CLIMATE CHANGE IS THREATENING AIR QUALITY ACROSS THE COUNTRY

Source: Wikipedia

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Research brief by
Climate Central

CLIMATE CENTRAL

Climate Change is Threatening Air Quality Across the Country

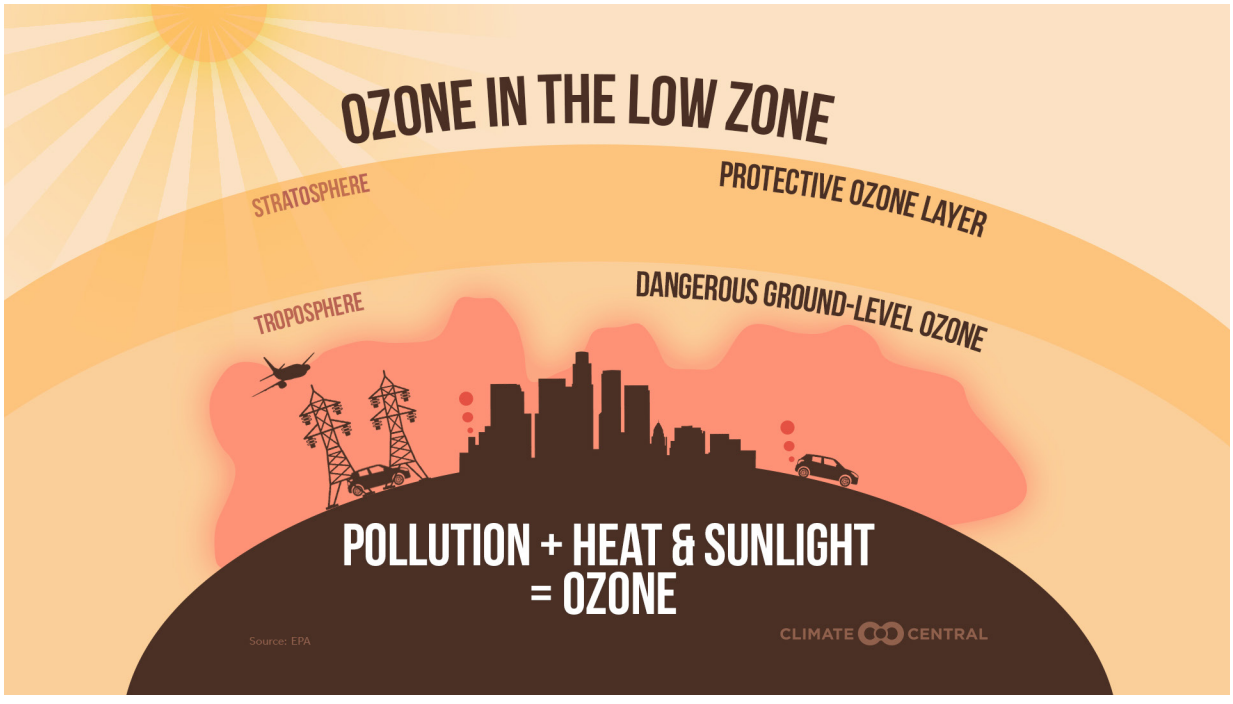
As summers heat up, the air we breathe is increasingly at risk of becoming unhealthy, despite decades of air quality improvements.

Hotter summers come with an increase in "stagnation events"—stationary domes of hot air that can cause air pollutants to get trapped and persist in the lower atmosphere. Climate Central found a positive correlation between summer maximum temperatures and the number of summer stagnant days in 98% of the contiguous U.S. cities analyzed. Further, the data showed that stagnation events are becoming more prevalent, with the number of annual stagnant days increasing in 83% of the cities.

These stagnant days set up the perfect conditions for ground-level ozone, a dangerous air pollutant, to develop. "Ozone season," the period when states and communities monitor local air quality for unhealthy levels of ozone, is now year-long in eight states and in dozens of urban areas across the country.

Looking at ozone levels in 244 locations, Climate Central identified 54 cities with an "ozone problem," defined as either having a high number of unhealthy ozone days or experiencing a recent increase in unhealthy ozone days, potentially posing a threat to the long-term trend of air quality improvement.

Exposure to high levels of ozone has long been known to have serious health consequences, especially for children, the elderly, people with cardiovascular or lung diseases, and for those who work outside. Recent research also shows that low levels of ozone exposure can be hazardous for anyone spending time outdoors. As our climate heats up, increasing numbers of the U.S. population could be exposed to unhealthy ozone days, leading to more hospital and emergency room visits, missed school and work, and long-term health risks.



OZONE: THE GOOD, THE BAD, THE DIRTY

High-altitude ozone is a gas made up of three oxygen atoms that forms naturally in the upper atmosphere. This stratospheric ozone is essential to our existence, protecting our planet from harmful ultraviolet radiation from the sun, like a benevolent layer of SPF for the Earth.

Ground-level ozone is chemically equivalent to high-altitude ozone, but is not formed naturally. Rather, it is a byproduct of two pollutants (nitrogen oxides and volatile organic compounds) that react in the presence of heat and sunlight. Emissions from chemical and industrial plants, electric utilities, refineries, exhaust from cars and trucks, and increasingly wildfire smoke and oil and gas extraction are sources of these pollutants. Ground-level ozone doesn't rise into the stratosphere, but builds up at the Earth's surface where we live and breathe. Ozone is colorless on its own—an invisible pollutant—although it has a distinctive smell and is a primary component of smog. A slow-moving high pressure system, with no wind or rain to wash the pollution away, can contribute to increased concentrations of ground-level ozone that not only make it uncomfortable to breathe, but can be unhealthy or even dangerous for vulnerable populations including children, the elderly, and people with asthma or other lung diseases.

Urban areas tend to be most impacted by ground-level ozone, but winds can transport ozone hundreds of miles away to rural regions as well. Both the formation and transport of ozone are greatly influenced by weather conditions and topography.

MILLIONS OF AMERICANS LIVE IN AREAS WITH AN "OZONE PROBLEM"

Using county-level data collected by the U.S. Environmental Protection Agency (EPA), Climate Central looked at the annual number of unhealthy ozone days—those exceeding the current EPA standard —for 244 U.S. cities since 2000. We studied the average annual number of unhealthy ozone days over the period 2000 to 2014, as well as for each of the past four years. This 19-year timeframe allowed us to observe the historical average of unhealthy ozone days in the wake of emission controls implemented to meet requirements of the Clean Air Act of 1970, as well as during the last four years when episodes of high heat occurred.

Overwhelmingly, the data showed that air quality has improved in most cities since the early part of this century. Yet 40 cities had at least 20 unhealthy ozone days since 2015—including four cities that had more than 300. Another 14 cities had fewer unhealthy days overall, but experienced an uptick in unhealthy ozone days in recent years, a potential sign that progress is stagnating or slowing.

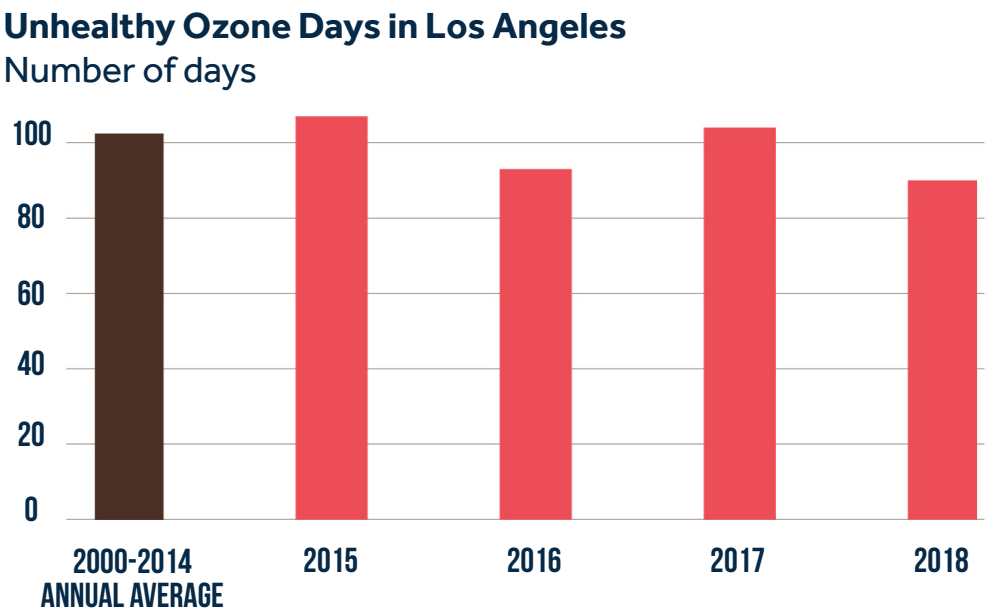
And while the United States overall experienced a 16 percent decrease in unhealthy ozone levels since 2000, there are currently 124 million people living in 201 counties that are not in attainment with national air quality standards for ozone. As the climate continues to warm, bringing hot and sunny conditions that create more ground-level ozone, these areas (and many others) will likely have a difficult time meeting federal health-based standards for ozone.

HIGHLIGHTS OF CITIES WITH OZONE PROBLEMS

WEST AND SOUTHWEST

The West and Southwest have seen a decline in unhealthy days over the last 19 years, but a number of cities in these regions are experiencing the highest number of unhealthy ozone days in the country overall. The high ozone levels could result from several interacting factors, including but not limited to higher temperatures, topography, increased emissions of ozone-forming chemicals from more frequent wildfires, high levels of automobile emissions, and an increase in gas and oil extraction operations.

- California has some of the worst air quality in the nation. **Palm Springs** had the highest 2000-2014 average of 130 unhealthy ozone days per year and also had 450 days occur since the start of 2015. **Los Angeles** experienced 103 unhealthy days per year on average from 2000-2014, but recently saw unhealthy days happen even more frequently, with 107 days in 2015 and 104 days in 2017.
- Oil and gas extraction is likely having an effect on increased ozone levels in Colorado, according to a 2017 CIRES study. **Denver's** ozone levels improved down to 0 unhealthy days in 2017, but spiked back up to 7 days in 2018,



Los Angeles County data
Annual number of days the 8-hour ozone max exceeded the current NAAQS of 0.070 ppm
Source: EPA Air Quality System

which was higher than the average during the 2000-2014 period. **Colorado Springs** similarly saw an increase to 7 days in 2018 from just 1 unhealthy ozone day in 2015.

- In Nevada, lingering wildfire smoke and high temperatures increased unhealthy ozone days last year. **Las Vegas'** average of about 45 days a year of unhealthy ozone between 2000 and 2014 was nearly cut in half from 2015 to 2017. But last year the unhealthy days skyrocketed back to 46. **Reno** also had an unhealthy 2018, with nearly 20 high ozone days, compared to an average of about 7 from 2000-2014.
- **Houston** has the worst ozone record in Texas, with an average of 46 annual unhealthy days from 2000-2014 and 97 days total over the last 4 years. **Dallas** saw a drop to just 3 unhealthy days in 2016 compared to 31 days on average in the 2000-2014 period—but the number of unhealthy days rose to 7 in 2017 and 14 in 2018. **El Paso** had 14 unhealthy days in 2018, nearing its average of 18 days from 2000-2014. Austin recorded a similar pattern, with just 1 unhealthy ozone day in 2016, down from 14 on average, but an increase to 3 in 2017 and 6 days in 2018.
- **Phoenix**, which was the nation's fastest growing city last year (with a population over 50,000), averaged 37 unhealthy ozone days over the last 4 years, and had an average of 55 per year from 2000-2014.
- **Salt Lake City** had significantly more unhealthy ozone days in 2017 and 2018 than on average during the 2000-2014 period. Last year, Salt Lake City had 31 unhealthy ozone days compared to an average of about 22 per year in 2000-2014. A number of factors may be contributing, including its increasing population and its bowl-like topography which can act as a trap for pollutants.

PACIFIC NORTHWEST

Our analysis shows that a number of cities in the Pacific Northwest have an ozone problem. Despite their relatively few unhealthy ozone days, such days have increased over the last few years. Overall, the region experienced an 8% increase in unhealthy ozone levels over the last 19 years—the only NOAA/NCEI region that did not improve during that time period.

- In 2017, **Seattle** had 12 days of unhealthy ozone—a year in which the city went for a record 56 days without rain—and 6 days in 2018. This is an increase from about 4 days on average between 2000 and 2014.
- **Portland, Oregon** had just 2 unhealthy ozone days in each of the last 2 years, but this is up from about a half day on average per year from 2000-2014. Similarly, **Medford, Oregon** went from fewer than 2 days per year from 2000 to 2014 to 6 days in 2018.

MIDWEST

Midwestern cities have also shown marked improvements in bad ozone days, but there are signs that this progress is plateauing as heat indexes climb.

- **Chicago's** unhealthy ozone days have been consistent in the last three years, similar to its annual average of 19 unhealthy days from 2000 to 2014.
- **Louisville, Kentucky** has seen a drop from an average of 21 unhealthy days from 2000-2014 to just 7 in 2015, but has averaged 9 unhealthy days over the last 3 years.
- After an average of 14 unhealthy ozone days in **Detroit** from 2000-2014, the city had only 3 unhealthy ozone days in 2015. But the improvements plateaued at about 7 days each year between 2016 and 2018.
- **Memphis** notched similar vast improvements in the number of unhealthy ozone days, from 25 annually on average between 2000 and 2014 to just 3 in 2015. But the numbers showed an uptick to 6 in 2016 and 8 in 2018.

NORTHEAST AND SOUTHEAST

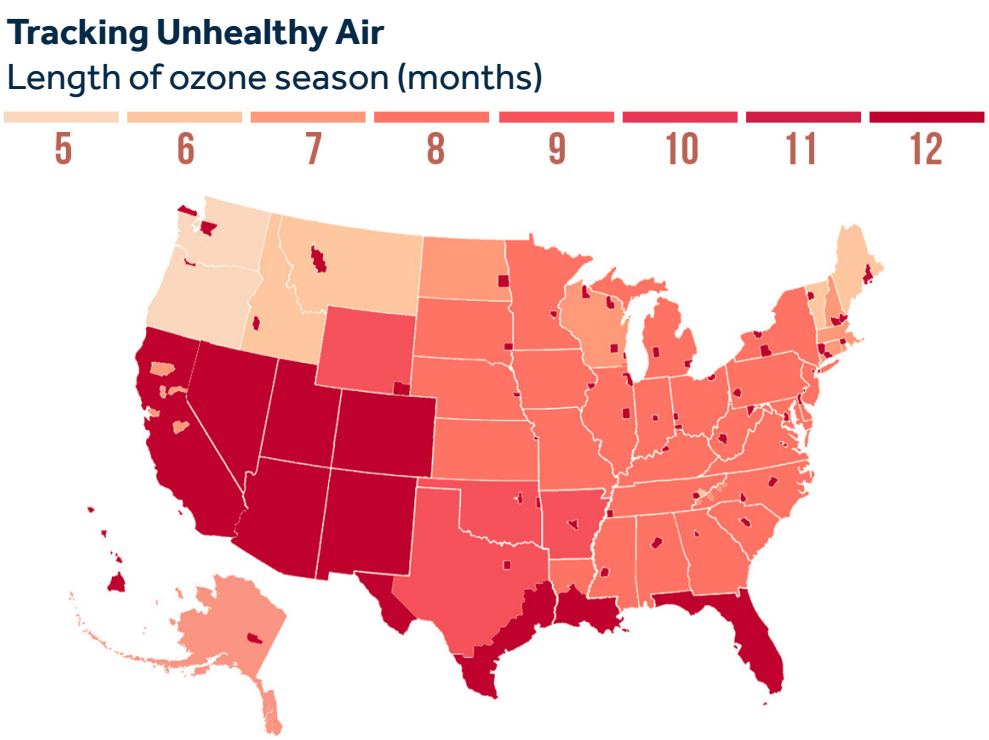
Most communities across the Eastern seaboard saw a decrease in unhealthy ozone days in recent decades hold steady, although our analysis revealed a number of cities with an increase in unhealthy days over the last 4 years. The EPA has acknowledged that its air quality programs have helped to reduce interstate transport of ozone in the eastern United States, in which air pollution from upwind states crosses state lines and affects air quality in downwind states. These air quality improvements are also likely being supported by a major decline in coal consumption since 2007 and recent closures of older coal-fired power plants throughout the Midwest.

- Our nation's capital improved from 21 days of unhealthy ozone on average between 2000 and 2014, but **Washington, D.C.** still had 5 days of unhealthy ozone levels on average over the last 4 years.
- In 2018, **New York City** reported a rise to 10 days of unhealthy ozone levels, compared to 4 days or fewer in the previous three years and compared to about 7 days on average in the 15 years prior.
- **Providence** saw improvement from nearly 11 annual days of unhealthy ozone on average from 2000-2014 to just 4 days each in 2015 through 2017, but an uptick to 8 days in 2018.
- **Philadelphia** had 24 unhealthy days on average from 2000 to 2014, and while the number of unhealthy ozone days has fallen, the city experienced 45 unhealthy days over the last 4 years, the highest number among the East Coast cities on our list. Similarly, **Pittsburgh** improved from 25 days on average between 2000-2014 to under 10 days in each of the past 4 years, but still experienced 33 unhealthy days since 2014.
- **Atlanta** has experienced local unhealthy ozone days decline from 26 on average between 2000 and 2014, to fewer than 5 in 2018. Still, the city had 32 unhealthy days over the last 4 years.
- **Tampa** improved from 16 high ozone days on average between 2000-2014 to just 1 unhealthy ozone day in 2015. However, unhealthy days have ticked back up to 4 days in 2018.

OZONE SEASON ISN'T JUST FOR SUMMER ANYMORE

"Ozone seasons" are designated time periods when ground-level ozone typically reaches its highest levels and requires monitoring. Intensely sunny, hot days are most conducive for chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC) to create ground-level ozone. Ozone season is generally associated with summer months, but the length of the season is set to match the times of year when ozone is most likely to approach unhealthy levels, so it varies from state to state and tends to be longer in highly populated areas.

Ozone levels are typically elevated in urban areas, partly due to the urban heat island effect. In cities, vast amounts of pavement and traditional asphalt or shingled roofs soak up more heat than do fields and forests; this heat is then trapped more efficiently overnight, keeping the city hotter than rural and suburban environments that have more trees and vegetation. Further, cities often have more vehicles, manufacturing, power plants, and other sources of emissions that are the precursors to ozone.



In 2015, the U.S. Environmental Protection Agency lowered the standard for ozone from .075 ppm (parts per million) to 0.070 ppm to improve public health outcomes. They also extended the ozone season in 32 states, as a review showed that ozone levels that either exceeded or approached the new standard were occurring outside the previous seasons when states were required to monitor it.

The ozone season is now monitored year-round in 8 states: Florida, Nevada, Hawaii, Arizona, New Mexico, Utah, Colorado, and California (save for a few counties). Many counties across southern Texas and the lower half of Louisiana also monitor for ozone 12 months a year. Only two states have ozone seasons shorter than a half year—Washington and Oregon—but both have counties with year-round ozone seasons. And the EPA lists 192 sites in counties around the country that currently monitor year-long ozone seasons, generally corresponding with highly populated urban areas.

CLIMATE CHANGE, STAGNATION, AND AIR QUALITY ARE ALL LINKED

Heat and stagnation are closely linked. Climate Central analyzed summer high temperatures and used data from the NOAA/NCEI Air Stagnation Index, which incorporates upper atmospheric winds, surface winds, and precipitation to identify the number of stagnant days in a month. Looking back to 1973 when the index began, 98% of the cities analyzed show a positive correlation between summer maximum temperatures and the number of summer stagnant days.

Stagnation is happening more frequently. Since the NOAA/NCEI Air Stagnation Index began in 1973, annual stagnant days have increased in 83% of the contiguous U.S. cities analyzed. McAllen, Texas tops the list with 36 more days per year on average, followed by Los Angeles and San Francisco (where stagnation is less correlated with the heat). The largest increases have occurred across the South and West Coast as well as the East, while most of the decreases have occurred in the Mountain West. As the climate warms, stagnant days are projected to increase further, with up to 40 more days per year by late-century.

And stagnation impacts air quality. When the air is stagnant, pollutants react together in the heat and sun, and high concentrations of ground-level ozone can build up.

To protect human health under the Clean Air Act, the U.S. Environmental Protection Agency requires states to adopt plans to achieve and maintain National Ambient Air Quality Standards (NAAQS) for pollutants like ozone and particle pollution.

EPA's regulations have had a pronounced effect, with many communities across the United States experiencing improved air quality and lower ozone levels while the population and economy have continued to grow. However, air quality is localized and very sensitive to weather, and consequently to climate change. As shown by the Climate Central analysis, ozone levels are recently plateauing or are on the rise in some localities as the climate heats up. Emissions of human-made ozone precursors have been on the decline in the United States, due to better air quality policies and cleaner technologies, and this trend is expected to continue. But as the climate continues to warm, unhealthy ozone days are projected to worsen in some areas in the years ahead. This effect is known as the "climate penalty," though higher levels of atmospheric water vapor (another effect of climate change) may help ameliorate the effect in some places. With hotter temperatures projected, more air stagnation days, and increases in natural emissions from wildfire smoke, the climate penalty will make it difficult for many areas of the country to achieve mandated air quality standards.

OZONE AND YOUR HEALTH

Even just a few unhealthy ozone days a year pose health concerns, as an increasing number of health risks are being linked to exposure to ozone and other air pollutants. According to the American Lung Association, ozone pollution is associated with asthma attacks; pneumonia; coughing and shortness of breath; cardiovascular damage; increased susceptibility to infections; and decreased lung functions. Ozone can cause developmental issues in children, and increase the risk of reproductive harm in adults. Studies have shown that hospital admissions and visits to the emergency room for asthma are increased due to elevated ozone levels.

Additionally, a number of vulnerable populations are at higher risk when exposed to ozone. School-age children with still-developing lungs are at increased risk for long-term damage, including developing asthma. Compared to adults, children tend to be more active outside and breathe in more air per pound of body weight, therefore taking in a "higher dose" of ozone. In times of extreme heat or cold, the effects of short-term ozone exposure have been shown to increase rates of mortality, especially for women and the elderly.

WHAT YOU CAN DO

Protect your health:

- Enter your zip code into EPA's Air Quality Index to find out conditions in your area. The color-coded charts provide guidance on health risks and which activities are safe for various populations.
- Avoid exercise or working outside on high ozone days.

Prevent more ozone from forming on hot, dry days:

- Limit your driving as much as possible—carpool, take public transportation.
- Don't let your engine idle.
- Electric vehicles don't emit pollutants and have been found to be better for air quality and climate change, even if their electricity is derived from fossil fuels.
- Refrain from barbecuing or using your fire pit.
- Postpone any painting projects unless the paints are VOC-free. Solvent gases from many paints include VOCs that can contribute to ground-level ozone formation.
- Fuel your vehicle in the early morning or later evening, since sunlight triggers ozone formation.
- Mow your lawn late in the evening or if possible, use electric lawn equipment instead of gasoline-powered equipment.

METHODOLOGY

Ozone Analysis:
Climate Central analyzed daily ozone data for the counties of 244 cities from 2000-2018, as obtained from the EPA Air Quality System. Annual unhealthy ozone days were calculated for each county as well as a 2000-2014 annual average. An "unhealthy" ozone day is defined as one where the 8-hour max exceeds the most current NAAQS standard of 0.070 ppm (equivalent to an AQI value greater than 100). To highlight areas with an ozone problem, locations were identified that had either:

- A large number of ozone days over the past four years in terms of pure count (greater than 20 days over the past four years)
- An increase in recent years (a continuous increase in days over at least 3 of the past 4 years)
- More ozone days in a single recent year (2015-2018) than their 2000-2014 average

Stagnation Analysis:
Climate Central analyzed gridded stagnation data from the NOAA/NCEI Air Stagnation Index, calculating annual trends since the dataset began in 1973. Correlation plots were created using annual average summer (June, July, and August) maximum temperature data obtained from the Applied Climate Information System and summer stagnation data from NOAA/NCEI. Although winter stagnation can greatly reduce the air quality in places like Salt Lake City, it is not fundamentally driven by increasing hot days which is the focus of this Climate Central analysis.