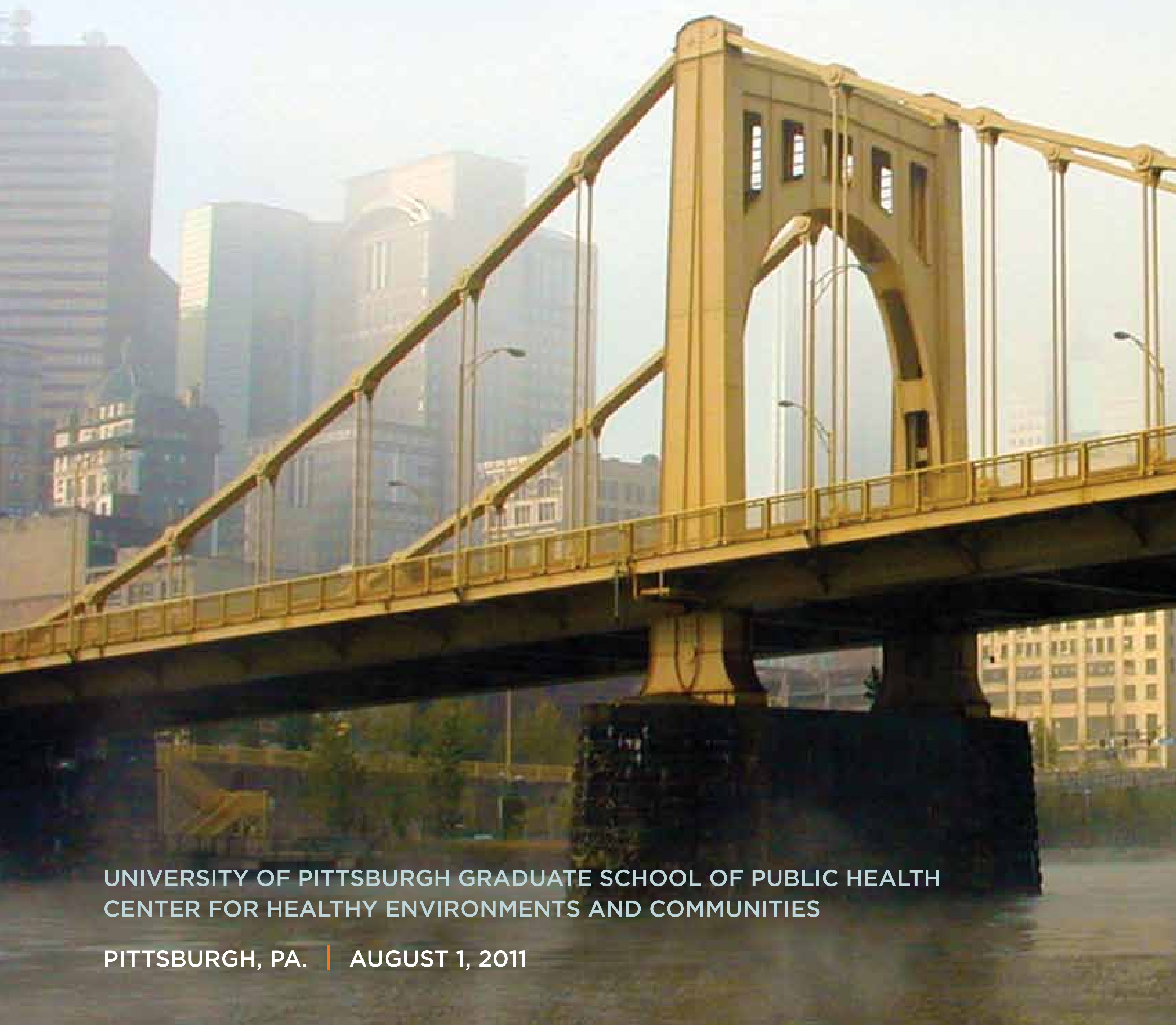
PITTSBURGH REGIONAL ENVIRONMENTAL THREATS ANALYSIS (PRETA) REPORT

PRETA AIR: OZONE



UNIVERSITY OF PITTSBURGH GRADUATE SCHOOL OF PUBLIC HEALTH
CENTER FOR HEALTHY ENVIRONMENTS AND COMMUNITIES

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PRETA AIR: OZONE

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The Center for Healthy Environments and Communities (CHEC), part of the University of Pittsburgh Graduate School of Public Health's Department of Environmental and Occupational Health, was founded in 2004 under a grant from The Heinz Endowments. CHEC's mission is to improve environmental health in Western Pennsylvania through community-based research.

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THE PURPOSE OF PRETA

The Pittsburgh Regional Environmental Threats Analysis (PRETA) project puts together information about the major threats to human health and the environment within Southwestern Pennsylvania. PRETA is intended to cover the core public health functions—assessment, policy development, and assurance—and relies heavily on figures, maps, and other visuals. PRETA is meant to encourage stakeholders to incorporate scientific analysis and public values for sound policy development and remedial action against environmental threats. PRETA also is meant to be informative, highlighting the populations most at risk to those threats. Ideally, PRETA will inspire initiatives to address the highest risks to human health and the environment in Southwestern Pennsylvania. The preliminary assessments employed early in the project identified air quality as the number one current environmental threat to the welfare of the greater Pittsburgh region. This first of a series of reports on environmental threats to the region, called *PRETA Air*, focuses on ground-level ozone, which has been elevated significantly above health-based governmental standards in the summer months.

PRETA STUDY AREA

10 Southwestern Pennsylvania counties:

- Allegheny
- Armstrong
- Beaver
- Butler
- Fayette
- Greene
- Indiana
- Lawrence
- Washington
- Westmoreland

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EXECUTIVE SUMMARY

Ozone is a powerful, toxic gas. It is formed when sunlight acts on ozone-forming chemicals, notably hydrocarbons and oxides of nitrogen. Major sources of these ozone precursors in our area are mobile sources, such as automobiles and trucks, and stationary sources, such as power plants and industries. Preventing ozone formation requires a concerted effort to control all of these sources. Our analysis indicates that while mobile sources are particularly important for Allegheny County, stationary sources are the dominant source of nitrogen oxides for Southwestern Pennsylvania.

Because of ozone in our outdoor air, children in the Pittsburgh region suffer from asthma attacks, visit hospital emergency rooms more often, and experience additional respiratory illnesses, just like children in any area of the country where ozone levels are elevated as a whole. Adults also are susceptible, particularly those with respiratory conditions, who are more likely to die when ozone levels are high. Pollution sources exist throughout Pennsylvania, Ohio, West Virginia, and Maryland. Many small stationary emissions sources exist in major urban cities, while larger sources tend to cluster along major rivers and in more rural areas, especially in the counties surrounding Allegheny County, Pa.

Increasing evidence of the harm caused by ozone has led to more protective outdoor standards. The U.S. Environmental Protection Agency (EPA)'s ongoing review of the damaging health effects of ozone is likely to further lower the allowable outdoor ozone level, resulting in even more of the Pittsburgh region's being designated as having unhealthy air because of ozone. Global climate change, by causing warmer days, and Marcellus Shale activities, through release of ozone-forming chemicals, may contribute further to the ozone problem in the Pittsburgh area. Geographical areas that exceed a health-based air pollutant standard, such as our region, are subject to control measures that can limit community growth and development.

Ground-level ozone is not just an urban problem. Ozone-forming chemicals can travel many miles downwind from areas that have heavy automobile traffic and industrial sources of ozone precursors. It is not surprising that in our region, ozone levels tend to be highest in the areas northeast of Pittsburgh, such as Harrison Township, Allegheny County.

We can avoid ozone by limiting our outdoor activities on high-ozone days, which are mostly warm days during spring and summer. Because sunlight is needed for ozone formation, ozone levels tend to be lowest in the morning before the sun is too high. Sensitive populations, such as children and older adults with respiratory conditions, should avoid exercising outdoors beginning midday until after the sun goes down. We also can avoid ozone formation by supporting pollution control policies that decrease the emission precursors, particularly oxides of nitrogen, and by limiting our personal contribution to ozone precursors, such as by driving less and using less electrical power.

OZONE EFFECTS

Ozone is an exceptionally powerful oxidizing gas that penetrates deeply into the lung. Children particularly are at risk from ozone. The major health impacts of ozone are:

- increased likelihood of asthma attacks;
- decline in lung function, even among healthy athletes;
- infections of the respiratory tract;
- premature death; and
- links to low birth weight and preterm delivery of infants.

To avoid ozone, focus on your outdoor activities in the early morning hours rather than late afternoon.

RECOGNIZING THE EFFECTS

What are the effects of ozone?

Ozone is an exceptionally powerful oxidizing gas that penetrates deeply into the lung. Breathing ozone causes lung inflammation leading to narrowing of the airways and resulting in acute and chronic health effects. Children particularly are at risk from ozone. They are often outdoors exercising during warm summer days when ozone levels are likely to be high.

Described below are some of the major health effects that have been related to ozone. Ozone does not occur by itself as an air pollutant. As discussed in more detail in subsequent sections of this document, ozone results from a complex photochemical process that produces other oxidants and is involved in the formation of fine particulates. It is often difficult for the public health community to be certain that a health effect observed on a high-ozone day is due to ozone itself, ozone in combination with other associated pollutants, or one of the other pollutants. However, it is abundantly clear that the measures that will lessen ozone formation also will decrease the formation of these other pollutants and prevent health effects associated with ozone exposure.

ASTHMA

Ozone exposure increases the likelihood of asthma attacks. When children with asthma are followed throughout the year, they are found to be more likely to have asthma attacks and to increase their medication use on high-ozone days. Ozone exposure also increases the number of hospital emergency room admissions for asthma. Recent studies have suggested that ozone not only makes asthma worse among asthmatics, but that exposure to ozone and other related pollutants increases the likelihood that children will become asthmatic. A more than tripling of the incidence of asthma was observed in high-ozone communities among children who played outdoor sports, while no such effect was observed in low-ozone communities (McConnell et al., 2002). A nationwide study showed that children living in metropolitan areas with high ozone levels, such as the Pittsburgh region, were about 50 percent more likely to suffer from asthma than those living in areas with low ozone levels (Akinbami et al., 2010).

Ozone appears to cause asthma attacks both by directly narrowing the airways, making it more difficult to breathe, and by causing lung changes that enhance the impact of allergens, such as dog dander, in causing an asthma attack. Respiratory allergies and hay fever also are associated with living in a high-ozone area (Parker et al., 2011).

Asthma is a major cause of disability and death, particularly among children. Close to 6 million American children suffer from asthma; asthma attacks account for approximately 25 percent of all hospital emergency room admissions; and asthma is the major chronic disease responsible for school absences, approximately 14 million school days per year. The annual costs of asthma are estimated to be as much as $18 billion. The extent to which ozone is responsible for the totality of asthma effects and costs is being evaluated as part of EPA's current reconsideration of the ozone standard.

LUNG FUNCTION

Ozone causes a decline in lung function, even among healthy athletes. Studies in human or laboratory animals experimentally exposed to ozone have demonstrated transient decreases in lung function. The higher the level of ozone, or the longer the duration of exposure, the greater the effect and the longer it persists. Studies of the lung function of children in summer camps have demonstrated effects on their ability to breathe after exercising outdoors on high-ozone days. There is suggestive evidence linking chronic ozone exposure to long-term loss of respiratory function.

INFECTIONS OF THE RESPIRATORY TRACT

Animal and human data suggest that ozone increases the likelihood of respiratory tract infections. When mice inhale relatively low levels of ozone, a subsequent exposure to bacteria is more likely to lead to fatal pneumonia. Studies of respiratory infections in communities have shown an association with higher ozone levels.

PREMATURE DEATH

A growing body of studies now clearly demonstrates that ozone exposure is associated with deaths. Among these is a study of more than 150,000 nonaccidental deaths among adults older than 35 years from 1995 to 2002, which showed a 1.61 percent increase in deaths in relation to a 0.01 parts-per-million (ppm) increase in the average maximum eight-hour ozone level in the previous week. Not surprisingly, some studies have shown that the elderly and those with pre-existing lung disease are particularly at risk.

PREGNANCY AND BIRTH OUTCOMES

There is a growing scientific literature evaluating the effects of air pollutants on pregnancy and birth outcomes. Studies report a relationship between air pollutants, including ozone, and low birth weight and preterm delivery, suggesting an effect on the growing fetus. Pre-eclampsia, a complication of pregnancy, also has been associated with a number of air pollutants. But not all studies show these effects. While the data remain inconclusive, the subject is of significant concern. A better understanding of the relationship between air pollution and pregnancy outcomes is a major focus of current research (Parker, 2011).

NONHEALTH OUTCOMES

Ozone also affects growing plants, can cause the loss of many significant agricultural crops, and negatively affects materials such as natural rubber products.

What are the effects of other components of photochemical smog?

Ozone is part of a mixture of chemicals that are produced by the photochemical action of sunlight on hydrocarbons and oxides of nitrogen. Among these chemicals, ozone is the most powerful oxidant and the easiest to measure, so it receives the most attention. However, there are many other potentially harmful agents produced by the same photochemical process, although far less is known about their toxicity. Photochemical oxidation also is partially involved in the oxidation of sulfur dioxide to fine particle sulfates, which themselves cause health effects and acid rain. Controlling the formation of ozone also will control the formation of these other harmful components of photochemical smog.

Who is susceptible to ozone?

We are all susceptible to ozone. It is a chemical irritant that affects the lungs of anyone breathing it. Children are more susceptible to air pollutants, because they breathe more for their size than adults so their pollutant uptake is higher. The relative susceptibility of children to ozone is particularly high because they are more likely to be outdoors exercising on the warm summer days when there are higher ozone levels. Their growing lungs also appear to put them more at risk for the chronic effects of ozone. Further, compared to adults, children have relatively higher levels of asthma and respiratory tract infections, and those with asthma or respiratory infections are at higher risk from the effects of ozone. The elderly and those with chronic lung disease also are more at risk.

GROUND-LEVEL OZONE

What is ozone and where does it come from?

Ground-level ozone is a highly reactive chemical form of oxygen. The oxygen (O_2) we breathe is made up of molecules that contain two oxygen atoms, while ozone (O_3) contains three oxygen atoms. Ground-level ozone is produced mainly through the reaction of sunlight with oxides of nitrogen and with hydrocarbons in a complex process known as photochemical oxidation. Ozone is the most toxic and thoroughly studied of the many pollutants produced by photochemical oxidation. The mixture of these pollutants is often called photochemical smog, oxidant smog, or just smog.

Sources of the oxides of nitrogen and of hydrocarbons that can form ozone include the following:

- motor vehicles
- coal-fired power plants
- petrochemicals
- industrial use of solvents, paints, and degreasing agents
- off-road engines such as gasoline-powered lawn and garden equipment

Small levels of ozone exist in a natural environment. Atmospheric nitrogen oxides and volatile organic compounds, the precursors to ozone, also can be formed by natural processes in soil and vegetation.

Ground-level ozone should be clearly distinguished from stratospheric ozone in the upper atmosphere. Stratospheric ozone occurs naturally and protects us from the sun's harmful ultraviolet rays. Concern about the loss of this stratospheric ozone layer has led to the banning of chemicals such as chlorofluorocarbons that can penetrate into the upper atmosphere and react with ozone. At the Earth's surface, or ground level, rather than being protective, ozone causes adverse health effects as well as damage to agriculture and property. Scientific understanding of the photochemical process that produces ozone has improved ozone control measures, including the recognition that ozone can be created hundreds of miles downwind of the source. But much of our region still exceeds the health-based ozone guidelines. Ground-level ozone formation occurs mostly during the summer due to its dependence on sunlight. The ozone season in Pennsylvania extends from April 1 to September 30, with June, July, and August considered the core of the ozone season.

MOBILE SOURCES

Mobile pollution sources are a major contributor to ozone formation throughout the 10-county PRETA study area. Examples of mobile sources include on-road cars and trucks, farm equipment, airplanes, construction vehicles, trains, marine vessels, lawnmowers, generator sets, and gas compressors. Mobile sources come from numerous types of combustion engines, industries, and commercial operations, and all emit both types of pollutants that lead to ozone formation: oxides of nitrogen and hydrocarbons. Most of the mobile source emissions in the region come from on-road car and truck traffic. Traffic volumes and miles traveled are indicators of the mobile source pollution burden within the PRETA region. The current annual average daily traffic is an estimate of the amount of traffic for an average day. These counts include both car traffic and heavy-duty truck traffic.

Table 1. Traffic and heavy truck counts and volumes by county, last updated January 2011 (Derived from the Pennsylvania Department of Transportation Bureau of Planning and Research, Geographic Information Division)

COUNTY	ROAD LENGTH (miles)	TOTAL DAILY TRAFFIC	DAILY TRAFFIC PER ROADWAY	DAILY MILES
ALLEGHENY	2,181	21,950,658	8,081	19,979,301
ARMSTRONG	704	1,197,551	2,443	1,438,442
BEAVER	730	3,016,589	4,403	3,167,347
BUTLER	815	3,282,141	5,268	4,131,654
FAYETTE	897	2,190,684	3,034	2,306,194
GREENE	611	674,304	1,673	933,968
INDIANA	886	1,514,326	2,511	1,945,381
LAWRENCE	474	1,508,690	3,405	1,643,347
WASHINGTON	1,268	3,683,532	3,555	4,506,932
WESTMORELAND	1,506	6,331,716	4,255	7,747,095

WHAT DOES THIS TABLE TELL US?

Cars and trucks drive nearly 20 million miles on major roads in Allegheny County on a typical day. (The 10-county region experiences about 50 million miles traveled per day.) The average segment of major road within Allegheny County sees more than 8,000 cars and trucks. Butler County is the second-busiest traveled county, experiencing an average road segment traffic volume of 5,268 per day. Westmoreland County sees a greater total number of traffic counts than Butler County and is second in miles traveled with 7.7 million.

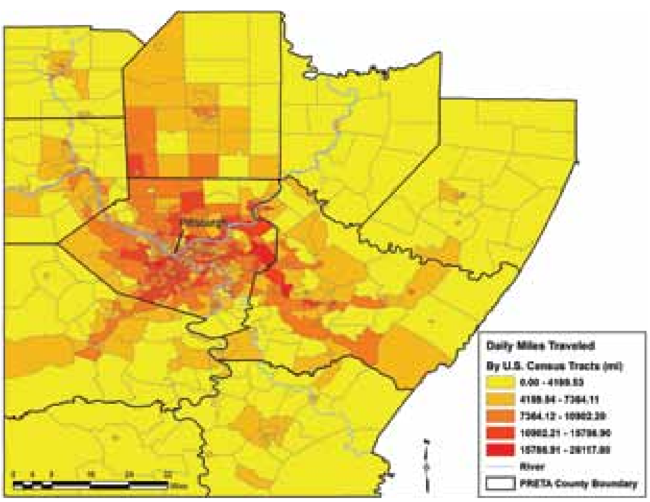


Figure 1. Miles driven per day in Southwestern Pennsylvania by U.S. Census tracts

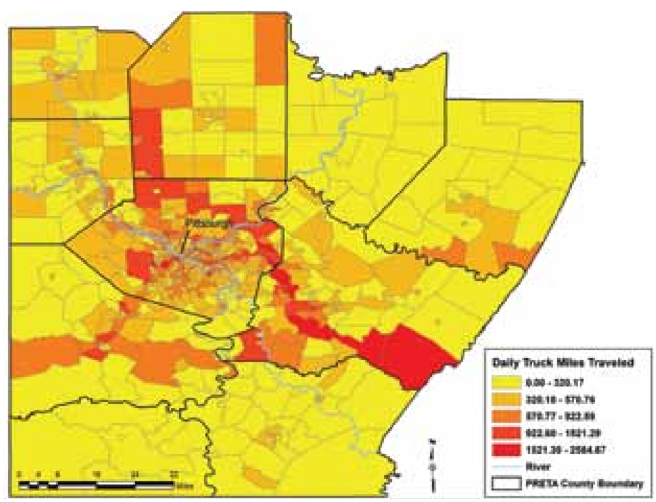


Figure 2. Truck miles driven per day in Southwestern Pennsylvania by U.S. Census tracts

WHAT DO THESE MAPS TELL US?

Aggregates of total miles driven were compiled within U.S. Census tracts throughout the region. The Pennsylvania Turnpike (Interstate 76) has a particularly high volume of heavy-duty trucks and experiences about 7.7 million miles traveled from trucks alone over a typical 24-hour period.

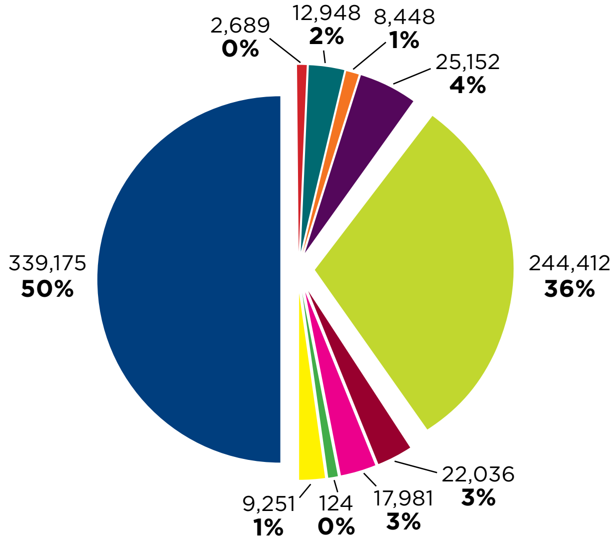


Figure 3. 2008 10-county mobile emissions of NO_X, CO, and VOCs by sector, showing percentage and amount in tons

- AIRCRAFT
- COMMERCIAL MARINE VESSELS
- LOCOMOTIVES
- NONROAD EQUIPMENT—DIESEL
- NONROAD EQUIPMENT—GASOLINE
- NONROAD EQUIPMENT—OTHER
- ON-ROAD DIESEL HEAVY-DUTY VEHICLES
- ON-ROAD DIESEL LIGHT-DUTY VEHICLES
- ON-ROAD GASOLINE HEAVY-DUTY VEHICLES
- ON-ROAD GASOLINE LIGHT-DUTY VEHICLES

Once the ozone precursors are weighted by ozone-forming potential, approximately 69 percent of ozone precursors come from mobile gasoline-powered sources.

Region wide, there are almost 48 million personal vehicle miles traveled, of which 4 million miles come from heavy-duty trucks driven on primary roads on the typical day. The average location sees 3,863 cars and light trucks and 276 heavy-duty trucks go by in a 24-hour period (table 1).

Figure 3 displays the mobile emissions by sector of oxides of nitrogen (NO_X), carbon monoxide (CO), and volatile organic compounds (VOCs) across the 10-county region in 2008. Approximately 87 percent of mobile ozone precursor emissions comes from gasoline-powered sources. The proportion of gasoline sources to diesel sources contributing to NO_X, CO, and VOCs remains fairly constant across the respective counties. Gasoline emissions of CO are 48 times higher than diesel CO emissions. VOCs from gasoline emissions are 23 times higher than VOCs from diesel emissions. NO_X diesel emissions, however, are 1.3 times higher than NO_X gasoline emissions. NO_X is about 11 times more potent than CO in forming ozone and slightly stronger than

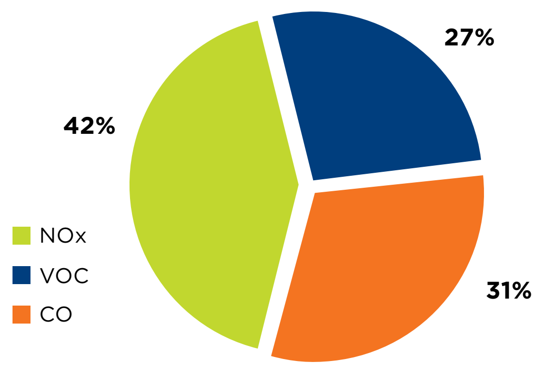


Figure 4. 2008 mobile emissions of CO, NO_X, and VOCs weighted by ozone-forming potential, showing weighted percentage

VOCs (1.22 times). Once these weighting factors are taken into account, NO_X contributes most to ozone formation, followed by VOCs (see figure 4). The top two sectors that emit NO_X are on-road gasoline light-duty vehicles (102,922 tons) and on-road diesel heavy-duty vehicles (93,237 tons). The top two sectors that emit VOCs are nonroad equipment gasoline sources (138,741 tons) and on-road gasoline light-duty vehicles (116,900 tons). Once the ozone precursors are weighted by ozone-forming potential, approximately 69 percent of ozone precursors come from mobile gasoline-powered sources.

STATIONARY SOURCES

Stationary sources, also known as point sources, contribute substantially to ozone formation in our region. As with mobile sources, the major ozone precursors emitted from stationary sources are NO_X and hydrocarbons. Emissions occur at locations where there is large-scale combustion, such as coal-fired power plants, coke ovens, steel mills, and other large industrial facilities. Point source emissions within the 10-county region have decreased since 1999 for NO_X, CO, and VOCs (see table 2). In 2008, the total NO_X stationary emissions within the 10-county region from EPA's National Emissions Inventory was 141,939 tons. Approximately 119,662 tons, or about 84 percent, can be attributed to coal-fired power generation units. Incorporating the steel production boilers (USS Edgar Thompson Works, USS Irvin, and USS Clairton Works) accounts for almost 90 percent of NO_X stationary emissions and just a little more than 55 percent of total point and mobile NO_X emissions combined (224,109 tons).

Table 2. Ozone precursor emissions from point sources in 1999 compared to 2007 (TPY = tons per year)

OZONE PRECURSOR	1999 TPY	2007 TPY	% CHANGE
CO	52,777	48,229	-8.6%
NO_X	166,412	142,078	-14.6%
VOCs	7,922	5,066	-36.5%

Table 3. Top 10 stationary sources of nitrogen oxides in 2010

RANK	NAME	COUNTY	LOCATION	NO_X (TPY)[A]	SIC[B]
1	Hatfield's Ferry Power Station	Greene	Masontown	22,246.63	4911
2	Conemaugh	Indiana	New Florence	19,564.11	4911
3	Bruce Mansfield	Beaver	Shippingport	11,388.64	4911
4	Homer City	Indiana	Homer City	8,426.56	4911
5	Keystone	Armstrong	Shelocta	5,594.22	4911
6	Armstrong Power Station	Armstrong	Kittanning	2,873.82	4911
7	AES Beaver Valley LLC	Beaver	Monaca	2,717.47	4911
8	Cheswick	Allegheny	Springdale	2,521.91	4911
9	Seward	Indiana	New Florence	2,272.24	4911
10	Elrama	Washington	Elrama	1,702.89	4911

[A]TPY: tons per year emitted

[B]SIC code: 4911—Electric Services (fossil fuel power generation)

Figures 5–8 below describe the major stationary sources of oxides of nitrogen and of hydrocarbons within the PRETA and four-state regions. Nitrogen dioxide is itself a primary air quality pollutant for which an annual average National Ambient Air Quality Standard (NAAQS) was set based on its direct health effects. The region, and the entire nation, is in compliance with this standard; however, a new standard is being established to avoid the short-term effect of high nitrogen dioxide levels near roadways. Nitrogen oxide emitters also are subject to control because of their role in ozone formation. Literally thousands of different hydrocarbons are emitted from stationary sources. They vary greatly in their ability to promote ozone formation, depending in large part on their chemical structure. Accordingly, the measurement of tonnage of hydrocarbons can be misleading. Certain hydrocarbons, such as benzene and formaldehyde, also are regulated as hazardous air pollutants (HAPs, or air toxics). For such pollutants, the regulatory approach focuses on control technology to limit emissions. In contrast to the six NAAQS pollutants, no outdoor (ambient) standards are set by EPA for HAPs.

POINT SOURCES FOR OXIDES OF NITROGEN

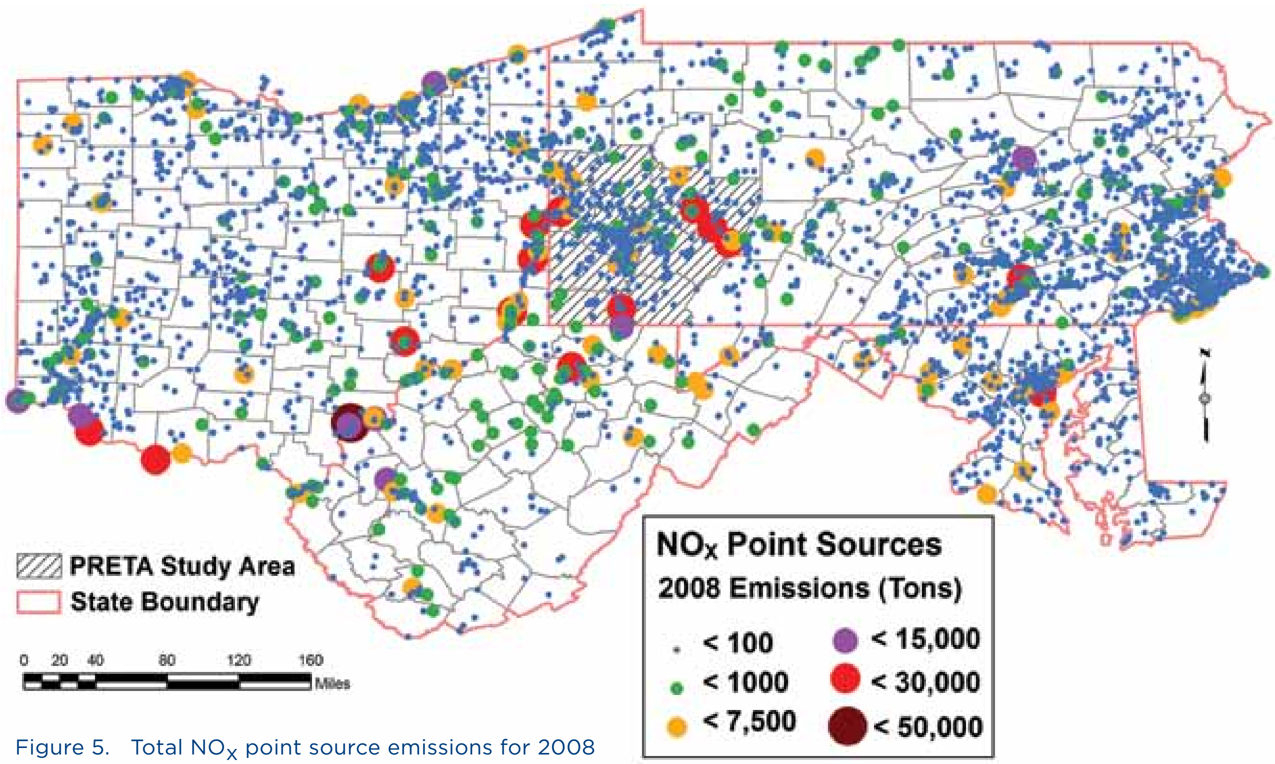


Figure 5. Total NO_X point source emissions for 2008

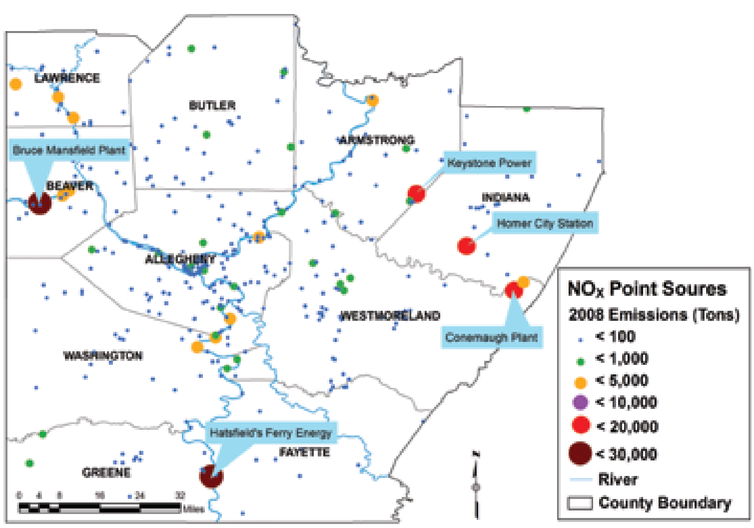


Figure 6. Major NO_X point sources for 2008 in Southwestern Pennsylvania

WHAT DO THESE MAPS TELL US?

In contrast to NO_X from mobile sources, which dominate Allegheny County (see table 4), NO_X from point sources outweighs the amount from mobile sources in most of the counties surrounding Allegheny and in the region as a whole.

Table 4. Percentage of NO_X from point sources emitted by county in 2002, 2005, and 2008

COUNTY	2002 NO_X POINT SOURCE	2005 NO_X POINT SOURCE	2008 NO_X POINT SOURCE
ALLEGHENY	30.6%	31.4%	31.8%
ARMSTRONG	92.2%	91.6%	90.7%
BEAVER	84.9%	84.7%	85.9%
BUTLER	32.5%	35.2%	33.8%
FAYETTE	22.6%	17.9%	9.0%
GREENE	90.8%	89.2%	91.3%
INDIANA	93.6%	93.5%	93.3%
LAWRENCE	71.0%	71.6%	69.1%
WASHINGTON	57.1%	53.8%	52.7%
WESTMORELAND	23.5%	27.4%	21.6%
10 COUNTY TOTAL	64.6%	64.4%	66.3%

WHAT DOES THIS TABLE TELL US?

NO_X mostly comes from mobile sources (68.7 percent average over three time periods) in Allegheny County. But in the rest of the PRETA region, NO_X overwhelmingly comes from point sources. The ratio in Armstrong county is almost 10:1 stationary, Beaver is 6:1 stationary, Greene is 10:1 stationary, and Indiana is almost 14:1. Note that ozone can be produced many miles from the source of the ozone precursors. These trends have remained relatively constant over the previous three emissions inventories, so local emissions do not tell us everything about local ozone production. Most importantly, the overall source of nitrogen oxides for the 10-county region is stationary sources by a ratio of almost two to one.

Further, figure 5 shows that the majority of major NO_X sources of the four-state area are directly upwind of the PRETA region and tend to follow the Ohio River Valley (putting Pittsburgh downwind of major sources). The top 10 major point source emitters of NO_X are fossil fuel power generation plants. Hatsfield's Ferry Power Station in Masontown, Greene County, along the Monongahela River was the largest emitter of NO_X last year, releasing more than 22,000 tons. Point sources for VOCs tend to be clustered in the more urban areas (see figures 7 and 8).

The top 10 major point source emitters of NO_X in 2008 were all coal-fired power generation plants.

VOLATILE ORGANIC COMPOUNDS

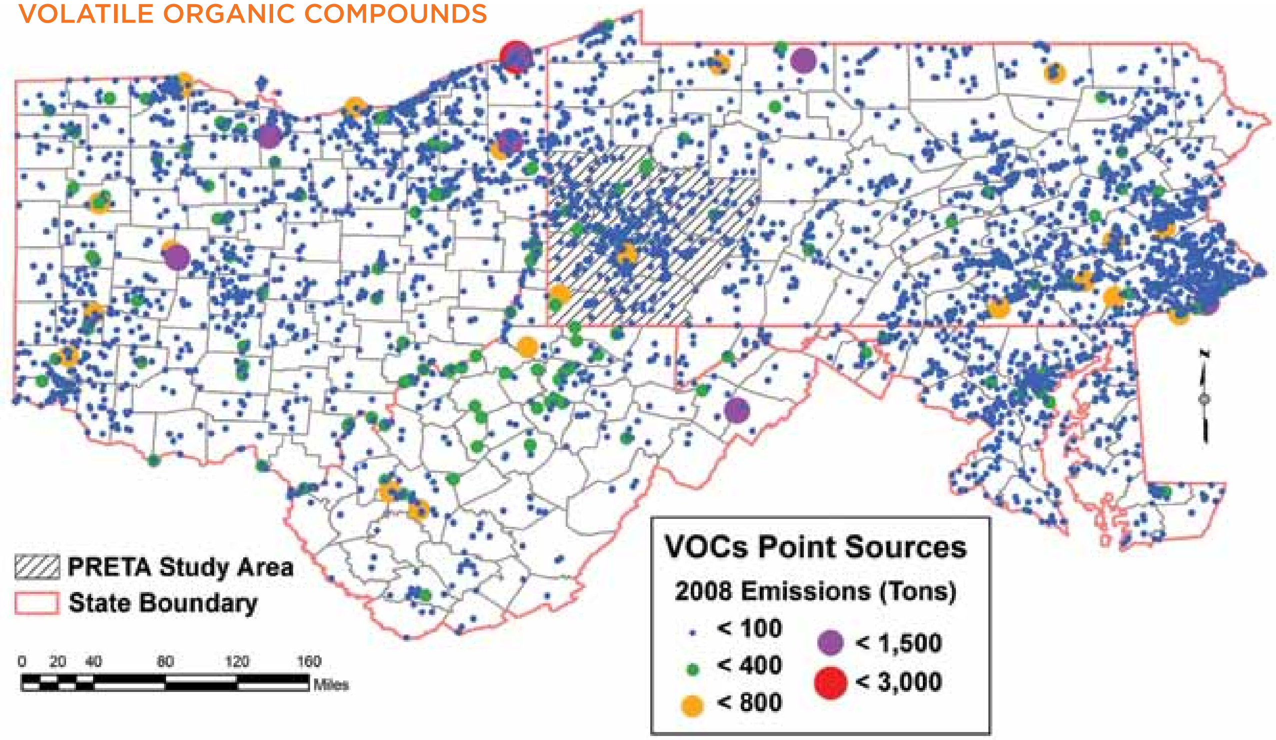


Figure 7. Total VOC point source emissions in 2008 over the four-state region

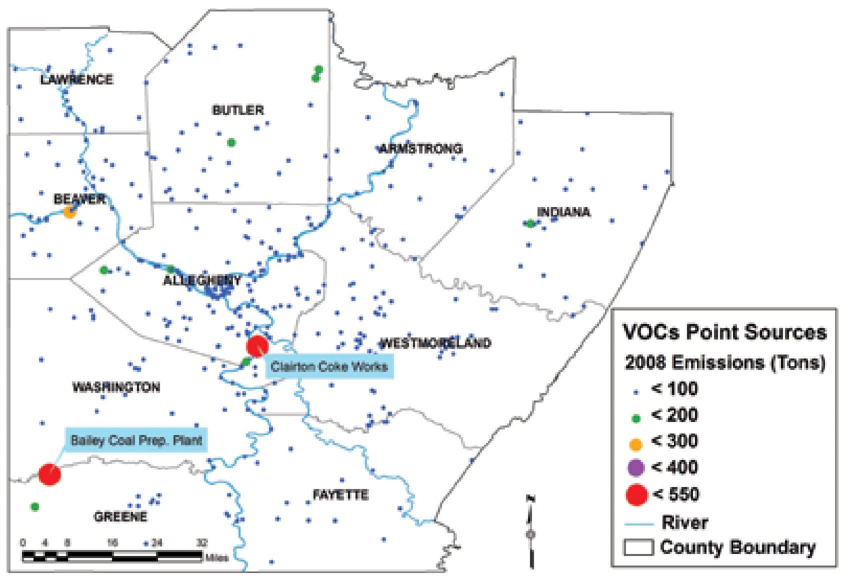


Figure 8. Total VOC point source emissions in 2008 in Southwestern Pennsylvania

WHAT DO THESE MAPS TELL US?

These maps show a cluster of sources in the 10-county region relative to the other four states, and over the 10-county region, many VOC point sources are along the three rivers.

EMERGING THREATS

Two ongoing phenomena, one global and one local, will be adding to the challenges of controlling ozone in Pennsylvania. Global climate change already is leading to warmer summer days that contribute to high levels of ozone formation. Computer models also suggest that global climate change in our region will lead to longer periods of stagnant high-pressure air, which also promotes ozone formation. Locally, Marcellus Shale activities are likely to increase a wide range of ozone precursors from both on-site releases and mobile sources.

MOBILE AND POINT SOURCE CONTRIBUTIONS TO OZONE

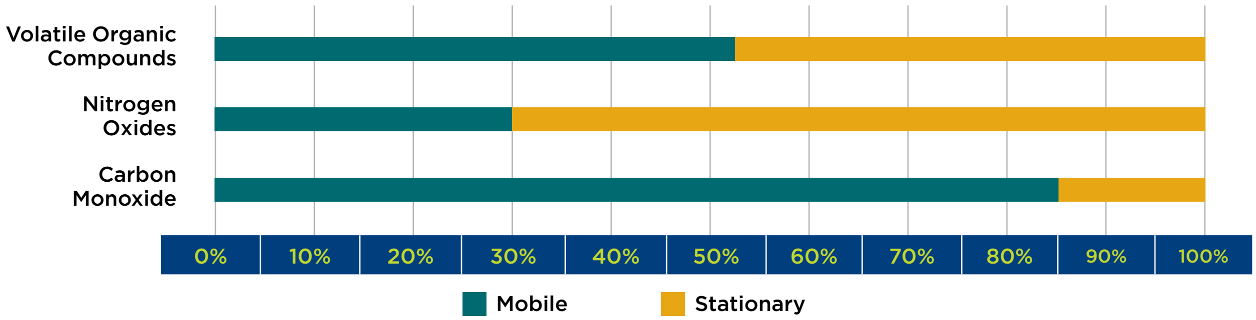


Figure 9. Percentage of mobile and stationary source contributions to the three pollutant categories of VOCs, nitrogen oxides, and carbon monoxide

Figure 10. Tonnage and percentage of carbon monoxide, nitrogen oxides, and volatile organic compounds emitted by mobile sources

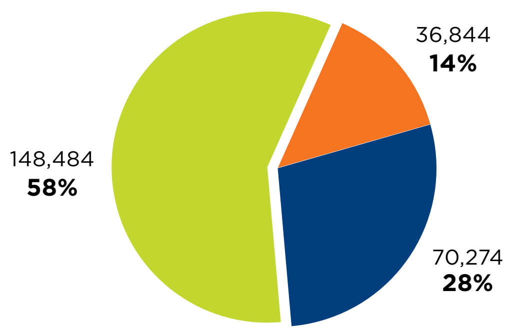


Figure 11. Tonnage and percentage of carbon monoxide, nitrogen oxides, and volatile organic compounds emitted by stationary sources

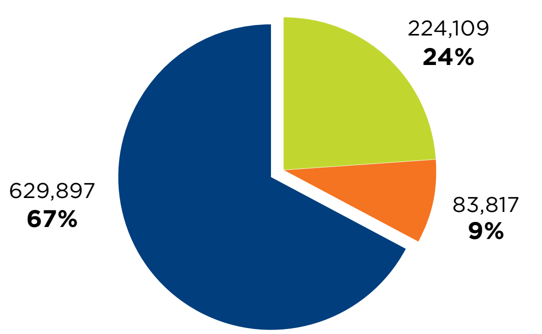


Figure 12. Tonnage and percentage of carbon monoxide, nitrogen oxides, and volatile organic compounds emitted by all sources

- CARBON MONOXIDE
- NITROGEN OXIDES
- VOLATILE ORGANIC COMPOUNDS

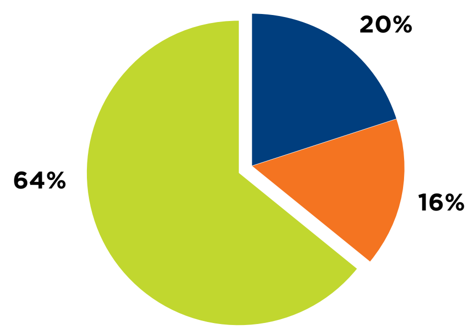


Figure 13. Weighted emissions contribution to ozone potential for carbon monoxide, nitrogen oxides, and volatile organic compounds

NOTE: To determine their contribution to ozone formation, tons of carbon monoxide were multiplied by 0.11, tons of nitrogen oxides by 1.22, and tons of volatile organic compounds by 1.

WHAT DO THESE CHARTS TELL US?

From these 2008 data charts, we can see that CO dominates the mobile source category in Figure 10. Figure 11 shows that NO_X is the majority contributor to point source emissions, and CO again is the largest contributor by mass of all three ozone precursors. Figure 13, however, shows that NO_X is the largest contributor to ozone in our region based on the weighted emissions contribution to forming ozone (figure 12). In other words, a smaller amount of NO_X leads to more ozone formation compared to CO and VOCs.

What are the government standards for ozone exposure?

Ozone is one of six primary air quality pollutants for which a NAAQS has been established. The other NAAQS pollutants are fine particulates, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead. These outdoor standards are chosen by the EPA administrator to protect human health with an adequate margin of safety. The standards are based largely on the recommendations of the Clean Air Scientific Advisory Committee (CASAC), a congressionally mandated committee that every five years reviews the scientific evidence relating the NAAQS pollutant to health and welfare effects.

The ozone standards are becoming more stringent because of increasing scientific evidence of adverse health effects at lower levels. The averaging time for the standard also has increased to eight hours from the original one hour, largely based on work done by faculty at the University of Pittsburgh. This change enhances consideration of control strategies that protect children who are outdoors for much of a summer day. The 1997 standard, which was effectively at 0.084 ppm as an eight-hour average, was lowered to 0.075 ppm in 2008 (see table 5). CASAC's recent review of ozone has led to the recommendation of a more stringent ozone standard, in the range of 0.06–0.07 ppm, based on further accumulation of scientific evidence about adverse health effects at even lower ozone levels. The EPA administrator has not yet acted on this recent recommendation. The Pittsburgh region regularly exceeds NAAQS standards for both ozone and fine particulates.

EPA uses a number of terms to designate air pollution. "Attainment" is the desired designation, indicating that the air pollution standard has not been exceeded, while "nonattainment" is used to indicate that the area is above the pollutant level that has been established as permissible under the Clean Air Act. Nonattainment triggers the requirement for a State Implementation Plan (SIP), which must specify to the satisfaction of EPA how the state will lower emissions to achieve air pollution standards.

The complexity of the photochemical processes leading to ozone formation makes estimation of the impact of control measures aimed at ozone precursors particularly challenging. For ozone, assigning an area to nonattainment depends on how often it exceeds the ozone standard of 0.075 ppm over an average of eight hours. The level for an area on which attainment is based is known as the design value. The design value for ozone is

Table 5. Ozone National Ambient Air Quality Standards (NAAQS)

PRIMARY STANDARDS				SECONDARY STANDARDS
POLLUTANT	LEVEL	UNITS	AVERAGING TIME	LEVEL
Ozone	0.075 ppm (2008 std.)	ppm	eight-hour (1)	Same as Primary
	0.08 ppm (1997 std.)	ppm	eight-hour (2)	Same as Primary
	0.12 ppm	ppm	one-hour (3)	Same as Primary

Primary standards are based on human health. Secondary standards are based on protecting ecosystems and on other welfare considerations.

(1) To attain this standard, the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).

(2) (a) To attain this standard, the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rule making to address the transition from the 1997 ozone standard to the 2008 ozone standard.

(c) EPA is in the process of reconsidering these standards (set in March 2008).

(3) (a) EPA revoked the one-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").

(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than one.

a formula based on the three-year average of the fourth-highest daily maximum eight-hour ozone concentration. This more complex approach has evolved from the original standard that was based on the second-highest ozone level. The reason for the change is that the highest ozone values in any given year are dependent on seasonal weather conditions, which makes it difficult to provide a stable base for making environmental control decisions.

EPA has developed a somewhat confusing approach to designating the extent to which an area has unhealthy air and to specifying the categories that require specific action. The most recent measurements of ozone show our region did not exceed the 1997 eight-hour ozone standard of 0.08 ppm during the period 2007–10.[I] This achievement lessens the extent to which the Commonwealth of Pennsylvania must develop and submit plans to EPA for controlling ozone in the Pittsburgh area. However, because our region did exceed this standard before 2007, EPA requires Pennsylvania to continue to carefully monitor ozone levels and to report plans to maintain ozone levels within the standard. More importantly, our area still exceeds EPA's 2008 health-based ozone standard of 0.075 ppm, but as this more stringent standard has been held up by legal battles, EPA is not enforcing it. Further, consideration of recent evidence concerning the health effects of ozone has led EPA's scientific advisory process to recommend an even stricter standard in the range of 0.06–0.07 ppm. EPA Administrator Lisa Jackson is now considering this standard.

EPA uses the term "maintenance" to designate an area that has decreased its level of pollutants from a previous designation of nonattainment to a level that warrants the designation of attainment. Such an area is required to have continued monitoring and a 10-year maintenance plan to ensure attainment is maintained. EPA has created an indicator, labeled the Air Quality Index, to alert the public about healthy to poor ozone levels (see table 7).

How much ozone are we exposed to?

The health-based ozone standard of 0.075 ppm for an eight-hour period is exceeded in most of our region (see figure 14). Because we exceed the ozone standard and because of our population density, our region is required to have a relatively extensive monitoring station network for ozone (see figure 15). Monitoring stations measuring ozone are located throughout the Southwestern Pennsylvania region, and the coverage by these stations extends into nearby areas of Ohio and West Virginia. Eight of the 10 PRETA counties maintain air monitoring stations for ozone. Butler and Fayette Counties do not have ozone monitors.

Because we exceed the ozone standard and because of our population density, our region is required to have a relatively extensive monitoring station network for ozone.

Of the 10 counties in the PRETA region, six are in nonattainment for the eight-hour ozone standard. Indiana and Greene counties have been redesignated for attainment of the eight-hour ozone standard. Lawrence County is the only county within the PRETA region that has neither a nonattainment nor maintenance designation for ozone.

[I] Federal Register, Volume 76, Issue 104, pp. 31,237–9, May 31, 2011. An example of the confusing use of terms is EPA's statement about the ozone levels in the Pittsburgh/Beaver Valley area: "This determination of attainment is not equivalent to a redesignation to attainment." Briefly put, an area such as Pittsburgh/Beaver Valley that has previously exceeded a NAAQS standard, known as "nonattainment," could be moved to a "maintenance" category. This maintenance category requires certain actions, including monitoring, to be sure that there is no backsliding to nonattainment. The term "attainment" is applied to areas that are not now exceeding and have not in recent years exceeded the specific air pollutant standard. For example, our area is in attainment for the carbon monoxide standard.

The PRETA region estimated eight-hour maximum ozone concentrations ranged between 0.0769 ppm and 0.0902 ppm in 2005. This indicates that the entire PRETA region experienced high ozone concentrations above the eight-hour NAAQS of 0.075 ppm.

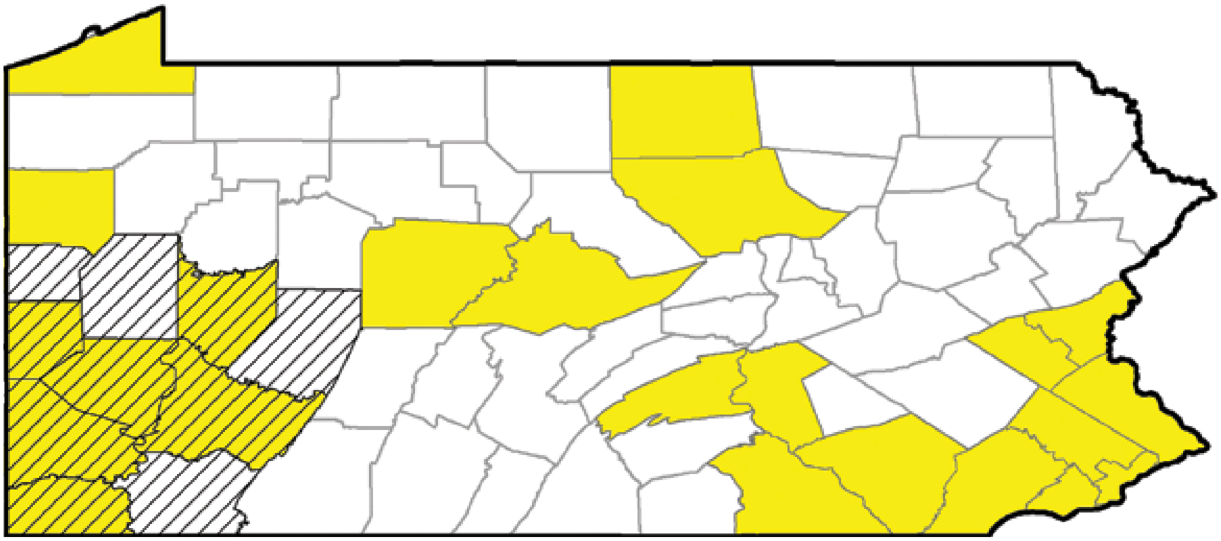


Figure 14. Eight-hour ozone areas designated for the 2008 air quality standards of 0.075 ppm as of 2010, based on 2004–06 design values. Yellow-shaded counties indicate areas of nonattainment. The PRETA study area is indicated by hatched lines.

WHAT DOES THIS MAP TELL US?

Of the 10 counties in the PRETA region, six are in nonattainment for the eight-hour ozone standard. Indiana and Greene counties have been redesignated for attainment of the eight-hour ozone standard. Lawrence County is the only county within the PRETA region that does not have either a nonattainment or maintenance designation for ozone.

AIR MONITORING

Ambient air monitoring in Pennsylvania is performed to assess compliance with federal, state, and county ambient air quality standards as well as to provide real-time data for use in identifying pollution episodes and to further develop air quality standards. The Pennsylvania Department of Environmental Protection (DEP) is responsible for monitoring air quality in Pennsylvania and does so by monitoring high-density population areas and areas of high expected contaminants or a combination of these factors. Monitoring has been divided into 13 air basins as defined by the Pennsylvania Code. DEP does not monitor air quality directly in Allegheny County, as monitoring and air quality compliance is performed by the Allegheny County Health Department. Criteria pollutants as defined by the Clean Air Act are carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter measuring 10 and 2.5 microns (PM 10, PM 2.5), ozone (O_3), sulfur dioxide (SO_2), and lead (Pb).

WHAT DOES THIS MAP TELL US?

There are 27 ambient ozone air monitoring stations in our area.

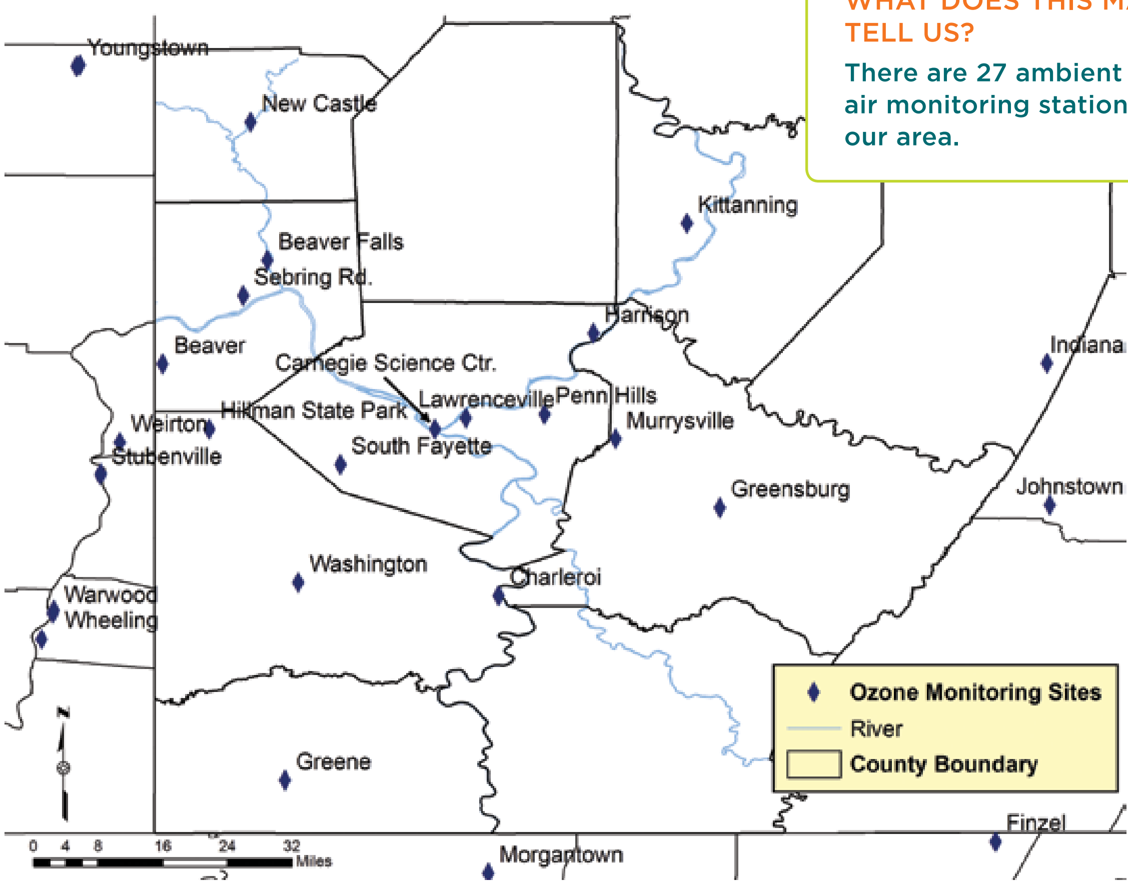
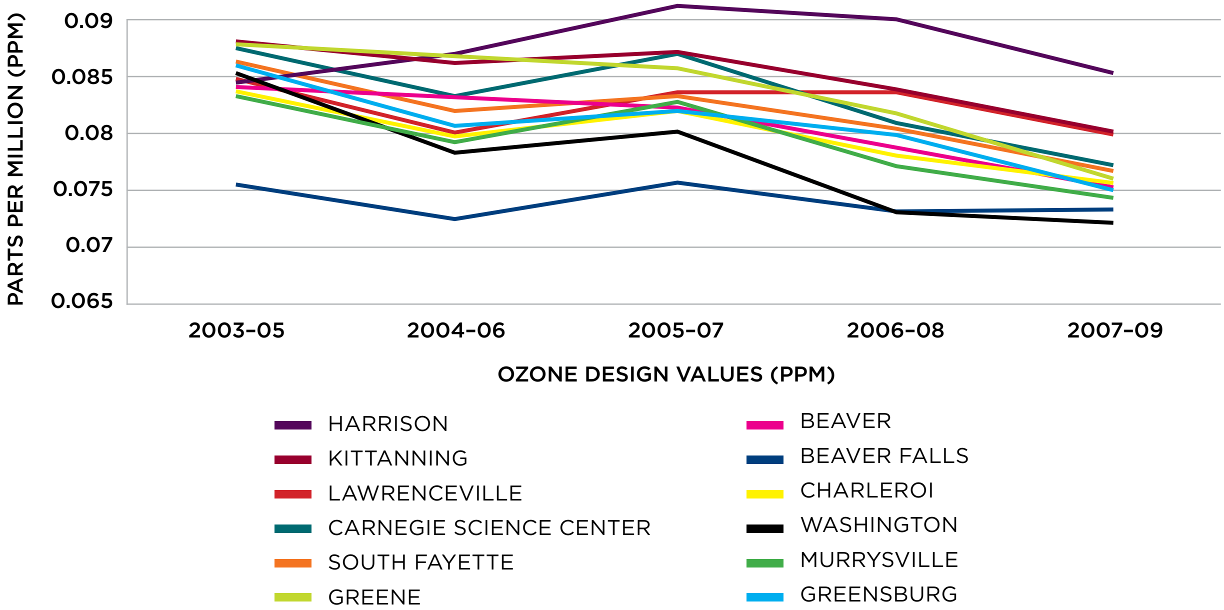


Figure 15. Ozone monitoring stations throughout the PRETA region as of January 2010

TIME SERIES OF OZONE CONCENTRATIONS FROM 2003 TO 2009 USING THREE-YEAR AVERAGES

Figure 16. Time series of ozone eight-hour maximum concentrations (in ppm) by design values from 2003 to 2009 by monitoring site using three-year averages. A design value is a term used by EPA to designate the measured level of a pollutant for pollution control. Exceedance of the standard also can be described as the number of times pollutant levels were above allowable standards (see below).



Ozone concentrations throughout the area displayed substantial decreases beginning in 2006. However, the monitors at Harrison (Harrison Township), Kittanning, and Lawrenceville still show ozone levels above the 2008 NAAQS of 0.075 ppm. These three sites are located downwind, or northeast, of Downtown Pittsburgh.

Figures 17 and 18 display the 2005 estimated maximum eight-hour ambient air concentrations of ground-level ozone across the greater four-state region and PRETA region and, as a comparison, the four-state area. Figure 17 displays a map of the average concentrations of ozone in 2005 in Pennsylvania, Ohio, West Virginia, and Maryland. The darker brown color represents a higher average ozone concentration compared to the lighter brown and yellow colors, which represent lower average levels of ozone in the air. The brown and yellow areas differ across the state and county lines indicated in white. There appears to be spatial variability across the four states in figure 17 and, to a lesser degree, across the PRETA region (see figure 18).

The range of estimated eight-hour maximum concentrations in 2005 from figure 17 were 0.0483–0.0945 ppm. The PRETA region's estimated eight-hour maximum ozone concentrations ranged between 0.0769 ppm and 0.0902 ppm in 2005. This metric indicates that the entire PRETA region experiences high ozone concentrations above the eight-hour NAAQS of 0.075 ppm. Table 6 displays the number of days per year by county that exceeded the NAAQS eight-hour standard for ozone. The highest levels of ozone across four states are estimated to have occurred northeast of Cleveland, Ohio, near Lake Erie (0.0942 ppm). This area of high ozone concentration (dark brown) extends south of Cleveland to Akron, Ohio, and includes urban areas of Youngstown and Warren to the southeast. Other areas of elevated ozone concentrations include Cincinnati, Ohio; Columbus, Ohio; Washington, D.C.; southeastern Pennsylvania counties; and the majority of the PRETA region.

Within the PRETA region, the highest eight-hour ozone maximum levels in 2005 were estimated to be northeast of Downtown Pittsburgh, traversing the Allegheny River Valley from Cheswick to Kittanning, with the highest predicted levels just north of Freeport. These areas of elevated concentrations of ozone are validated by the design values calculated for the Harrison air monitor (Natrona, Harrison Township) located within this area (see figure 18). Since 2004–06, the Harrison monitor has recorded the highest levels of ozone of the 10 continuous monitors in the PRETA region. The lowest estimated ozone eight-hour maximum concentration in 2005 was in southeastern Fayette County at 0.0769 ppm. This value still exceeds the standard of 0.075 ppm, demonstrating that the entire 10-county region experiences ozone concentrations above the primary health-based standard.

In areas where there is a sufficient number of air monitoring stations, other techniques can be used to create surface maps of pollutant levels. We should point out that these estimates of ozone concentrations are predictions based on the data available. These maps represent average concentrations over periods of time, therefore introducing a degree of error and approximation for the sake of visual representation.

Table 6. Number of days over the eight-hour ozone maximum concentration NAAQS eight-hour standard (0.075 ppm) by county. Note the eight-hour standard changed in 2008 from 0.08 ppm to 0.075 ppm. (From Environmental Public Health Tracking Network)

COUNTY	2001	2002	2003	2004	2005	2006	2007	2008	2009
ALLEGHENY	30	37	15	7	22	14	21	13	6
ARMSTRONG	28	27	10	10	16	11	19	9	1
BEAVER	27	37	11	7	18	8	11	6	0
WASHINGTON	27	34	9	3	16	8	7	5	0
GREENE	31	21	6	2	19	5	8	1	0
WESTMORELAND	15	26	6	3	14	4	6	3	0
LAWRENCE	5	21	4	1	3	2	3	2	0
INDIANA	No Data	No Data	No Data	No Data	17	3	9	4	1
TOTAL # EXCEEDANCES	163	203	61	33	125	55	84	43	8

WHAT DOES THIS TABLE TELL US?

Table 6 indicates the number of days that an air monitor within a county exceeded the eight-hour ozone maximum concentration standard. Air monitors do not exist in Butler and Fayette counties. All other counties have displayed a decreasing trend in the number of days of recorded high ozone levels since 2001. The total number of exceedances represents the total number of exceedances throughout the eight counties and does not represent total separate days in a given year. For example, all eight counties may experience an eight-hour maximum exceedance on the same day, totaling eight exeedances. The total number of exceedances decreased from 2001 to 2004, then increased to 125 exceedances in 2005 and decreased to eight total exceedances in 2009. Allegheny, Armstrong, and Beaver counties have experienced the most days of nonattainment over the last decade.

ESTIMATED EIGHT-HOUR OZONE MAXIMUM CONCENTRATIONS[2]

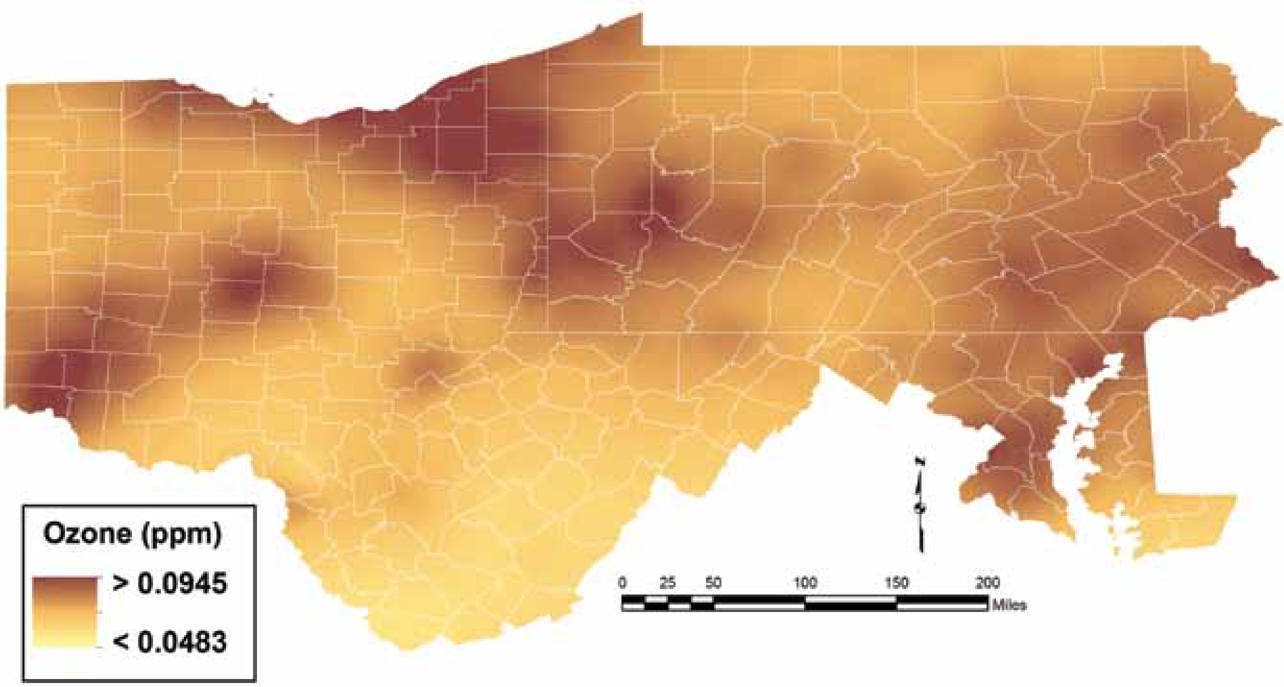


Figure 17. Estimated eight-hour ozone maximum concentrations (ppm; 2005 EPA Hierarchical Bayesian Modeling) in the PRETA air study region

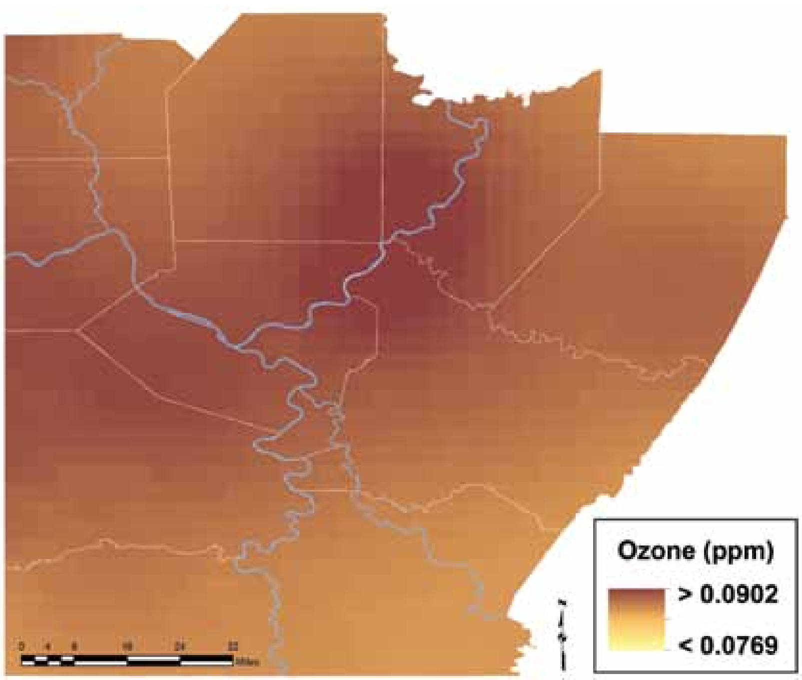


Figure 18. Estimated eight-hour ozone maximum concentrations (ppm; 2005 EPA Hierarchical Bayesian Modeling) in the PRETA air study region

WHAT DO THESE MAPS TELL US?

Within the PRETA region, the highest average ozone levels in 2005 were estimated to be northeast of Downtown Pittsburgh, traversing the Allegheny River Valley from Cheswick to Kittanning, with the highest predicted levels just north of Freeport. The dark brown indicates higher concentrations of ozone. The lack of intense gradation in color reflects the similarity in ozone levels in our area.

[2] These maps were produced from output data from EPA's Hierarchical Bayesian Model (HBM)-derived Estimates of Air Quality for 2005. These data estimate daily concentrations of ozone and particulate matter across the continental United States using both monitored concentration values and model-predicted concentration values. The modeled and monitored air quality data are combined to create a map of concentration values averaged across the entire surface of the map. The process to determine the air concentration values at each location includes multiple levels of statistical tests that take into account the amount of uncertainty, bias, and errors in the data at each location.

A nationwide study showed that children living in metropolitan areas with high ozone levels, such as the Pittsburgh region, were about 50 percent more likely to suffer from asthma than those living in areas with low ozone levels (Akinbami et al., 2010).

PREVENTING OZONE EFFECTS AND FORMATION

What are the most effective ozone control strategies?

Preventing ozone formation depends on limiting the formation of ozone precursors, which come from a wide variety of sources. The city of Los Angeles, Calif., recognized the complex chemistry that results in oxidant smog more than 50 years ago. Not surprisingly, those industries primarily responsible for emitting oxides of nitrogen claimed hydrocarbons were the major source of ozone precursors, and those industries primarily responsible for hydrocarbon emissions pointed their finger at sources of oxides of nitrogen. During the past half century, it has become abundantly clear that limiting ozone formation requires a broad attack on all sources of precursors.

For the Pittsburgh region, as for much of the nation, control of oxides of nitrogen appears to be most effective in limiting ozone. As is clear from table 4, both mobile and stationary sources are major contributors to nitrogen oxide formation in our region and should be major targets for pollution control.

What can my family and I do to limit our exposure to ozone outdoors?

Personal actions can help you to avoid ozone exposure. During ozone season, focus on your outdoor activities in the early morning hours rather than late afternoon. This is because sunlight is required for ozone formation, and a few hours of daylight are needed before substantial ozone formation occurs and ozone accumulates. Once the sun goes down, ozone often will linger for a few hours. Plan your outdoor activities on bad ozone days during the morning, ideally before 9 a.m. Outdoor exercise can be a problem because it causes you to have to breathe in more air, and the more air you breathe, the more air contaminants can enter your body. During ozone season, those who jog regularly in late afternoon should switch to early morning, senior citizens should plan their walks or shopping excursions for the morning, and summer camps should plan outdoor activities as early in the day as possible.

What about indoors?

The bad news about ozone is that it is so highly reactive that very small amounts can cause toxicity. This same reactivity limits the ability of ozone to penetrate or accumulate indoors because it reacts with the first surface it touches. Staying indoors prevents exposure to ozone, although there are exceptions. Exercising on a stationary bike next to an open window when there are high outdoor ozone levels can lead to significant ozone exposure. Other sources of indoor air exposure that are particularly unfortunate are certain "air purifiers" that work by electrostatic precipitation. These can be a source of ozone if they are not tuned correctly, but this can be avoided by paying close attention to manufacturer specifications.

What are the economic benefits of avoiding ozone?

The Clean Air Act does not permit the EPA administrator to take economic considerations into account in setting the standard for ozone or for the other primary air quality pollutants (lead, sulfur dioxide, carbon monoxide, fine particulates, and nitrogen dioxide). However, economic costs can be used to determine the most effective way to meet the standard. Moreover, EPA is required to calculate the economic benefits and costs for each of its clean air standards.

The most recent EPA estimate is that the annual economic benefit from meeting the current 0.075 ppm standard will range from $6.4 to $18 billion in the year 2020. This benefit would increase further if EPA were to adopt the more stringent standard now being considered. Note that this benefit includes an estimate for the decrease in the health effects of fine particulates that would not be formed because of the necessary reduction in nitrogen oxide emissions to meet the ozone standard. Nitrogen oxides also are a source of fine particulates. Further, EPA has intentionally omitted two California areas from its estimates, as these heavily polluted areas would not be expected to meet the new ozone standard in 2020.

A number of health and economic estimates have been made for both the benefits and costs of meeting the ozone standard. For example, EPA scientists estimated for the 2000–02 time period that achieving the then 0.08 ppm ozone standard nationally would result in an average yearly decrease of 800 premature deaths, 4,500 hospital and emergency department admissions, 900,000 school absences, and more than 1 million minor restricted activity days. The average of benefits across the three years was estimated as $4.9 or $5.7 billion per year, depending on the method used (Hubbell et al., 2005). All of the methods used for predicting total health effects due to ozone and their economic costs, which in the past have given widely differing numbers, are undergoing intense scrutiny as part of the current active consideration of the new ozone standard.

FACTORS LIKELY TO INCREASE FUTURE OZONE LEVELS

GLOBAL CLIMATE CHANGE

Outdoor temperature is one of the factors determining the extent of ozone formation. The anticipated temperature increase due to global warming has been calculated to add 0.001–0.002 ppm of ozone by the year 2020 and 0.002–0.007 ppm by the year 2050 (Union of Concerned Scientists). Pennsylvania is projected to be the fifth-hardest hit state in the nation. The central estimate is that if there is an increase of 0.002 ppm ozone due to climate change, in the year 2020, there will be 133,010 more occurrences of acute respiratory symptoms in Pennsylvania. The Union of Concerned Scientists projects more than $300 million in overall health care costs associated with this climate penalty in Pennsylvania in 2020.

MARCELLUS SHALE ACTIVITY

Ozone precursors are released from a variety of Marcellus Shale activities, ranging from the initial fracturing to the leakage of natural gas product. An individual site is unlikely to contribute substantially to total ozone formation, but in the aggregate, the expected development of many thousands of wells poses a significant risk that Marcellus Shale activities will contribute substantially to ozone formation in our state.

How do I know when ozone levels are high?

Almost all major newspapers and television, radio, and online weather reports provide daily information about air pollution levels. Check these media sources daily, particularly if you are among those populations most sensitive to ozone. If you are unable to access a report on air pollution in your area, you can do a reasonably good job of predicting high ozone levels. Ozone levels tend to be highest on warm summer days when there has not been any rain. For example, if ozone levels are elevated today and it does not rain tonight, they will be elevated each subsequent day it does not rain. Each successive day during which there is a warm, high-pressure system tends to be worse than the previous day, because the ozone precursors continue to accumulate. Those who are sensitive to ozone toxicity tend to know when it is higher because of eye irritation. This irritation actually is caused by other components of oxidant smog that accompany ozone formation. For some, the effects of ozone are recognizable by a tightness in the chest due to the narrowing of their airways in reaction to the higher levels of ozone.

What can my family and I do to decrease the formation of ground-level ozone?

We all can contribute to decreasing ozone levels in our area by reducing our use of automobiles, saving energy, and supporting citizens groups that advocate for effective ozone control strategies. During the summertime ozone season, specific recommendations include the following:

- Use a push mower wherever possible. When using a gas-powered mower, wait until evening.
- Wait until evening to refuel your car. Keep your car tuned and tires properly inflated.
- Do not use charcoal lighter fluid when grilling. Use a charcoal chimney or propane.
- Use air conditioning judiciously and turn off unnecessary lights, electric appliances, and computers.

AIR QUALITY INDEX

EPA has developed the Air Quality Index (AQI; see table 7) as a simplified standard approach across the United States to reporting the threat of major pollutants based on pollution levels. EPA calculates AQI daily, and the *Pittsburgh Post-Gazette* and *Pittsburgh Tribune-Review* report it. The AQI value scale ranges from zero to 500 and is based on the levels of carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter. An AQI value of 100 or above is equivalent to air containing concentrations of pollutants that are over their NAAQS.

Table 7. The Air Quality Index (AQI) is a guide for indexing air quality that is reported daily by EPA across the entire United States. AQI describes how clean or polluted the air in an area is and the associated health effects that may be experienced a few hours or days after breathing polluted air. AQI is calculated based on the concentrations of five air pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide.

AIR QUALITY INDEX (AQI) VALUES	AIR QUALITY CONDITIONS	AQI EXPLANATION AND AFFECTED POPULATIONS
0–50	Good	Overall air quality is satisfactory, and little or no health risk is expected from air pollution.
51–100	Moderate	Air quality is acceptable, though for some pollutants there may be a moderate health concern for a very small number of people who are extremely sensitive to air pollution.
101–150	Unhealthy for Sensitive Groups	Sensitive groups such as children and the elderly may experience health effects from air pollution; little health risk is posed to the general public.
151–200	Unhealthy	All people may experience health effects, with more sensitive groups of people experiencing more serious health effects caused by air pollution.
201–300	Very Unhealthy	Health alert: Everyone may experience more serious health effects from air pollution.
301 and higher	Hazardous	Health warning of emergency conditions: The entire population is more likely to be affected.

Table 8. Air Quality Index statistics by county in 2008

COUNTY	AQI DATA (days)	AQI GOOD (days)	AQI MODERATE (days)	AQI UNHEALTHY FOR SENSITIVE GROUPS (days)	AQI UNHEALTHY (days)	MAX AQI	MEDIAN AQI
ALLEGHENY	306	119	153	33	1	152	55
ARMSTRONG	215	167	39	9	0	129	40
BEAVER	306	247	53	6	0	109	39
GREENE	209	176	32	1	0	122	41
INDIANA	305	260	41	4	0	119	33
LAWRENCE	306	263	41	2	0	119	35
WASHINGTON	306	223	78	5	0	114	42
WESTMORELAND	306	252	51	3	0	119	36

Table 9. Major air pollutant contribution to the Air Quality Index in 2008 by county; blank space indicates no data available

COUNTY	MAJORITY AQI POLLUTANT CONTRIBUTION BY DAYS					
	CO	NO_2	O_3	SO_2	PM2.5	PM10
ALLEGHENY	1	0	74	0	229	2
ARMSTRONG			215			
BEAVER	3	0	184	38	55	26
GREENE	0		209	0		
INDIANA		0	214	91		
LAWRENCE	6	0	173	5		122
WASHINGTON	1	0	153	11	140	1
WESTMORELAND	2	0	183	10	58	53

WHAT DO THESE TABLES TELL US?

It is possible to use AQI data to evaluate which pollutant contributed most to the overall AQI. Of the eight counties for which data were available, in all but Allegheny County, ozone was the largest pollutant contributor to the overall AQI. Note that the goal of AQI is to be a warning system for community residents and only indirectly provides information about which of the major pollutants causes the most health effects.

Where do I find additional information about ozone?

Allegheny County Health Department Air Quality/Pollution Control: www.achd.net/air/index.html

American Lung Association: www.lungusa.org/healthy-air/outdoor/resources/ozone.html

Centers for Disease Control and Prevention National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards: www.cdc.gov/niosh/npg/npgd0476.html

U.S. Environmental Protection Agency Ground-level Ozone: www.epa.gov/ozone

Group Against Smog and Pollution (GASP): www.gasp-pgh.org

Pennsylvania Department of Environmental Protection:
www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/pollutants.htm

Pennsylvania Department of Environmental Protection Ozone Transport and NO_X Information:
www.dep.state.pa.us/dep/deputate/airwaste/aq/transport/transport.htm

Southwest Pennsylvania Air Quality Partnership, Inc.: www.spaqp.org

GLOSSARY

ACID RAIN
Broad term referring to a mixture of wet and dry deposition from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. Acid rain forms as a result of both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and oxides of nitrogen (NO_X) resulting from fossil fuel combustion.

AMBIENT AIR
Air found in the outdoors; the opposite of indoor air.

ATTAINMENT
Desired designation issued by EPA indicating that a pollution standard has not been exceeded.

CFCS—*see Chlorofluorocarbons*

CHLOROFLUOROCARBONS (CFCS)
Organic compounds that contain carbon, chlorine, and fluorine and are used in a variety of industrial, commercial, and household applications. They have been linked to the accelerated depletion of ozone in the Earth's stratosphere.

CRITERIA POLLUTANTS—*see National Ambient Air Quality Standards*

DESIGN VALUE
Term used by EPA to designate the measured level of a pollutant for pollution control or a level for an area on which attainment is based.
See also eight-hour Ozone Standard

EIGHT-HOUR OZONE STANDARD
In 1997, EPA completed an analysis of the one-hour ozone standard and adopted a new, more protective eight-hour standard to address the impacts of exposure of the public to longer periods of elevated ozone pollution. To meet the standard, the three-year average of the annual fourth-highest daily maximum eight-hour ozone concentration measured at each monitoring site must be less than 0.075 ppm.

EPA—*see U.S. Environmental Protection Agency*

GROUND-LEVEL OZONE—*see Ozone*

HIERARCHICAL BAYESIAN MODEL (HBM)
A model used by EPA to interpolate unobserved data values based on data that have been collected by nearby monitors

HYDROCARBONS
Simplest organic compounds, containing only carbon and hydrogen. Hydrocarbons can be gases, liquids, waxes, low-melting solids, or polymers. Their main use is as a combustible fuel source.

MAINTENANCE
Term used by EPA to designate an area that has decreased its pollutant level from a previous designation of nonattainment to a level that would warrant being designated as in attainment

NAAQS—*see National Ambient Air Quality Standards*

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)
The Clean Air Act, which was last amended in 1990, requires EPA to set NAAQS for pollutants considered harmful to public health and the environment. The six common NAAQS air pollutants, or "criteria pollutants," are ozone, fine particulates, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead.

NONATTAINMENT
Term used by EPA to indicate that the area is above the pollutant level that has been established as permissible under certain regulations

O_3—*see Ozone*

OXIDANT SMOG—*see Photochemical Smog*

OZONE (O_3)
Gas composed of three oxygen atoms. It is not usually emitted directly into the air but at ground level and is created by a chemical reaction between oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone has the same chemical structure whether it occurs miles above the earth, called "stratospheric ozone," or at ground-level and can be good or bad, depending on its location in the atmosphere.

PARTICULATE MATTER (PM)
Small particles of solids and liquids, commonly formed as by-products of combustion. Sometimes, particulate emissions are visible in the form of soot or smoke, because the particles are so large. However, most are not visible, which is part of what makes them dangerous, because people do not realize that the emissions are occurring. Small particles also are more dangerous because they are less likely to be trapped in the mucus linings of the nose and throat and taken deeply into the lungs.

PARTS PER MILLION (PPM)
Way of quantifying small concentrations

PHOTOCHEMICAL OXIDATION
Chemical reaction influenced or triggered by light that removes electrons from a compound or part of a compound

PHOTOCHEMICAL SMOG
Air pollution containing ozone and other reactive chemical compounds formed by the action of sunlight on nitrogen oxides and hydrocarbons, especially those in automobile exhaust

PITTSBURGH REGIONAL ENVIRONMENTAL THREATS ANALYSIS (PRETA)
Environmental assessment project developed by the Center for Healthy Environments and Communities in the Department of Environmental and Occupational Health at the University of Pittsburgh Graduate School of Public Health, with generous support from The Heinz Endowments. The 10-county region in which this project was conducted includes the following counties in Southwestern Pennsylvania: Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Lawrence, Indiana, Washington, and Westmoreland.

(CONTINUED ON NEXT PAGE)

GLOSSARY (CONTINUED)

PM—*see Particulate Matter*

PPM—*see Parts per Million*

PRECURSOR
Indication that a specific event will soon take place

PRETA—*see Pittsburgh Regional Environmental Threats Analysis*

PRIMARY STANDARDS
Pollutant standards based on human health

SECONDARY STANDARDS
Pollutant standards based on protecting ecosystems and on other welfare considerations

SMOG
In some uses, the term refers only to photochemical smog.

STRATOSPHERIC OZONE—*see Ozone*

TOXICITY
Degree to which a substance can cause damage to an organism

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
Federal agency whose mission is to protect human health and the environment

VOLATILE ORGANIC COMPOUND (VOC)
Chemical or compound that contains such vapor pressure that it does not require excessive heat to vaporize the compound into a gaseous form

VOC—*see Volatile Organic Compound*

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PITTSBURGH AND ITS SURROUNDING COUNTIES

With Lake Erie to the northwest and the Laurel Mountains to the east, the city of Pittsburgh and the surrounding counties shape the gateway to the Ohio River valley, located in the eastern United States. The U.S. Census Bureau estimates 2,666,258 people live within the 10-county Southwestern Pennsylvania region from the latest 2010 decennial census. The urban core of the greater Pittsburgh region is situated at the point where the Allegheny and Monongahela rivers converge to form the Ohio River, but vast urban sprawl continues to occur. The meeting point of the three rivers marks one of the lowest elevations in the region, sitting just 710 feet above sea level. This is in stark contrast with the surrounding area, where, in Westmoreland County, the elevation reaches a height of 2,950 feet. The 10-county region is full of valleys, rivers, and mountains, making up 6,755 square miles. It is home to 528 municipalities; 197,970 acres of floodplains; and nine distinct river-based watersheds.

The 10-county region consists of irregular topography; a history of industry and pollution; a relatively stable political and economic environment; and a number of environmental concerns, including legacy and emerging threats. While some of these environmental and public health issues are experienced in other places around the world, Pittsburgh exhibits a cumulation of unique factors that warrants a comprehensive analysis of the regional environmental public health threats.





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