

Air Quality Lesson 3



Subject/Target Grade

Science and Social Studies/
Middle School (7-9)

Duration

Two 45-50 minute periods –
Classroom setting

Materials

per class

- Clear 2-L pop bottle with pollutants from Lesson 1
- pan of water
- Air Quality Unit Poster
- *Air Pollution Sources* (transparency master)
- *Name That Source* (answer key)
- *Percentage of Air Emissions in Michigan by Source Type* (transparency master)
- *What Causes the Most Pollution?* (answer key)
- *Michigan Air Toxics* (transparency master)
- *Estimate of Mercury Air Emissions in Michigan* (transparency master)
- *Great Lakes Airshed* (transparency master)

per student

- *Looking for Air Pollution* (student activity)
- *Name That Source* (student resource)
- *Name That Source* (student activity)
- *What Causes the Most Pollution?* (student activity)

Michigan Grade Level Content Expectations

Grade 6-7 Science:

- Analyze information from data tables and graphs to answer scientific questions.
S.IA.06.11
- Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere and how pollution impacts habitats, climatic change, threatens or endangers species.
E.ES.07.42

(continued on next page)

What Are the Sources of Air Pollution?

Lesson Overview

This lesson looks at the sources of air pollutants. Students examine the sources of air pollutants (point, mobile, area, and natural) using charts of actual data for Michigan. The concept of an airshed and its importance for understanding air pollution is developed.

An enhancement activity on the MEECS Air Quality CD has students attending “smoke school” so they can see how air quality regulators do their work. An extension using online mapping capabilities for emissions and their sources is presented.

Students answer two essential questions: What are the sources of air pollutants? What are the relative amounts of pollutants from these sources?

Objectives

Students will be able to:

1. Categorize pollution sources as point, mobile on-road, mobile off-road, area, or natural.
2. Demonstrate an understanding of the relative contributions of each type of pollution source.
3. Define the term “airshed” and relate it to air pollution in Michigan.

Michigan Grade Level Content Expectations (continued)**Grade 6-8 Social Studies:**

- Describe the environmental effects of human action on the atmosphere, biosphere, lithosphere and hydrosphere. 6 - G5.1.1, 7 - G5.1.1

HS Social Studies:

- Read and interpret data in tables and graphs. P2.2

Advance Preparation

1. Prepare either a set of student handouts or transparencies of *Air Pollution Sources*, *Percentage of Emissions in Michigan by Source*, *Estimates of Mercury Emissions in Michigan*, and *The Great Lakes Airshed*. The charts are also available as a PowerPoint on the MEECS Air Quality CD.
2. Set up and test the demonstration of the effect of adding air pollutants to a body of water. Use the clear 2-L pop bottle with pollutants from Lesson 1 and a pan of water.

Background Information

Sources of air pollution can be local, regional, or global. An airshed is the area that contributes to a region's air and the contaminants found in air. Its area is vast and it does not recognize any political boundaries. Another definition of an airshed from the U.S. EPA's Office of Water is "the geographic area responsible for emitting 75% of the air pollution reaching a body of water." While watersheds are actual physical features of the landscape, airsheds are determined using mathematical models of atmospheric deposition. Airsheds are very useful in explaining the transportation of pollutants and can help to effectively manage ambient air and a body of water.

Many types of sources contribute to air pollution in an airshed, both natural and anthropogenic (human-produced). Volcanoes, desert dust, sea spray, meteorites, decay of radon, and fires produce natural air pollution. Volcanic ash can travel hundreds to thousands of miles downwind from a volcano. Fresh volcanic ash is gritty, abrasive, sometimes corrosive, and always unpleasant. Although ash is not highly toxic, it can trouble infants, the elderly, and those with respiratory ailments. Besides particles, volcanoes produce gases such as carbon dioxide, sulfur dioxide, carbon monoxide, and hydrochloric acid. Lightning contributes to the formation of ozone. Gaseous (biogenic) emissions are produced

from biological sources such as trees, bacteria, algae, and animals. Biological particles include pollen, spores, bacteria, and viruses. Livestock produce significant quantities of methane, ammonia gas, and carbon dioxide.

Clearing land (which produces particles) and burning wood (which produces gases and particles) are ways early humans caused air pollution. Today, burning of fossil fuels contributes significantly to air pollution with the release of soot (black carbon), sulfate, metals, fly ash, carbon dioxide, carbon monoxide, toxic organic compounds, and nitrogen oxides. Evaporative emissions such as gasoline spills and solvents in certain paints also contribute to air pollution.

Anthropogenic (human-produced) air emission sources in an airshed can be classified as stationary or mobile. Stationary sources include **point** sources such as a factory or power plant with significant emissions and **area** sources such as painting operations, dry cleaners, service stations, landfills, light industry, and agricultural burning. Mobile sources are classified as **on-road** including automobiles and trucks and **non-road** or off-road including gasoline or diesel-powered lawn and garden, construction, and agricultural equipment; airplanes; trains; ships; and recreational vehicles.

National and state emission inventories that categorize human-produced emission sources are done periodically. These inventories help to track changes in emissions and aid in planning emission reductions. Ozone is not included in the inventories since it is not usually emitted directly from a source. Special inventories of air toxics and greenhouse gases are being developed. In 2000, it was estimated that the United States contributed 22.6% of world carbon dioxide emissions. There has been an effort to quantify natural emissions, which will assist regulators in understanding the natural background contributions to air pollution.

About 67% of sulfur dioxide (SO_2) released into the air in the United States in 2002, or more than 13 million tons, came from electric utilities, especially those that burn coal. Other sources of SO_2 are industrial facilities that derive their products from raw materials such as metallic ore, coal, and crude oil, or that burn coal or oil to produce heat. Examples of such industrial facilities are petroleum refineries, cement manufacturing, and metal processing facilities. Also, locomotives, large ships, and some non-road diesel equipment currently burn high sulfur fuel and release SO_2 emissions into the air.

Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. Nationwide, the primary human-produced sources of NO_x are motor vehicles (55%), electric utilities (22%), and other industrial, commercial, and residential sources that burn fuels (22%). NO_x can also be formed naturally.

Almost 7 million tons of fine particles ($\text{PM}_{2.5}$) and 22 tons of coarse particles (PM_{10}) were released nationwide according to the 2002 inventory. Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Other particles may be formed in the air from the chemical change of gases. They are indirectly formed when gases from burning fuels react with sunlight and water vapor. These can result from fuel combustion in motor

vehicles, at power plants, and in other industrial processes. In 2002, the majority of the nation's particle pollution (64% for $\text{PM}_{2.5}$ and 86% for PM_{10}) was from fugitive dust from roads and construction, agriculture/forestry operations, and fires.

Volatile organic compounds (VOCs), which are important in the formation of ozone and which may be toxic, are included in emission inventories. Of the 16.5 million tons reported nationwide in 2002, 45% of the VOCs were from industrial processes, 27% were from highway vehicles, and 16% were from off-road vehicles. A study indicated that 30% of all the VOCs emitted in urban areas in eastern Texas were of biogenic origin including oak, pine, sycamore, poplar, and eucalyptus trees.

Carbon monoxide is a component of motor vehicle exhaust, which contributes about 56% of all CO emissions nationwide. Other non-road engines and vehicles (such as construction equipment and boats) contribute about 22% of the CO emissions. Higher levels of CO generally occur in areas with heavy traffic congestion. In cities, 85% to 95% of all CO emissions can come from motor vehicle exhaust. Other sources of CO emissions include industrial processes (such as metals processing and chemical manufacturing), residential wood burning, and natural sources such as forest fires. Woodstoves, gas stoves, cigarette smoke, and unvented gas and kerosene space heaters are sources of CO indoors. The highest levels of CO in the outside air typically occur during the colder months of the year when inversion conditions are more frequent and the air pollution becomes trapped near the ground beneath a layer of warm air.

The major sources of lead emissions have historically been motor vehicles and industrial sources. Due to the phase out of leaded gasoline, as of 1997 metals processing (52%) is the major source of lead emissions into the air in the United States. The highest levels of lead in air are generally found near lead smelters. Other stationary sources are waste incinerators, utilities, and lead-acid battery manufacturers. Non-road vehicles (13%), fuel

combustion (13%), and waste disposal (16%) are other sources.

The sources and fate of air toxics are not as well known as the criteria pollutants. Both wet and dry deposition are mechanisms for moving air toxics from their sources to lakes and land. These sources may be literally from the other side of the world. Up to 83% of the mercury load to the Great Lakes comes from atmospheric deposition. It is estimated that atmospheric deposition is responsible for over 90% of the polychlorinated biphenyls (PCBs) in Lake Superior, 58% in Lake Michigan, and 63% in Lake Huron. PCBs are a class of chemicals that were manufactured for industrial purposes as

coolants and lubricants for electrical equipment until they were phased out in 1977. Mercury and PCBs bioaccumulate and high levels in fish result in fish consumption advisories.

Sources:

Michigan Department of Environmental Quality.

Air Quality Division. *Michigan's Air*. Retrieved June 22, 2005, from <http://www.michigan.gov/deqair/>

U.S. Environmental Protection Agency. *Air Trends*.

Retrieved June 22, 2005, from <http://www.epa.gov/airtrends/>

U.S. Environmental Protection Agency. *Atmospheric*

Deposition and Water Quality. Retrieved June 22, 2005, from <http://www.epa.gov/owow/oceans/airdep/air1.html>

Procedure



1. Identify local sources of air pollution.

Can you find 10 sources and/or signs of air pollution on your way to or from school? Ask students to record them on the Looking for Air Pollution student page. If necessary, prompt them by listing “cars and trucks” as the first example. The completed list could include cars and trucks, industries, coal-fired power plants, motorboats, trains, planes, fireplaces, and wood stoves. Other possibilities are dry cleaners, gas stations, and wind-blown dust.

Source: Adapted from U.S. Environmental Protection Agency. Project A.I.R.E. *Activity 9: Finding Sources of Air Pollution*. Retrieved June 22, 2005, from <http://www.epa.gov/region01/students/teacher/aire.html>

2. Define the different types of pollution sources.

How are pollution sources categorized? Use the Air Pollution Sources transparency to define the different types of pollution sources: point, area, mobile (on-road, non-road), and natural. As a class, classify several sources by type. Then have students complete their Looking for Air Pollution student page by classifying each of the sources they listed as point, mobile, area, or natural.

Discuss the link between the possible health effects of pollution discussed in Lesson 2 to pollution sources. Record possible health effects of pollution to complete *Looking for Air Pollution* student page.

As a review, have students complete the *Name That Source* student activity page either in class or as homework. The *Name That Source* student resource provides background information.

3. Identify the relative contributions of different sources to air pollution.

What causes the most pollution? Show students the *Percentage of Air Emissions in Michigan by Source Type* transparencies or you can use the PowerPoint on the MEECS Air Quality CD. Note that the pie charts do not indicate the actual amounts of emissions, only percentages. The charts were generated from Michigan's 2002 emission inventory.

Note: Five of the six criteria pollutants and VOCs are part of the inventory. Ozone is not in the inventory since it is a pollutant that is created in the atmosphere (secondary pollutant). Consult the U.S. EPA Air Pollution Emissions Overview site and the MDEQ web site (<http://www.michigan.gov/deqair>) for updates on the emission inventory including the most current air quality reports.

Work with the students to complete the *What Causes the Most Pollution?* student activity page. It will be evident from this exercise that mobile sources contribute significantly to air pollution in Michigan, which also is true of the rest for the United States. Relate the sources of various pollutants to the problems of acid rain, ozone, and particle pollution. Point out that lead began to be phased out of gasoline in the late 1970s, so the relatively small amounts of lead are mostly from industrial sources. Show the transparency *Michigan Air Toxics*, which includes 213 toxic chemicals, to complete the examination of sources.

4. Tying it all together.

What is an airshed? Show the transparency of the *Great Lakes Airshed* as you define the term “airshed” as a geographic area sharing the same air. Explain that there are many sources of air pollution in several states in our airshed that contribute to our air quality and that regional and even global cooperation is necessary for controlling air pollution.

What could we do to improve air quality? Imagine that the classroom is the Great Lakes airshed. Speculate what the air quality in the room would be like if there was a single candle burning and 1 mL of perfume spilled, 10 candles burning and 10 mL of perfume spilled, 100 candles burning and 100 mL of perfume spilled, etc. Lead a discussion of how to maintain or improve the air quality while allowing for growth (e.g., increase in “candle” and “perfume” emissions from more vehicles, industries, etc.).

Is what happens in the airshed connected to water quality? Referencing Lesson 1, recall the cumulative effect of adding “pollutants” to the 2-L bottle. Pour some of the contents of that bottle into a pan of water to model the interaction of the air “pollutants” with a body of water. You could add some powdered drink mix to the bottle for an even more dramatic demonstration of air pollutants on water bodies such as the Great Lakes.

Note that there are five categories of air pollutants most likely to degrade water quality through atmospheric deposition: nitrogen compounds, mercury, other metals, pesticides, and combustion emissions. Bioaccumulation in organisms of some of these pollutants, such as mercury, has led to fish consumption advisories in Michigan. The *Estimate of Mercury Air Emissions in Michigan* transparency gives an idea of the origin of this pollutant. This material is a link to material covered in the *Water Quality Unit* of this series.

Assessment Options

1. Have students use the Air Quality Unit Poster or magazines like *National Geographic* as the data source to fill out the *Looking for Air Pollution* student activity page.
2. Assign students to write a paragraph or create a chart showing similarities and differences between a tall smoke stack at a power plant and the tailpipe of a car. [Similarities: both emit pollutants from burning; both have pollution control devices before the exhaust is emitted. Differences: stacks have a vertical orientation, tailpipes are horizontal; type of fuel; mix of pollutants; amount of pollutants.]

Adaptations/Extensions/Enhancements

1. In an enhancement lesson on the MEECS Air Quality CD, students take on the role of air quality regulators by learning some of the skills needed for reading smoke plumes. Invite an air pollution inspector from a MDEQ district office to speak about his/her job.
2. The U.S. EPA *Where You Live* web site has a page where you can select a zip code and find out about emission sources in your community. Lists and maps of facilities that have air emissions can be generated on this site found at <http://www.epa.gov/epahome/whereyoulive.htm>.
3. Ask students to select a pollutant and predict what the levels might be in various areas of Michigan. Then they can test their hypothesis by looking at the Michigan maps on the MEECS Air Quality CD showing county distributions of the criteria air pollutants. National trend maps are also found on the CD.
4. If students want to look at emissions from specific sources and generate their own maps, the U.S. EPA's AirData web site (www.epa.gov/air/data) has summaries and maps. Data concerning air monitoring, emissions of criteria pollutants, and emissions of hazardous air pollutants are available. The "source reports" section has estimated annual emissions from individual industrial sources and emissions by county. The "monitor reports" section has annual summaries of emissions at individual monitor locations. Maps of emission amounts and facility locations can be generated online.
5. Some lakes in the Upper Peninsula have concentrations of pesticides such as toxaphene, PCBs, dioxin, mercury, and other metals that are higher than expected based on their remote location. The Great Lakes also have these chemicals. Pose this as a Pollutant Source Investigation (PSI) and have students use the Internet to research how this could happen (i.e., atmospheric deposition) and what is known about the problem.

Additional Resources

Air Pollution and Water Quality

This very informative U.S. EPA site answers the questions: Which atmospheric deposition pollutants pose the greatest problems for water quality? What are the major effects of common atmospheric pollutants on water quality, ecosystems, and human health? United States Environmental Protection Agency. (2011). *Air Pollution and Water Quality*. Retrieved June 4, 2011, from http://water.epa.gov/polwaste/stormwater/airdeposition_index.cfm

Air Pollution Emissions Overview

This comprehensive EPA site contains links to air trends reports, emission inventories, air pollution sources, criteria pollutants, air toxics, rules, and regulations. United States Environmental Protection Agency. (2011). *Air Pollution Emissions Overview*. Retrieved June 4, 2011, from <http://www.epa.gov/airquality/emissions.html#about>

Atmospheric Deposition in the Great Lakes

The Delta Institute in Chicago has convened a work group to study atmospheric deposition of toxics in the Great Lakes. A summary of the policy and science implications of air toxics is found in this online report. Delta Institute. (2000). *Atmospheric Deposition in the Great Lakes*. Retrieved June 4, 2011, from <http://www.delta-institute.org/sites/default/files/airtoxics.pdf>

Deposition of Air Pollutants to the Great Waters (Third Report: 2000)

The main objective of this report is to present information about atmospheric deposition of pollutants to the Great Lakes and other large bodies of water based on the scientific data available. United States Environmental Protection Agency. (2000). *Deposition of Air Pollutants to the Great Waters*. Retrieved June 4, 2011, from <http://www.epa.gov/oar/oaqps/gr8water/3rdrpt/>

Detroit Exposure and Aerosol Research Study (DEARS)

A research study that the U.S. Environmental Protection Agency conducted in Detroit, Michigan, named the Detroit Exposure and Aerosol Research Study (DEARS), will help develop data that improves our understanding of human exposure to various air pollutants in our environment. The primary objective of DEARS was to compare air pollutant concentrations and their sources measured at central or community air-monitoring stations with those measured in various neighborhoods in the Detroit, Michigan area. A video explains the DEARS research effort. United States Environmental Protection Agency. (2009). *Detroit Exposure and Aerosol Research Study (DEARS)*. Retrieved June 4, 2011, from <http://www.epa.gov/dears/>

Grand Rapids Air Toxics Initiative

The Michigan Department of Environmental Quality received Community-scale Air Toxics Ambient Monitoring grant to support this paper that compares the levels of air toxics risk in Grand Rapids with the Detroit Air Toxics risk assessment. Michigan Department of Environmental Quality. (2011). *Grand Rapids Air Toxics Initiative*. Retrieved October 14, 2011 from http://www.michigan.gov/documents/deq/deq-aqd-aqe-toxics-Final-GRATI-July-2011_359564_7.pdf

The Great MTBE Controversy

Until recently, methyl tert-butyl ether (MTBE) was used as an additive in gasoline. This helped make automobile exhaust cleaner. However, leaking underground storage tanks at gas stations allowed gasoline to seep into the groundwater, causing drinking water contamination by MTBE. As part of a webquest series, there are activities for students to explore this issue. The Chemical Heritage Foundation. (2001). *The Great MTBE Controversy*. Retrieved June 4, 2011, from <http://imet.csus.edu/imet6/dibble/courses/ed286/wqcomments/chfchemistrywebquests.pdf>. Additional information is available at: United States Environmental Protection Agency. (2007). *Methyl Tertiary Butyl Ether (MTBE)*. Retrieved June 4, 2011, from <http://www.epa.gov/mtbe/>

Introduction to Air Toxics: Student Manual

Developed for the U.S. EPA's Air Pollution Training Institute, this advanced manual has information on the history of air toxics, sources, regulations, risk assessment, modeling, and air toxics control. Lake Michigan Air Directors Consortium. (2009). *Introduction to Air Toxics: Student Manual*. Retrieved June 4, 2011, from <http://www.epa.gov/apti/Materials/400AirToxicsManual.pdf>

Mercury

This site provides a broad range of information about mercury: actions by the EPA and others, including international actions; effects on people and the environment; and how to protect yourself and your family. United States Environmental Protection Agency (2011). *Mercury*. Retrieved June 4, 2011, from <http://www.epa.gov/mercury/>

National-Scale Air Toxics Assessment

This site provides emissions and health risk information on air toxics that present the greatest threat to public health in the largest number of urban areas. Maps and lists are available and can be requested or generated online by state or county. United States Environmental Protection Agency. (2011). *Technology Transfer Network National Air Toxics Assessments*. Retrieved June 4, 2011, from <http://www.epa.gov/ttn/atw/natamain/>

Toxics Release Inventory

The Toxics Release Inventory (TRI) provides information on the release of air toxics and other chemicals. The TRI Explorer provides fast and easy access to data that helps communities identify facilities and chemical releases that warrant further study. United States Environmental Protection Agency. (2011). *TRI Explorer*. Retrieved June 4, 2011, from <http://www.epa.gov/triexplorer/>

Volcanoes and Air Pollution

With many links to U.S. Geological Survey and other sites, this site addresses air quality issues associated with volcanic eruptions. The volcanic gases that pose the greatest potential hazard to people, animals, agriculture, and property are sulfur dioxide, carbon dioxide, and hydrogen fluoride. Sulfur dioxide gas can lead to acid rain and air pollution downwind from a volcano. United States Environmental Protection Agency. (2010). *Natural Events*. Retrieved June 4, 2011, from <http://www.epa.gov/naturalevents/volcanoes.html>



Looking for Air Pollution

Signs of Air Pollution

Draw pictures to show air pollution.

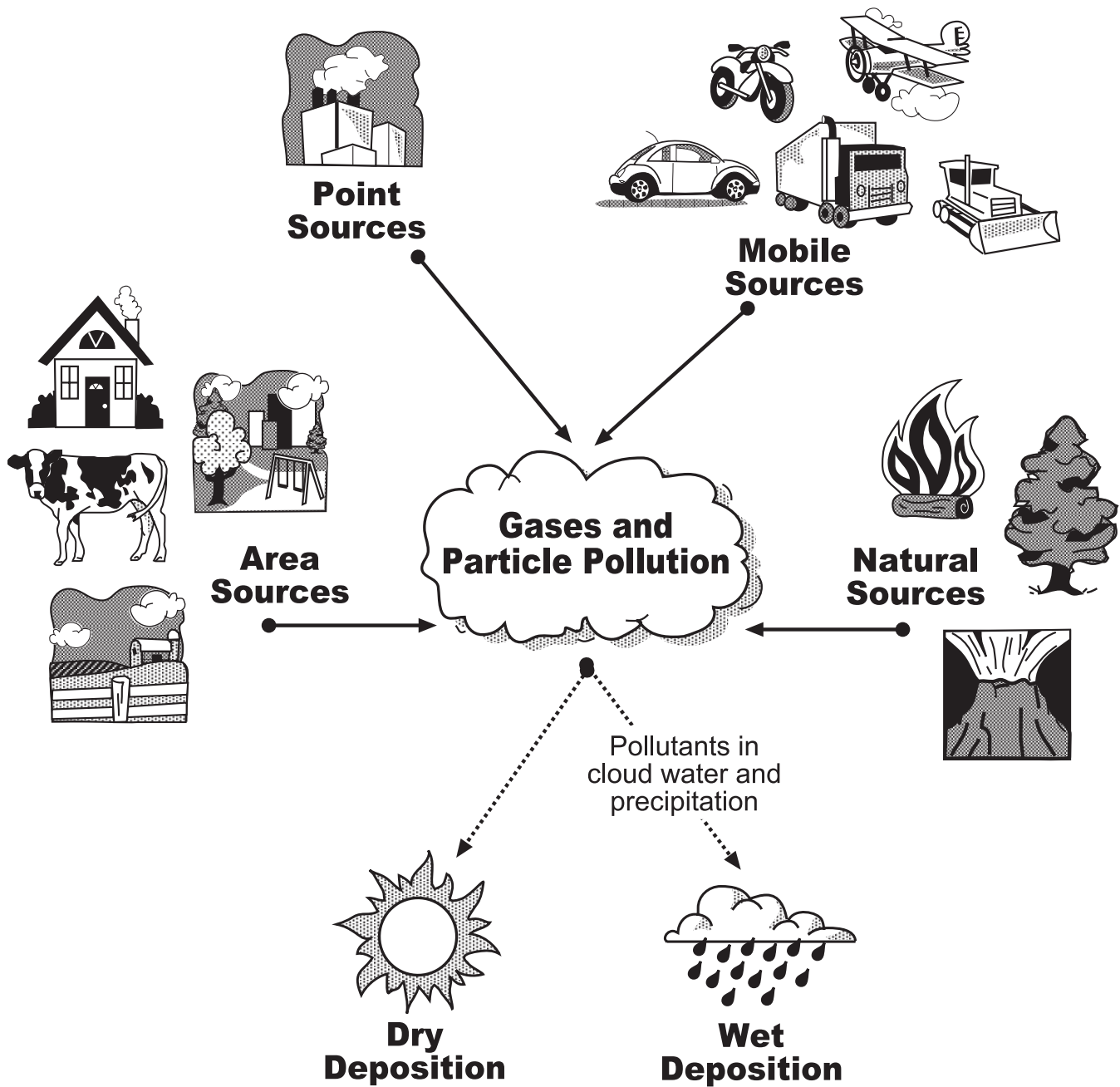
Sources of Air Pollution

Type of Source (fill in later)

1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Possible Health Effects of This Air Pollution

Air Pollution Sources



Name That Source

1. Point Sources

These are specific places or stationary sources, such as a factory or power plant that produce a significant amount of air pollution. There are often smoke stacks associated with point sources. A facility is considered to have significant emissions if it emits about one ton or more of pollution in a calendar year.

Examples of point sources include:

- Factories, paper mills, refineries, and chemical processing plants.
- Power plants and turbine engines.
- Municipal incinerators (where things are burned).
- Petroleum storage tanks.

2. Area Sources

These stationary sources are many small sources of air pollution in which the contribution of each source is relatively small, but combined they may be a significant source of air pollution.

Major categories of area sources are:

- Stationary sources that burn fuel—home fireplace, wood-burning furnace.
- Solvent use—paint thinner, dry cleaners.
- Storing and transporting chemicals—gasoline storage, gas stations.
- Light industrial/commercial sources—wood working, surface coating, metal working.
- Agriculture—feedlots, crop burning.
- Waste management—landfills.
- Miscellaneous area sources—agricultural fires, wind erosion, unpaved roads.

3. Mobile Sources

These are a wide variety of vehicles, engines, and equipment that generate air pollution and that move, or can be moved, from place to place. Mobile sources pollute the air mostly by burning fuel. These emissions contribute greatly to air pollution nationwide and are the primary cause of air pollution in many urban areas. Emissions per car have decreased, but there are more cars on the road.

On-road source — (also called **Highway source**) includes vehicles used on roads for transportation of people or freight. On-road vehicles may be fueled with gasoline, diesel fuel, or alternative fuels such as alcohol or natural gas.

Non-road source — (also called **Off-road source**) includes vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. Some examples are motor boats, jet skis, planes, trains, freighters, tractors, snowmobiles, and all-terrain vehicles.

4. Natural Sources

This is air pollution that is naturally produced by volcanoes, desert dust, wildfires, sea spray, meteorites, radon, and living things. Volcanoes produce particles and gases such as carbon dioxide, sulfur dioxide, carbon monoxide, and hydrochloric acid. Some plants emit VOCs. Animals and decomposition give off carbon dioxide. Livestock produce significant quantities of methane, ammonia gas, and carbon dioxide. Biological particles such as pollen, spores, bacteria, and viruses can also become pollutants if enough of them enter the air. Lightning contributes to ozone production.

Source: U. S. Environmental Protection Agency. *Air Pollution Control Orientation Course*. Retrieved June 22, 2005, from <http://www.epa.gov/apti/course422/ap.html>.

Name _____



Name That Source

1. What are point sources of air pollution?
2. What are mobile sources of air pollution?
3. Identify each of the following mobile sources as either an "On-Road" or "Non-Road" mobile source.

Mobile Source	On-Road	Non-road
Dirt bikes, all-terrain vehicles (ATVs), golf carts, snowmobiles		
Construction equipment		
Light-duty and medium vehicles (cars)		
Industrial equipment (fork lifts)		
Lawn and garden equipment		
Light-duty trucks		
Farm equipment		
Heavy-duty vehicles (RVs, trucks)		
Logging equipment		
Aircraft		
Motorcycles		
Marine vessels such as cruise ships		
Locomotives (trains)		

4. What are area source emissions?
5. What are some natural sources of air pollution?



Name That Source

1. What are point sources of air pollution?

Point sources are specific locations or stationary sources of pollution, such as factories, petroleum storage tanks, and power plants.

2. What are mobile sources of air pollution?

Mobile sources are a wide variety of vehicles, engines, and equipment that generate air pollution as they move from place to place, such as cars, trucks, planes, motor boats, and tractors.

3. Identify each of the following mobile sources as either an “On-Road” or “Non-Road” mobile source.

Mobile Source	On-Road	Non-road
Dirt bikes, all-terrain vehicles (ATVs), golf carts, snowmobiles		X
Construction equipment		X
Light-duty and medium vehicles (cars)	X	
Industrial equipment (fork lifts)		X
Lawn and garden equipment		X
Light-duty trucks	X	
Farm equipment		X
Heavy-duty vehicles (RVs, trucks)	X	
Logging equipment		X
Aircraft		X
Motorcycles	X	
Marine vessels such as cruise ships		X
Locomotives (trains)		X

4. What are area source emissions?

Area source emissions come from stationary sources that are small individually but taken together in a given area may be significant. Examples include wood-burning fireplaces, dry cleaners, gas stations, landfills, and many more.

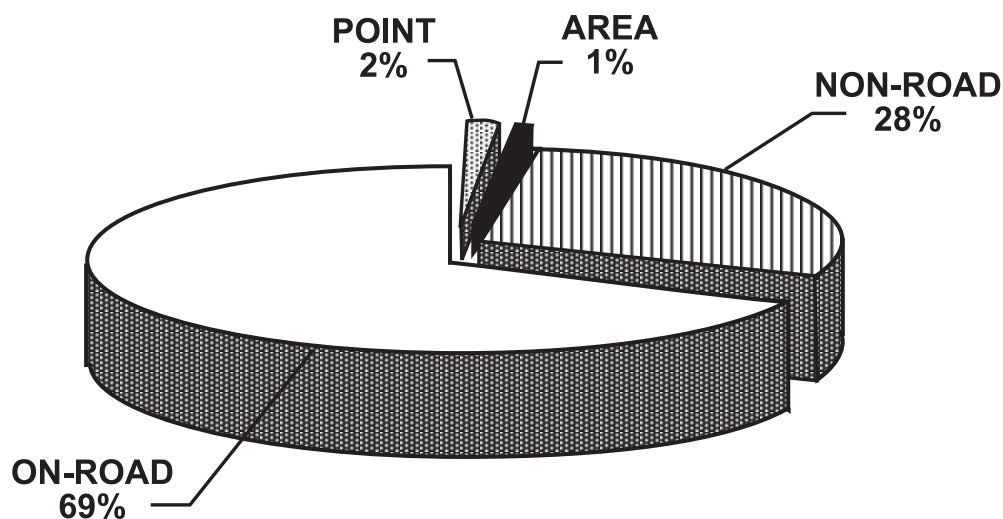
5. What are some natural sources of air pollution?

Volcanoes, wildfires, animals, lightning, sea spray, radon, meteorites, dust storms, some plants, and other biological particles (pollen, spores, bacteria, viruses).

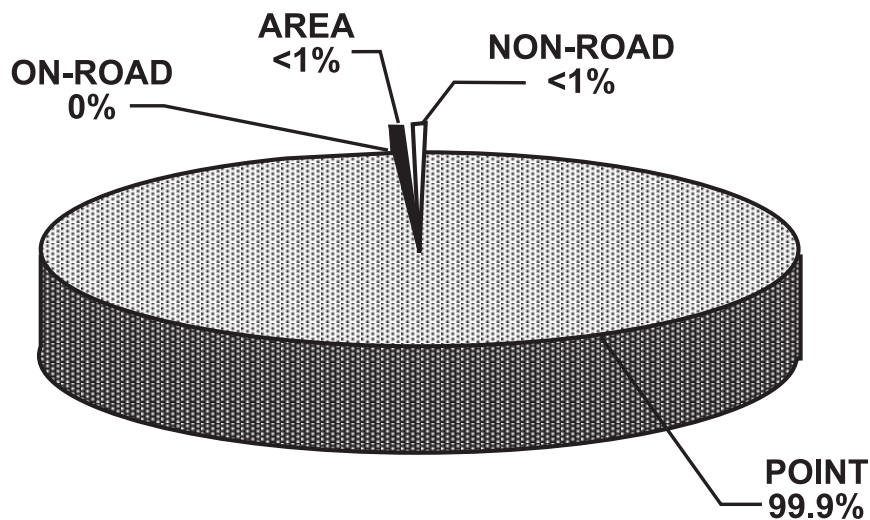


Percentage of Air Emissions in Michigan by Source Type

Percentage of Carbon Monoxide Emissions in Michigan By Source Type (EPA Emissions Inventory Data) 3,745,963 tons



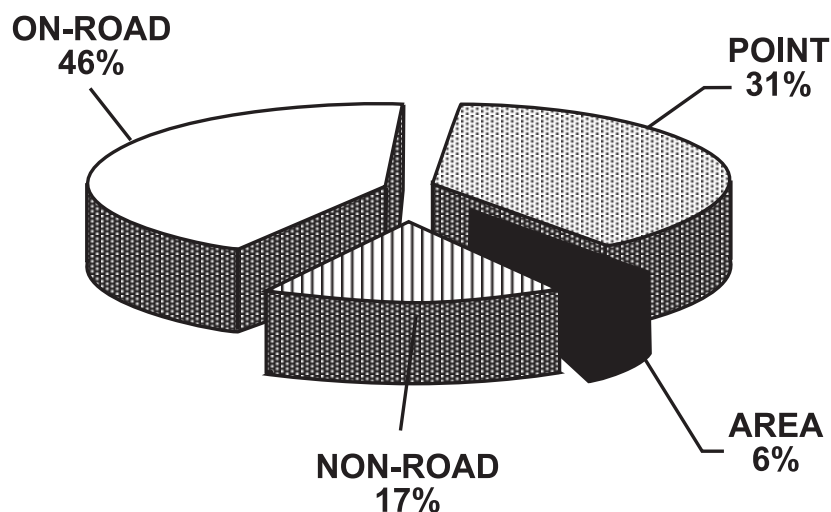
Percentage of Lead Emissions in Michigan By Source Type (EPA Emissions Inventory Data) 40 tons



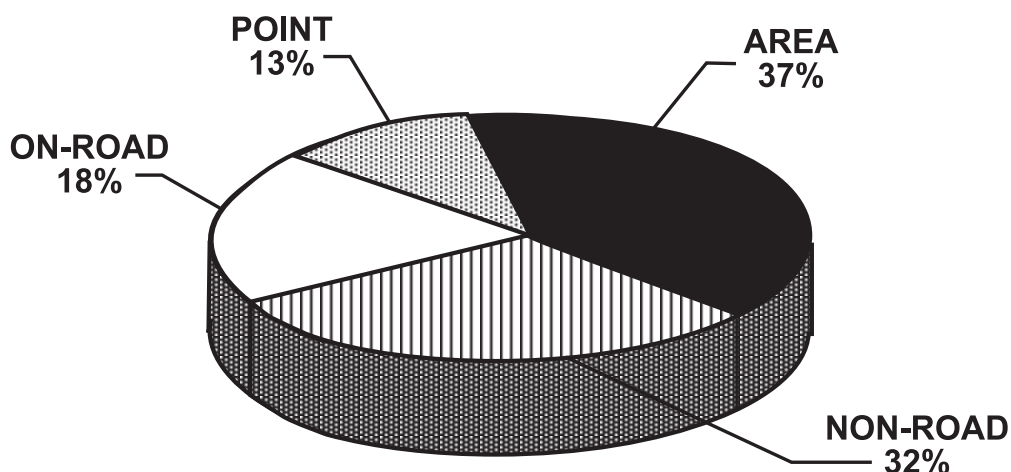


Percentage of Air Emissions in Michigan by Source Type

Percentage of Nitrogen Oxide Emissions in Michigan By Source Type (EPA Emissions Inventory Data)
695,799 tons



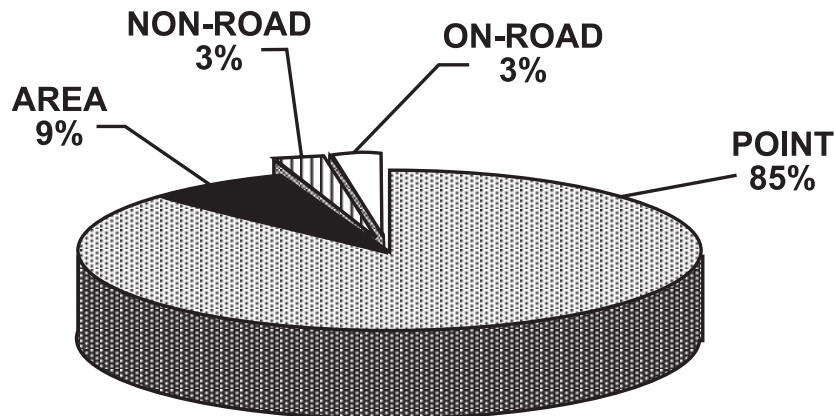
Percentage of PM_{2.5} Emissions in Michigan By Source Type (EPA Emissions Inventory Data)
33,535 tons



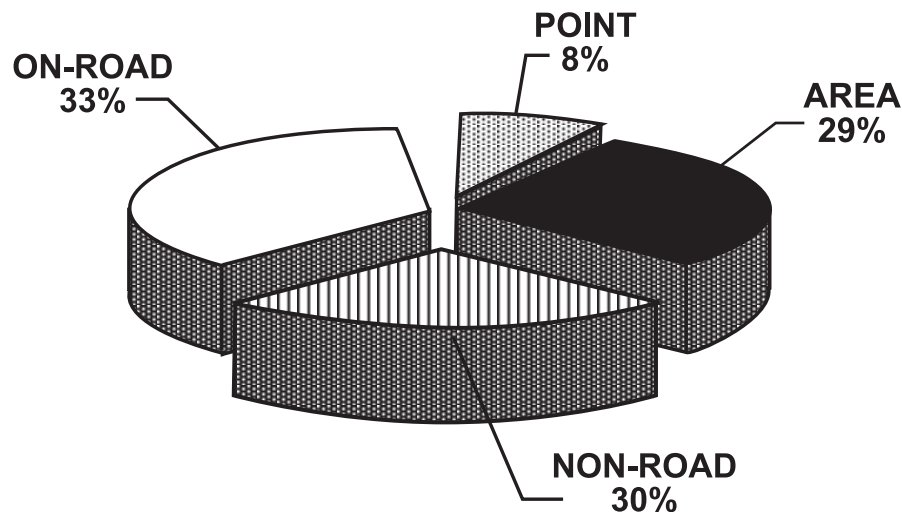


Percentage of Air Emissions in Michigan by Source Type

**Percentage of Sulfur Dioxide Emissions
in Michigan By Source Type
(EPA Emissions Inventory Data)
479,944 tons**



**Percentage of VOC Emissions
in Michigan By Source Type
(EPA Emissions Inventory Data)
486,166 tons**





What Causes the Most Pollution?

Directions: Determine what type of source causes the most pollution in each of six categories of pollutants. Study the charts showing the percentage of emissions in Michigan by source. For each chart, give 4 points for the source with the highest percentage, 3 points for the next highest, 2 points for the next one, and 1 point for the lowest percentage. In the case of a tie, assign an average to both sources. Calculate the total for each source to determine which source ranks the highest overall and answer the questions that follow.

Source Type	Carbon Monoxide	Lead	Nitrogen Oxides (NO _x)	Particles (PM _{2.5})	Sulfur Dioxide	VOCs	Total
Point							
Area							
Non-Road							
On-Road							

- Which source of air pollution ranked the highest overall? Give some examples of this type of source. Is this what you would have predicted? Explain why or why not.
- Point sources such as factories and power plants release the greatest percentages of which air pollutants?
- Non-road sources, such as construction equipment and trains, release the greatest percentage of which air pollutants?
- On-road sources, such as cars, release the greatest percentage of which air pollutants?



What Causes the Most Pollution?

Directions: Determine what type of source causes the most pollution in each of six categories of pollutants. Study the charts showing the percentage of emissions in Michigan by source. For each chart, give 4 points for the source with the highest percentage, 3 points for the next highest, 2 points for the next one, and 1 point for the lowest percentage. In the case of a tie, assign an average to both sources. Calculate the total for each source to determine which source ranks the highest overall and answer the questions that follow.

Source Type	Carbon Monoxide	Lead	Nitrogen Oxides (NO _x)	Particles (PM _{2.5})	Sulfur Dioxide	VOCs	Total
Point	2	4	3	1	4	1	15
Area	1	2.5	1	4	3	2	13.5
Non-Road	3	2.5	2	3	1.5	3	15
On-Road	4	1	4	2	1.5	4	16.5

- Which source of air pollution ranked the highest overall? Give some examples of this type of source. Is this what you would have predicted? Explain why or why not.

On-road vehicles, such as cars and trucks. Many students may think that factories would rank first, but the cumulative effect of emissions from mobile sources is considerable.

- Point sources such as factories and power plants release the greatest percentages of which air pollutants?

Sulfur dioxide (85%) and lead (99.9%); lesser percentages of nitrogen oxides (31%)

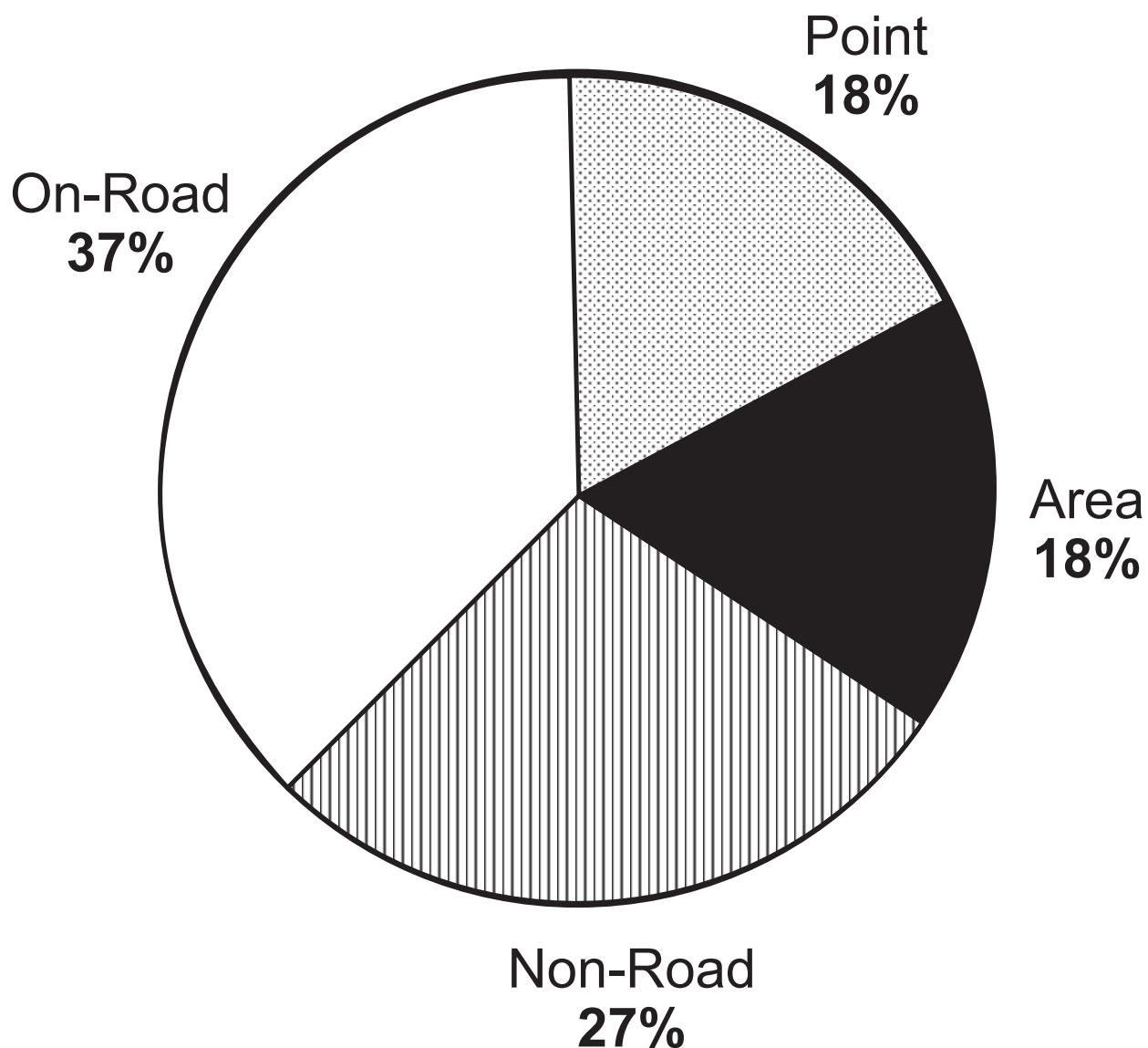
- Non-road sources, such as construction equipment and trains, release the greatest percentage of which air pollutants?

Fine particle pollution (32%); VOCs (30%); and carbon monoxide (28%).

- On-road sources, such as cars, release the greatest percentage of which air pollutants?

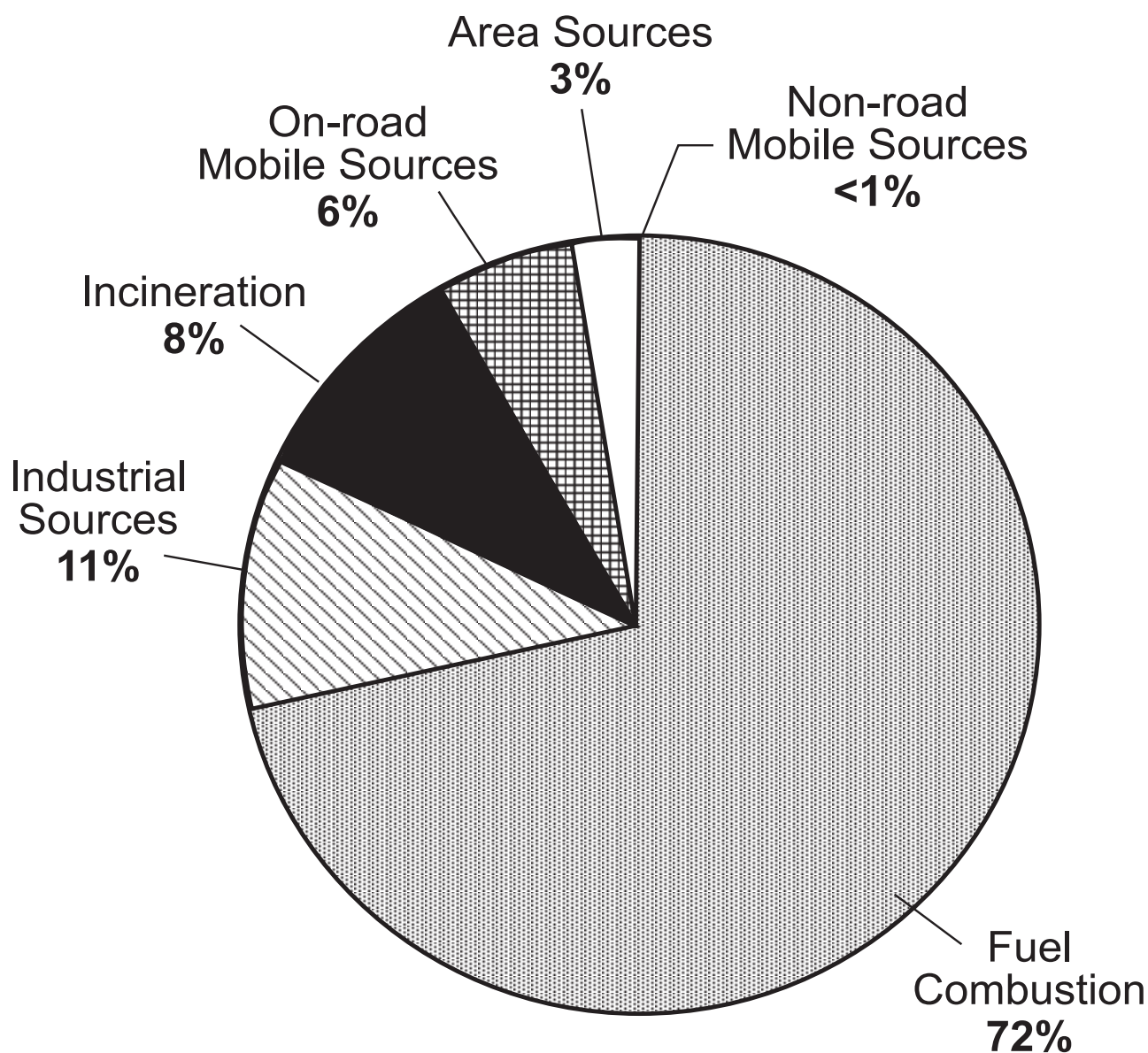
Carbon monoxide (69%); lesser percentages of nitrogen oxides (46%), particles (18%), and VOCs (33%).

Michigan Air Toxics



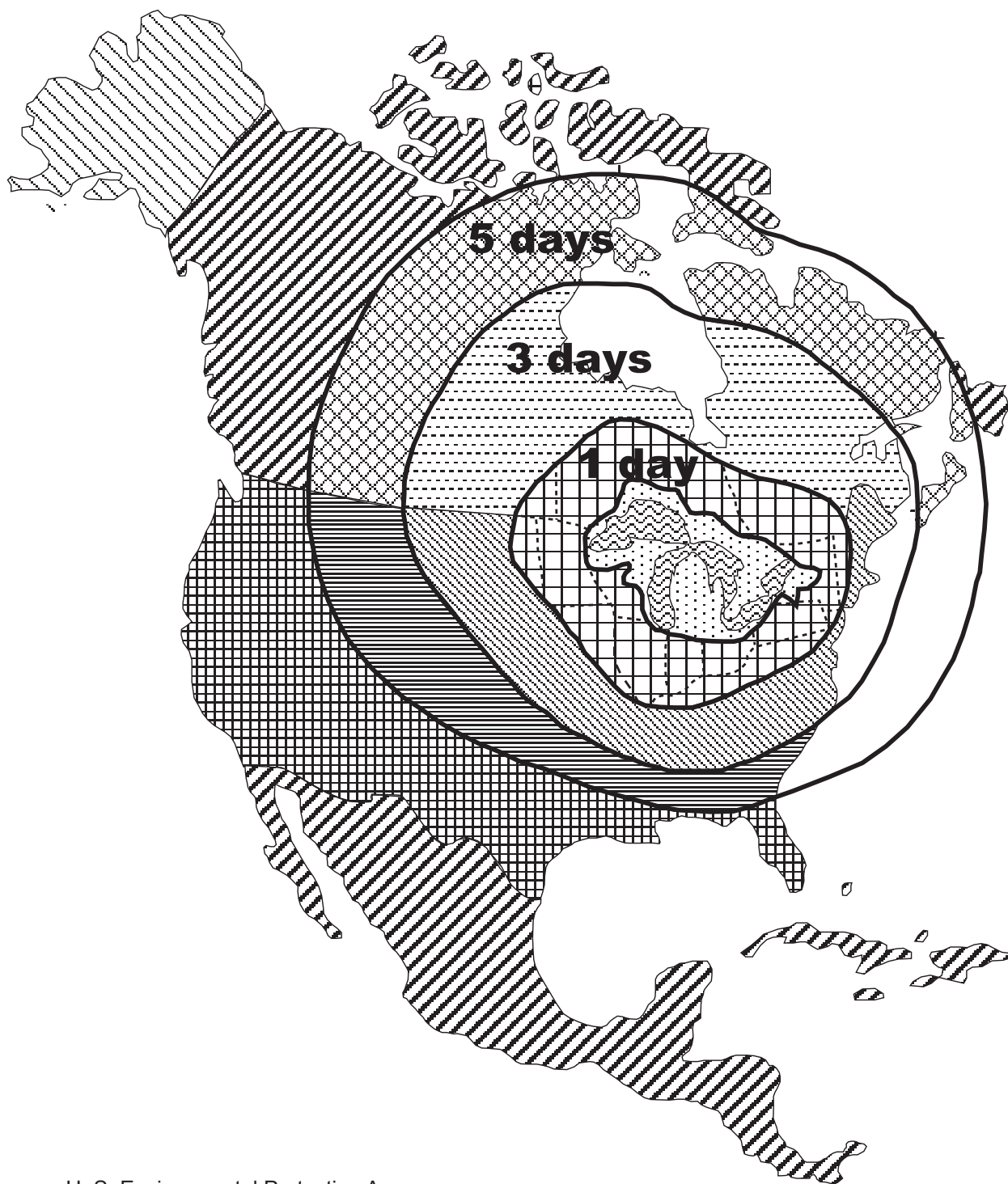
Source: Great Lakes Commission. (2001). *Inventory of Toxic Air Emissions: Point, Area and Mobile Sources*. Retrieved June 22, 2005, from <http://www.glc.org/air/inventory/2001/>.

Estimate of Mercury Air Emissions in Michigan



Source: Great Lakes Commission. (2001). *Inventory of Toxic Air Emissions: Point, Area and Mobile Sources*. Retrieved June 22, 2005, from <http://www.glc.org/air/inventory/2001/>.

Great Lakes Airshed



Source: U. S. Environmental Protection Agency.
 Great Lakes National Program Office, Great Lakes – Lake Michigan.
 Retrieved June 22, 2005, from <http://www.epa.gov/glnpo/lakemich/intro.html>.

