

## READING WARM-UP

## Objectives

- Compare primary and secondary air pollutants.
- Identify point-sources and nonpoint-sources of air pollution in North Carolina.
- Identify sources of human-caused air pollution.
- Describe how acid precipitation affects the environment.

## Terms to Learn

air pollution  
acid precipitation

## READING STRATEGY

**Reading Organizer** As you read this section, make a table that identifies major sources of air pollution and the effects of each.

**air pollution** the contamination of the atmosphere by the introduction of pollutants from human and natural sources

## Air Pollution

*In December 1952, one of London's dreaded "pea souper" fogs settled on the city. But this was no ordinary fog—it was thick with coal smoke and air pollution. It burned people's lungs, and the sky grew so dark that people could not see their hands in front of their faces. When the fog lifted four days later, thousands of people were dead!*

London's killer fog shocked the world and caused major changes in England's air-pollution laws. People began to think that air pollution was not simply a part of urban life that had to be endured. Air pollution had to be reduced. Although this event is an extreme example, air pollution is common in many parts of the world. However, nations are taking major steps to reduce air pollution. But what is air pollution? **Air pollution** is the contamination of the atmosphere by the introduction of pollutants from human and natural sources. Air pollutants are classified according to their source as either primary pollutants or secondary pollutants.

## Primary Pollutants

Pollutants that are put directly into the air by human or natural activity are *primary pollutants*. Primary pollutants from natural sources include dust, sea salt, volcanic gases and ash, smoke from forest fires, and pollen. Primary pollutants from human sources include carbon monoxide, dust, smoke, and chemicals from paint and other substances. In urban areas, vehicle exhaust is a common source of primary pollutants. Examples of primary pollutants are shown in **Figure 1**.

**Reading Check** List three primary pollutants from natural sources. (See the Appendix for answers to Reading Checks.)

**Figure 1** Examples of Primary Pollutants

Industrial emissions



Vehicle exhaust



Volcanic ash

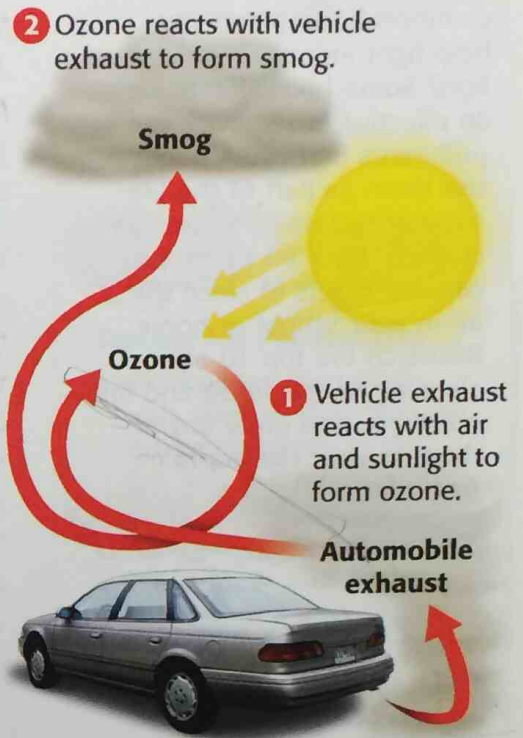


## Secondary Pollutants

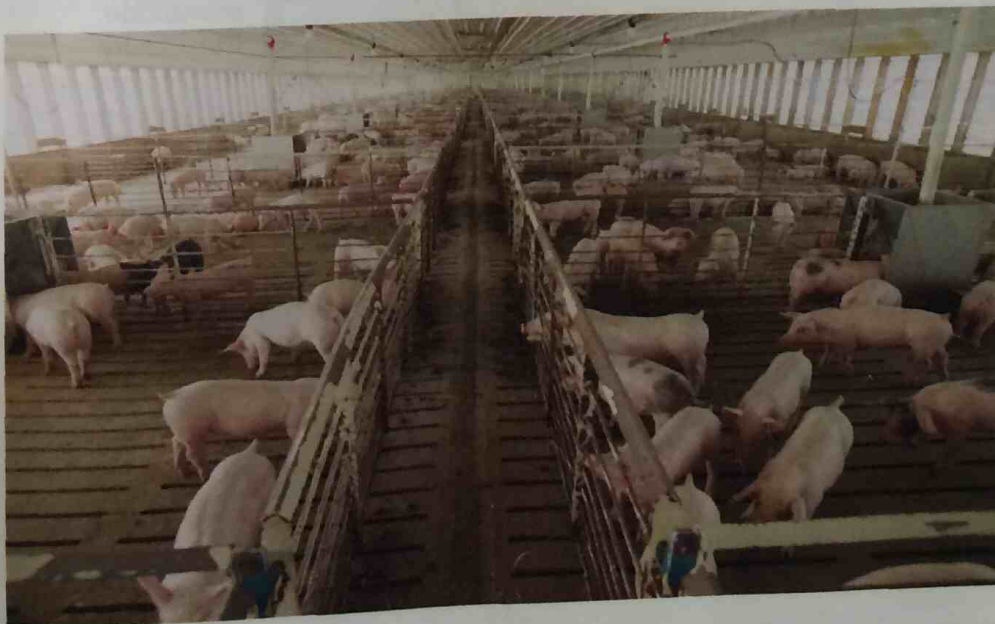
Pollutants that form when primary pollutants react with other primary pollutants or with naturally occurring substances are *secondary pollutants*. Ozone and smog are examples of secondary pollutants. Ozone is formed when sunlight reacts with vehicle exhaust and air. You may have heard of “Ozone Action Day” warnings in your community. When such a warning is issued, people are discouraged from outdoor physical activity because ozone can damage their lungs. In the stratosphere, ozone forms a protective layer that absorbs harmful radiation from the sun. Near the Earth’s surface, however, ozone is a dangerous pollutant that negatively affects the health of organisms. **Figure 2** shows how smog is formed.

## Point and Nonpoint-Source Pollutants

All sources of pollutants can be classified as either point-source pollutants or non-point source pollutants. *Point-source pollutants* are pollutants that are released from a single source. Examples of point-source pollutants in North Carolina are smoke from burning brush, chemical wastes and gases from agricultural industries as shown in **Figure 3**, and particulate matter. Particulate matter is any small particle of dust, dirt, or soot in the air. *Nonpoint-source pollutants* are pollutants that come from many different sources and are often difficult to identify. Examples of nonpoint-source pollutants in North Carolina include ozone and haze. Ozone forms when emissions from industries and motor vehicles react with air and sunlight. Haze forms when emissions from power plants react with air.



**Figure 2** Smog forms when sunlight reacts with ozone and vehicle exhaust.



**Figure 3** Chemicals such as methane from animal waste, are considered point-source pollutants.



## CONNECTION TO Biology

**Cleaning the Air with Plants** Did you know that common houseplants can help fight indoor air pollution? Some houseplants are so effective at removing air pollutants that NASA might use them as part of the life-support system in future space stations. Back on Earth, you can use plants to clean the air in your school or home. Research the top 10 air-cleaning houseplants, and find out if you can grow any of them in your classroom or home.

## ACTIVITY

## Sources of Human-Caused Air Pollution

Human-caused air pollution comes from a variety of sources. A major source of air pollution today is transportation. Cars contribute about 10% to 20% of the human-caused air pollution in the United States. Vehicle exhaust contains nitrogen oxide, which contributes to smog formation and acid precipitation. However, pollution controls and cleaner gasoline have greatly reduced air pollution from vehicles.

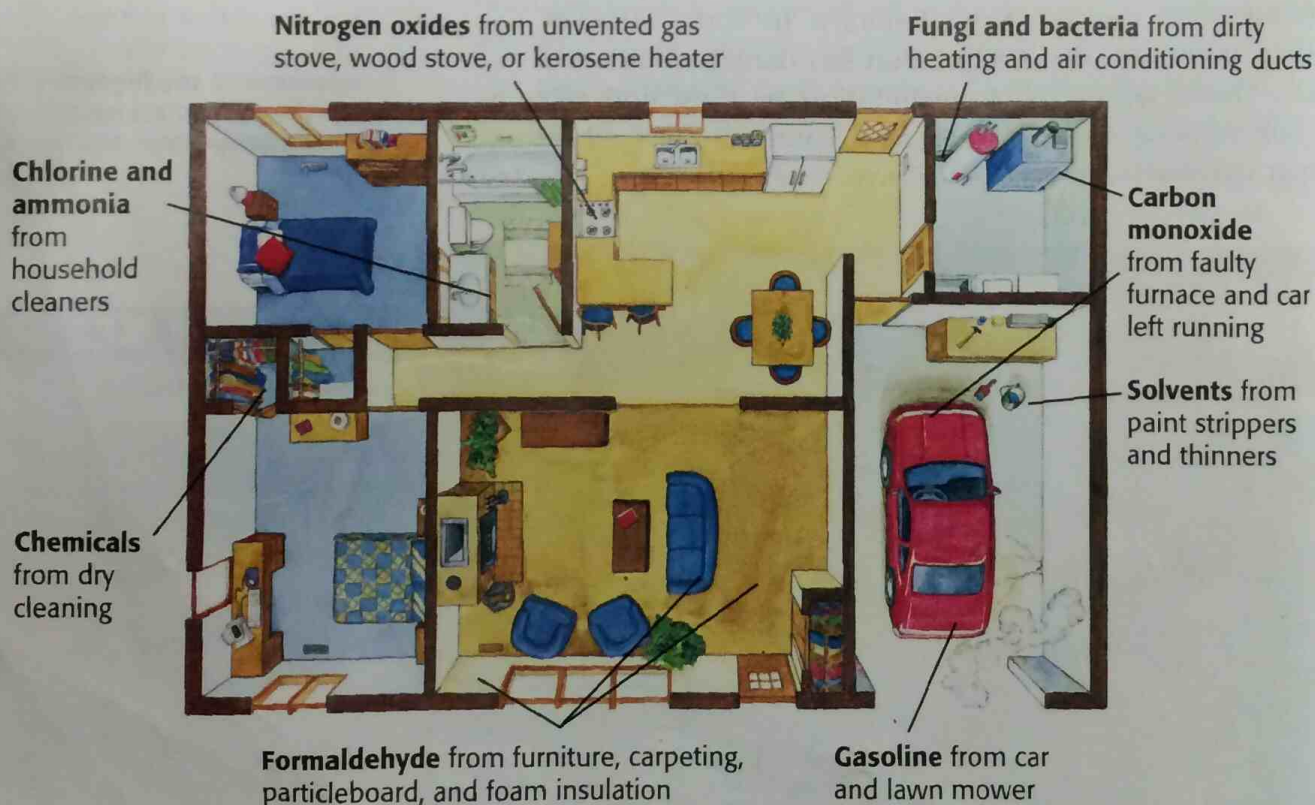
### Industrial Air Pollution

Many industrial plants and electric power plants burn fossil fuels, such as coal, to produce energy. Burning some types of coal without pollution controls can release large amounts of air pollutants. Some industries also produce chemicals that can pollute the air. Oil refineries, chemical manufacturing plants, dry-cleaning businesses, furniture refinishers, and auto body shops are all potential sources of air pollution.

### Indoor Air Pollution

Sometimes, the air inside a building can be more polluted than the air outside. Some sources of indoor air pollution are shown in **Figure 4**. *Ventilation*, or the mixing of indoor air with outdoor air, can reduce indoor air pollution. Another way to reduce indoor air pollution is to limit the use of chemical solvents and cleaners.

**Figure 4** There are many sources of indoor air pollution. Indoor air pollution can be difficult to detect because it is often invisible.





## Acid Precipitation

When fossil fuels are burned, they can release sulfur dioxide and nitrogen oxide into the atmosphere. When these pollutants combine with water in the atmosphere, they form sulfuric acid and nitric acid. Precipitation such as rain, sleet, or snow that contains these acids from air pollution is called **acid precipitation**. Precipitation is naturally acidic, but sulfuric acid and nitric acid can make it so acidic that it can negatively affect the environment. In most areas of the world, pollution controls have helped reduce acid precipitation.

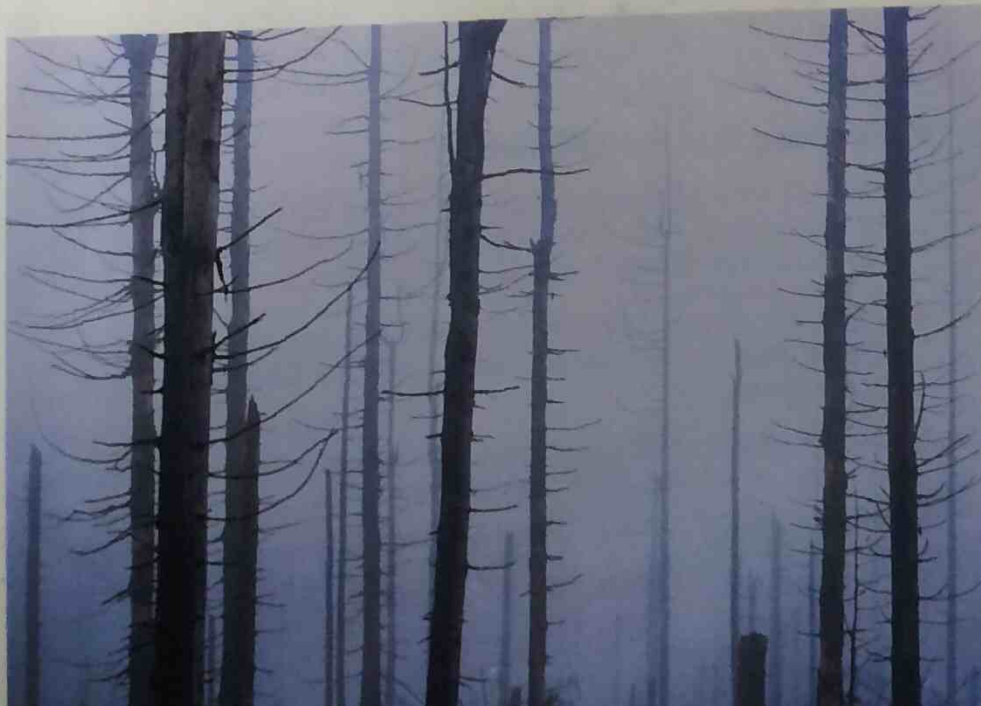
### Acid Precipitation and Plants

Plant communities have adapted over long periods of time to the natural acidity of the soil in which they grow. Acid precipitation can cause the acidity of soil to increase. This process, called *acidification*, changes the balance of a soil's chemistry in several ways. When the acidity of soil increases, some nutrients are broken down. Nutrients that plants need for growth get washed away by acidic rainwater. Increased acidity also releases aluminum and other toxic metals from the soil. Some of these toxic metals are absorbed by the roots of plants.

**Reading Check** How does acid precipitation affect plants?

### The Effects of Acid Precipitation on Forests

Forest ecology is complex. Scientists are still trying to fully understand the long-term effects of acid precipitation on groups of plants and their habitats. In some areas of the world, however, acid precipitation has damaged large areas of forest. The effects of acid precipitation are most noticeable in Eastern Europe, as shown in **Figure 5**. Forests in the northeastern United States and in eastern Canada have also been affected by acid precipitation.



**Figure 5** This forest in Poland was damaged by acid precipitation.

**acid precipitation** rain, sleet, or snow that contains a high concentration of acids

## Quick Lab

### Testing for Particulates

1. Particulates are pollutants such as dust that are extremely small. In this lab, you will measure the amount of particulates in the air. Begin by covering **ten 5 in. × 7 in. index cards** with a thin coat of **petroleum jelly**.
2. Hang the cards in various locations inside and outside your school.
3. One day later, use a **magnifying lens** to count the number of particles on the cards. Which location had the fewest number of particulates? Which location had the highest number of particulates? Hypothesize why.






**Figure 6** Acid shock, which is a rapid change in a body of water's acidity, can prevent fish from absorbing oxygen and nutrients. Acid shock can cause populations of fish to die.

## Acid Precipitation and Aquatic Ecosystems

Aquatic organisms have adapted to live in water that has a particular range of acidity. If acid precipitation increases the acidity of a lake or stream, aquatic plants, fish, and other aquatic organisms living in the lake or stream may die.

The effects of acid precipitation are worst in the spring, when the acidic snow that built up in the winter melts and acidic water flows into lakes and rivers. A rapid change in a body of water's acidity is called *acid shock*. Acid shock can cause large numbers of fish in a population to die, as shown in **Figure 6**. Acid shock can affect how fish absorb oxygen and nutrients. To reduce the effects of acid precipitation on aquatic ecosystems, some communities add powdered limestone (calcium carbonate) to acidified lakes in the spring. Limestone neutralizes acids in the lakes. Unfortunately, limestone cannot prevent all acid damage to lakes.

 **Reading Check** Why is powdered limestone added to lakes in the spring instead of the fall?

## Acid Precipitation and Humans

Acid precipitation can also affect humans. An increase in soil acidity can cause toxic metals, such as aluminum and mercury, to be released from the soil. These toxic metals can find their way into crops, water, fish, and then eventually into the human body. Studies have also shown that acid precipitation may harm the respiratory health of children.

## QUICK Lab

### Neutralizing Acid Precipitation

1. Pour 1/2 tbsp of **vinegar** into one cup of **distilled water**, and stir the mixture well. Check the pH of the mixture by using pH paper. The pH should be about 4.
2. Crush one stick of **blackboard chalk** into powder. Pour the powder into the vinegar and water mixture. Check the pH of the mixture.
3. Did the vinegar and water mixture become more or less acidic after the powdered chalk was poured in?



## International Cooperation

Controlling acid precipitation is complicated. Pollutants that are released in one area may later fall to the ground as acid precipitation in an area hundreds of kilometers away. Sometimes, pollution from one country results in acid precipitation in another country. For example, almost half of the acid precipitation that falls in southeastern Canada results from pollution produced in the United States. In the spirit of cooperation, the governments of Canada and the United States signed the Canada-U.S. Air Quality Agreement in 1991. Both countries agreed to reduce acidic emissions that flowed across the Canada-U.S. boundary. More of these international agreements may be necessary to control acid precipitation.

## CONNECTION TO Chemistry

### Acidity of Precipitation

Acidity is measured by using a pH scale, the units of which range from 1 to 14. Solutions that have a pH of less than 7 are acidic. Research recorded pH levels of acid rain in your area. Then, compare these pH levels with the pH levels of other common acids, such as lemon juice and acetic acid.

## SECTION Review

### Summary

- Primary pollutants are pollutants that are put directly into the air by human or natural activity. Secondary pollutants form when primary pollutants react with other primary pollutants or with naturally occurring substances.
- Point-source pollutants in North Carolina are smoke, outdoor odors, and particulate matter. Nonpoint-source pollutants in North Carolina are ozone and haze.
- Transportation, industry, and natural sources are the main sources of air pollution.
- Acid precipitation can have harmful effects on plants, animals, and humans.

### Using Key Terms

The statements below are false. For each statement, replace the underlined term to make a true statement.

- Air pollution is a sudden change in the acidity of a stream or lake.
- Smog is rain, sleet, or snow that has a high concentration of acid.

### Understanding Key Ideas

- Which of the following is a primary pollutant?
  - ozone
  - smog
  - vehicle exhaust
  - rain
- List the main point-source pollutants and nonpoint-source pollutants in North Carolina.

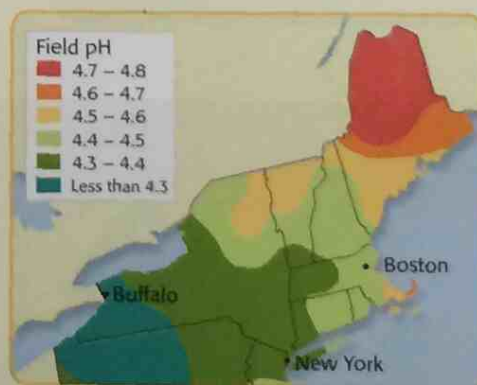
### Critical Thinking

- Expressing Opinions** How do you think that nations should resolve air-pollution problems that cross national boundaries?

### Interpreting Graphics

Use the map to answer the questions below.

- Which areas have the most acidic precipitation?
- Boston is a larger city than Buffalo is, but the precipitation measured in Buffalo is more acidic than the precipitation in Boston. Explain why.



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