Trouble in the Air

Millions of Americans Breathe Polluted Air

Environment Ohio Research & Policy Center

Frontier Group

Ohio PIRG Education Fund

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Executive Summary

People across America regularly breathe unhealthy air that increases their risk of premature death, asthma attacks and other adverse health impacts.

In 2016, **73 million Americans experienced more than 100 days of degraded air quality** with the potential to harm human health**.** That is equal to more than three months of the year in which smog and/or particulate pollution was above the level that the EPA has determined presents "little to no risk." Millions more people in urban and rural areas experienced less frequent but still damaging levels of air pollution.

To safeguard public health, the nation needs to preserve and strengthen existing air quality protections at the federal and state level and move to reduce the future air pollution threats posed by global warming.

Burning fossil fuels such as coal, diesel, gasoline and natural gas creates air pollution in the form of smog, particulates and air toxics. Wildfires, wood stoves, agricultural dust and other sources create additional air pollution. There is no documented safe level of exposure to some of these pollutants.[1]

- Smog, or ground-level ozone, causes a host of respiratory problems, ranging from coughing, wheezing and throat irritation to asthma, increased risk of infection, and permanent damage to lung tissue.[2]
- Particulate pollution ($PM_{2.5}$) can cause similar respiratory harm and also trigger a range of cardiovascular problems, including heart attacks, strokes, congestive heart failure, and reduced blood supply to the heart.[3] These problems can result in increased hospital admissions and premature deaths. Particulate pollution has also been shown to trigger premature birth, raise the risk of autism, stunt lung development in children, and increase the risk that they may develop asthma.[4] Recent studies also implicate particulate pollution in an increased risk of dementia.[5]
- Levels of air pollution that meet current federal air quality standards can be harmful to health, especially with prolonged exposure. Researchers can detect negative health impacts, such as increased premature deaths, for people exposed to pollution at levels the EPA considers "good" or "moderate."[6] Current federal standards are less stringent than those recommended by the World Health Organization. They may also fail to reflect the impact of frequent exposure to moderate levels of pollution. For these reasons, the analysis in this report includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Millions of Americans live in urban and rural areas that experience frequent smog and/or particulate pollution.

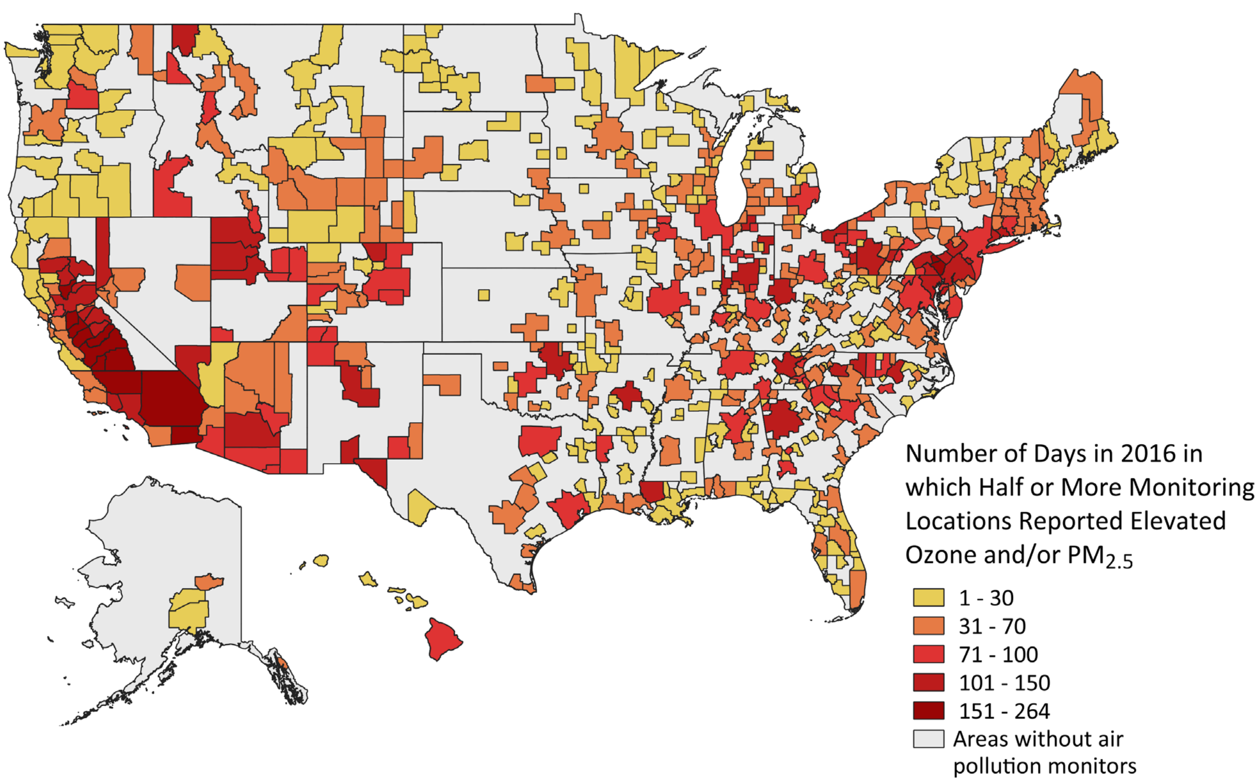
- 56 metropolitan and micropolitan areas and four rural counties experienced more than 100 days on which smog and/or particulate pollution was "moderate" or higher – in other words, above the level that the EPA has

Table ES-1. Ten Most Populated Metropolitan Areas with More than 100 Days of Elevated Air Pollution in 2016

Metropolitan Area	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated Ozone and/or $PM_{2.5}$	Population
Los Angeles-Long Beach-Anaheim, CA	138	13,328,261
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	111	6,077,152
Atlanta-Sandy Springs-Roswell, GA	118	5,795,723
Phoenix-Mesa-Scottsdale, AZ	110	4,648,498
Riverside-San Bernardino-Ontario, CA	209	4,523,653
Baltimore-Columbia-Towson, MD	114	2,801,028
Pittsburgh, PA	121	2,341,536
Sacramento–Roseville–Arden-Arcade, CA	105	2,295,233
Cincinnati, OH-KY-IN	119	2,166,029
Las Vegas-Henderson-Paradise, NV	145	2,156,724

Note: This count includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Figure ES-1. Both Urban and Rural Areas Experienced Frequent Smog and/or Particulate Pollution in 2016[7]



determined presents "little to no risk." Seventy-three million Americans live in those places. (See Table ES-1.)

- Another 241 urban areas and 42 rural counties faced 31 to 100 days – a month or more – of smog and/or particulate pollution above the "little to no risk" level. Those places include large metropolitan areas such as Chicago, Miami and Hartford, and smaller communities such as Macon, Georgia; Yuma, Arizona; and Gettysburg, Pennsylvania. These places are home to 173 million Americans.

Smog pollution is a frequent health threat in some regions.

- 8 million people, living in 12 urban areas and two rural counties, were exposed to more than 100 days of elevated smog pollution in 2016. All of those places were located in inland California, where the wind carries pollution from urban centers, and hot, sunny days facilitate the reaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs) that creates smog.

- Another 159 million residents of 208 areas breathed air with excess ozone pollution on 31 to 100 days in 2016. Those urban areas and rural counties were located in 38 different states, plus the District of Columbia.

Particulate pollution affected people living in a broad range of places in 2016.

- 21 million people, living in 21 urban and rural areas, were exposed to more than 100 days of elevated particulate pollution in 2016. These urban areas and rural counties were located in California, Georgia, Louisiana, Montana, New Jersey, North Carolina, Ohio, Pennsylvania and West Virginia.

- An additional 132 places, home to 154 million Americans, experienced 31 to 100 days of elevated particulate pollution. These areas include many of the nation's largest metropolitan areas, and also much less populated areas where wintertime wood-burning for heat and summertime wildfires create extensive particulate pollution.

Global warming threatens to exacerbate the nation's smog and particulate pollution problems.[8] Higher temperatures will facilitate formation of smog and altered wind patterns may increase the number of days with stagnant air that prevents dilution of contaminants.[9] Wildfires, which generate particulate pollution and smog precursors that can travel hundreds of miles, are predicted to become more frequent and intense.[10]

To reduce the pollution that threatens the health of people across the country, and to avoid global warming-related increases in air pollution in the future, the nation should:

- **Defend and build upon improvements in air quality achieved through rules implementing the Clean Air Act**. Pollution reductions achieved under regulations of the Clean Air Act Amendments of 1990 helped prevent more than 160,000 early deaths, 130,000 non-fatal heart attacks, and 41,000 hospital admissions in 2010 alone.[11] These benefits are in addition to those created by the original Clean Air Act. Maintaining the gains already achieved through implementation of the Clean Air Act and seeking greater emission reductions are crucial for ensuring that Americans can breathe cleaner air.

- **Strengthen federal fuel economy standards for cars and light trucks.** These standards are critical to the nation's efforts to reduce global warming pollution from passenger vehicles.

- **Continue to allow states to adopt stronger standards for pollution from vehicles to help reduce global warming emissions and health-threatening air pollution.** The clean car standards pioneered by 13 states plus the District of Columbia have been highly effective in reducing pollution.

- **Support policies at every level of government to reduce global warming pollution**, including increasing the use of wind, solar and other clean energy, and placing state and regional limits on climate pollution.

How Air Pollution Threatens Health

Air pollution is a threat to public health. Ground-level ozone and particulate pollution, along with other toxic air pollutants, are the by-products of burning fossil fuels like gasoline, diesel, coal and natural gas. Wildfires, agricultural activity and volcanoes also contribute to air pollution. When inhaled, these air pollutants cause respiratory and cardiovascular damage.

Smog

Burning fossil fuels creates nitrogen oxides (NO_x). Volatile organic compounds (VOCs) result from combustion or evaporation of gasoline, diesel and other petroleum fuels, from chemical solvents used in products such as cleaners or paints, and even from natural sources such as some plants.[12]

When NO_x and VOCs mix in the presence of sunlight, they form ozone – a powerfully reactive gas that is a principal component of smog. A natural layer of "good" ozone exists high in the atmosphere that protects us from exposure to ultraviolet radiation, but when pollutants create ozone near the ground it becomes a threat to public health. (As the impacts of global warming become more pronounced, smog pollution likely will become worse. See "Global Warming May Make Air Pollution Worse," p. 19.)

Ground-level ozone quickly reacts with airway tissues and produces inflammation analogous to a sunburn on the inside of the lungs. This inflammation makes lung tissues less elastic, more sensitive to allergens, and more prone to infections.[13]

Minor exposure to ozone can cause coughing, wheezing and throat irritation. Frequent exposure to ozone over time permanently damages lung tissues, decreases the ability to breathe normally, and exacerbates or even causes chronic diseases like asthma.[14]

Children, adults who are active outdoors, and people with pre-existing respiratory system ailments suffer most from ozone's effects. Children's vulnerability to air pollution is the result of several factors: their lungs are not yet fully developed; they spend more time outside; they breathe more air than adults do, relative to their size; and they are more likely to have asthma.[15] Asthma is a common reason that children are forced to miss school.[16]

On days with elevated levels of ozone pollution:

- Hospitals admit increased numbers of patients for respiratory and cardiovascular disease.[17] Scientists have estimated that on the most polluted summer days, smog pollution is responsible for up to half of all respiratory hospital admissions.[18]
- More people visit hospital emergency rooms for asthma, pneumonia and upper respiratory infections.[19]
- Children and adults suffer more asthma attacks, increased respiratory difficulty, and reduced lung function.[20]
- More adults miss work and more children miss school due to illness.[21]

Air pollution hangs over downtown Baltimore in this photo from early January 2016.[22] A winter weather condition, known as an inversion, can trap pollution from cars, industrial activity and other combustion sources close to the ground. The markings on the image show how the pollution lifted during the day as the air warmed up. Credit: Maryland Department of the Environment

Particulates

Particulate matter consists of extremely small particles that can contain hundreds of toxic chemicals. Fine particles, those of 2.5 micrometers or less, present the greatest health risk because such small contaminants can be inhaled deeper into the lungs and even enter the bloodstream.[23] Both short-term and long-term exposure to elevated levels of particulates can harm health.

Exposure to particulate pollution can cause many of the same respiratory problems as exposure to ozone, along with a range of cardiovascular problems, including heart attack, stroke, congestive heart failure, and reduced blood supply to the heart.[24] These problems can result in increased hospital admissions and premature deaths. Particulate pollution can also cause coughing, shortness of breath, asthma attacks, and increased emergency room visits.[25]

Children are particularly at risk from exposure to particulate pollution. For example:

- A pregnant woman's exposure to elevated levels of particulate pollution increases her risk of having her baby early. More than 15,000 preterm births in the U.S. in 2010 were likely the result of particulate pollution.[26]
- Exposure in utero to particulate pollution raises the risk that a child will have an autism spectrum disorder.[27] The higher the mother's exposure to particulate pollution, the higher the autism risk for her child.
- Particulate pollution may trigger changes in children's brains that are early physical markers of Alzheimer's disease.[28]
- Children who are exposed to elevated levels of particulates may experience irreversible

damage as particulate pollution interferes with lung growth and development.[29] Exposure to particulates may also cause children to be less able to fully inhale and more likely to develop asthma.[30]

- Short-term increases in particulate pollution may raise the risk that children will develop respiratory infections, such as influenza. A study of people living in Utah's Wasatch Front region, which includes Salt Lake City, found that more young children received medical care for lower-respiratory infections in the weeks following spikes in particulate pollution.[31]

Older people are vulnerable to neurological damage from particulate pollution. Older women who live in areas with higher levels of particulate pollution are more likely to develop dementia.[32] Another study that looked at both older men and women exposed to elevated ozone and particulate pollution found elevated Alzheimer's disease risk.[33]

Air Toxics

Fossil fuel combustion releases toxic air contaminants such as benzene, formaldehyde and 1,3-butadiene that contribute to smog and particulate pollution, and that are also hazardous on their own. At sufficient levels of exposure, these pollutants can irritate airways and lungs, cause asthma, worsen asthma symptoms, and cause leukemia and other types of cancer.[34] Levels of air toxics are not included in the analysis presented in this report.

Outdoor Air Quality Influences Indoor Air Quality

Outdoor air quality influences the quality of air inside homes, workplaces, day cares, schools and other buildings, where Americans spend approximately 90 percent of their time.[39] Ozone and particulate matter from outdoor air adds to air pollution from indoor sources, as do sulfur dioxide, nitrogen oxides and carbon monoxide. Polluted air can enter into buildings through ventilation systems, open windows and doors, and cracks and gaps in exterior walls.[40]

Indoor activities and products add to air quality problems inside buildings. Smoking tobacco, burning wood and cooking can all degrade indoor air quality.[41] For example, cooking with natural gas rather than electricity has been linked to respiratory harm in women.[42] Common household chemicals used for cleaning, home maintenance or hobbies, as well as in cosmetics, can release organic compounds that create health threats. As a result, the concentration of organic gases may be as much as five times higher indoors than outdoors.[43] Pesticides, products containing asbestos, and pressed-wood furniture that releases formaldehyde can add to indoor air pollution.

The share of total indoor air pollution that comes from outside sources varies greatly depending on the pollutant, the types and amount of activity taking place inside the building, the extent of ventilation that draws in outside air, and other factors.[44] For example, well-sealed buildings that have air filtration systems contain less particulate pollution from outdoor sources.

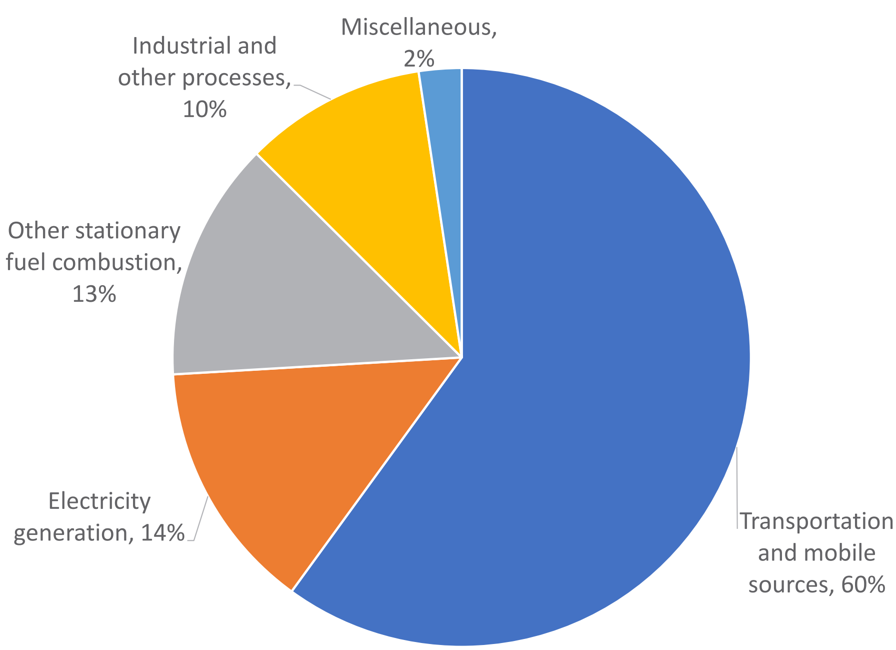
Steps to reduce outdoor air pollution will help to improve indoor air quality, but additional measures are needed to address indoor-specific sources of air pollution.

Sources of Air Pollution

Burning gasoline, diesel, coal and other fossil fuels for transportation, electricity generation, industrial processes, heating and other purposes is a major source of the NO_x and VOC emissions that create smog. Fossil fuel combustion, along with dust and fires, is a major contributor to particulate pollution, both by releasing particulates directly and by producing precursor chemicals that combine into particulates.

Nationally, on-road transportation – passenger vehicles, buses and trucks – is the biggest source of NO_x emissions.[35] Non-road vehicles – from airplanes and locomotives to construction and lawn equipment – are the next largest source. Together, these mobile sources account for more than half of NO_x emissions. Pollution from electricity generation is the next largest source of NO_x. (See Figure 1.)

Figure 1. Sources of Nitrogen Oxide Pollution in 2014[36]



Agricultural activity, wildfires and dust from unpaved roads are some of the largest sources of particulate pollution nationally, adding to pollution from fossil fuel combustion.[37] Fossil fuel combustion, however, is a major source of particulate pollution in the cities and suburban areas where most Americans live. A recent study of particulate pollution in Iowa found that pollution from gasoline and diesel engines added significantly to particulate pollution in urban areas.[38]

Appendix B provides state-by-state data on the share of NO_x, VOCs and particulate pollution that comes from electricity generation and mobile sources.

Air Pollution Harms People Throughout the United States

Degraded air quality affects residents of every state in the country. In the summer, ozone pollution is a widespread problem, while in the winter, many areas suffer from particulate pollution. Even a single day of elevated air pollution represents a threat to public health.

Air Pollution Indicators

Thousands of air quality monitors in both urban and rural areas across the nation sample air pollution levels multiple times each hour. Based on this information, the U.S. Environmental Protection Agency (EPA) identifies potentially harmful air quality conditions. To communicate potential health risks to the public, the EPA has designed an Air Quality Index (AQI) that classifies pollutant levels into different risk categories. (See Table 1.) The categories are:

- "Good" (green), which means air quality poses "little or no risk," according to the EPA.[45]
- "Moderate" (yellow), a level at which air quality is deemed "acceptable."
- "Unhealthy for sensitive groups" (orange), such as children, older adults, and people with heart or lung disease, who may experience health problems at this level of air pollution.
- "Unhealthy" (red), which means air is unhealthy for all people in the area, and health impacts may increase for sensitive people.
- "Very unhealthy" (purple), meaning health impacts will be more severe.
- "Hazardous" (maroon), which means air pollution is severe and presents a risk to the entire population.

The pollution categories within the AQI provide a tool for communicating relative risk. Different

Table 1. Air Quality Index Values and Colors[46]

Air Quality Category	Air Quality Index Values	Color	Ozone Readings (ppb)	$PM_{2.5}$ Readings (µg/m³)
Good	0-50	Green	0-54	0-12
Moderate	51-100	Yellow	55-70	12.1-35.4
Unhealthy for Sensitive Groups	101-150	Orange	71-85	35.5-55.4
Unhealthy	151-200	Red	86-105	55.5-150.4
Very Unhealthy	201-300	Purple	106-200	150.5-250.4
Hazardous	301-500	Maroon	201+	250.5+

individuals may experience health impacts at lower or higher levels than the AQI suggests.

The AQI is linked to the National Ambient Air Quality Standards, which are periodically reviewed and adjusted based on the latest research on the links between pollution and public health. For example, currently the EPA has concluded that ozone levels above 70 parts per billion for eight hours or more are unhealthy for sensitive people, and when ozone exceeds that level, the EPA warns that children, older adults and people with lung disease should consider limiting their exposure.[47] The EPA has concluded that sensitive people are at risk when levels of fine particulates (particulate matter of 2.5 microns or less) average 35 micrograms per cubic meter of air (μg/m^3) over 24 hours.[48] (Table 1 presents AQI values and colors alongside ozone and particulate pollution thresholds.)

However, even "moderate" levels of air pollution can be harmful, particularly when people are exposed to them over a long period. A growing body of evidence suggests that current standards may not adequately account for the public health risks from air pollution.

The World Health Organization (WHO) recommends lower ozone and particulate pollution standards to protect public health. The WHO published air quality guidelines in 2006 that recommended an ozone pollution standard equal to 50 parts per billion over eight hours.[49] In comparison, the current U.S. ozone standard is 70 parts per billion. The WHO recommended that particulates be limited to 25 μg/m^3 over 24 hours, more protective than the current U.S. standard of 35 μg/m^3. Above these levels, death rates increase. The American Thoracic Society, the American Lung Association and other health associations support the same standard as the WHO.[50]

Beyond that, it is not clear that there is a safe or "acceptable" level of short-term ozone or particulate exposure at all. Researchers can detect negative health impacts for people exposed to very low concentrations of pollution.

- Even when concentrations of smog are at levels considered by the EPA to be "good" or "moderate," a 2006 study found that a modest increase in smog pollution results in more premature deaths.[51]

- In a 2017 study, researchers examined more than 22 million deaths in the Medicare population from 2000 to 2012 and found that a 10-parts-per-billion rise in smog pollution increased the daily mortality rate by 0.5 percent, regardless of how low pollution levels had been initially.[52] In the same population, a small (10 μg/m^3) increase in particulate pollution increased the daily death rate by 1.05 percent. The authors conclude that there is "no evidence of a threshold" below which smog or particulate pollution is safe.

- The World Health Organization in 2006 concluded that there is no documented safe level of exposure to particulate pollution.[53]

In addition, averaging pollution data over eight hours for ozone and 24 hours for particulate pollution, as is the case for the AQI data used in this report, may mask short-term spikes in pollution that can damage health.[54]

Finally, current standards may not reflect the long-term harm of air pollution. The EPA notes that repeated exposure to ozone pollution increases the risk of health impacts, especially in children.[55] A study of air pollution in Stockholm, Sweden, found that a policy that limited driving – and thus air pollution – in the central city reduced asthma attacks in children in subsequent years.[56] The authors suggest that curbing air pollution can have significant long-term benefits.

Separately, researchers at the Harvard School of Public Health have found that death rates for older Americans rise as air pollution increases – even when air pollution levels are below current national standards.[57] The U.S. does not have an annual standard for smog, and the researchers suggest that the nation adopt one because of ozone's long-term health impacts.

In short, there is strong evidence that U.S. air

National Park Service staff check an air quality monitor. Credit: National Park Service

pollution standards are inadequate to protect public health, that exposure to even "moderate" levels of pollution is a serious public health concern, and that any incremental reduction in air pollution is likely to produce public health benefits.

Threshold Used in This Analysis

This report estimates the number of days of degraded air quality experienced in 2016 by people living across the country, based on the number of days when air quality monitors reported an AQI of 51 or higher. This includes days that the EPA coded as moderate, unhealthy for sensitive groups, unhealthy, very unhealthy and hazardous. Air pollution data were grouped regionally, primarily by metropolitan and micropolitan areas. A relatively small number of rural counties also have air pollution monitors and were included.

In areas that contain more than one monitoring location, days in which half or more of the monitoring locations in the area reported an air quality problem were included in the tally of days with degraded air quality. People who live close to individual air pollution monitors may experience worse air pollution than indicated by this measure. However, counting every elevated reading from individual air pollution monitors runs the risk that a high reading from one or a handful of monitors may overstate the extent of the air pollution problem in a geographically dispersed metropolitan area.[58]

This report presents the number of days with elevated smog pollution and with elevated particulate pollution, which present different types of threats to health. It also presents the number of days with elevated smog and/or particulate pollution, a measure of how often residents have to breathe polluted air.

Table 2. Ten Most Populated Metropolitan Areas with More than 100 Days of Elevated Air Pollution in 2016

Metropolitan Area	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated Ozone and/or $PM_{2.5}$	Population
Los Angeles-Long Beach-Anaheim, CA	138	13,328,261
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	111	6,077,152
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Las Vegas-Henderson-Paradise, NV	145	2,156,724

Note: This count includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Number of Days with Smog or Particulate Pollution

In 2016, air pollution affected people across the nation. Seventy-three million Americans living in 56 metropolitan and micropolitan areas and four rural counties experienced more than 100 days of degraded air quality in 2016. That is equal to more than three months of the year in which smog and/or particulate pollution was above the level that the EPA has determined presents "little to no risk." (See Table 2.)

Another 173 million Americans live in 241 urban areas and 42 rural counties that faced 31 to 100 days – a month or more – of elevated smog and/or particulate pollution. Those places include large metropolitan areas such as Chicago, Miami and Hartford. (See Table 3.) Pollution also affects smaller communities such as Macon, Georgia; Yuma, Arizona; and Gettysburg, Pennsylvania.

Number of Days with Smog Pollution

More than 8 million people, living in 12 urban areas and two rural counties, experienced more than 100 days of smog pollution in 2016. All of those places were located in inland California, such as in the Central Valley or Sierra Nevada foothills, where the wind carries pollution from coastal urban centers and hot, sunny days facilitate the reaction between extensive amounts of NO_x and VOCs to create smog.

Residents of another 208 places breathed air with excess ozone pollution on 31 to 100 days in 2016. That means that for one to three months in 2016, those 159 million Americans were exposed to elevated smog pollution. Those rural counties and urban areas were located in 38 different states, plus the District of Columbia.

Number of Days with Particulate Pollution

Particulate pollution was a problem for 21 million people on more than 100 days in 21 areas in 2016. Those urban areas and rural counties were located in California, Georgia, Louisiana, Montana, New Jersey, North Carolina, Ohio, Pennsylvania and West Virginia. As with smog pollution in California, elevated particulate pollution occurs most often in inland regions. In Pennsylvania, the five cities with frequent particulate pollution are located west and northwest of Philadelphia, stretching from Harrisburg and Lancaster to the Allentown-Bethlehem-Easton area. (See Table 5.)

Table 3. Ten Most Populated Metropolitan Areas with 31 to 100 Days of Elevated Air Pollution in 2016

Metropolitan Area	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated Ozone and/or $PM_{2.5}$	Population
New York-Newark-Jersey City, NY-NJ-PA	75	20,275,179
Chicago-Naperville-Elgin, IL-IN-WI	84	9,546,326
Dallas-Fort Worth-Arlington, TX	72	7,253,424
Houston-The Woodlands-Sugar Land, TX	85	6,798,010
Washington-Arlington-Alexandria, DC-VA-MD-WV	84	6,150,681
Miami-Fort Lauderdale-West Palm Beach, FL	35	6,107,433
Boston-Cambridge-Newton, MA-NH	32	4,805,942
San Francisco-Oakland-Hayward, CA	41	4,699,077
Detroit-Warren-Dearborn, MI	97	4,305,869
Minneapolis-St. Paul-Bloomington, MN-WI	37	3,557,276

Note: This count includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Figure 2. Both Urban and Rural Areas Experienced Frequent Smog and/or Particulate Pollution in 2016[59]

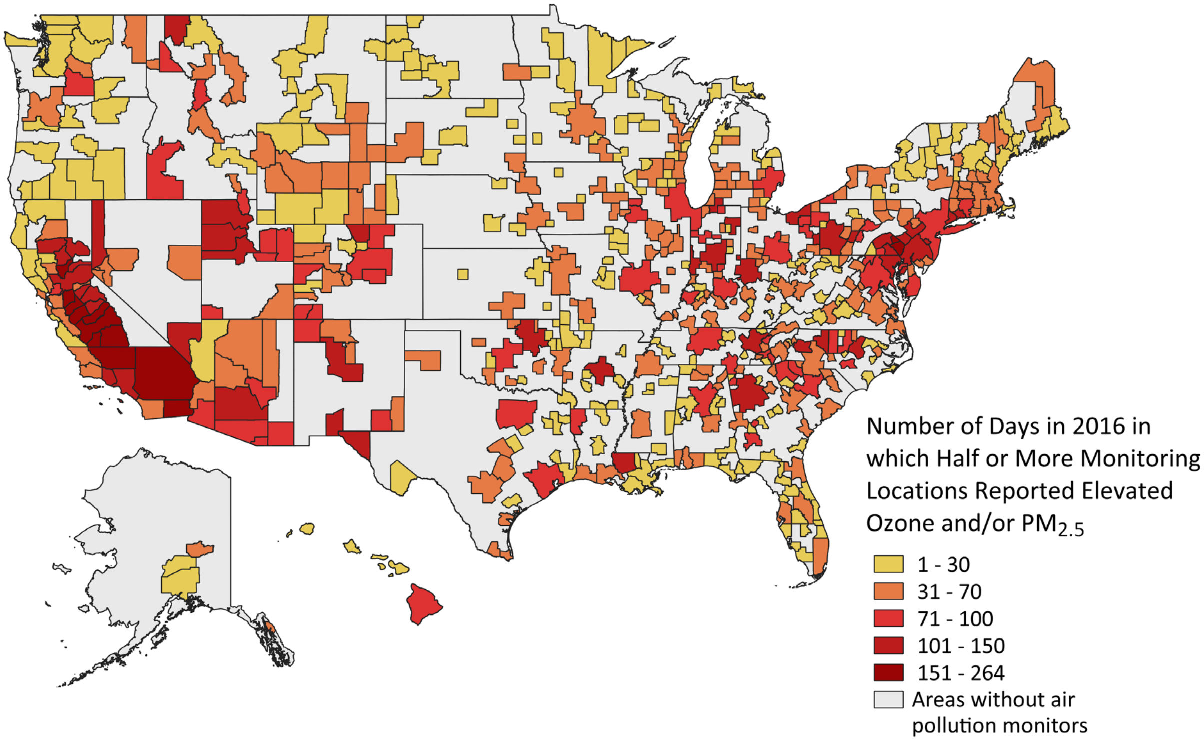


Table 4. Areas with More than 100 Days of Smog Pollution in 2016

Urban Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated Ozone	Population
Riverside-San Bernardino-Ontario, CA	155	4,523,653
Fresno, CA	140	979,534
Bakersfield, CA	159	885,086
Modesto, CA	102	541,353
Visalia-Porterville, CA	151	460,835
Merced, CA	116	268,878
Yuba City, CA	115	171,243
Madera, CA	131	154,966
Hanford-Corcoran, CA	146	149,797
Truckee-Grass Valley, CA	121	99,053
Red Bluff, CA	134	63,444
Sonora, CA	131	53,787
Calaveras County, CA	105	45,171
Mariposa County, CA	117	17,410

Note: This count includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

An additional 132 places, home to 154 million Americans, experienced 31 to 100 days of elevated particulate pollution in 2016. These include many of the nation's largest metropolitan areas, such as the New York, Los Angeles, and Chicago regions, where diesel trucks, industrial activity, and other combustion sources can produce particulate pollution and its precursors. Particulate pollution is also a recurring problem in a number of less populated areas where wintertime wood-burning for heat and summertime wildfires create extensive particulate pollution. (See Table 6.)

Table 5. Ten Most Populated Metropolitan Areas with More Than 100 Days of Particulate Pollution in 2016

Metropolitan Area	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated $PM_{2.5}$	Population
Atlanta-Sandy Springs-Roswell, GA	103	5,795,723
Riverside-San Bernardino-Ontario, CA	145	4,523,653
Cleveland-Elyria, OH	105	2,060,065
Raleigh, NC	105	1,304,896
Fresno, CA	140	979,534
Bakersfield, CA	179	885,086
Baton Rouge, LA	125	835,596
Allentown-Bethlehem-Easton, PA-NJ	106	835,233
Stockton-Lodi, CA	201	734,294
Harrisburg-Carlisle, PA	112	568,008

Note: This count includes particulate pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Table 6. Rural Counties with 31 to 100 Days of Particulate Pollution in 2016

Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated $PM_{2.5}$	Population
Aroostook County, ME	34	67,959
Oxford County, ME	47	57,217
Calaveras County, CA	38	45,171
Ravalli County, MT	73	42,088
Randolph County, IL	31	32,621
Swain County, NC	64	14,346
Shoshone County, ID	90	12,452
Benewah County, ID	51	9,092
Lemhi County, ID	40	7,723
Powder River County, MT	32	1,746

Note: This count includes particulate pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Areas with High Pollution Levels or Hot Spots

Regional-level smog and particulate data can mask episodes of especially severe pollution or pollution hot spots where residents regularly breathe polluted air. Residents of these air pollution "hot spots" face greater health risks from the air they breathe.

Some Regions Suffer from Chronic and Severe Pollution

Some areas experience pollution that is both frequent and severe. For example, the Riverside-San Bernardino-Ontario metropolitan area, home to 4.5 million people east of Los Angeles, experienced 155 days in 2016 in which more than half the region's air pollution monitoring locations reported smog above the level the EPA says presents "little to no risk." On 50 of those days, at least one monitoring location in Riverside reported smog levels as "unhealthy" and on 13 days at least one location reported "very unhealthy" pollution. The EPA says that unhealthy (red-level) air pollution is unhealthy for everyone, not just sensitive groups, and very unhealthy (purple-level) pollution creates even more severe health impacts. Table 7 reproduces the list from Table 4 of all the places that experienced more than 100 days of smog pollution in 2016, and adds further detail about especially high pollution levels.

Other regions that suffer from particulate pollution that is both chronic and severe. Four metropolitan areas that had chronic particulate pollution (more than 50 days on which more than half of air pollution monitoring locations reported particulate pollution above the level the EPA says presents "little to no risk") also had several days of severe pollution. Fairbanks, Alaska, which had 65 days of elevated particulate pollution experienced five days on which at least one monitor reported "red" level pollution. Yakima, Washington; Knoxville, Tennessee; and Salt Lake City, Utah, each had more than 50 days of particulate pollution and three days on which at least one monitor reported "red" level pollution.

Table 7. Pollution Severity in Areas with More than 100 Days of Smog Pollution in 2016

Urban Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated Ozone	Number of Days in 2016 in which at Least One Monitoring Location Reported "Unhealthy" Ozone Pollution	Number of Days in 2016 in which at Least One Monitoring Location Reported "Very Unhealthy" Ozone Pollution
Bakersfield, CA	159	11	0
Riverside-San Bernardino-Ontario, CA	155	50	13
Visalia-Porterville, CA	151	21	0
Hanford-Corcoran, CA	146	2	0
Fresno, CA	140	25	0
Red Bluff, CA	134	5	0
Madera, CA	131	3	0
Sonora, CA	131	7	0
Truckee-Grass Valley, CA	121	5	0
Mariposa County, CA	117	1	0
Merced, CA	116	2	0
Yuba City, CA	115	0	0
Calaveras County, CA	105	0	0
Modesto, CA	102	3	0

Pollution Levels Vary within Regions

Pollution levels can vary significantly across a region.

Air quality in the Atlanta metropolitan area, for example, is monitored at 11 locations scattered across the metro area's more than 8,000 square miles.[60] Smog levels can vary across this immense region. For the region as a whole, smog levels were above the "little or no risk" threshold on 10 percent of days in 2016, meaning half or more of the region's 11 monitors reported a problem on those days. However, smog levels were above levels that the EPA has identified as presenting "little or no risk" on approximately one-fourth of the days at two of the monitoring locations in the southeastern portion of the metro region. People who live close to those monitoring stations encountered worse air pollution than people who live elsewhere in the Atlanta area.

Cars and trucks are major contributors to Atlanta's smog pollution. Credit: Doug Waldron via Flickr CC BY-SA 2.0

Global Warming May Make Air Pollution Worse

Air pollution may become a greater problem as climate change warms the planet, alters weather patterns, and triggers other shifts that will create more air pollution. 2017 was the third hottest year on record, according to the National Oceanic and Atmospheric Administration, behind 2016 and 2015, and the 41st consecutive year in which annual temperatures exceeded the 20th century average.[61]

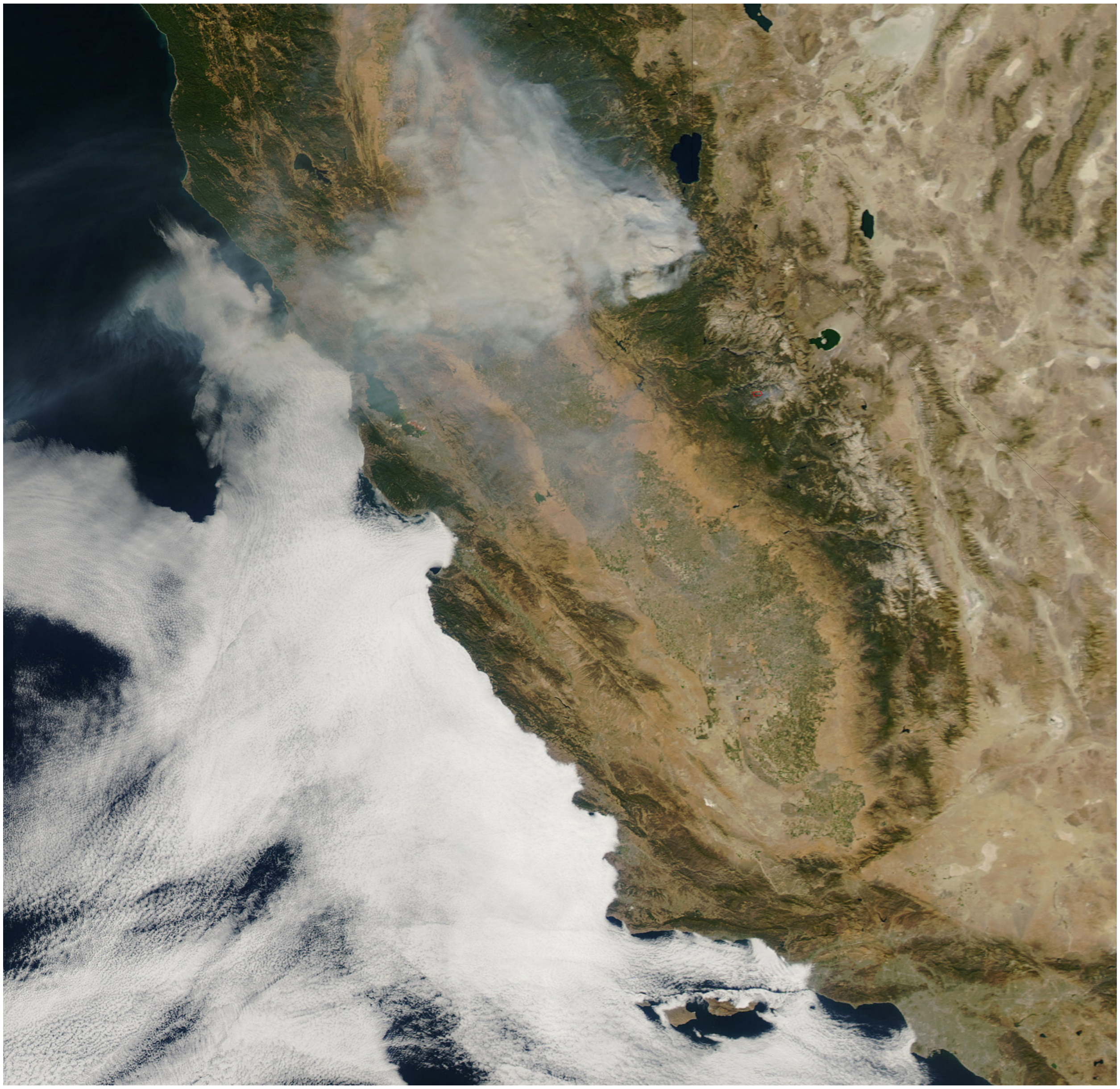
Changes caused by global warming may worsen smog and particulate pollution.[62] For example:

- Temperatures will rise, speeding up the chemical reactions that create smog.[63] In addition, with higher temperatures throughout the year, people may experience more spring and fall days with unhealthy levels of ozone, in addition to the summer ozone problems that are common today.[64]
- Changed wind patterns may increase the number of days with stagnant air, keeping pollution from being diluted. Decreased air circulation may already be worsening air quality by trapping pollution precursors and pollution near the ground.[65] Multiple days of stagnant air can lead to especially high levels of pollution.
- Wildfires, already increasing in intensity and frequency due to drought and higher temperatures, create particulates and other air pollution that can travel for hundreds of miles.[66]
- Higher temperatures could increase evaporative emissions of volatile organic compounds, precursors to ozone.[67]

One study estimates global warming will increase the number of air-pollution-related premature deaths if no measures are implemented to counteract global warming's impact on air quality. (Premature deaths are deaths that occur before the average age of death for a given population cohort.) The analysis, published in 2017, estimates that 1,130 Americans may die prematurely in the year 2030 from smog pollution made worse by global warming, and that the number of premature smog-related deaths could rise to 8,810 annually by the year 2100.[68] The study also estimates that particulate pollution worsened by global warming could cause 6,900 premature deaths in 2030 and 19,400 premature deaths in the year 2100.

The U.S. Global Change Research Program has concluded that global warming will make it more difficult to control smog pollution, and that maintaining current pollution levels in a warmer world will require reduced emissions of the chemicals that form smog.[69]

In many cases, the activities that cause air pollution also contribute to global warming. Efforts to reduce our reliance on fossil fuels, which contribute to global warming, have the potential to help reduce smog pollution as well.



Smoke from wildfires, which are projected to become more intense and more frequent in a warmer climate, can degrade air quality hundreds of miles away. Here, smoke from a fire in Northern California covers the width of the state and affects both the San Francisco Bay region and the Central Valley. Credit: NASA

Recommendations

Air pollution plagues metropolitan areas and rural counties across the country. Millions of Americans regularly breathe air that contains smog or particulate pollution, which creates a risk to public health, including the threat of respiratory, cardiovascular and developmental damage. Increasing evidence also suggests that routine exposure to relatively modest levels of air pollution increases mortality rates.[70] Global warming-related increases in temperature and wildfires and changes in weather patterns will further exacerbate air pollution problems.

These threats to public health are unnecessary and can be addressed. Much air pollution and global warming is a result of our reliance on fossil fuels. The nation should move as quickly as possible to clean, renewable sources of energy to meet our energy needs without contributing to global warming. During the transition to clean energy, the nation should continue to limit pollution from burning fossil fuels.

Protect Progress Achieved under the Clean Air Act

At the national level, we should **defend and build upon improvements in air quality achieved through rules developed to implement the Clean Air Act**, which have reduced air pollution and improved public health across the nation since its enactment more than four decades ago. In 2010, air quality improvements made possible by regulations under the Clean Air Act Amendments of 1990 helped prevent more than 160,000 early deaths, 130,000 non-fatal heart attacks, and 41,000 hospital admissions.[71] Better air quality enabled adults to go to work on an additional 13 million days and children to attend school on an additional 3.2 million days. These benefits are in addition to improvements stemming from the original Clean Air Act. Yet, as the elevated levels of smog and particulate pollution that continue to be experienced by Americans demonstrate, the problem of air pollution is far from solved. Maintaining the gains already achieved under implementation of the Clean Air Act and seeking greater regulatory protections are crucial for ensuring Americans can breathe cleaner air.

Ozone and particulate matter standards should be strengthened. Mounting evidence suggests that current standards fail to fully protect public health. In addition, the nation should adopt an annual limit for ozone pollution to help reduce harm from long-term exposure, an important concern as higher global temperatures are likely to increase the length of the annual ozone season.

State and local air quality regulators should set pollution permits for specific polluters at levels that will ensure a region's residents are not breathing polluted air and should commit to strong and consistent enforcement of those permits to protect public health.

Reduce Pollution from Transportation

The EPA and the National Highway Traffic Safety Administration should not weaken federal fuel economy and global warming pollution standards that are critical to the nation's efforts

to reduce global warming pollution from cars and light trucks. Unfortunately, the Trump administration has announced its intention to reconsider standards that, when fully phased in, would avoid emissions of 6 billion metric tons of global warming pollution over the lifetime of cars sold from 2012 to 2025.[72] These standards should be implemented as planned and strengthened in the coming years to reduce future air pollution threats.

The EPA should respect the power of states to adopt stronger pollution standards for passenger vehicles, and to tighten those standards as needed to protect public health. Developed in response to the state's widespread air pollution problems, California's clean car standards help to reduce global warming emissions and health-threatening air pollution from cars and trucks. Federal law allows other states with air pollution problems to adopt these clean car standards instead of federal standards. Twelve other states, plus the District of Columbia, have done so.[73] These standards have been highly effective in reducing pollution and are one reason cars, light trucks and other passenger vehicles today are 99 percent cleaner than vehicles sold in the 1960s.[74] The federal government should not take away the ability of states to develop policies that have been so important in addressing pollution from passenger vehicles.

State and local governments should pursue policies to hasten the transition to zero-emission vehicles. Ten states – California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island and Vermont – already have electric vehicle sales requirements.[75] Elected officials in other states should establish goals for sales of electric passenger vehicles

Though air quality has greatly improved in the Los Angeles region thanks to the Clean Air Act and California's policies to reduce pollution, including the clean car standard, air pollution remains a problem for the region's millions of residents, as seen in this 2018 photo. Credit: Elizabeth Ridlington and support the development of infrastructure needed to recharge those vehicles. State governments should allocate money from Volkswagen's "Dieselgate" settlement to subsidize the purchase of electric school and transit buses, as well as charging infrastructure. Transit agencies and school districts should replace buses powered by fossil fuels with electric buses as they replace aging buses in their fleets. Policies to encourage electrification of heavy-duty trucks and nonroad equipment would help to further reduce air pollution and limit global warming pollution.

Policymakers should also act to address pollution from other forms of transportation. Pollution from medium- and heavy-duty vehicles, airplanes, locomotives and other mobile sources should also be reduced. Transportation is a major source of global warming pollution and transitioning to zero-carbon transportation is an essential part of addressing the public health threat presented by global warming.

Reduce Pollution from Electricity Generation

State leaders in the Northeast and Mid-Atlantic regions can continue to support and strengthen the Regional Greenhouse Gas Initiative (RGGI), an agreement among nine northeastern and mid-Atlantic states to limit carbon pollution from power plants.[76] From the beginning of the program through 2016, carbon dioxide emissions from power plants in the RGGI states declined 40 percent.[77] In addition to helping to reduce the future severity of global warming and its potential air quality impacts, the program has directly improved air quality in the region. From 2009 to 2014, improved air quality due to the program avoided up to 830 premature deaths, 390 non-fatal heart attacks, and 47,000 lost work days in the nine participating states, plus New Jersey, Pennsylvania, Virginia and Washington, D.C.[78] RGGI could be strengthened in several ways. States should change policies that could undermine the effectiveness of the program, such as by retiring excess pollution permits that have built up over time. Additional states – including New Jersey and Virginia – should join the program to accelerate progress in cleaning up air pollution from power plants and show strong climate leadership by setting caps that are stringent enough to drive significant reductions in emissions.

State leaders in other regions should draw upon the model offered by the Regional Greenhouse Gas Initiative and create similar programs. Policies to **increase the use of wind, solar and other clean energy** and to **improve energy efficiency** help to reduce the need for electricity from coal and natural gas power plants that produce air pollution and add to global warming. Community leaders and policymakers should work to ensure the rapid deployment of renewable energy. Policymakers should also adopt policies to increase energy savings. Conserving energy and using it more efficiently can ease the transition from dirty fuels to clean, renewable energy. Policies to increase energy savings include zero net energy requirements for new buildings and statewide energy efficiency standards that require utilities to hit annual energy savings targets.

Methodology

Air pollution data for 2016 are from U.S. Environmental Protection Agency, Air Data, Pre-Generated Files, accessed at https://aqs.epa.gov/aqsweb/airdata/download_files.html, 15 February 2018. The relevant files are the daily summary data for ozone and daily summary data for $PM_{2.5}$ measured with FRM/FEM mass methods.

Those files include a daily EPA-calculated Air Quality Index (AQI) score from 0 to 500 for each monitoring station and for each pollutant. Per the EPA, an AQI score of 51 to 100 is moderate (yellow), 101 to 150 is unhealthy for sensitive groups (orange), a score of 151 to 200 is unhealthy (red), a score of 201 to 300 is very unhealthy (purple), and a score of 301 to 500 is hazardous (maroon).[79]

The geographic units included in this analysis were core-based statistical areas (CBSA) (metropolitan and micropolitan urban areas identified by the federal Office of Management and Budget), and counties that are not part of a CBSA but that include one or more air quality monitoring locations. Each CBSA or county may have more than one monitoring location, and each location may have multiple monitors or air quality reports daily.

The method for each pollutant was as follows:

1. Identify the highest (worst) AQI score from each monitoring location for each day to obtain a single reading per location.

2. Count the number of those with an AQI above 50.

3. Divide that by the total number of monitoring locations that reported an AQI that day.

4. Tally the number of days on which half or more reporting locations in each CBSA or county reported an AQI above 50.

2016 population data for CBSAs came from U.S. Census Bureau, *Metropolitan and Micropolitan Statistical Areas Population Totals: 2010-2017*, downloaded 4 May 2018 from https://www.census.gov/data/tables/2017/demo/popest/total-metro-and-micro-statistical-areas.html.

2016 population for counties came from U.S. Census Bureau, *County Population Totals and Components of Change: 2010-2016*, downloaded 4 May 2018 from https://www.census.gov/data/tables/2016/demo/popest/counties-total.html.

Appendix A.

Days with Elevated Smog, Particulates and Total Pollution, by Geographic Area, 2016

This count includes air pollution at or above the level the EPA labels "moderate" and indicates in yellow or worse in its Air Quality Index.

Air pollution data are listed by state. Results for urban areas are listed first, in alphabetical order, followed by results for rural counties that are not part of a metropolitan or micropolitan area. Many rural counties do not have an air pollution monitor and therefore do not appear here. Metropolitan and micropolitan areas that extend into more than one state are listed multiple times, once for each state.

Table A1. Days with Elevated Smog, Particulates and Total Pollution, by Geographic Area, 2016

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
Alabama	Birmingham-Hoover, AL	43	82	100	1,146,888
	Columbus, GA-AL	38	27	61	306,712
	Daphne-Fairhope-Foley, AL	26	6	32	207,509
	Decatur, AL	40	5	44	152,051
	Dothan, AL	12	4	15	147,781
	Florence-Muscle Shoals, AL	17	9	24	146,646
	Fort Payne, AL	42	8	47	71,216
	Gadsden, AL	46	10	52	102,726
	Huntsville, AL	48	6	51	449,232
	Mobile, AL	23	10	33	414,852
	Montgomery, AL	27	18	44	373,475
	Talladega-Sylacauga, AL	0	18	18	91,195
	Tuscaloosa, AL	22	4	26	241,444
	Clay County, AL	0	7	7	13,492
	Sumter County, AL	7	0	7	13,040
Alaska	Anchorage, AK	0	22	22	401,499
	Fairbanks, AK	0	65	65	100,602
	Juneau, AK	0	50	50	32,405
	Denali Borough, AK	1	0	1	1,953
Arizona	Flagstaff, AZ	60	0	60	140,079
	Lake Havasu City-Kingman, AZ	0	1	1	205,385
	Nogales, AZ	0	84	84	46,075
	Payson, AZ	87	0	87	53,297
	Phoenix-Mesa-Scottsdale, AZ	83	27	110	4,648,498
	Prescott, AZ	50	0	50	224,363
	Show Low, AZ	65	0	65	108,322
	Sierra Vista-Douglas, AZ	70	1	71	125,355

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Tucson, AZ	62	10	71	1,012,519
	Yuma, AZ	49	49	91	205,463
	La Paz County, AZ	65	4	69	20,317
Arkansas	Arkadelphia, AR	4	0	4	22,550
	El Dorado, AR	0	24	24	39,867
	Fayetteville-Springdale-Rogers, AR-MO	16	13	27	525,176
	Fort Smith, AR-OK	17	15	32	281,032
	Harrison, AR	10	0	10	45,060
	Hot Springs, AR	0	22	22	98,231
	Little Rock-North Little Rock-Conway, AR	23	95	109	733,461
	Texarkana, TX-AR	0	25	25	150,185
	Arkansas County, AR	0	19	19	18,214
	Ashley County, AR	0	16	16	20,492
	Jackson County, AR	0	21	21	17,221
	Polk County, AR	27	15	42	20,173
California	Bakersfield, CA	159	179	255	885,086
	Bishop, CA	39	40	69	3,879
	Chico, CA	91	53	122	226,525
	Clearlake, CA	7	0	7	63,950
	El Centro, CA	77	123	164	180,980
	Eureka-Arcata-Fortuna, CA	0	9	9	136,449
	Fresno, CA	140	140	234	979,534
	Hanford-Corcoran, CA	146	197	264	149,797
	Los Angeles-Long Beach-Anaheim, CA	69	97	138	13,328,261
	Madera, CA	131	143	236	154,966
	Merced, CA	116	150	207	268,878
	Modesto, CA	102	150	218	541,353
	Napa, CA	7	63	70	141,649
	Oxnard-Thousand Oaks-Ventura, CA	60	81	114	851,096
	Red Bluff, CA	134	13	139	63,444
	Redding, CA	50	2	51	178,774
	Riverside-San Bernardino-Ontario, CA	155	145	209	4,523,653
	Sacramento–Roseville–Arden-Arcade, CA	72	37	105	2,295,233
	Salinas, CA	3	16	19	436,363
	San Diego-Carlsbad, CA	44	36	70	3,317,200
	San Francisco-Oakland-Hayward, CA	7	35	41	4,699,077
	San Jose-Sunnyvale-Santa Clara, CA	17	58	70	1,990,910
	San Luis Obispo-Paso Robles-Arroyo Grande, CA	24	48	65	282,282
	Santa Cruz-Watsonville, CA	3	16	19	275,196
	Santa Maria-Santa Barbara, CA	5	28	33	446,296
	Santa Rosa, CA	6	12	18	503,833

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Sonora, CA	131	0	131	53,787
	Stockton-Lodi, CA	83	201	227	734,294
	Truckee-Grass Valley, CA	121	11	125	99,053
	Ukiah, CA	0	30	30	87,609
	Vallejo-Fairfield, CA	13	69	81	440,318
	Visalia-Porterville, CA	151	62	189	460,835
	Yuba City, CA	115	49	152	171,243
	Amador County, CA	62	0	62	37,383
	Calaveras County, CA	105	38	134	45,171
	Colusa County, CA	49	20	60	21,588
	Glenn County, CA	30	0	30	28,085
	Mariposa County, CA	117	0	117	17,410
	Plumas County, CA	0	104	104	18,627
	Siskiyou County, CA	4	1	5	43,603
Colorado	Boulder, CO	2	12	14	321,173
	Colorado Springs, CO	92	3	95	710,746
	Craig, CO	30	0	30	13,161
	Denver-Aurora-Lakewood, CO	68	31	98	2,851,848
	Durango, CO	86	0	86	55,216
	Fort Collins, CO	86	36	121	338,531
	Glenwood Springs, CO	36	0	36	76,800
	Grand Junction, CO	42	44	86	149,794
	Greeley, CO	37	54	80	294,243
	Montrose, CO	18	0	18	41,160
	Chaffee County, CO	60	0	60	19,058
	Grand County, CO	21	0	21	15,008
	Gunnison County, CO	45	0	45	16,408
	Montezuma County, CO	77	0	77	26,999
	Rio Blanco County, CO	36	7	39	6,545
	San Miguel County, CO	51	0	51	8,017
Connecticut	Bridgeport-Stamford-Norwalk, CT	64	89	126	949,191
	Hartford-West Hartford-East Hartford, CT	43	61	95	1,210,075
	New Haven-Milford, CT	54	68	109	859,973
	Norwich-New London, CT	38	15	52	269,307
	Torrington, CT	50	16	55	183,097
	Worcester, MA-CT	23	28	47	936,723
Delaware	Dover, DE	43	31	64	174,754
	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	51	74	111	6,077,152
	Salisbury, MD-DE	57	27	76	400,025

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
District of Columbia	Washington-Arlington-Alexandria, DC-VA-MD-WV	47	44	84	6,150,681
Florida	Cape Coral-Fort Myers, FL	25	1	26	722,506
	Crestview-Fort Walton Beach-Destin, FL	19	0	19	265,355
	Deltona-Daytona Beach-Ormond Beach, FL	18	2	20	636,843
	Gainesville, FL	19	5	24	281,551
	Homosassa Springs, FL	0	3	3	142,990
	Jacksonville, FL	29	31	57	1,476,503
	Lake City, FL	24	0	24	69,274
	Lakeland-Winter Haven, FL	25	5	30	667,018
	Miami-Fort Lauderdale-West Palm Beach, FL	18	19	35	6,107,433
	Naples-Immokalee-Marco Island, FL	15	0	15	366,095
	North Port-Sarasota-Bradenton, FL	19	5	23	788,442
	Ocala, FL	20	0	20	348,139
	Orlando-Kissimmee-Sanford, FL	25	17	41	2,453,333
	Palm Bay-Melbourne-Titusville, FL	26	1	26	577,899
	Panama City, FL	22	0	22	199,092
	Pensacola-Ferry Pass-Brent, FL	33	5	37	481,774
	Port St. Lucie, FL	20	0	20	464,563
	Sebastian-Vero Beach, FL	24	0	24	151,382
	Sebring, FL	16	0	16	101,558
	Tallahassee, FL	22	8	28	379,047
	Tampa-St. Petersburg-Clearwater, FL	30	25	53	3,036,525
	Holmes County, FL	17	0	17	19,487
	Liberty County, FL	9	0	9	8,202
Georgia	Albany, GA	0	100	100	152,440
	Americus, GA	27	0	27	35,513
	Athens-Clarke County, GA	43	10	50	205,421
	Atlanta-Sandy Springs-Roswell, GA	36	103	118	5,795,723
	Augusta-Richmond County, GA-SC	30	21	50	594,889
	Brunswick, GA	8	24	29	116,955
	Chattanooga, TN-GA	71	18	84	551,957
	Columbus, GA-AL	38	27	61	306,712
	Dalton, GA	39	0	39	144,074
	Gainesville, GA	0	16	16	196,237
	Macon, GA	42	75	96	229,163
	Rome, GA	0	72	72	96,620
	Savannah, GA	10	35	41	383,785
	Summerville, GA	25	0	25	24,833

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Valdosta, GA	0	7	7	144,434
	Warner Robins, GA	0	13	13	190,068
	Washington County, GA	0	11	11	20,457
	Wilkinson County, GA	0	19	19	9,104
Hawaii	Hilo, HI	0	93	93	198,681
	Kahului-Wailuku-Lahaina, HI	0	4	4	165,472
	Kapaa, HI	0	2	2	71,769
	Urban Honolulu, HI	0	8	8	992,761
Idaho	Boise City, ID	53	25	72	690,810
	Idaho Falls, ID	13	0	13	142,405
	Jackson, WY-ID	27	11	35	34,266
	Logan, UT-ID	30	63	88	135,689
	Pocatello, ID	0	43	43	84,379
	Benewah County, ID	0	51	51	9,092
	Lemhi County, ID	0	40	40	7,723
	Shoshone County, ID	0	90	90	12,452
Illinois	Bloomington, IL	36	23	57	188,847
	Champaign-Urbana, IL	40	30	64	239,135
	Chicago-Naperville-Elgin, IL-IN-WI	36	58	84	9,546,326
	Davenport-Moline-Rock Island, IA-IL	25	60	79	382,671
	Decatur, IL	33	7	38	106,651
	Effingham, IL	33	0	33	34,182
	Fort Madison-Keokuk, IA-IL-MO	0	18	18	59,406
	Mount Vernon, IL	36	24	59	38,308
	Paducah, KY-IL	41	12	46	97,083
	Peoria, IL	38	6	43	375,600
	Quincy, IL-MO	15	0	15	76,756
	Rockford, IL	26	14	38	339,650
	Springfield, IL	32	16	45	209,990
	St. Louis, MO-IL	35	68	93	2,806,782
	Clark County, IL	28	0	28	15,938
	Jo Daviess County, IL	20	0	20	21,770
	Randolph County, IL	26	31	55	32,621
Indiana	Bloomington, IN	44	24	62	166,614
	Chicago-Naperville-Elgin, IL-IN-WI	36	58	84	9,546,326
	Cincinnati, OH-KY-IN	54	85	119	2,166,029
	Columbus, IN	46	41	80	81,873
	Elkhart-Goshen, IN	38	64	93	204,146
	Evansville, IN-KY	46	60	87	315,700
	Fort Wayne, IN	42	80	112	431,296
	Huntington, IN	24	0	24	36,368
	Indianapolis-Carmel-Anderson, IN	34	83	103	2,005,612

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Jasper, IN	0	23	23	54,884
	Kokomo, IN	0	82	82	82,339
	Lafayette-West Lafayette, IN	35	42	75	217,296
	Louisville/Jefferson County, KY-IN	40	67	93	1,284,848
	Michigan City-La Porte, IN	28	13	39	110,208
	Muncie, IN	28	14	40	115,483
	New Castle, IN	0	13	13	48,364
	Seymour, IN	37	0	37	43,933
	South Bend-Mishawaka, IN-MI	42	79	105	320,822
	Terre Haute, IN	40	87	111	170,220
	Vincennes, IN	46	0	46	37,542
	Wabash, IN	38	0	38	31,551
	Perry County, IN	43	0	43	18,966
	Spencer County, IN	0	20	20	20,648
Iowa	Ames, IA	14	0	14	96,816
	Cedar Rapids, IA	23	47	63	267,925
	Clinton, IA	22	65	83	47,236
	Davenport-Moline-Rock Island, IA-IL	25	60	79	382,671
	Des Moines-West Des Moines, IA	15	28	41	634,740
	Fort Madison-Keokuk, IA-IL-MO	0	18	18	59,406
	Iowa City, IA	0	36	36	168,742
	Muscatine, IA	0	49	49	42,904
	Omaha-Council Bluffs, NE-IA	22	46	66	924,003
	Sioux City, IA-NE-SD	18	31	44	169,049
	Waterloo-Cedar Falls, IA	17	14	31	169,894
	Delaware County, IA	0	15	15	17,327
	Montgomery County, IA	15	7	22	10,225
	Palo Alto County, IA	18	11	29	9,047
	Van Buren County, IA	17	10	27	7,271
Kansas	Kansas City, MO-KS	30	26	50	2,106,382
	St. Joseph, MO-KS	26	50	68	126,927
	Topeka, KS	23	9	30	232,948
	Wichita, KS	23	15	35	644,680
	Neosho County, KS	20	13	30	16,146
	Trego County, KS	18	3	21	2,872
Kentucky	Bowling Green, KY	33	14	44	171,839
	Cincinnati, OH-KY-IN	54	85	119	2,166,029
	Clarksville, TN-KY	39	33	66	280,843
	Elizabethtown-Fort Knox, KY	36	13	47	148,940
	Evansville, IN-KY	46	60	87	315,700
	Huntington-Ashland, WV-KY-OH	27	10	36	358,857
	Lexington-Fayette, KY	42	12	51	506,760

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Louisville/Jefferson County, KY-IN	40	67	93	1,284,848
	Middlesborough, KY	14	11	25	27,192
	Owensboro, KY	43	20	59	117,923
	Paducah, KY-IL	41	12	46	97,083
	Richmond-Berea, KY	0	10	10	106,408
	Somerset, KY	21	12	33	64,014
	Carter County, KY	19	3	22	27,046
	Morgan County, KY	35	0	35	13,298
	Perry County, KY	12	6	18	27,343
	Pike County, KY	19	8	26	60,555
	Simpson County, KY	26	0	26	18,083
	Washington County, KY	34	0	34	12,189
Louisiana	Alexandria, LA	0	6	6	154,394
	Baton Rouge, LA	20	125	132	835,596
	Hammond, LA	0	7	7	130,623
	Houma-Thibodaux, LA	24	4	28	211,740
	Lafayette, LA	40	6	44	491,646
	Lake Charles, LA	22	10	32	207,518
	Monroe, LA	14	18	30	179,546
	New Orleans-Metairie, LA	21	5	25	1,271,195
	Shreveport-Bossier City, LA	42	36	73	442,403
Maine	Augusta-Waterville, ME	10	3	13	121,328
	Bangor, ME	6	40	46	151,515
	Lewiston-Auburn, ME	8	17	24	107,269
	Portland-South Portland, ME	13	17	26	528,261
	Rockland, ME	10	0	10	7,297
	Aroostook County, ME	1	34	35	67,959
	Franklin County, ME	0	6	6	30,001
	Hancock County, ME	21	3	23	54,419
	Oxford County, ME	3	47	50	57,217
	Washington County, ME	6	0	6	31,450
Maryland	Baltimore-Columbia-Towson, MD	68	63	114	2,801,028
	Cambridge, MD	45	30	63	32,267
	Hagerstown-Martinsburg, MD-WV	50	53	95	263,080
	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	51	74	111	6,077,152
	Washington-Arlington-Alexandria, DC-VA-MD-WV	47	44	84	6,150,681
	Garrett County, MD	28	13	41	29,425
	Kent County, MD	52	24	72	19,730
Massachusetts	Barnstable Town, MA	22	0	22	213,440
	Boston-Cambridge-Newton, MA-NH	22	16	32	4,805,942

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Greenfield Town, MA	18	17	32	70,618
	Pittsfield, MA	0	45	45	126,858
	Providence-Warwick, RI-MA	25	32	49	1,615,878
	Springfield, MA	38	23	52	630,661
	Vineyard Haven, MA	13	0	13	17,312
	Worcester, MA-CT	23	28	47	936,723
Michigan	Adrian, MI	45	14	58	98,510
	Ann Arbor, MI	39	15	52	364,752
	Bay City, MI	0	12	12	104,481
	Cadillac, MI	28	4	32	48,122
	Detroit-Warren-Dearborn, MI	41	74	97	4,305,869
	Flint, MI	37	15	51	408,607
	Grand Rapids-Wyoming, MI	36	30	61	1,048,826
	Holland, MI	44	13	56	114,955
	Kalamazoo-Portage, MI	44	22	61	336,257
	Lansing-East Lansing, MI	43	16	57	474,310
	Ludington, MI	22	0	22	28,846
	Monroe, MI	0	17	17	149,223
	Muskegon, MI	41	0	41	173,102
	Niles-Benton Harbor, MI	49	15	62	154,157
	Sault Ste. Marie, MI	11	12	21	37,696
	South Bend-Mishawaka, IN-MI	42	79	105	320,822
	Traverse City, MI	28	0	28	148,231
	Huron County, MI	20	0	20	31,481
	Manistee County, MI	18	5	21	24,373
	Schoolcraft County, MI	25	0	25	8,001
	Tuscola County, MI	28	0	28	53,338
Minnesota	Bemidji, MN	0	14	14	46,011
	Brainerd, MN	8	16	23	92,771
	Duluth, MN-WI	8	12	20	278,954
	La Crosse-Onalaska, WI-MN	19	11	30	136,442
	Marshall, MN	9	11	20	25,861
	Minneapolis-St. Paul-Bloomington, MN-WI	9	31	37	3,557,276
	Red Wing, MN	12	0	12	46,240
	Rochester, MN	15	24	37	216,096
	St. Cloud, MN	11	19	28	196,039
	Becker County, MN	11	13	24	33,734
	Cook County, MN	0	2	2	5,286
	Lake County, MN	6	2	8	10,625
Mississippi	Cleveland, MS	22	0	22	32,634
	Grenada, MS	0	10	10	21,219

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Gulfport-Biloxi-Pascagoula, MS	20	10	28	390,836
	Hattiesburg, MS	0	24	24	148,943
	Jackson, MS	22	15	35	579,558
	Memphis, TN-MS-AR	36	16	48	1,345,193
	Meridian, MS	9	0	9	103,078
	Tupelo, MS	15	0	15	139,656
	Yalobusha County, MS	7	0	7	12,471
Missouri	Branson, MO	9	0	9	86,283
	Columbia, MO	16	0	16	176,555
	Fayetteville-Springdale-Rogers, AR-MO	16	13	27	525,176
	Fort Madison-Keokuk, IA-IL-MO	0	18	18	59,406
	Jefferson City, MO	14	0	14	151,455
	Joplin, MO	17	0	17	177,517
	Kansas City, MO-KS	30	26	50	2,106,382
	Quincy, IL-MO	15	0	15	76,756
	Springfield, MO	26	31	53	457,897
	St. Joseph, MO-KS	26	50	68	126,927
	St. Louis, MO-IL	35	68	93	2,806,782
	Cedar County, MO	15	24	35	14,016
	Monroe County, MO	13	0	13	8,558
	Perry County, MO	41	0	41	19,285
	Ste. Genevieve County, MO	29	0	29	18,030
Montana	Billings, MT	0	16	16	168,961
	Butte-Silver Bow, MT	0	56	56	34,467
	Helena, MT	6	44	50	78,562
	Kalispell, MT	0	28	28	97,693
	Missoula, MT	1	67	68	115,896
	Fergus County, MT	4	8	10	11,413
	Lincoln County, MT	0	101	101	19,259
	Phillips County, MT	1	13	13	4,133
	Powder River County, MT	6	32	35	1,746
	Ravalli County, MT	0	73	73	42,088
	Richland County, MT	10	6	14	11,482
	Rosebud County, MT	7	19	24	9,287
Nebraska	Grand Island, NE	0	3	3	84,968
	Lincoln, NE	14	10	22	327,633
	Omaha-Council Bluffs, NE-IA	22	46	66	924,003
	Scottsbluff, NE	0	4	4	38,539
	Sioux City, IA-NE-SD	18	31	44	169,049
	Knox County, NE	27	0	27	8,571

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
Nevada	Carson City, NV	55	10	59	54,283
	Fallon, NV	67	0	67	24,016
	Fernley, NV	69	0	69	52,854
	Gardnerville Ranchos, NV	0	35	35	47,947
	Las Vegas-Henderson-Paradise, NV	93	63	145	2,156,724
	Reno, NV	67	50	103	456,418
	White Pine County, NV	59	0	59	9,682
New Hampshire	Berlin, NH-VT	49	0	49	38,163
	Boston-Cambridge-Newton, MA-NH	22	16	32	4,805,942
	Claremont-Lebanon, NH-VT	5	16	19	216,458
	Concord, NH	14	0	14	148,133
	Keene, NH	18	34	49	75,697
	Laconia, NH	8	8	16	60,606
	Manchester-Nashua, NH	31	3	31	407,718
New Jersey	Allentown-Bethlehem-Easton, PA-NJ	44	106	133	835,233
	Atlantic City-Hammonton, NJ	31	28	50	270,830
	New York-Newark-Jersey City, NY-NJ-PA	40	50	75	20,275,179
	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	51	74	111	6,077,152
	Trenton, NJ	64	69	109	373,660
	Vineland-Bridgeton, NJ	34	44	65	153,914
New Mexico	Albuquerque, NM	74	65	130	906,877
	Carlsbad-Artesia, NM	71	0	71	57,456
	Española, NM	57	0	57	39,158
	Farmington, NM	75	0	75	127,772
	Hobbs, NM	50	3	52	69,850
	Las Cruces, NM	80	81	138	213,874
	Santa Fe, NM	65	0	65	147,943
New York	Albany-Schenectady-Troy, NY	32	9	39	882,801
	Buffalo-Cheektowaga-Niagara Falls, NY	40	8	44	1,134,914
	Corning, NY	24	3	25	96,830
	Ithaca, NY	29	0	29	104,561
	Jamestown-Dunkirk-Fredonia, NY	40	3	42	129,638
	Malone, NY	1	0	1	51,139
	New York-Newark-Jersey City, NY-NJ-PA	40	50	75	20,275,179
	Rochester, NY	31	19	46	1,078,352
	Syracuse, NY	25	7	30	656,931
	Utica-Rome, NY	9	0	9	293,752
	Watertown-Fort Drum, NY	25	0	25	114,084

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Essex County, NY	16	0	16	38,102
	Hamilton County, NY	15	0	15	4,542
North Carolina	Asheville, NC	34	35	67	450,914
	Charlotte-Concord-Gastonia, NC-SC	38	21	54	2,475,519
	Cullowhee, NC	64	16	80	42,268
	Durham-Chapel Hill, NC	29	82	99	558,920
	Fayetteville, NC	36	57	80	386,646
	Greensboro-High Point, NC	58	58	95	756,564
	Greenville, NC	30	10	38	177,627
	Hickory-Lenoir-Morganton, NC	40	82	105	364,506
	Kinston, NC	22	0	22	57,432
	Morehead City, NC	19	0	19	68,855
	Oxford, NC	34	0	34	58,824
	Raleigh, NC	48	105	135	1,304,896
	Rocky Mount, NC	21	0	21	147,301
	Sanford, NC	24	0	24	59,746
	Virginia Beach-Norfolk-Newport News, VA-NC	16	22	36	1,722,766
	Wilmington, NC	15	19	30	282,131
	Winston-Salem, NC	46	75	107	661,708
	Avery County, NC	41	0	41	17,516
	Caswell County, NC	26	0	26	22,910
	Graham County, NC	44	0	44	8,558
	Macon County, NC	24	0	24	34,376
	Martin County, NC	12	0	12	23,172
	Mitchell County, NC	0	25	25	15,126
	Montgomery County, NC	23	22	41	27,418
	Swain County, NC	26	64	85	14,346
	Yancey County, NC	50	0	50	17,678
North Dakota	Bismarck, ND	3	9	12	131,397
	Dickinson, ND	8	4	10	30,856
	Fargo, ND-MN	2	40	41	237,483
	Williston, ND	3	9	10	34,195
	Burke County, ND	4	6	8	2,198
	Dunn County, ND	5	7	10	4,366
	McKenzie County, ND	5	4	7	12,621
	Mercer County, ND	2	6	7	8,694
Ohio	Akron, OH	20	83	97	702,556
	Ashtabula, OH	42	0	42	98,169
	Athens, OH	0	2	2	66,320
	Canton-Massillon, OH	49	62	90	401,165

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Cincinnati, OH-KY-IN	54	85	119	2,166,029
	Cleveland-Elyria, OH	38	105	114	2,060,065
	Columbus, OH	45	33	71	2,046,977
	Dayton, OH	49	15	61	800,886
	Huntington-Ashland, WV-KY-OH	27	10	36	358,857
	Lima, OH	46	6	50	103,626
	Marietta, OH	24	0	24	60,535
	Mount Vernon, OH	38	0	38	60,832
	Portsmouth, OH	0	10	10	76,240
	Springfield, OH	51	20	67	134,621
	Toledo, OH	42	22	58	604,591
	Washington Court House, OH	43	0	43	28,662
	Weirton-Steubenville, WV-OH	37	128	147	119,242
	Wheeling, WV-OH	54	18	68	142,871
	Wilmington, OH	58	0	58	41,881
	Youngstown-Warren-Boardman, OH-PA	44	68	90	544,543
	Noble County, OH	38	0	38	14,294
Oklahoma	Ardmore, OK	45	5	50	48,359
	Bartlesville, OK	27	41	59	51,914
	Fort Smith, AR-OK	17	15	32	281,032
	Lawton, OK	35	25	57	127,311
	McAlester, OK	20	44	59	44,395
	Miami, OK	2	0	2	31,523
	Oklahoma City, OK	31	51	76	1,372,463
	Ponca City, OK	21	31	47	44,983
	Tahlequah, OK	19	0	19	48,751
	Tulsa, OK	31	98	116	987,465
	Adair County, OK	18	0	18	22,098
	Caddo County, OK	3	0	3	29,557
	Dewey County, OK	30	12	42	4,819
	Johnston County, OK	19	0	19	11,087
	Mayes County, OK	30	0	30	40,920
Oregon	Eugene, OR	5	6	11	368,283
	Grants Pass, OR	0	5	5	85,338
	Hermiston-Pendleton, OR	20	0	20	87,868
	Klamath Falls, OR	0	19	19	66,283
	Medford, OR	0	17	17	214,706
	Portland-Vancouver-Hillsboro, OR-WA	5	32	37	2,423,102
	Prineville, OR	0	16	16	22,344
	Salem, OR	11	0	11	417,208
	The Dalles, OR	6	0	6	25,871
	Harney County, OR	0	25	25	7,292

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Lake County, OR	0	9	9	7,837
Pennsylvania	Allentown-Bethlehem-Easton, PA-NJ	44	106	133	835,233
	Altoona, PA	25	60	81	123,927
	Chambersburg-Waynesboro, PA	12	0	12	153,564
	DuBois, PA	35	0	35	80,035
	East Stroudsburg, PA	31	30	55	166,516
	Erie, PA	30	57	71	276,321
	Gettysburg, PA	54	43	81	101,684
	Harrisburg-Carlisle, PA	45	112	132	568,008
	Indiana, PA	45	0	45	85,256
	Johnstown, PA	33	86	102	134,313
	Lancaster, PA	46	168	179	539,137
	Lebanon, PA	45	157	177	138,557
	New Castle, PA	29	0	29	87,631
	New York-Newark-Jersey City, NY-NJ-PA	40	50	75	20,275,179
	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	51	74	111	6,077,152
	Pittsburgh, PA	46	97	121	2,341,536
	Reading, PA	47	132	144	415,732
	Sayre, PA	10	38	43	60,986
	Scranton-Wilkes-Barre-Hazleton, PA	31	46	68	555,171
	Somerset, PA	33	0	33	75,070
	St. Marys, PA	24	0	24	30,423
	State College, PA	37	55	76	162,083
	Williamsport, PA	31	0	31	114,708
	York-Hanover, PA	59	95	128	443,809
	Youngstown-Warren-Boardman, OH-PA	44	68	90	544,543
	Greene County, PA	40	3	42	37,197
	Tioga County, PA	30	27	50	41,467
Rhode Island	Providence-Warwick, RI-MA	25	32	49	1,615,878
South Carolina	Augusta-Richmond County, GA-SC	30	21	50	594,889
	Charleston-North Charleston, SC	16	26	41	761,904
	Charlotte-Concord-Gastonia, NC-SC	38	21	54	2,475,519
	Columbia, SC	28	71	87	817,443
	Florence, SC	21	14	33	205,818
	Gaffney, SC	32	0	32	56,725
	Greenville-Anderson-Mauldin, SC	42	66	99	884,512
	Greenwood, SC	26	0	26	94,889
	Seneca, SC	22	19	39	76,407
	Spartanburg, SC	50	45	86	328,751

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Walterboro, SC	8	0	8	5,401
	Chesterfield County, SC	25	8	32	46,013
South Dakota	Aberdeen, SD	0	4	4	42,856
	Brookings, SD	14	10	22	34,057
	Pierre, SD	0	5	5	22,020
	Rapid City, SD	20	16	35	144,879
	Sioux City, IA-NE-SD	18	31	44	169,049
	Sioux Falls, SD	31	26	53	254,372
	Watertown, SD	0	12	12	28,033
	Jackson County, SD	14	2	16	3,326
Tennessee	Athens, TN	0	18	18	52,659
	Chattanooga, TN-GA	71	18	84	551,957
	Clarksville, TN-KY	39	33	66	280,843
	Cookeville, TN	0	6	6	109,703
	Dyersburg, TN	0	1	1	37,605
	Jackson, TN	0	4	4	129,083
	Kingsport-Bristol-Bristol, TN-VA	47	16	61	305,893
	Knoxville, TN	60	61	108	867,870
	Lawrenceburg, TN	0	2	2	42,979
	Morristown, TN	82	0	82	116,874
	Nashville-Davidson—Murfreesboro—Franklin, TN	36	49	75	1,868,855
	Sevierville, TN	56	0	56	96,609
	Claiborne County, TN	23	0	23	31,757
	DeKalb County, TN	21	0	21	19,361
Texas	Amarillo, TX	44	0	44	263,036
	Austin-Round Rock, TX	39	10	46	2,060,558
	Beaumont-Port Arthur, TX	19	0	19	410,909
	Brownsville-Harlingen, TX	4	28	32	421,766
	Corpus Christi, TX	16	26	42	454,066
	Corsicana, TX	22	0	22	48,375
	Dallas-Fort Worth-Arlington, TX	29	52	72	7,253,424
	El Paso, TX	45	86	119	841,220
	Houston-The Woodlands-Sugar Land, TX	23	74	85	6,798,010
	Killeen-Temple, TX	34	0	34	436,803
	Longview, TX	30	0	30	217,314
	Marshall, TX	15	11	23	66,730
	McAllen-Edinburg-Mission, TX	2	30	32	850,187
	San Antonio-New Braunfels, TX	28	10	36	2,426,211
	Texarkana, TX-AR	0	25	25	150,185
	Tyler, TX	24	0	24	225,305

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Victoria, TX	20	0	20	99,900
	Waco, TX	20	0	20	264,809
	Brewster County, TX	29	0	29	9,200
	Polk County, TX	5	0	5	47,916
Utah	Ogden-Clearfield, UT	51	64	104	652,995
	Price, UT	81	0	81	20,371
	Provo-Orem, UT	91	69	133	601,478
	Salt Lake City, UT	93	51	136	1,185,978
	St. George, UT	73	9	80	159,237
	Vernal, UT	65	23	75	36,194
	Duchesne County, UT	78	27	91	20,337
	San Juan County, UT	55	0	55	16,895
Vermont	Bennington, VT	20	6	22	35,854
	Burlington-South Burlington, VT	8	9	15	217,429
	Claremont-Lebanon, NH-VT	5	16	19	216,458
	Rutland, VT	11	38	46	59,172
Virginia	Blacksburg-Christiansburg-Radford, VA	29	0	29	182,635
	Charlottesville, VA	21	19	36	231,160
	Harrisonburg, VA	21	11	32	133,241
	Kingsport-Bristol-Bristol, TN-VA	47	16	61	305,893
	Lynchburg, VA	0	5	5	260,092
	Richmond, VA	29	51	69	1,282,205
	Roanoke, VA	23	27	49	313,102
	Virginia Beach-Norfolk-Newport News, VA-NC	16	22	36	1,722,766
	Washington-Arlington-Alexandria, DC-VA-MD-WV	47	44	84	6,150,681
	Winchester, VA-WV	20	14	34	135,593
	Madison County, VA	33	0	33	13,078
	Prince Edward County, VA	14	0	14	23,142
	Rockbridge County, VA	10	0	10	22,392
	Wythe County, VA	17	0	17	29,016
Washington	Bellingham, WA	0	7	7	216,274
	Bremerton-Silverdale, WA	0	1	1	263,109
	Ellensburg, WA	0	40	40	44,928
	Kennewick-Richland, WA	20	0	20	283,799
	Mount Vernon-Anacortes, WA	5	7	11	123,390
	Olympia-Tumwater, WA	5	0	5	273,923
	Port Angeles, WA	1	0	1	74,098
	Portland-Vancouver-Hillsboro, OR-WA	5	32	37	2,423,102

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
	Seattle-Tacoma-Bellevue, WA	8	21	26	3,802,660
	Spokane-Spokane Valley, WA	7	44	51	554,777
	Wenatchee, WA	0	18	18	117,240
	Yakima, WA	0	84	84	249,323
	Okanogan County, WA	0	28	28	41,554
West Virginia	Charleston, WV	31	30	57	217,735
	Clarksburg, WV	0	7	7	93,810
	Fairmont, WV	0	9	9	56,477
	Hagerstown-Martinsburg, MD-WV	50	53	95	263,080
	Huntington-Ashland, WV-KY-OH	27	10	36	358,857
	Morgantown, WV	12	9	21	138,482
	Parkersburg-Vienna, WV	36	10	45	91,488
	Washington-Arlington-Alexandria, DC-VA-MD-WV	47	44	84	6,150,681
	Weirton-Steubenville, WV-OH	37	128	147	119,242
	Gilmer County, WV	12	0	12	8,249
	Greenbrier County, WV	18	0	18	35,279
	Tucker County, WV	23	0	23	6,926
Wisconsin	Appleton, WI	20	15	34	234,302
	Baraboo, WI	19	6	25	63,604
	Beaver Dam, WI	23	15	37	87,428
	Chicago-Naperville-Elgin, IL-IN-WI	36	58	84	9,546,326
	Duluth, MN-WI	8	12	20	278,954
	Eau Claire, WI	18	7	25	166,452
	Fond du Lac, WI	24	0	24	102,210
	Green Bay, WI	27	17	42	317,441
	Janesville-Beloit, WI	28	0	28	161,421
	La Crosse-Onalaska, WI-MN	19	11	30	136,442
	Madison, WI	24	16	39	647,432
	Manitowoc, WI	28	0	28	79,331
	Milwaukee-Waukesha-West Allis, WI	28	26	49	1,576,143
	Minneapolis-St. Paul-Bloomington, MN-WI	9	31	37	3,557,276
	Platteville, WI	0	12	12	51,993
	Racine, WI	44	0	44	195,010
	Sheboygan, WI	36	0	36	115,127
	Watertown-Fort Atkinson, WI	25	0	25	84,545
	Wausau, WI	16	0	16	135,195
	Whitewater-Elkhorn, WI	27	0	27	102,775
	Ashland County, WI	11	1	12	15,714
	Door County, WI	27	0	27	27,587
	Forest County, WI	13	0	13	9,064
	Taylor County, WI	17	5	22	20,439
	Vilas County, WI	11	1	12	21,435

State	Metropolitan Area or Rural County	Number of Days in 2016 in which Half or More Monitoring Locations Reported Elevated			Population
		Ozone	$PM_{2.5}$	Ozone and/or $PM_{2.5}$	
Wyoming	Casper, WY	28	4	32	80,892
	Cheyenne, WY	46	5	50	97,968
	Evanston, WY	25	0	25	20,711
	Gillette, WY	34	5	39	48,800
	Jackson, WY-ID	27	11	35	34,266
	Laramie, WY	67	1	68	37,987
	Riverton, WY	37	5	41	40,245
	Rock Springs, WY	21	3	24	44,245
	Sheridan, WY	14	19	33	30,049
	Big Horn County, WY	5	0	5	12,005
	Carbon County, WY	27	2	29	15,618
	Converse County, WY	31	5	36	14,191
	Goshen County, WY	21	13	32	13,390
	Park County, WY	0	3	3	29,353
	Sublette County, WY	26	9	34	9,769
	Weston County, WY	35	4	39	7,236

Appendix B.

Sources of Pollutants that Contribute to Smog and Particulate Pollution, by State, 2014

Data are from the EPA's 2014 National Emissions Inventory. "Mobile sources" include on- and off-road vehicles. "Industrial sources" include fuel combustion for industrial purposes, chemical and related product manufacturing, metals processing, and other industrial processes.

Table B1. Share of Nitrogen Oxides from Selected Emission Sources

Selected sources do not add up to 100 percent.

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Alabama	15%	51%	21%	3%
Alaska	13%	43%	27%	2%
Arizona	14%	72%	4%	0%
Arkansas	14%	50%	18%	3%
California	1%	72%	9%	1%
Colorado	14%	45%	13%	12%
Connecticut	3%	69%	6%	0%
Delaware	7%	71%	13%	0%
District of Columbia	0%	75%	7%	0%
Florida	13%	72%	7%	0%
Georgia	10%	64%	11%	0%
Hawaii	42%	40%	4%	0%
Idaho	0%	65%	10%	0%
Illinois	10%	60%	12%	2%
Indiana	27%	52%	11%	1%
Iowa	14%	57%	9%	0%
Kansas	8%	41%	12%	19%
Kentucky	29%	50%	8%	4%
Louisiana	11%	45%	27%	9%
Maine	2%	61%	21%	0%
Maryland	9%	72%	5%	0%
Massachusetts	4%	66%	9%	0%
Michigan	15%	55%	14%	3%
Minnesota	11%	56%	16%	0%

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Mississippi	12%	61%	14%	0%
Missouri	19%	59%	8%	0%
Montana	12%	47% 5	%	3%
Nebraska	12%	60%	5%	0%
Nevada	11%	69%	5%	0%
New Hampshire	8%	59%	18%	0%
New Jersey	4%	73%	3%	1%
New Mexico	10%	46%	11%	17%
New York	5%	67%	8%	0%
North Carolina	13%	67%	11%	0%
North Dakota	23%	39%	3%	18%
Ohio	20%	56%	11%	1%
Oklahoma	10%	35%	21%	19%
Oregon	3%	64%	9%	0%
Pennsylvania	25%	47%	15%	4%
Rhode Island	2%	79%	4%	0%
South Carolina	9%	66%	15%	0%
South Dakota	10%	48%	2%	0%
Tennessee	7%	69%	13%	0%
Texas	9%	48%	13%	20%
Utah	25%	50%	7%	9%
Vermont	2%	67%	7%	0%
Virginia	7%	65%	15%	3%
Washington	3%	73%	7%	0%
West Virginia	37%	30%	12%	14%
Wisconsin	9%	65%	12%	0%
Wyoming	23%	36%	16%	13%

Table B2. Share of Volatile Organic Compounds from Selected Emission Sources
Selected sources do not add up to 100 percent.

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Alabama	0%	5%	1%	1%
Alaska	0%	5%	0%	5%
Arizona	0%	4%	0%	0%
Arkansas	0%	4%	1%	1%
California	0%	6%	1%	3%
Colorado	0%	8%	1%	9%
Connecticut	0%	24%	0%	0%
Delaware	0%	28%	1%	1%
District of Columbia	0%	40%	1%	0%
Florida	0%	11%	1%	0%
Georgia	0%	6%	1%	0%
Hawaii	0%	24%	0%	3%
Idaho	0%	4%	0%	0%
Illinois	0%	20%	3%	4%
Indiana	0%	20%	3%	3%
Iowa	0%	14%	4%	0%
Kansas	0%	7%	1%	13%
Kentucky	0%	8%	4%	3%
Louisiana	0%	4%	2%	4%
Maine	0%	7%	0%	0%
Maryland	0%	23%	1%	0%
Massachusetts	0%	24%	1%	0%
Michigan	0%	22%	1%	3%
Minnesota	0%	16%	1%	0%
Mississippi	0%	4%	1%	0%
Missouri	0%	8%	0%	0%
Montana	0%	3%	0%	5%
Nebraska	0%	9%	1%	0%
Nevada	0%	3%	0%	0%
New Hampshire	0%	15%	0%	0%
New Jersey	0%	23%	2%	0%
New Mexico	0%	2%	0%	11%
New York	0%	21%	1%	1%
North Carolina	0%	9%	2%	0%
North Dakota	0%	3%	0%	64%

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Ohio	0%	22%	2%	2%
Oklahoma	0%	4%	1%	13%
Oregon	0%	4%	1%	0%
Pennsylvania	0%	15%	1%	13%
Rhode Island	0%	25%	1%	0%
South Carolina	0%	7%	2%	0%
South Dakota	0%	5%	1%	1%
Tennessee	0%	10%	3%	0%
Texas	0%	4%	1%	16%
Utah	0%	5%	0%	12%
Vermont	0%	11%	0%	0%
Virginia	0%	10%	1%	1%
Washington	0%	9%	1%	0%
West Virginia	0%	5%	1%	17%
Wisconsin	0%	20%	1%	0%
Wyoming	0%	2%	1%	26%

Table B3. Share of $PM_{2.5}$ from Selected Emission Sources
Selected sources do not add up to 100 percent.

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Alabama	2%	4%	27%	0%
Alaska	0%	1%	1%	0%
Arizona	3%	9%	14%	0%
Arkansas	1%	4%	13%	0%
California	0%	5%	7%	0%
Colorado	1%	10%	11%	3%
Connecticut	2%	17%	17%	0%
Delaware	2%	23%	14%	1%
District of Columbia	0%	30%	34%	0%
Florida	4%	7%	15%	0%
Georgia	2%	6%	10%	0%
Hawaii	7%	4%	5%	0%
Idaho	0%	3%	4%	0%
Illinois	3%	8%	7%	1%
Indiana	27%	7%	15%	0%
Iowa	3%	7%	6%	0%
Kansas	1%	4%	3%	1%
Kentucky	7%	6%	11%	0%
Louisiana	2%	4%	14%	2%
Maine	1%	11%	15%	0%
Maryland	5%	16%	10%	0%
Massachusetts	1%	13%	16%	0%
Michigan	2%	12%	16%	1%
Minnesota	1%	6%	11%	0%
Mississippi	2%	5%	11%	0%
Missouri	3%	4%	3%	0%
Montana	2%	3%	5%	0%
Nebraska	1%	8%	3%	0%
Nevada	2%	7%	30%	0%
New Hampshire	1%	11%	11%	0%
New Jersey	3%	19%	14%	1%
New Mexico	1%	5%	5%	1%
New York	1%	16%	14%	0%
North Carolina	6%	11%	25%	0%
North Dakota	3%	4%	3%	1%

State	Percent from Electricity Generation	Percent from Mobile Sources	Percent from Industrial Sources	Percent from Oil & Gas Production and Refining
Ohio	12%	7%	12%	1%
Oklahoma	3%	4%	6%	2%
Oregon	0%	2%	2%	0%
Pennsylvania	8%	10%	23%	1%
Rhode Island	1%	21%	12%	0%
South Carolina	4%	7%	19%	0%
South Dakota	0%	3%	1%	0%
Tennessee	3%	8%	21%	0%
Texas	4%	9%	10%	2%
Utah	6%	10%	10%	2%
Vermont	0%	6%	4%	0%
Virginia	2%	10%	18%	0%
Washington	0%	4%	4%	0%
West Virginia	15%	6%	11%	1%
Wisconsin	2%	8%	12%	0%
Wyoming	3%	6%	12%	3%

Notes

1 Michelle L. Bell, Roger D. Peng and Francesca Dominici, "The Exposure-Response Curve for Ozone and Risk of Mortality and the Adequacy of Current Ozone Regulations," *Environmental Health Perspectives*, 114(4): 532-6, doi:10.1289/ehp.8816, April 2006; and World Health Organization, *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide, Global Update 2005, Summary of Risk Assessment*, 2006, archived at web.archive.org/web/20170316035918/http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf.

2 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards: Ozone and Health* (factsheet), no date, archived at web.archive.org/web/20170322214936/https://www.epa.gov/sites/production/files/2016-04/documents/20151001healthfs.pdf; Kendall Powell, "Ozone Exposure Throws Monkey Wrench into Infant Lungs," *Nature Medicine*, 9(5), May 2003; R. McConnell et al., "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *The Lancet* 359: 386-391, 2002; N. Kunzli et al., "Association Between Lifetime Ambient Ozone Exposure and Pulmonary Function in College Freshmen – Results of a Pilot Study," *Environmental Research* 72: 8-16, 1997; I.B. Tager et al., "Chronic Exposure to Ambient Ozone and Lung Function in Young Adults," *Epidemiology,* 16: 751-9, November 2005.

3 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards for Particle Pollution: Particle Pollution and Health* (factsheet), no date; and J. Pekkanen et al., "Daily Variations of Particulate Air Pollution and ST-T Depressions in Subjects with Stable Coronary Heart Disease: The Finnish ULTRA Study," *American Journal of Respiratory Critical Care Medicine,* 161: A24, 2000.

4 L. Trasande, P. Malecha and T.M. Attina, "Particulate Matter Exposure and Preterm Birth: Estimates of U.S. Attributable Burden and Economic Costs," *Environmental Health Perspectives*, 124(12): 1913-1918, dx.doi.org/10.1289/ehp.1510810, December 2016; Raanan Raz et al., "Autism Spectrum Disorder and Particulate Matter Air Pollution before, during, and after Pregnancy: A Nested Case-Control Analysis within the Nurses' Health Study II Cohort," *Environmental Health Perspectives*, 123: 264-270, dx.doi.org/10.1289/ehp.1408133, 1 March 2015; W.J. Gauderman et al., "The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age," *The New England Journal of Medicine* 351: 1057-67, 9 September 2004; and U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards for Particle Pollution: Particle Pollution and Health* (factsheet), no date, archived at https://web.archive.org/web/20170819075126/https://www.epa.gov/sites/production/files/2016-04/documents/health_2012_factsheet.pdf.

5 M. Cacciottolo et al., "Particulate Air Pollutants, APOE Alleles and Their Contributions to Cognitive Impairment in Older Women and

to Amyloidogenesis in Experimental Models," *Translational Psychiatry*, doi:10.1038/tp.2016.280, 31 January 2017.

6 Michelle L. Bell, Roger D. Peng and Francesca Dominici, "The Exposure-Response Curve for Ozone and Risk of Mortality and the Adequacy of Current Ozone Regulations," *Environmental Health Perspectives*, 114(4): 532-6, doi:10.1289/ehp.8816, April 2006, and Qian Di et al., "Association of Short-Term Exposure to Air Pollution with Mortality in Older Adults," *JAMA*, 318(24): 2446-2456, doi:10.1001/jama.2017.17923, 26 December 2017.

7 The map shows Census-designated metropolitan and micropolitan areas, plus rural counties that have an air pollution monitor. Note that Macon, Georgia, is mapped to Macon County. The towns of Bishop, CA; Rockland, ME; and Walterboro, SC, are not shown because they are not included in the Census Bureau shapefiles for mapping.

8 Neal Fann et al., "Chapter 3: Air Quality Impacts," *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, U.S. Global Change Research Program, dx.doi.org/10.7930/J0GQ6VP6, 2016.

9 Climate Central, *Stagnant Air on the Rise, Upping Ozone Risk*, 17 August 2016, archived at web.archive.org/web/20170218012058/http://www.climatecentral.org/news/stagnation-air-conditions-on-the-rise-20600.

10 George Luber et al., "Chapter 9: Human Health," *Climate Change Impacts in the United States: The Third National Climate Assessment*, U.S. Global Change Research Program, doi:10.7930/J0PN93H5, 2014.

11 U.S. Environmental Protection Agency, Office of Air and Radiation, *The Benefits and Costs of the Clean Air Act from 1990 to 2020*, April 2011, archived at web.archive.org/web/20151019090948/https://www2.epa.gov/sites/production/files/2015-07/documents/fullreport_rev_a.pdf.

12 Environmental Protection Agency, "Volatile Organic Compounds Emissions," *Report on the Environment*, no date, archived at web.archive.org/web/20170315172122/https://cfpub.epa.gov/roe/indicator.cfm?i=23.

13 M. Lippman, "Health Effects of Ozone: A Critical Review," *Journal of the Air Pollution Control Association,* 39: 672-695, 1989; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine,* 21: 1-48, 2000; M. Gilmour et al., "Ozone-Enhanced Pulmonary Infection with Streptococcus Zooepidemicus in Mice: The Role of Alveolar Macrophage Function and Capsular Virulence Factors," *American Review of Respiratory Disease,* 147: 753-760, March 1993.

14 See note 2.

15 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards: Ozone and Children's Health* (factsheet), no date, archived at web.archive.org/web/20170322220255/https://www.epa.gov/sites/production/files/2016-04/documents/20151001childrenhealthfs.pdf.

16 Centers for Disease Control and Prevention, *Asthma in Schools*, accessed 25 May 2018, archived at https://web.archive.org/web/20171217221204/https://www.cdc.gov/healthyschools/asthma/.

17 Joel Schwartz, "Air Pollution and Hospital Admissions for the Elderly in Birmingham, Alabama," *American Journal of Epidemiology*, 139: 589-98, 15 March 1994; Joel Schwartz, "Air Pollution and Hospital Admissions for the Elderly in Detroit, Michigan," *American Journal of Respiratory Critical Care Medicine,* 150: 648-55, 1994; Joel Schwartz , "PM10, Ozone, and Hospital Admissions for the Elderly in Minneapolis-St. Paul, Minnesota," *Archives of Environmental Health,* 49: 366-374, 1994; Joel Schwartz, "Short-Term Fluctuations in Air Pollution and Hospital Admissions of the Elderly for Respiratory Disease," *Thorax,* 50: 531-538, 1995; J. Schwartz and R. Morris, "Air Pollution and Hospital Admissions

for Cardiovascular Disease in Detroit, Michigan," *American Journal of Epidemiology,* 142: 23-25, 1995; Joel Schwartz, "Air Pollution and Hospital Admissions for Respiratory Disease," *Epidemiology,* 7: 20-28, 1996; Joel Schwartz, "Air Pollution and Hospital Admissions for Cardiovascular Disease in Tucson," *Epidemiology,* 8: 371-377, 1997.

18 George Thurston et al., "Respiratory Hospital Admissions and Summertime Haze Air Pollution in Toronto, Ontario: Consideration of the Role of Acid Aerosols," *Environmental Research,* 65: 271-290, 1994.

19 R. Cody et al., "The Effect of Ozone Associated with Summertime Photochemical Smog on the Frequency of Asthma Visits to Hospital Emergency Departments," *Environmental Research*, 58: 184-194, 1992; C. Weisel et al., "Relationship Between Summertime Ambient Ozone Levels and Emergency Department Visits for Asthma in Central New Jersey," *Environmental Health Perspectives*, 103, Supplement 2: 97-102, 1995; Jennifer Peel et al., "Ambient Air Pollution and Respiratory Emergency Department Visits," *Epidemiology,* 6:164-174, March 2005.

20 George Thurston et al., "Summertime Haze Air Pollution and Children with Asthma," *American Journal of Respiratory Critical Care Medicine*, 155: 654-660, February 1997; A. Whittemore and E. Korn, "Asthma and Air Pollution in the Los Angeles Area," *American Journal of Public Health*, 70: 687-696, 1980; J. Schwartz et al., "Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children," *American Journal of Respiratory Critical Care Medicine,* 150: 1234-1242, 1994; M. Friedman et al., "Impact of Changes in Transportation and Commuting Behaviors During the 1996 Summer Olympic Games in Atlanta on Air Quality and Childhood Asthma," *Journal of the American Medical Association,* 285: 897-905, 2001; Janneane Gent et al., "Association of Low-level Ozone and Fine Particles with Respiratory Symptoms in Children with Asthma," *Journal of The American Medical Association,* 290, 1859-1867, 8 October 2003; E.W. Triche et al, "Low Level Ozone Exposure and Respiratory Symptoms in Infants," *Environmental Health Perspectives,* doi:10.1289/ehp.8559, online 29 December 2005.

21 B. Ostro and S. Rothschild, "Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants," *Environmental Research*, 50: 238-47, 1989; F. Gilliland et al., "The Effects of Ambient Air Pollution on School Absenteeism Due to Respiratory Illness," *Epidemiology*, 12: 43-54, 2001; H. Park et al., "Association of Air Pollution with School Absenteeism Due to Illness," *Archives of Pediatric and Adolescent Medicine,* 156: 1235-1239, 2002.

22 Maryland Department of the Environment, *Current Air Quality Conditions*, accessed 18 May 2018, archived at https://web.archive.org/web/20180518163403/http://www.mde.state.md.us/programs/Air/AirQualityMonitoring/Pages/index.aspx.

23 U.S. Environmental Protection Agency, *Particle Pollution and Your Health*, September 2003, archived at web.archive.org/web/20170322220713/https://www3.epa.gov/airnow/particle/pm-color.pdf.

24 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards for Particle Pollution: Particle Pollution and Health* (factsheet), no date; and J. Pekkanen et al., "Daily Variations of Particulate Air Pollution and ST-T Depressions in Subjects with Stable Coronary Heart Disease: The Finnish ULTRA Study," *American Journal of Respiratory Critical Care Medicine,* 161: A24, 2000.

25 See note 23.

26 L. Trasande, P. Malecha and T.M. Attina, "Particulate Matter Exposure and Preterm Birth: Estimates of U.S. Attributable Burden and Economic Costs," *Environmental Health Perspectives*, 124(12): 1913-1918, doi:10.1289/ehp.1510810, December 2016.

27 Raanan Raz et al., "Autism Spectrum Disorder and Particulate Matter Air Pollution before,

during, and after Pregnancy: A Nested Case-Control Analysis within the Nurses' Health Study II Cohort," *Environmental Health Perspectives*, 123: 264-270, dx.doi.org/10.1289/ehp.1408133, 1 March 2015.

28 Lilian Calderón-Garcidueñas et al., "Hallmarks of Alzheimer Disease Are Evolving Relentlessly in Metropolitan Mexico City Infants, Children and Young Adults. APOE4 Carriers Have Higher Suicide Risk and Higher Odds of Reaching NFT Stage V at ≤40 Years of Age," *Environmental Research*, 164: 475-487, doi: 10.1016/j.envres.2018.03.023, March 2018.

29 W.J. Gauderman et al., "The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age," *The New England Journal of Medicine* 351: 1057-67, 9 September 2004.

30 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards for Particle Pollution: Particle Pollution and Health* (factsheet), no date.

31 Benjamin Horne et al., "Short-Term Elevation in Fine Particulate Matter Air Pollution and Acute Lower Respiratory Infection," *American Journal of Respiratory and Critical Care Medicine*, doi:10.1164/rccm.201709-1883OC, 13 April 2018.

32 See note 5.

33 Chau-Ren Jung, Yu-Ting Lin and Bing-Fang Hwang, "Ozone, Particulate Matter, and Newly Diagnosed Alzheimer's Disease: A Population-Based Cohort Study in Taiwan," *Journal of Alzheimer's Disease*, 44(2): 573-584, doi:10.3233/JAD-140855, 2015.

34 Asthma: Ralph Delfino et al., "Asthma Symptoms in Hispanic Children and Daily Ambient Exposures to Toxic and Criteria Air Pollutants," *Environmental Health Perspectives,* 111(4), 647-656, April 2003; I.L. Bernstein, M. Chan-Yeung, J.L. Malo and D.I. Bernstein, *Asthma in the Workplace*, (New York, NY: Marcel Dekker), 1999; Cancer: D. Glass et al., "Leukemia Risk Associated with Low-Level Benzene Exposure," *Epidemiology,* 14: 569-577, 2003; A. Blair and N. Kazerouni, "Reactive Chemicals and Cancer," *Cancer Causes Control,* 8: 473-490, May 1997.

35 U.S. Environmental Protection Agency, *National Emissions Inventory: Average Annual Emissions: Criteria Pollutants National Tier 1 for 1970-2017* (spreadsheet), 27 March 2018, downloaded 7 May 2018.

36 Ibid.

37 William M. Hodan and William R. Barnard, MACTEC for the Federal Highway Administration, *Evaluating the Contribution of PM2.5 Precursor Gases and Re-entrained Road Emissions to Mobile Source PM2.5 Particulate Matter Emissions*, no date, archived at https://web.archive.org/web/20170504091406/https://www3.epa.gov/ttnchie1/conference/ei13/mobile/hodan.pdf.

38 Shuvashish Kundu and Elizabeth A. Stone, "Composition and Sources of Fine Particulate Matter across Urban and Rural Sites in the Midwestern United States," *Environmental Science: Processes & Impacts*, 16(6): 1360-1370, https://dx.doi.org/10.1039%2Fc3em00719g, 2014.

39 U.S. Environmental Protection Agency, *Report on the Environment: Indoor Air Quality*, no date, archived at https://web.archive.org/web/20180226072535/https://cfpub.epa.gov/roe/chapter/air/indoorair.cfm.

40 Dennis Leung, "Outdoor-Indoor Air Pollution in Urban Environment: Challenges and Opportunity," *Frontiers in Environmental Science*, doi:10.3389/fenvs.2014.00069, 15 January 2015.

41 Don Fugler, ROCIS Initiative, *Protecting Homes from Outdoor Pollutants*, 15 November 2014, archived at https://web.archive.org/web/20160826113531/http://rocis.org/sites/default/files/user-files/ROCIS_HomesFINAL1120.pdf.

42 Institute of Medicine, *Climate Change, the Indoor Environment, and Health* (Washington, DC: The National Academies Press, 2011), 83.

43 U.S. Environmental Protection Agency, *The Inside Story: A Guide to Indoor Air Quality*, no date, archived at https://web.archive.org/web/20180418160409/https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality.

44 See note 40.

45 U.S. Environmental Protection Agency, *Air Quality Index (AQI) Basics,* 31 August 2016, archived at web.archive.org/web/20170215191308/https://airnow.gov/index.cfm?action=aqibasics.aqi.

46 Ibid., and U.S. Environmental Protection Agency, *AQI Breakpoints*, accessed 25 May 2018, archived at https://web.archive.org/web/20170804233336/https://aqs.epa.gov/aqsweb/documents/codetables/aqi_breakpoints.html.

47 U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards: Overview of EPA's Updates to the Air Quality Standards for Ground-Level Ozone*, no date, archived at web.archive.org/web/20170129154331/https://www.epa.gov/sites/production/files/2015-10/documents/overview_of_2015_rule.pdf.

48 U.S. Environmental Protection Agency, *NAAQS Table*, accessed 29 April 2018, archived at https://web.archive.org/web/20180428122407/https://www.epa.gov/criteria-air-pollutants/naaqs-table.

49 World Health Organization, *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide, Global Update 2005, Summary of Risk Assessment*, 2006, archived at https://web.archive.org/web/20180430002838/http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=0ECB237CCEA2E516899D1EE7985100E8?sequence=1.

50 Kevin Cromar et al., "American Thoracic Society and Marron Institute Report Estimated Excess Morbidity and Mortality Associated with Air Pollution above American Thoracic Society–recommended Standards, 2013–2015," *Annals of the American Thoracic Society*, doi: 10.1513/AnnalsATS.201710-785EH, May 2018; and American Lung Association, *Letter to Lisa Jackson, Administrator, U.S. EPA, RE: Docket EPA-HQ-OAR-2007-0492*, 31 August 2012, archived at https://web.archive.org/web/20180524220432/http://www.lung.org/assets/documents/advocacy-archive/epa-proposed-particle-soot-standard-natl.pdf.

51 Michelle L. Bell, Roger D. Peng and Francesca Dominici, "The Exposure-Response Curve for Ozone and Risk of Mortality and the Adequacy of Current Ozone Regulations," *Environmental Health Perspectives*, 114(4): 532-6, doi:10.1289/ehp.8816, April 2006.

52 Qian Di et al., "Association of Short-Term Exposure to Air Pollution with Mortality in Older Adults," *JAMA*, 318(24): 2446-2456, doi:10.1001/jama.2017.17923, 26 December 2017.

53 See note 49.

54 Yi Tan et al., "Characterizing the Spatial Variation of Air Pollutants and the Contributions of High Emitting Vehicles in Pittsburgh, PA," *Environmental Science & Technology*, 48: 14186-14194, dx.doi.org/10.1021/es5034074, 13 November 2014; Albert Presto et al., "BTEX Exposures in an Area Impacted by Industrial and Mobile Sources: Source Attribution and Impact of Averaging Time," *Journal of the Air & Waste Management Association*, 66(4): 387-401, 2016, dx.doi.org/10.1080/10962247.2016.1139517; and David Brown, Celia Lewis and Beth Weinberger, "Human Exposure to Unconventional Natural Gas Development: A Public Health Demonstration of Periodic High Exposure to Chemical Mixtures in Ambient Air," *Journal of Environmental Science and Health, Part A*, 50(5): 460-472, dx.doi.org/10.1080/10934529.2015.992663, 2015.

55 See note 47.

56 Emilia Simeonova et al., National Bureau of Economic Research, *Congestion Pricing, Air Pollution and Children's Health, Working Paper*

24410, March 2018, available at http://www.nber.org/papers/w24410.

57 Qian Di et al., "Air Pollution and Mortality in the Medicare Population," *The New England Journal of Medicine*, 376(26): 2513-2522, doi://10.1056/NEJMoa1702747, 29 June 2017.

58 This methodology is different from the previous version of this report, in which a moderate (yellow) level air quality report or higher from a single monitoring location in a region triggered inclusion in the region's annual count of days with unacceptable air quality.

59 See note 7.

60 Steven Wilson et al., U.S. Census, *Patterns of Metropolitan and Micropolitan Population Change: 2000 to 2010*, September 2012. The CBSA name in EPA's air pollution data is "Atlanta-Sandy Springs-Roswell" and the CBSA name in the census data is "Atlanta-Sandy Springs-Marietta"

61 NOAA, National Centers for Environmental Information, *State of the Climate: Global Climate Report for Annual 2017*, January 2018, archived at https://web.archive.org/web/20180119010127/https://www.ncdc.noaa.gov/sotc/global/201713.

62 See note 8 and note 10.

63 See note 8.

64 National Center for Environmental Assessment, *U.S. Environmental Protection Agency, Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone. An Interim Report of the U.S. EPA Global Change Research Program*, 2009, archived at web.archive.org/web/20170218011015/https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=203459&CFID=75007939&CFTOKEN=61566426.

65 See note 9.

66 See note 10.

67 Ibid.

68 Raquel Silva et al., "Future Global Mortality from Changes in Air Pollution Attributable to Climate Change," *Nature Climate Change* 7: 647-651, doi:10.1038/nclimate3354, 31 July 2017.

69 See note 8.

70 Michelle L. Bell, Roger D. Peng and Francesca Dominici, "The Exposure-Response Curve for Ozone and Risk of Mortality and the Adequacy of Current Ozone Regulations," *Environmental Health Perspectives*, 114(4): 532-6, doi:10.1289/ehp.8816, April 2006; see also note 52 and note 57.

71 See note 11.

72 U.S. Environmental Protection Agency, *Regulations for Greenhouse Gas Emissions from Passenger Cars and Trucks*, accessed 7 May 2018, archived at https://web.archive.org/web/20180507221553/https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-passenger-cars-and.

73 Luke Tonachel and David Doniger, NRDC, *Clean Car and Fuel Economy Standards: What's Next?*, 10 May 2018, archived at https://web.archive.org/web/20180527210555/https://www.nrdc.org/experts/luke-tonachel/clean-car-and-fuel-economy-standards-whats-next.

74 California Air Resources Board, *LEV II - Amendments to California's Low-Emission Vehicle Regulations (*factsheet), February 1999, archived at web.archive.org/web/20170322223124/https://www.arb.ca.gov/msprog/levprog/levii/factsht.pdf.

75 Simon Mui, Natural Resources Defense Council, *The World's Biggest EV Program Was Just Adopted. Here's Why,* 28 September 2017, archived at https://web.archive.org/web/20180502193357/https://www.nrdc.org/experts/simon-mui/most-important-electric-vehicle-program-was-just-adopted, and National Conference of State Legislatures, *State Efforts to Promote Hybrid and*

Electric Vehicles, 26 September 2017, archived at https://web.archive.org/web/20180212060146/http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.

76 States participating in the program are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont.

77 Jordan Stutt, Acadia Center, *RGGI Emissions Fell Again in 2016* (blog), 10 March 2017, archived at https://web.archive.org/web/20180307192536/http://acadiacenter.org/rggi-emissions-fell-again-in-2016/.

78 Michelle Manion et al., Abt Associates, *Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative, 2009-2014*, January 2017, archived at web.archive.org/web/20170322215723/http://abtassociates.com/AbtAssociates/files/7e/7e38e795-aba2-4756-ab72-ba7ae7f53f16.pdf.

79 See note 45.