Physical Geography: Earth Environments and Systems

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CHAPTER PREVIEW

Physical geography investigates and seeks to explain the spatial aspects, functions, and characteristics of Earth's physical phenomena.

- Why is geography often called the spatial science?
- Why are the topics of spatial interaction and change important in physical geography?

Although it is closely related to many other sciences, physical geography has its own unique focus and perspectives for studying Earth.

- What are the three major perspectives of physical geography?
- Why is a holistic approach important to understanding physical geography?

The use of models and the analysis of various Earth systems are important research and educational techniques used by geographers.

- What kinds of models may be used to portray Earth, its features, and its physical processes?
- In what ways can systems analysis lead to an understanding of complex environments?

Unlike some other physical sciences, physical geography places a special emphasis on human–environment relationships.

- Why is geography so important in the study of the environmental sciences today?
- Why do ecosystems provide such excellent opportunities for physical geographers to study the interactions between humans and the natural environment?

Every physical environment offers an array of advantages as well as challenges or hazards to the human residents of that location.

- What environmental adaptations are necessary for humans to live in your area?
- What impacts do humans have on the environment where you live?

◀ **Earth's incredible environmental diversity: An oasis of life in the vastness of space.**

Image provided by GeoEye and NASA SeaWiFs Project

Viewed from far enough away to see an entire hemisphere, Earth is both beautiful and intriguing—a life-giving planetary oasis. From this perspective we can begin to appreciate "the big picture," a global view of our planet's physical geography through its display of environmental diversity. Characteristics of the oceans, the atmosphere, the landmasses, and evidence of life as revealed by vegetated regions, are apparent. Looking carefully, we can recognize geographic patterns, shaped by the processes that make our world dynamic and ever-changing. Except for the external addition of energy from the sun, our planet is a self-contained system that has all the requirements to sustain life.

Earth may seem immense and almost limitless from the perspective of humans living on its surface. In contrast, viewing the "big picture" reveals its conspicuous limits and fragility—a spherical island of life surrounded by the vast, dark emptiness of space. However, from our vantage point in space, we cannot comprehend the details of how processes involving air, water, land, and living things interact to create a diverse array of landscapes and environmental conditions on Earth. These distant images display the basic aspects of Earth that make our existence possible, but they only hint at the complexity of our planet. Being aware of "the big picture" is important, but this knowledge should be bolstered by a detailed understanding of how Earth's features and processes interact to develop the extraordinary environmental diversity that exists on our planet. Developing this understanding is the goal of a course in physical geography.

The Study of Geography

Geography is a word that comes from two Greek roots. *Geo-* refers to "Earth," and *-graphy* means "picture or writing." The primary objective of geography is the examination, description, and explanation of Earth—its variability from place to place, how places and features change over time, and the processes responsible for these variations and changes. Geography is often called the **spatial science** because it includes recognizing, analyzing, and explaining the variations, similarities, or differences in phenomena located (or distributed) on Earth's surface. The major geographic organizations in the United States have provided us with a good description of geography.

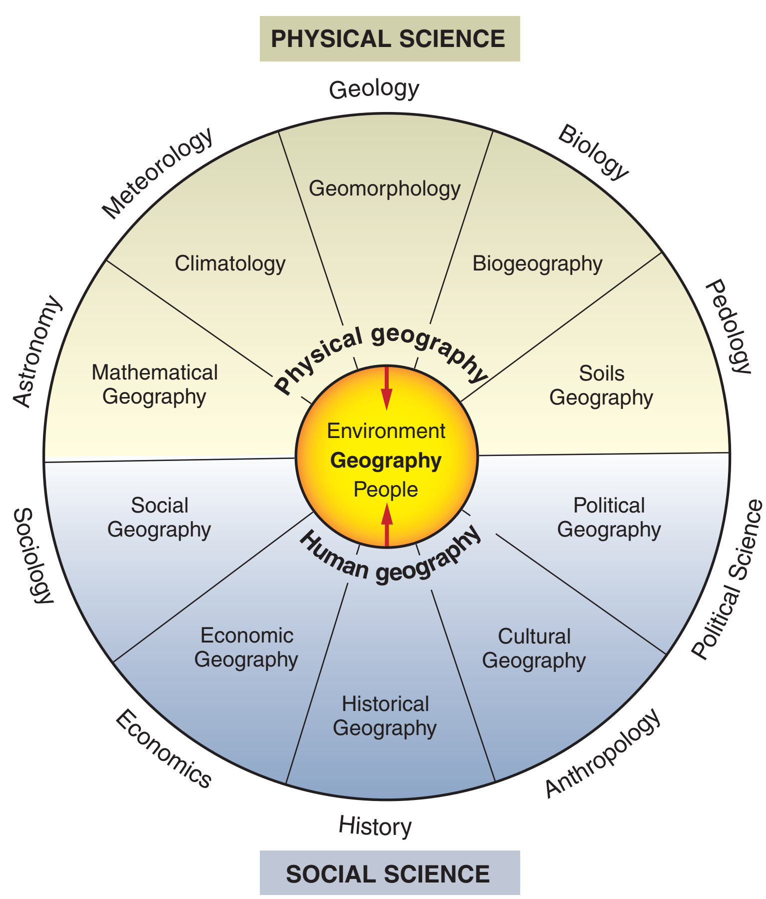
> Where is something located? Why is it there? How did it get there? How does it interact with other things? Geography is not a collection of arcane information. Rather it is the study of spatial aspects of human existence.
>
> People everywhere need to know about the nature of their world and their place in it. Geography has much more to do with asking questions and solving problems than it does with rote memorization of facts.
>
> So what exactly is geography? It is an integrative discipline that brings together the physical and human dimensions of the world in the study of people, places, and environments. Its subject matter is the Earth's surface and the processes that shape it, the relationships between people and environments, and the connections between people and places.
>
> Geography Education Standards Project, 1994
> *Geography for Life*

Geography is distinctive among the sciences by virtue of its definition and central purpose. Unlike most scientists in related disciplines (for example, biologists, geologists, chemists, economists), who are bound by the phenomena they study, geographers may focus their research on nearly any topic related to the scientific analysis of human or natural processes on Earth (• Fig. 1.1). Geographers generally consider all of the human and natural phenomena that are relevant to a given problem or issue; in other words, they often take a **holistic** approach to understanding aspects of our planet.

Geographers study the physical and/or human characteristics of places, seeking to identify and explain characteristics that two or more locations may have in common as well as why places vary in their geographic attributes. Geographers gather, organize, and analyze many kinds of geographic data and information, yet a unifying factor among them is a focus on explaining spatial locations, distributions, and relationships. They apply a variety of skills, techniques, and tools to the task of answering geographic questions. Geographers also study processes that influenced Earth's landscapes in the past, how they continue to affect them today, how a landscape may change in the future, and the significance or impact of these changes.

Because geography embraces the study of virtually any global phenomena, it is not surprising that the subject has many subdivisions and it is common for geographers to specialize in one or more subfields of the discipline. Geography is also subdivided along academic lines; some geographers are social scientists and some are natural scientists, but most are involved in studying human or natural processes and how they affect our planet, as well as the interactions among these processes. The main subdivision that deals with human activities and the impact of these activities is called cultural or **human geography.** Human geographers are concerned with such subjects as population distributions, cultural patterns, cities and urbanization, industrial and commercial location, natural resource utilization, and transportation networks (• Fig. 1.2). Geographers are interested in how to divide and synthesize areas into meaningful divisions called **regions,** which are areas identified by certain characteristics they contain that make them distinctive and distinguish them from surrounding areas. A

• FIGURE 1.1
When conducting research or examining one of society's many problems, geographers are prepared to consider any information or aspect of a topic that relates to their studies.
What advantage might a geographer have when working with other physical scientists seeking a solution to a problem?



USGS/Cascades Volcano Observatory

FIGURE 1.2
Settlement patterns, economic activities, recreational opportunities, and many aspects of human activities are a function of interactions among geographic factors, both human and physical.
What human geographic characteristics can you interpret from this scene?

region can be defined by characteristics that are physical, human, or a combination of factors. Geographic study that concentrates on both the general physical and human characteristics of a region, such as Canada, the Great Plains, the Caribbean, or the Sahara, is termed **regional geography.**

Physical Geography

Physical geography encompasses the processes and features that make up Earth, including human activities where they interface with the environment. In fact, physical geographers are concerned with nearly all aspects of Earth and can be considered generalists because they are trained to view a natural environment in its entirety, and how it functions as a unit (Fig. 1.3). However, after completing a broad education in basic physical geography, most physical geographers focus their expertise on advanced study in one or two specialties. For example, *meteorologists* and *climatologists* consider how the interaction of atmospheric components influences weather and climate. Meteorologists are interested in the atmospheric processes that affect daily weather, and they use current data to forecast weather conditions. Climatologists are interested in the averages and extremes of long-term weather data, regional classification of climates, monitoring and understanding climatic change and climatic hazards, and the long-range impact of atmospheric conditions on human activities and the environment.

The study of the nature, development, and modification of landforms is a specialty called *geomorphology*, a major subfield of physical geography. Geomorphologists are interested in understanding and explaining variation in landforms, the processes that produce physical landscapes, and the nature and geometry of Earth's surface features. The factors involved in landform development are as varied as the environments on Earth, and include gravity, running water, stresses in the Earth's crust, flowing ice in glaciers, volcanic activity, and the erosion or deposition of Earth's surface materials. *Biogeographers* examine natural and human-modified environments and the ecological processes that influence their characteristics and distributions, including vegetation change over time. They also study the ranges and patterns of vegetation and animal species, seeking to discover the environmental factors that limit or facilitate their distributions. Many *soil scientists* are geographers, who are involved in mapping and analyzing soil types, determining the suitability of soils for certain uses, such as agriculture, and working to conserve soil as a natural resource.

• FIGURE 1.3
Physical geographers study the elements and processes that affect natural environments. These include rock structures, landforms, soils, vegetation, climate, weather, and human impacts.
What physical geography characteristics can you interpret from this scene?

Finally, because of the critical importance of water to life on Earth, geographers are widely involved in the study of water bodies and their processes, movements, impact, quality, and other characteristics. They may serve as *hydrologists, oceanographers*, or *glaciologists*. Many geographers involved with water studies also function as water resource managers, who work to ensure that lakes, watersheds, springs, and groundwater sources are suitable to meet human or environmental needs, provide an adequate water supply, and are as free of pollution as possible.

Technology, Tools, and Methods

The technologies that physical geographers use in their efforts to learn more about Earth are rapidly changing. The abilities of computer systems to capture, process, model, and display spatial data—functions that can be performed on a personal computer—were only a dream 30 years ago. Today the Internet provides access to information and images on virtually any topic. The amounts of data, information, and imagery available for studying Earth and its environments have exploded. Graphic displays of environmental data and information are becoming more vivid and striking as a result of sophisticated methods of data processing and visual representation. Increased computer power allows the presentation of high-resolution images, three-dimensional scenes, and animated images of Earth features, changes, and processes (• Fig. 1.4).

Continuous satellite imaging of Earth has been ongoing for more than 30 years, which has given us a better perspective on environmental changes as they occur. Using satellite imagery it is possible to monitor changes in a single place over time or to compare different places at a point in time. Using various energy sources to produce images from space, we are able to see, measure, monitor, and map processes and the effects of certain processes including many that are invisible to the naked eye. Satellite technology is being used to determine the precise location of a positioning receiver on Earth's surface, a capability that has many useful applications for geography and mapping. Today, most mapmaking (*cartography*) and many aspects of map analysis are computer-assisted operations, although the ability to visually interpret a map, a landscape, or an environmental image remains an important geographic skill.

Making observations and gathering data in the field are valuable skills for most physical geographers, but they must

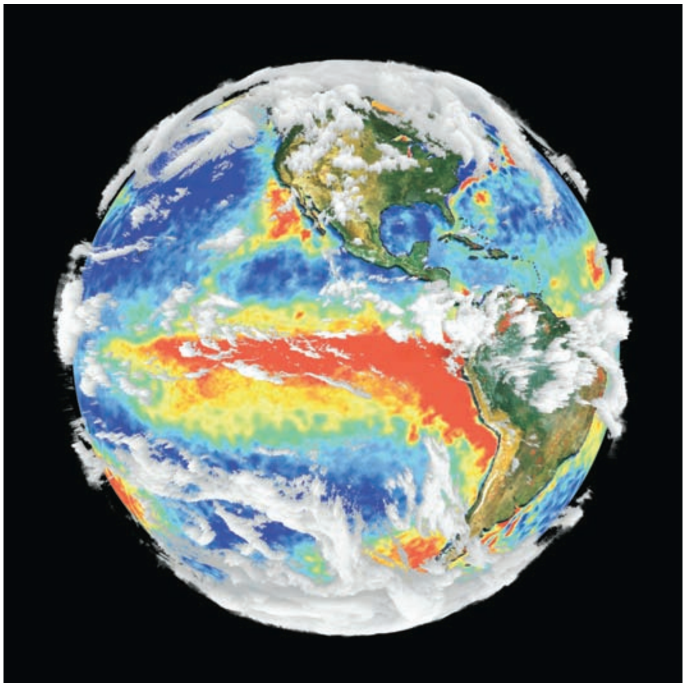


Image by R. B. Husar, Washington University; the land layer from the SeaWiFS Project; fire maps from the European Space Agency; the sea surface temperature from the Naval Oceanographic Office's Visualization Laboratory; and cloud layer from SSEC, University of Wisconsin

• FIGURE 1.4
Complex computer-generated model of Earth, based on data gathered from satellites.
How does this image compare to the Earth image in the chapter opening?

• FIGURE 1.5
A geographer uses computer technology to analyze maps and imagery.
In what ways are computer-generated maps and landscape images helpful in studies of physical geography?

© Ashley Cooper/CORBIS

also keep up with new technologies that support and facilitate traditional fieldwork. Technology may provide maps, images, and data, but a person who is knowledgeable about the geographical aspects of the subject being studied is essential to the processes of analysis and problem solving (• Fig. 1.5). Many geographers are gainfully employed in positions that apply technology to the problems of understanding our planet and its environments, and their numbers are certain to increase in the future.

Major Perspectives in Physical Geography

Your textbook has been designed to demonstrate three major perspectives that physical geography emphasizes: spatial science, physical science, and environmental science. Although the emphasis on each of these perspectives may vary from chapter to chapter, the contributions of all three perspectives to scientific study will be apparent throughout the book. As you read this chapter, take note of how directly each scientific perspective relates to the unique nature of geography as a discipline.

The Spatial Science Perspective

A central role of geography among the sciences is best illustrated by its definition as the ***spatial science*** (the science of Earth space). No other discipline has the specific responsibility for investigating and attempting to explain the spatial aspects of Earth phenomena. Even though physical geographers may have many divergent interests, they share a common goal of understanding and explaining the spatial variation existing on Earth's surface.

How do physical geographers examine Earth from a spatial point of view? What are the spatial questions that physical geographers raise, and what are some of the problems they seek to understand and solve? From among the nearly unlimited number of topics available to physical geographers, we have chosen five to clearly illustrate the role of geography as the spatial science. In keeping with the quote from *Geography for Life*, that geography is about asking questions and solving problems, common study questions have been included for each topic.

Location Geographic knowledge and studies often begin with locational information. The location of a feature usually employs one of two methods: **absolute location,** which is expressed by a coordinate system (or address), or **relative location,** which identifies where a feature exists in relation to something else, usually a fairly well-known location. For example, Pikes Peak, in the Rocky Mountains of Colorado, with an elevation of 4302 meters (14,115 ft), has a location of latitude 38°51' north and longitude 105°03' west. A global address like this is an absolute location. However, another way to report its location would be to state that it is 36 kilometers (22 mi) west of Colorado Springs (• Fig. 1.6). This is an example of relative location (its position in relation to Colorado Springs). Typical spatial

GEOGRAPHY'S SPATIAL SCIENCE PERSPECTIVE

The Regional Concept: Natural and Environmental Regions

The term *region* is familiar to us all, but it has a precise meaning and special significance to geographers. Simply stated, a region is an area that is defined by a certain shared characteristic (or a set of characteristics) existing within its boundaries. Regions are spatial models, just as systems are operational models. Systems help us understand how things work, and regions help us make spatial sense of our world. The concept of a region is a tool for thinking about and analyzing logical divisions of areas based on their geographic characteristics. Just as it helps us to understand Earth by considering smaller parts of its overall system, dividing space into coherent regions helps us understand the arrangement and nature of areas on our planet. Regions can be described based on either human or natural characteristics, or a combination of the two.

Regions can also be divided into subregions. For example, North America is a region, but it can be subdivided into many subregions. Examples of subregions based on natural characteristics include the Atlantic Coastal Plain (similarity of landforms, geology, and locality), the Prairies (ecological type), the Sonoran Desert (climate type, ecological type, and locality), the Pacific Northwest (general locality), and Tornado Alley (region of high potential for these storms).

The regions that physical geographers are mainly interested in are based on *natural* and human–environmental characteristics. The term natural, as used here, means

USDA Forest Service

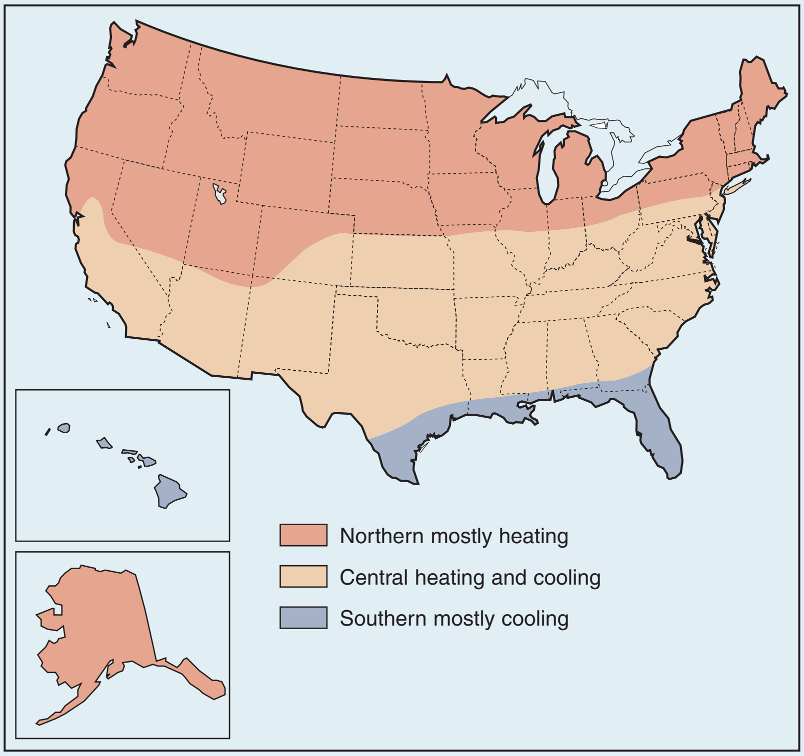
The Great Basin of the Western United States is a landform region that is clearly defined based on important physical geographic characteristic. No rivers flow to the ocean from this arid and semiarid region of mountains and topographic basins. The rivers and streams that exist flow into enclosed basins, where the water evaporates away from temporary lakes, or they flow into lakes like the Great Salt Lake, which has no outlet to the sea. Topographic features called drainage divides (mountain ridges) form the outer edges of the Great Basin, defining and enclosing this natural region. **Using topographic maps of the region, would it be relatively easy to outline the Great Basin?**

primarily related to natural processes and landscape features. However, we recognize that today human activities have an impact on virtually every natural process, and human–environmental regions offer significant opportunities for geographic analysis. Geographers not only study and explain regions, their locations, and their characteristics but also strive to delimit them—to outline their boundaries on a map. An unlimited number of regions can be derived for each of the four major Earth subsystems.

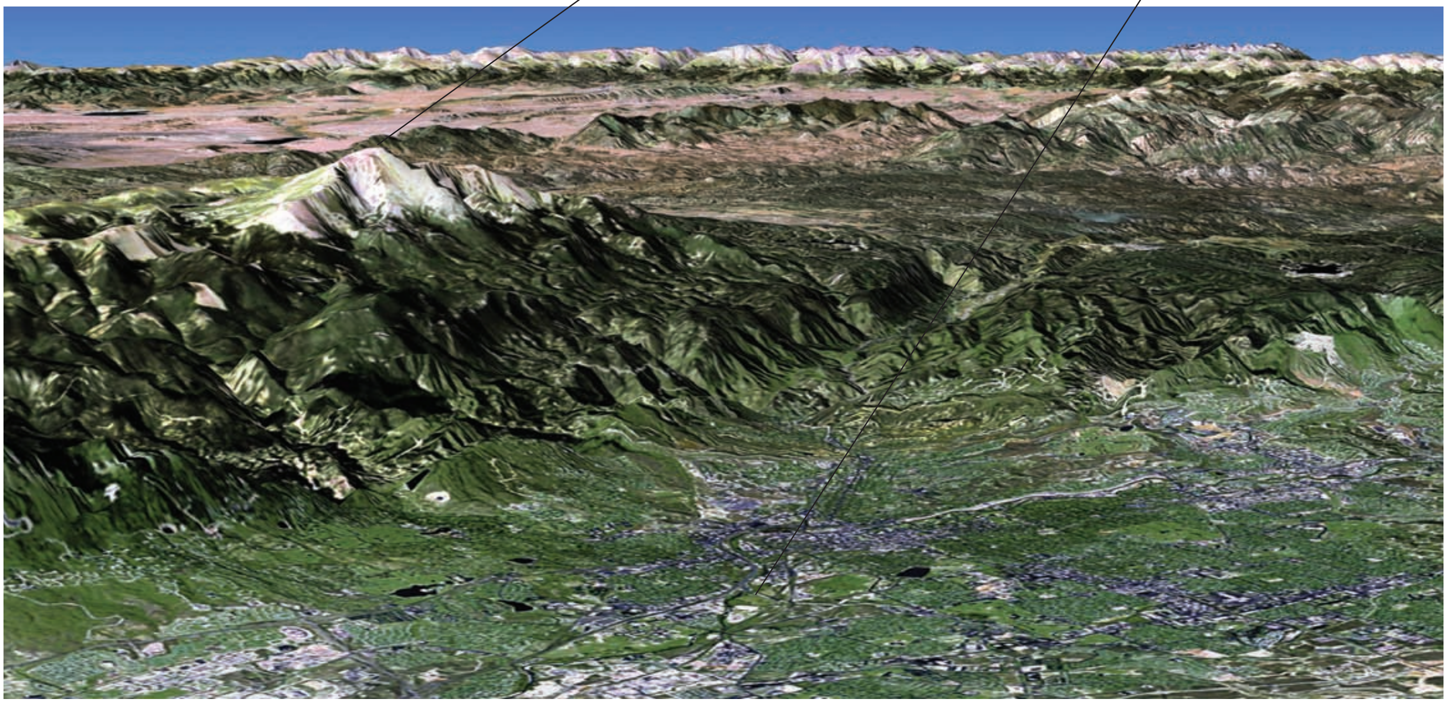
There are three important points to remember about natural and environmental regions. Each of these points has endless applications and adds considerably to the questions that the process of defining regions based on spatial characteristics seeks to answer.

- **Natural regions can change in size and shape over time in response to environmental changes.** These changes can be fast enough to observe as they occur, or so gradual that they require intensive study to detect. An example is desertification, the expansion of desert regions that has occurred in recent years in response to climatic change and human impacts on the land, such as overgrazing, which can form a desertlike landscape. Using images from space, we can see and monitor changes in the area covered by deserts, as well as other natural regions.
- **Boundaries separating different natural or environmental regions tend to be indistinct or transitional, rather than sharp.** For example, on a climate map, lines separating desert from nondesert regions do not imply that extremely arid conditions instantly appear when the line is crossed; rather, if we travel to a desert, it is likely to get progressively more arid as we approach our destination.
- **Regions are spatial models, devised by humans, for geographic analysis, study, and understanding.** Natural or environmental regions, like all regions, are conceptual models that are specifically designed to help us comprehend and organize spatial relationships and geographic distributions. Learning geography is an invitation to think spatially, and regions provide an essential, extremely useful, conceptual framework in that process.

Understanding regions, through an awareness of how areas can be divided into geographically logical units and why it is useful to do so, is essential in geography. Regions help us to understand, reason about, and make sense of, the spatial aspects of our world.



This human–environmental map divides the United States into three regions based on annual heating and cooling needs. Using spatial climatic data, the United States was divided into regions according to their similar home-heating or -cooling requirements. The reddish-brown means that heating is required more often than cooling. The tan region represents roughly equal heating and cooling needs. Blue represents a stronger or greater demand for cooling than for heating. The map is clearly related to climate regions. **Do you think that the boundaries between these regions are as sharply defined in reality as they are on this map? Can you recognize the spatial patterns that you see? Do the shapes of these regions, and the ways that they are related to each other, seem spatially logical?**



© NASA/Goddard Space Flight Center/Earth Observatory

• FIGURE 1.6
A three-dimensional digital model shows the relative location of Pikes Peak to Colorado Springs, Colorado. Because this is a perspective view, the 36-km (22-mi) distance appears to be shorter than its actual ground distance. A satellite image was merged with elevation data gathered by radar from the space shuttle to create this scene.
What can you learn about the physical geographic characteristics of this place from the image?

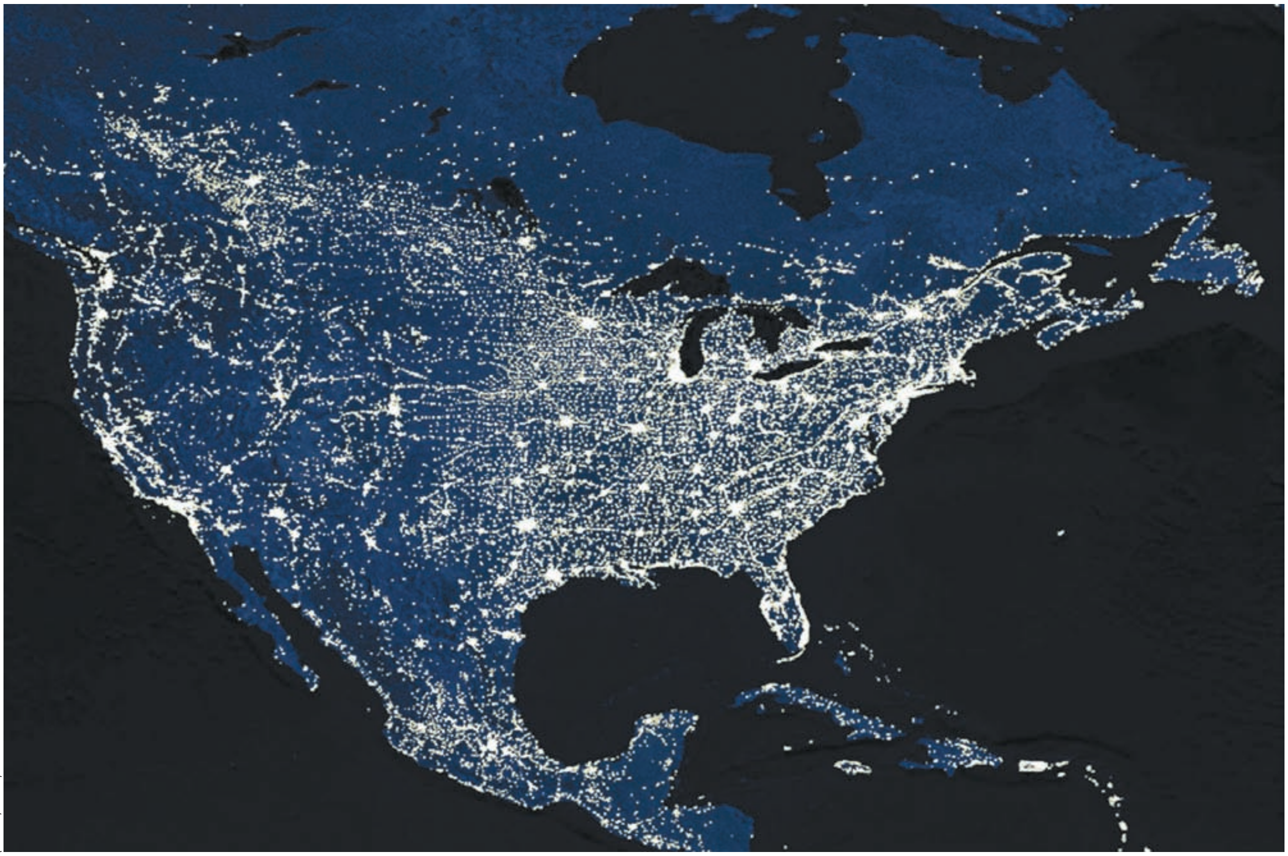
questions involving location include the following: *Where is a certain type of Earth feature found, and where is it not found? Why is a certain feature located where it is? What methods can we use to locate a feature on Earth? How can we describe its location? What is the most likely or least likely location for a certain Earth feature?*

Characteristics of Places Physical geographers are interested in the environmental features and processes that combine to make a place unique, and they are also interested in the shared characteristics between places. For example, what physical geographic features make the Rocky Mountains appear as they do? Further, how are the Appalachian Mountains different from the Rockies, and what characteristics are common to both of these mountain ranges? Another aspect of the characteristics of places is analyzing the environmental advantages and challenges that exist in a place. Other examples might include: *How does an Australian desert compare to the Sonoran Desert of the southwestern United States? How do the grasslands of the Great Plains of the United States compare to the grasslands of Argentina? What are the environmental conditions at a particular site? How do places on Earth vary in their environments, and why? In what ways are places unique, and in what ways do they share similar characteristics with other places?*

Spatial Distributions and Spatial Patterns

When studying how features are arranged in space, geographers are usually interested in two spatial factors. **Spatial distribution** means the extent of the area or areas where a feature exists. For example, where on Earth do we find the tropical rainforests? What is the distribution of rainfall in the United States on a particular day? Where on Earth do major earthquakes occur? **Spatial pattern** refers to the arrangement of features in space—are they regular or random, clustered together or widely spaced? The distribution of population can be either dense or sparse (• Fig. 1.7). The spatial pattern of earthquakes may be aligned on a map because earthquake faults display similar linear patterns. *Where are certain features abundant, and where are they rare? How are particular factors or elements of physical geography arranged in space, and what spatial patterns exist, if any? What processes are responsible for these distributions or patterns? If a spatial pattern exists, what does it signify?*

Spatial Interaction Few processes on Earth operate in isolation; areas on our planet are interconnected, which means linked to conditions elsewhere on Earth. A condition, an occurrence, or a process in one place generally has an impact on other places. Unfortunately, the exact nature of this **spatial interaction** is often difficult to establish with certainty except after years of study. A cause–effect relationship can often only be suspected because a direct relationship is often difficult to prove. It is much easier to observe that changes seem to be associated with each other, without knowing if one event causes the other or if this result is coincidental.



Data courtesy Marc Imhoff (NASA/GSFC) and Christopher Elvidge (NOAA/NGDC). Image by Craig Mayhew (NASA/GSFC) and Robert Simmon (NASA/GSFC).

FIGURE 1.7

A nighttime satellite image provides several good illustrations of distribution and pattern, shown here on most of North America. Spatial distribution is where features are located (or perhaps, absent). Spatial pattern refers to their arrangement. Geographers seek to explain these spatial relationships.

Can you locate and propose possible explanations for two patterns and two distributions in this scene?

For example, the presence of abnormally warm ocean waters off South America's west coast, a condition called El Niño, seems to be related to unusual weather in other parts of the world. Clearing the tropical rainforest may have a widespread impact on world climates. Interconnections are one reason for considering interactions, impacts, and their potential links, at various scales from local, to regional, to global. *What are the relationships among places and features on Earth? How do they affect one another? What important interconnections link the oceans to the atmosphere and the atmosphere to the land surface?*

Ever-Changing Earth Earth's features and landscapes are continuously changing in a spatial context. Weather maps show where and how weather elements change from day to day, over the seasons, and from year to year. Storms, earthquakes, landslides, and stream processes modify the landscape. Coastlines may change position because of storm waves, tsunamis, or changes in sea level. Areas that were once forested have been clear-cut, changing the nature of the environment there. Vegetation and wildlife are becoming reestablished in areas that were devastated by recent volcanic eruptions or wildfires. Desertlike conditions seem to be expanding in many arid regions of the world. Volcanic islands have been created in historic times (Fig. 1.8), and a new Hawaiian island is now forming beneath the waters of the Pacific Ocean.

World climates have changed throughout Earth's history, with attendant shifts in the distributions of plant and animal life. Today, changes in Earth's climates and environments are complicated by the impact of human activities. Earth and its environments are always changing, although at different time scales so the impact and direction of certain changes can be difficult to ascertain. *How are Earth features changing in ways that can be recorded in a spatial sense? What processes contribute to the change? What is the rate of change? Does change occur in a cycle? Can humans witness this change as it is taking place, or is a long-term study required to recognize the change? Do all places on Earth experience the same levels of change, or is there spatial variation?*

The previous five topics illustrate geography's strong emphasis on the spatial perspective. Learning the relevant questions to ask is the first step toward finding answers and explanations, and it is a major objective of your physical geography course.

Icelandic Ministry for the Environment

• FIGURE 1.8
Surtsey, Iceland, is an island in the north Atlantic that did not exist until about 45 years ago when undersea eruptions reached the ocean surface to form this new volcanic island. Since the 1960s when the volcanic eruptions stopped, erosion by waves and other processes have reduced the island by half of its original size.
Once the island formed and cooled, what other environmental changes should slowly begin to take place?

The Physical Science Perspective

As physical geographers apply their expertise to the study of Earth, they observe phenomena, compile data, and seek solutions to problems or the answers to questions that are also of interest to researchers in one or more of the other physical sciences. Physical geographers who specialize in climatology share many ideas and information with atmospheric physicists. Soil geographers study some of the same elements and compounds analyzed by chemists. Biogeographers are concerned about environments that support the same plants and animals that are classified by biologists. However, to whatever questions are raised and whatever problems require a solution, physical geographers bring unique points of view—a spatial perspective and a holistic approach that will carefully consider all Earth phenomena that may be involved. Physical geographers are concerned with the processes that affect Earth's physical environments at scales from global to regional to local. By examining the factors, features, and processes that influence the environment and learning how these elements work together, we can better understand our planet's ever-changing physical geography. We can also appreciate the importance of viewing Earth in its entirety as a constantly functioning system.

The Earth System A **system** is any entity that consists of interrelated parts or components, and the analysis of systems provides physical geographers with ideal opportunities to study these relationships as they affect Earth's features and environments. Earth certainly fits this definition because many continuously changing variables combine to make our home planet, the **Earth system,** function the way that it does. The individual components of a system, termed **variables,** are studied or grouped together because these variables interact with one another as parts of a functioning unit.

A change in one aspect of the Earth system affects other parts, and the impact of these changes can be significant enough to appear in regional or even worldwide patterns, clearly demonstrating the interconnections among these variables. For example, the presence of mountains influences the distribution of rainfall, and variations in rainfall affect the density, type, and variety of vegetation. Plants, moisture, and the underlying rock affect the kind of soil that forms in an area. Characteristics of vegetation and soils influence the runoff of water from the land, leading to completion of the circle, because the amount of runoff is a major factor in stream erosion, which eventually can reduce the height of mountains. Many cycles such as this operate

GEOGRAPHY'S PHYSICAL SCIENCE PERSPECTIVE

The Scientific Method

Science . . . is the systematic and organized inquiry into the natural world and its phenomena. Science is about gaining a deeper and often useful understanding of the world.

Multicultural History of Science web page, Vanderbilt University

The real purpose of the scientific method is to make sure nature hasn't misled you into thinking you know something you don't actually know.

Robert M. Pirsig,
Zen and the Art of Motorcycle Maintenance

Physical geography is a science that focuses on the Earth system, how its components and processes interact, and how and why aspects that affect Earth's surface are spatially arranged, as well as how humans and their environments are interrelated.

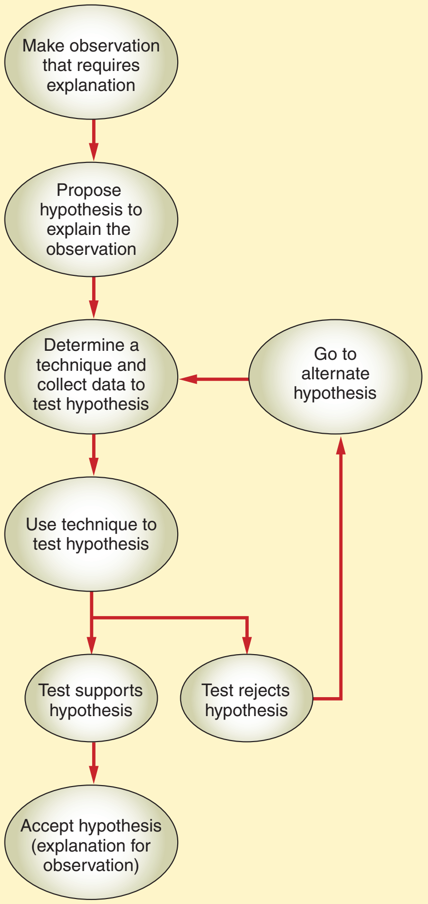
To wonder about your environment and attempt to understand it is a fundamental basis of human life. Increasing our awareness, satisfying our curiosity, learning how our world works, and determining how we can best function within it are all parts of a satisfying but never-ending quest for understanding. Without curiosity about the world, supported by making observations, noting relationships and patterns, and applying the knowledge discovered, humans would not have survived beyond their earliest beginnings. Science gives us a method for answering questions and testing ideas by examining evidence, drawing conclusions, and making new discoveries.

The sciences search for new knowledge using a strategy that minimizes the possibility of erroneous conclusions. This highly adaptable process is called the *scientific method*. It is a general framework for research, but it can accommodate an infinite number of topics and strategies for deriving conclusions. Although the scientific method is strongly associated with the physical sciences, it is applicable to nearly all fields of scientific research including studies that involve all three perspectives in physical geography—the physical, environmental, and spatial sciences.

Scientific method generally involves the following steps:

- **Making an observation that requires an explanation.** We may wonder if the observation represents a general pattern or is a "fluke" occurrence. For example, on a trip to the mountains, you notice that it gets colder as you go up in elevation. Is that just a result of conditions on the day you were there, or just the conditions at the location where you were, or is it a relationship that generally occurs everywhere?
- **Restating the observation as a hypothesis.** Here is an example: As we go higher in elevation, the temperature gets cooler (or, as a question, Does it get cooler as we go up in elevation?). The answer may seem obvious, yet it is generally but not always true, depending on environmental conditions that will be discussed in later chapters. Many scientists recommend a strategy called *multiple working hypotheses*, which means that we consider and test many possible hypotheses to discover which one best answers the questions while eliminating other possibilities.
- **Determining a technique for testing the hypothesis and collecting necessary data.** The next step is finding a technique for evaluating data (numerical information) and/or facts that concern that hypothesis. In our example, we would gather temperature and elevation data (taken at about the same time for all data points) for the area we are studying.
- **Applying the technique or strategy to test the validity of the hypothesis.** Here we discover if the hypothesis is supported by adequate evidence, collected under similar conditions to minimize bias. The technique will recommend either acceptance or rejection of the hypothesis.

If the hypothesis is rejected, we can test an alternate hypothesis or modify our existing one and try again, until we discover a hypothesis that is supported by the data. If the test supports the hypothesis, our observation is confirmed, at least for the location and environmental conditions in which our data and information were gathered.



Steps in applying the scientific method.

After similar tests are conducted, if the hypothesis is supported in many places and under other conditions, then the hypothesis may become a theory. Theories are well-tested concepts or relationships that, given specified circumstances, can be used to explain and predict outcomes.

The processes of asking questions, seeking answers, and finding solutions through the scientific method have contributed greatly to human existence, our technologies, and our quality of life. Obviously, there are always more questions to be answered and problems yet to be solved. In fact, new findings typically yield new questions. Human curiosity, along with an intrinsic need for knowledge through observation and experience, has formed the basis for scientific method, an objective, structured approach that leads us toward the primary goal of physical geography—understanding how our world works.

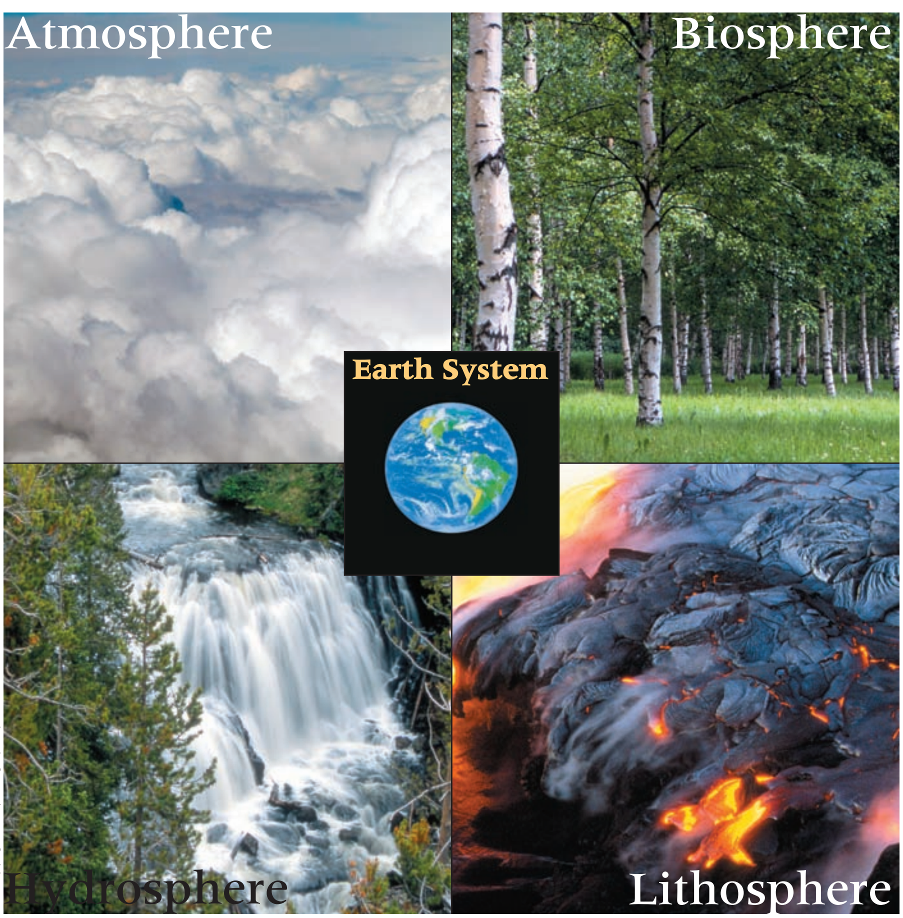
to change our planet, but the Earth system is complex, and these cycles and processes operate at widely varying rates and over widely varying time spans.

Earth's Major Subsystems Systems can be divided into **subsystems**, which are functioning units of a major system and demonstrate strong internal connections (for example, a car has a fuel system, an electrical system, and a suspension system, etc.). Examining the Earth system as being composed of a set of interdependent subsystems is a major concept in understanding the physical sciences. The Earth system comprises four major subsystems (● Fig. 1.9). The **atmosphere** is the gaseous blanket of air that envelops, shields, and insulates Earth. The movements and processes of the atmosphere create the changing conditions that we know as weather and climate. The solid Earth—landforms, rocks, soils, and minerals—makes up the **lithosphere.** The waters of the Earth system—oceans, lakes, rivers, and glaciers—constitute the **hydrosphere.** The fourth major division, the **biosphere,** is composed of all living things: people, other animals, and plants.

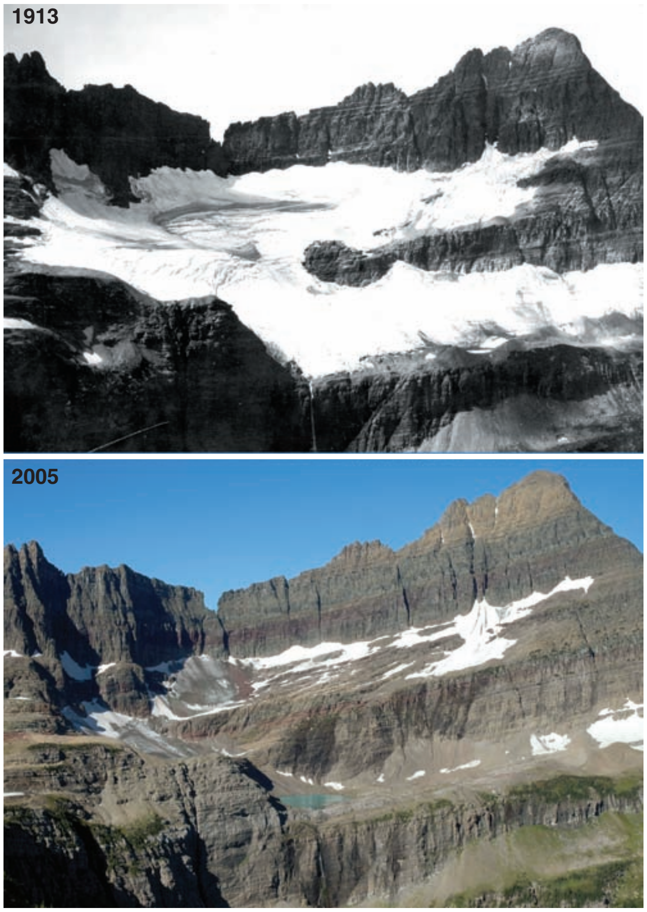
It is the nature of these four major subsystems and the interactions among them that create and nurture the conditions necessary for life on Earth. For example, the hydrosphere provides the water supply for life on Earth, including humans, and provides a home environment for aquatic plants and animals. The hydrosphere directly affects the lithosphere as water moving in streams, waves, and currents shapes landforms. It also influences the atmosphere through evaporation, condensation, and the effects of ocean temperatures on climate. The impact and intensity of interactions among Earth's subsystems are not identical everywhere on our planet, and it is these variations that lead to the geographic patterns of environmental diversity.

Many other examples of overlap exist among these four major subsystems of Earth. Soil can be examined as part of the lithosphere, the biosphere, or the hydrosphere, because soils typically contain minerals, organisms, and water (and gases as well). The water stored in plants and animals is part of both the biosphere and the hydrosphere, and the water in clouds is a component of the atmosphere as well as the hydrosphere. The fact that we cannot draw sharp boundaries between these divisions underscores the interrelatedness among various components of the Earth system. However, like a machine, a computer, or the human body, planet Earth is a system that functions well only when all of its parts (and its subsystems) work together harmoniously.

Earth Impacts We are aware that the Earth system is *dynamic*, responding to continuous changes in its four major subsystems, and that we can directly observe some of these changes—the seasons, the ocean tides, earthquakes, floods, volcanic eruptions. Other aspects of our planet may take years, or even more than a lifetime, to accumulate enough change so that humans can recognize their impact. Long-term changes in our planet are often difficult to understand or predict with certainty. The evidence must be carefully and scientifically studied to determine what is really occurring and what the potential consequences might be (● Fig. 1.10). Changes of this type include shifts in world climates, drought cycles, the spread of deserts, worldwide rise or fall in sea level, erosion of coastlines, and major changes in river systems. Yet understanding changes in our planet is critical to human existence. We are, after all, a part of the Earth system. Changes in the system may be naturally caused or human induced, or they may result from a combination of these factors. Today, much of the concern about environmental changes, such as the many potential impacts of global warming, centers on the increasing impact that human activities are exerting on Earth's natural systems. To understand our planet, therefore, we must learn about its components and the processes that operate to change or regulate the Earth system. Such knowledge is in the best interest for humankind as they interact with and influence Earth's natural systems, which form the habitat for all living things.



● **FIGURE 1.9**
Earth's four major subsystems. Studying Earth as a system is central to understanding changes in our planet's environments and adjusting to or dealing with these changes. Earth consists of many interconnected subsystems.
How do these systems overlap? For example, how does the atmosphere overlap with the hydrosphere, or the biosphere?



Top, W. C. Alden (USGS), Courtesy of Glacier National Park Archives; Bottom, Blase Reardon (USGS), Courtesy of Glacier National Park Archives

● **FIGURE 1.10**
Photographs taken 92 years apart in Montana's Glacier National Park show that Shepard Glacier, like other glaciers in the park, has dramatically receded during that time. This retreat is in response to climate warming and droughts, which have reduced the amount of snowfall that would form into glacial ice. The U.S. Geological Survey estimates that if this climatic trend continues, the glaciers in the park will disappear by 2030.
What other kinds of environmental change might require long-term observation and recording of evidence?

The Environmental Science Perspective

Today, we regularly hear talk about the environment and ecology and we are concerned about damage to ecosystems caused by human activity. We also hear news reports of disasters caused by humans being exposed to such violent natural processes as earthquakes, floods, tornadoes, or the terrible consequences of the South Asia tsunami in 2004 and Hurricane Katrina in 2005. Newspapers and magazines often devote entire sections to discussions of these and other environmental issues. But what are we really talking about when we use words like *environment, ecology,* or *ecosystem?* In the broadest sense, our **environment** can be defined as our surroundings; it is made up of all physical, social, and cultural aspects of our world that affect our growth, our health, and our way of living.

Environments are also systems because they function through the interrelationships among many variables. Environmental understanding involves giving consideration to a wide variety of factors, characteristics, and processes involving weather, climate, soils, rocks, terrain, plants, animals, water, humans, and how these factors interconnect and interact with each other to produce an environment. The holistic approach of physical geography is an advantage in this understanding, because the potential influence of each of these factors must be considered not only individually, but also in terms of how they affect one another as parts of an environmental system.

Human Impacts Physical geographers are keenly interested in environmental processes and interactions, and they give special attention to the relationships that involve humans and their activities. Much of human existence throughout time has been a product of the adaptations that various cultures have made and the modifications they have imposed on their natural surroundings. Primitive skills and technology generally require people to make greater adjustments in adapting to their environment. The more complex a culture's technology is, the greater the amount of environmental modification. Thus, human–environment interaction is a two-way relationship, with the environment influencing human behavior and humans impacting the environment. Today, meeting the needs of a growing population exerts an ever-increasing pressure on our planet's resources and environments.

Just as humans interact with their environment, so do other living things. The study of relationships between organisms, whether animal or plant, and their environments is a science known as **ecology.** Ecological relationships are complex but naturally balanced "webs of life." Altering the natural ecology of a community of organisms may have negative results (although this is not always so). For example, filling in or polluting coastal marshlands may disrupt the natural ecology of those wetlands. As a result, fish spawning grounds may be destroyed, and the food supply of some marine animals and migratory birds could be depleted. The end product of certain environmental impacts may be the destruction of valuable plant and animal life. Human activities will always affect the environment in some way, but if we understand the factors and processes involved, we can minimize the negative impacts.

The word *ecosystem* is a contraction of *ecological system*. An **ecosystem** is a community of organisms and the relationships of those organisms to each other and to their environment (● Fig. 1.11). An ecosystem is dynamic in that its various parts are always in flux. For instance, plants grow, rain falls, animals eat, and soils develop—all changing the environment of a particular ecosystem. Because each member of the ecosystem belongs to the environment of every other part of that system, a change in one alters the environment for the others. As those components react to the alteration, they in turn continue to transform the environment for the others. A change in the weather, for example, from sunshine to rain, affects plants, soils, and animals. Heavy rain, however, may carry away soils and plant nutrients so that plants may not be able to grow as well and animals, in turn, may not have as much to eat. In contrast, the addition of moisture to the soil may help some plants grow, increasing the amount of shade beneath them and thus keeping other plants from growing.

GEOGRAPHY'S ENVIRONMENTAL SCIENCE PERSPECTIVE

Human–Environment Interactions

As the world population has grown, the effects of human activities on the environment, as well as the impacts of environmental processes on humans, have become topics of increasing concern. There are many circumstances where human–environment relationships have been mutually beneficial, yet two negative aspects of those interactions have gained serious attention in recent years. Certain environmental processes, with little or no warning, can become dangerous to human life and property, and certain human activities threaten to cause major, and possibly irrevocable, damage to Earth environments.

Earth Impacts

The environment becomes a hazard to humans and other life forms when relatively uncommon and extraordinary natural events occur that are associated most directly with the atmosphere, hydrosphere, or lithosphere. Living under the conditions provided by these three subsystems, it is elements of the biosphere, including humans, that suffer the damaging consequences of sporadic natural events of extraordinary intensity. The routine processes of these three subsystems become a problem and spawn environmental hazards for two reasons. First, on occasion and often unpredictably, they operate in an unusually intense or violent fashion. Summer showers may become torrential rains that occur repeatedly for days or even weeks. Ordinary tropical storms gain momentum as they travel over warm ocean waters, and they reach coastlines as full-blown hurricanes, as Hurricane Katrina did in 2005. Molten rock and associated gases from deep beneath Earth move slowly toward the surface and suddenly trigger massive eruptions that literally blow apart volcanic mountains. The 2004 tsunami wave that devastated coastal areas along the Indian Ocean provided an example of the potential for the occasional occurrences of natural processes that far exceed our expectable "norm."

Each of these examples of Earth systems operating in sudden or extraordinary fashion is a noteworthy environmental event, but it does not become an environmental hazard unless people or their properties are affected. Thus, the second reason environmental hazards exist is because people live where potentially catastrophic environmental events may occur.

Why do people live where environmental hazards pose a major threat? Actually, there are many reasons. Some people have no choice. The land they live on could be their land by birthright; it was their family's land for generations. Especially in densely populated developing nations, there may be no other place to go. Other people choose to live in hazardous areas because they believe the advantages outweigh the potential for natural disaster. They are attracted by productive farmland, the natural beauty of a region or building site, or the economic possibilities available at a location. In addition, nearly every populated area of the world is associated with an environmental

USGS Western Coastal and Marine Geology

Environmental impacts on humans: a destructive tsunami. In December of 2004, a powerful undersea earthquake generated a large tsunami, which devastated many coastal areas along the Indian Ocean, particularly in Thailand, Sri Lanka, and Indonesia. Nearly a quarter of a million people were killed, and the homes of about 1.7 million people were destroyed. Here a huge barge was left onshore by the tsunami, which leveled buildings, and stripped the vegetation from the cliffs to a height of 31 meters (102 ft). Some natural-environmental processes, like this one, can be detrimental to humans and their built environment, and others are beneficial. **Can you cite some examples of natural processes that can affect the area where you live?**

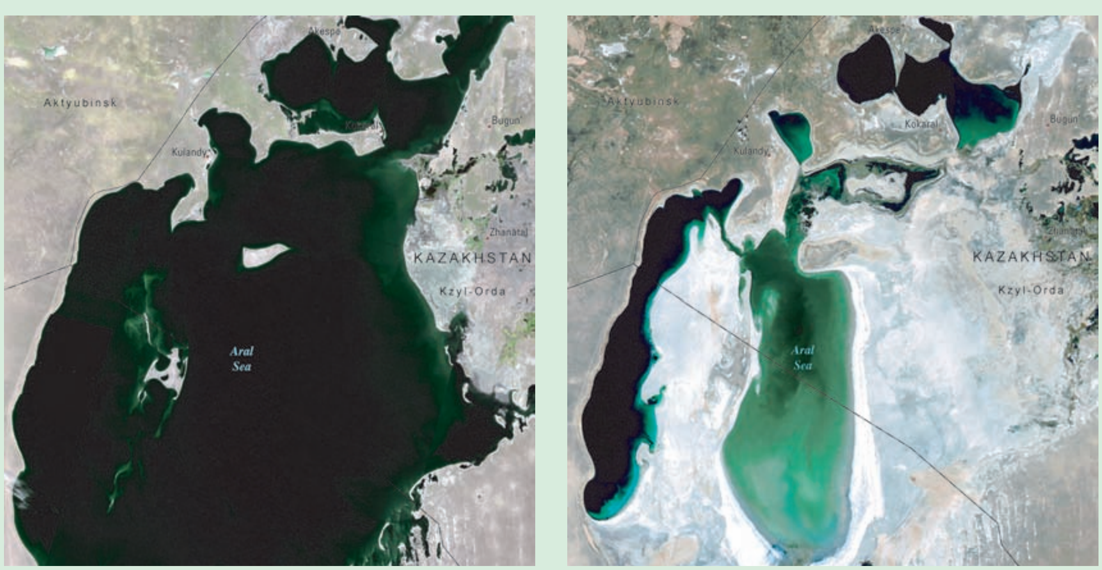
hazard or perhaps several hazards. Forested regions are subject to fire; earthquake, landslide, and volcanic activities plague mountain regions; violent storms threaten interior plains; and many coastal regions experience periodic hurricanes or typhoons (the term used for hurricanes that strike Asia).

Human Impacts

Just as the environment can pose an ever-present danger to humans, through their activities, humans can constitute a serious threat to the environment. Issues such as global warming, acid precipitation, deforestation and the extinction of biological species in tropical areas, damage to the ozone layer of the atmosphere, and desertification have risen to the top of agendas when world leaders meet and international conferences are held. Environmental concerns are recurring subjects of magazine and newspaper articles, books, and television programs.

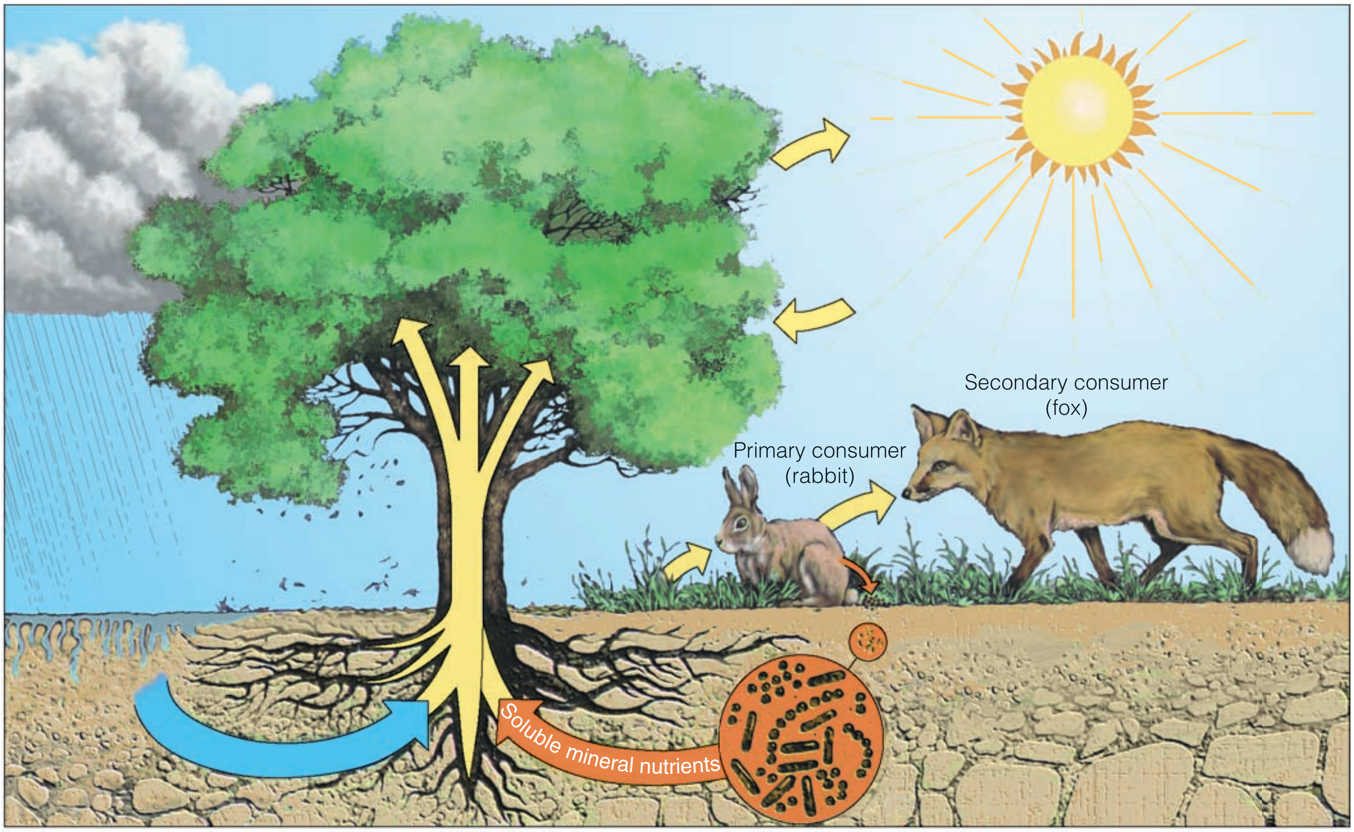
Much environmental damage has resulted from atmospheric pollution associated with industrialization, particularly in support of the wealthy, developed nations. But as population pressures mount and developing nations struggle to industrialize, human activities are exacting an increasing toll on the soils, forests, air, and waters of the developing world as well. Environmental deterioration is a problem of worldwide concern, and solutions must involve international cooperation in order to be successful. As citizens of the world's wealthiest nation, Americans must seriously consider what steps can be taken to counter major environmental threats related to human activities. What are the causes of these threats? Are the threats real and well documented? What can I personally do to help solve environmental problems? With limited resources on Earth, what will we leave for future generations?

Examining environmental issues from the physical geographer's perspective requires that characteristics of both the environment and the humans involved in those issues be given strong consideration. As will become apparent in this study of geography, physical environments are changing constantly, and all too frequently human activities result in negative environmental consequences. In addition, throughout Earth, humans live in constant threat from various and spatially distributed environmental hazards such as earthquake, fire, flood, and storm. The natural processes involved are directly related to the physical environment, but causes and solutions are imbedded in human–environment interactions that include the economic, political, and social characteristics of the cultures involved. The recognition that geography is a holistic discipline—that it includes the study of all phenomena on Earth—requires that physical geographers play a major role in the environmental sciences.



Both, United Nations Environmental Program (UNEP)

Human impacts on the environment: the shrinking Aral Sea. Located in the central Asian desert between Kazakhstan and Uzbekistan, the Aral Sea is an inland lake that does not have an outlet stream. The water that flows in is eventually lost by evaporation to the air. Before the 1960s, rivers flowing out of mountain regions supplied enough water to maintain what was the world's fourth-largest body of inland water. Since that time, diversion of river water for agriculture has caused the Aral Sea to dramatically shrink, and its salinity has increased by 600%. The result has been the disappearance of many species that relied on the lake for survival, along with frequent dust storms, and an economic disaster for the local economy. Without the waters of the lake to moderate temperatures, the winters have become colder, and the summers hotter. Today, efforts are under way to restore at least part of the lake and its environments.
What are some examples of how humans have impacted the environment where you live?



● **FIGURE 1.11**
Ecosystems are an important aspect of natural environments, which are affected by the interaction of many processes and components.
How do ecosystems illustrate the interactions in the environment?

The ecosystem concept (like other systems models) can be applied on almost any scale from local to global, in a wide variety of geographic locations, and under all environmental conditions that support life. Hence, your backyard, a farm pond, a grass-covered field, a marsh, a forest, or a portion of a desert can be viewed as an ecosystem. Ecosystems exist wherever there is an exchange of materials among living organisms and where there are functional relationships between the organisms and their natural surroundings. Although some ecosystems, such as a lake or a desert oasis, have relatively clear-cut boundaries, the limits of many others are not as precisely defined. Typically, the change from one ecosystem to another is obscure and transitional, occurring gradually over distance.

A Life-Support System Certainly the most critical and unique attribute of Earth is that it is a **life-support system.** On Earth, natural processes produce an adequate supply of oxygen; the sun interacts with the atmosphere, oceans, and land to maintain tolerable temperatures; and photosynthesis or other continuous cycles of creation provide new food supplies for living things. If a critical part of a life-support system is significantly changed or fails to operate properly, living organisms may no longer be able to survive. Spacecraft can also provide a life-support system for astronauts, but they are dependent on Earth for sustenance, maintenance, and supplies of necessities (● Fig. 1.12). For instance, if all the oxygen in a spacecraft is used up, the crew inside will die. If a spacecraft cannot control the proper temperature range, its occupants may burn or freeze. If food supplies run out, the astronauts will starve. Other than the input of energy from the sun, the Earth system provides the necessary environmental constituents and conditions to permit life, as we know it, to exist.

Earth, then, is made up of a set of interrelated components, operating within systems that are vital and necessary for the existence of all living creatures. About 40 years ago, Buckminster Fuller, a distinguished scientist, philosopher, and inventor, coined the notion of Spaceship Earth—the idea that our planet is a life-support system, transporting us through space. Fuller also thought that knowing how Earth works is important—indeed this knowledge may be required for human survival—but that humans are only slowly learning the processes involved. He compared this information to an operating manual, like the owner's manual for an automobile.

> One of the most interesting things to me about our spaceship is that it is a mechanical vehicle, just as is an automobile. If you own an automobile, you realize that you must put oil and gas into it, and you must put water in the radiator and take care of the car as a whole. You know that you are going to have to keep the machine in good order or it's going to be in trouble and fail to function.
>
> We have not been seeing our Spaceship Earth as an integrally designed machine which to be persistently successful must be comprehended and serviced in total . . . there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it.
>
> R. Buckminster Fuller
> *Operating Manual for Spaceship Earth*

NASA

FIGURE 1.12
The International Space Station can function as a life-support system and astronauts can venture out on a spacewalk, but they remain dependent on resources like air, food, and water that are shipped in from Earth.
What do the limited resources on space vehicles suggest about our environmental situation on Earth?

Today, we realize that critical parts of our planet's life-support system, **natural resources,** can be abused, wasted, or exhausted, potentially threatening the function of planet Earth as a human life-support system. A concern is that humans may be rapidly depleting critical natural resources, especially those needed for fuel. Many natural resources on our planet are nonrenewable, meaning that nature will not replace them once they are exhausted. Coal and oil are nonrenewable resources. When nonrenewable resources such as these mineral fuels are gone, the alternative resources may be less desirable or more expensive.

One type of abuse of Earth's resources is **pollution,** an undesirable or unhealthy contamination in an environment resulting from human activities (● Fig. 1.13). We are aware that critical resources, such as air, water, and even land areas, can be polluted to the point where they become unusable or even lethal to some life forms. By polluting the oceans, we may be killing off important fish species, perhaps allowing less desirable species to increase in number. Acid rain, caused by atmospheric

U.S. Environmental Protection Agency

FIGURE 1.13
Pollution of the air, water, and land remains a significant environmental problem.
What pollutants threaten the air and water in your community and what are the probable sources of this pollution?

pollutants from industries and power plants, is damaging forests and killing fish in freshwater lakes. Air pollution has become a serious environmental problem for urban centers throughout the world (● Fig. 1.14). What some people do not realize, however, is that pollutants are often transported by winds and waterways hundreds or even thousands of kilometers from their source. Lead from automobile exhausts has been found in the ice of Antarctica, as has the insecticide DDT. Pollution is a worldwide problem that does not stop at political, or even continental, boundaries.

In modern times, the ability of humans to alter the landscape has been increasing. For example, a century ago the interconnected Kissimmee River–Lake Okeechobee–Everglades ecosystem constituted one of the most productive wetland regions on Earth. But marshlands and slow-moving water stood in the way of urban and agricultural development. Intricate systems of ditches and canals were built, and since 1900, half of the original 1.6 million hectares (4 million acres) of the Everglades has disappeared (● Fig. 1.15). The Kissimmee River was channelized into an arrow-straight ditch, and wetlands along the river were drained. Levees have prevented water in Lake Okeechobee from contributing water flow to the Everglades, and highway construction further disrupted the natural drainage patterns.

Fires have been more frequent and more destructive, and entire biotic communities have been eliminated by lowered water levels. During excessively wet periods, portions of the Everglades are deliberately flooded to prevent drainage canals from overflowing. As a result, animals drown and birds cannot rest and reproduce. South Florida's wading bird population has decreased by 95% in the last hundred years. Without the natural purifying effects of wetland systems, water quality in south Florida has deteriorated; with lower water levels, saltwater encroachment is a serious problem in coastal areas.

Today, backed by government agencies, scientists are struggling to restore south Florida's ailing ecosystems. There are extensive plans to allow the Kissimmee River to flow naturally across its former flood plain, to return agricultural land to wetlands, and to restore water-flow patterns through the Everglades. The problems of south Florida should serve as a useful lesson. Alterations of the natural environment should not be undertaken without serious consideration of all consequences.

Both, Courtesy John Day and the University of Colorado Health Services Center

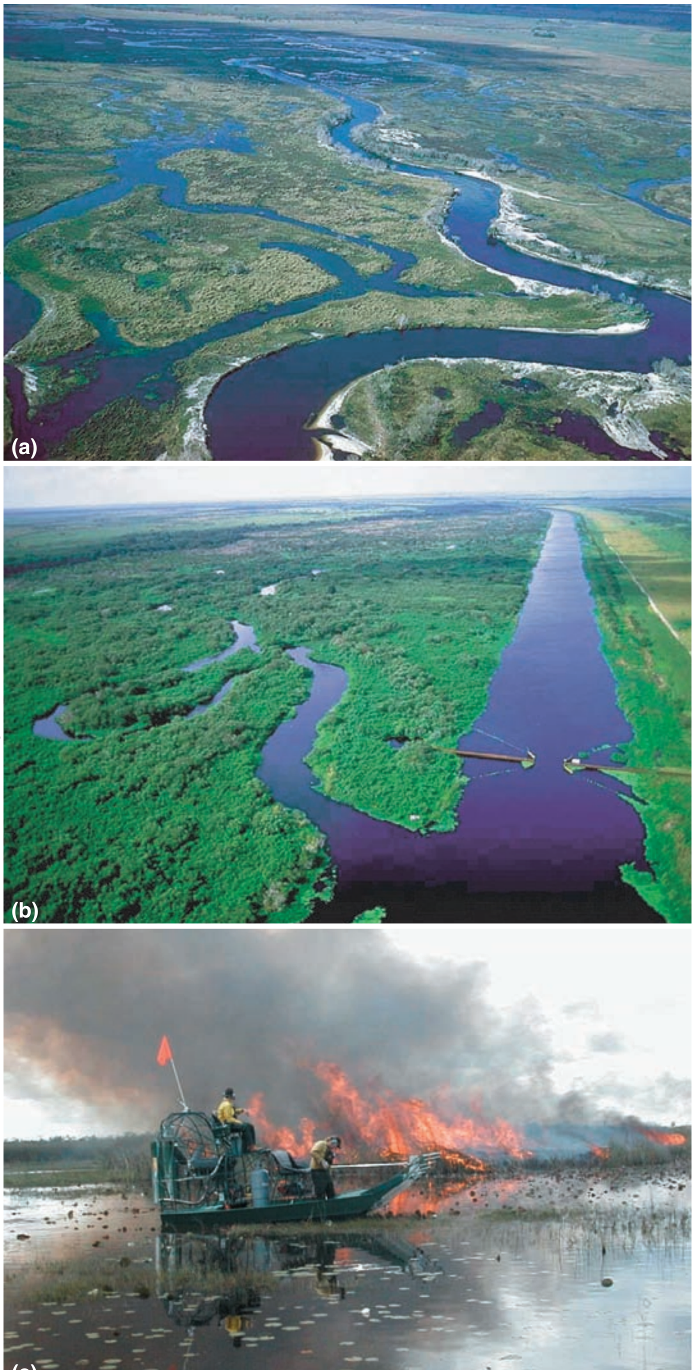
● FIGURE 1.14
(a) Denver, Colorado, on a clear day, with the Rocky Mountains visible in the background. (b) On a smoggy day from the same location, even the downtown buildings are not visible.
If you were choosing whether to live in a small town, a rural area, or a major city, would pollution affect your decision?

The Human–Environment Equation

Despite the wealth of resources available from the air, water, soil, minerals, vegetation, and animal life on Earth, the capacity of our planet to support the growing numbers of humans may have an ultimate limit, a threshold population. Dangerous signs indicate that such a limit may someday be reached. The world population has passed the 6.7 billion mark, and United Nations' estimates indicate more than 9 billion people by 2050 if current growth rates continue. Today, more than half the world's people must tolerate substandard living conditions and insufficient food. A major problem today is the distribution of food supplies, but ultimately, over the long term, the size of the human population cannot exceed the environmental resources necessary to sustain them.

Although our current objective is to study physical geography, we should not ignore the information shown in the World Map of Population Density (inside textbook back cover). The map shows the distribution of people over the land areas of Earth and illustrates an important aspect of the human–environment equation. World population distributions are highly irregular; people have chosen to live and have multiplied rapidly in some places but not in others. One reason for this uneven distribution is the differing capacities of Earth's varied environments to support humans in large numbers. We are learning that, much like life on a spaceship, there are limits to the suitable living space on Earth, and we must use our lands wisely. Usable land is a limited resource (● Fig. 1.16). In our search for livable space, we occasionally construct buildings in locations that are not environmentally safe. Also, we sometimes plant crops in areas that are ill suited to agriculture while at the same time paving over prime farmland for other uses.

The relationships between humans and the environments in which they live will be emphasized throughout this book. Geographers are keenly aware that the nature or behavior of each of the parties in the relationship may have direct effects on the other. However, when considering the human–environment equation and the sustaining of acceptable human living standards for generations to come, it is important to note that environments do not change their nature to accommodate humans. Humans should make greater attempts to alter their behavior to accommodate the limitations and potentials of Earth environments. It has been said that humans are not passengers on Spaceship Earth; rather, they are the crew. This means we have the responsibility to maintain our own habitat. Poised at the interface between Earth and human existence, geography has much to offer in helping us understand



EPA, South Florida Water Management Division

EPA, South Florida Water Management Division

U.S. Fish and Wildlife Service

FIGURE 1.15
(a) As a natural stream channel, the Kissimmee River originally meandered (flowed in broad, sweeping bends) on its floodplain for a 100-mile stretch from Lake Kissimmee to Lake Okeechobee. (b) In the 1960s and early 1970s, the river was artificially straightened, disrupting the previously existing ecosystem at the expense of plants, animals, and human water supplies. As part of a project to restore this habitat, the Kissimmee is today reestablishing its flood plain, wetland environments, and its meandering channel. (c) An ongoing problem is the invasion of weedy plants that cause a serious fire hazard during the dry season. Controlled burns by the U.S. Fish and Wildlife Department are necessary to avoid more catastrophic fires, and to help restore the natural vegetation.
What factors should be considered prior to any attempts to return rivers and wetland habitats to their original condition?

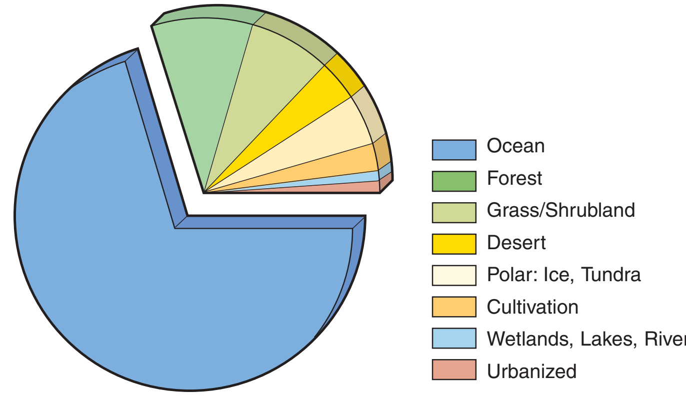


FIGURE 1.16
The percentages of land and water areas on Earth. Habitable land is a limited resource on our planet.
What options do we have for future settlement of Earth's lands?

the factors involved in meeting this responsibility. Scientific studies directed toward environmental monitoring are helping us learn more about the changes on Earth's surface that are associated with human activities. All citizens of Earth must understand the impact of their actions on the complex environmental systems of our planet.

Models and Systems

As physical geographers work to describe, understand, and explain the often-complex features of planet Earth and its environments, they support these efforts, as other scientists do, by developing representations of the real world called models. A **model** is a useful simplification of a more complex reality that permits prediction, and each model is designed with a specific purpose in mind. As examples, maps and globes are models—representations that provide us with useful information required to meet specific needs. Models are simplified versions of what they depict, devised to convey the most important information about a feature or process without an overwhelming amount of detail. Models are essential to understanding and predicting the way that nature operates, and they vary greatly in their levels of complexity. Today, many models are computer generated because computers can handle great amounts of data and perform the mathematical calculations that are often necessary to construct and display certain types of models.

There are many kinds of models (Fig. 1.17). **Physical models** are solid three-dimensional representations, such as a world globe or a replica of a mountain. **Pictorial/graphic models** include pictures, maps, graphs, diagrams, and drawings. **Mathematical/statistical models** are used to predict possibilities such as the flooding of rivers or changes in weather conditions that may result from climate change. Words, language, and the definitions of terms or ideas can also serve as models.

Another important type is a **conceptual model**—the mind imagery that we use for understanding our surroundings and experiences. Imagine for a minute (perhaps with your eyes closed) the image that the word *mountain* (or *waterfall, cloud, tornado, beach, forest, desert*) generates in your mind. Can you describe this feature's characteristics in detail? Most likely what you "see" (conceptualize) in your mind is sketchy rather than