



**Legislative Council Staff**  
*Nonpartisan Services for Colorado's Legislature*

# Memorandum

November 3, 2023

**TO:** Interested Persons

**FROM:** Colin Gaiser, Fiscal Analyst, 303-866-2677

**SUBJECT:** Overview of Ground-Level Ozone in Colorado

## Summary

This memorandum focuses on ground-level ozone, the harmful air pollutant that is the main ingredient of "smog." Ground-level ozone significantly impacts the health of Coloradans and the environment. It is also important to note that ground-level ozone differs from "good" ozone, or stratospheric ozone, which occurs naturally in the upper atmosphere and forms a protective layer that shields the earth from the sun's harmful ultraviolet rays.

## Causes of Ground-Level Ozone

*Ground-level ozone*<sup>1</sup> is not emitted directly into the air, but instead created by the reaction of heat and sunlight with chemicals such as oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOCs). These chemicals – also known as "ozone precursors" – are emitted by gasoline-powered vehicles, other equipment that runs on gas, and industry operations. Hot, dry, and sunny Colorado summers create ideal conditions for ground-level ozone to form, and even winter sunshine may lead to high levels of ozone pollution.

**Emissions.** According to *a 2017 report*<sup>2</sup> by the Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ), vehicle emissions and oil and gas production-related emissions are the largest contributors to local ozone production along the Northern Colorado Front Range Metropolitan Area (NFRMA). "On average, oil and gas emissions show a stronger influence in the northern part of the NFRMA and the northern foothills," the report concludes, "while mobile

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<sup>1</sup> "Ground-level Ozone Basics," United States Environmental Protection Agency.

<sup>2</sup> "Process-Based and Regional Source Impact Analysis for FRAPPÉ and DISCOVER-AQ 2014," Front Range Air Pollution and Photochemistry Experiment.



emissions dominate farther south and in the southern foothills.” On high ozone days, these sectors contribute an average of 30 to 40 percent each to total NFRMA ozone production. The report also found that prevailing daytime winds often transport ozone to the west and expose the foothills and mountains to air pollution.

**Wildfires.** Wildfire smoke contributes to the formation of ground-level ozone pollution as sunlight reacts with the ozone precursors in wildfire smoke. According to [a study](#)<sup>3</sup> published earlier this year in *Environmental Science and Technology*, even when the NO<sub>x</sub> in the smoke is gone, it may still create ground-level ozone along the Front Range. As plumes of smoke blow over populated areas, any VOCs in the smoke that have not already chemically reacted can mix with the abundant levels of NO<sub>x</sub> produced by the burning of fossil fuels. [A study](#)<sup>4</sup> by the National Oceanic and Atmospheric Administration (NOAA) found wildfire smoke was a “major contributor” to ground-level ozone pollution along the Front Range in the summer of 2021, when average ozone levels exceeded EPA health standards a record 67 times.

**Denver Cyclone.** The combination of specific meteorological conditions plus the terrain of the Front Range can produce a counter-clockwise rotation of air across the region known as the “Denver Cyclone.” This phenomenon can limit the area-wide dispersion of ozone and ozone precursors, as visualized in [this article from NASA](#).<sup>5</sup>

The cyclone effect will often produce stagnation conditions during the morning hours, which leads to a buildup of ozone precursors along the NFRMA. By afternoon, differential heating between the foothills and adjacent plains can lead to the upslope movement of warming air from the metro area and plains, carrying ozone precursors toward the foothills. Under hot and sunny conditions, this can often result in perfect conditions for ozone formation. Pollutants can also get trapped high aloft in the atmosphere and mix down to the surface the following day, which can lead to consecutive days of high ozone under certain meteorological conditions.

**Out-of-state contributions to ozone.** Background ozone from interstate and international sources is rising as cities and populations continue to grow. Regional modeling conducted by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division shows that up to 70 percent of the ozone concentrations in certain areas of Colorado come from ozone precursors that move into Colorado from other states and even Canada and Mexico.<sup>6</sup>

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<sup>3</sup> “Influence of Wildfire on Urban Ozone: An Observationally Constrained Box Modeling Study at a Site in the Colorado Front Range,” *Environmental Science and Technology*, 2023.

<sup>4</sup> “Were Wildfires Responsible for the Unusually High Surface Ozone in Colorado During 2021?” *JGR Atmospheres*, 2023.

<sup>5</sup> “A Rising Problem: Tackling Denver’s ozone requires looking high and low.” *NASA EarthData*, 2017.

<sup>6</sup> “Addressing High Ozone Background Levels Under the Clean Air Act,” *Western Regional Air Partnership*, 2017.



Colorado and the federal government operate “background” monitoring stations in parts of the state where there are virtually no man-made sources of pollution in the area, such as *atop Gothic Mountain near Crested Butte*. At times, these monitors *show ozone concentrations near the 2015 EPA standard of 70 parts per billion*.<sup>7</sup> Regional modeling has demonstrated that this background concentration is primarily made up of natural and out-of-state contributions, depending on prevailing winds and other meteorological conditions.

## Health Effects

High levels of ground-level ozone may cause immediate breathing problems and be harmful to human and animal health. Ground-level ozone may cause coughing, throat irritation, and chest pains, and those with asthma might suffer more frequent asthma attacks. According to the EPA, prolonged exposure may have numerous long-term health consequences, including lung and cardiovascular disease and premature death.

Though everyone may experience ozone’s harmful effects, some people may be at greater risk. Those at greater risk include:

- people with lung disease such as asthma;
- children, including teenagers;
- older adults; and
- people who are active outdoors, including those who work outdoors.

**Further resources.** More information on the risks of ozone pollution may be found at the *Centers for Disease Control and Prevention* and the *Environmental Protection Agency*.

## Ozone Action Day Alert Days

The Air Pollution Control Division in the CDPHE issues daily ozone pollution forecasts from May 31 through August 31 each year. If the division forecasts that ozone will exceed the *National Ambient Air Quality Standard*<sup>8</sup>, it issues an Ozone Action Day Alert. An alert means the division forecasts a ground-level ozone pollution concentration of 70 parts per billion over an eight-hour average (this standard was reduced from 75 parts per billion in 2016). Figure 1 below shows the annual number of alert days during ozone season.

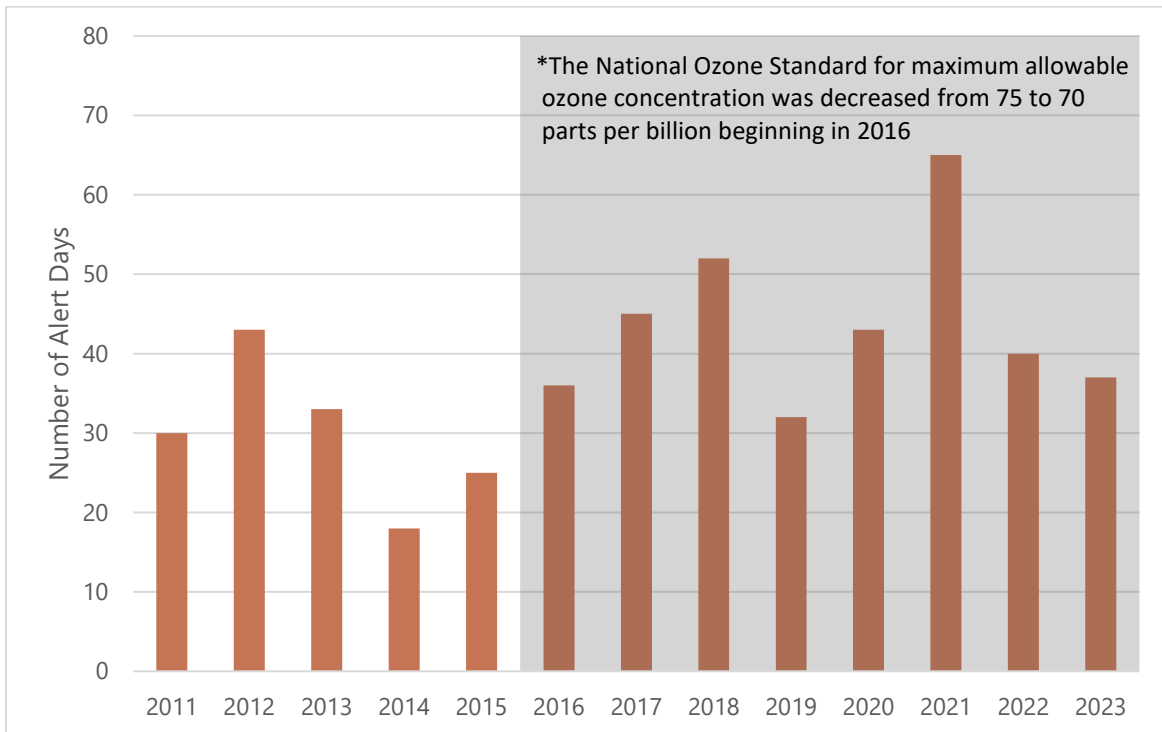
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<sup>7</sup> “Annual 8-hour Daily Maximum Ozone Concentration.” Environmental Protection Agency, 2021.

<sup>8</sup> “Ozone (O3) Air Quality Standards,” United States Environmental Protection Agency.



**Figure 1**  
**Annual Ozone Action Day Alerts**  
*May 31 through August 31*



Source: Colorado Department of Public Health and Environment.

There were 37 Ozone Action Day Alerts in 2023. In Colorado, the highest number of ozone alert days occurred in 2021, with 65 ozone action alert days. There were an additional 10 alert days in September of that year. Although the traditional summer ozone season ends on August 31, high ozone days may extend into early September depending on meteorological conditions.

If an Ozone Action Day Alert is issued, CDHPE recommends that people avoid rigorous activity during the heat of the day. Other recommendations include choosing a cleaner commute, such as carpooling or using public transportation, and deferring any lawn and gardening chores that require gasoline-powered equipment.



## Efforts to Reduce Ground-Level Ozone

While Colorado’s air quality has improved over the past several decades, the state – and especially the Denver metro area and the Front Range – is still addressing ozone pollution. The EPA *announced in September 2022*<sup>9</sup> that it had reclassified Denver and several counties along the Front Range as a “severe” nonattainment area under federal air quality standards. Unless EPA grants a waiver, the severe label requires motorists in summer months to use a special blend of gasoline, starting in the summer of 2024, that reduces harmful greenhouse gas emissions. This may lead to higher gas prices and increase the number of businesses required to apply for air pollution permits.

The Air Pollution Control Division, the Air Quality Control Commission, and the Regional Air Quality Council, along with other local partners, are continuously evaluating and implementing control strategies aimed at reducing emissions and ozone precursors. These strategies include:

- pursuing new technologies to control emissions;
- developing State Implementation Plan requirements for both nonattainment and attainment areas;
- adopting contingency measures if an area fails to reach attainment; and
- developing emission inventories for milestone years and tracking progress toward air quality goals.

## Recent Legislation

In recent years, the legislature enacted legislation with the intent to reduce ground-level ozone and improve air quality in Colorado.

### House Bill 23-1101 Ozone Season Transit Grant Program Flexibility

The bill updated the eligibility requirements of the Ozone Season Transit Grant Program by allowing an eligible transit agency that operates where ozone levels are typically highest during a period different than June 1 through August 31 to designate an alternate period for its “ozone season.”

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<sup>9</sup> “EPA says Colorado Front Range now a ‘severe’ air quality violator: Here’s what it means,” Coloradoan, 2022.



### House Bill 23-1294 Pollution Protection Measures

The bill created the Legislative Interim Committee on Ozone Air Quality, and updated requirements for how the Air Quality Control Commission in CDPHE and Colorado Energy and Carbon Management Commission in the Department of Natural Resources (DNR) regulate pollution control measures.

### Senate Bill 22-193 Air Quality Improvement Investments

The bill created a number of grant programs to fund voluntary efforts to reduce air pollution. It also modified certain definitions, form and filing requirements, hearing deadlines, and the legislative review process for revisions to the State Implementation Plan in the CDPHE air quality control program. These grant programs included:

- The **Industrial and Manufacturing Operations Clean Air Grant Program** in the Colorado Energy Office (CEO) to help private entities, local governments, tribal governments, and public-private partnerships finance voluntary projects to reduce emissions of air pollutants from industrial and manufacturing operations;
- The **Community Access to Electric Bicycles Grant Program** in the CEO to finance bike share programs and ownership programs administered by local governments or nonprofit organizations;
- The **Cannabis Resource Optimization Cash Fund** administered by the CEO to provide assessments of financing, grants, credit enhancement offerings, and direct incentives to producers to reduce energy and water uses, promote renewable energy, and encourage sustainable practices in cannabis operations; and
- The **Electrifying School Buses Grant Program** in the CDPHE to help school districts and charter schools finance the conversion and replacement of fossil fuel-powered school buses with electric-powered school buses.

### House Bill 22-1244 Public Protections from Toxic Air Contaminants

The bill created a new program in the CDPHE to regulate toxic air contaminants (TACs) based on adverse health effects. Toxic air contaminants are defined in the bill as hazardous air pollutants, covered air toxics, and any other air pollutant designated by the Air Quality Control Commission. As required by the bill, the CDPHE *published an initial list of TACs* in October of 2022 (revised in June 2023 to eliminate typographical errors). Beginning no later than September 30, 2030, and every five years thereafter, the Air Quality Control Commission must review the list of TACs and determine by rule whether to add additional TACs to the list.



### **Senate Bill 22-180 Programs to Reduce Ozone through Increased Transit**

The bill created the Ozone Season Transit Grant Program in the CEO to help transit agencies provide new or expanded free transit services during ozone season, defined as the period from June 1 through August 31 of each year. It also established a pilot project in the Transit and Rail Division of CDOT to increase ridership on state-run transit, reduce vehicle travel, and reduce ground-level ozone.

### **Senate Bill 20-204 Additional Measures to Protect Air Quality**

The bill created the *Air Quality Enterprise* to conduct air quality modeling and monitoring, and provide emission mitigation services. The enterprise is currently soliciting an organization “to conduct research related to ozone pollution, the State of Colorado's ozone State Implementation Plan (SIP) model, and ozone precursor emissions characterization.”