TOPIC 9

Resources and the Environment

Humans must make use of Earth resources and energy resources to survive. Earth resources include renewable resources, such as living things, fresh air, and water; and nonrenewable resources, such as minerals. Energy resources include both renewable solar and wind energy and nonrenewable fossil fuels. Because many Earth and energy resources are present in only limited amounts, people must find ways to conserve these resources or find alternatives. In addition, the use of some types of resources can have negative effects on the environment. People are working together to find ways to solve these problems.

SUBTOPIC A
EARTH RESOURCES

Covers National Content Science Standards UCP.1, UCP.2, UCP.3; A.1, A.2; D.1, D.2; E.2; F.1, F.2, F.3, F.4, F.5, F.6

Unifying Concepts and Processes

UCP.1	Systems, order, and organization
UCP.2	Evidence, models, and explanation
UCP.3	Change, constancy, and measurement

Science as Inquiry

A.1	Abilities necessary to do scientific inquiry
A.2	Understandings about scientific inquiry

Earth and Space Science

D.1	Energy in the Earth System
D.2	Geochemical cycles

Science and Technology

E.2	Understandings about science and technology

Science in Personal and Social Perspectives

F.1	Personal and community health
F.2	Population growth
F.3	Natural resources
F.4	Environmental quality
F.5	Natural and human-induced hazards
F.6	Science and technology in local, national, and global challenges

VOCABULARY

natural resource	**greenhouse effect**
renewable	**global warming**
nonrenewable	**ozone**
desertification	**precipitation**
fossil fuel	**evapotranspiration**
ore	**transpiration**
pollutant	**aquifer**

A **natural resource** is any useful Earth material. A natural resource that can be replaced relatively quickly (within a person's lifetime) or is present in an essentially unlimited amount is said to be **renewable.** An example of a renewable resource is solar energy. A **nonrenewable** resource, by contrast, is one that is present in a fixed supply and takes thousands or millions of years to form. Petroleum is an example of a nonrenewable resource. Resources, both renewable and nonrenewable, are distributed unevenly on Earth.

Land Resources

One important land resource is soil. Mature soil that contains topsoil is rich in the nutrients needed to grow crops. Topsoil can be lost through erosion by wind or water. Plant roots normally help to hold soil in place, but if plant cover is removed and not replaced, erosion of soil can rapidly increase.

The loss of topsoil in dry climates can result in **desertification.** In this process, land that could once be used to grow crops or raise animals is converted into desert. Causes of desertification include plowing land or cutting down forests without replanting the land, grazing too many animals on the land, and overusing water resources. Desertification is currently a problem in parts of

northern Africa, the Middle East, Australia, and the western United States.

Fossil fuels are another important land resource. **Fossil fuels** are sources of energy formed from the ancient remains of plants and other organic material. They include coal, natural gas, and petroleum (or crude oil). Fossil fuels are currently the main source of energy for many industrialized nations, such as the United States.

A reserve is a known deposit of a natural resource. Coal reserves are distributed fairly evenly around the world. Reserves of natural gas and petroleum, however, are spread much more unevenly. For example, the Middle East has more than 65 percent of Earth's petroleum reserves and, along with the former Soviet Union, about 70 percent of Earth's natural gas reserves.

Ores are a third important land resource. An **ore** is a mineral or rock that can be mined at a profit. Important ores include minerals or rocks with high concentrations of valuable metals, such as iron, copper, aluminum, and gold. The mining of ores can result in environmental problems. Waste rock produced from mining operations may release pollutants into the air or water. A **pollutant** is a substance that negatively affects the health or survival of an organism. Pollutants can be natural, such as pollen, or human-made, such as automobile exhaust. In addition, some types of mining disturb large areas of land. However, attempts can be made to restore the land by returning topsoil and replanting vegetation after a mining operation is complete. This practice is known as land reclamation.

Air Resources

Air on Earth consists mainly of the gases nitrogen (78%) and oxygen (21%). Air also includes carbon dioxide, water vapor, and argon, as well as many other gases present in very small amounts. Human activities can disrupt Earth processes that determine the balance of these gases in the atmosphere.

The Greenhouse Effect

Part of the sunlight, or solar radiation, that reaches Earth is reflected back into space and part is absorbed. Earth, in turn, reradiates some of the absorbed sunlight back into the atmosphere. Most of this reradiated light is in the infrared portion of the electromagnetic spectrum. Certain gases in the atmosphere absorb infrared radiation. When they do, their temperature increases, which helps to keep Earth warm. This trapping of radiation by gases in the atmosphere is called the **greenhouse effect** and is illustrated in Figure 9-1. Gases that contribute to the greenhouse effect are referred to as greenhouse gases. The most important greenhouse gases are water vapor and carbon dioxide.

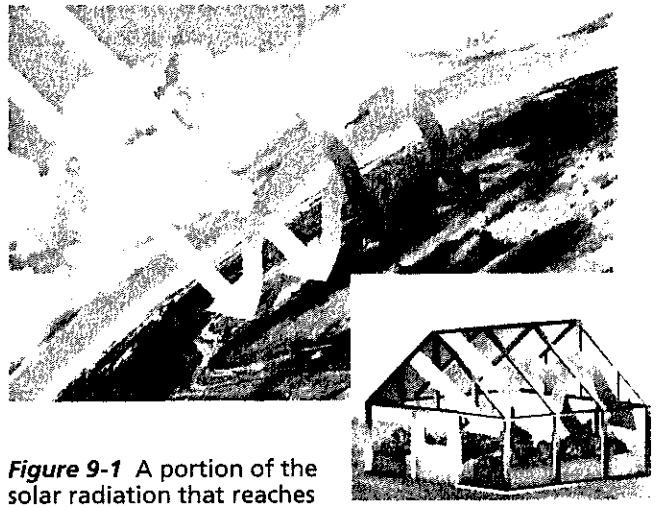


Figure 9-1 A portion of the solar radiation that reaches Earth's surface is reradiated as infrared radiation, which is absorbed and rereleased by atmospheric gases. The absorption of this radiation heats the atmosphere. This process is known as the greenhouse effect, because it is similar to the way heat is trapped in a greenhouse.

The greenhouse effect is not the result of human activities. It is a natural feature of the atmosphere that has been occurring for millions of years. However, people can influence the greenhouse effect. For example, the burning

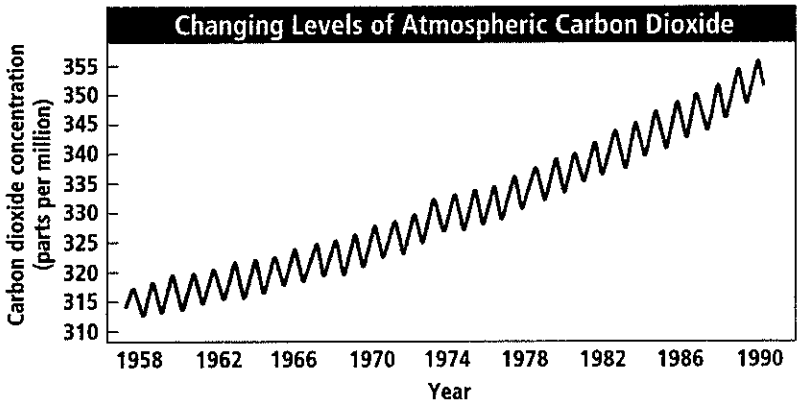


Figure 9-2 The concentration of carbon dioxide in Earth's atmosphere has increased over time. The annual low points on this graph correspond to summers, when plants are growing and removing carbon dioxide from the atmosphere for photosynthesis. The annual high points correspond to winters, when many plants are dormant and removing less carbon dioxide.

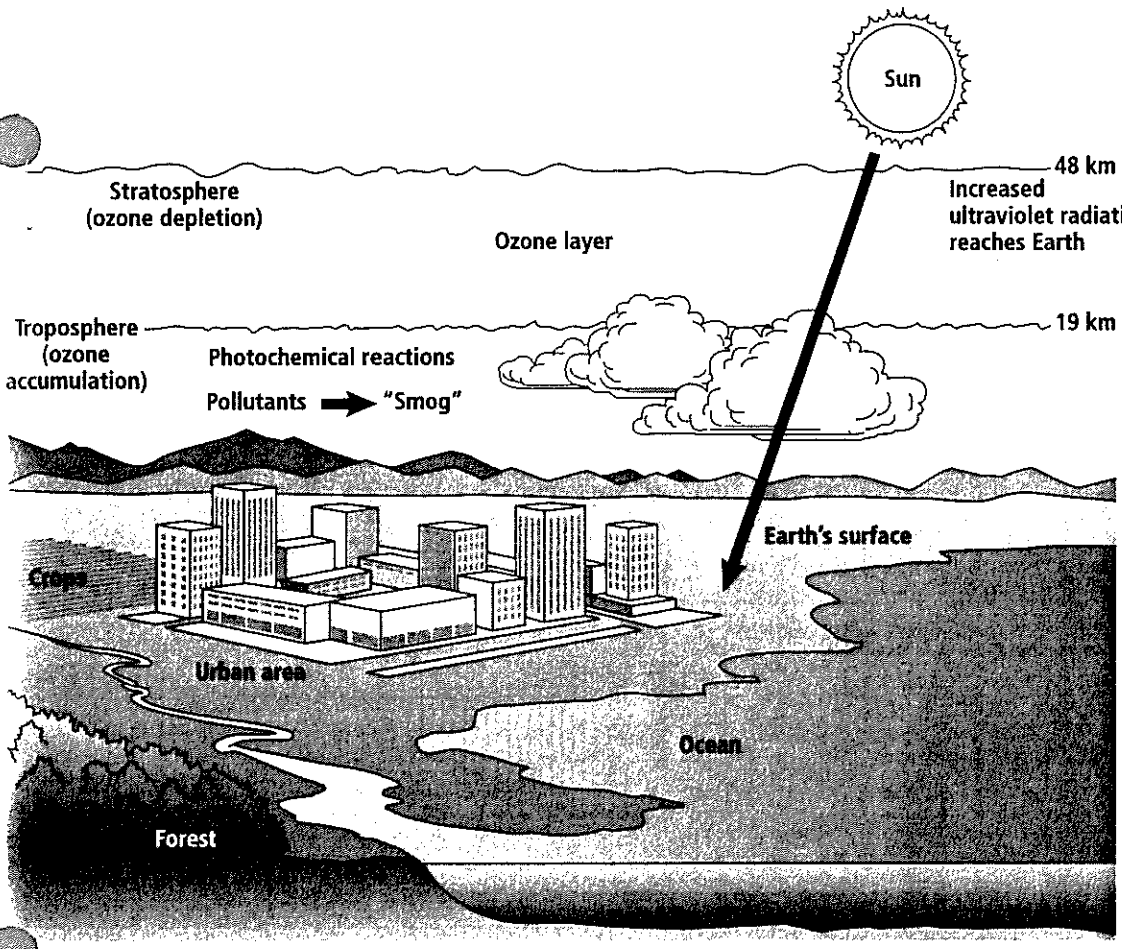


Figure 9-3 The levels of ozone in the stratosphere are decreasing, leading to an increase in the amount of ultraviolet light that reaches Earth's surface. However, the levels of ozone in the troposphere are increasing, contributing to the production of smog. Both changes in ozone levels present potential human health problems.

of fossil fuels has been linked to a steady rise in the concentration of atmospheric carbon dioxide over the past century. Figure 9-2 on the previous page shows how the concentration of this gas has changed since 1958. Because carbon dioxide is a greenhouse gas, most scientists believe the rise in its concentration is contributing to global warming. **Global warming** is a gradual increase in the Earth's average surface temperature.

Ozone

Ozone is a gas that is present in two areas in Earth's atmosphere: in the stratosphere (between about 19 km and 48 km above the Earth's surface) and in the troposphere (near the ground). Ozone in the stratosphere occurs naturally. This ozone layer absorbs harmful ultraviolet radiation from the Sun and prevents it from reaching Earth's surface. Scientists began detecting a thinning of the ozone layer in the 1980s. The most probable cause of this thinning is the presence of chlorofluorocarbons in the atmosphere. These compounds were once widely used in air conditioners, refrigerators, and aerosol cans. They destroy ozone molecules when they reach the stratosphere.

In contrast to ozone in the stratosphere, ozone in the troposphere is a pollutant. Ground-level ozone is produced by the action of sunlight on other air pollutants, such as nitrogen oxides, carbon monoxide, and hydrocarbons. These pollutants result primarily from the burning of fossil fuels, chiefly in automobiles. Ground-level ozone is the main component of smog. Figure 9-3 contrasts the role of ozone in the troposphere with the role of ozone in the stratosphere.

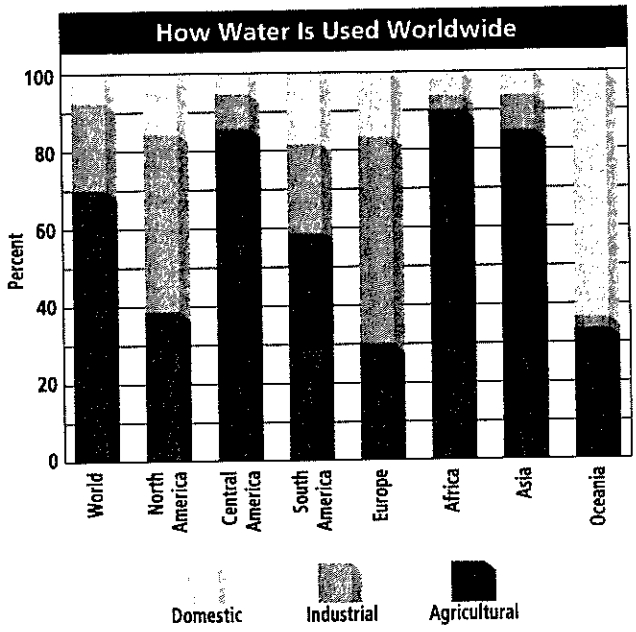
Water Resources

About 97 percent of Earth's water is salt water. The remaining 3 percent is freshwater. However, only about 0.003 percent, or 3/100 000, of Earth's water is available for human use.

Distribution and Use

Most continents have enough freshwater. However, this water is not distributed evenly. For example, there are currently about 25 nations, most of which are in Africa and the Middle East, that have chronic shortages of water. As world population grows, the number of countries with inadequate water supplies is expected to increase. Figure 9-4 gives information about world water usage.

Figure 9-4 The relative amount of freshwater that is used for domestic, industrial, and agricultural purposes varies in different parts of the world.



Water Budget

A water budget is a way of showing how the amount of water in soil changes over time. A sample water budget is shown in Figure 9-5. The solid line on this graph represents the amount of **precipitation** (water in the form of rain, hail, sleet, or snow) that the city receives. The dotted line on the graph represents the soil's potential evapotranspiration. **Evapotranspiration** includes both the direct evaporation of water from the soil and the evaporation from plants, a process called **transpiration.** Potential evapotranspiration is the amount of water that would be evaporated or transpired if the soil contained an unlimited amount of water. Potential evapotranspiration depends primarily on temperature. As the temperature increases, so does the amount of water evaporating from the soil and from plants.

The two lines on the graph show how precipitation and evapotranspiration combine to affect the soil. During January and February, potential evapotranspiration is very low compared to the amount of precipitation. As a result, there is a water surplus. During March and April, potential evapotranspiration increases and the amount of surplus water decreases.

From May until September, potential evapotranspiration is greater than the amount of precipitation. At the beginning of May, the soil still holds the maximum amount of water it is capable of holding.

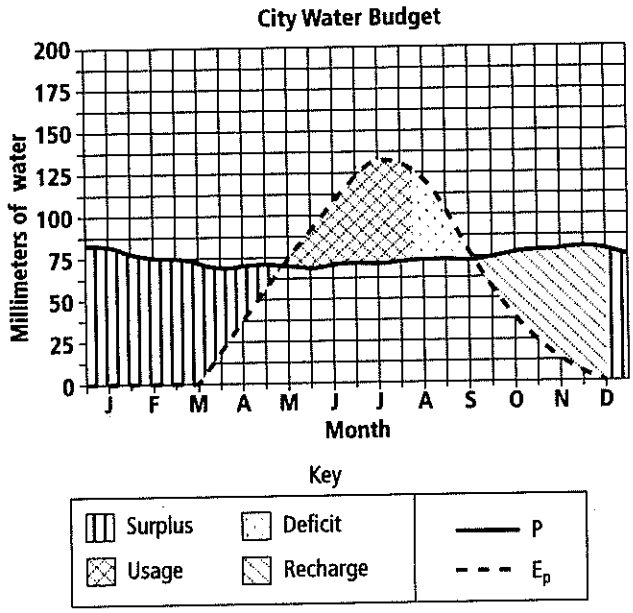


Figure 9-5 In this water budget, P stands for precipitation, and E_p stands for potential evapotranspiration.

However, the amount of stored water begins to decrease in May. By late July, the stored water in the soil is depleted, and a water shortage, or deficit, begins. In September, precipitation once again exceeds potential evapotranspiration, and the soil begins to store moisture.

Water Management

One of the ways that countries manage their resources of freshwater is by building dams. When a dam is built across a river, a reservoir forms behind the dam. The reservoir traps the flow of the river as well as runoff from precipitation. Sediment also builds up behind the dam.

Another way to manage water resources is to transport water from one place to another. Water can be moved through pipes and tunnels from regions that have abundant water supplies to areas that have water shortages, as is done in parts of California.

Countries also manage freshwater supplies by pumping groundwater to the surface from **aquifers,** as shown in Figure 9-6. Aquifers are water-saturated layers of sand, gravel, and bedrock. If the rate at which water is pumped out of an aquifer exceeds the rate at which the aquifer is recharged, then the water table may be lowered so much that wells run dry. In the case of shallow aquifers near oceans, salt water may enter the groundwater supplies if the water table is lowered.

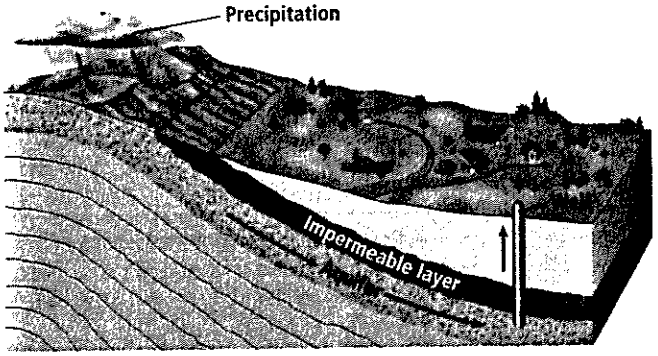


Figure 9-6 This aquifer is located in a permeable sandstone layer. It is sealed beneath an impermeable rock layer. A well has been dug into the aquifer to bring groundwater to the surface for human use.

SUBTOPIC B
ENERGY RESOURCES

Covers National Science Content Standards D.1; F.2, F.3, F.4, F.5, F.6

Earth and Space Science

D.1	Energy in the Earth system

Science and Personal and Social Perspectives

F.2	Population growth
F.3	Natural resources
F.4	Environmental quality
F.5	Natural and human-induced hazards
F.6	Science and technology in local, national and global challenges

VOCABULARY

geothermal energy **sustainable energy**

Communities meet their energy needs in many different ways. Factors that may influence a community's energy choices include its climate, available natural resources, the cost of energy production, the socioeconomic status of the community members, and risk factors or negative side effects of using some energy resources.

Fossil Fuels

The United States, along with the majority of the world's industrialized nations, relies primarily on nonrenewable fossil fuels to meet its energy needs. Fossil fuels are formed largely from the compressed remains of plants, marine plankton, and other photosynthetic organisms. The energy stored by these organisms originally came from the Sun. Therefore, the Sun is the ultimate source of the energy in fossil fuels and the source of almost all energy on Earth.

Coal, a solid fossil fuel, formed from organic matter that was buried in ancient swamps. Petroleum and natural gas are believed to have formed from the remains of marine organisms that became buried under sediments on the ocean floor. Petroleum can be processed and separated into a variety of compounds that contain carbon and hydrogen. Gasoline is a mixture of several of those compounds. One of the main disadvantages of burning fossil fuels is that it releases pollutants, including carbon dioxide, into the atmosphere.

Alternative Energy Resources

Because there is only a limited supply of fossil fuels, these resources may eventually become too expensive for many nations to continue to rely on them. As a result, governments, scientists, and businesses are investigating alternative, often renewable, energy sources. Like fossil fuels, however, each energy resource has its advantages and disadvantages, which are summarized in Table 9-1.

Solar Energy

One type of alternative energy resource is solar energy. An enormous amount of solar energy reaches Earth each day. Solar energy can be captured with solar panels or other materials that store heat well. This heat can then be used to warm houses. In addition, devices called photovoltaic cells can convert solar energy into electricity. However, there is still no inexpensive and effective method for storing a large amount of solar energy for an extended period of time.

Water and Wind Energy

Two other renewable energy sources are water and wind. The energy of moving water can be used to turn turbines that generate electricity. Power plants that produce electricity in this way are called hydroelectric power plants. Some hydroelectric power plants are built near dams. The water stored in the reservoir behind the dam is used to turn turbines as the water moves through large pipes.

Table 9-1 Energy Resources

Type	Requirements for use	Advantages	Disadvantages
Fossil fuels	Access to coal, petroleum, or natural gas reserves	Very efficient Used to fuel both power plants and vehicles	Nonrenewable Contributes to air pollution and global warming
Solar energy	Large number of sunny days and intense direct sunlight	Sunlight itself is free No pollution Photovoltaic cells can be installed and moved easily	Backup source of power often needed No existing inexpensive and practical method of storing energy for long periods of time
Water or hydroelectric energy	Waterfall or a dam and reservoir Source of water	No air pollution Dams provide flood control, irrigation, and drinking water	Dams can cause destruction of wildlife habitats, sediment accumulation in reservoirs
Wind energy	Consistent, steady winds Areas of open land for wind farms	No air pollution Wind farms can be installed and moved easily Inexpensive	Backup source of power often needed Can kill wildlife, such as migrating birds Can be noisy and interfere with radio and television reception
Geothermal energy	Near plate boundaries (usually) Water for use in heat transfer	Reliable and abundant energy at specific sites	Development can harm ecosystems Can cause some local air and water pollution Energy can only be used locally
Nuclear energy	Nuclear power plant Radioactive fuel, such as uranium	No greenhouse gases	Safety concerns Produces radioactive waste
Biomass	Source of biomass, such as rapidly growing trees, dried field crops, or peat	Biomass fuels often readily available Biomass fuels can be converted to liquid and gaseous fuels	Contributes to air pollution and global warming

Table 9-1 Some energy resources are more suitable for certain communities than others. The table summarizes some of the principal advantages and disadvantages of Earth's energy resources and the main requirements for using each resource.

Other hydroelectric power plants use the falling water from waterfalls to move turbines. One waterfall used to generate hydroelectric power is Niagara Falls. Power plants at the falls produce electricity for portions of New York and Canada.

Wind turbines, or windmills, use the energy of the wind to generate electricity. A group of wind turbines is called a wind farm. Currently, most wind farms in the United States are in California.

Geothermal and Nuclear Energy

Geothermal energy is one energy source that does not directly originate from solar energy. Instead, the source of geothermal energy is heat from Earth's interior. In certain areas, Earth's internal heat raises the temperature of water trapped underground. If the water becomes hot enough, it is converted to steam. Energy generated by this heated water and steam is called **geothermal energy.** Reservoirs of geothermal energy are usually located near the boundaries of tectonic plates.

Another energy source that does not directly originate from solar energy is nuclear energy. Nuclear fission releases large amounts of nuclear energy. Nuclear fission is the process by which an unstable radioactive atom with a high mass number splits to produce atoms with lighter nuclei and one or two neutrons.

Sustainable Energy

As the human population continues to grow and reserves of nonrenewable energy sources such as fossil fuels continue to shrink, the ways in which people use and obtain energy will likely undergo a variety of changes. Presently, industrialized nations obtain only about 10 percent of their energy from renewable sources, as shown in Figure 9-7. However, researchers believe that the best way to meet future energy needs is to use a variety of local, renewable energy sources instead of relying on a single nonrenewable source.

A policy of **sustainable energy** is intended to meet both present and future energy needs without harming the environment. Because Earth's energy resources are interconnected, sustainable energy is likely to be possible only if nations around the world work together to manage their resources.

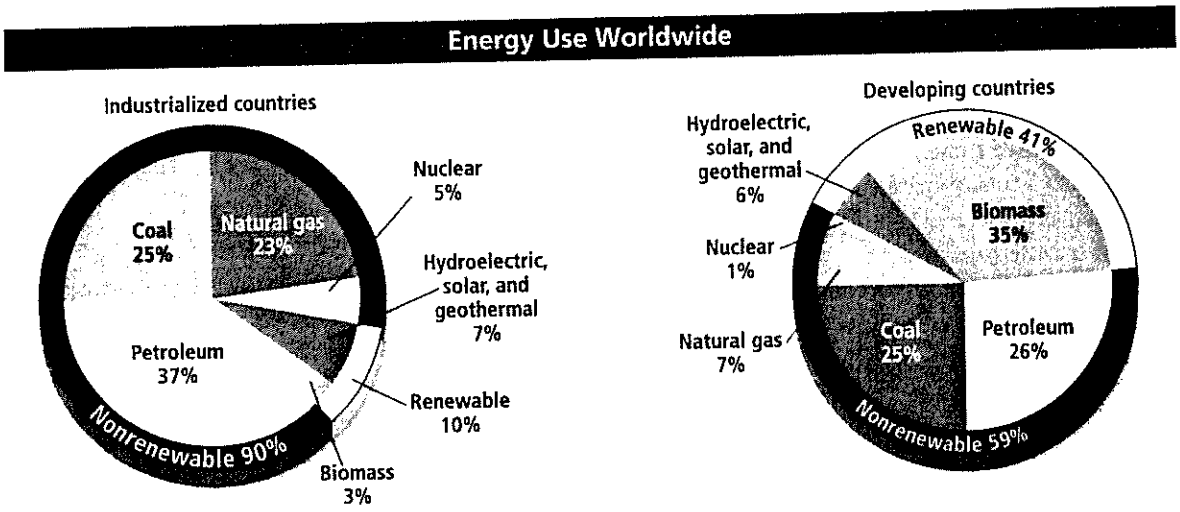


Figure 9-7 The use of energy resources in industrialized countries is very different from that in developing countries.

SUBTOPIC C
HUMAN IMPACT ON EARTH RESOURCES

Covers National Science Content Standards F.2, F.3, F.4, F.5, F.6

Science in Personal and Social Perspectives

F.2	Population growth
F.3	Natural resources
F.4	Environmental quality
F.5	Natural and human-induced hazards
F.6	Science and technology in local, national, and global challenges

VOCABULARY

deforestation
acid precipitation
atmospheric inversion
point source
nonpoint source
cultural eutrophication

People and other organisms make changes to their environments to meet their needs. Some of these changes may have negative effects on other organisms; some may have positive effects. Humans are capable of changing the environment to a greater degree than other organisms. As a result, people have a large impact on natural resources.

Impact on Land Resources

Human activities that affect land resources include agriculture, deforestation, and urbanization.

Agriculture

One way in which agriculture can have a negative effect on the environment is through the loss of topsoil. Whenever plants are removed from soil, such as when fields are cleared or plowed, the soil becomes more likely to be eroded by wind or water. Farmers can help conserve topsoil by leaving plants in place after crops have been harvested.

Another aspect of agriculture that must be carefully monitored is the use of pesticides and fertilizers. If used improperly, these chemicals can be washed from fields and contaminate nearby surface water and groundwater.

Deforestation

Deforestation occurs when trees are removed from an area of land and the land is not replanted with new trees. Deforestation is a huge problem in the tropical rain forests of South America. It can cause loss of topsoil due to erosion. It can also cause nearby streams to fill with sediment washed from the bare ground. However, U.S. laws require that when a forested area is logged, buffer zones of trees must be left along streams to capture sediment. In addition, the practice of selective logging can help minimize the effects of erosion. This method involves cutting down only some of the trees in an area, instead of removing all of them.

Deforestation also alters the carbon cycle. Trees take in carbon dioxide during photosynthesis. When forests are cleared by burning, much of the carbon stored in the trees is converted back to carbon dioxide, which leads to an increase in the concentration of this greenhouse gas.

Urbanization

As the human population increases, so does the number of people living in cities. Although urbanization is associated with a variety of environmental problems, people are working to solve many of them.

As cities grow, more land is cleared and developed, which can destroy ecosystems. New construction in cities may contribute to erosion when the ground is left unplanted for extended periods. To prevent such erosion, barriers may be placed around cleared land to reduce the runoff of sediments. Large areas of paved land can prevent precipitation from seeping into the soil and reaching groundwater supplies. This problem can be partially solved by increasing the ratio of grassy areas to paved areas in cities.

Cities also produce large amounts of solid waste. A significant portion of this waste is buried in landfills. Older landfills were not always well constructed, resulting in the seepage of harmful chemicals into underground water supplies. Landfills being used today are designed to prevent leaks into groundwater, as shown in Figure 9-8.

Impact on Air Resources

Air pollution has led to global changes that include global warming, ozone depletion, acid precipitation, and urban air pollution.

Global Warming

Some scientists predict that increased concentrations of greenhouse gases may cause Earth's average surface temperature to increase by 1°C to 3.5°C within the next 100 years. This rise in temperature would likely alter wind and precipitation patterns, which in turn could affect agriculture. Polar ice and glaciers could partially melt, causing sea level to rise and flood some coastal areas. Some scientists, however, believe there is not enough information to determine whether global warming is due primarily to human activities or whether it is part of a natural cycle of temperature changes.

Ozone Depletion

The ozone layer in the stratosphere blocks ultraviolet (UV) radiation from the Sun. As discussed earlier, it is now known that the use of chlorofluorocarbons has led to a thinning of the ozone layer. As a result, more UV radiation is reaching Earth's surface. The increased intensity of UV radiation at Earth's surface is associated with higher rates of sunburn, skin cancer, and eye damage in humans. It also has negative effects on the growth of plants, including those grown for food.

Acid Precipitation

Precipitation is naturally slightly acidic. The term **acid precipitation** is used to refer to any precipitation having a pH value of less than 5.0. Acid precipitation is caused by the reaction of sulfur oxides and nitrogen oxides with water vapor in the air to form sulfuric acid and nitric acid.

The major sources of sulfur oxides and nitrogen oxides are automobiles and electric power plants, especially coal-burning plants in the Midwest. Because the coal used in these plants is rich in sulfur, it produces large quantities of sulfur dioxide when burned. Prevailing winds carry this pollutant from the Midwest to the eastern United States and Canada, where it contributes to the production of acid precipitation. Figure 9-9 shows that acid precipitation falls mainly in the eastern half of the United States.

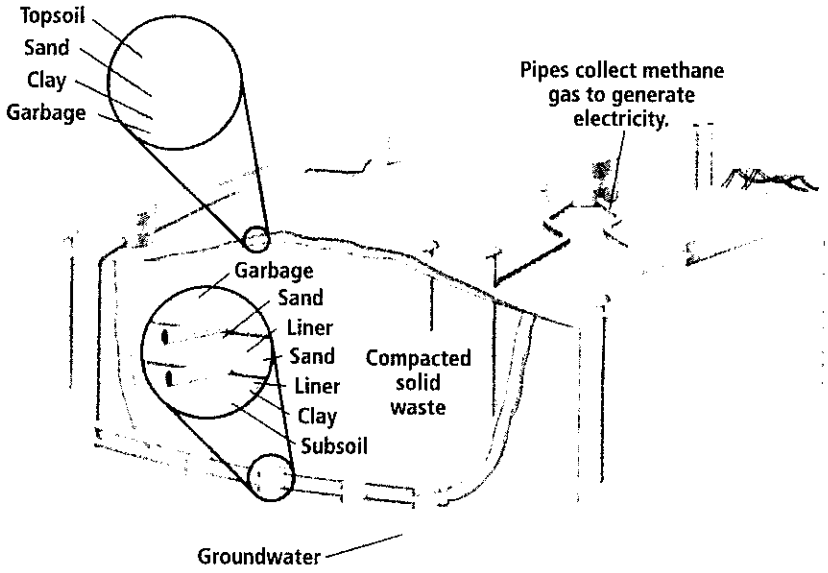


Figure 9-8 Several methods are used to reduce the environmental impact of landfills.

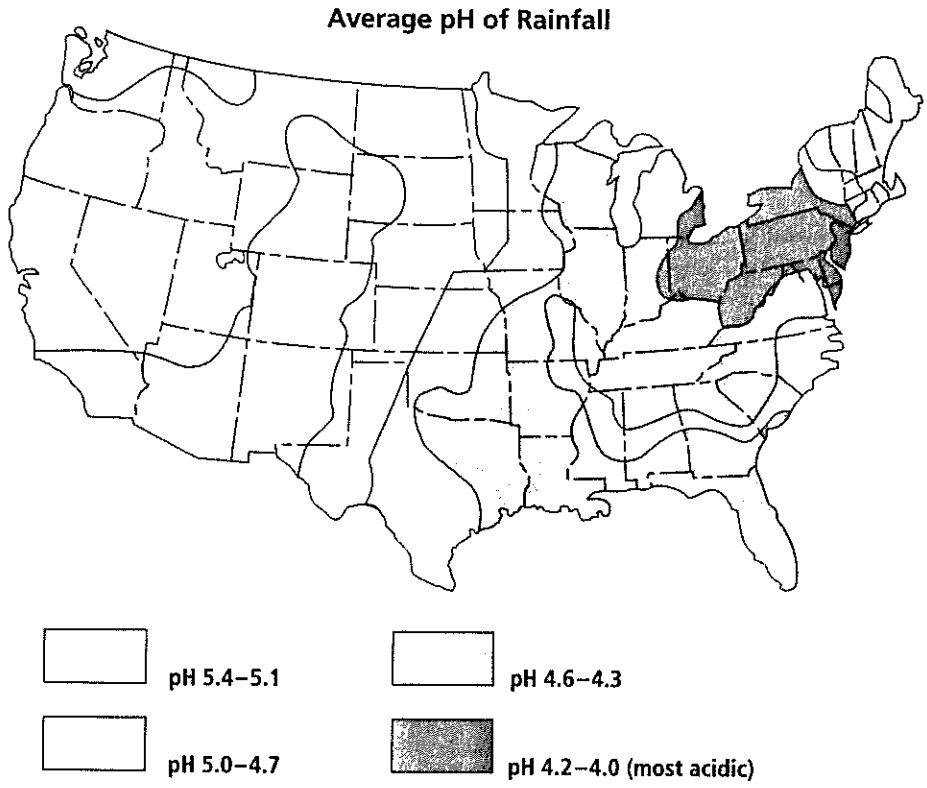


Figure 9-9 The average pH of rain in the eastern United States is lower than that in the western states. The lower the pH level, the more acidic the rain is.

Acid precipitation that enters surface water can harm aquatic animals and plants. It also weakens trees and makes them more likely to die from disease or pests. In addition, acid precipitation increases the chemical weathering of metal and some types of rock, especially limestone.

Urban Air Pollution

Air pollution, particularly smog, tends to be concentrated near cities, where most air pollution is produced. If pollutants are generated in an area more quickly than they are transported out of the area, dangerous levels of pollutants can build. Such an event may occur during an **atmospheric inversion,** when a layer of warm air is present above a layer of cool air. The layer of warm air acts as a barrier that keeps the pollutants produced by the city from being transported and diluted.

Impact on Water Resources

Sources of water pollution are divided into point and nonpoint sources. **Point sources** are those that are confined to a single location, such as a sewage-treatment plant or a chemical plant. Examples of point sources include microorganisms associated with improperly treated sewage and polluted water released into streams by certain industries.

By contrast, **nonpoint sources** have multiple locations. For example, rainwater and runoff are nonpoint sources of pollution. Rain may absorb pollutants in the atmosphere before it falls. Once it reaches the ground, it may pick up pesticides and fertilizers from fields before it enters surface water supplies. Figure 9-10 on the next page illustrates common point and nonpoint sources of water pollution.

Cultural Eutrophication

When lakes are geologically young, they often have steep sides and are very deep and cold. The water in such lakes tends to be clear, because it has little organic matter and few nutrients. Lakes with little organic matter or nutrients are known as oligotrophic (little-nourished) lakes. Over time, oligotrophic lakes gradually fill in as a result of sedimentation, runoff, and the addition of organic matter such as plankton. As these lakes become shallower, sunlight is able to penetrate to the bottom, allowing the growth of aquatic plants along the edges. As organic matter becomes more abundant, oligotrophic lakes develop into eutrophic (well-nourished) lakes. Eutrophic lakes are rich in organic matter and nutrients. They support abundant aquatic life, including algae, plankton, floating and emergent plants, insects and other invertebrates, and many species of fishes. When these aquatic organisms die, they fall to the bottom of the lake and

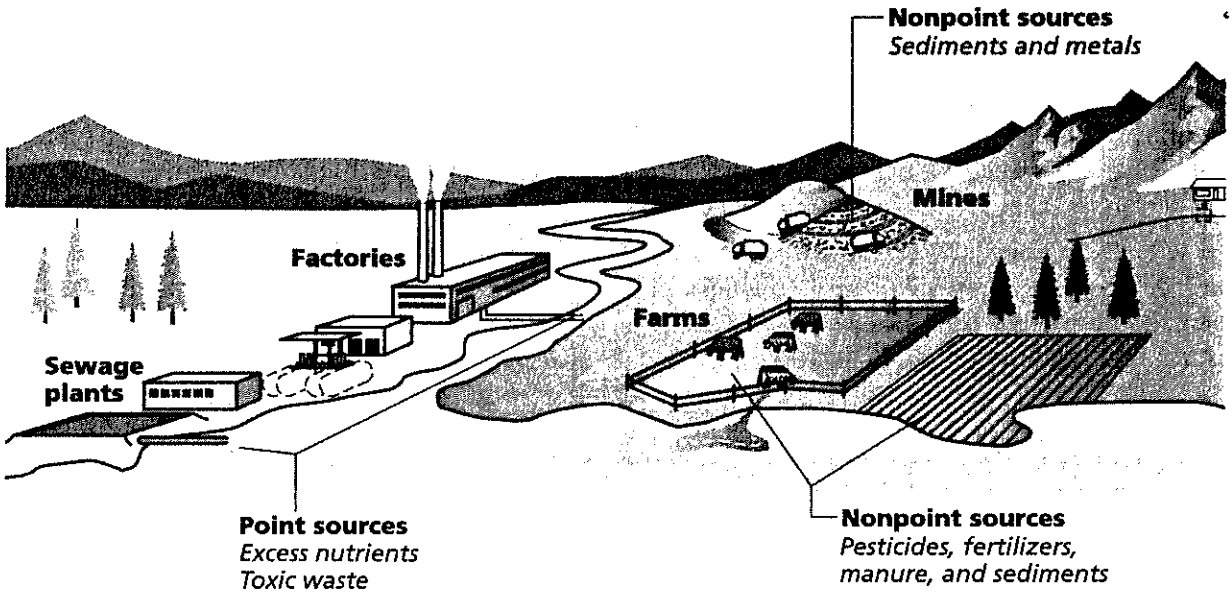


Figure 9-10 Point sources of water pollution consist of single locations. Nonpoint sources have multiple locations.

decompose, contributing to the filling in of the lake. Eventually, eutrophic lakes become wetlands such as swamps and marshes.

Eutrophication is a natural process that takes place over a long period of time. However, the rate at which eutrophication occurs can sometimes be increased by the addition of excessive nutrients. Sources of excessive nutrients include fertilizers, detergents, and untreated sewage. When excessive nutrients are added to a lake, they can cause rapid growth of plant and algal populations living there. Algae may grow so rapidly that they cover the entire surface of the lake in a short period of time. Once the excessive nutrients are used up, the population crashes; algae die and fall to the bottom of the lake, and the bacteria at the lake bottom begin the process of decomposition. Bacterial decomposition uses up oxygen in the lake's water, which causes stress to other organisms. The process by which excessive nutrients result in increased productivity and resulting stress is known as **cultural eutrophication.** Cultural eutrophication usually is the result of human activities in the watershed that feeds a lake. Figure 9-11 shows the stages of cultural eutrophication caused by the addition of excess nitrates and phosphates to a lake.

Reducing Water Pollution

Pollutants that seep into the soil can enter groundwater and supplies of drinking water. Sources of groundwater pollutants include landfills, underground tanks of gasoline, and containers used for storing chemicals, fertilizers, and sewage. Because pollutants cannot be easily removed from groundwater, it is important to reduce leakage of potential water pollutants.Nations around the world are making efforts to reduce and prevent water pollution by passing laws to protect water supplies.

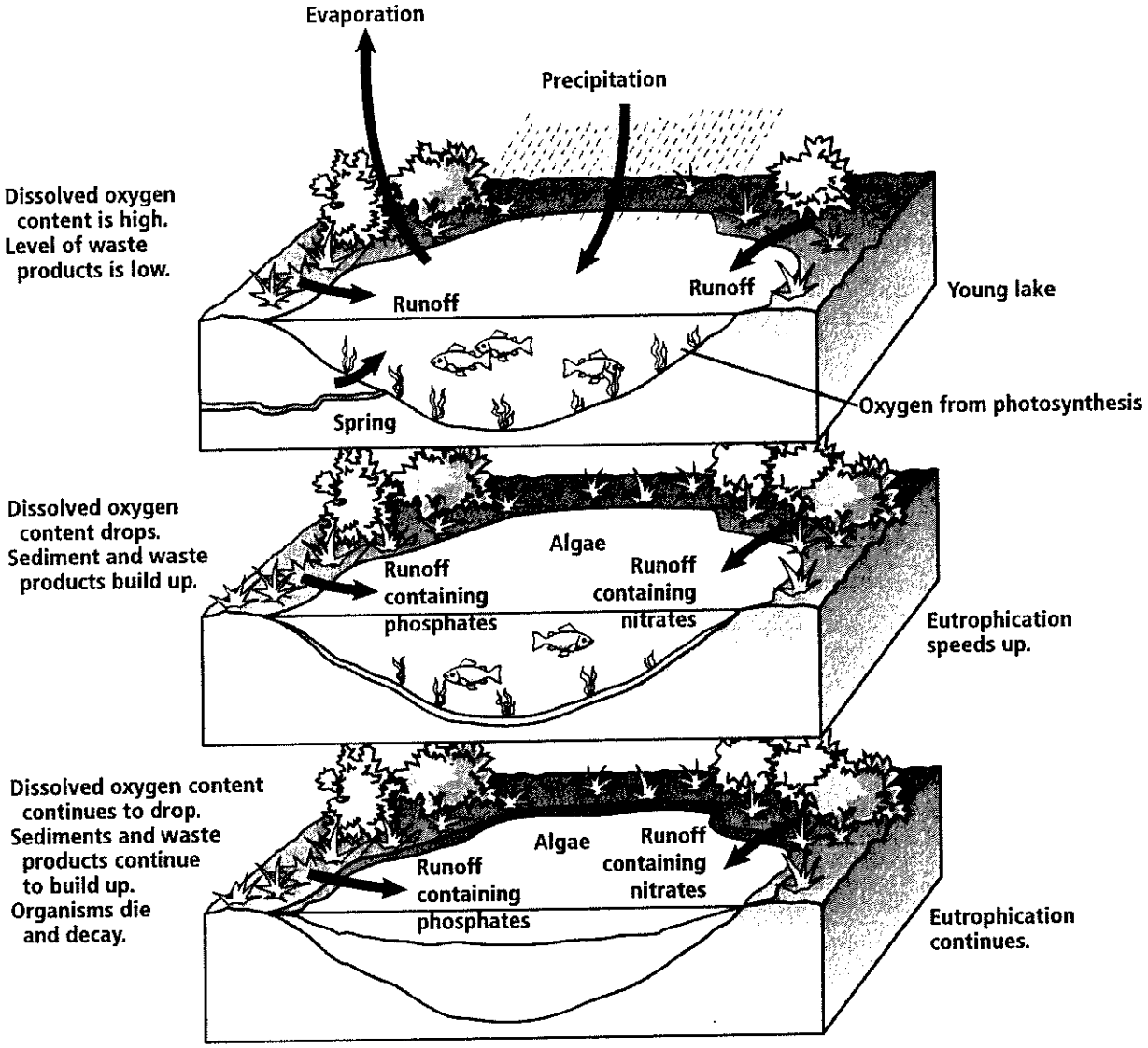


Figure 9-11 The addition of excessive nutrients, such as phosphates and nitrates, can lead to cultural eutrophication.

QUESTIONS FOR SUBTOPIC A

Type A

1. Most scientists believe that an increased concentration of atmospheric carbon dioxide is contributing to an increase in Earth's average surface temperature. This belief is based on the fact that carbon dioxide is a

- **a.** good absorber of infrared radiation.
- **b.** poor absorber of infrared radiation.
- **c.** good reflector of ultraviolet radiation.
- **d.** poor reflector of ultraviolet radiation.

2. Ozone is important to life on Earth because ozone

- **a.** cools refrigerators and air conditioners.
- **b.** absorbs energy that is reradiated by Earth.
- **c.** absorbs harmful ultraviolet radiation.
- **d.** destroys excess atmospheric carbon dioxide.

3. Which action would be most likely to help reduce the desertification of an area?

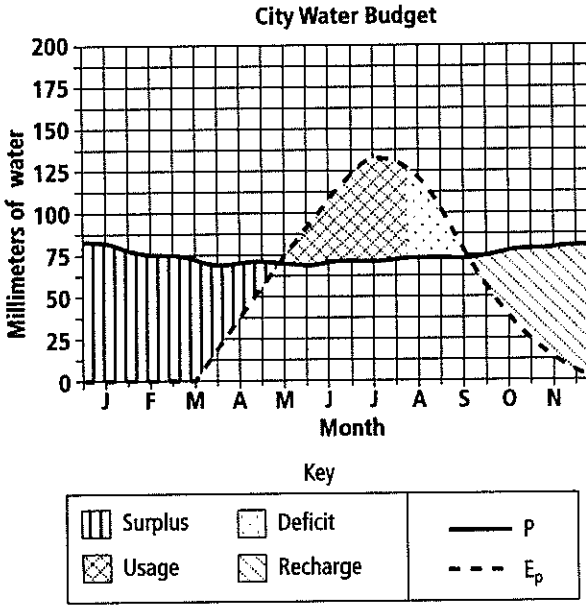
- **a.** reducing the amount of fossil fuels used
- **b.** replanting cleared land with native plants
- **c.** increasing the amount of irrigation on fields
- **d.** drilling into aquifers to tap groundwater supplies

4. The gasoline that leaks from an underground tank is considered a pollutant because the gasoline
   - **a.** floats on the water table.
   - **b.** destroys nonliving organic substances.
   - **c.** reacts chemically with minerals in the soil.
   - **d.** harms living things.

5. Which action would be most likely to help reduce the concentration of ground-level ozone?
   - **a.** encourage the use of carpools or mass transit
   - **b.** prohibit the use of chlorofluorocarbons as refrigerants
   - **c.** increase the amount of fertilizers applied to fields
   - **d.** use coal as a fuel source rather than natural gas

Type B

Base your answer to question 6 on the water budget below.



6. During which month is irrigation most needed to grow crops at the location that has this water budget?
   - **a.** April
   - **b.** June
   - **c.** August
   - **d.** October

Base your answers to questions 7 and 8 on the table below. The table shows water budget data expressed in millimeters of water.

Water Budget Data

Month	Precipitation	Potential evaporation transpiration	Storage
J	72	0	100
F	68	0	100
M	81	3	100
A	75	34	100
M	74	83	91
J	87	115	63
J	84	134	13
A	82	122	0
S	72	84	0
O	76	46	30
N	63	15	78
D	72	0	100
Yearly Total	906	636	—

7. What is the total amount of moisture added to soil storage during October?
   - **a.** 0 mm
   - **b.** 30 mm
   - **c.** 46 mm
   - **d.** 76 mm

8. Surplus soil moisture exists during the month of
   - **a.** June.
   - **b.** October.
   - **c.** November.
   - **d.** December.

9. The concentration of carbon dioxide (CO_2) in Earth's atmosphere has increased over the past century. This change in CO_2 concentration has most likely caused
   - **a.** a decrease in the average wavelength of radiation emitted by the Sun.
   - **b.** a decrease in the production of ground-level ozone.
   - **c.** an increase in the rate of evapotranspiration.
   - **d.** an increase in the thickness of Earth's glaciers.

10. Which of these is probably a current problem in Saudi Arabia, a country in the Middle East?
    a. shortages of freshwater supplies
    b. high costs of importing fossil fuels
    c. clearing of forests to produce farmland
    d. air and water pollution due to mining of ores

Type C

Base your answers to questions 11 and 12 on the passage below.

> **Oil Shale: A Future Source of Fossil Fuels?**
>
> Oil shale is a type of sedimentary rock that contains a mixture of hydrocarbons. Oil shale can be mined and then subjected to a heating process that produces a fossil fuel called shale oil. In the United States, the cost of mining and processing of oil shale is currently greater than the cost of purchasing petroleum. However, the United States is estimated to possess about two-thirds of Earth's oil shale resources. U.S. oil shale resources are believed to be equivalent to about 2 trillion barrels of petroleum.

11. Explain whether shale oil is a renewable or a nonrenewable resource.
12. Suppose new technology makes it possible for oil shale to be mined and processed at a much lower cost. Describe one advantage (other than lower cost) and one disadvantage to the United States' use of this land resource.
13. A county on the Atlantic coast of the United States relies on groundwater pumped from an aquifer to meet its water needs. One problem that threatens the county's aquifer is the intrusion of salt water from the Atlantic Ocean. Describe one law that could be passed by the county government to help prevent this intrusion from happening.

QUESTIONS FOR SUBTOPIC B

Type A

14. What is the primary source of most of Earth's energy resources?
    a. radioactive decay within the Earth's interior
    b. convection currents in the Earth's mantle
    c. radiation received from the Sun
    d. earthquakes along fault zones
15. A community is debating whether to build a hydroelectric power plant or a wind farm. Which of the following is an advantage that wind farms have over hydroelectric power plants?
    a. Wind farms present no threat to wildlife.
    b. Wind farms do not contribute to air pollution.
    c. Wind farms can be constructed quickly.
    d. Wind farms produce electricity from a renewable energy source.
16. Most reservoirs of geothermal energy are
    a. distributed evenly around the world.
    b. located in the Middle East.
    c. located near waterfalls.
    d. located near the boundaries of tectonic plates.

Type B

17. Which action to provide additional energy resources would have the most positive impact on a community's health and safety?
    a. construction of a nuclear power plant
    b. expansion of an array of photovoltaic cells
    c. conversion from solid biomass fuel to liquid fuels
    d. burning coal with a higher sulfur content
18. Which statement best explains why a developing nation is more likely than an industrialized nation to use renewable energy sources?
    a. Developing nations tend to be located in areas that receive large amounts of sunlight.
    b. Developing nations are less likely to support the use of nuclear power as an energy resource.
    c. The large number of rivers in developing nations encourages the use of hydroelectric power.
    d. Biomass fuels are sometimes the only readily available energy resource in developing nations.

19. Which action would be the most likely to conserve energy resources?

a. A community begins to switch from the use of biomass fuels to the use of fossil fuels.

b. A newly designed automobile uses excess heat to generate electric power.

c. A nation passes a law banning the use of chlorofluorocarbons.

d. A state government encourages competition among electric utilities.

Type C

Some questions may require the use of the *Earth Science Tables and Charts.*

Base your answers to questions 20 and 21 on the following newspaper article.

> **Residents Debate Energy Plan**
>
> The Sun City town council's energy plan came under attack at Thursday night's meeting. The plan calls for the construction of a solar energy power plant to meet the growing demand for electricity. The plant will have a backup system that relies on the burning of natural gas.
>
> Opponents of the plan are pushing for a power plant that will produce electricity entirely from the burning of natural gas. They point out that electricity produced in this way will be less expensive than electricity produced by a combination solar/natural gas plant.

20. What are two valid arguments that a town council member could make in support of the plan that calls for a solar/natural gas power plant?

21. Suppose another group of residents demands a power plant that generates electricity entirely from solar power. What is one valid argument that a town council member could make to oppose this plan?

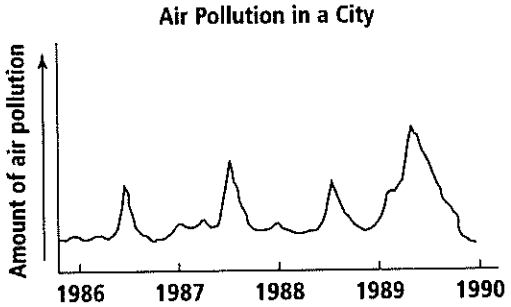
22. The geothermal gradient of an area is the increase in temperature with depth below the surface. Areas with large geothermal gradients tend to be suitable sites for geothermal power plants. A geothermal gradient of 30°C to 45°C per kilometer is considered moderate. Suppose that a site has a temperature of 52°C at a depth of 1 km below the surface and 146°C at a depth of 3 km below the surface. Based on this information, would the site be suitable for a geothermal power plant? Explain your answer.

QUESTIONS FOR SUBTOPIC C

Type A

Some questions may require the use of the *Earth Science Tables and Charts.*

23. The graph below shows the relative amount of air pollution over a city over a period of several years.



Which statement about the amount of air pollution over this city is best supported by the graph?

a. It is decreasing at a constant rate.

b. It is increasing at a constant rate.

c. It has a cyclic pattern.

d. It has no pattern.

24. A rapid growth of algae at the surface of a lake is often caused by

a. the addition of excessive nutrients to the lake.

b. the removal of nitrates and phosphates from the lake.

c. more rapid bacterial decomposition at the bottom of the lake.

d. a decrease in the concentration of oxygen in the lake.

25. Adding automobile exhaust gases to the atmosphere can affect landscape development by

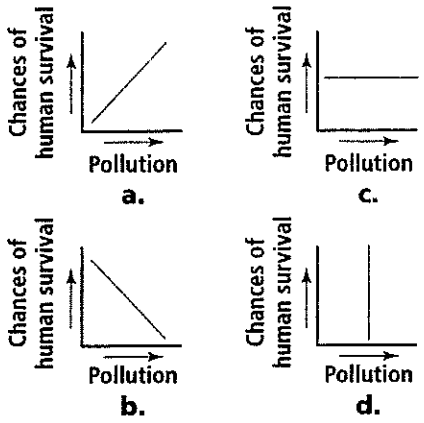
a. changing the position of crustal plates.

b. increasing the pH of precipitation.

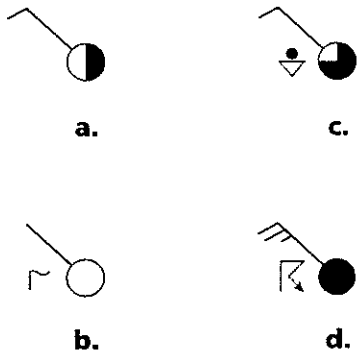
c. increasing the rate of chemical weathering.

d. increasing the amount of ozone in groundwater.

26. Which graph shows the most probable effect of pollution on human survival?

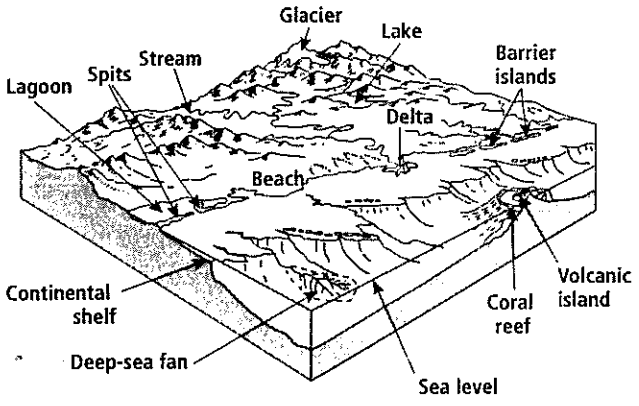


27. Which weather station model below represents a location that is probably experiencing an atmospheric inversion?



Type B

28. The diagram below shows a coastal area with a variety of landforms.



The environment of the area shown above would be polluted least by

a. building fossil-fuel power plants along the stream.

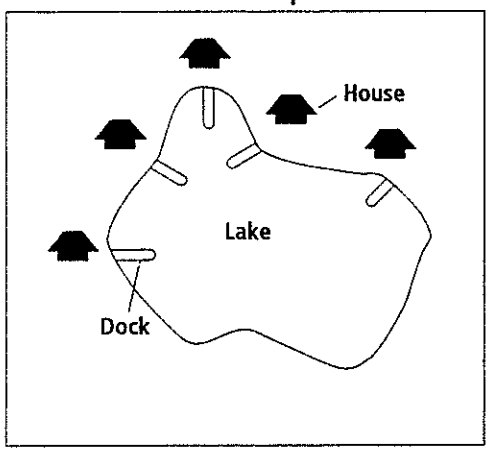
b. constructing sewage-treatment plants and landfills on the edge of the lagoon.

c. developing vacation homes on the barrier islands.

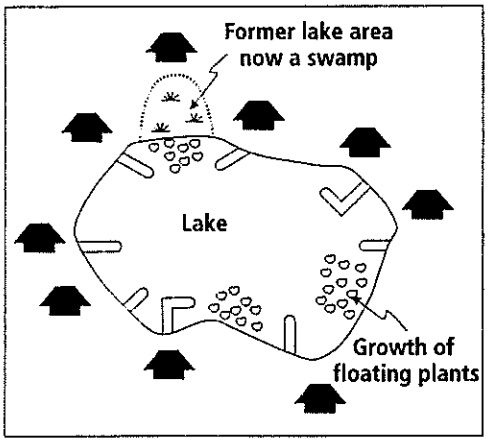
d. establishing a wildlife refuge around the lake.

Base your answers to questions 29 and 30 on the maps below. The maps show changes around a small lake over a 30-year period.

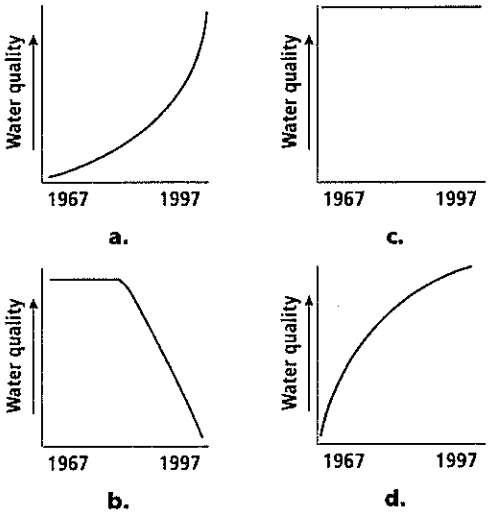
1967 Map



1997 Map



29. Which graph below best shows the probable changes from 1967 to 1997 in the quality of lake water in this region?



30. Describe one law that could have helped to prevent the changes that occurred in the lake between 1967 and 1997.

31. Lime is a chemical that neutralizes acids. It is added to some acidified lakes to help lower their pH levels. The addition of lime represents a temporary solution to problems caused by acid precipitation. The solution is temporary because it does not affect

a. the runoff of fertilizers into surface water.

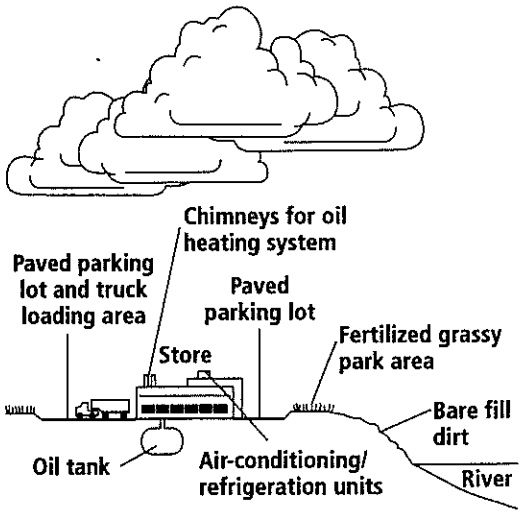
b. the erosion of sediments into surface water.

c. the concentration of ozone in the atmosphere.

d. the concentration of sulfur oxides and nitrogen oxides in the atmosphere.

Type C

Base your answers to questions 32 and 33 on the diagram below. The diagram shows a developed area of land.



32. Describe one way in which human activity at this site could have a negative impact on water resources and one way in which it could have a negative impact on air resources.

33. Name one action that could help prevent the area of bare fill dirt from eroding into the river. Explain why this action would be effective.

Base your answers to questions 34 and 35 on the diagram below. The diagram shows a cross section of a completed landfill and the wells used to monitor it.

34. Suppose the concentration of pollutants at well A were identical to the concentration of pollutants at well D. Give one conclusion that can be drawn about the landfill based on this information.

35. What is the most likely purpose of wells B and C? What information can they provide that wells A and D cannot?