasoline vapors. State regulations enacted in 1973 led to the development of catalytic converters, which

[12] California Energy Commission (2021). California Energy Commission Zero Emission Vehicle and Infrastructure Statistics. Data last updated April 30, 2021. Retrieved December 3, 2021 from *https://www.energy.ca.gov/zevstats*

reduced emissions that contribute to the formation of smog. In 1986, state rules were adopted requiring vehicles to have OBDs, computers capable of detecting whether emission control equipment is working properly. The 1990 Low Emission Vehicle (LEV) standards established limits on smog forming emissions from passenger vehicles for 1994-2003 model years. The 1999 LEV II standards tightened emission standards for model year 2004-2010 passenger vehicles. In 2012, the Advanced Clean Cars (ACC) regulatory package was adopted and included LEV III standards. The ACC regulations combined measures targeting greenhouse gases and criteria pollutant emissions from passenger cars, light-duty trucks, and some medium-duty vehicles for model years 2017-2025. As a result of California's vehicle rules, the average new car sold in California today is 99 percent cleaner than a car from the 1970s in terms of smog-forming pollution.

California has continued efforts to foster the development of new emission control technologies and implement strategies to reduce emissions from light-duty vehicles. California is currently developing the ACC II regulations aimed at reducing criteria pollutant and greenhouse gas emissions from vehicles beyond the 2025 model year. The ACC II regulations will include LEV IV emissions standards and Zero Emission Vehicle (ZEV) measures aimed at further reducing emissions from vehicles powered by internal combustion engines and accelerating the transition to vehicles equipped with zero-emission technologies, respectively.

The LEV IV standards proposed in the current draft ACC II regulations maintain the fleet average emissions standard of 0.03 g/mile of smog forming pollutants but phase out the inclusion of ZEVs that manufacturers can include in the fleet calculation used to demonstrate compliance. Additional emission certification limits for aggressive driving and cold starts would be established to ensure that emission testing of vehicles reflects real-world conditions. The current draft ZEV measures include requirements for zero emission vehicles to make up an increasing share of manufacturers' light-duty vehicle sales in California. The sales share scales up over the implementation period. By 2035, all light-duty vehicles sold in California would be ZEVs.

### On-Road Mobile Sources: Additional Reasonable Controls Determination

After consideration of the four reasonable progress factors, which are detailed in Appendix H, staff determined that the measures proposed in the four on-road mobile source control regulations discussed in this section are reasonable and necessary to meet 2028 reasonable progress goals for visibility in Class I areas impacted by emissions from California.

## Off-Road Mobile Sources

Emissions from off-road mobile sources contribute to California's air quality challenges, accounting for around 30 percent of total NOx emissions. California's authority to control engine emissions from off-road equipment categorized as new farm and construction

equipment rated at less than 175 horsepower (hp) is preempted by the 1990 amendments to the federal Clean Air Act. U.S. EPA has sole authority to establish emission standards for these types of preempt engines. Emissions from some in-use (existing) equipment in the preempted categories are controlled through CARB's in-use off-road vehicle regulation programs. Recognizing the contribution of these sources to California's air quality challenges, CARB has continued to consider programs to regulate non-preempted categories of off-road sources.

Measures intended to reduce emissions from four off-road mobile source categories are discussed in detail on the following pages. The Transport Refrigeration Unit Regulation aims to reduce emissions by implementing more stringent emission standards and accelerating the transition to zero-emission equipment technologies. The amendments to the Small Off-Road Engine Regulation aims to reduce emissions by accelerating the transition to zero-emission engine technologies in a sector that is well-positioned for rapid transition. The In-Use Locomotive Regulation aims to reduce emissions by improving local enforcement of idling limits and accelerating the transition to low and zero-emission engine technologies. The amendments to the Ocean-Going Vessel At-Berth Regulations aim to reduce emissions by expanding the scope of an effective, existing regulatory program for vessels at-berth in California ports. Like the measures discussed for on-road sources, these off-road mobile source control measures have been developed through an integrated planning process and are projected to lead to significant NOx emission reductions that will foster progress towards meeting air quality, climate, and community health goals in California.

### Transport Refrigeration Units

Transport Refrigeration Units (TRUs) are cold-storage systems installed on trucks, trailers, shipping containers, and railcars that transport perishable goods. TRUs are typically powered by integral internal combustion diesel engines. TRU generator sets are diesel internal combustion engine-powered generators that provide electric power to refrigeration shipping containers. TRUs operate in large numbers near distribution centers, food manufacturing facilities, packing houses, and intermodal facilities. TRUs are a significant source of NOx and PM emissions.

Actions to reduce emissions from TRUs began in 2004 when CARB adopted the Airborne Toxic Control Measure for In-Use Diesel-Fueled TRUs and TRU Generator Sets, and Facilities where TRUs Operate (TRU ATCM). This 2004 measure required diesel engines that power TRUs to meet in-use diesel engine emission standards. Implementation of the measure occurred in phases beginning in 2008. Amendments in 2010 and 2011 added requirements for reporting and record keeping.

The measures added to the TRU ATCM through the amendments in 2010 and 2011 are fully implemented and provide four compliance options for TRU owners:

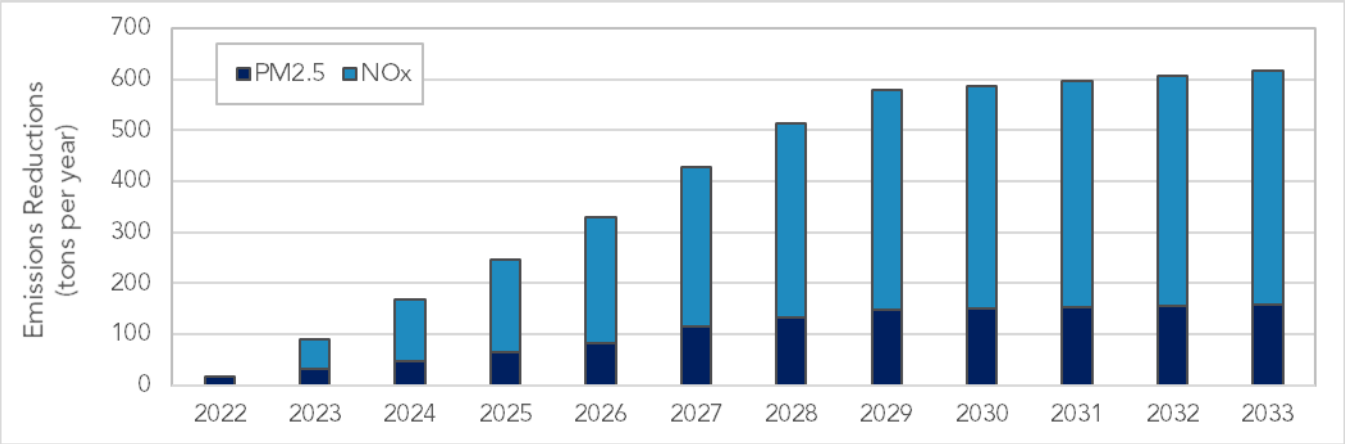
- Use a TRU equipped with an engine that meets the U.S. EPA Tier 4 final emission standards for 25-50 horsepower engines.
- Retrofit the existing TRU with a Level 3 Verified Diesel Emission Control Strategy with 85 percent PM control.
- Use an alternative technology that eliminates TRU diesel engine operation while at a facility. Alternative technologies include electrification, cryogenic refrigeration systems, alternative fuel systems, exclusive use of alternative diesel fuel, fuel cell-powered refrigeration systems, and other technologies that eliminate emissions while at a facility.
- Replace the existing unit with a new TRU equipped with an engine that meets the U.S. EPA Tier 4 final emission standards for less than 25 horsepower engines, which would comply until the seventh year after the replacement TRU's engine year of manufacture.

In 2021, CARB staff proposed additional amendments to the TRU ATCM to achieve further emission reductions. The additional amendments include the following key measures:

- Require certain TRUs to meet a 0.02 g/bhp-hr PM standard beginning with model year 2023
- Establish reporting requirements for facility owners and TRU owners
- Assess operating fees for TRU owners
- Require TRU owners to affix CARB compliance labels on TRUs operating in California
- Require TRU owners to transition at least 15 percent of their TRU fleet to zero emission technologies each year for seven years.
- Require all truck TRUs operating in California to be zero-emission by the end of 2029.

The proposed amendments would achieve emission reductions of NOx and directly emitted PM from diesel-powered TRUs and accelerate the transition to zero emission technologies in the off-road sector. As shown in Figure 6-3, the annual estimated emissions benefits scale up over time as an increasing number of TRUs are transitioned to operate using zero emission technologies. This transition is critical to meeting air quality, climate, and community health goals. The annual NOx emission benefits for the measures in the proposed amendments are projected to amount to 312 tons in 2028, the end of the second regional haze implementation period.

*Figure 6-3: Estimated Annual Emission Benefits from the Additional Amendments to the TRU ATCM Regulations*




## Small Off-Road Engines

Small off-road engines (SORE) are spark-ignition engines rated at or below 25 hp. There are more than 15 million SOREs in California. Residential lawn and garden equipment account for 77 percent of these SOREs. Federally regulated farm and construction equipment account for another 11 percent, commercial lawn and garden equipment account for 9 percent, and the remaining 3 percent are a variety of equipment types including generators and utility carts.

Emissions from SORE equipment are significant. Operating the best-selling commercial lawn mower for one hour emits as much smog-forming pollution (NOx and ROG) as driving 300 miles in a Toyota Camry, the best-selling passenger car in 2017. Operating the best-selling commercial leaf blower for one hour emits as much smog-forming pollution as driving 1,100 miles in a 2017 Toyota Camry.

CARB adopted emission standards for small off-road engines in 1990. As a result of these emission standards, SOREs sold in California emit 40 to 80 percent less smog-forming emissions than before implementation of the1990 standards began. The population of SOREs has continued to increase markedly over the last twenty years.

Emission reductions gained through implementation of the CARB adopted standards have helped to offset the growth in the SORE population, but overall emissions from this sector have remained stable over the last decade. In contrast, emissions from passenger vehicles have decreased significantly over the past ten years despite the marked growth in the population of passenger vehicles on California roadways. These divergent trajectories are especially noteworthy because the combined NOx and ROG emissions from small off-road engines are projected to surpass emissions from passenger vehicles in 2021. The proposed amendments to the SORE regulations will be instrumental in changing the trajectory for this source category and provide statewide reductions that will support progress toward meeting air quality, climate change, and community health goals.

Amendments to the SORE regulations include several concepts intended to foster the transition of small off-road engines to zero-emission equipment and reduce emissions from the small off-road engine source sector. Initially, CARB staff proposed to implement more stringent emission standards for model year (MY) 2024 through 2027 equipment and then establish an emission standard of zero for new sales beginning with MY 2028. Following feedback from stakeholders, the proposal was amended to eliminate the interim standard for most SORE equipment types and allow more time for certain sectors to transition to zero emissions. The amendments to the SORE regulations also extend the exhaust emissions durability period for several engine displacement categories.

As shown in Table 6-4, the exhaust emission standard for most SORE equipment will be set to zero requiring sales to be limited to zero-emission equipment beginning in MY 2024 under the amended SORE regulation. Further development of the technology needed to transition portable generators to zero-emission is needed. More stringent emissions standards will apply to generators in MY 2024 to 2027. Beginning with MY 2028, the engine emission standard for generators will be set to zero. The proposed amendments include a provision for zero-emission generator credits to encourage growth, foster innovation, and incentivize the transition to zero-emission portable generator technologies.

*Table 6-4: Current and Proposed Exhaust Emission Standards for SORE equipment*

| Displacement category | Current HC + NOx Emission Standard | MY 2024 and later (excluding Generators) Emission Standard | MY 2024-2027 Generators HC + NOx Emission Standard | MY 2028 Generators HC + NOx Emission Standard |
|---|---|---|---|---|
| < 225 cc | 10-72 g/kW-hr | 0 g/kW-hr | 6.0 g/kW-hr | 0 g/kW-hr |
| 225 to 825 cc | 8 g/kW-hr | 0 g/kW-hr | 3.0 g/kW-hr | 0 g/kW-hr |
| > 825 cc | 8 g/kW-hr | 0 g/kW-hr | 0.8 g/kW-hr | 0 g/kW-hr |

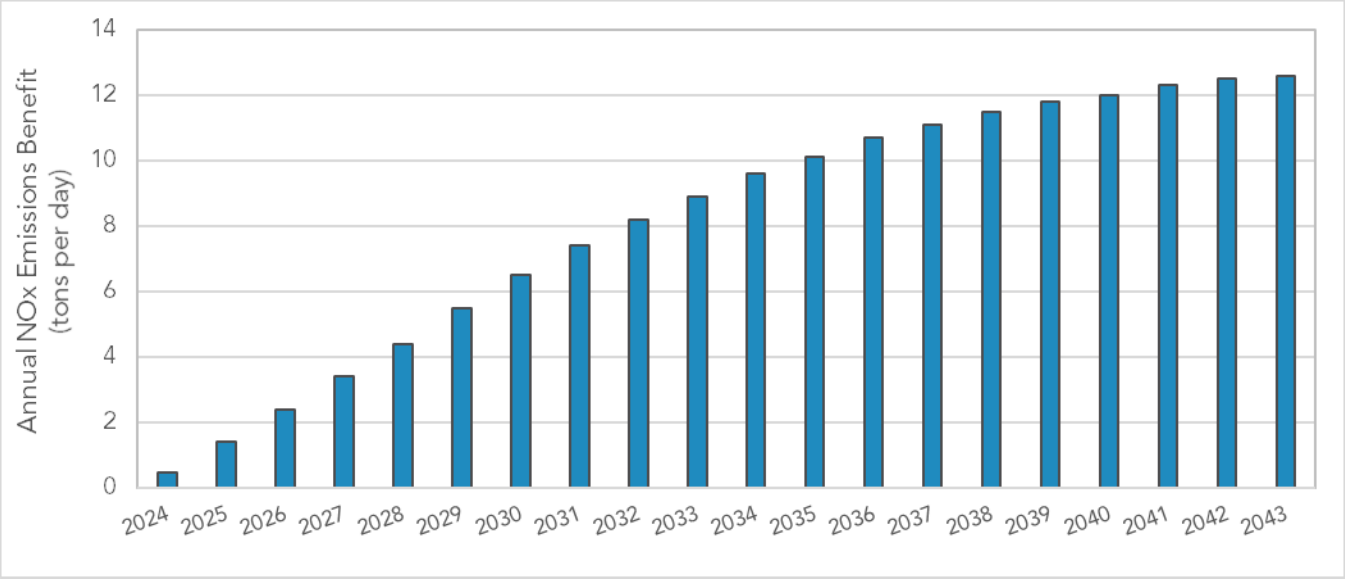
*Definitions of acronyms used in the table above: hydrocarbons (HC), cubic cylinder (cc), grams per kilowatt hour (g/kW-hr)*

More than half of household lawn and garden equipment is already equipped with zero-emission electric engines. At least 25 brands offer zero-emission options in each major lawn and garden equipment category: mower, string trimmer, hedge trimmer, chainsaw, and leaf blower. Commercial lawn and garden equipment users have been much slower to transition zero-emission engine technologies; however, at least eight brands do offer zero-emission commercial options in each major lawn and garden equipment category. An estimated 414,000 units of commercial zero-emission SORE lawn and garden equipment were in use in California in 2020, which accounts for 0.5 percent of the commercial SORE fleet.

The estimated NOx emission reductions from the proposed strategy relative to the emissions projected under the current regulations (baseline) are shown in Figure 6-4. With the implementation of the SORE amendments, NOx emissions from the small off-road engine sector in 2028 are projected to be 4.4 tons per day (tpd) lower than emissions projected under baseline conditions. Emission benefits will increase as a larger portion of new

equipment sales transition to zero-emission technologies where feasible and gasoline powered equipment has reached the end of its useful life.

*Figure 6-4: Average Annual Emission Benefits from Implementation of Amendments to SORE Regulation*



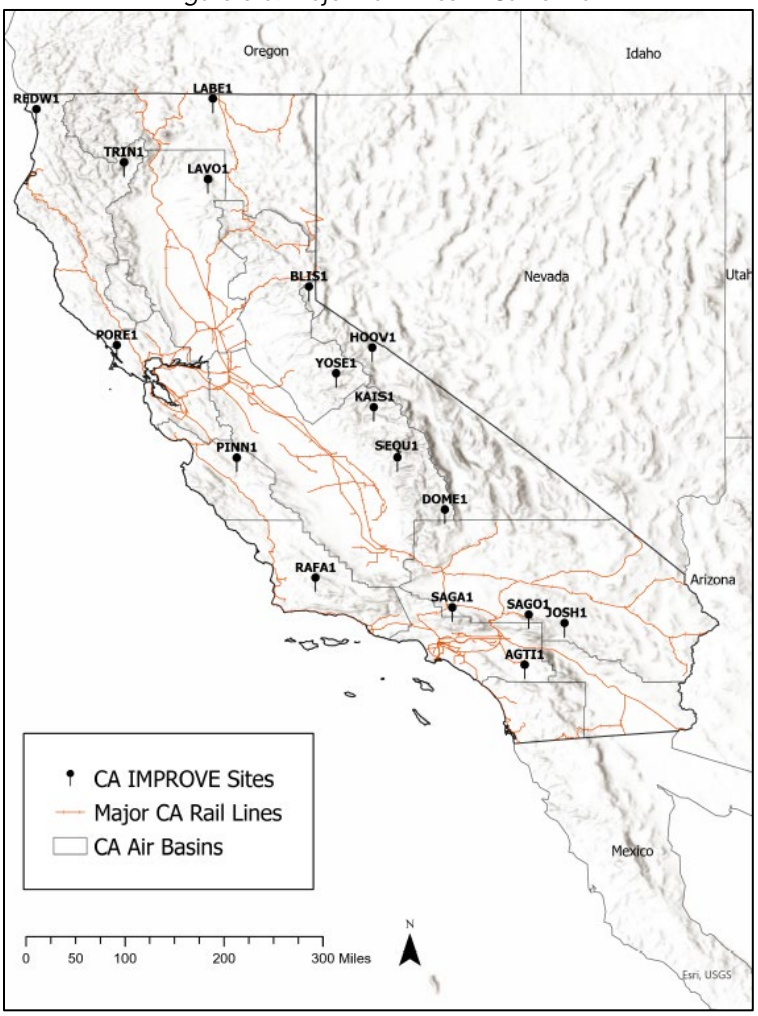

## Locomotives

Locomotives are self-propelled vehicles, typically powered by a diesel engine, that are used to move rail cars. Rail operations move goods and people to areas throughout the state. Rail corridors transect a variety of landscapes, with many lines adjacent to Class I areas. The proximity of California's IMPROVE monitoring network to major rail lines is shown in Figure 6-5. California's rail infrastructure is heavily used. According to 2019 data from the Association of American Railroads, California ranks number two in the country by the volume of carloads originating and terminating in the state.

Rail operators are categorized by the scope of their operations and their annual operating revenues. A summary of rail operations in California is provided in Table 6-5. Class I railroads, also known as line haul or freight railroads, have the largest operations in the State. Burlington Northern Santa Fe (BNSF) and Union Pacific are the two Class I operators in California and each company generates over $475 million in annual revenue. California's freight rail system includes more than 5,000 miles of rail routes. Class I railroads own and operate line haul and switcher locomotives.

Class III railroads are also known as short line or switching railroads. Class III railroads are typically locally owned and operated. They haul a variety of products ranging from lumber to agricultural commodities. There are 1,317 miles of Class III railroad routes in California.

*Figure 6-5: Major Rail Lines in California*




Military and Industrial railroad operations are limited to military installations and industrial facilities, respectively. Passenger rail operations are concentrated in the commuter corridors and include 887 miles of long-distance routes, 1,663 miles of intercity routes, 830 miles of commuter and regional rail routes, and 382 miles of urban mass transit routes.

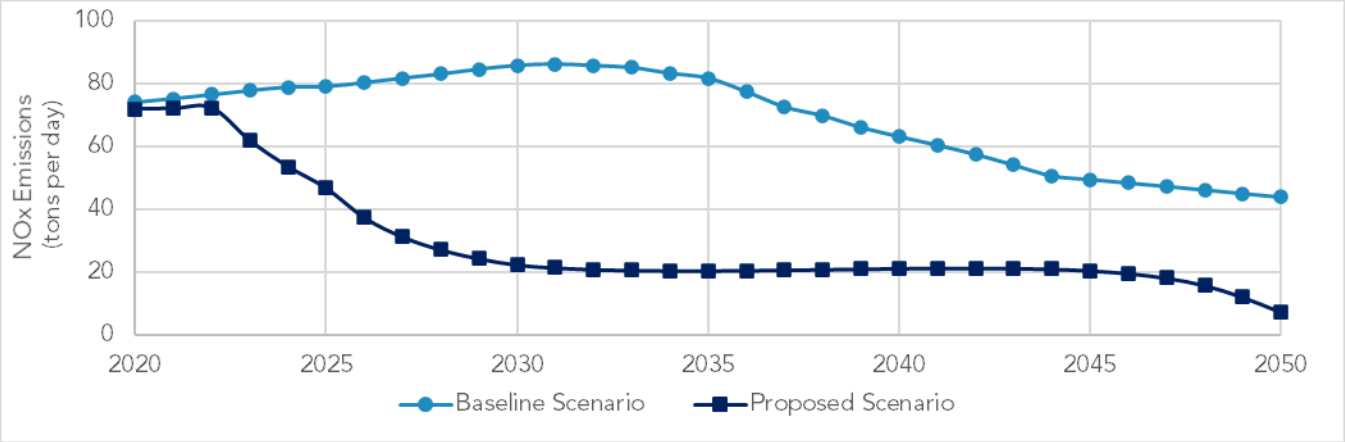
*Table 6-5: Descriptions of California Rail Operations*

| Rail Operator Category | Type of Operations | Approximate Number of Locomotives | Operators |
|---|---|---|---|
| Class I | 24/7 | 2000 | Union Pacific<br>BNSF |
| Class III | Daily | 200 | 20+ operators |
| Military & Industrial | Daily | 80 | 40 operators |
| Passenger | Daily | 150 | State and local municipalities including Amtrak and Caltrain |

Emissions from locomotives represent one of the largest NOx emission source categories in the off-road mobile source sector. While locomotive emission standards are under the jurisdiction of U.S. EPA, enforceable agreements to reduce emissions in specific locales have been developed directly with railroads operating in California. Emission reductions were realized following these agreements; however, the pace of improvement has slowed in recent years.

Adoption of the In-Use Locomotive Regulation would provide emission reductions to support air quality, climate, and community health goals. In the absence of federal or State action, emissions from locomotives are projected to increase in the near-term. As shown in Figure 6-6, emissions in 2028 will be 67 percent lower under the proposed scenario than those under the baseline scenario, where no new regulatory measures are put in place.

*Figure 6-6: Comparison of Two Scenarios for Locomotive NOx Emissions*




*Data source: https://arb.ca.gov/emfac/meta/off-road*

Locomotive engines are categorized into tiers based on their original year of manufacture (Table 6-6). Newer, higher tier engines are required to meet more stringent emission limits. The lowest tier engines were manufactured prior to 2001 and are considered Pre-Tier 0 engines. The highest tier engines were manufactured in 2015 or later and are considered Tier 4 engines. The difference in NOx emissions between Pre-Tier 0 and Tier 4 engines is significant. On average, Tier 4 engines emit 90 percent less NOx that Pre-Tier 0 engines.

*Table 6-6: Emission tiers for locomotive engines*

| Emissions Tier | Year of Manufacture | Line Haul NOx (g/bhp-hr) | Line Haul PM (g/bhp-hr) | Switcher NOx (g/bhp-hr) | Switcher PM (g/bhp-hr) |
|---|---|---|---|---|---|
| Pre-Tier 0 | 1973-2001 | 13.5 | 0.60 | 17.4 | 0.72 |
| Tier 0 - 2 | 2001-2011 | 9.5 to 5.5 | 0.60 to 0.20 | 14.0 to 8.1 | 0.72 to 0.24 |
| Tier 3 | 2012-2014 | 5.5 | 0.10 | 5.0 | 0.10 |
| Tier 4 | 2015-present | 1.3 | 0.03 | 1.3 | 0.03 |

Federal emission standards for locomotive engines were first established in 1998. During this rule making, standards were established for Tier 0, Tier 1, and Tier 2 engines manufactured between 1973 and 2001. Amendments in 2008 established more stringent standards for Tier 0, Tier 1, and Tier 2 engines and established standards for Tier 3 and Tier 4 engines. Since the 2008 amendments, emission control technologies for locomotive engines have advanced significantly.

Despite the increased availability of improved emission control technologies, locomotive fleet turnover is slow. The operating lifetime of locomotives is often extended by remanufacturing the engine or changing the type of service. Thus, locomotives can operate for 40 years or more after their original date of manufacture. This extensive lifetime is a significant barrier to a voluntary transition to cleaner locomotives.

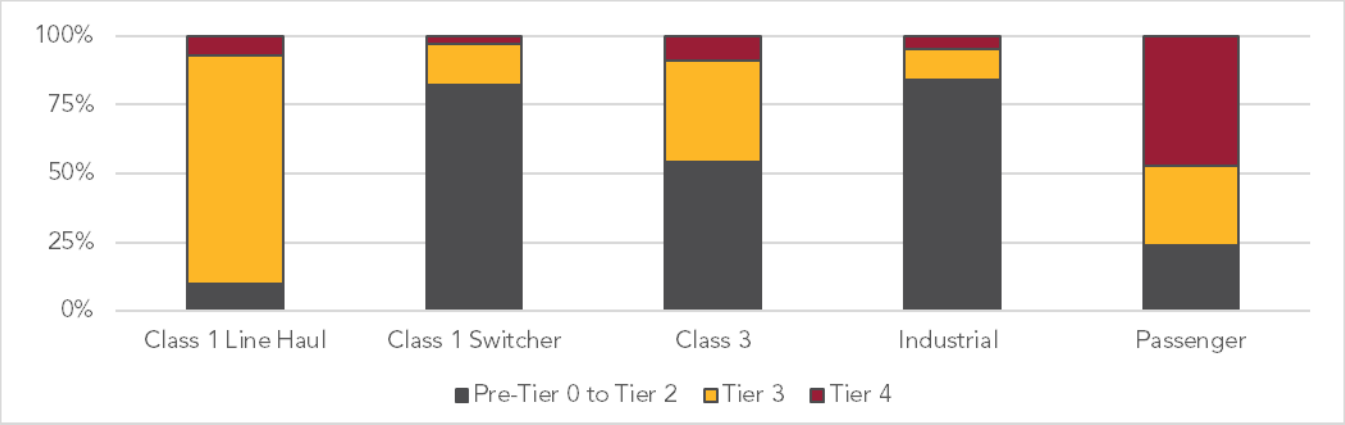
As shown in Figure 6-7, passenger rail operators have made the most progress in transitioning their fleet to cleaner engine locomotives, while industrial operators have been the slowest to transition their fleets. Class I operators have made some progress in transitioning beyond Tier 0 locomotives; however, less than 10 percent of the Class I locomotive fleet operating in California meets Tier 4 emission standards. Pre-Tier 3 locomotives make up over 80 percent of the Class I switcher and industrial fleet, highlighting the fact that when older, dirtier locomotives are retired from line haul service many continue operation in service at rail yards, ports, or industrial facilities.

Since the 2008 amendments to the federal locomotive emission standards, technology has continued to advance. Aftertreatment technologies, like SCR and diesel oxidation catalyst filters, are now widely available. Global efforts to further advance locomotive engine technologies have accelerated in the past decade.

Several locomotive demonstration projects have taken place domestically in recent years to showcase the feasibility of transitioning to low- and zero-emission engine technologies. At the Port of Long Beach, a demonstration project showcasing the feasibility of using battery powered switcher locomotives began in 2021. San Bernardino County Transit Authority will begin piloting a zero-emission commuter passenger train powered by hydrogen fuel cell technology in 2022 with plans to be fully operational for passengers in 2024. A new six-axle 3,200 hp locomotive developed by EMD Joule, powered by lithium-ion battery technologies, is zero-emission, zero idle, and low noise. The battery has a capacity of 2.4 megawatt hour (MWh) and a potential run time of 24 hours depending on charging and utilization. In the San Joaquin Valley, BNSF began piloting a battery electric locomotive on a line haul route between Barstow and Fresno in 2021 to demonstrate the feasibility of the near zero

emissions technologies for the line haul rail sector. More information about advanced locomotive technology demonstration projects is available online.[13]

*Figure 6-7: Tier Activities for Locomotive Operator Classes*




The application of low and zero emission locomotive engine technologies has become increasingly feasible in the last decade and there is room to further reduce emissions from the nation's fleet of locomotives. California recently petitioned U.S. EPA to update locomotive engine standards for remanufactured locomotives in 2023 and for newly built locomotives in 2025. New emission standards would provide NOx and PM reductions critical to meeting air quality goals. While U.S. EPA has acknowledged receipt of California's petition, no federal action has been taken.

In the absence of federal action, California has developed a suite of regulatory concepts aimed at reducing emissions from locomotives and accelerating the transition to cleaner locomotive engines operating in the state. These concepts were first detailed in California's 2016 Mobile Source Strategy and have been more fully articulated in the draft In-Use Locomotive Regulation. The consideration of the four reasonable progress factors for these concepts is summarized in Appendix H to highlight how these factors are embodied in California's rule making process.

The proposed In-Use Locomotive Regulation is one piece of the broader strategy to reduce mobile source emissions to meet air quality, climate, and community health goals. The proposed regulation is comprised of three main concepts:

- Establishment of spending accounts for locomotive operators
- Establishment of a useful life limit for locomotives operating in California
- Adoption of federal idling limits

[13] *https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotive-emission-verifications-technology*

For the spending account concept, locomotive operators will be required to report annual operation activities and deposit funds into a spending account annually based on reported operation activities. Deposit amounts will scale in relation to emissions, requiring operators using lower tier locomotives with higher emissions to pay more per MWh. Every year the spending account rate will adjust from the previous year to account for changes in inflation and the locomotive fleet population. The balance of the spending accounts will be used by operators to purchase higher tier locomotives.

For the useful life limit concept, the regulation will establish a useful life limit of 23 years. Locomotives that are older than 23 years will be banned from operating in California.

For the idling limit concept, federal idling limits will be adopted in the draft In-Use Locomotive Regulation. Idling is currently restricted by the U.S. EPA to 30 minutes, with exemptions for essential functions. Adoption of the federal limit will allow CARB to enforce these idling limits.

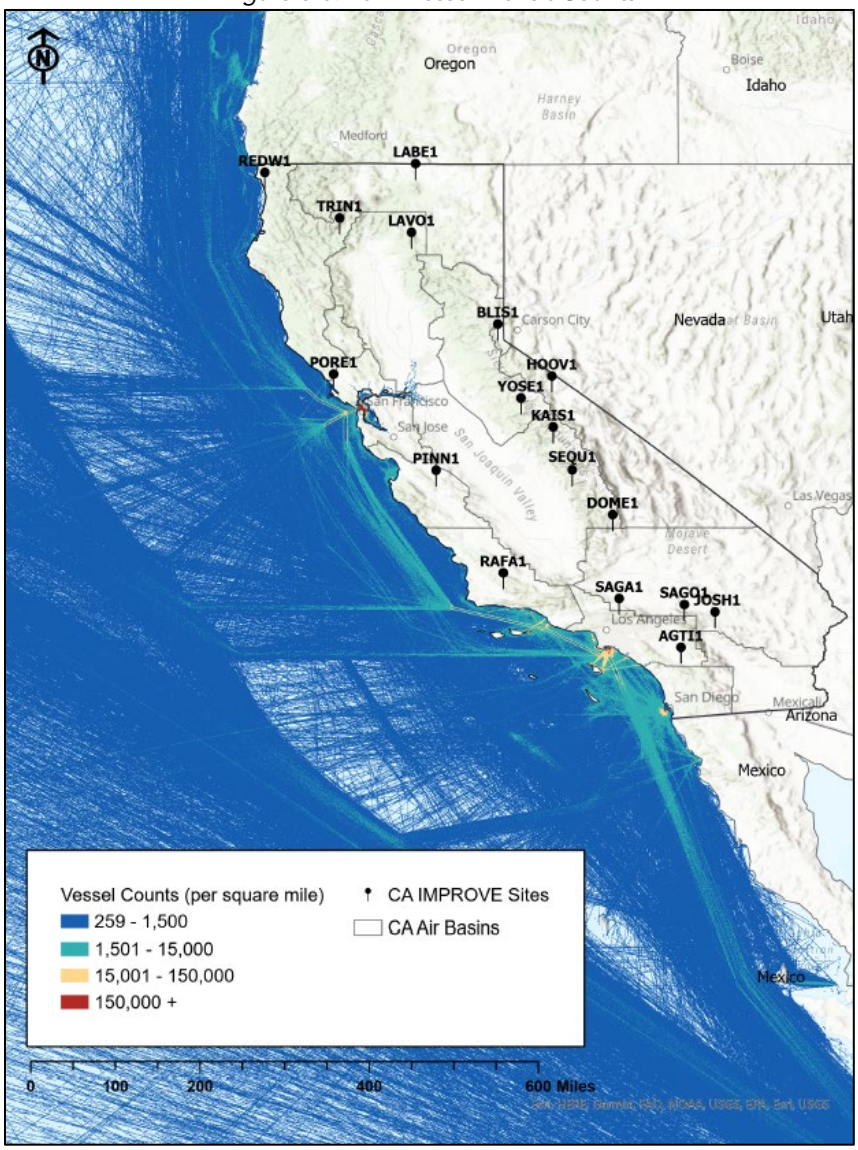
### Ocean-Going Vessels

Ocean-going vessels (OGV) are a subset of commercial marine vessels that transport goods around the globe. The global fleet of OGVs includes several different vessel types. Container vessels are designed to carry cargo stored in ocean shipping containers and are classified by the number of twenty-foot-equivalent units (TEU) that can be carried on board. A refrigerated cargo vessel, also known as a reefer, is designed to carry perishable goods that require a temperature-controlled environment during transit. Cruise vessels carry people on recreational trips. Roll-on roll-off vessels, also known as ro-ros, are designed to carry wheeled cargo. Goods like automobiles and mobile equipment are typically transported on ro-ros. Tankers are vessels designed to carry goods in a liquid or gas state. Goods like crude oil and fuel additives are typically transported in tanker vessels. Bulk and general cargo vessels typically carry low value cargo like dry grain and aggregate materials.

As shown in Figure 6-8, the waters off the coast of California are a major transport corridor for OGVs. California is home to 12 major seaports including the San Pedro Bay Ports, the busiest port complex in the country. Emissions from OGVs contribute to the air pollution burden in many areas of California and to the formation of visibility impairing PM species.

Emissions from OGVs occur under several operating conditions including during transit, at anchor, while maneuvering, and at berth. Emissions may come from operation of the main engine, auxiliary engines, and boilers. Strategies to control emissions from OGVs can target fuels, engine technologies, and operating practices.

*Figure 6-8: 2017 Vessel Transit Counts*




*Vessel Data Source: NOAA Bureau of Ocean Management (https://marinecadastre.gov/)*

## Fuels

Global emissions limits and fuel standards are generally established by the International Maritime Organization (IMO), a specialized agency of the United Nations. Annex VI of the IMO's Marine Pollution (MARPOL) Convention includes limits for NOx emissions from OGVs and limits for the sulfur content in fuels used by OGVs. The Annex VI emission limits and fuel standards apply globally and include more stringent emission limits and fuel standards for areas designated as Emission Control Areas (ECA).

Annex VI was amended in 2010 to include the North American ECA, which includes areas within 200 nm of the coast of California. The more stringent ECA emission limits and fuel

standards became enforceable for the North American ECA in August 2012. U.S. EPA and U.S. Coast Guard have enforcement authority for ensuring that vessels operating in U.S. waters comply with these requirements.

The international fuel standards and engine NOx emission limits are shown in Table 6-7. The recent strides in reducing sulfur content of fuels used in OGVs began in 2012 when global fuel sulfur limits were reduced from 4.5 percent to 3.5 percent. Global fuel sulfur limits were further reduced in 2020 to their current limit of 0.5 percent by weight. In the North American ECA, global fuel sulfur limits are more stringent. Fuel sulfur limits for ECAs were set to 1 percent in July 2010 and reduced to 0.5 percent in January 2015. Beginning in January 2020, the fuel sulfur limit for vessels operating within the North American ECA was lowered to 0.1 percent. The IMO 2020 regulation allows alternative emission control technologies such as scrubbers to be used when fuel oil exceeds the sulfur limit; however, California has a separate fuel regulation that applies to vessels operating in regulated California waters that does not allow for compliance via scrubbers.

*Table 6-7: International Fuel Standards and Emission Limits in MARPOL Convention Annex VI*

| | ECA Fuel Sulfur Standard | Global Fuel Sulfur Standard | ECA NOx Emission Limit | Global NOx Emission Limit |
|---|---|---|---|---|
| 2014 | 1% by weight | 3.5% by weight | Tier II | Tier II |
| 2015 | 0.1% by weight | 3.5% by weight | Tier II | Tier II |
| 2016 | 0.1% by weight | 3.5% by weight | Tier III | Tier II |
| 2020 | 0.1% by weight | 0.5% by weight | Tier III | Tier II |

Enforcement of California's OGV Fuel Regulation began in July 2009. The Regulation requires the use of distillate grade marine fuels with a maximum sulfur level of 0.1 percent while operating main engines, diesel-electric engines, auxiliary engines, and auxiliary boilers on OGVs within Regulated California Waters (waters within 24 nm of the coast). CARB has enforcement authority for this regulation.

The impacts of the implementation and enforcement of the sulfur fuel limits for OGVs is evident in the PM source apportionment data detailed in Chapter 4. The contribution of ammonium sulfate to visibility impairment in Class I areas has been markedly reduced following the transition to fuels with lower sulfur content. The most significant reductions have occurred at coastal Class I areas. Further reductions from fuel changes will likely require transitioning to different engine technologies.

### Engine Technologies

Data included in the 2020 Handbook of Statistics published by the United Nations Conference on Trade and Development[14] indicated that over 50,000 OGVs are registered globally. The largest portion of vessels are registered (flagged) in Panama and China. Most of the vessels transiting California's Regulated Waters and visiting California's ports are flagged or registered outside of the U.S.

Vessels operating in ECAs were required to meet international Tier III engine standards by 2016. This transition to Tier III engines was expected to result in an 80 percent NOx emission reduction for vessels transiting ECAs when compared to 2012 emissions.[15] Regulatory efforts aimed at further transitioning OGVs to cleaner engine technologies will require cooperative federal and international action. Options for state and local agencies to regulate emissions engine technologies during transit are limited.

The Port of Los Angeles developed a voluntary Environmental Ship Index Program to reward vessel operators for reducing emissions from their fleet by going beyond compliance and bringing their newest and cleanest vessels to the Port. Operators receive incentive funds scaled to the number of points earned. Points are earned through reducing NOx, SOx, and carbon dioxide emissions, use of higher tier engines, and demonstrating feasibility of advanced emission reduction technologies. The lessons learned from this program serve as a model for other ports to encourage the transition to cleaner technologies and federal and international bodies to take action to accelerate the transition to low- and zero-emission engine technologies.

### Operating Practices

Operating practices including transit speed and at-berth power usage affect the quantity of emissions from vessels. Studies examining the potential impacts of implementing vessel speed reduction zones have reported benefits for air quality and marine life. In California, several local organizations have implemented voluntary vessel speed reduction zones for areas around the largest ports and marine sanctuaries.

In 2001, the San Pedro Bay Ports (includes the Ports of Los Angeles and Long Beach), U.S. EPA Region 9, CARB, South Coast AQMD, Pacific Merchant Shipping Association, and the Marine Exchange of Southern California established a four-year voluntary speed reduction program aimed at reducing emissions of NOx, diesel PM, and greenhouse gases from OGVs transiting coastal areas en route to the San Pedro Bay Ports. The San Pedro Bay Ports have continued this voluntary vessel speed reduction program, which provides financial incentives for operators in exchange for reducing vessel speeds in voluntary vessel speed

[14] https://stats.unctad.org/handbook/

[15] https://nepis.epa.gov/Exe/ZyPDF.cgi/P100AU0I.PDF?Dockey=P100AU0I.PDF

reduction zones established at 20 nm and 40 nm from Point Fermin, a headland in San Pedro. At the Port of Los Angeles, there were 2,840 unique vessel visits recorded in 2020. Data from the Port of Los Angeles' Vessel Speed Reduction Program indicates that more than 90 percent of these operators complied with the voluntary vessel speed reductions in the 20 nm and 40 nm zones. At the Port of Long Beach, 3,708 unique vessel legs were reported in 2020 and more than 90 percent complied with the voluntary vessel speed reductions in the 20 nm and 40 nm zones.

The Protecting Blue Whales and Blue Skies program is organized by the National Oceanic and Atmospheric Administration (NOAA) with cooperation from the Bay Area AQMD, Santa Barbara Air Pollution Control District (APCD), Ventura County APCD, and several other local partners. The program offers incentives for shipping companies that participate in a voluntary speed reduction program aimed at reducing emissions, particularly NOx emissions, and fatal ship strikes on whales. The program runs from May through November, which coincides with the peak ozone season for California and the peak in whale activity in the shipping channels in the San Francisco Bay Area and Southern California. The voluntary program is in its seventh year and participation has increased during each year of the program, as has the size of the voluntary speed reduction zones. Following the 2020 program, program staff estimated that NOx emissions from participating ships were reduced by 25 percent, which amounts to 748 tons of NOx.

Vessel speed reduction zones serve multiple purposes including to reduce pollutant emissions and protect wildlife. Integrated planning efforts by local stakeholders have led to robust participation in voluntary vessel speed reduction programs. The number of operators and the rate of compliance has steadily increased over the last decade. NOAA's Automatic Identification System allows for reliable data collection and compliance tracking. Program indicators demonstrate that these voluntary, locally led efforts will continue to be an effective means to meet multiple planning objectives.

Further emission reductions may be possible with the integration of cleaner engine technologies. Several demonstration projects are planned for low and zero-emission engine technologies around the globe. Programs like the Port of Los Angeles' Emission Ship Index program are incentivizing the piloting or early adoption of cleaner engine technologies; however, a larger scale transition to cleaner engine technologies will require collaborative federal and international action.

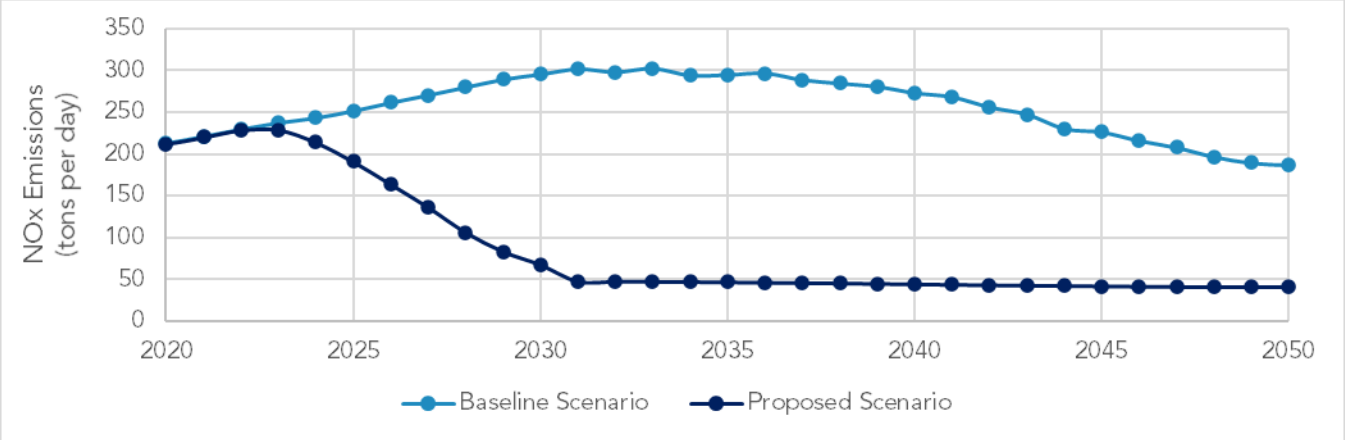
The implementation of at-berth regulations has had a demonstrated impact on reducing pollutant emissions from ocean-going vessels. CARB adopted the Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in California Ports regulation in 2007. The regulation applies to container vessels, reefer vessels, and cruise vessels while at-berth in six California ports: Hueneme, Los Angeles, Long Beach, Oakland, San Diego, and San Francisco.

The regulation requires these regulated vessels to reduce on-board power generation when at-berth by connecting to shore power systems or utilize an equivalent emissions reduction option when visiting ports covered by the regulation. The goal of this regulation is to reduce emissions of NOx and diesel PM from OGVs when they are docked at California ports. Implementation of this regulation began in 2010 with full implementation in 2020. With full implementation, this regulation has achieved an 80 percent reduction in emissions from regulated vessels.

Activities in and around ports continue to contribute to emissions that affect public health, NAAQS attainment, and visibility. CARB recognized the potential to expand the scope and increase the emission benefits of existing regulations, which could expand public health and environmental benefits of the at-berth regulation. Part of the expanded scope that would result from amending the regulation includes the addition of ro-ros and tanker vessels as regulated vessel types, which is expected to affect an additional 2,300 vessel visits, amounting to an increase of more than 50 percent from the 2007 at-berth regulation. Further, an expanded scope would include ports and terminals that have more than 20 annual visits from any of the covered vessel types. This threshold will result in the likely addition of several terminals and ports in Northern California including the Carquinez complex, Richmond complex, Rodeo complex, a Benicia terminal, and the Port of Stockton.

Implementation of the proposed amendments to the at-berth regulation will provide emission reductions to support air quality, climate, and public health goals. In the absence of federal or State action, emissions from ocean-going vessels are projected to increase as the increase in vessel activity will outweigh the emission reductions achieved with the current at-berth regulation. Implementation of the proposed amendments and the expanded scope of these requirements will have a marked impact on reducing NOx emissions from OGVs. As shown in Figure 6-9, implementation of the proposed amendments would achieve a 62 percent reduction in NOx emissions in 2028 relative the current regulatory scenario.

*Figure 6-9: Comparison of NOx Emissions from Ocean-Going Vessels for Two Scenarios*




*Data source: https://arb.ca.gov/emfac/meta/off-road*

### Off-Road Mobile Sources: Additional Reasonable Controls Determination

After consideration of the four reasonable progress factors, which are detailed in Appendix H, staff determined that the measures proposed in the four off-road mobile source control regulations discussed in this section are not reasonable for the purposes of regional haze planning. However, California intends to pursue adoption of these measures to meet health-based air quality and climate targets. Emission reductions associated with future adoption and implementation of these measures will provide co-benefits to the regional haze program and contribute to reduction of haze pollutants in Class I areas impacted by emissions from California.

## Stationary Source Emissions

### Collins Pine Company

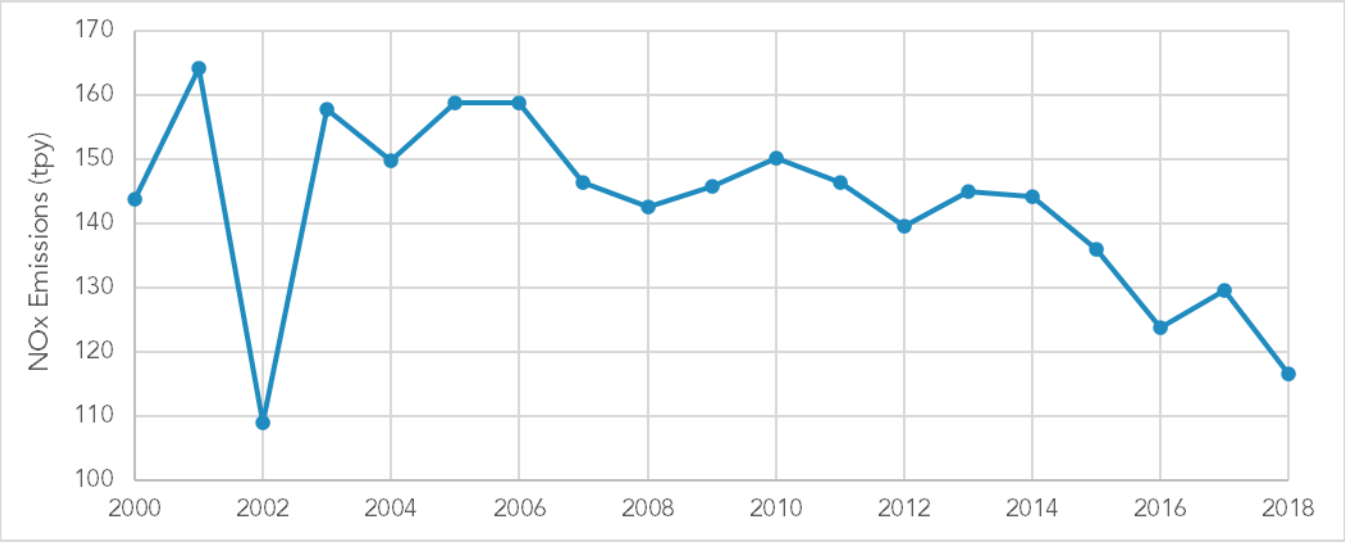
The Collins Pine Company operates a wood products and cogeneration facility in Plumas County. Lumber drying kilns are indirectly heated with steam produced by a Keeler cogeneration boiler. Steam energy is also used to generate electricity to power the sawmill operations. The facility does not currently provide power to the electrical grid.

Clean lumber, clean hogged fuel, wood fuel, and yard waste are combusted in the Keeler cogeneration boiler to produce steam. The boiler typically operates year-round and has a heat input capacity of 242 million British thermal units (MMBtu) per hour. The boiler is the source of all NOx emissions at the facility. A continuous emissions monitoring system is installed to measure boiler stack emissions of carbon monoxide (CO), carbon dioxide, and NOx. A dry electrostatic precipitator is used to control PM emissions from the boiler. Per local air district staff, the boiler does not currently have any post-combustion NOx emission controls in place.

The facility underwent Prevention of Significant Deterioration (PSD) review for NOx, CO, and PM when the new powerhouse was installed. The PSD permit was amended by U.S. EPA Region 9 in 2017. The facility is subject to Title V permitting. The Northern Sierra AQMD administers the Title V permit program for Plumas County.

Collins Pine is located 12 km from the Caribou Wilderness Area. As shown in Figure 6-10, between 2000 and 2018, district staff reported average annual NOx emissions from the facility have ranged from 108 to 164 tons per year. Due to the proximity of the facility to the Caribou Wilderness Area and the status of NOx controls on the cogeneration boiler, CARB requested that the facility provide information on each of the four reasonable progress factors to support an evaluation of available reasonable controls for NOx emissions.

*Figure 6-10: Annual NOx Emissions from Collins Pine Company reported by Northern Sierra AQMD*




Collins Pine Company retained an environmental consulting firm, Maul Foster & Alongi, Inc. (MFA), to assist with the preparation of information to support the evaluation of available reasonable controls. The full text of the analysis prepared by MFA is provided in Appendix H.

Information on five NOx control options was provided:

- Good combustion practices
- Flue Gas Recirculation
- Selective non-catalytic reduction
- Selective catalytic reduction
- Low NOx burners

An overview of these control strategies follows.

### Good Combustion Practices

Good combustion practices are measures taken by the facility operator ensure that the boiler is well-maintained and operated in a manner consistent with manufacturer recommendations. Specific measures used in good combustion practices include following manufacturer recommendations for operation, periodic inspection, periodic maintenance, and periodic boiler tuning to ensure excess air is maintained at optimum levels. Good combustion practices are feasible and currently employed by the facility.

Good combustion practices were the basis of the NOx BACT determination in the PSD permit. The NOx emission rate limit identified in New Source Performance Standards (NSPS) Part 60 subpart Db Section 60.44b(d), which applies to Industrial-Commercial-Industrial Steam Generating Units, is 0.3 lb/MMBtu. The boiler underwent performance testing most

recently in 2020. The NOx emission rate during performance testing was 0.189 lb/MMBtu, which is below the facility's Title V permit limit of 0.22 lb/MMBtu (55 lb/hr).

### Flue Gas Recirculation

Flue gas recirculation (FGR) is a control strategy that limits the formation of thermal NOx, i.e. NOx formed when nitrogen and oxygen in the air react at high temperatures. In FGR systems, exhaust gas is recirculated back through the combustion chamber to reduce peak flame temperature and oxygen in the combustion zone, thereby reducing the amount of thermal NOx formed during combustion. The application of FGR systems involves installation of ductwork and combustion air fans to redirect exhaust air.

Due to space constraints, modifying the existing boiler ducting and circulation of the exhaust stream would be a significant challenge at Collins Pine. Further, it is expected that minimal thermal NOx is formed by combustion in the Collins Pine boiler due to the high moisture content of the wood fuels. The high moisture content, which ranges from 45 to 55 percent, results in peak flame temperatures below 1,750 ºF. Most NOx is expected to be fuel NOx, that is NOx formed by the oxidation of nitrogen in the wood fuel. Retrofitting the existing boiler with an FGR system would be technically challenging and unlikely to yield emission benefits due to the relatively low flame temperature in the combustion chamber. Due to these reasons, FGR is not considered a feasible control option for Collins Pine.

### Selective Non-Catalytic Reduction

Selective non-catalytic reduction (SNCR) systems are post-combustion controls that rely on the reaction between ammonia and nitric oxide to reduce NOx emissions. Operation of SNCR systems involve the injection of ammonia or urea into the combustion chamber. If temperatures in the combustion chamber are in the optimum range, between 1,550 to 1,950 ºF, and adequate residence time is available, then ammonia and nitric oxide will react to produce molecular nitrogen and water and emissions of NOx are reduced. SNCR systems have the potential to yield increases in ammonia emissions due to incomplete reaction in the combustion chamber due to inadequate combustion temperatures or residence times. Increased safety concerns associated with handling and storage of reagent chemicals also arise with installation of SNCR systems. Industry has found that retrofit systems may achieve lower NOx control efficiencies when compared to systems engineered for construction of new boilers.

SNCR may be a feasible control option if the temperatures in the optimum range are present in the exhaust stream in locations that allow for adequate residence time for the reaction to occur and can be cost-effectively retrofit with injection ports.

### Selective Catalytic Reduction

SCR systems employ ammonia in the presence of a catalyst to reduce NOx emissions. The optimal temperature range for SCR systems is 650 to 850 ºF. Contaminants in the exhaust stream can bind, plug, and foul the catalyst, which can reduce the control efficiencies of SCR systems. Alkali metals, such as sodium and potassium which are common in wood, can poison SCR catalysts.

SCR is not a feasible control option for Collins Pine. The wood-fueled boiler would require installation of a high temperature PM control system upstream of the SCR system. Exhaust gas exiting the PM control system is 417ºF in the current configuration, well-below the optimum range for SCR systems. The presence of alkali metals and the potential for other contaminants to foul the catalyst are also a concern. Retrofitting the current boiler with an SCR system in a cost-effective manner is not a technically feasible option for controlling NOx at Collins Pine.

### Low NOx Burners

Low NOx burners are used to moderate fuel and air mixing rates in the combustion zone. Oxygen available for thermal NOx formation is reduced, which results in control of thermal NOx emissions. Retrofit of the existing boiler at Collins Pine with a low NOx burner is not technically feasible in a cost-effective manner due to furnace geometry, air flow controls, and burner zone stoichiometry.

## Collins Pine: Additional Reasonable Controls Determination

Five NOx control options were initially brought forward for consideration. Good combustion practices are currently utilized at the facility. FGR, SCR, and low NOx burner systems are not technically feasible to install on the current boiler system for control of NOx emissions from the Collins Pine boiler. An SNCR system was identified as a potentially feasible control option. A detailed discussion of each of the four reasonable progress factors for this option is provided in Appendix H.

After consideration of the four reasonable progress factors and boiler specific factors, staff determined that retrofit of the existing boiler system with an SNCR system was not reasonable. The existing boiler configuration does not provide for adequate residence time without injection of excess reagent, which is likely to lead to high levels of ammonia slip. However, the use of good combustion practices is necessary to ensure control of NOx emissions from the boiler at Collins Pine. Good combustion practices are already in place at the facility and are enforceable as they are a condition in their Title V operating permit.

## Identification of Reasonable Controls

Based on the consideration of the four reasonable progress factors, four control options were identified as necessary to make reasonable progress towards reducing visibility impairment and preventing visibility degradation in Class I areas impacted by emissions from California. Emission reductions associated with the implementation of measures in the Heavy-Duty Omnibus Regulation, the Heavy-Duty I/M Program Regulation, the Advanced Clean Trucks Regulation, and the Advanced Clean Cars II Regulation will promote the reduction in haze pollutants and attainment of reasonable progress goals in 2028. California's long-term strategy for regional haze, including an emission reduction commitment from implementation of these four measures, is detailed in the following chapter.

## 7. California's Long-Term Strategy

The Regional Haze Rule requires states to develop long-term strategies for addressing regional haze in Class I areas. The long-term strategy must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period. U.S. EPA has opined that elements of the 2017 Regional Haze Rule revisions are intended to provide states with flexibility to take state-specific facts and circumstances into account when developing long-term strategies.[16]

The unique and widespread air quality challenges in California are directly relevant to the development of California's long-term strategy for regional haze. With nearly 40 million people, California is the most populous state in the country. Many areas in California are designated as nonattainment for NAAQS and many of California's Class I areas are in or adjacent to designated nonattainment areas. Emissions from mobile sources drive NAAQS nonattainment as well the formation of haze pollutants. California's authority to control emissions from mobile sources has already led and will continue to lead to significant reductions in emissions that contribute to regional haze.

The next section will provide an overview of the integrated planning process used to develop strategies to address air quality challenges in California. The sections that follow the overview detail the elements of California's long-term strategy and provide an explanation for how the four statutory reasonable progress factors and five additional factors were considered in developing this strategy.

### Integrated Planning in California

CARB is responsible for protecting the public from the harmful effects of air pollution and developing programs to fight climate change. In these roles, CARB is involved in the development of plans to address numerous air quality challenges. These plans include SIPs to meet federal requirements,[17] the State Scoping Plan[18] to reduce emissions that contribute to climate change and provide a path towards California's goal of achieving carbon neutrality by 2045, and the Community Air Protection Blueprint[19] that outlines the process for identifying communities disproportionately impacted by air pollution and strategies to reduce emissions in these communities. Air quality planning efforts target a host of air pollutants including criteria pollutants, air toxics, and greenhouse gases.

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[16] See 82 FR 3090 (January 10, 2017)

[17] https://ww2.arb.ca.gov/our-work/programs/california-state-implementation-plans

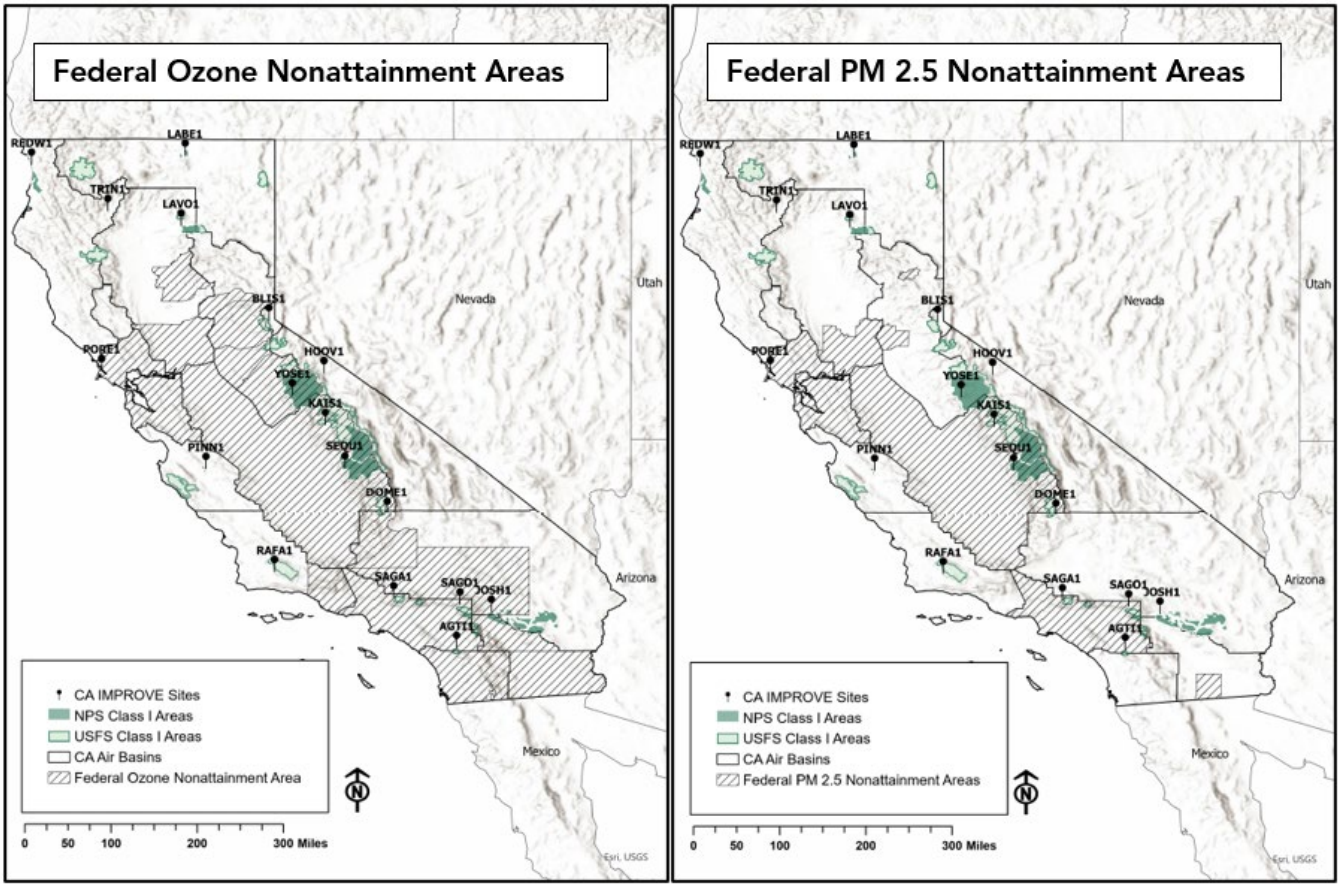
[18] https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan

[19] https://ww2.arb.ca.gov/capp-blueprint

Integrated planning efforts are essential to addressing the interplay between pollutants and sources and to identifying the most effective pathways forward to meet air quality, climate, and community health goals. Statewide, more than 28 million people live in areas that exceed the federal ozone and PM2.5 standards. Efforts to meet near-term health-based standards and reduce adverse health outcomes in disproportionately impacted communities are driving policies to transition to cleaner technologies.

Figure 7-1 depicts the large portions of California that are nonattainment for federal air quality standards. Emissions that drive nonattainment of federal air quality standards also drive the formation of regional haze and contribute to visibility impairment in Class I areas. Integrated planning efforts to reduce emissions and improve air quality have led to significant emission reductions throughout the State and improved visibility in Class I areas impacted by California emissions.

*Figure 7-1: California's Designated Federal Ozone and PM2.5 Nonattainment Areas, Class I Areas, and IMPROVE Sites*



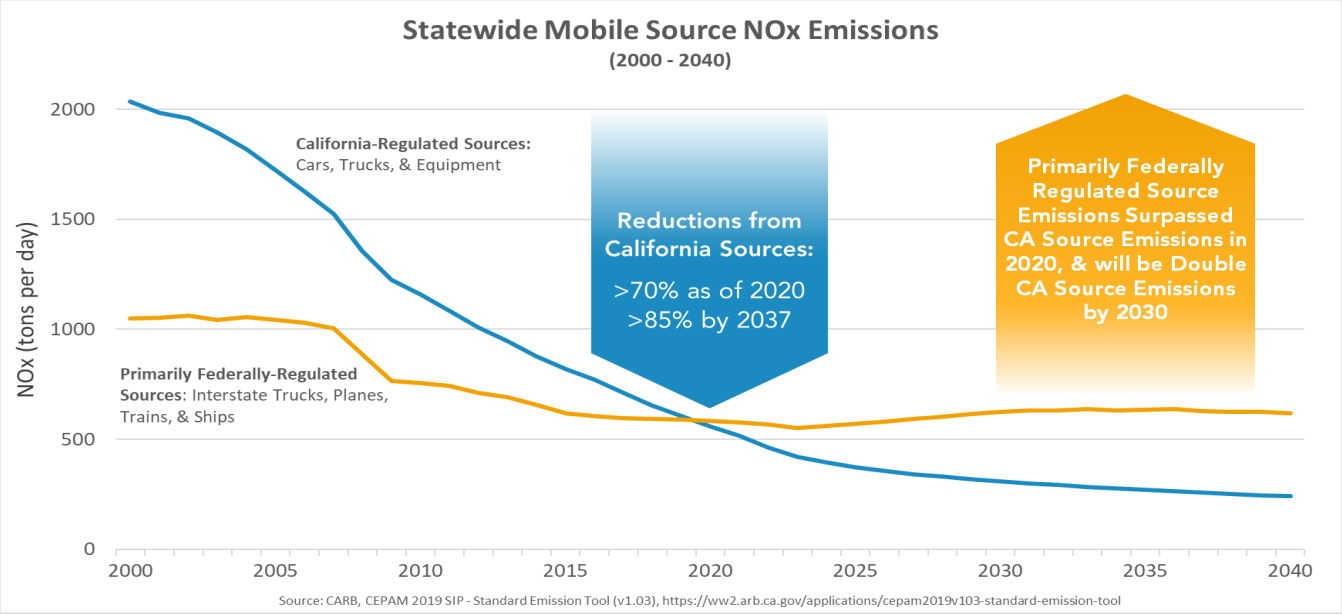

The myriad air quality challenges that California is grappling with are unique and widespread. Through the process laid out in the federal Clean Air Act, California has demonstrated the need to establish stricter-than-federal standards to address its compelling and extraordinary air quality challenges. Over the past 50 years, California has applied for and been granted

more than 100 waivers[20] to adopt regulations that establish emission standards and other emission-related requirements for new motor vehicles or new motor vehicle engines. Waivers approved for California regulations, which are developed based on extensive research and science, have been instrumental in driving innovation and the development of new technologies that have improved air quality. CARB is a recognized leader in pioneering effective approaches to address air quality challenges.

The emission standards on new vehicles that California adopts provide opportunities for emission reductions in other states, as the federal Clean Air Act also allows for other states to adopt California emission standards. As of November 2021, fifteen states have chosen to adopt California emissions standards for light-duty passenger cars and trucks. Collectively, these states and California account for nearly 40 percent of new light-duty vehicle sales in the U.S.[21]

As shown in Figure 7-2, statewide emissions from California-regulated and primarily federally-regulated mobile sources are currently comparable. Projections indicate that emissions from California-regulated mobile sources will continue to decrease, while emissions from primarily federally-regulated mobile sources will increase. By 2030, emissions from primarily federally-regulated mobile sources will be twice the amount of emissions from California-regulated sources (Figure 7-2). U.S. EPA action to reduce emissions from federally-regulated mobile sources would accelerate progress towards meeting multiple air quality goals in California.

*Figure 7-2: Statewide Mobile Source NOx Emissions, 2000 to 2040*




[20] https://www.epa.gov/state-and-local-transportation/vehicle-emissions-california-waivers-and-authorizations

[21] https://ww2.arb.ca.gov/sites/default/files/2021-12/177_states_110321_nada_sales.pdf

The emission sources that drive visibility impairment in Class I areas are the same emission sources driving nonattainment with federal air quality standards, contributing to climate change, and causing adverse health outcomes in California communities. Integrated planning efforts represent an efficient path to rely upon to establish a long-term strategy for the regional haze program.

CARB's regulatory rulemaking process involves extensive research, technology assessments, stakeholder input, feasibility studies, and pilot projects. Consideration of the four statutory factors identified in the Regional Haze Rule are an integral part of CARB's rulemaking process. The specific considerations for the cost of compliance, the time necessary for compliance, the energy and environmental impacts of compliance, and the remaining useful life of affected sources are included in the regulatory documents prepared by CARB staff for consideration of proposed measures during the formal rulemaking process.

Local air districts follow the public process for rule development in their specific jurisdictions, which generally includes an internal scoping process, development of technical assessments that include cost considerations, time considerations, and environmental impact considerations, engagement with stakeholders to gather public input, and presentation of proposed rules to local oversight boards at a public hearing. The availability of incentives, public funding, incremental costs, and socioeconomic impacts are also used to inform decisions. Rules that are necessary to maintain or attain compliance with NAAQS are forwarded to CARB for review and submittal to U.S. EPA.

## Elements of California's Long-Term Strategy

The Regional Haze Rule requires states to include the following elements in their long-term strategies for regional haze:

- the technical basis on which the state is relying to determine the emission reduction measures necessary to make reasonable progress,
- a description of criteria used to determine which sources or groups of sources to evaluate and how the four statutory factors were taken into consideration in selecting measures for inclusion in the long-term strategy,
- a determination of emission reduction measures necessary to make reasonable progress by considering the four statutory factors,
- enforceable emissions limitations, compliance schedules, and other measures as necessary to achieve reasonable progress goals, and
- documentation of consultations with states that have emissions reasonably anticipated to contribute to visibility impairment in the State's Class I areas.

A discussion of how each of these elements was included in the development of the long-term strategy for the second implementation period for regional haze planning follows.

## Technical Basis for Long-Term Strategy

The technical basis for California's long-term strategy includes consideration of monitoring data from the IMPROVE network, State and regional emissions inventories, regional photochemical modeling, and source apportionment analyses. Detailed descriptions of each of these components are provided in this Regional Haze Plan. The monitoring network and visibility conditions are described in Chapter 2. The emission inventory is described in Chapter 3. Results of photochemical modeling and source apportionment are discussed in Chapter 4.

## Source Selection Criteria and Consideration of Four Statutory Factors

California used available monitoring and modeling data to develop a consistent source selection process to focus planning efforts and strategy development on the pollutants and emission sources that matter most for visibility impairment during this planning period. Further, CARB assessed the success of past strategies in improving visibility across the State. Regional haze strategies, by rule, are focused on human-made sources. The technical analyses for this planning period indicate that ammonium nitrate is generally the dominant visibility impairing PM species in the U.S. light extinction budget at Class I areas in California. Past work has indicated that reducing NOx is the most effective path for reducing ammonium nitrate formation in California. California is focusing its long-term strategy for this Regional Haze Plan on ensuring that reasonable controls are in place for the major sectors that emit NOx. A description of the source selection process is detailed in Chapter 5 and a discussion of the four statutory reasonable progress factors for selected sources is in Appendix H.

## Measures Necessary to Make Reasonable Progress

Following consideration of the four statutory reasonable progress factors, California has identified four measures targeting on-road mobile source emissions that are necessary to ensure that reasonable progress is made in Class I areas affected by emissions from California. Following the procedure laid out in California's 2016 State SIP Strategy, the State is proposing to make an aggregate commitment to achieve emission reductions through development and adoption of these measures as part of the strategy to make reasonable progress towards the interim reasonable progress goals and the regional haze program targets identified in the federal Clean Air Act.

### State Control Measures for Mobile Sources

In March 2017, CARB adopted the *2016 State Strategy for the State Implementation Plan* (2016 State SIP Strategy) that included additional control measures to reduce emissions from mobile sources that are primarily under State and federal jurisdiction, including on-road and off-road mobile sources. The 2016 State SIP Strategy includes California's SIP commitment to take action on defined new measures according to a schedule and to achieve aggregate

emissions reductions in the South Coast and San Joaquin Valley. The 2016 State SIP Strategy also included a statement that if additional emissions reduction commitments are needed to meet federal standards or other Clean Air Act requirements, CARB will quantify specific reductions as part of individual planning efforts. In October 2018, CARB adopted an updated schedule for action on the measures in the *San Joaquin Valley Supplement to the 2016 State SIP Strategy for the State Implementation Plan* (Valley State SIP Strategy) that contained an updated and expanded version of the Heavy-Duty Vehicle Inspection and Maintenance Program measure, as well as a Valley-specific State commitment. As a part of the California Regional Haze SIP, CARB is including a State commitment of 40 tpd of NOx emissions reductions in 2028 from mobile sources that is needed to improve visibility across the State and meet the reasonable progress goals. These reductions are beyond the emissions reductions from current programs as included in the inventory provided with this plan.

The State's proposed commitment to achieve an aggregate emissions reduction of 40 tpd of NOx in 2028 represents the estimated Statewide emissions reductions from four rules that CARB committed to adopt in the 2016 State SIP Strategy, as supplemented by the Valley State SIP Strategy, that address emissions from on-road light-duty vehicles and heavy-duty diesel trucks – one of the largest sources of NOx emissions in California. While other measures in the 2016 State SIP Strategy will yield benefits across the State, these emissions reductions represent the amount that is needed to reduce haze and enhance visibility, in addition to the reductions from current programs. The table below shows the four CARB measures providing the needed emissions reductions as well as the schedule by which CARB anticipates taking action on each measure.

*Table 7-1: CARB 2016 State SIP Strategy Measures and Schedule of Anticipated Action*

| Regulation | Action | Implementation Begins |
|---|---|---|
| Heavy-Duty Omnibus Regulation | 2020 | 2024 |
| Advanced Clean Trucks (Last Mile Delivery Measure) | 2020 | 2024 |
| Heavy-Duty Vehicle Inspection and Maintenance Program | 2021 | 2023 |
| Advanced Clean Cars II | 2022 | 2026 |

CARB adopted the Heavy-Duty Omnibus and Advanced Clean Trucks regulations in 2020. In addition, staff has been hard at work developing the remaining measures and has held numerous workshops since adoption of the 2016 State SIP Strategy. Beginning in 2019, CARB staff initiated public workshops on the development of a Heavy-Duty Inspection and Maintenance Program, which was recently adopted by the Board in December 2021. Finally, the Advanced Clean Cars II measure has also been underdoing the regulatory public process for over two years and is planned for consideration by the Board in 2022. This program will

increase the number of new ZEVs and plug-in hybrid electric vehicles sold in California and maximize emissions reductions by setting standards for post-2025 model year vehicles.

The following table represents the State's commitment to achieve aggregate emissions reductions of 40 tpd of NOx emissions Statewide based upon implementation of the four measures just described. While the table shows the anticipated emissions reductions associated with each measure, the measures as proposed by CARB staff or adopted by the Board may provide more or less reductions than the amount shown. The State's commitment is to achieve an aggregate emissions reduction of 40 tpd of NOx emissions in 2028 to demonstrate reductions in haze and enhance visibility at the Class I areas throughout the State.

*Table 7-2: Expected Statewide Emissions Reductions From 2016 State SIP Strategy Measures*

| Regulation | NOx Reductions 2028 (tpd) |
|---|---|
| Heavy-Duty Omnibus Regulation | 9 |
| Advanced Clean Trucks (Last Mile Delivery Measure) | 2 |
| Heavy Duty Vehicle Inspection and Maintenance Program | 28 |
| Advanced Clean Cars II | 1 |
| **Total Aggregate Commitment** | **40** |

## Emissions Limitations and Compliance Schedules Necessary to Make Reasonable Progress

California is proposing to commit to achieving an aggregate emission reduction of 40 tpd of NOx by 2028. This aggregate emission reduction will be achieved through the implementation of four regulatory measures: Heavy-Duty Omnibus, Advanced Clean Trucks, Heavy-Duty Inspection & Maintenance Program, and Advance Clean Cars II. The obligation to take these regulatory actions and achieve this aggregate emission reduction becomes enforceable upon approval of this Regional Haze Plan by U.S. EPA.

## Consultation

The Regional Haze Rule requires consultation with neighboring states and federal land managers during the development of state implementation plans for regional haze. The details of California's consultation efforts are provided in Chapter 9. Neighboring states were supportive of California's long-term strategy and the focus on mobile source emissions reductions for this planning period. None of the neighboring states involved in the interstate consultation process identified, requested, or agreed to any specific measures for this planning period.

## Consideration of the Five Additional Factors

In developing the long-term strategy, states are required to also consider the following five additional factors:

- Emission reductions due to ongoing air pollution control programs,
- Measures to mitigate the impacts of construction activities,
- Source retirement and replacement schedules,
- Basic smoke management practices, and
- The anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the period addressed by the long-term strategy.

A detailed discussion of the consideration of these five additional factors follows.

### Emission Reductions Due to Ongoing Air Pollution Control Programs

Ongoing air pollution control programs have resulted in significant emissions reductions between the baseline and current periods and improved visibility metrics at all California Class I areas. Implementation of the suite of adopted measures identified in the 2016 State SIP Strategy are projected to reduce statewide NOx emissions by 75 percent between 2017 and 2031. The adoption and implementation timelines for the key measures in the 2016 State SIP Strategy are shown in Table 7-3.

*Table 7-3: Status of Key Measures from the 2016 State SIP Strategy*

| Final Regulation Title | Adoption Timeline | Implementation Begins |
|---|---|---|
| South Coast On-Road Heavy-Duty Incentive Measure | Adopted March 2018 | 2019 |
| Amendments to HDVIP and PSIP | Adopted May 2018 | 2019 |
| Innovative Clean Transit Regulation | Adopted December 2018 | 2023 |
| Zero Emission Airport Shuttle Bus Regulation | Adopted June 2019 | 2027 |
| Advanced Clean Truck Regulation | Adopted June 2020 | 2024 |
| Heavy-Duty Omnibus Regulation | Adopted August 2020 | 2024 |
| Control Measure for Ocean-Going Vessels at Berth | Adopted August 2020 | 2024 |
| Small Off-Road Engines | Adopted in December 2021 | 2024 |
| Heavy-Duty Inspection & Maintenance Program | Adopted in December 2021 | 2023 |
| Transport Refrigeration Units | Adoption Expected in 2022 | 2024 |
| Advanced Clean Cars II | Adoption Expected in 2022 | 2026 |
| Zero-Emission Forklift Regulation | Adoption Expected in 2022 | 2025 |

Additional reductions are expected from measures identified in the 2022 State SIP Strategy.[22] The focus of the 2022 State SIP Strategy is continued acceleration of the transition to zero-emission technologies where feasible to maximize criteria pollutant reductions across multiple sectors. This accelerated transition to zero-emission technologies is supported by actions taken by the Governor. In 2020, Governor Newsom signed Executive Order N-79-20 which directed state agencies to develop a plan to transition 100 percent of new passenger car and truck sales to zero-emission vehicles by 2035, transition all short-haul/drayage trucks to zero-emission vehicles by 2035, transition all off-road equipment to zero-emission technologies where feasible by 2035, and transition buses and heavy-duty long-haul trucks to zero-emission vehicles where feasible by 2045. Reducing emissions from mobile sources is a critical element in achieving air quality goals in California.

In addition to control of mobile sources, agencies in California also look for emission reduction opportunities from stationary sources. Regulatory authority for control of criteria pollutant emissions from stationary sources in California is delegated to 35 local air districts. Due to the extent of air quality challenges in California, stationary source control programs in California are among the most stringent in the country and emissions are generally much lower than equivalent sources located elsewhere. In addition to federal requirements, California has State requirements for new source review. Stationary permitting programs adopted by local air districts comply with State and federal laws.

New stationary sources and existing stationary sources that undergo significant modification are subject to certain emission control requirements. Construction or modification of stationary sources may trigger New Source Review (NSR) program requirements. The NSR program ensures that when major sources are constructed or modified air quality standards are maintained, significant deterioration of air quality does not occur, and progress towards meeting standards is not slowed in areas that do not meet air quality standards. The NSR program helps to ensure sources are as clean as possible, any new emissions are offset, and provides for consultation with federal land managers of Class I areas. The level of control required to limit criteria pollutant emissions from new or modified sources varies by the quantity and type of the source's emissions, an area's attainment designation, and criteria defined in district NSR program policies.

The three levels of control that may apply to new and modified sources in California are federal BACT, federal lowest achievable emissions rate (LAER), and California BACT. Federal BACT is required on major new or modified sources in areas that meet national ambient air quality standards. Federal LAER is required on major new or modified sources in areas that are designated as nonattainment for federal air quality standards. California BACT allows air

[22] https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy

districts to require more stringent controls that go beyond LAER on sources if controls are technologically feasible and cost effective.

The California Clean Air Act of 1988 established State ambient air quality standards. California ambient air quality standards are generally more stringent than federal air quality standards. Attainment designations for State ambient air quality standards are made annually. The most recent areas designated as nonattainment for the State ozone standard are shown in Figure 7-3.

For areas designated as nonattainment for the State ambient air quality standards, the California Clean Air Act requires local air districts to develop plans to achieve State standards as expeditiously as possible and include regulations to reduce emissions from existing sources. Existing stationary sources located in areas that do not meet State ambient air quality standards are required to meet BARCT. In addition to the BARCT requirements, areas designated as nonattainment for State ambient air quality standards must adopt all feasible controls for sources contributing to nonattainment.

Stationary source emissions are also an element of CARB's Community Air Protection Program (CAPP), which was developed following the 2017 adoption of California AB 617. CAPP's focus is to reduce exposure in communities disproportionately impacted by pollution. One of the measures included in AB 617 is an expedited BARCT requirement. The expedited BARCT requirement applies to stationary sources located in 18 of California's air districts. These air districts were required to adopt an expedited schedule by January 1, 2019 for the implementation of BARCT by December 31, 2023. In developing the expedited schedules for implementation of BARCT, affected air districts were required to prioritize the retrofit of emissions sources that have not been addressed for the longest period.

*Figure 7-3: Areas Designated as Nonattainment for State Ozone Standards*

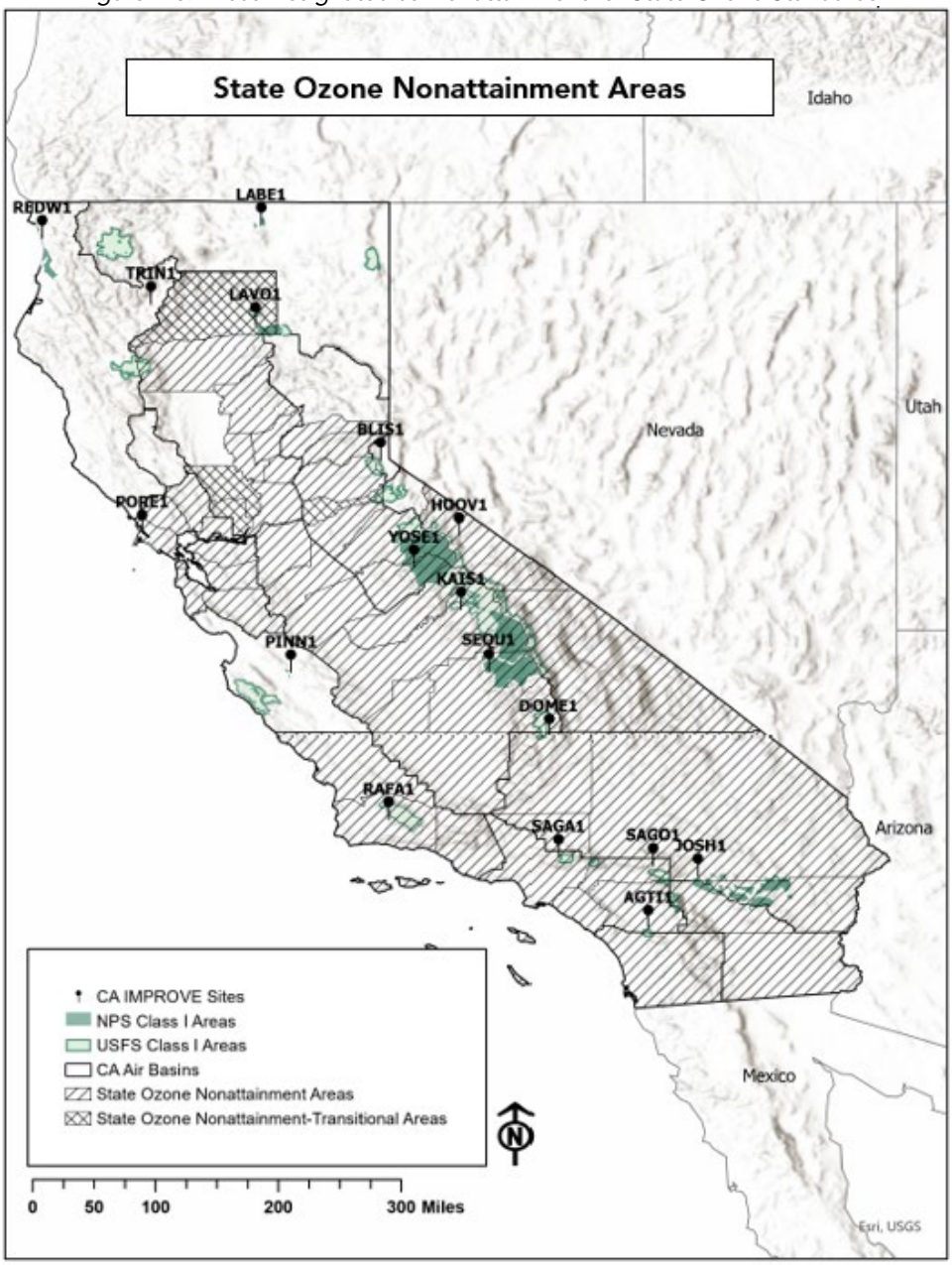
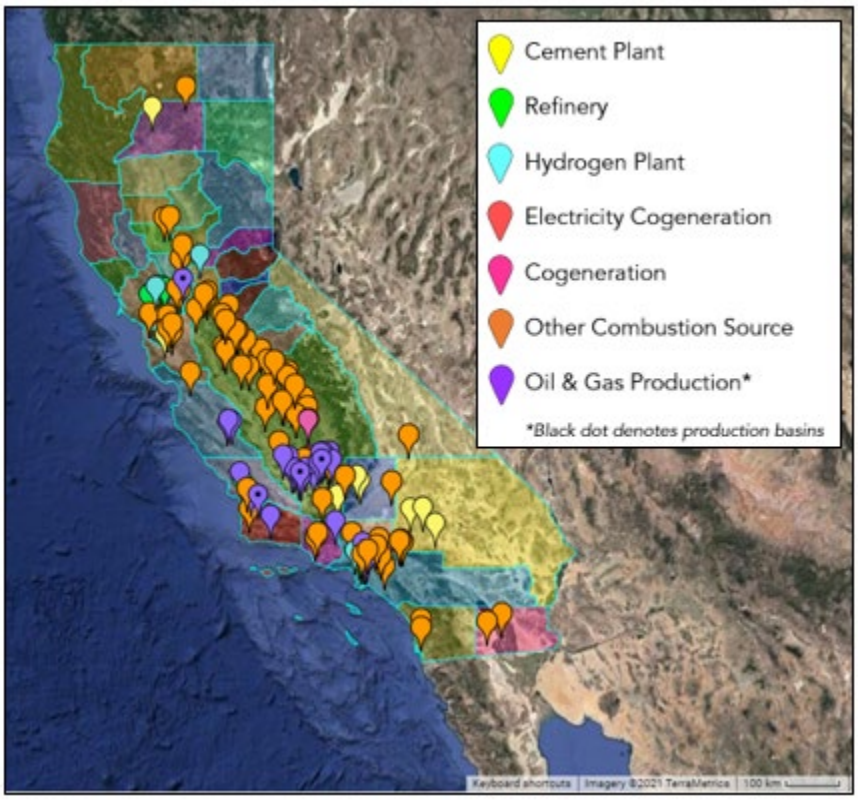



Figure 7-4 shows the location of the 152 stationary sources subject to the AB 617 expedited BARCT requirement for the 2017 emission year and the air district boundaries from CARB's web-based Pollution Mapping Tool.[23] The stationary sources subject to this requirement include cement production facilities, oil and gas facilities, refineries, and other types of combustion sources.

[23] https://ww3.arb.ca.gov/ei/tools/pollution_map/

*Figure 7-4: Stationary Sources Subject to AB 617 Expedited BARCT Requirements and Local Air District Boundaries*




Emission controls that will be in place at facilities subject to the AB 617 expedited BARCT requirement are expected to be equivalent or greater than BART. Control of stationary sources may be revisited if the technical analyses conducted for future regional haze planning periods indicates that further consideration is warranted.

Local air districts have developed innovative programs to help address air quality issues in their jurisdictions. South Coast AQMD adopted the Regional Clean Air Incentives Market (RECLAIM) program in 1993 to provide market incentives for companies to use the cleanest possible technologies for NOx and SOx emission control at facilities emitting four tons per year or more of these pollutants. Since the original adoption, the program has been revised multiple times to achieve greater emission reductions to meet targets identified in the district's air quality management plans. While South Coast AQMD is in the process of sunsetting the RECLAIM program, it garnered significant emissions reductions at the onset faster than would have been possible under a strict command and control approach.

The San Joaquin Valley APCD adopted Rule 9510 in 2005 in response to significant growth and ongoing air pollution challenges. Rule 9510 established an Indirect Source Review Program intended to reduce NOx and PM emissions from new residential, commercial, and industrial development projects. Under the rule, new projects are required to reduce construction NOx by 20 percent, construction PM by 45 percent, operation NOx by

33.3 percent, and operation PM by 50 percent relative to unmitigated project baseline emissions. The San Joaquin Valley APCD has developed a list of air friendly project design elements to support mitigation strategies for developers. Rule 9510 was last amended in 2017 to ensure implementation of the rule is consistent throughout the district's jurisdiction.

More recently, the South Coast AQMD adopted Rule 2305, an indirect source rule to target the reduction of local and regional emissions of NOx and PM from warehouse operations. This rule was developed in response to the significant growth in warehouse operations. The South Coast AQMD estimates the portion of NOx emissions attributable to sources associated with warehouse operations is nearly equivalent to those from all other stationary sources in the South Coast Air Basin combined.

California's unique and widespread air quality challenges drive stringent air quality control programs. State and local air agencies continue to lead efforts to advance emission control technologies and pioneer strategies to improve air quality. These efforts have led to emission reductions across the State and improved visibility in Class I areas impacted by emissions from California sources. California's commitment to continue efforts to improve air quality provide the foundation for the State's long-term strategy for regional haze.

### Measures to mitigate impacts of construction activities

Construction activities can contribute to the local air pollution burden and exacerbate regional air quality challenges. To mitigate impacts of construction activities, CARB adopted the In-Use Off-Road Diesel Fueled Fleets Regulation in 2007, the country's first regulation aimed at reducing emissions from off-road construction equipment. The regulation is intended to reduce PM and NOx emissions from off-road heavy-duty diesel vehicles including those used in construction. The regulation requires fleet owners to gradually replace the oldest and dirtiest equipment with newer, cleaner models and restricts fleet owners from adding older, dirtier equipment. Implementation of the regulation began in 2010.

Amendments to the In-Use Off-Road Diesel Fueled Fleets Regulation were adopted in 2011. The amended regulation allows for continued use of older equipment if fleet average emission requirements are met. To accelerate fleet turnover, CARB is developing a proposal to further amend the regulation to require full fleet turnover of older equipment (Tier 0, 1, and 2 engines) by 2033. Implementation of the proposed amendments would begin in 2023 and by 2031 would reduce NOx emissions further compared to the emissions projected under the current regulation. These amendments will complement efforts directed at meeting the goals laid out in the Governor's Executive Order N-79-20, which includes a directive to transition all off-road equipment to zero-emissions technologies by 2035 where feasible.

Fugitive dust emissions from construction activities are areawide sources regulated by local air districts. Most air districts in California have adopted rules to specifically limit fugitive dust

emissions from construction activities. Innovative strategies like those exemplified in the San Joaquin Valley APCD's Indirect Source Review Program are aimed at substantially mitigating emissions from construction activities.

Further, consideration of construction impacts is required in the California Environment Quality Act (CEQA) analysis for proposed projects in California. The purpose of the CEQA analysis is to identify and disclose environmental impacts of a proposed project to stakeholders, including the lead public agency tasked with making approval decisions for the project. CEQA analysis for projects is also required to include potential mitigation measures for environmental impacts identified and project alternatives. Local air districts are responsible for ensuring conformity with SIPs for federal air quality standards. To support this effort, many local air districts have developed CEQA guidance with recommended thresholds and mitigation options for construction activities.

### Source Retirement and Replacement

The rapid improvement in emission control technologies for a range of emission sources has led to significant reductions in air pollutant emissions. The pace and magnitude of emission reductions can be stalled if source retirement and replacement is slow. California has implemented several programs to accelerate source retirement and the transition to less polluting sources.

Mobile sources are the dominant source of emissions driving air quality challenges in California. California has several source retirement strategies focused on mobile sources. State and regional Voluntary Accelerated Vehicle Retirement Programs have been developed to accelerate the turnover of older on-road vehicles. The Statewide program is administered by the Bureau of Automotive Repair (BAR) through its Consumer Assistance Program and provides payment of up to $1,500 for the voluntary scrappage of an eligible operational vehicle. Regional programs are administered by local air districts. Like BAR's Consumer Assistance Program, regional programs offer monetary incentives to scrap older vehicles. CARB's Clean Cars 4 All Program provides incentives of up to $9,500 to lower-income California drivers to scrap an older, high-polluting car and replace it with a cleaner, more efficient vehicle equipped with zero-emission or near zero-emission technologies. The average vehicle retired through the program is 22 years old. More than 10,000 residents have received incentive payments through this program.

To further accelerate the replacement of on-road sources, several statewide programs offer incentives for consumers to purchase vehicles equipped with low- and zero-emission technologies. CARB's Clean Vehicle Rebate Project provides consumer rebates of up to $7,000 to purchase or lease an eligible zero-emission or plug-in hybrid electric vehicle. Since 2010, rebates for more than 400,000 vehicles have been provided through the project. The

California Clean Fuel Reward program offers up to $1,500 off the vehicle cost at the point of sale for California residents purchasing eligible battery electric or plug-in hybrid vehicles.

The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project provides point-of-sale price reductions for purchases of the cleanest medium- and heavy-duty trucks. Base vehicle price reductions range from $20,000 to $240,000 depending on the vehicle and the consumer's eligibility for voucher modifiers. Voucher modifiers include incentive increases for Class 8 vehicles equipped with fuel cell technologies, vehicles domiciled in disadvantaged communities, and school buses for public school districts. CARB launched the program in 2009 and pioneered the model to demonstrate the functionality, flexibility, and effectiveness of first-come, first-served incentives to accelerate the commercialization and adoption of advanced technologies. The program has provided incentives for the purchase of more than 7,500 vehicles which have accumulated more than 188 million cleaner-than-diesel miles traveled on California roadways.

The Carl Moyer Memorial Air Quality Standards Attainment Program (Moyer Program) is a grant program that provides funding for the incremental cost of cleaner-than-required engines, equipment, and other emission sources. The Moyer Program began in 1998 and has been instrumental in promoting cost-effective emission reductions to complement implementation of regulations. Funding is provided through consumer surcharges for new tires, smog abatement fees for new vehicle purchases, and consumer surcharges for vehicle registration. The Moyer Program guidelines were updated in 2017 to increase the cost-effectiveness threshold for purchases, allow for co-funding of projects, and provide added eligibility for infrastructure projects. Each local air district can direct the focus of its share of funds to specific source categories and tailor projects to meet local air quality objectives. The Moyer Program has provided more than $900 million in funding.

Areawide sources such as residential wood stoves and agricultural operations contribute to poor air quality and diminished visibility. California SB 563 authorized funding for CARB to establish a residential Woodsmoke Reduction Program. The Woodsmoke Reduction Program is being implemented by the California Air Pollution Control Officers Association (CAPCOA) in coordination with local air districts and provides financial incentives for residents to replace old, inefficient, highly polluting residential heating devices with certified wood stoves or non-wood home heating devices. The State Legislature committed $5 million in funding for the 2016-2017 fiscal year and an additional $3 million in funding for the 2018-2019 fiscal year. Eligible residents can receive up to $5,000 to cover the changeout of their home heating device.

California's agricultural industry includes over 77,000 farms and ranches that produce 400 different commodities. Reducing emissions from the vehicles and equipment used in agricultural operations is an important step in meeting California's air quality goals. The natural turnover rate of agriculture-related equipment is not sufficient to meet the pace of

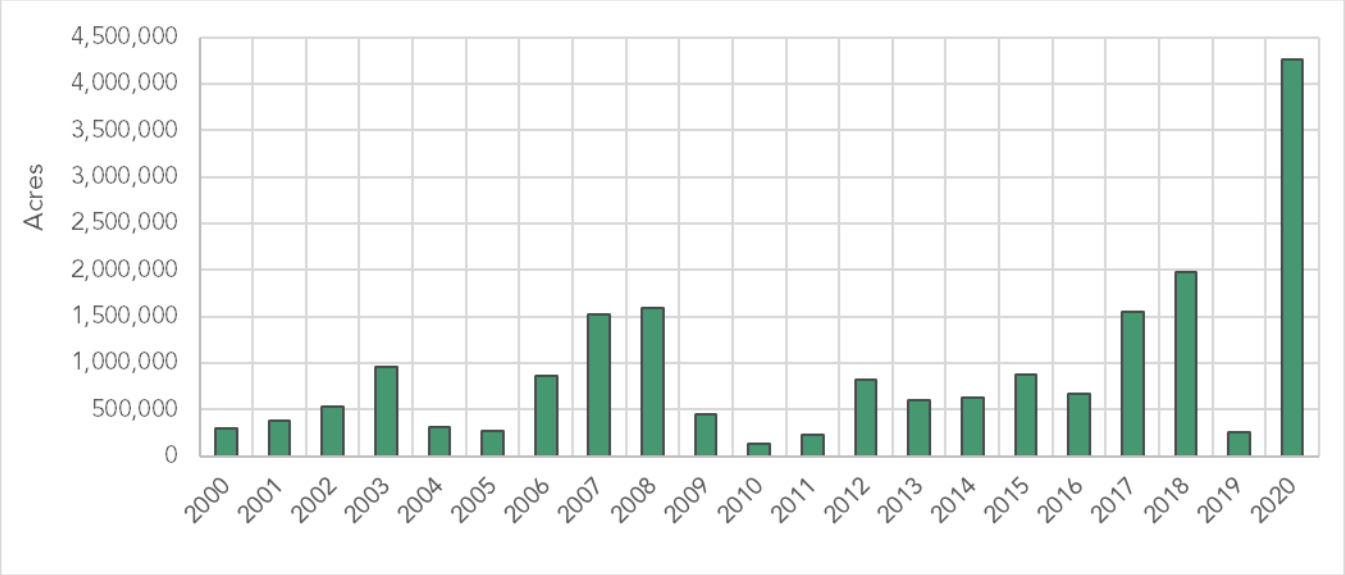
California's air quality needs. In 2017, California Assembly Bills 109 and 134 provided $135 million in funding to CARB to reduce emissions from the agricultural sector. In collaboration with local air districts and stakeholders, CARB developed the Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program. The FARMER Program helps fund purchases of cleaner equipment like harvesters, heavy-duty trucks, agricultural pump engines, and tractors that are used in agricultural operations. The FARMER Program is administered by local air districts. Incentive funds for the program can cover up to 90 percent of the purchase cost of low and zero-emission agricultural-related equipment.

Accelerated source retirement and replacement through implementation of these programs will continue to reduce emissions that contribute to a host of air quality challenges in California, including visibility impairment in Class I areas.

### Basic Smoke Management Practices for Prescribed Fire

Emissions from wildfires are the largest source of PM in California and can markedly affect visibility in Class I areas. Wildfire activity in California is increasing at an unprecedented rate and occurring across unprecedented spatiotemporal scales. Wildfire data compiled by the California Department of Forestry and Fire Protection (CAL FIRE) are shown in Figure 7-5. For the regional haze baseline period (2000-2004), the average annual acreage burned by wildfire was 497,475 acres. During the current period (2014-2018), the average annual acreage increased by 129 percent to 1,139,898 acres.

*Figure 7-5: Annual Acreage Burned by Wildfire in California Across All Jurisdictions*




As shown in Table 7-4, eight of the top ten largest wildfires in State history have occurred in the last five years and four of those fires started during a single month in 2020. Climate

change and decades of fire suppression have combined to affect this dramatic increase in wildfire activity throughout the state.

*Table 7-4: Top 10 Largest California Wildfires*

| Fire Name | Date | County | Acres |
|---|---|---|---|
| August Complex | August 2020 | Mendocino, Humboldt, Trinity, Tehama, Glenn, Lake, Colusa | 1,032,648 |
| Dixie | July 2021 | Butte, Plumas, Lassen, Shasta, Tehama | 963,309 |
| Mendocino Complex | July 2018 | Colusa, Lake, Mendocino, Glenn | 459,123 |
| SCU Lightning Complex | August 2020 | Stanislaus, Santa Clara, Alameda, Contra Costa, San Joaquin | 396,624 |
| Creek | September 2020 | Fresno, Madera | 379,895 |
| LNU Lightning Complex | August 2020 | Napa, Solano, Sonoma, Yolo, Lake, Colusa | 363,220 |
| North Complex | August 2020 | Butte, Plumas, Yuba | 318,935 |
| Thomas | December 2017 | Ventura, Santa Barbara | 281,893 |
| Cedar | October 2003 | San Diego | 273,246 |
| Rush | August 2012 | Lassen (CA)/Washoe (NV) | 271,911 CA/43,666 NV |

California is expanding efforts and investments to address the unprecedented increase in wildfire activity. The guiding document for these efforts is California's Wildfire and Forest Resilience Action Plan[24] prepared the Governor's Forest Management Task Force (Task Force). The Task Force was established in 2018 to create an interagency organization to develop and implement an integrated approach toward effective forest management. California's Wildfire and Forest Resilience Action Plan is the framework for implementation of this integrated approach and lays out a comprehensive action plan to reduce wildfire risk, improve the ecological health of forests and wildlands, and accelerate action to address climate change. One of the key steps identified in the Plan is to significantly increase forest and fuels management programs. The State and federal target is to conduct fuels treatment on one million acres in California on an annual basis by 2025. To meet this combined target, CAL FIRE will put systems in place to conduct fuels treatment on 500,000 acres annually by 2025. The USFS will increase forest treatment levels on federally managed lands to 500,000 acres annually.

California and the USFS signed a memorandum of understanding (MOU)[25] in 2020 to formalize the agreement for shared stewardship of California's forests and rangelands. The MOU acknowledges that several factors have made it nearly impossible for nature to self-correct the overly dense and ailing forests that are the dominant feature on California's

[24] *https://fmtf.fire.ca.gov/media/cjwfpckz/californiawildfireandforestresilienceactionplan.pdf*

[25] *https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf*

wildlands today. Significant increases in forest management activities are necessary to increase forest resilience and reduce the catastrophic wildfire risk.

A significant expansion of the use of prescribed fire across the State is an integral part of California's Wildfire and Forest Resilience Action Plan for increased forest management activity aimed at increasing forest resilience and reducing catastrophic wildfire risk. More than 11 million people in California live in high-fire risk areas. Community protection and forest health concerns underscore the need to significantly increase the use of prescribed fire in California. CARB proactively oversees statewide smoke forecasting, smoke monitoring, and smoke management efforts for prescribed fire projects.

In California, 57 percent of the land is managed by federal agencies, 40 percent is under private ownership, and the remaining three percent is managed by State agencies. Coordination is critical for effective smoke management during prescribed fire projects. California's Smoke Management Guidelines for Agricultural and Prescribed Burning[26] were adopted into State law in March 2001. The Guidelines apply to all local air districts in California and provide a framework to ensure that smoke management programs developed by local air districts minimize the air quality and public health impacts from prescribed burn projects. In 2003, U.S. EPA accepted CARB's certification that California's Smoke Management Guidelines for Agricultural and Prescribed Burning met U.S. EPA's Enhanced Smoke Management requirements.

CARB and local air districts have a shared responsibility to administer smoke management program under Title 17 of the California Code of Regulations. CARB is responsible for general oversight of smoke management programs and makes daily burn decisions for most air basins in California. Four large air districts (South Coast AQMD, Bay Area AQMD, San Joaquin Valley APCD, and San Diego County APCD) are certified to prepare their own daily forecasts and burn determinations. CARB's daily burn decisions are issued based on air quality forecasts and meteorological conditions that affect smoke dispersion. The potential for public health impacts from smoke emissions are a factor in daily burn decisions. Class I areas are considered sensitive receptors and are also a factor in the daily burn decisions.

Local air districts provide final approval for burn projects on the day they are scheduled and use CARB's burn day decisions as a guide when deciding to issue final approval. Local air districts have developed comprehensive smoke management programs to meet the needs of their jurisdictions and comply with Title 17 requirements. Local air district programs include requirements for permitting, reporting, communication, and development of smoke management plans for burn projects.

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[26] California Code of Regulations Title 17 Sections 80100-80330

State and local air regulators work closely with burners to minimize smoke impacts from prescribed burn projects. Before conducting their prescribed burn project, burners must complete the following planning steps:

- Register the burn with the local air district,
- Obtain burn permit from local air district or fire agency,
- Submit a smoke management plan to local air district, and
- Receive approval from local air district for smoke management plan.

The smoke management plan prepared for the prescribed burn project must include an assessment of air quality, meteorological, and fuel conditions of the proposed burn project. Depending on the size and complexity of the project, the smoke management plan may include the following information:

- Burner name and contact information
- Burn method and fuel type
- Nearby population centers
- Planned burn time
- Acceptable burn ignition conditions
- Contingency planning
- Burn monitoring procedures
- Location and size of the burn
- Expected pollutant emissions
- Smoke travel projections – including maps
- Duration of the burn
- Smoke minimization techniques
- Description of alternatives to burning
- Public notification procedures

Burn managers may begin making final preparations to carry out the project after they have received approval of their smoke management plan and their prescribed burn permit has been issued. The burner may contact the air district up to four days in advance of the burn to receive meteorology and air quality forecasts provided by CARB for the proposed burn period. Burners are provided with final authorization to conduct a prescribed burn typically no more than 24 hours prior to the burn.

The burn manager, or individual granted authority to burn, is responsible for ensuring that all conditions in the approved permit and smoke management plan are met for the duration of the burn project. The burn manager is responsible for implementing smoke mitigation measures laid out in their approved smoke management plan if adverse smoke impacts are observed or the burn otherwise goes out of prescription.

CARB supports the maintenance of the Prescribed Fire Information Reporting System (PFIRS), a web-based platform that serves as an interface between air quality managers, land management agencies, and individuals that conduct prescribed burning in California. CARB's daily burn decisions for the State's 15 air basins are posted on the website by 3 pm (local time) each day. Contact information for each local air district and the CARB duty meteorologist are provided. The mapping interface provides tools to visualize the location of planned, approved, and active prescribed burn projects. The managing agency, the acreage, date of approval, and status of burn projects are also accessible from the mapping interface.

CARB released the California Smoke Spotter mobile application (app) in May 2021. The app provides users with information about when and where prescribed fires are being planned so they can prepare for potential smoke impacts. The key information provided in the app includes prescribed fire details, daily smoke forecasts, and current air quality index. Users can personalize alerts to receive notifications when prescribed fire projects will be conducted in their selected area(s). The app serves as a central public resource for prescribed fire, smoke, and health information.

Coordination among local, State, and federal agencies is essential to effectively managing smoke from prescribed burns. To facilitate coordination among agencies involved in, or impacted by, prescribed fire operations, CARB facilitates quarterly meetings of the Air and Land Managers (ALM) workgroup. The workgroup is chaired by representatives of the USFS and CAPCOA. Participants in the workgroup meetings include representatives from local, state, and federal agencies. The meetings provide opportunities for interagency collaboration, training, communication, and planning.

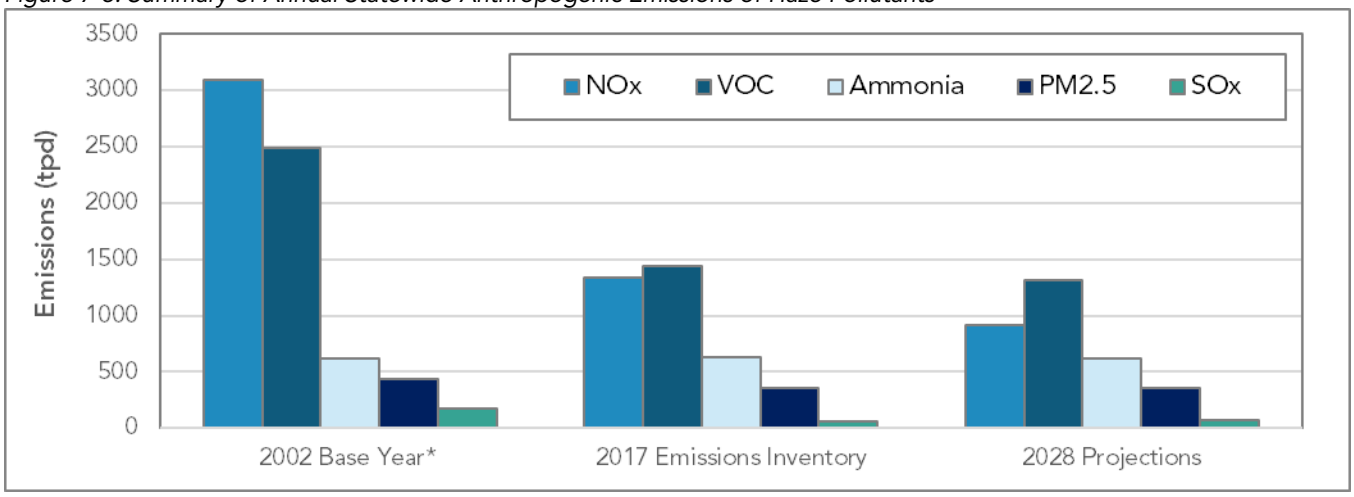
### Anticipated Net Effect on Visibility due to Projected Emissions Changes

California's air quality challenges are unique and widespread. Considerable effort has been geared toward reducing emissions under State and local jurisdiction that drive air quality challenges. As shown in Figure 7-6, these efforts have yielded substantial reductions. Between the 2002 baseline inventory used for preparation of California's first Regional Haze Plan and 2017:

- VOC emissions were reduced by 42 percent,
- NOx emissions were reduced by 57 percent,
- SOx emissions were reduced by 63 percent, and
- PM2.5 emissions were reduced by 29 percent.

These considerable emission reductions in haze pollutants have led to improved visibility metrics for the clearest days and the most impaired days in all Class I areas in California.

*Figure 7-6: Summary of Annual Statewide Anthropogenic Emissions of Haze Pollutants*




**Data from California's First Regional Haze SIP*

Adopted emission control strategies are expected to yield emission reductions for the second planning period and result in improved visibility conditions on the most impaired days at all Class I areas in California. For this planning period, strategies developed through CARB's integrated planning process have been focused on NOx emission reductions from mobile sources. Average daily NOx emissions in 2028 are expected to be more than 400 tons lower than 2017 emissions due to implementation of controls that were adopted at the time of the inventory preparation for this Regional Haze Plan. Potential additional controls, specifically the four mobile source measures discussed in earlier sections of this chapter, will yield additional NOx reductions amounting to 40 tons per day, during the latter half of this implementation period.

The magnitude of emission reductions achieved in California highlights the value of an integrated planning process to address air quality targets. Integrated planning efforts are employed to develop strategies to attain targets for ambient air quality, community health, and climate change. The collective progress than can be achieved through leveraging resources with an integrated planning effort is greater than what is possible through isolated efforts. Integrated planning efforts represent an efficient path to leverage resources for a long-term strategy that will improve visibility in areas subject to the regional haze program.

Regional photochemical modeling indicates baseline controls will lead to improved visibility in all of California's Class I areas on the most impaired days in 2028. As the data in Table 7-5 show, visibility conditions on the most impaired days are projected to improve by 6 to 11 percent at Class I areas represented by IMPROVE sites in Northern California, 8 to 12 percent at IMPROVE sites in Central California, and 9 to 16 percent at IMPROVE sites in Southern California. Implementation of potential additional controls will begin in the latter half of the current planning period and are projected to yield additional visibility improvements at some sites near high population areas by 2028. A detailed discussion of

visibility projections and reasonable progress goals established for 2028 is provided in Chapter 8.

*Table 7-5: Visibility Conditions and 2028 Projections for the Most Impaired Days*

| CA Region | IMPROVE Site | 2014-2018 Visibility Conditions (dv) IMPROVE Data | 2028 Visibility Projections (dv) with On-the-Books Controls (2028 OTBa2 Emissions) | 2028 Visibility Projections (dv) with Potential Additional Controls (PAC2 Emissions) |
|---|---|---|---|---|
| Northern | LABE1 | 9.7 | 8.9 | 8.9 |
| Northern | REDW1 | 12.7 | 11.9 | 11.9 |
| Northern | TRIN1 | 10.4 | 9.5 | 9.5 |
| Northern | LAVO1 | 10.2 | 9.4 | 9.4 |
| Northern | BLIS1 | 9.3 | 8.3 | 8.3 |
| Northern | PORE1 | 15.3 | 14.4 | 14.4 |
| Northern | YOSE1 | 11.6 | 10.4 | 10.4 |
| Central | HOOV1 | 7.8 | 7.1 | 7.1 |
| Central | KAIS1 | 11.0 | 9.8 | 9.8 |
| Central | PINN1 | 14.1 | 13.0 | 13.0 |
| Central | SEQU1 | 18.4 | 16.2 | 16.1 |
| Central | RAFA1 | 14.1 | 13.0 | 13.0 |
| Southern | DOME1 | 15.1 | 13.8 | 13.7 |
| Southern | SAGA1 | 13.2 | 11.6 | 11.5 |
| Southern | SAGO1 | 14.5 | 12.2 | 12.0 |
| Southern | JOSH1 | 12.9 | 11.3 | 11.3 |
| Southern | AGTI1 | 16.3 | 14.6 | 14.5 |

California's long-term strategy for regional haze is focused on NOx emission reductions to reduce ammonium nitrate, the dominant PM species in the U.S. light extinction budget for California's Class I areas. The iterative process for regional haze planning, laid out by the Clean Air Act, allows for routine reassessment of state strategies. California will continue to assess the sources contributing to regional haze, articulate those findings in routine progress reports and future regional haze plans, and adjust our strategies as necessary to continue to improve visibility in Class I areas.

# 8. Reasonable Progress Goals

States must establish reasonable progress goals (RPG) for each Class I area to provide for progress towards achieving natural visibility conditions in 2064 and include them in their Regional Haze Plans. The RPGs established by states are intended to ensure visibility does not degrade on the clearest days and improves on the most impaired days. The RPGs in this Regional Haze Plan represent the visibility condition targets for the clearest days and the most impaired days in 2028 for each of California's Class I area. RPGs are not directly enforceable but are considered by U.S. EPA in evaluating the adequacy of measures in the Regional Haze Plan to provide for progress towards achieving natural visibility conditions in Class I areas, including Joshua Tree National Park (Figure 8-1).

*Figure 8-1: Sunset over Queen Valley in Joshua Tree National Park*

*Public domain photograph, courtesy NPS/Emily Hassell*

The regional air quality modeling coordinated by the WRAP provides the basis for establishing the RPGs for the most impaired days in each Class I area. The RPGs for the most impaired days are based on the emissions inputs that include implementation of control programs adopted at the time of the emissions inventory development and the additional aggregate emission reduction commitment proposed in California's long-term strategy. RPGs for the clearest days are equal to average visibility conditions on the clearest days during the 2000-2004 baseline period.

## RPGs for California's Class I Areas

RPGs for California's 29 Class I areas are shown in Table 8-1, which is organized by the geographic region where the representative IMPROVE monitoring site is located. Within each region, IMPROVE monitors are listed from north to south. For IMPROVE monitors that

represent visibility conditions for more than one Class I area, the Class I areas are listed from north to south.

In Northern California, 2028 RPGs for the most impaired days range from 8.3 to 14.4 dv. These RPGs provide for an improvement in visibility ranging from 1.8 to 5.0 dv from visibility conditions during the baseline period. The RPGs for the clearest days range from 2.5 to 10.5 dv. These RPGs provide for no degradation between visibility conditions during the baseline period and 2028.

*Table 8-1: 2028 Reasonable Progress Goals for California Class I Areas*

| CA Region | IMPROVE Site | Class I Area | Clearest Baseline (dv) | Clearest RPG (dv) | Most Impaired Baseline (dv) | Most Impaired RPG (dv) |
|---|---|---|---|---|---|---|
| Northern | LABE1 | Lava Beds National Monument<br>South Warner Wilderness Area | 3.2 | 3.2 | 11.3 | 8.9 |
| Northern | REDW1 | Redwood National Park | 6.1 | 6.1 | 13.7 | 11.9 |
| Northern | TRIN1 | Marble Mountain Wilderness Area<br>Yolla Bolly-Middle Eel Wilderness Area | 3.4 | 3.4 | 11.9 | 9.5 |
| Northern | LAVO1 | Thousand Lakes Wilderness Area<br>Lassen Volcanic National Park<br>Caribou Wilderness Area | 2.7 | 2.7 | 11.5 | 9.4 |
| Northern | BLIS1 | Desolation Wilderness Area<br>Mokelumne Wilderness Area | 2.5 | 2.5 | 10.1 | 8.3 |
| Northern | PORE1 | Point Reyes National Seashore | 10.5 | 10.5 | 19.4 | 14.4 |
| Northern | YOSE1 | Emigrant Wilderness Area<br>Yosemite National Park | 3.4 | 3.4 | 13.5 | 10.4 |
| Central | HOOV1 | Hoover Wilderness Area | 1.4 | 1.4 | 8.9 | 7.1 |
| Central | KAIS1 | Ansel Adams Wilderness Area<br>John Muir Wilderness Area<br>Kaiser Wilderness Area | 2.3 | 2.3 | 12.9 | 9.8 |
| Central | PINN1 | Pinnacles National Park<br>Ventana Wilderness Area | 8.9 | 8.9 | 17.0 | 13.0 |
| Central | SEQU1 | Kings Canyon National Park<br>Sequoia National Park | 8.8 | 8.8 | 23.2 | 16.1 |
| Central | RAFA1 | San Rafael Wilderness Area | 6.5 | 6.5 | 17.3 | 13.0 |
| Southern | DOME1 | Domeland Wilderness Area | 5.1 | 5.1 | 17.2 | 13.7 |
| Southern | SAGA1 | San Gabriel Wilderness Area<br>Cucamonga Wilderness Area | 4.8 | 4.8 | 17.9 | 11.5 |
| Southern | SAGO1 | San Gorgonio Wilderness Area<br>San Jacinto Wilderness Area | 5.4 | 5.4 | 20.4 | 12.0 |
| Southern | JOSH1 | Joshua Tree Wilderness Area | 6.1 | 6.1 | 17.7 | 11.3 |
| Southern | AGTI | Agua Tibia Wilderness Area | 9.6 | 9.6 | 21.6 | 14.5 |

In Central California, 2028 RPGs for the most impaired days range from 7.1 to 16.1 dv. These RPGs provide for an improvement in visibility ranging from 1.8 to 7.1 dv from visibility conditions during the baseline period. The RPGs for the clearest days range from 1.4 to 8.9 dv. These RPGs provide for no degradation in visibility conditions between the baseline period and 2028.

In Southern California, 2028 RPGs for the most impaired days range from 11.3 to 14.5 dv. These RPGs provide for an improvement in visibility conditions ranging from 3.5 to 8.4 dv from visibility conditions during the baseline period. The RPGs for the clearest days range from 5.1 to 9.6 dv and provide for no degradation in visibility conditions between visibility conditions during the baseline period and 2028.

## Uniform Rate of Progress and Proposed 2064 Endpoint Adjustments

To assess the extent to which the selected RPGs provide for progress towards natural conditions, RPGs can be compared to the uniform rate of progress (URP), which represents the linear rate of progress that would be needed to return to estimated natural visibility conditions on the most impaired days in 2064. The starting period is the 2000 to 2004 baseline period. The hypothetical straight-line trajectory between visibility conditions during the baseline period and estimated natural visibility conditions in 2064 is known as the glidepath. The slope of the glidepath is called the URP.

The URP is reported in deciviews per year and calculated according to the following equation:

$$URP = (B - N) / 60 \text{ years}$$

*B represents the average visibility conditions in dv during the 2000-2004 baseline on the most impaired days.*
*N represents estimated natural visibility conditions in dv on the most impaired days.*

The Regional Haze Rule allows for the adjustment of the URP to account for impacts of international sources and certain types of wildland prescribed fire. California is proposing to adjust the 2064 natural conditions end point to account for the impact of international sources and certain types of wildland prescribed fire on visibility in all of the State's Class I areas.

International emission sources are relevant to regional haze planning in California because the State's Class I areas are ideally positioned to be impacted by international emissions. The geographic location of California's Class I areas coupled with prevailing meteorological conditions facilitate the interception of transported emissions. Transport across the U.S.-Mexico border, long-range trans-Pacific transport, and transport of emissions from OGVs in international waters contribute to visibility impairment in Class I areas throughout California.

Wildland prescribed fire emissions are also relevant to regional haze planning in California because the use of prescribed fire is an integral component of fuel treatment efforts in the State. Fuel treatment projects are expected to increase markedly in the coming years to reduce the risk of catastrophic wildfires and restore sustainable, resilient wildland ecosystems. The use of prescribed fire employed during fuels treatment projects is subject to California's requirements for the application of basic smoke management practices. Despite the use of basic smoke management practices, emissions from wildland prescribed fire projects can contribute to visibility impairment in Class I areas throughout California.

The estimated impacts of international emissions and wildland prescribed fire emissions were developed through the WRAP's regional photochemical modeling analyses for this regional haze planning period. Estimated prescribed fire emissions and international emissions were held constant through 2064 at levels estimated for the 2014-2018 period. Additional details about the WRAP's regional photochemical modeling analyses are provided in Chapter 4 and Appendix F. The adjustments proposed for the 2064 endpoints were used to determine the adjusted URP using the following equation:

$$URP = [B - (N + Adjustment)] / 60 \text{ years}$$

*B represents the average visibility conditions in dv during the 2000-2004 baseline on the most impaired days.*
*N represents estimated natural visibility conditions in dv on the most impaired days.*
*Adjustment represents estimated impact of international anthropogenic and prescribed fire emissions in 2064.*

Following the release of the WRAP's proposed adjustments to the 2064 endpoints, the USFS raised concerns that the estimated impacts of prescribed fire are too low for some areas and do not reflect the land management policy change of increasing acres treated with prescribed fire. The USFS developed an alternative adjustment that utilized future fire emissions scenarios to scale up the light extinction attributable to prescribed fire in 2064 projections from the WRAP.

As shown in Table 8-2, the alternative prescribed fire adjustments to the 2064 endpoint proposed by the USFS range from 0.1 to 2.5 dv and are generally slightly higher than the WRAP's estimates for prescribed fire. Details of the procedures and supporting data used by USFS to calculate the alternative 2064 endpoint adjustments are provided in Appendix F.

California is proposing to adjust the 2064 endpoint to account for the impact of international anthropogenic sources and certain types of wildland prescribed fire using the adjustments developed by the WRAP. The USFS alternative adjusted URP is also provided in this plan for informational purposes and as another point of reference to underscore that emissions from prescribed fire projects may impair visibility despite the application of basic smoke management practices; however, the extent of impacts that will occur in 2064 are uncertain.

*Table 8-2: Comparison of the 2064 Incremental Endpoint Adjustments Estimated by the WRAP and the USFS*

| CA Region | IMPROVE Site | WRAP International 2064 Endpoint Adjustment (dv) | WRAP Prescribed Fire 2064 Endpoint Adjustment (dv) | USFS Prescribed Fire 2064 Endpoint Adjustment (dv) |
|---|---|---|---|---|
| Northern | LABE1 | 0.7 | 0.2 | 0.3 |
| Northern | REDW1 | 0.8 | 0.1 | 0.1 |
| Northern | TRIN1 | 1.9 | 0.4 | 0.8 |
| Northern | LAVO1 | 1.6 | 0.2 | 0.4 |
| Northern | BLIS1 | 1.4 | 0.3 | 0.6 |
| Northern | PORE1 | 1.1 | 0.2 | 0.3 |
| Northern | YOSE1 | 2.0 | 0.2 | 0.4 |
| Central | HOOV1 | 1.9 | 0.1 | 0.2 |
| Central | KAIS1 | 2.2 | 1.2 | 2.5 |
| Central | PINN1 | 1.7 | 0.5 | 0.6 |
| Central | SEQU1 | 4.0 | 0.4 | 0.9 |
| Central | RAFA1 | 1.9 | 0.1 | 0.2 |
| Southern | DOME1 | 2.9 | 0.2 | 0.3 |
| Southern | SAGA1 | 1.6 | 0.1 | 0.1 |
| Southern | SAGO1 | 2.1 | 0.1 | 0.2 |
| Southern | JOSH1 | 2.2 | 0.1 | 0.1 |
| Southern | AGTI | 2.9 | 0.4 | 0.4 |

## Assessment of Current and Projected Progress

The glidepath determined for each of California's Class I areas does not represent a safe harbor or a bright line, but it provides a checkpoint. Comparison of the current rate of progress with the URP associated with the proposed glidepath provides an indicator for whether the Class I area is on track to meet 2064 targets. The current rate of progress was calculated using the following equation:

Current Rate of Progress = (B – C) / 14 years

*B represents the average visibility conditions in dv during the 2000-2004 period on the most impaired days.*
*C represents the average visibility conditions in dv during the 2014-2018 period on the most impaired days.*

The current rate of progress and the URPs associated with the proposed adjustment to the 2064 endpoint and the unadjusted endpoint are shown in Tables 8-3, 8-4, and 8-5 for Class I areas represented by IMPROVE monitoring sites in Northern California, Central California, and Southern California, respectively. If the current rate of progress is greater than the adjusted URP, then visibility conditions are improving at a rate that indicates natural visibility conditions would be attained prior to the end of 2064.

In Northern California, visibility on the most impaired days is improving at a rate that ranges from 0.06 dv per year in the Desolation and Mokelumne Wilderness Areas to 0.29 dv per year in Point Reyes National Seashore. Among the Class I areas in Northern California, Point Reyes National Seashore has the worst visibility on the most impaired days and the greatest portion of light extinction attributable to U.S. emission sources. The current rate of progress for this area is 107 percent greater than the adjusted URP. As shown in Table 8-3, the current rate of progress at all Class I areas in Northern California is equal to or greater than the adjusted URP, indicating that visibility on the most impaired days is on track to reach natural visibility conditions by the end of 2064.

*Table 8-3: Comparison of the Current Rate of Progress and URP Glidepath for Class I areas in Northern California*

| IMPROVE Site | Class I Area | Current Rate of Progress (dv/year) | Adjusted Uniform Rate of Progress (dv/year) | Uniform Rate of Progress (dv/year) |
|---|---|---|---|---|
| LABE1 | Lava Beds National Monument<br>South Warner Wilderness Area | 0.11 | 0.07 | 0.09 |
| REDW1 | Redwood National Park | 0.08 | 0.07 | 0.09 |
| TRIN1 | Marble Mountain Wilderness Area<br>Yolla Bolly-Middle Eel Wilderness Area | 0.11 | 0.05 | 0.09 |
| LAVO1 | Thousand Lakes Wilderness Area<br>Lassen Volcanic National Park<br>Caribou Wilderness Area | 0.09 | 0.06 | 0.09 |
| BLIS1 | Desolation Wilderness Area<br>Mokelumne Wilderness Area | 0.06 | 0.06 | 0.09 |
| PORE1 | Point Reyes National Seashore | 0.29 | 0.14 | 0.16 |
| YOSE1 | Emigrant Wilderness Area<br>Yosemite National Park | 0.14 | 0.08 | 0.12 |

In Central California, visibility on the most impaired days is improving at a rate that ranges from 0.08 dv per year in the Hoover Wilderness Area to 0.34 dv per year in Kings Canyon and Sequoia National Parks. Among the Class I areas in Central California, Kings Canyon and Sequoia National Parks have the worst visibility on the most impaired days and the greatest portion of light extinction attributable to U.S. emission sources. The current rate of progress for this area is 62 percent greater than the adjusted URP. As shown in Table 8-4, the current rate of progress at all Class I areas in Central California is greater than the adjusted URP, indicating that visibility on the most impaired days is on track to reach the natural visibility conditions before the end of 2064.

*Table 8-4: Comparison of the Current Rate of Progress and URP Glidepath for Class I areas in Central California*

| IMPROVE Site | Class I Area | Current Rate of Progress (dv/year) | Adjusted Uniform Rate of Progress (dv/year) | Uniform Rate of Progress (dv/year) |
|---|---|---|---|---|
| HOOV1 | Hoover Wilderness Area | 0.08 | 0.03 | 0.07 |
| KAIS1 | Ansel Adams Wilderness Area<br>John Muir Wilderness Area<br>Kaiser Wilderness Area | 0.14 | 0.06 | 0.11 |
| PINN1 | Pinnacles National Park<br>Ventana Wilderness Area | 0.21 | 0.13 | 0.11 |
| SEQU1 | Kings Canyon National Park<br>Sequoia National Park | 0.34 | 0.21 | 0.28 |
| RAFA1 | San Rafael Wilderness Area | 0.23 | 0.14 | 0.18 |

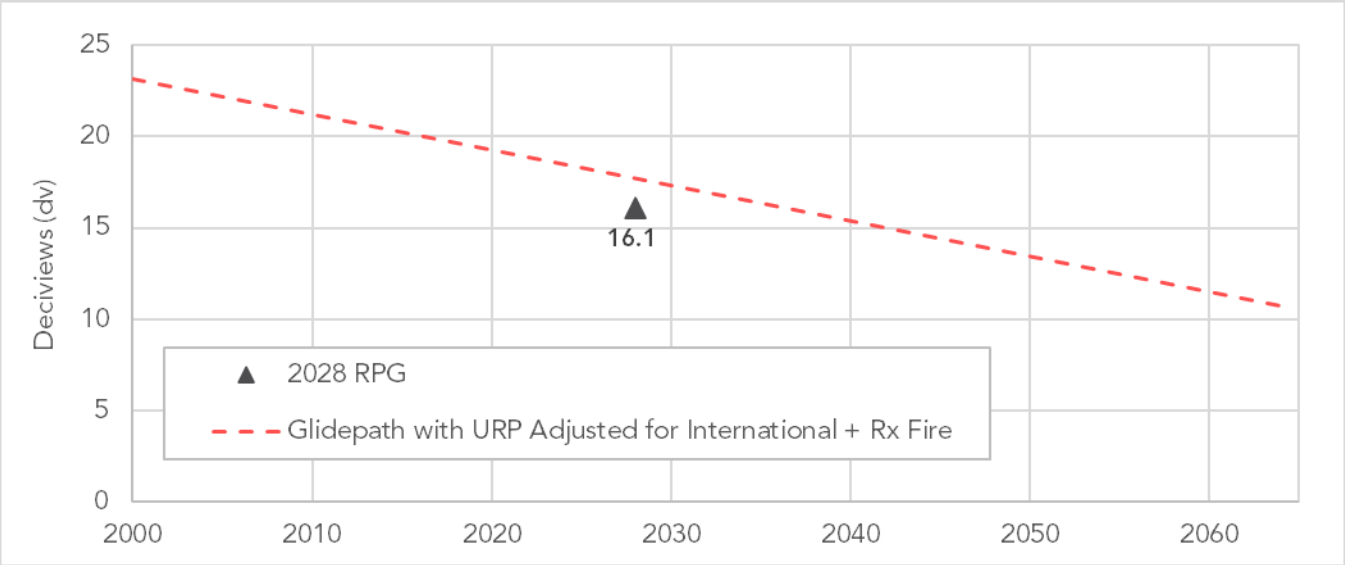
In Southern California, visibility on the most impaired days is improving at a rate that ranges from 0.15 dv per year in the Domeland Wilderness Area to 0.43 dv per year in the San Gorgonio and San Jacinto Wilderness Areas. Among the Class I areas in Southern California, the Agua Tibia Wilderness Area has the worst visibility on the most impaired days. The current rate of progress for this area is 111 percent greater than the adjusted URP. As shown in Table 8-5, the current rate of progress at all Class I areas in Southern California is greater than the adjusted URP, indicating that visibility on the most impaired days is on track to reach natural conditions before the end of 2064.

*Table 8-5: Comparison of the Current Rate of Progress and URP Glidepath for Class I areas in Southern California*

| IMPROVE Site | Class I Area | Current Rate of Progress (dv/year) | Adjusted Uniform Rate of Progress (dv/year) | Uniform Rate of Progress (dv/year) |
|---|---|---|---|---|
| DOME1 | Domeland Wilderness Area | 0.15 | 0.13 | 0.18 |
| SAGA1 | San Gabriel Wilderness Area<br>Cucamonga Wilderness Area | 0.34 | 0.17 | 0.20 |
| SAGO1 | San Gorgonio Wilderness Area<br>San Jacinto Wilderness Area | 0.43 | 0.20 | 0.24 |
| JOSH1 | Joshua Tree National Park | 0.34 | 0.15 | 0.19 |
| AGTI1 | Agua Tibia Wilderness Area | 0.38 | 0.18 | 0.23 |

Comparison of the 2028 RPG with the glidepath offers a means to assess projected future progress. Figure 8-2 provides an example of this comparison for Kings Canyon and Sequoia National Parks, the Class I areas represented by the SEQU1 monitoring site. Figures that offer this comparison are provided in Appendix C for all of California's Class I areas. These comparisons show that 2028 RPGs for all of California's Class I areas are on or below the glidepath.

*Figure 8-2: Comparison of 2028 RPG and Adjusted Glidepath for Kings Canyon and Sequoia National Parks*




The State believes the 2028 RPGs established for its Class I areas in this Regional Haze Plan are adequate. California is controlling in-State sources at levels well beyond those achieved through national programs. The four statutory factors for reasonable progress were considered in the development of measures that will achieve emission reductions in California's long-term strategy. Specifically, adopted measures included in the emission inventory used for the modeling projections were developed through California's rule-making process which has embodied the consideration of the four statutory factors for decades. The four statutory factors were also explicitly considered for the four measures identified in the State's emission reduction commitment in the long-term strategy. The 2028 RPGs for the clearest days provide for the prevention of visibility degradation. The 2028 RPGs for the most impaired days provide for improvement in visibility from conditions during the 2000-2004 baseline period and are on or below the adjusted glidepath for each of California's Class I areas. Further, the current rate of progress at Class I areas is an average of 81% greater than the adjusted URP. Collectively, these multiple lines of evidence indicate that the emission control strategies being put in place in California are reducing emissions that contribute to visibility impairment and California's Class I areas are on track to meet 2064 visibility targets.

## 9. Consultation

The Regional Haze Rule includes requirements for consultations during the preparation of the Regional Haze Plan. States are required to consult with other states that have emissions reasonably anticipated to contribute to visibility impairment. The interstate consultation process allows for states to share and consider technical information and to develop coordinated emission control strategies.

States are also required to consult with federal land managers (FLMs) and provide an opportunity to comment on draft materials at least 60 days prior to the start of a public comment period or public hearing on the planned Regional Haze SIP submittal. Early engagement with FLMs is encouraged and allows for states to share their planned approaches for SIP development and technical work.

Consultation with tribes is encouraged as the content of regional haze plans may affect air quality in and around tribal lands. Further, consultation may be necessary if a source located on tribal lands causes or contributes to visibility impairment in Class I areas.

States are also required to provide procedures for continuing interstate consultation and consultation with FLMs on the implementation of strategies included in the regional haze plan, development of plan revisions and progress reports, and implementation of other programs that have the potential to contribute to impairment of visibility in Class I areas.

### Consultation with Neighboring States

For more than 20 years California has worked in coordination with other western states to address regional haze. The first coordinated work on regional haze began in 1991 when the Grand Canyon Visibility Transport Commission was formed. Regional work for the western states is now coordinated through the WRAP, which is the successor organization to the Grand Canyon Visibility Transport Commission. The WRAP is a voluntary partnership between fifteen western states, local air agencies, federal land managers, and tribes.

CARB staff have been actively engaged in the WRAP's regional haze planning efforts through participation in workshops, contributions to workgroups, and regular meeting attendance. Active engagement in these planning efforts has provided opportunities for continuous engagement with other western states. Workshops, work groups, and meetings held to support the development of regional haze plans for this planning period are documented on the WRAP Regional Haze Planning Work Group's website.[27]

[27] *https://www.wrapair2.org/RHPWG.aspx*

In addition to the engagement with states through the WRAP regional haze planning efforts, California has participated in state-to-state regional haze consultations with Oregon, Nevada, and Arizona. The dates of these state-to-state regional haze consultations are listed below:

- Oregon: April 14, 2020 and November 3, 2021
- Nevada: January 31, 2020 and December 15, 2020
- Arizona: December 18, 2019 and September 21, 2021

Class I areas in these states are most likely to be impacted by emission sources in California. During these consultations, staff discussed potential contributions to neighboring states, the results of technical analyses, strategies planned for carrying out the reasonable progress analyses, and strategies for achieving emission reductions for the current planning period. Neither party involved in these consultations identified, requested, or agreed to any measures during the consultation meetings.

Due to the terrain and prevailing meteorological patterns, emissions from other U.S. states do not have significant, routine impacts on visibility in California's Class I areas. Emissions from California are the dominant source in the U.S. light extinction budgets for California's Class I areas. A more detailed discussion of source apportionment for California's Class I areas is provided in Chapter 4. Given the available technical analyses, California believes it has fulfilled the requirement to have reasonably consulted with each of the states having emissions that are reasonably anticipated to contribute to visibility impairment in the affected Class I areas and conversely, states with Class I areas that are reasonably anticipated to be impacted by contributions from emissions from sources in California.

## Consultation with Federal Land Managers

CARB's engagement with WRAP's regional haze planning efforts provided opportunities for continuous engagement with federal land managers. To meet the requirement for early engagement, CARB staff held multiple informal consultation teleconferences with staff from the National Park Service and the USFS. During these calls, CARB staff provided updates on regional haze plan development, technical analyses, planned approaches to conducting the reasonable progress analyses, and strategies for achieving emission reductions to improve visibility in Class I areas.

Federal land managers from the Bureau of Land Management, National Park Service, USFS, and U.S. Fish and Wildlife Service were provided with the opportunity to comment on California's draft Regional Haze Plan more than 60 days prior to the release of the document for public review. The comments received from federal land managers and CARB's responses to these comments are provided in Appendix I.

## Consultation with Tribes

While there are no tribal lands with Class I areas located in California, California has the largest Native American population in the country. Within California, there are 109 federally recognized tribes and 57 non-federally recognized tribes. As the original stewards of the lands in California, tribes can provide unique knowledge and insight. Announcements for California's Regional Haze Workshops for this planning period were posted on CARB's Tribal Relations website and were distributed to California tribes via email through the tribal listserv. Notification that the draft Regional Haze Plan was available for review and comment was provided through the tribal listserv.

## Procedures for Continuing Consultation

California will continue to engage with stakeholders on the implementation of the regional haze program requirements. Consultation with neighboring states and federal land managers will be accomplished through participation in the WRAP's regional haze planning efforts and direct communication. We will also continue to engage with FLMs through participation in the State's Air and Land Managers workgroup. Consultation will occur through teleconference, in-person meetings, and workshops as appropriate. Specific timelines for consultation established by the Regional Haze Rule will be met when developing progress reports and periodic updates to California's Regional Haze Plan. To ensure ready and open communication channels are in place, CARB staff or staff from the federal land management agency may initiate communication and request consultation at any point in the planning process.

# 10. Progress Report

This chapter will serve as California's second progress report, addressing the period since the submission of the State's first progress report. California's first progress report was approved by the Board at a public hearing on May 22, 2014 and submitted to the U.S. EPA on June 16, 2014. The first progress report covered visibility conditions through 2011 and progress made towards 2018 RPGs.

## Implementation Status of Measures

The long-term strategy articulated in California's first Regional Haze Plan relied upon already adopted CARB control measures for mobile sources and consumer products to reduce precursors of haze pollutants. Measures to address emissions from mobile sources were focused on requirements for cleaner engines and cleaner fuels. Measures to address emissions from consumer products were focused on requirements to reduce emissions of volatile compounds. CARB continues to actively work towards meeting air quality targets by developing stringent, technology forcing regulatory measures. Measures adopted by CARB between 2012 and 2018 are summarized in Table 10-1. Detailed descriptions and supporting documents for CARB rulemaking activities are available online.[28]

*Table 10-1: Measures Adopted by CARB between 2012 and 2018 with Date of Approval by the Office of Administrative Law*

| Regulatory Measure | Date(s) of Approval by Office of Administrative Law |
|---|---|
| LEV III Amendments to the CA Greenhouse Gas and Criteria Pollutant Exhaust and Evaporative Emission Standards and Test Procedures to the On-Board Diagnostic System Requirements for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, and the Evaporative Emission Requirements for Heavy-Duty Vehicles | 2012 |
| Amendments to Zero Emission Vehicle Regulation | 2012, 2014, 2015 |
| Amendments to Verification Procedures, Warranty, and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines | 2013 |
| Revisions to On-Board Diagnostic System Requirements for Heavy-Duty Vehicle Engines, Passenger Cars, Light-Duty Trucks, Medium-Duty Vehicles and Engines | 2013, 2016 |
| Amendments to the Regulations for Gasoline and Diesel Fuel Test Methods | 2013 |
| Regulation for State Implementation Plan Credit from Mobile Agricultural Equipment | 2014 |
| Amendments to the Evaporative Emission Control Regulation for Off-Highway Recreational Vehicle | 2014 |
| New Greenhouse Gas Emission Standards for Medium and Heavy-Duty Engines and Vehicles and Optional NOx Standards for Medium and Heavy-Duty Engines | 2014 |
| Amendments to Vapor Recovery Certification and Test Procedures for Underground and Aboveground Storage Tanks Used at Gasoline Dispensing Facilities | 2014, 2016, 2019 |

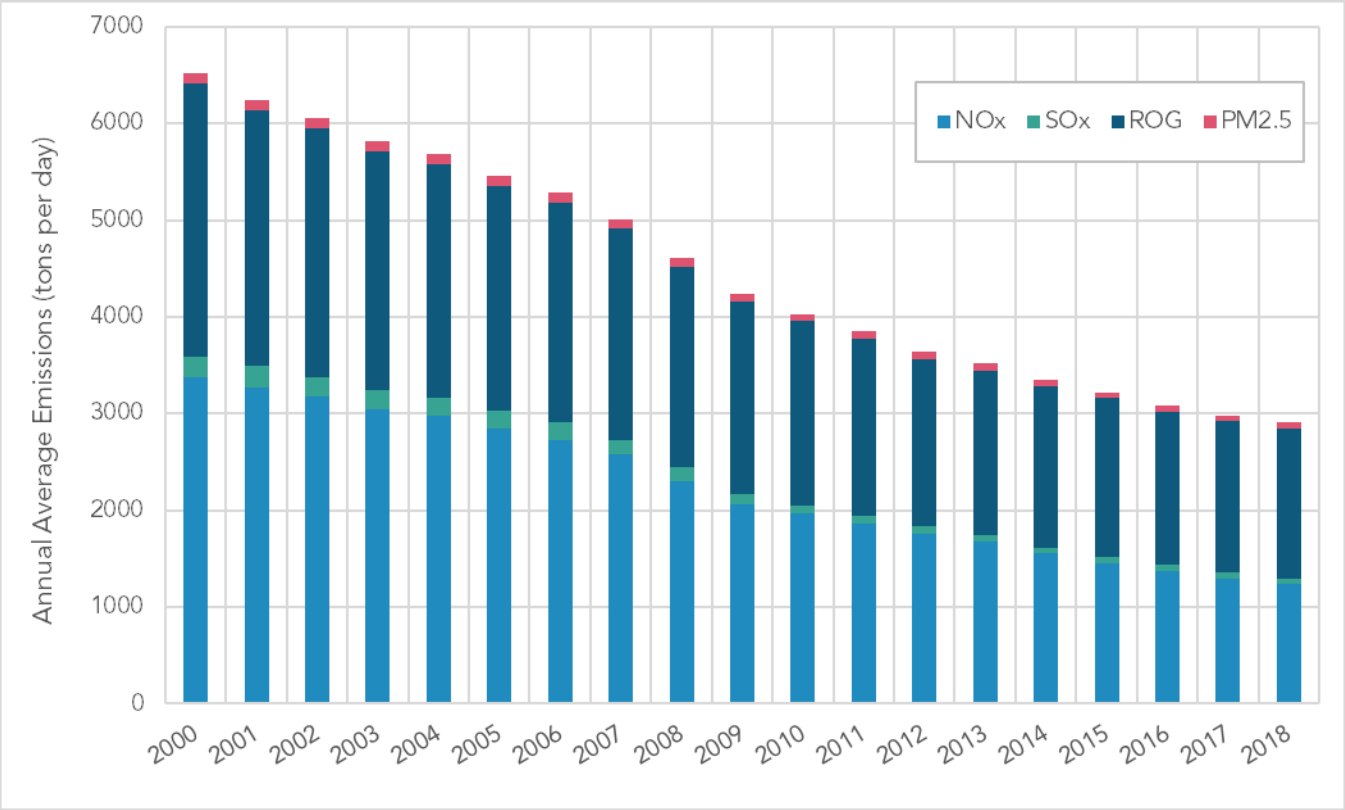
[28] *https://ww2.arb.ca.gov/rulemaking-activity*

| Regulatory Measure | Date(s) of Approval by Office of Administrative Law |
|---|---|
| Amendments to Truck and Bus Regulation | 2014 |
| Amendments to the Enhanced Fleet Modernization Program Regulation | 2015 |
| Amendments to Low Carbon Fuel Standard | 2015, 2019 |
| Amendments to the Regulation on Commercialization of Alternative Diesel Fuels | 2015, 2019 |
| Amendments to the LEV III Criteria Pollutant Requirements for Light and Medium-Duty Vehicles, the Hybrid Electric Vehicle Test Procedures, and the Heavy-Duty Otto-Cycle and Heavy-Duty Diesel Test Procedures | 2015 |
| Evaporative Emission Control Requirements for Spark-Ignition Marine Watercraft | 2016 |
| Regulation to Provide Certification Flexibility for Innovative Heavy-Duty Engines and California Certification and Installation Procedures for medium and heavy-Duty Vehicle Hybrid Conversion Systems | 2017 |
| Amendments to the Regulation for Small Containers of Automotive Refrigerant | 2017 |
| Amendments to the Portable Fuel Container Regulation | 2017 |
| Amendments to the Large Spark-Ignition Engine Fleet Requirements Regulation | 2017 |
| Amendments to the Aftermarket Diesel Particulate Filters Regulation | 2017 |
| Amendments to the Evaporative Emission Requirements for Small Off-Road Engines | 2017 |
| Amendments to the Consumer Products Regulation | 2018 |
| Amendments to the Low Emission Vehicle III Greenhouse Gas Regulation | 2018 |
| Amendments to the Enhanced Fleet Modernization Program and Guidelines for the Clean Cars 4 All Program | 2019 |
| Regulation for the Reporting of Criteria Air Pollutants and Toxic Air Contaminants | 2019 |
| Innovative Clean Transit Regulation | 2019 |
| Amendments to the Heavy-Duty Vehicle Inspection and Periodic Smoke Inspection Programs | 2019 |
| Revisions to On-Board Diagnostic System Requirements, Including the introduction of Real Emissions Assessment Logging for Heavy-duty Engines, Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines | 2019 |
| Amendments to CA Emission Control System Warranty Regulations and Maintenance Provisions for 2022 and Subsequent Model Year On-Road Heavy-Duty diesel Vehicles with Gross Vehicle Weight Ratings Greater than 14,000 Pounds and Heavy-Duty Diesel Engines in Such Vehicles | 2019 |
| CA Regulation and Certification Procedures for Light-Duty Engine Packages for Use in New Light-Duty Motor Vehicles for 2019 and Subsequent Years | 2019 |
| Amendments to CA Specifications for Fill Pipes and Openings of Motor Vehicle Fuel Tanks | 2019 |
| CA Greenhouse Gas Emissions Standards for Medium and Heavy-Duty Engines and Vehicles (Phase 2) and Amendments to the Tractor Trailer Greenhouse Gas Regulation | 2019 |

## Emission Reductions

Implementation of regulatory measures have led to significant reductions in emissions that serve as precursors to haze pollutants. Annual average emissions for NOx, SOx, ROG, and PM2.5 are shown in Figure 10-1. Emissions data reported in this summary may be slightly different than emissions data reported in California's first Regional Haze Plan, the progress report for the first implementation period, and other areas of this Regional Haze Plan. The differences arise from updated inputs and estimation procedures associated with inventory development over time and the tools available for the preparation of each of these documents.

*Figure 10-1: Statewide Annual Average Emissions of NOx, SOx, ROG, and PM2.5*




*Data Source: CARB CEPAM 2019 SIP Baseline Emission Projections Version 1.03*

Annual average emissions for NOx, SOx, ROG, and PM2.5 have decreased between the 2007 to 2011 time period reported on in the progress report for the first implementation period, and 2014 to 2018, the current period for this Regional Haze Plan. When annual averages for these periods are considered, NOx emissions have decreased 36 percent, SOx emissions have decreased 45 percent, ROG emissions have decreased 20 percent, and PM2.5 has decreased by 28 percent. Table 10-2 shows that emission reductions for each of these pollutants across the stationary, areawide, and mobile source categories have been achieved.

*Table 10-2: Statewide Five-year Annual Average Emissions by Source Category*

| Pollutant | Source Category | 2000-2004 (tpd) | 2007-2011 (tpd) | 2014-2018 (tpd) |
|---|---|---|---|---|
| NOx | Stationary | 423 | 292 | 221 |
| NOx | Areawide | 90 | 80 | 66 |
| NOx | Mobile | 2653 | 1782 | 1097 |
| NOx | **Total** | **3167** | **2154** | **1384** |
| SOx | Stationary | 128 | 69 | 44 |
| SOx | Areawide | 6 | 6 | 4 |
| SOx | Mobile | 72 | 34 | 12 |
| SOx | **Total** | **206** | **110** | **61** |
| ROG | Stationary | 505 | 399 | 369 |
| ROG | Areawide | 759 | 680 | 613 |
| ROG | Mobile | 1320 | 920 | 620 |
| ROG | **Total** | **2584** | **1999** | **1602** |
| PM2.5 | Stationary | 90 | 73 | 61 |
| PM2.5 | Areawide | 345 | 275 | 256 |
| PM2.5 | Mobile | 106 | 84 | 61 |
| PM2.5 | **Total** | **541** | **433** | **378** |

*Data Source: CARB CEPAM 2019 SIP Baseline Emission Projections Version 1.03*

These emission reductions have led to visibility improvements in Class I areas throughout California. NOx emissions from mobile sources remain the largest source category of emissions that contribute precursors to haze pollutants. The long-term strategy for this planning period continues to focus NOx emission reduction efforts on mobile sources.

Catastrophic wildfires continue to impact visibility in California's Class I areas. The duration and intensity of wildfire seasons have been increasing in recent years at unprecedented rates. A summary of wildfire emissions estimates developed by CARB staff are shown in Table 10-3. The five-year averages of PM2.5 emissions between the baseline period, 2000-2004, and the current period, 2014-2018, increased by nearly 200 percent. While the metric used to track progress for purposes of the Regional Haze Rule is designed to exclude impacts from episodic events like wildfires, these events do have impacts on visibility in protected areas. The substantial increase in fuels treatment projects called for in California's Wildfire and Forest Resilience Action Plan will be critical to mitigating the risk of catastrophic wildfires and reducing impacts of wildfire emissions. The increased use of prescribed fire will be an important component of the fuel treatment projects. The administration of California's

Smoke Management Program will be help ensure the use of basic smoke management practices to minimize impacts on Class I areas during prescribed burn projects.

*Table 10-3: Summary Statistics for Statewide Annual PM2.5 Emissions from Wildfires*

| | 2000-2004 Average (Range) | 2007-2011 Average (Range) | 2014-2018 Average (Range) |
|---|---|---|---|
| PM2.5 (thousand short tons) | 86 (42-141) | 152 (11-505) | 254 (104-421) |

*Data Source: CARB Wildfire Emissions & Burned Area Estimates 2000-2020*[29]

## Visibility Conditions

Visibility conditions on the most impaired days have improved at all Class I areas in California since the 2000-2004 baseline period (Table 10-4). Between the baseline and current periods, the amount of improvement ranged from 8 to 29 percent. Visibility conditions on the most impaired days for the current period ranged from 7.8 dv to 18.4 dv.

*Table 10-4: Visibility on the Most Impaired Days at IMPROVE Monitoring Sites Representing California Class I areas*

| IMPROVE Site | Baseline 2000-2004 (dv) | Progress Report 2007-2011 (dv) | Current 2014-2018 (dv) | Baseline – Current (dv) [% Improvement] | Progress Report - Current (dv) [% Improvement] |
|---|---|---|---|---|---|
| LABE1 | 11.3 | 10.4 | 9.7 | 1.6 [14%] | 0.7 [7%] |
| REDW1 | 13.7 | 14.0 | 12.6 | 1.1 [8%] | 1.4 [10%] |
| TRIN1 | 11.9 | 11.2 | 10.4 | 1.5 [13%] | 0.8 [7%] |
| LAVO1 | 11.5 | 10.5 | 10.2 | 1.3 [11%] | 0.3 [3%] |
| BLIS1 | 10.1 | 9.9 | 9.3 | 0.8 [8%] | 0.6 [6%] |
| PORE1 | 19.4 | 17.6 | 15.3 | 4.1 [21%] | 2.3 [13%] |
| YOSE1 | 13.5 | 12.7 | 11.6 | 1.9 [14%] | 1.1 [9%] |
| HOOV1 | 8.9 | 8.0 | 7.8 | 1.1 [12%] | 0.2 [3%] |
| KAIS1 | 12.9 | 12.1 | 11.0 | 1.9 [15%] | 1.1 [9%] |
| PINN1 | 17.0 | 15.7 | 14.1 | 2.9 [17%] | 1.6 [10%] |
| SEQU1 | 23.2 | 20.8 | 18.4 | 4.8 [21%] | 2.4 [12%] |
| RAFA1 | 17.3 | 15.6 | 14.1 | 3.2 [18%] | 1.5 [10%] |
| DOME1 | 17.2 | 16.4 | 15.1 | 2.1 [12%] | 1.3 [8%] |
| SAGA1 | 17.9 | 15.5* | 13.2 | 4.7 [26%] | 2.3 [15%] |
| SAGO1 | 20.4 | 17.1 | 14.4 | 6.0 [29%] | 2.7 [16%] |
| JOSH1 | 17.7 | 14.7 | 12.9 | 4.8 [27%] | 1.8 [12%] |
| AGTI1 | 21.6 | 18.7 | 16.3 | 5.3 [25%] | 2.4 [13%] |

**Represents average of annual visibility impairment in 2007 and 2008 only. Data from 2009-2011 were not available.*

[29] https://ww2.arb.ca.gov/sites/default/files/2021-07/Wildfire%20Emission%20Estimates%20for%202020%20_Final.pdf

As shown in Table 10-5, visibility conditions on the clearest days did not deteriorate at any Class I area in California. Rather, visibility conditions improved between the baseline and current periods. Visibility conditions on the clearest days for the current period ranged from 1.0 to 8.2 dv.

*Table 10-5: Visibility on the Clearest Days at IMPROVE Monitoring Sites Representing California Class I areas*

| IMPROVE Site | Baseline 2000-2004 (dv) | Progress Report 2007-2011 (dv) | Current 2014-2018 (dv) | Baseline – Current (dv) | Progress Report - Current (dv) |
|---|---|---|---|---|---|
| LABE1 | 3.2 | 2.9 | 2.5 | 0.7 | 0.4 |
| REDW1 | 6.1 | 5.5 | 5.3 | 0.8 | 0.2 |
| TRIN1 | 3.4 | 3.1 | 3.1 | 0.3 | 0.0 |
| LAVO1 | 2.7 | 2.4 | 2.2 | 0.5 | 0.2 |
| BLIS1 | 2.5 | 2.1 | 1.8 | 0.7 | 0.3 |
| PORE1 | 10.5 | 8.7 | 8.2 | 2.3 | 0.5 |
| YOSE1 | 3.4 | 2.6 | 2.9 | 0.5 | 0.3 |
| HOOV1 | 1.4 | 1.3 | 1.0 | 0.4 | 0.3 |
| KAIS1 | 2.3 | 1.6 | 1.5 | 0.8 | 0.1 |
| PINN1 | 8.9 | 7.8 | 7.7 | 1.2 | 0.1 |
| SEQU1 | 8.8 | 7.6 | 7.0 | 1.8 | 0.6 |
| RAFA1 | 6.5 | 5.3 | 4.9 | 1.6 | 0.4 |
| DOME1 | 5.1 | 5.0 | 4.4 | 0.7 | 0.6 |
| SAGA1 | 4.8 | 4.6* | 2.8 | 2.6 | 1.8 |
| SAGO1 | 5.4 | 4.0 | 3.3 | 2.1 | 0.7 |
| JOSH1 | 6.1 | 4.8 | 4.7 | 1.4 | 0.1 |
| AGTI1 | 9.6 | 7.2 | 7.0 | 2.6 | 0.2 |

**Represents average of annual visibility impairment in 2007 and 2008 only. Data from 2009-2011 were not available.*

Implementation of the long-term strategy articulated in California's first Regional Haze Plan, which relied upon already adopted CARB control measures for mobile sources and consumer products to reduce precursors of haze pollutants, has led to measurable emission reductions. These emission reductions have led to improved visibility on the most impaired days and prevented degradation of visibility on the clearest days. The implementation of the strategies laid out in the California's first Regional Haze Plan were sufficient to enable California and other states with Class I areas affected by emissions from California to meet established reasonable progress goals.

Under the current Regional Haze Rule, California's next Progress Report will be due January 31, 2025. The draft Progress Report will be made available for public inspection and comment for at least 30 days prior to submission to U.S. EPA.