KEY ISSUE 3

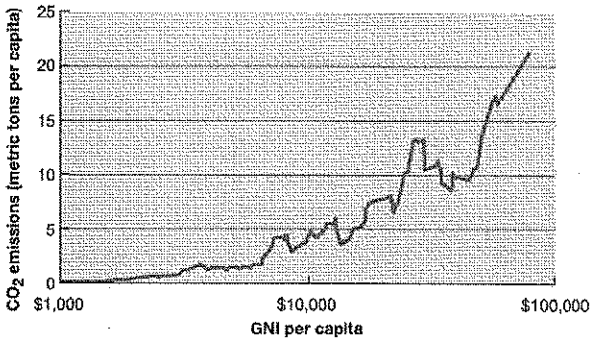
Where Does Industry Cause Pollution?

- Air Pollution
- Solid Waste Pollution
- Water Pollution

Learning Outcome 11.3.1
Describe causes and effects of global warming and damage to the ozone layer.

Industry is a major polluter of air, water, and land. People rely on air, water, and land to remove and disperse waste from factories as well as from other human activities. Pollution occurs when more waste is added than air, water, and land resources can handle.

As a country's per capita income increases, its per capita carbon dioxide emissions also increase. Some of the wealthiest countries, located primarily in Europe, with gross national income (GNI) per capita between $30,000 and $50,000, show declines in pollution. However, the world's richest countries, including the United States and several countries in Southwest Asia, display the highest pollution levels (Figure 11-30).



▲ FIGURE 11-30 GNI AND POLLUTION Carbon dioxide emissions generally increase with rising income. The principal exception is in Europe, where some relatively wealthy countries have curbed emissions.

Air Pollution

At ground level, Earth's average atmosphere is made up of about 78 percent nitrogen, 21 percent oxygen, and less than 1 percent argon. The remaining 0.04 percent includes several trace gases, some of which are critical. **Air pollution** is concentration of trace substances at a greater level than occurs in average air. Concentrations of these trace gases in the air can damage property and adversely affect the health of people, other animals, and plants.

Most air pollution is generated from factories and power plants, as well as from motor vehicles. Factories and power plants produce sulfur dioxides and solid particulates, primarily from burning coal. Burning petroleum in motor vehicles produces carbon monoxide, hydrocarbons, and nitrogen oxides.

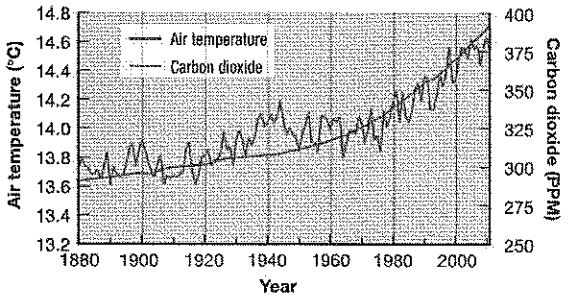
GLOBAL-SCALE AIR POLLUTION

Air pollution concerns geographers at three scales—global, regional, and local. At the global scale, air pollution may contribute to global warming. It may also damage the atmosphere's ozone layer.

GLOBAL WARMING. The average temperature of Earth's surface has increased by 1°C (2°F) since 1880 (Figure 11-31). Human actions, especially the burning of fossil fuels in factories and vehicles, may have caused this.

Earth is warmed by sunlight that passes through the atmosphere, strikes the surface, and is converted to heat. When the heat tries to pass back through the atmosphere to space, some gets through and some is trapped. This process keeps Earth's temperatures moderate and allows life to flourish on the planet. A concentration of trace gases in the atmosphere can block or delay the return of some of the heat leaving the surface heading for space, thereby raising Earth's temperatures. When fossil fuels are burned, one of the trace gases, carbon dioxide, is discharged into the atmosphere. Plants and oceans absorb much of the discharges, but increased fossil fuel burning during the past 200 years, as shown in Figure 11-30, has caused the level of carbon dioxide in the atmosphere to rise by more than one-fourth, according to the UN Intergovernmental Panel on Climate Change.

The anticipated increase in Earth's temperature, caused by carbon dioxide and other greenhouse gases trapping some of the radiation emitted by the surface, is called the **greenhouse effect.** The term is somewhat misleading because a greenhouse does not work in the same way as do trace gases in the atmosphere. In a real greenhouse, the interior gets very warm when the windows remain closed on a sunny day. The Sun's light energy passes through the glass



▲ FIGURE 11-31 GLOBAL-SCALE AIR POLLUTION: GLOBAL WARMING AND CARBON DIOXIDE CONCENTRATIONS, 1880–2010 Since 1880, carbon dioxide concentration has increased by more than one-third, and Earth has warmed by about 1°C (2°F).

into the greenhouse and is converted to heat, and the heat trapped inside the building is unable to escape out through the glass. Although this is an imprecise analogy, "greenhouse effect" is a term that has been widely adopted to describe the anticipated warming of Earth's surface when trace gases block some of the heat trying to escape into space.

Regardless of what it is called, global warming of only a few degrees could melt the polar ice sheets and raise the level of the oceans many meters (Figure 11-32). Coastal cities such as New York, Los Angeles, Rio de Janeiro, and Hong Kong would flood (see the Sustainability and Inequality in Our Global Village feature). Global patterns of precipitation could shift: Some deserts could receive more rainfall, and currently productive agricultural regions, such as the U.S. Midwest, could become too dry for farming. Humans can adapt to a warmer planet, but the shifts in coastlines and precipitation patterns could require massive migration and could be accompanied by political disputes.

GLOBAL-SCALE OZONE DAMAGE. Earth's atmosphere has zones with distinct characteristics. The stratosphere—the zone 15 to 50 kilometers (9 to 30 miles) above Earth's surface—contains a concentration of **ozone** gas. The ozone layer absorbs dangerous ultraviolet (UV) rays from the Sun. Were it not for the ozone in the stratosphere, UV rays would damage plants, cause skin cancer, and disrupt food chains.

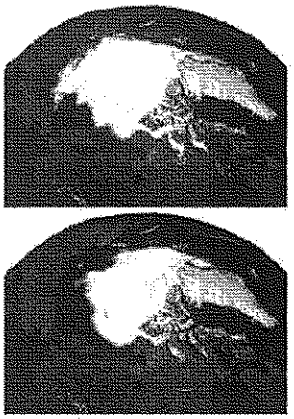


FIGURE 11-32 RECEDING NORTH POLAR ICE SHEET These images taken by NASA show that between 1979 (top) and 2005 (bottom), the north polar ice sheet melted visibly.

Earth's protective ozone layer is threatened by pollutants called **chlorofluorocarbons (CFCs).** CFCs such as Freon were once widely used as coolants in refrigerators and air conditioners. When they leak from these appliances, the CFCs are carried into the stratosphere, where they break down Earth's protective layer of ozone gas. In 2007, virtually all countries of the world agreed to cease using CFCs, by 2020 in developed countries and by 2030 in developing countries.

Pause and Reflect 11.3.1
What gas is now most commonly used as a coolant instead of CFC? Google "what replaced CFCs?"

SUSTAINABILITY AND INEQUALITY IN OUR GLOBAL VILLAGE

Climate Change in the South Pacific

One consequence of global warming is a rise in the level of the oceans. The large percentage of the world's population—including one-half of Americans—who live near the sea face increased threat of flooding. The threat is especially severe for island countries in the Pacific Ocean; they could be wiped off the map entirely.

Kiribati is a collection of approximately 32 small islands, one of the world's most isolated countries (Figure 11-33). Despite its extreme isolation, global forces threaten Kiribati's existence. Rising sea levels due to global warming threaten Kiribati because the entire country is within a few meters of sea level. Two of Kiribati's islands—Tebua Tarawa and Abanuea—have already disappeared.

Kiribati and other Pacific island microstates are atolls—that is, islands made of coral reefs. A coral is a small sedentary marine animal that has a horny or calcareous skeleton. Corals form colonies, and the skeletons build up to form coral reefs. Coral is very fragile. Humans are attracted to coral for its beauty and the diversity of species it supports, but handling coral can kill it. The threat of global warming to coral is especially severe. Coral stays alive in only a narrow range of ocean temperatures, between 23°C and 25°C (between 73°F and 77°F), so global warming threatens the ecology of Kiribati, even if it remains above sea level.

Kiribati has an emergency response to rising sea levels. The government has negotiated with Fiji to purchase 2,000 hectares (5,000 acres) of land on the island of Vanua Levu to relocate people from Kiribati someday.

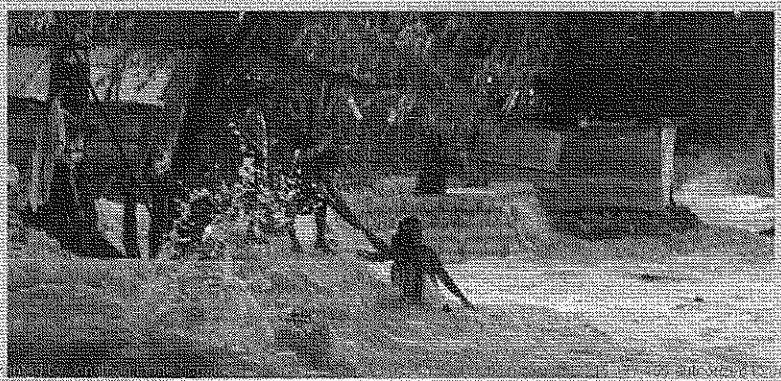


FIGURE 11-33 KIRIBATI Global warming may cause the oceans to rise, submerging small island countries such as Kiribati.

REGIONAL-SCALE AIR POLLUTION

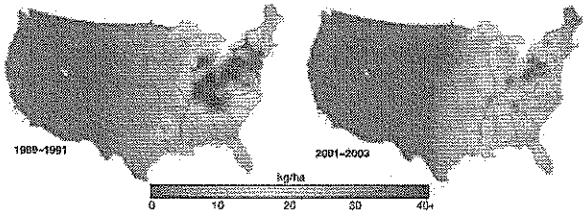
Learning Outcome 11.3.2
Describe causes and effects of regional and local-scale air pollution and solid waste pollution.

At the regional scale, air pollution may damage a region's vegetation and water supply through acid deposition. The world's three principal industrial regions are especially affected by acid deposition.

Sulfur oxides and nitrogen oxides, emitted by burning fossil fuels, enter the atmosphere, where they combine with oxygen and water. Tiny droplets of sulfuric acid and nitric acid form and return to Earth's surface as **acid deposition**. When dissolved in water, the acids may fall as **acid precipitation**—rain, snow, or fog. The acids can also be deposited in dust. Before they reach the surface, these acidic droplets might be carried hundreds of kilometers.

Acid precipitation damages lakes, killing fish and plants. On land, concentrations of acid in the soil can injure plants by depriving them of nutrients and can harm worms and insects. Buildings and monuments made of marble and limestone have suffered corrosion from acid rain.

Geographers are particularly interested in the effects of acid precipitation because the worst damage is not experienced at the same location as the emission of the pollutants. Within the United States the major generators of acid deposition are in Ohio and other industrial states along the southern Great Lakes. However, the severest effects of acid rain are felt in several areas farther east. The United States reduced sulfur dioxide emissions significantly during the late twentieth century (Figure 11-34).



▲ FIGURE 11-34 **REGIONAL-SCALE AIR POLLUTION: ACID DEPOSITION IN THE UNITED STATES** As a result of emissions controls, the rate of acid deposition has declined.

LOCAL-SCALE AIR POLLUTION

At the local scale, air pollution is especially severe in places where emission sources are concentrated, such as in urban areas. The air above urban areas may be polluted because a large number of factories, motor vehicles, and other polluters emit residuals in a concentrated area. Urban air pollution has three basic components:

- **Carbon monoxide.** Breathing carbon monoxide reduces the oxygen level in blood, impairs vision and alertness, and threatens those with breathing problems.
- **Hydrocarbons.** In the presence of sunlight, hydrocarbons, as well as nitrogen oxides, form **photochemical smog**, which causes respiratory problems, stinging in the eyes, and an ugly haze over cities.
- **Particulates.** They include dust and smoke particles. The dark plume of smoke from a factory stack and the exhaust of a diesel truck are examples of particulate emission.

The worst urban air pollution occurs when winds are slight, skies are clear, and a temperature inversion exists. When the wind blows, it disperses pollutants; when it is calm, pollutants build. Sunlight provides the energy for the formation of smog. Air is normally cooler at higher elevations, but during temperature inversions—in which air is warmer at higher elevations—pollutants are trapped near the ground.

According to the American Lung Association, the worst area in the United States for concentrations of particulates is in southern California, including Los Angeles and nearby communities. Worldwide, according to the World Health Organization, the 10 most polluted cities are all in developing regions, including 4 each in Iran and South Asia. Mexico City is an example of a city in a developing country that has improved its air quality since the 1990s (Figure 11-35).

Pause and Reflect 11.3.2
What environmental features can be seen in Mexico City on a clear day but not during smog periods? What is their role in the city's air pollution problem?

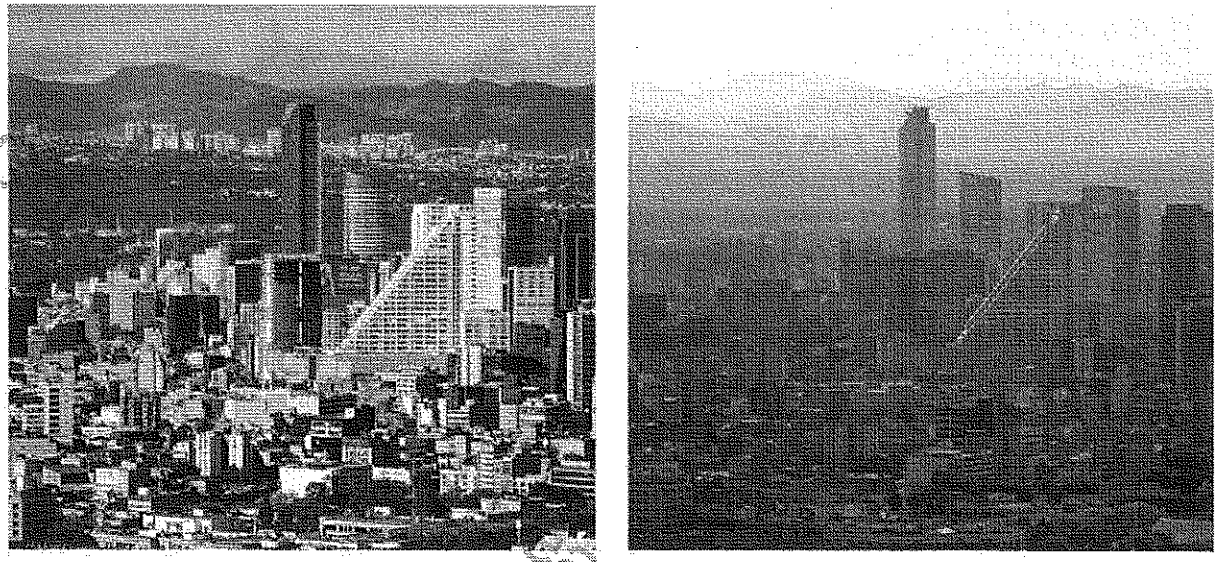
Progress in controlling urban air pollution is mixed. In developed countries, air has improved where strict clean-air regulations are enforced. Limited emission controls in developing countries are contributing to severe urban air pollution. Changes in manufacturing processes, motor vehicle engines, and electric generation have all helped. For example, since the 1970s, when the U.S. government began to require catalytic converters on motor vehicles, carbon monoxide emissions have been reduced by more than three-fourths, and nitrogen oxide and hydrocarbon emissions have been reduced by more than 95 percent. But more people are driving, offsetting gains made by emission controls.

Solid Waste Pollution

About 2 kilograms (4 pounds) of solid waste per person is generated daily in the United States, about 60 percent from residences and 40 percent from businesses. Paper products, such as corrugated cardboard and newspapers, account for the largest percentage of solid waste in the United States, especially among residences and retailers. Manufacturers discard large quantities of metals as well as paper.

SANITARY LANDFILL

Using a **sanitary landfill** is by far the most common strategy for disposal of solid waste in the United States: More than one-half of the country's waste is trucked to landfills



▲ FIGURE 11-35 **LOCAL-SCALE AIR POLLUTION: MEXICO CITY SMOG** Downtown Mexico City without smog (left) and with smog (right).

and buried under soil. But the number of landfills in the United States has declined by three-fourths since 1990.

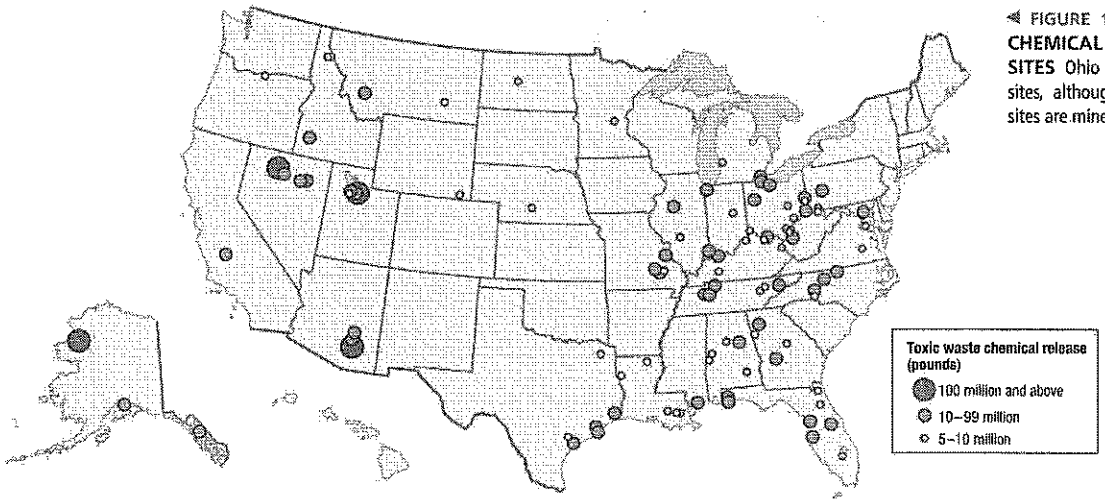
Given the shortage of space in landfills, alternatives have been sought to disposal of solid waste. A rapidly growing alternative is incineration. Burning trash reduces its bulk by about three-fourths, and the remaining ash demands less landfill space. Incineration also provides energy: The incinerator's heat can boil water to produce steam heat or operate a turbine that generates electricity.

HAZARDOUS WASTE

Disposing of hazardous waste is especially difficult. Hazardous wastes include heavy metals (including mercury, cadmium, and zinc), PCB oils from electrical equipment, cyanides, strong solvents, acids, and caustics. These may be unwanted by-products generated in manufacturing or waste to be discarded after usage.

According to the toxic waste inventory published by the U.S. Environmental Protection Agency (EPA), 1.78 billion kilograms (3.93 billion pounds) of toxic chemicals were released into the environment in 2010. Mining operations were the largest polluters. Ohio had 10 of the 100 largest polluting firms (Figure 11-36).

If poisonous industrial residuals are not carefully placed in protective containers, the chemicals may leach into the soil and contaminate groundwater or escape into the atmosphere. Breathing air or consuming water contaminated with toxic wastes can cause cancer, mutations, chronic ailments, and even immediate death.



◀ FIGURE 11-36 **TOXIC CHEMICAL RELEASE SITES** Ohio has the most sites, although the largest sites are mines in the West.

Water Pollution

Learning Outcome 11.3.3
Compare and contrast point and nonpoint sources of water pollution.

Some manufacturers are heavy users of water. One example is the aluminum industry. Aluminum producers locate near dams to take advantage of cheap hydroelectric power. A large amount of electricity is needed to separate pure aluminum from bauxite ore (Figure 11-37). Alcoa, the world's largest aluminum producer, even owns dams in North Carolina and Tennessee.

Water also serves many human purposes:

- It must be drunk to survive.
- It is used for cooking.
- It is used for bathing.
- It provides a location for boating, swimming, fishing, and other recreation activities.
- It is home to fish and other edible aquatic life.

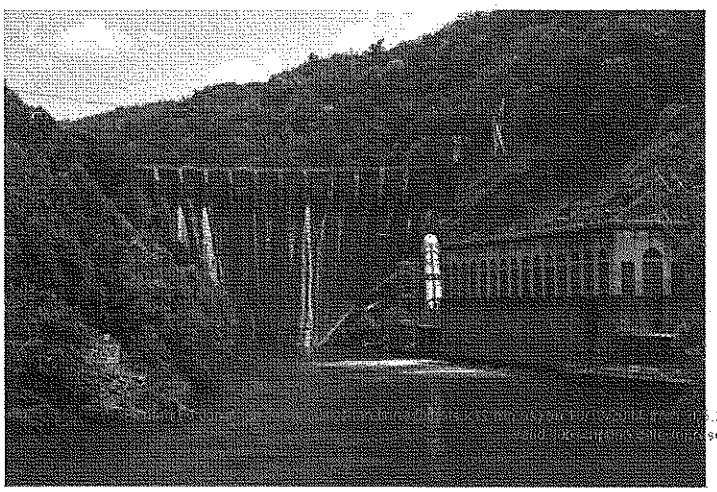
When all these uses are totaled, the average American consumes 5,300 liters (1,400 gallons) of water per day, including 680 liters (180 gallons) for drinking, cooking, and bathing. These uses require fresh, clean, unpolluted water.

But clean water is not always available because people and industries also use water for purposes that pollute it. Pollution is widespread because it is easy to dump waste into a river and let the water carry it downstream, where it becomes someone else's problem. By polluting water, humans harm the health of aquatic life and the health of land-based life (including humans themselves).

WATER POLLUTION SOURCES

The sources of pollution can be divided into point sources and nonpoint sources. **Point-source pollution** enters a body of water at a specific location, whereas **nonpoint-source pollution** comes from a large, diffuse area.

▼ FIGURE 11-37 **HYDROELECTRIC POWER** The Cheoah Dam in Tapoco, Tennessee, provides electricity for Alcoa's nearby aluminum factory.



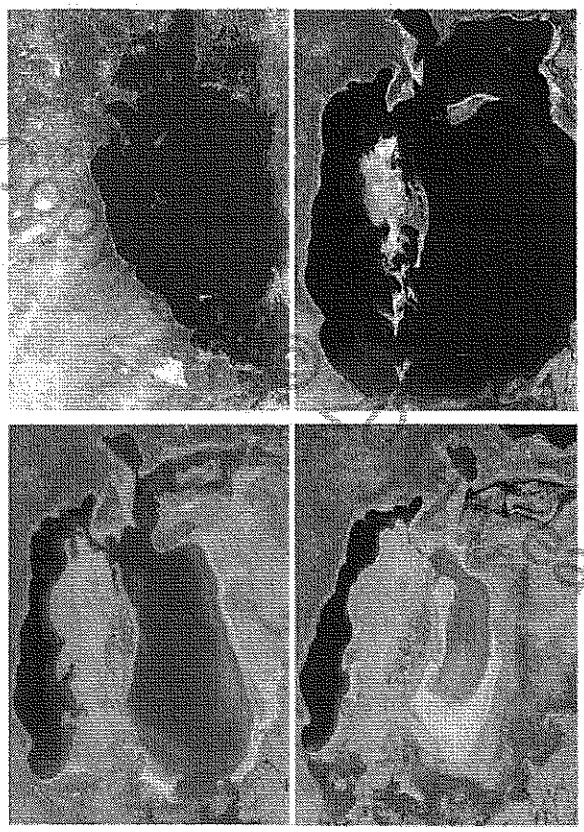
POINT SOURCES. Point-source pollutants are usually smaller in quantity and much easier to control than nonpoint-source pollutants. Point-source water pollution originates from a specific point, such as a pipe from a wastewater treatment plant. The two main point sources of pollution are manufacturers and municipal sewage systems:

- **Water-using manufacturers.** Steel, chemicals, paper products, and food processing are major industrial polluters of water. Each requires a large amount of water in the manufacturing process and generates a lot of wastewater. Food processors, for example, wash pesticides and chemicals from fruit and vegetables. They also use water to remove skins, stems, and other parts. Water can also be polluted by industrial accidents, such as petroleum spills from ocean tankers and leaks from underground tanks at gasoline stations.
- **Municipal sewage.** In developed countries, sewers carry wastewater from sinks, bathtubs, and toilets to a municipal treatment plant, where most—but not all—of the pollutants are removed. The treated wastewater is then typically dumped back into a river or lake. Since passage of the U.S. Clean Water Act and equivalent laws in other developed countries, most treatment plants meet high water-quality standards. In developing countries, sewer systems are rare, and wastewater usually drains, untreated, into rivers and lakes. The drinking water, usually removed from the same rivers, may be inadequately treated as well. The combination of untreated water and poor sanitation makes drinking water deadly in developing countries. Waterborne diseases such as cholera, typhoid, and dysentery are major causes of death.

NONPOINT SOURCES. Nonpoint sources usually pollute in greater quantities and are much harder to control than point sources of pollution. The principal nonpoint source is agriculture. Fertilizers and pesticides spread on fields to increase agricultural productivity are carried into rivers and lakes by irrigation systems or natural runoff. Expanded use of these products may help to avoid a global food crisis, but they destroy aquatic life by polluting rivers and lakes.

One of the world's most extreme instances of nonpoint water pollution is the Aral Sea in the former Soviet Union, now divided between the countries of Kazakhstan and Uzbekistan. The Aral Sea was the world's fourth-largest lake in 1960, at 68,000 square kilometers (26,000 square miles). It had shrunk to approximately 5,000 square kilometers (2,000 square miles) in 2010, and it could disappear altogether by 2020 (Figure 11-38). The shrinking has been captured in air photos and satellite imagery:

- **1975.** In 1975, the Aral Sea was in the early stages of destruction. Small islands are barely visible in the center of the sea (Figure 11-38, upper left).
- **1989.** A large island had formed in the middle of the sea by 1989 (Figure 11-38, upper right).



▲ FIGURE 11-38 THE DISAPPEARING ARAL SEA In 1975 (upper left), 1989 (upper right), 2003 (lower left), and 2009 (lower right).

- **2003.** By 2003, the sea was divided into two portions, western and eastern (Figure 11-38, lower left).
- **2009.** In 2009, the western portion had not changed much, but the eastern portion had dried up into a wasteland of salt. A small northern lake also remained (Figure 11-38, lower right).

The Aral Sea died because beginning in 1954, the Soviet Union diverted its tributary rivers, the Amu Dar'ya and the Syr Dar'ya, to irrigate cotton fields. Ironically, the cotton now is withering because winds pick up salt from the exposed lakebed and deposit it on the cotton fields. Carp, sturgeon, and other fish species have disappeared; the last fish died in 1983. Large ships lie aground in salt flats that were once the lakebed, outside abandoned fishing villages that now lay tens of kilometers from the rapidly receding shore.

Pause and Reflect 11.3.3

How might sustainable agriculture practices, as discussed in Chapter 10, help to improve water quality?

IMPACT OF WATER POLLUTION ON AQUATIC LIFE

Polluted water can harm aquatic life. Aquatic plants and animals consume oxygen, and so does the decomposing organic waste that humans dump in the water. The oxygen consumed by the decomposing organic waste constitutes the **biochemical oxygen demand (BOD)**. If too much waste is discharged into water, the water becomes oxygen starved and fish die.

This condition is typical when water becomes loaded with municipal sewage or industrial waste. The sewage and industrial pollutants consume so much oxygen that the water can become unlivable for normal plants and animals, creating a "dead" stream or lake. Similarly, when runoff carries fertilizer from farm fields into streams or lakes, the fertilizer nourishes excessive aquatic plant production—a "pond scum" of algae—that consumes too much oxygen. Either type of pollution reduces the normal oxygen level, threatening aquatic plants and animals. Some of the residuals may become concentrated in the fish, making them unsafe for human consumption. For example, salmon from the Great Lakes became unfit to eat because of high concentrations of the pesticide DDT, which washed into streams from farm fields.

Many factories and power plants use water for cooling and then discharge the warm water back into the river or lake. The warm water may not be polluted with chemicals, but it raises the temperature of the body of water it enters. Fish adapted to cold water, such as salmon and trout, might not be able to survive in the warmer water.

CHECK IN: KEY ISSUE 3

Where Does Industry Cause Pollution?

- ✓ **Industry is a major polluter of air, land, and water.**
- ✓ **Air pollution can occur at global, regional, and local scales.**
- ✓ **Solid waste that is not recycled is either transported to landfills or incinerated; some of it is hazardous.**
- ✓ **Water pollution can have point or nonpoint sources.**

KEY ISSUE 4

Why Are Situation and Site Factors Changing?

- Changes within Developed Regions
- Emerging Industrial Regions
- Renewed Attraction of Traditional Industrial Regions

Learning Outcome 11.4.1
Explain reasons for changing distribution of industry within the United States.

Industry is on the move around the world. Changing site factors have been especially important in stimulating industrial growth in new regions internationally and within developed countries. At the same time, some industries remain in the traditional regions, primarily because of changing situation factors.

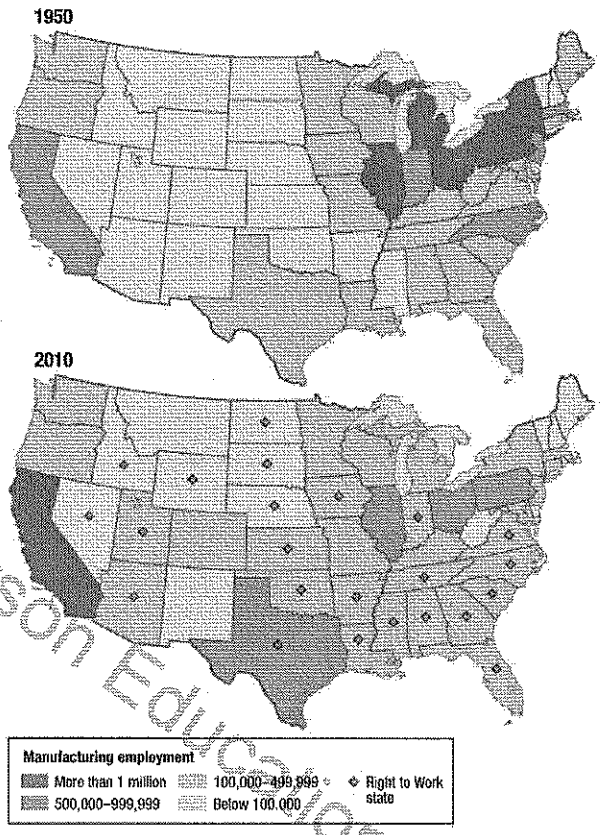
Changes within Developed Regions

Within developed countries, industry is shifting away from the traditional industrial areas of northwestern Europe and the northeastern United States. In the United States, industry has shifted from the Northeast toward the South and West. In Europe, government policies have encouraged relocation toward economically distressed peripheral areas.

SHIFTS WITHIN THE UNITED STATES

The northeastern United States lost 6 million jobs in manufacturing between 1950 and 2010 (Figure 11-39). Especially large declines were recorded by New York State and Pennsylvania, states that once served as centers for clothing, textile, steel, and fabricated metal manufacturing. Meanwhile, 2 million manufacturing jobs were added in the South and West between 1950 and 2009. California and Texas had the largest increases.

Industrialization during the late nineteenth and early twentieth centuries largely bypassed the South, which had not recovered from losing the Civil War. The South lacked the infrastructure needed for industrial development: Road and rail networks were less intensively developed in the South, and electricity was less common than in the North. As a result, the South was the poorest region of the United States. Industrial growth in the South since the 1930s has been stimulated in part by government policies



▲ FIGURE 11-39 **CHANGING U.S. MANUFACTURING** Manufacturing has decreased in the Northeast.

to reduce historical disparities. The Tennessee Valley Authority brought electricity to much of the rural South, and roads were constructed in previously inaccessible sections of the Appalachians, the Piedmont, and the Ozarks. Air-conditioning made living and working in the South more tolerable during the summer.

Steel, textiles, tobacco products, and furniture industries have become dispersed through smaller communities in the South, many in search of a labor force willing to work for less pay than in the North and forgo joining a union. The Gulf Coast has become an important industrial area because of its access to oil and natural gas. Along the Gulf Coast are oil refining, petrochemical manufacturing, food processing, and aerospace product manufacturing.

RIGHT-TO-WORK LAWS. The principal lure for many manufacturers has been right-to-work laws. A **right-to-work law** requires a factory to maintain a so-called "open shop" and prohibits a "closed shop." In a "closed shop," a company and a union agree that everyone must join the union to work in the factory. In an "open shop," a union and a company may not negotiate a contract that requires workers to join a union as a condition of employment.

Twenty-three U.S. states (refer to Figure 11-39) have right-to-work laws that make it much more difficult for unions to organize factory workers, collect dues, and bargain with employers from a position of strength. Right-to-work laws send a powerful signal that antiunion attitudes will be tolerated and perhaps even actively supported. As a result, the percentage of workers who are members of a union is much lower in the South than elsewhere in the United States. More importantly, the region has been especially attractive for companies working hard to keep out unions altogether.

Pause and Reflect 11.4.1

Laws to curb unions have been enacted or proposed in several U.S. states in the past few years. What are the arguments in favor of and against restricting unions?

TEXTILE PRODUCTION. The textile and apparel industry has been especially prominent in opening production in lower-wage locations while shutting down production in higher-wage locations. The U.S. textile and apparel industry was heavily concentrated in the Northeast during the early twentieth century, and then it shifted to the South and West.

Most textile and apparel production in the United States moved from the Northeast to the Southeast during the mid-twentieth century. Favored sites were small towns in the Appalachian, Piedmont, and Ozark mountains, especially western North and South Carolina and northern Georgia and Alabama. The area is home to 99 percent of U.S. hosiery and sock producers, half of them in North Carolina.

In the mid-twentieth century, prevailing wage rates were much lower in the Southeast than elsewhere in the United States. Even more important for manufacturers, workers in the Southeast showed little interest in joining the unions established by Northeastern textile and apparel workers to bargain for higher wages and safer working conditions.

INTERREGIONAL SHIFTS IN EUROPE

Manufacturing has diffused from traditional industrial centers in northwestern Europe toward Southern and Eastern Europe. In contrast to the United States, European government policies have explicitly encouraged this industrial relocation (Figure 11-40). The European Union Structural Funds provide assistance to what it calls convergence regions and competitive and employment regions:

- Convergence regions are primarily in Eastern and Southern Europe, where incomes lag behind Europe's average.
- Competitive and employment regions are primarily Western Europe's traditional core industrial areas, which have experienced substantial manufacturing job losses in recent years.

▲ FIGURE 11-40 EUROPEAN UNION STRUCTURAL FUNDS The European Union provides subsidies to regions with economic difficulties because of declining industries, as well as to regions that have lower-than-average incomes.

The Western European country with the most rapid manufacturing growth during the late twentieth century was Spain, especially after its admission to the European Union in 1986. Until then, Spain's manufacturing growth had been impeded by physical and political isolation. Spain's motor-vehicle industry has grown into the second largest in Europe, behind only Germany's, although it is entirely foreign owned. Spain's leading industrial area is Catalonia, in the northeast, centered on the city of Barcelona. The region has the country's largest motor-vehicle plant and is the center of Spain's textile industry as well. Spain's industry, though, has been especially hard hit by the severe recession of the early twenty-first century.

Several European countries situated east of Germany and west of Russia have become major centers of industrial investment since the fall of communism in the early 1990s. Poland, Czech Republic, and Hungary have had the most industrial development, though other countries in the region have shared in the growth. The region prefers to be called *Central Europe*, reverting to a common pre–Cold War term, to signify its more central location in Europe's changing economy. Central Europe offers manufacturers an attractive combination of two important site and situation factors: labor and market proximity. Central Europe's workers offer manufacturers good value for money; they are less skilled but much cheaper than in Western Europe, and they are more expensive but much more skilled than in Asia and Latin America. At the same time, the region offers closer proximity to the wealthy markets of Western Europe than other emerging industrial centers.

Emerging Industrial Regions

Learning Outcome 11.4.2

Explain reasons for the emergence of new industrial regions.

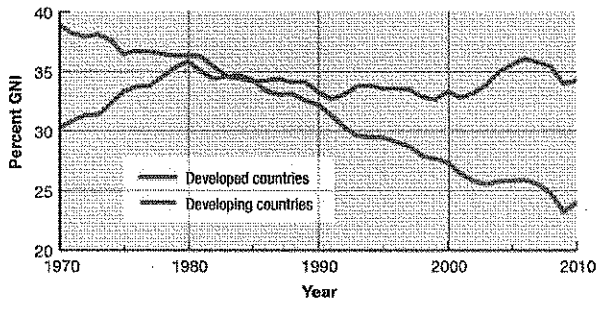
In 1970, nearly one-half of world industry was in Europe and nearly one-third was in North America; now these two regions account for only one-fourth each. Industry's share of total economic output has steadily declined in developed countries since the 1970s (Figure 11-41). The share of world industry in other regions has increased—from one-sixth in 1970 to one-half in 2010.

Labor is the site factor that is changing especially dramatically in the twenty-first century. To minimize labor costs, some manufacturers are locating in places where prevailing wage rates are lower than in traditional industrial regions. Labor-intensive industries have been especially attracted to emerging industrial regions.

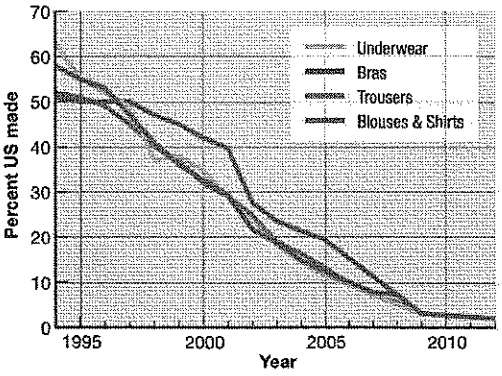
For example, the number of apparel workers in the United States declined from 900,000 in 1990 to 500,000 in 2000 and to 150,000 in 2010. During this period, most apparel sold in the United States switched from being domestically made to being foreign made (Figure 11-42). As apparel from other countries has become less expensive and less complicated to import into the United States, mills in the Southeast paying wages of $10 to $15 per hour have been unable to compete with manufacturers in countries paying less than $1 per hour. European countries have been even harder hit by international competition. Compensation for manufacturing employees exceeds $30 per hour in much of Europe.

OUTSOURCING

Transnational corporations have been especially aggressive in using low-cost labor in developing countries. To remain competitive in the global economy, they carefully review their production processes to identify steps that can be performed by low-paid, low-skilled workers in developing countries. Despite the greater transportation cost, transnational corporations can profitably transfer some work



▲ **FIGURE 11-41 MANUFACTURING VALUE AS A PERCENTAGE OF GNI** Manufacturing has accounted for a much higher share of GNI in developing countries than in developed countries since the 1990s.



▲ **FIGURE 11-42 U.S. CLOTHING** The percentage of clothing made in the United States declined from around 50 percent in the 1990s to around 2 percent today.

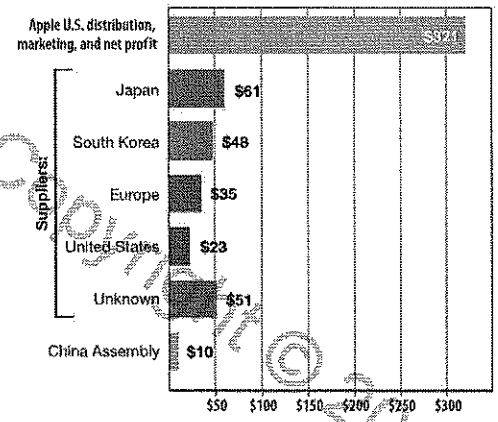
to developing countries, given their substantially lower wages compared to those in developed countries. At the same time, operations that require highly skilled workers remain in factories in developed countries. This selective transfer of some jobs to developing countries is known as the **new international division of labor.**

Transnational corporations allocate production to low-wage countries through **outsourcing,** which is turning over much of the responsibility for production to independent suppliers. Outsourcing contrasts with the approach typical of traditional mass production, called **vertical integration,** in which a company controls all phases of a highly complex production process. Vertical integration was traditionally regarded as a source of strength for manufacturers because it gave them the ability to do and control everything. Carmakers once made nearly all their own parts, for example, but now most of this operation is outsourced to other companies that are able to make the parts cheaper and better. As another example, the parts in an iPhone are made by independent companies.

Outsourcing has had a major impact on the distribution of manufacturing because each step in the production process is now scrutinized closely in order to determine the optimal location. For example, most of the cost of an iPhone is in the parts, which are made by relatively skilled workers in Japan, Germany, and South Korea. Most of the profits go to the United States, where Apple is based. But one step in the production process is especially labor intensive—snapping all the parts together at an assembly plant—and this step is done in China, by relatively low-wage, low-skilled workers (Figure 11-43).

MEXICO AND NAFTA

Manufacturing has been increasing in Mexico. The North American Free Trade Agreement (NAFTA), effective in 1994, eliminated most barriers to moving goods among Mexico, the United States, and Canada. Because it is the nearest low-wage country to the United States, Mexico attracts labor-intensive industries that also need proximity to the U.S. market.



▲ **FIGURE 11-43 iPHONE PRODUCTION** iPhones are assembled in China from parts made in the United States, Europe, and East Asia.

Plants in Mexico near the U.S. border are known as **maquiladoras**. The term originally applied to a tax when Mexico was a Spanish colony. Under U.S. and Mexican laws, companies receive tax breaks if they ship materials from the United States, assemble components at a *maquiladora* plant in Mexico, and export the finished product back to the United States. More than 1 million Mexicans are employed at over 3,000 *maquiladoras*.

Integration of North American industry has generated fear in the United States and Canada:

- Labor leaders fear that more manufacturers relocate production to Mexico to take advantage of lower wage rates. Labor-intensive industries such as food processing and textile manufacturing are especially attracted to regions where prevailing wage rates are lower.
- Environmentalists fear that NAFTA encourages firms to move production to Mexico because laws governing air- and water-quality standards are less stringent than in the United States and Canada. Mexico has adopted regulations to reduce air pollution in Mexico City; catalytic converters have been required on Mexican automobiles since 1991. But environmentalists charge that environmental protection laws are still not strictly enforced in Mexico.

Mexico faces its own challenges: It lost a quarter-million *maquiladora* jobs during the first decade of the twenty-first century. Electronics firms were especially likely to pull out of Mexico. The reason: Although much lower than in the United States, Mexican wages at $6 an hour were higher than $1 wages in China and India. Despite the higher site costs, however, Mexico still competes effectively with China because of situation factors. Because of its proximity, Mexico has much lower shipping costs to the United States than does China.

Pause and Reflect 11.4.2

Can you identify any products in your house that were made in Mexico?

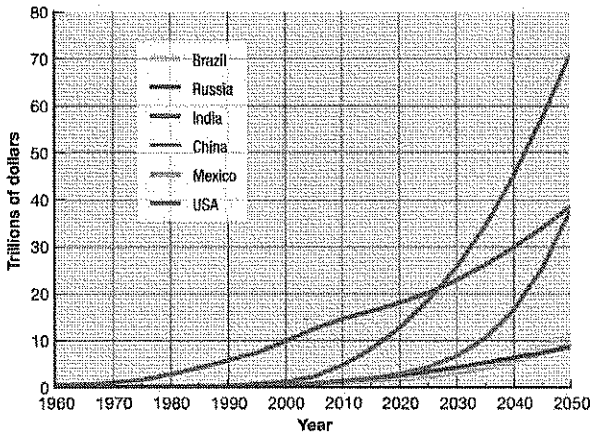
BRIC AND BRICS

Much of the world's future growth in manufacturing is expected to locate outside the principal industrial regions described earlier. The investment banking firm Goldman Sachs coined the acronym BRIC to indicate the countries it expects to dominate global manufacturing during the twenty-first century: Brazil, Russia, India, and China. The foreign ministers of these four countries started meeting in 2006. The four BRIC countries together currently control one-fourth of the world's land area and contain 3 billion of the world's 7 billion inhabitants, but the four countries combined account for only one-sixth of world GDP (Figure 11-44). Their economies rank second (China), seventh (Brazil), ninth (Russia), and eleventh (India) in the world.

China is expected to pass the United States as the world's largest economy around 2020, and India is expected to become second around 2035. In 2050, Brazil and Russia are expected to rank sixth and seventh. Two other developing countries, Indonesia and Nigeria, are expected to be fourth and fifth. Thus, in 2050 the United States would be the only developed country to rank among the world's seven largest economies.

China and India have the two largest labor forces, whereas Russia and Brazil are especially rich in inputs critical for industry. As an industrial region, BRIC has the obvious drawback of Brazil's being on the other side of the planet from the other three. China, India, and Russia could form a contiguous region, but long-standing animosity among them has limited their economic interaction so far. Still, the BRIC concept is that if the four giants work together, they can be the world's dominant industrial bloc in the twenty-first century.

In 2010, South Africa was invited to join a meeting with the other four emerging countries, and the group adopted the acronym BRICS. Although South Africa has the largest economy, population, and land area in the southern portion of sub-Saharan Africa, it is much smaller by all of these measures than the four original BRIC members.



▲ **FIGURE 11-44 GDP FOR BRIC COUNTRIES** The BRIC countries are expected to increase GDP relatively rapidly during the twenty-first century.

Renewed Attraction of Traditional Industrial Regions

Learning Outcome 11.4.3
Explain reasons for renewed attraction of traditional industrial regions.

Given the strong lure of low-cost labor in new industrial regions, why would any industry locate in one of the traditional regions, especially in the northeastern United States or northwestern Europe? Two location factors influence industries to remain in these traditional regions: availability of skilled labor and rapid delivery to market.

PROXIMITY TO SKILLED LABOR

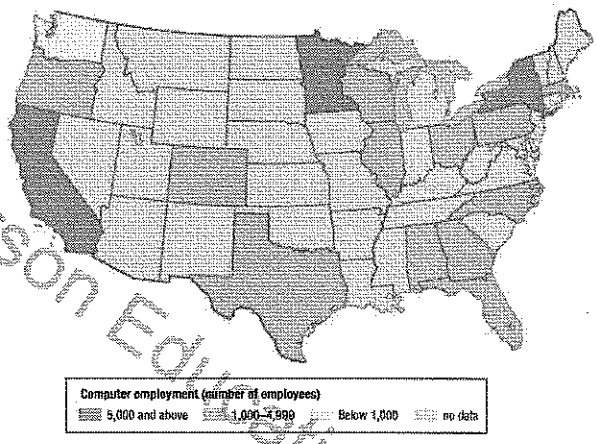
Henry Ford boasted that he could take people off the street and put them to work with only a few minutes of training. That has changed for some industries, which now want skilled workers instead. The search for skilled labor has important geographic implications because it is an asset found principally in the traditional industrial regions.

Traditionally, factories assigned each worker one specific task to perform repeatedly. Some geographers call this approach **Fordist production**, or mass production, because the Ford Motor Company was one of the first companies to organize its production this way early in the twentieth century. At its peak, Ford's factory complex along the River Rouge in Dearborn, Michigan, near Detroit, employed more than 100,000. Most of these workers did not need education or skills to do their jobs, and many were immigrants from Europe or the southern United States.

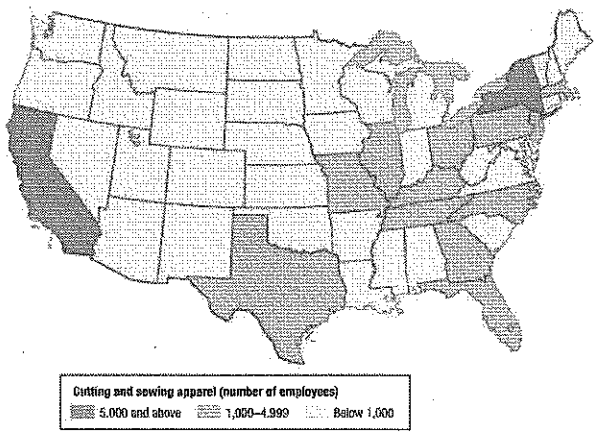
Many industries now follow a lean, or flexible, production approach. The term **post-Fordist production** is sometimes used to describe lean production, in contrast with Fordist production. Another carmaker is best known for pioneering lean production—in this case, Toyota. Four types of work rules distinguish post-Fordist lean production:

- **Teams.** Workers are placed in teams and told to figure out for themselves how to perform a variety of tasks. Companies are locating production in communities where workers are willing to adopt more flexible work rules.
- **Problem solving.** A problem is addressed through consensus after consulting with all affected parties rather than through filing a complaint or grievance.
- **Leveling.** Factory workers are treated alike, and managers and veterans do not get special treatment; they wear the same uniform, eat in the same cafeteria, park in the same lot, and participate in the same athletic and social activities.
- **Productivity.** Factories have become more productive through introduction of new machinery and processes. Rather than requiring physical strength, these new machines and processes require skilled operators, typically with college degrees.

Computer manufacturing is an example of an industry that has concentrated in relatively high-wage, high-skilled communities of the United States (Figure 11-45). Even the clothing industry has not completely abandoned the Northeast. Dresses, woolens, and other "high-end" clothing products are still made in the region. They require more skill in cutting and assembling the material, and skilled textile workers are more plentiful in the Northeast and California than in the South (Figure 11-46).



▲ **FIGURE 11-45 COMPUTER AND PERIPHERAL EQUIPMENT MANUFACTURING** Manufacturers of computing equipment seek access to skilled workers to perform precision tasks. The assembly work that requires lower-skilled workers is done abroad, mostly in Asia, as shown in the case of the iPhone (Figure 11-46).



▲ **FIGURE 11-46 THE APPAREL INDUSTRY** What's left of the U.S. apparel industry is concentrated in California and the Northeast.

JUST-IN-TIME DELIVERY

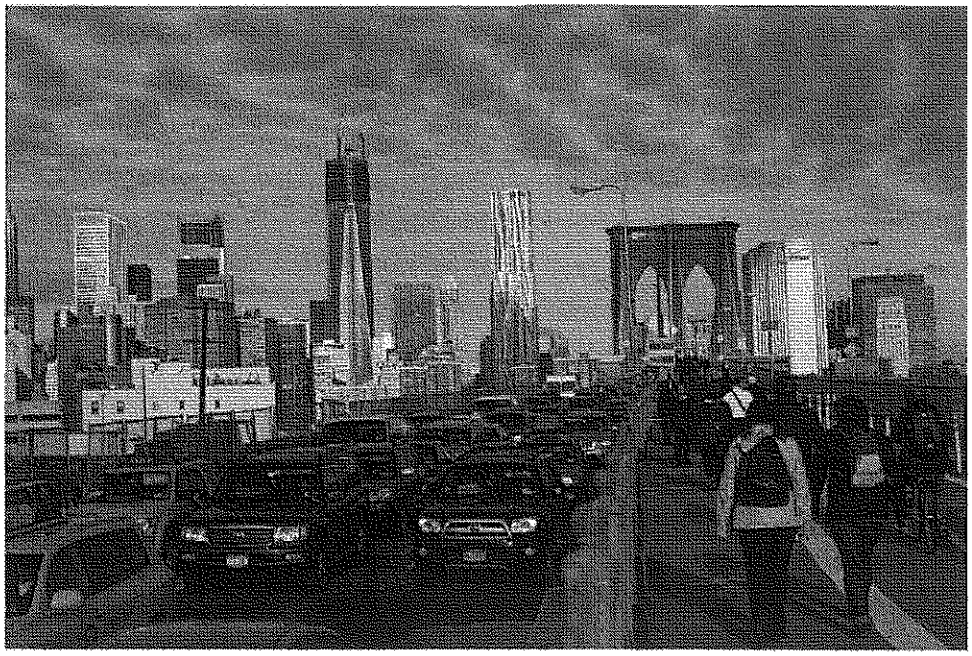
Proximity to market has long been important for many types of manufacturers, as discussed earlier in this chapter. This factor has become even more important in recent years because of the rise of **just-in-time delivery**. As the name implies, just-in-time is shipment of parts and materials to arrive at a factory moments before they are needed. Just-in-time delivery is especially important for delivery of inputs, such as parts and raw materials, to manufacturers of fabricated products, such as cars and computers.

Under just-in-time, parts and materials arrive at a factory frequently, in many cases daily or even hourly. Suppliers of the parts and materials are told a few days in advance how much will be needed over the next week or two, and first thing each morning, they are told exactly what will be needed at precisely what time that day. To meet a tight timetable, a supplier of parts and materials must locate factories near its customers. If given only an hour or two of notice, a supplier has no choice but to locate a factory within 50 miles or so of the customer.

Just-in-time delivery reduces the money that a manufacturer must tie up in wasteful inventory. In fact, the percentage of the U.S. economy tied up in inventory has been cut in half during the past three decades. Manufacturers also save money through just-in-time delivery by reducing the size of the factory because space does not have to be wasted on piling up a mountain of inventory. Leading computer manufacturers have eliminated inventory altogether. They build computers only in response to customer orders placed primarily over the Internet or by telephone. In some cases, just-in-time delivery merely shifts the burden of maintaining inventory to suppliers. Wal-Mart, for example, holds low inventories but tells its suppliers to hold high inventories "just in case" a sudden surge in demand requires restocking on short notice.

Just-in-time delivery means that producers have less inventory to cushion against disruptions in the arrival of needed parts. Three kinds of disruptions can result from reliance on just-in-time delivery:

- **Labor unrest.** A strike at one supplier plant can shut down the entire production within a couple of days. A strike in the logistics industry, such as a strike by truckers or dockworkers, could also disrupt deliveries.
- **Traffic.** Deliveries may be delayed when traffic is slowed by accident, construction, or unusually heavy volume. Trucks and trains are both subject to these types of delays, especially crossing international borders.
- **Natural hazards.** Poor weather conditions can afflict deliveries anywhere in the world. Blizzards and floods can close highways and rail lines. The 2011 earthquake and tsunami in Japan put many factories and transportation lines out of service for months. Carmakers around the world had to curtail production because key parts had been made at the damaged factories. Superstorm Sandy, which hit the East Coast of the United States in 2012, severely disrupted transportation and delivery of goods and energy in the most densely population region of the country (Figure 11-47).



▶ FIGURE 11-47 NATURAL HAZARDS: SUPERSTORM SANDY Superstorm Sandy, which hit the East Coast of the United States in 2012, disrupted travel for several days. In New York City, subways and tunnels were closed because of flooding. People walked across the Brooklyn Bridge to get to work, while private cars, taxis, and delivery trucks sat bumper-to-bumper on the bridge.

A GLOBAL INDUSTRY: WHAT IS AN AMERICAN CAR?

Distinctions between "American" and "foreign" motor vehicles have been blurred for the past three decades. Popular media have delighted in showcasing examples of "American" vehicles produced by the Detroit 3 (Chrysler, Ford, and General Motors) that have lower U.S. content than those produced by "Japanese" carmakers such as Honda and Toyota. The U.S. government distinguishes between domestic and foreign vehicles in three ways:

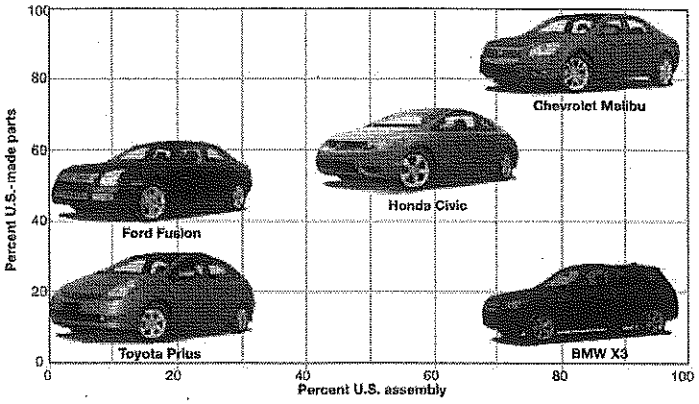
- For measuring fuel efficiency, the U.S. Environmental Protection Agency considers a vehicle domestic if at least 75 percent of its content comes from North America, originally defined as the United States and Canada, and, after enactment of the North American Free Trade Agreement (NAFTA), including Mexico.
- For setting import tariffs, the U.S. Department of Treasury Customs Service considers as domestic a vehicle having at least 50 percent U.S. and Canadian content.
- For informing consumers, the American Automobile Labeling Act of 1992 considers a vehicle domestic if at least 85 percent of the parts originate in the United States and Canada; a part is counted as domestic if at least 70 percent of its overall content comes from the United States and Canada.

According to data derived from Labeling Act reports, vehicles built by foreign-owned carmakers at assembly plants located in the United States have around 60 percent domestic content. Domestic content for the Detroit 3 is 76 percent. The lower domestic content for foreign carmakers masks differences among individual companies. Honda and Toyota have a level of U.S. content comparable to that of the Detroit 3. German-owned carmakers such as BMW and Daimler-Benz have much lower percentages.

After opening assembly plants in the United States during the 1980s, Japanese-owned carmakers convinced many of their Japanese-owned suppliers to build factories in the United States. The gap in domestic content has also narrowed because the Detroit 3 bought more foreign parts. More than one-fourth of all new vehicle parts are imported. Mexico has become the leading source of imported parts, and China has been increasing its share rapidly.

Figure 11-48 shows the extent to which several popular vehicles are "American." The x axis shows the percentage of these vehicles sold in the United States that were assembled in the United States in 2011. The y axis shows the percentage of U.S.-made parts in these vehicles.

- GM's Chevrolet Malibu was assembled entirely in the United States with all but a handful of U.S.-made parts.
- Toyota's Prius was assembled in Japan with Japanese-made parts.
- Ford's Fusion was assembled in Mexico with about one-half U.S. parts.



▲ FIGURE 11-48 "AMERICAN" AND "FOREIGN" CARS The x axis shows the percentage of these vehicles sold in the United States that were assembled in the United States in 2011. The y axis shows the percentage of U.S.-made parts in these vehicles.

- BMW's X3 was assembled in the United States with parts mostly imported from Germany.
- Honda Civics were assembled either in the United States with mostly U.S.-made parts, assembled in Canada with mostly U.S.-made parts, or imported from Japan with mostly Japanese-made parts.

Pause and Reflect 11.4.3
Why might weather conditions encourage companies to locate factories in the U.S. South rather than the North?

CHECK-IN: KEY ISSUE 4

Why Are Situation and Site Factors Changing?

- ✓ **Industry is moving from the North to the South within the United States; in many cases, lower-cost nonunion labor is the principal factor.**
- ✓ **Low-cost labor is also inducing firms to locate in countries that are not part of the traditional industrial regions.**
- ✓ **On the other hand, some industry is attracted to traditional industrial regions because of the need for skilled labor or rapid delivery to consumers.**