GLOBAL CONNECTIONS

ENVIRONMENT AND NATURAL RESOURCES

CHARLES F. GRITZNER

GLOBAL CONNECTIONS

ENVIRONMENT AND NATURAL RESOURCES

GLOBAL CONNECTIONS

America's Role in a Changing World
Changing Climates
The Changing Global Economy
Environment and Natural Resources
Feeding a Hungry World
The Human Population
Human Rights
One World or Many?
Pandemics and Global Health
Terrorism and Security

GLOBAL CONNECTIONS

ENVIRONMENT AND NATURAL RESOURCES

CHARLES F. GRITZNER

CHELSEA HOUSE PUBLISHERS
An imprint of Infobase Publishing

Environment and Natural Resources

Chelsea House
An imprint of Infobase Publishing
132 West 31st Street
New York, NY 10001

Library of Congress Cataloging-in-Publication Data
Gritzner, Charles F.
Environment and natural resources / by Charles F. Gritzner.
p. cm. -- (Global connections)
Includes bibliographical references and index.
ISBN 978-1-60413-289-2 (hardcover)
ISBN 978-1-4381-3166-5 (e-book)
1. Environmental sciences--Juvenile literature. 2. Natural resources--Juvenile literature. I. Title. II. Series.

GE115.G75 2010
304.2--dc22

2009033602

Chelsea House books are available at special discounts when purchased in bulk quantities for businesses, associations, institutions, or sales promotions. Please call our Special Sales Department in New York at (212) 967-8800 or (800) 322-8755.

You can find Chelsea House on the World Wide Web at http://www.chelseahouse.com

Text design by Annie O'Donnell
Cover design by Takeshi Takahashi
Composition by EJB Publishing Services
Cover printed by Bang Printing, Brainerd, MN
Book printed and bound by Bang Printing, Brainerd, MN
Date printed: February 2010
Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

This book is printed on acid-free paper.

All links and Web addresses were checked and verified to be correct at the time of publication. Because of the dynamic nature of the Web, some addresses and links may have changed since publication and may no longer be valid.

CONTENTS

A GLOBAL COMMUNITY

Globalization is the process of coming together as a closely connected global community. It began thousands of years ago, when tribal groups and small hunting parties wandered from place to place. The process accelerated following Columbus's epic voyage more than five centuries ago. Europeans—an estimated 50 million of them—spread out to occupy lands throughout the world. This migration transformed the distribution of the world's peoples and their cultures forever. In the United States and Canada, for example, most people speak a West European language. Most practice a religious faith with roots in the ancient Middle East and eat foods originating in Asia.

Today, we are citizens of a closely interwoven global community. Events occurring half a world away can be watched and experienced, often as they happen, in our own homes. People, materials, and even diseases can be transported from continent to continent in a single day, thanks to jet planes. Electronic communications make possible the instantaneous exchange of information by phone, e-mail, or other means with friends or business associates almost anywhere in the world. Trade and commerce, perhaps more so than any other aspect of our daily lives, amply illustrate the importance of global linkages. How many things in your home (including your clothing) are of international origin? What foods and beverages have you consumed today that came from other lands? Could Northern America's economy survive without foreign oil, iron ore, copper, or other vital resources?

The GLOBAL CONNECTIONS series is designed to help you realize how closely people and places are tied to one another within the expanding global community. Each book introduces you to political, economic, environmental, social, medical, and other timely issues, problems, and prospects. The authors and editors hope you enjoy and learn from these books. May they hand you a passport to intellectual travels throughout our fascinating, complex, and increasingly "intradependent" world!

—Charles F. Gritzner
Series Editor

OUR PLANETARY SPACESHIP

When seen from a distant vantage point, Earth appears as a small, fragile planet suspended in the vastness of space. The planet's mosaic of different colors, surface shapes, swirls, and textures gives it the appearance of a marble wandering about the heavens. Yet this small dot in space is our home—"Spaceship Earth." And within at least the solar system, it is a unique place in countless ways.

Like a spaceship, Earth is a self-contained "capsule." Other than solar energy and occasional debris from space, such as meteors and their dust, nothing is added to our planetary space capsule. And very little leaves it. Yet this amazing place has a natural environment that supports humankind—nearly 7 billion of us. The contents of our space capsule provide the nutrients, energy, and other materials that sustain us. Without Earth's land and water, plants and animals, air and fuels, there could be no human life. These elements are the natural resources, the things that we use to survive, build, and grow. In this book, you will

Planet Earth is a self-sustaining capsule that contains all that is needed to support billions of lives.

learn about Earth's different natural environments. You will also see how we culturally adapt to, use, and change our planet's elements and conditions.

THE NATURAL ENVIRONMENT

The environment refers to everything that surrounds us. Some things are natural in origin. Together, they are the elements that make up the natural environment. They include terrain, or land features such as plains, valleys, and uplands. Soils are a very important part of the environment in many places. So are mineral resources such as fuel, metals, and building materials. Weather and climate help shape the environment. They strongly influence, for example, what kind of wild plant and animal life a place will have. Many freshwater features, too, reflect a region's climate.

In most places on Earth's surface, we are also surrounded by things of human origin. They include towns and cities, homes and other structures, farms and fences, and transportation routes. All features created by humans are part of the cultural environment. Throughout this book, emphasis is on the natural environment and the natural landscapes created by various environmental conditions. You must remember, however, that most cultural environments and cultural landscapes are created as humans use and change natural elements.

Throughout this book, reference will be made to natural landscapes. Think of landscape as a "picture." It is what you actually see within a particular environmental setting. Look out the window. What do you see? Almost certainly, you see a landscape formed by both natural and cultural environmental features. How many things that you see involved humans using, hence changing, natural elements? (Don't forget to include things such as fields, concrete sidewalks and streets, planted vegetation, and building materials.)

Unless you are completely surrounded by an urban (city) landscape, you can see many things that are a part of the natural environment. They may, of course, have been changed by human activity. The sky, for example, may have smoke and other pollutants that create a haze. Trees may be planted in neat rows, and flowering plants may be arranged in a garden that has improved soil and a built-in sprinkler system. Land may have been cut away, leveled, or filled in to allow structures to be built. Water may be controlled in some way, whether channeled or confined in a lake, pond, or fountain.

The natural environment can be divided into four "spheres," or realms. Earth's solid portion forms the lithosphere. It includes all land features, soils, and minerals. Twenty-nine percent of Earth's surface is composed of lithosphere. Seen from space, much of Earth's surface (71 percent) is covered by water. There is so much water, in fact, that Earth has earned the nicknamed "the Blue Planet." Water features, both saline and fresh, form the hydrosphere. Surrounding the planet is a thin layer of air, water vapor, dust, and other impurities. This blanketing envelope is

MAKING CONNECTIONS

THE GLOBAL "SUPERMARKET"

Earth—our planetary "spaceship"—is like a giant supermarket in many ways. Both the planet and a grocery store possess a vast number of varied items. But for many reasons, not everyone wants or is able to take advantage of everything the store offers. In a store, a vegetarian will avoid the meat counter. Someone who doesn't drink alcohol will not be found in the liquor aisle. Those with limited incomes will not fill their shopping cart with items from the gourmet section. Many people simply do not know what to do with certain items. (Would you know what to do with squid, saffron, or manioc tubers?) Personal perceptions (tastes and needs) also play an important role. They can greatly influence what people will select in a store or from the natural environment.

A similar situation exists in terms of the ways in which humans, as cultural groups, interact with nature. Our needs, knowledge, tools, and skills greatly influence what a people will, or will not, do within a certain environmental setting. In Brazil's Amazon Basin, for example, some people live simple lives. They hunt, fish, and gather and do little to change the environment. Farmers, ranchers, and miners, on the other hand, destroy the forest. But each group focuses upon a the atmosphere. It is responsible for all of our weather, climate, and storms. Finally, there are the plants and animals that make up the biosphere.

NATURAL RESOURCES

Everything upon which humans depend for survival comes from the elements contained within Earth's four spheres. We cannot add to them. Through time, however, we have greatly expanded

different natural element. Farmers depend upon the soil; ranchers rely upon grass and forage for their livestock; miners see Earth's minerals as their key to wealth.

In most supermarkets, very little if any of what they contain is produced locally. So, too, many of Earth's nearly 7 billion people depend upon resources from many different locations. If the store does not stock something you want, you can ask the manager to order it for you. In this way, each of us depends upon far-flung global connections to provide many if not most of the things upon which we depend daily.

How many items that you have used, consumed, or otherwise come in contact with today are the product of one or more natural resources? Can you identify the origin of these resources? For example, where did the gasoline that powers your vehicle come from? Where did the various metals in the vehicle come from? Do you have a cell phone? If you do, are you aware that it contains coltan, a mineral almost certainly mined in the Democratic Republic of Congo, a country in Central Africa? The phone also contains tin, more than one-third of which is produced in the Congo. Could everyone in the world today enjoy all of the things that you use and take for granted? Why, or why not?

their potential use to humans. Once we realize that something can be of use, a way must be found to obtain it. Once a natural element is used, it becomes a natural resource.

Many, if not most, natural resources are changed in some way to make them more useful to us. Take, for example, this book. The paper, no doubt, was made from wood, perhaps by a process that also used clay. Ink, according to one definition, "is a complex medium consisting of comprising solvents, pigments, dyes, resins, lubricants, solubilizers, surficants, particulate matter, fluorescers, and other materials." (The author doesn't know what all of those items are, either, but the passage suggests that many natural elements were used to create the ink.) The important point is that several natural elements became useful natural resources. In turn, the resources were changed in some way to make them more useful. In this case wood and a variety of other elements became the book that you are reading and the ink with which it is printed.

ENVIRONMENTAL CHANGE

Today, nearly everyone is concerned about "the environment." We hear a great deal, for example, about global warming and its possible consequences. Environmental pollution, it seems, is fouling the land, water, and air throughout much of the world. Deforestation in the Amazon Basin and elsewhere is a huge problem. In many areas, including Australia and much of the western United States, the water supply is a major concern. Soils in many places have eroded away or become less fertile because of poor farming practices. Many of Africa's magnificent large animals are threatened by humans. The list goes on and on.

From the dawn of human history, humans have changed the environments in which they live. We breathe the air, drink the water, and eat plant and animal life. Each of these is taken from the natural environment. In turn, we pollute the environment when we exhale, or rid our body of wastes. When we walk on the land, we compact the soil and squash small plants and other organisms beneath our feet. As you can see, from the very beginning, humans have been active agents of environmental change.

Today, of course, we change the environment in ways unheard of even several decades ago. This is possible because culture—particularly technology—has advanced in ways that make Earth and its elements much more useful to us. And, of course, we have many more cultural needs today than in the past. (Humankind's biological needs have remained constant through time. What has changed is the way these needs are satisfied.)

Not all environmental change is bad. In fact, without it you would not be alive. Humans must do everything possible, however, to ensure that Earth and its resources are used in a way that is sustainable. That is, the planet and its environments and resources will continue to be available and productive indefinitely.

MAPPING OUR COURSE

This book is designed to give you a much better understanding of the importance of Earth's various environmental elements. It also emphasizes the role that culture plays in the relationship between humans and the environment. Of particular importance are the needs, knowledge, tools, skills, and capital resources possessed by a people. These factors help determine what people do, or are unable to do, in a particular environment. The traditional Inuit (Eskimo), for example, did not have a need for Alaska's oil; in fact, they were unaware of its existence. Today, Phoenix, Arizona, and Las Vegas, Nevada, are the two fastest-growing large U.S. cities. Without massive water control and diversion, neither community could have experienced such explosive growth. And how many people would want to live in the scorching desert without air-conditioning? As you can see, culture is more important than the environment in establishing the way people actually live and what they do. We will return to this theme time after time throughout this book.

Chapter 2 introduces some of the basic ideas that explain the relationship between humans and Earth's natural environments. You will examine how different cultures adapt to, use, and change the environments in which they live. You will learn, for example, that the environment and its potentials are not the same to everyone. Some cultures depend upon one or more resources in a location, while others ignore it (or them) entirely. Finally, it will discuss ways in which humans create unique cultural landscapes. All human societies change the environment to fit their own needs and desires.

In chapters 3 through 7, you will learn how Earth's environmental elements are important to humans. Each element will be discussed individually in terms of its nature and distribution. Each of them will also be looked at as an environmental hazard—how it can threaten humans. Finally, attention will be given to its use by humans, that is, its importance as a natural resource.

Finally, in Chapter 8, we will attempt to take a peek into the future. The human population is expected to grow to around 9 billion people by mid-century. Will there be enough natural resources to go around? Will there be enough food? Will new resources be found to replace those that are depleted? What impact will a population half again as large as today's have on Earth's fragile natural landscapes? These are just some of the questions that this book raises and attempts to answer.

HUMANS, ENVIRONMENT, AND RESOURCES

Imagine for a moment that you lived 25,000 years ago. What use could you have made of the environment in which you lived? You had little awareness of what was there. Basically, you knew only of those things that you could see. Little did you know, for example, that a huge reservoir of water was stored in the ground deep below the surface. Or that a deposit of oil (iron ore, copper, zinc, lead, gold . . . you get the idea!) was waiting to be tapped. (Of course, it would be more than 24,800 years before a major use would be found for oil.) And if you were aware of some metal, such as raw copper, could you have used it? How would you have obtained the resources that we take for granted today? Even if you were aware of something like iron ore, copper, or lead, could you have processed it? And if you did, how would you have used the metal?

HUMAN USE OF THE EARTH

Knowing that something "is there" is only a first step toward it actually being used. Twenty-five thousand years ago, what knowledge did people possess that allowed them to use the various natural elements within their environment to their advantage? Basically, they were aware of and used what was immediately available. And those things they did use were little changed from their natural state. For example, early humans used such things as wood, bark, stones, animal skins, and earth to build shelters. Their clothing may have been made from animal skins. The tools and weapons that they used were crafted from wood, stone, or bone. Everything they used was local in origin and used in pretty much the same condition in which it was found.

Of course, they breathed the fresh air. And the water upon which their life depended came straight out of a lake or a stream that flowed by their campsite. They hunted, fished, and gathered to obtain their food. If game was scarce, or the roots, fruits, nuts, and berries upon which people depended were in short supply, they went hungry. Starvation, it seemed, was never more than a step or two away. They lived very close to nature. And they lacked the knowledge, tools, and skills to greatly change what nature provided.

Now, think of the things that you will use, or otherwise come in contact with, today. What about your home? Of what materials is it made? Perhaps there is wood, stone, and clay (bricks or adobe). The plumbing may be made from plastic or some metal, and the wires, no doubt, are made from copper. Windows are made of glass (sand). Depending upon the kind, roofing can be made of many components. How many of these items are in their original natural form? In all probability, not a single one is! How were these natural elements—things taken from nature—changed to make them more useful? Where did they come from? Were any of the items produced locally, or did they come from distant locations, perhaps even another continent? The same questions can be asked about your vehicle, TV set, computer, or clothing that you are wearing.

In these very brief introductory passages, you have learned the basic nature of the age-old "man-land" relationship. Today, scientists call this relationship cultural (or human) ecology. Humans, after all, have many basic needs. In order to survive, we must have food and water. We must be protected against cold and other harsh natural elements. And we must have mobility for ourselves and the material things upon which we depend for our survival. But think for a moment about the huge differences in what people had long ago and what we have today. The difference is explained by *culture.* Simply stated, what we know, possess, and are able to do today is vastly greater than what humans knew, had, and could do thousands of years ago. The environment, for all practical purposes, is little changed in terms of what it offers. What has changed, and changed greatly, is our knowledge. We have a much greater understanding of Earth's elements and conditions and ways in which they can be used.

Of even greater importance has been the development through time of tools and skills needed to put nature to work for us. They have made it possible for us to change environmental elements in many ways. In so doing, we make them more useful. For example, a plain black rock, coal is used in more than 100,000 ways today. From electrical energy to fuel, and aspirin to plastics, coal is transformed into thousands of different products. Finally, as we live in and use the environment and its resources, we change Earth's natural landscapes. We will return to these important concepts many times throughout the book.

HOW DO HUMANS "ADAPT" TO NATURE?

Humans are animals. We are creatures within the animal kingdom and, as such, we are subject to the laws of nature. Every living organism—be it plant or animal—must adapt in some way to the natural environment. If they are unable to do this, they die. Human beings, for example, are tropical animals. Our bodies begin to suffer from hypothermia (react to cold) when the temperature drops into the mid-70s (around 24°C).

There is a huge difference, however, in *the way* humans and nonhuman animals adapt to nature. All creatures within the animal kingdom are biologically (physically) adapted to nature. In response to cold, for example, some species of wildlife will migrate while others hibernate. Still others grow an extra layer of dense fur or body fat to protect against frigid winter conditions. Each wild creature creates or finds some kind of shelter. It may be an elaborate nest as built by various bird species, or a simple hole created by burrowing in the ground. The beaver fells trees in order to build a dam (hence, create a reservoir) and construct a snug lodge.

Regardless of what wild animals do, they do it instinctively. Their actions are programmed genetically or by natural forces that they inherit, and they cannot be changed. An animal that burrows, for example, will not suddenly decide to migrate south for the winter.

Culture as Humankind's Adaptive Mechanism

Unlike any other form of life, culture is humankind's adaptive mechanism. We *learn* how to survive in various environments. This morning, for example, the temperature outside the author's home was –22°F (–30°C). Outside and with body unprotected, life expectancy would be a matter of only minutes. There is no gene in the human body that prepares us to survive a cold snap. It is our knowledge that allows us to create those things that must be done to survive harsh conditions. So the author was able to benefit from centuries of know-how. His home is well built and well insulated. It has a very effective central heating system. And when one lives in South Dakota, he or she has plenty of warm clothing!

Through time, several "influencing factors" have been suggested to explain the relationship between humans and the natural environment. Until the early twentieth century, some

Humans adapt to changing environments in ways different from non-human animals. When cold temperatures hit, most humans simply turn on the heat and unpack their hats and scarves. Animals, on the other hand, may burrow in the ground and hibernate or move to a warmer climate for the winter. These migrating black birds fly through North Carolina on their way farther south.

scholars believed that nature called the shots. This theory, called environmental determinism, held that humans were mere putty in the hands of nature. All people living in deserts (or tropical rain forests, polar regions, and so forth) lived pretty much the same way and did the same things. It takes only a basic understanding of world geography to see the flaw in this notion. In each of the regions cited above, for example, levels of cultural development range from among the world's most traditional to the most advanced.

Another view of the relationship is called possibilism. This idea was developed by French geographers during the late nineteenth century. It points to both the environment and culture as playing an important role in what people do and how they live within a particular setting. Possibilism suggests that the environment establishes limits to what is possible. But within those limits, humans, based upon their culture, have options.

To better understand the major flaw of this line of thinking, return for a moment to "The Global 'Supermarket'" example from the last chapter. Did the environment (the store itself, or surrounding physical conditions) limit the groceries and other items that the supermarket offered? Where did they come from? Most countries and cultures in the world illustrate that possibilism simply doesn't work. Japan, for example, is the world's second leading industrial power. Yet fully 97 percent of the natural resources and raw materials used in Japanese industry must be imported. Is it the country's natural environment or its dynamic culture and work ethic that makes success "possible"?

For more than a century, cultural anthropologists and geographers have turned to a third explanation of the people-environment relationship. It is one that places the emphasis on people: their *culture*. Ultimately, it is culture that determines what people will do (or will not be able to do) within an environment. How else can one explain, for example, desert dwellers? Traditionally, the belief was that the arid environment limited their options. They could be oasis farmers or camel herders, or live in a city. That was about it! Some desert people, of course, are involved in these activities. In North Africa, for example, traditional Bedouin, Tuareg, and Berber tribes herd livestock. Throughout much of North Africa and the Middle East, millions of desert-dwelling people depend upon oasis irrigation. But what about glittering Las Vegas, Nevada, and booming Phoenix, Arizona? They are the two driest cities of any size in America and also the two most rapidly growing. Las Vegas depends upon gambling and other forms of tourism. Phoenix depends largely upon service-based industries. Does the economy or way of life of either community depend upon desert conditions? The answer, of course, is "No!"

Let's return for a moment to early humans in what most scientists believe to have been the original homeland of humankind—equatorial East Africa. The region's climate is hot and humid. Plant and animal life is abundant throughout the year. Ample rainfall ensures that fresh water is always available. In the rain forest, there were no large, fierce, potentially deadly predators like lions or hyenas to threaten early humans. Nature provided an ample year-round supply of food and water. There was no need for well-built shelters or elaborate clothing to protect against the elements. This is the habitat (environment) to which humans are biologically adapted.

Today, however, humans have made a home for themselves in all of the world's climates and ecosystems. It is their culture that has made this possible. In terms of "influences," the United States is unique. It is the only country in the world that includes within its territory all of Earth's environments. Yet from Orlando, Florida, to Fairbanks, Alaska, and Honolulu, Hawaii, to Bangor, Maine, Americans are pretty much alike. They do mostly the same things, dress the same way, and speak the same language. Most Americans believe in democracy and a free market economy and practice Christianity in some form. They eat with a knife, fork, and spoon, and enjoy watching their favorite programs (the same ones nationwide) on television. If it is too cold, they turn up the heat; if it is too hot, they turn on the air conditioner. In each of these cases, it is culture, not the environment, that makes adaptation possible. Were the environment the determinant of culture, the way of life of Americans would be vastly different from place to place.

HUMANS *IN* THE ENVIRONMENT

If the foregoing section is true, how can one explain the huge differences in the way various cultures adapt to the natural environments in which they live? The answer lies in the understanding of cultural differences. People occupy space, consume resources, pollute, and change the environments they occupy. But not everyone does these things in the same way. In fact, huge differences exist between and among cultures in each category.

Humans Occupy Space

Certainly not everyone occupies the same amount of space. How much space (home, yard, your desk at school, and so forth) do you occupy? Think of a residential area with large homes and yards. How much space does each residence occupy? What about people in a traditional society? In tropical South America, for example, as many as 15 or 20 native people may live in a crowded home the size of your living room. The Japanese, on the other hand, are among the world's wealthiest people. Yet Japanese homes are very small—again, perhaps the size of a typical American living room.

People Consume Resources

Huge differences exist in the consumption of natural resources and raw materials. This is a theme to which we will return in numerous other sections of the book. Buying power is the key to consumption. On a per capita basis, residents of rich countries like the United States and Canada are huge consumers. Americans may use 100 or more times as much metal, energy, wood, plastic, and other materials as people in a developing country. The United States has about 5 percent of the world's people, yet Americans consume 25 to 30 percent of all the world's natural resources. U.S. culture (in this case, the U.S. economy) is responsible for this "excessive" consumption.

People Pollute

People also pollute. Many traditional societies, for example, will use fire to clear land for farming or grazing. The smoke and ash pollute both air and water. Industrial societies, on the other hand, also put smoke in the atmosphere. But it may be much more toxic and may even make people ill. Logically, you might think that the more “advanced” and affluent a society is, the more it would pollute. This is not necessarily true. In fact, living in a clean environment is an incredibly costly luxury. It is one that only a wealthy society can afford. In his travels, the author has been deeply saddened by the horrendous pollution he has seen in developing countries. They simply cannot afford to curb pollution, properly dispose of waste, and keep their environment clean and safe. In places like affluent Western Europe and Japan, however, huge sums of money have been spent to reduce pollution. In the United States alone, an estimated $2 trillion has been spent since 1950 to clean up the environment.

People Change the Environment

As humans live and work, they change the environments in which they dwell. Originally, most hunting-fishing-gathering peoples did little to visually change the land. Through time, however, as they developed tools such as the use of fire and the ax, their imprint increased drastically. This was particularly true as humans began to farm and raise livestock. Land had to be cleared. In many areas, such as portions of Asia and South America’s central Andean area, terraces were built to create level land. Water was diverted to fields of thirsty crops. The domesticated plants and animals, themselves, were greatly changed from their wild ancestors.

Wood, stone, sod, and other materials were used in building. Trees were cut to provide firewood and later charcoal. In chapters 3 through 8, you will learn more about the ways in which humans have changed each of the natural elements. In so doing, they have left their imprint on Earth’s surface. Humans, in fact, much more than natural forces, have long been the primary agent of landscape change.

HUMANS *AND* THE ENVIRONMENT

Many factors influence the interrelationship between humans and the environment. The environment itself, obviously, plays some role, but it is passive. (For example, you can ski in Houston, Texas, and swim year-round in Fairbanks, Alaska.) In this section, we will look very briefly at four key factors. Each of them helps to determine how humans relate to the natural environment and its potential resources. They are: recognition, needs and wants, capital resources, and technology.

Recognizing Environmental Potentials

At various stages of human history, people have recognized different environmental resource potentials. Many resources that we take for granted today were only "discovered" recently. Examples include petroleum, natural gas, uranium, and many plant and animal extracts used in medicines. There are hundreds of others. You may believe that "modern humans" use all of the resources that were recognized by traditional societies. This is

A boy crosses a polluted river in the shantytown where he lives in Islamabad, Pakistan. Underdeveloped nations suffer from pollution problems because they lack the funds to maintain a clean environment.

not necessarily true. Early humans, for example, obtained their food from more than 2,000 edible plants. Today we depend almost entirely upon only a half dozen different crops. Centuries ago, so called primitive people healed themselves using plant and animal extracts that remain unknown to (or unused by) modern medicine. It is true, of course, that the more highly developed a culture is, the more potential uses it sees within the environment.

Needs and Wants

Not all cultures need or want the same things. In fact, beyond life's fundamental necessities, it is culture that determines a society's nonessential needs and wants. Do we, for example, actually need a large single-family home on a large lot? Many Americans believe that they do. Do we need several cars (including a huge SUV), a boat, and an ATV? Certainly a great number of Americans believe that they do. People in many traditional tropical societies wear nothing more than a simple loincloth. Try that some August afternoon! Or pitch a tent and try to live in it as your permanent residence. The list could go on and on, but you get the idea. All humans, of course, need life's basic necessities. But different cultures differ greatly in terms of what they want, and even what its members need, in order to get by.

Needs and wants often come into direct conflict with a culture's values. South Dakota's Black Hills were once the world's leading producer of gold. Today all of the mines are closed. The mines scarred the land. Leaching ore from rock with deadly cyanide polluted streams and killed wildlife. Many people placed greater value on a clean, attractive environment than they did on gold production and jobs. A similar conflict exists today in northern Alaska. Should the area's huge petroleum reserves be tapped? If they are, a small portion of the Arctic National Wildlife Refuge—a pristine environment with

(continues on page 30)

CULTURE CLASH OVER RESOURCE DEVELOPMENT

Nearly everywhere in the world, and certainly in the United States and Canada, people often disagree on environmental issues. One major source of conflict is how a particular environment should (or should not) be used. Which of its elements or conditions, if any, should be developed economically? Should this or that resource be used and, if so, in what way? Should a forested area, for example, be cut for lumber, developed for recreational purposes, sold for residential development, or made into a park?

Perhaps there is a major controversy over some environmental or resource issue in your area. Can you think of any? What about mining? Logging? Fishing or hunting? Is there concern over urban sprawl destroying agricultural land? Where should a new garbage dump or municipal sewer system be built? Should a new industry, perhaps a refinery or power plant, be allowed to build? Issues such as these can be very controversial. And they can be found in almost any community, state, or province.

One such controversy directly affects the United States, the state of Alaska, millions of consumers, and numerous corporations. It also directly involves three cultures: Anglo-American, Inuit (Eskimo), and Gwich'in (Athabaskan Indian). At stake is how (or whether) Alaska's Arctic National Wildlife Refuge (ANWR) should be used.

The ANWR is a beautiful, raw, relatively untouched natural environment in northeastern Alaska. It is home to the huge Porcupine caribou herd. It is also believed that 5 billion to 11 billion barrels of petroleum lie beneath the ANWR's frigid tundra surface. Many Americans, however, strongly oppose drilling. They fear that oil exploitation would pollute the environment and also would disturb the Porcupine caribou herd. People in this camp see the ANWR as an aesthetic resource. That is, they believe its value lies in its relatively untouched natural beauty, caribou herd, and other wildlife. Amazingly, this is true despite the fact that the region is so remote that it is nearly inaccessible to casual visitors. Others are worried about the price of gasoline and America's dependence upon foreign sources for its oil. They see petroleum as the most important resource and, of course, want to drill, drill, drill!

But this is only the beginning of the controversy. The area is home to coastal Inupiat Inuit (Eskimo). For a generation, they have greatly benefited from Alaska's Prudhoe Bay oil boom. Inuit strongly support further development of the oil industry. The Prudhoe Bay oil production on which they have depended for their livelihood is in decline. They want both the oil—and money in the form of hefty incomes—to continue flowing.

A short distance inland from the area of proposed development live some 7,000 indigenous people, the Gwich'in Indians. They are caribou hunters. For several thousand years, their economy, diet, and many other aspects of their culture have depended upon the Porcupine caribou. They are afraid that if the caribou are disturbed or die out, their own culture will vanish as well. Needless to say, they strongly oppose development. But the issue becomes even more complex: It is the Gwich'in elderly who oppose further economic development of the ANWR. They are the ones who most fear the loss of their ancient traditional way of life. The young, on the other hand, welcome change and support drilling. They want the modern conveniences and lifestyle they see Inuit youngsters enjoying.

So, what do you believe should be done in the ANWR? Which do you believe to be more important: more petroleum or a relatively untouched natural environment? Should oil or caribou and scenery be the region's primary natural resource(s)? Do you believe that the Gwich'in elderly or young people are right? What would each group gain and lose if oil is, or is not, developed there?

(continued from page 27)

huge herds of caribou—would be disturbed. As of 2009, the area remains "hands off" in terms of exploitation. For the time being, at least, our wants (a preserved environment) hold sway over our needs (abundant petroleum).

Capital Resources

Capital resources are those things—money and equipment, for example—needed to acquire or produce the things that one wants. Tables showing the distribution of such resources reveal staggering differences. They appear in such categories as gross national product (GNP), gross domestic product (GDP), and per capita income. The United States, for example, has an annual GDP of about $13.7 trillion. Yet 10 of the world's countries have a GDP of less than $100 million, or less than one percent that of the United States. Their people have few capital resources with which to work.

Gross national income–purchasing power parity is also revealing. The figure represents the goods and services that an amount could purchase in the United States. In the small West European country of Luxembourg, the per capita figure is $64,400. In several West African states, it drops below $500, about a week's wages for many Americans. Again, the figure is less than one percent that of affluent Luxembourg. Such differences have a huge impact on what people are able to do and the goods and services that they can purchase.

Technology to Develop

The fourth factor—technology—is important because it can make things happen. Mining, offshore drilling for oil, and modern irrigated agriculture all depend upon advanced forms of technology. Such tools and techniques, in theory, are available to all countries. But in reality they are not. Many people and governments simply cannot afford costly forms of technology. Again, it is culture—a people's ability to put capital

MAKING CONNECTIONS

ENERGY AND CULTURE

In the mid-1900s, anthropologist Leslie A. White developed what was then an unusual idea. He believed that energy consumption fueled cultural growth. In other words, the more energy each member of a culture used, the more developed that culture would be. When one looks at the world's cultures, White's idea appears to hold true. There are many lists (you can find them online) that show per capita energy consumption by country. Such rankings correspond very well to such indicators of cultural development as the Human Development Index (HDI).

Energy, of course, comes from many sources. Early humans depended upon their own energy and that of the plants and animals that they hunted or gathered. Their culture was simple, and their culture traits meager. With the domestication of plants and animals perhaps 10,000 years ago in some places, culture took a huge leap. The production of energy, whether caloric or that provided by beasts of burden, greatly expanded. With more energy, cities began to grow and people began to write, read, and use numbers. What they knew, possessed, and were able to do increased dramatically. Finally, still other forms of energy were harnessed—water, the wind, and steam (coal). Today, our energy comes from many sources. In addition to all of those used in the past, we depend upon petroleum, natural gas, and nuclear energy, among others.

To better understand the importance of White's energy theory, do the following. Think for a moment of the most traditional culture you know. What are its major sources of energy? Does the average person use as much energy as you do? How does their way of life differ from your own? Is their life simpler or more complex than yours? What factors can you identify that help to explain their lack of access to a large energy supply? How many sources of energy do you use? How does your own use of energy make your life more comfortable, enjoyable—and complex?

and technology to work for them—that influences the human-environment interaction.

PRIMARY INDUSTRIES

Economists and others divide human economic activities into a number of different categories. The most basic of them, primary economic activities, involves the environment and resources directly. Primary industries include agriculture, mining, hunting and fishing, and logging. In each case, there is economic gain from growing and harvesting something from the Earth or extracting some resource. Secondary industries involve manufacturing with or processing of raw materials obtained from primary economic activity. Finally, tertiary activity involves the sale of the products created by secondary industries. In this book, our attention focuses exclusively on primary industries. We begin with perhaps the most important environmental elements, weather and climate.

EARTH'S ATMOSPHERE

American writer Mark Twain once supposedly said, "Ever body talks about the weather, but nobody does anything about it." He was only partially right. It is difficult to actually change, particularly control, the weather or climate. But humans certainly do adapt to atmospheric conditions in countless ways. And that is *doing* something about the weather! In terms of importance to our own lives, certainly no other element is more important to us.

The day-to-day (weather) and long-term (climate) conditions of the atmosphere affect us all. Meteorologists are the scientists who study weather; climatologists study Earth's climatic conditions. Just think, how has today's weather influenced you in any way? Have you changed any plans or done anything different because of it? Or have you taken advantage of beautiful weather conditions? Is your home being artificially heated or cooled? Did you take weather into consideration when you dressed this morning? Does the economic activity of your area depend in any way upon weather?

Climate also plays a very important role in our lives. Have you, relatives, or friends moved to take advantage of a more favorable climate? Millions of Americans, for example, have moved to a warmer "Sun Belt" location. At home or in school, have you discussed Earth's possibly warming global climate and its consequences? Many areas of the United States, particularly in the West, depend upon very limited water resources. Have you heard people express concern over dwindling moisture in the region? Recent drought has contributed to less winter snow accumulation in the mountains. This, in turn, results in less stream runoff and lower water reserves held in reservoirs.

Combined, weather and climate make up the single most important natural influence on other environmental elements.

The water level of Lake Mead, behind the Hoover Dam, has dropped considerably, as shown in the above photo. The American West has precious few water resources, yet the scant moisture it does have supports millions of people, huge cities, and the country's leading agriculture regions.

Compare Earth's surface with conditions on the moon. How do they differ? What about natural vegetation? Animal life? Water features? Soils? The moon is lifeless. Even its landform features differ from those on Earth. There is no water, ice, or wind to scour, gouge, erode, or deposit its land. Unlike Earth, the moon has no atmosphere. Of the weather elements, it experiences only temperature. And in the absence of an atmosphere to act as a shield, the temperature extremes are unbearable to life as known on Earth. This chapter focuses on the importance of weather and climate and its various conditions. (In this book, unless otherwise noted, weather and climate are referred to as a single combined influence.)

ELEMENTS OF WEATHER AND CLIMATE

Earth's atmosphere is a thin layer of life-sustaining gases, water vapor, and various impurities that surround the planet. The lower layer, the one in which all weather occurs, is called the troposphere. It extends outward about 7 miles (11.26 kilometers) at the poles and 11 miles (17.7 km) at the equator. This may seem like a great distance, but it is not when compared to Earth's size. Take a large globe and put a very thin piece of paper on its surface. Then run your finger back and forth over the edge of the paper. This proportion is about the same as Earth's atmosphere is to the planet.

Look again at the photograph of Earth in space on page 10. What visible signs do you see of weather conditions? Are high temperatures and ample moisture suggested by the dark band (vegetation) near the equator? What about the white (ice) color seen near the polar regions? Can you see areas of dense cloud cover that suggest areas of precipitation? What about large patches of area without clouds? Most of these are areas of high atmospheric (barometric) pressure. Winds blow outward from high pressure cells. Also, high pressure systems tend to have calm, stable weather. Does the surface color in areas of clear atmosphere suggest arid (desert) conditions? Even from distant space, many of the dynamics of Earth's atmosphere are clearly visible. Let's look briefly at the elements that make up weather and climate. They are temperature, precipitation, and atmospheric pressure and wind. (Storms, discussed separately, are extreme conditions of these three elements.)

Temperature

During midday, the moon's temperature soars to a torrid average of 225°F (107°C). At night, it plunges to a frigid –243°F (153°C) average. This represents a daily high-to-low average range of about 468 degrees (260 degrees)! Extreme high and low temperatures are much greater. Little, if any, life found on Earth could survive such temperature extremes.

By lunar standards, Earth has very mild temperatures. The highest temperature ever recorded, 136°F (58°C), occurred in Africa's Sahara Desert. The lowest, –129°F (–89°C), as you might expect, was recorded in Antarctica. Annual average temperatures have a much lower range. They vary from 94°F (35°C) at a location in Ethiopia to a bone-chilling –33°F (–36°C) in the heart of Antarctica. As you can see, however, Earth's extremes are small when compared to even the daily range of lunar temperatures. The difference can be explained in one word: atmosphere. Earth's envelope of gases protects the planet from extreme heat or cold. We can thank our atmosphere for life on Earth!

Globally, highest annual average temperatures tend to occur in the tropical latitudes, close to the equator. Coldest average temperatures occur in the polar regions. Many factors influence individual temperatures and temperature extremes. They include latitude, elevation, and whether a place is near or distant from a large body of water. Other factors influence temperatures, such as proximity to a cold or warm ocean current. So do conditions of atmospheric moisture. With their normal cloudless conditions, for example, desert areas tend to be the world's hottest places. Surprisingly, tropical locations rarely experience temperatures in the upper 90s. This is because the almost constant cloud cover blocks incoming heat energy from the sun.

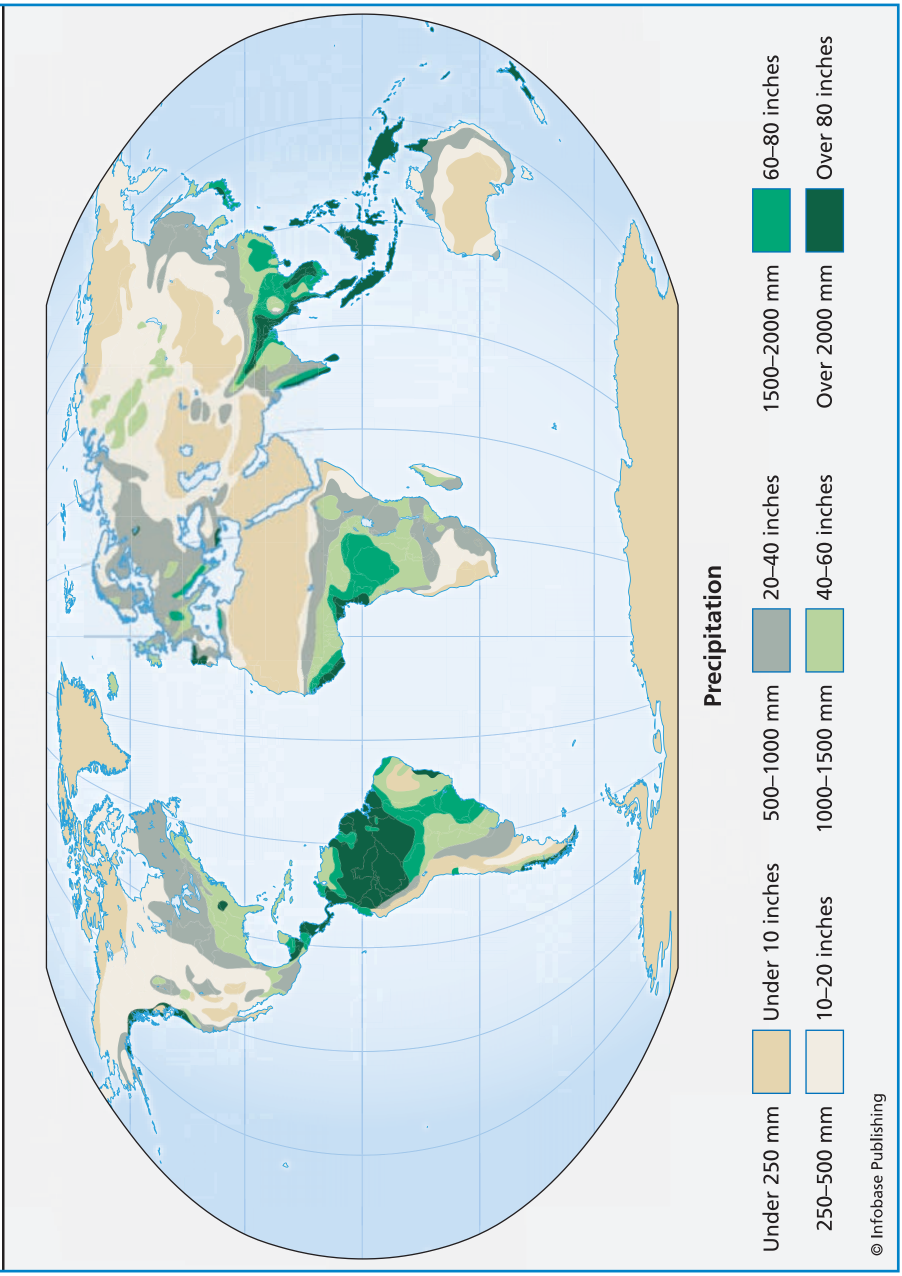
Precipitation

Precipitation is any form of falling moisture—rain, snow, hail, or sleet. The amount and type of precipitation that falls varies greatly from place to place and often from season to season. Both humans and many things within nature must adapt to amounts, seasonal patterns, and types of precipitation received. Can you imagine living in Lloro, a small community located in the steaming Pacific lowlands of tropical Colombia? It is the world's wettest spot. On average, Lloro receives a whopping 524 inches (1,330 centimeters) of rain each year—nearly 44 feet (13.1 meters)! Humans must adjust their lives and activities accordingly. Nature, too, must adapt to conditions of extreme moisture. The vegetation, for example, is a dense tropical rain forest. And hundreds of streams carry runoff to the sea.

Amazingly, the world's driest region also borders the Pacific Ocean, only some 1,700 miles (2,800 km) south of Lloro. There, in the Atacama Desert of northern Chile, several communities receive less than one-tenth of an inch (2.5 mm) of precipitation annually. Whereas rain falls almost daily in Lloro, 20 years may pass without a drop of moisture in areas of the Atacama Desert! Much of the desert is all but lifeless. Such human settlement as exists in the region is tightly clustered around the few scattered oasis sites or mining communities.

In some parts of the world, both the human way of life and nature's patterns of adaptation are keyed to seasonal changes in precipitation. Much of southern, southeastern, and eastern Asia, for example, is influenced by monsoonal conditions. Monsoons are seasonal winds. During the summer months, they blow across the warm tropical waters of the Indian and Pacific oceans and on to the continent. Over land, they release their moisture. This is the wet season during which torrential rains occur. One location in eastern India, Cherrapunji, received almost 1,000 inches (25.4 m) of rain in a single year. Even more amazing, however, nearly all of the rain fell during the six-month wet season! During the winter months, winds reverse direction

World Precipitation



and blow outward from the continent's dry interior. Conditions become bone dry, with weeks on end passing without a cloud in the sky or a drop of rain falling.

On both sides of the equator, located between the humid tropics and desert regions, is another region that experiences a seasonally wet-and-dry climate. During the summer (high sun) season of the year, conditions are similar to those of the humid tropics. Huge amounts of rain fall almost daily. During the other half year, the region falls under the influence of desert-creating conditions. Months can pass without a drop of rain. Vegetation becomes tinder dry. In most of this region, savanna conditions prevail. It is characterized by tall grasses with scattered drought-resistant trees. The savanna, particularly in Africa, is home to abundant wildlife.

For many people, snow is a nuisance they could do without. But try telling that to the millions of people who enjoy skiing and snowboarding, or the owners and operators of ski resorts. One great concern over possible global warming is that less snow will fall. This would ruin the ski industry. It would also have a very serious impact on the water supply of many places. Southern California and much of the interior western United States depend upon winter snow accumulations in the Sierra Nevada, Cascades, and Rocky Mountains. Summer snow melt feeds streams that carry precious water supplies to parched lands below. Throughout the West, hundreds of dams have been built. The reservoirs they create serve as the vault in a bank. They store water that, when needed, is distributed to thirsty fields, livestock, and millions of people throughout the year.

Hail and sleet are frozen forms of precipitation. Hail falls as rounded chunks of ice ranging from pea size to baseball size. For hailstones to form, there must be very strong updrafts. Such upward blowing winds are found in cumulonimbus clouds—huge thunderheads. Since these storm clouds depend upon heat to form, hail is most frequent during summer months and in the middle latitudes. Storms can inflict tremendous damage to buildings, vehicles, crops, and animals. The largest hailstone ever found was about 7 inches (17.8 cm) in diameter and weighed more than 1.5 pounds (6.8 kilograms).

Sleet is partially frozen raindrops or raindrops that freeze immediately upon contact. Such events are commonly called ice storms by the media. They occur in the midlatitudes and are mainly a winter phenomenon. Sleet creates extremely treacherous driving conditions. Sleet storms can result in an accumulation of ice on surfaces. Such buildups often result in

WEATHER'S GLOBAL CONNECTIONS

In 1972, Professor Edward Lorenz, a weather scientist at the Massachusetts Institute of Technology, caused quite a stir in scientific circles. In a talk, he asked the audience, "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" By asking the seemingly ridiculous question, Lorenz was simply trying to draw attention to a very important point. Any action, he cautioned, sets in motion a series of events that can have various outcomes—many of which can be unintended. This certainly is true in regard to global weather and its connections to distant events.

Environmental events that occur in one area can have a huge impact on weather conditions elsewhere, even globally. Explosive volcanic eruptions, for example, can cause a sharp drop in temperatures. In 1815, Mount Tambora, an Indonesian volcano, exploded violently. Millions of tons of volcanic ash, smoke, and gases were blown high into the stratosphere. Upper atmosphere winds then began to spread the volcanic debris around the world.

Once in space, the volcanic pollutants blocked incoming solar energy. The result was a global temperature drop of up to 1.3 degrees Fahrenheit (0.7°C) during 1816. In North America and Europe, its chilling effect is remembered as "the year without a summer." Most farm crops in the United States and Canada failed. So did many crops in Europe. The weather-related crop failures resulted in the nineteenth century's worst famine. Tens of thousands of people died extensive and costly damage to power and communication lines. A coating of ice can also devastate woodlands, as branches and even trees snap under the added weight.

Pressure and Wind

Winds blow from areas of high barometric (atmospheric) pressure to places with lower pressure. The equatorial region is an area of low pressure. Centered over about 30 degrees north and

of starvation. During recent decades, other volcanic eruptions have caused temperatures to drop. The eruption of Mount St. Helens (USA, 1980), El Chichón (Mexico, 1982), and Mount Pinatubo (Philippines, 1991) all caused a slight decline in global temperatures.

During recent decades, scientists have recognized another natural event that has a far-reaching impact on global weather—El Niño. During an El Niño event, water temperatures in the equatorial latitudes of the eastern Pacific change rapidly. Under normal conditions, the water of the Peruvian Current off the coast of Peru and Ecuador is cold. With the onset of an El Niño event, the cold water is replaced by much warmer water from the tropical Pacific.

What triggers the onset of an El Niño event remains somewhat of a mystery. But scientists now recognize that El Niño creates atmospheric havoc in many regions of the world. Some areas become much wetter and may experience devastating floods. Elsewhere, it causes severe drought. Some locations experience higher temperatures, while others shiver in temperatures well below normal. In some locations, storm frequency increases, whereas in other places storm activity declines. Atmospheric scientists are still working on the El Niño puzzle. They do not fully understand what conditions will occur where during an event. What they do now recognize is that a change in the water temperature off the coast of western South America has many connections to global weather conditions.

south latitude are belts of high pressure. It is these pressure systems that establish the world's major wind systems.

Between 30 degrees north and south latitude, winds generally blow from the east. In the Northern Hemisphere, they come from the northeast and are called the northeast trade winds. (Winds take the name of the direction from which they blow.) The name may seem strange, but in the era of sailing vessels, these very reliable winds pushed ships from Europe across the Atlantic to the Caribbean Sea. They were good for trade. The southeast trade winds are basically the same system in the Southern Hemisphere. Between 30 and 60 degrees north and south latitude, winds prevail from the west. They are called the prevailing westerlies.

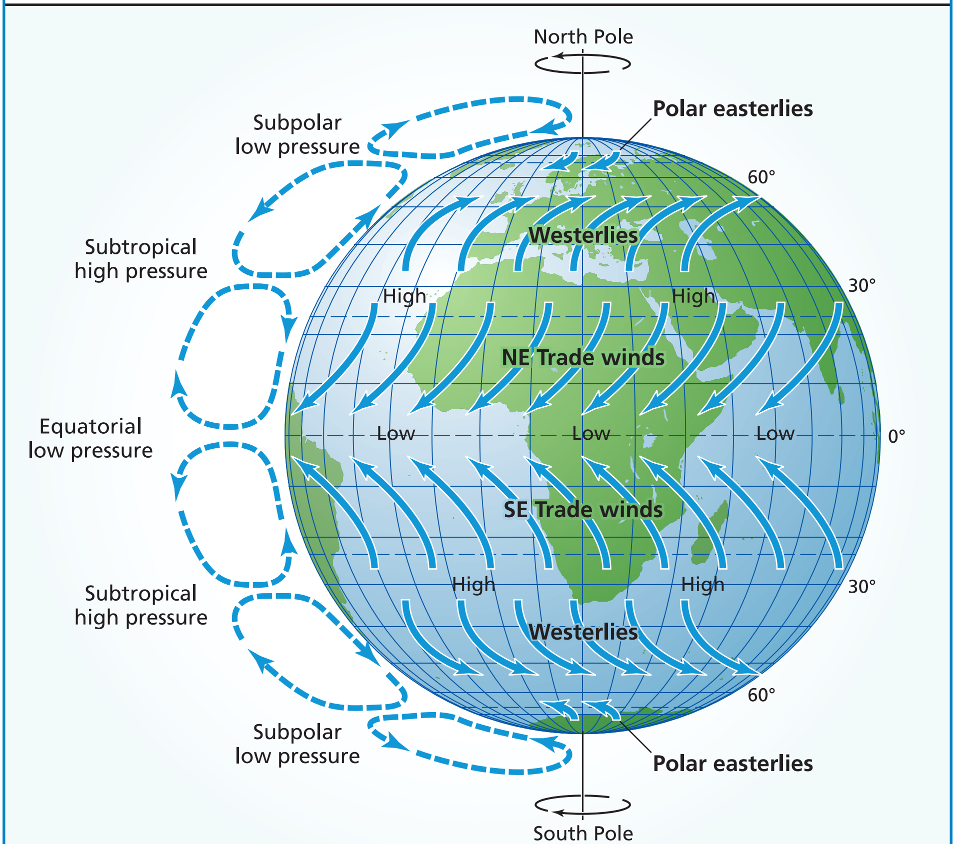
HUMAN ADAPTATION TO WEATHER AND CLIMATE

Humans adapt to weather and climate in countless ways. You will recall that biologically, humans are tropical animals. Therefore, we have had to adapt in some way to conditions found any place we live outside of the hot equatorial zone. Our culture, however, has provided humans with the ability to expand our habitat—the places we can survive. So successful has our species been in adapting that today we can survive—and even thrive—in every one of Earth's climates and ecosystems.

The means by which different cultures have adapted to the environment(s) in which they live vary greatly from place to place. First, we had to find ways to protect our body against the cold. This is done in a number of ways. Control of fire was the first great step forward in expanding the human habitat. It was followed through time by building better shelters and making warmer clothing and footwear.

Our activities, too, must be adapted to climatic conditions, including seasonal changes that occur in most of the world's climatic realms. Much of what we do economically must be keyed to weather and climate. Most agricultural crops, for example, are

Global Pressure and Wind Systems



adapted to a particular climatic condition. A great deal of tourism also depends upon certain weather conditions. This ranges from mountain snow skiing to basking on a tropical beach during the midlatitude winter.

WEATHER AND CLIMATE AS A NATURAL RESOURCE

Weather and climate are somewhat different than metals, timber, fish, or any other useful natural element. Yet in many ways the atmosphere and its various conditions serve as a valuable natural resource. To the owner of a ski resort, snow on a mountain slope is a source of income. As such, it is an important resource. In the warmer, snow-free valley far below, cities and agriculture depend upon a stream that flows from the mountain. To them, the snow is also a vital resource. They depend upon water from spring and summer snow melt for their water supply.

For more than 2,000 years, wind energy has been harnessed for various purposes. Throughout much of history, most ships were sailing vessels. They depended upon the wind as their source of power. Windmills have been used for centuries to pump water. Today, huge wind farms have been built in many locations throughout the United States and elsewhere. Their giant windmills harvest the wind's energy and convert it into more useable electricity.

Increasingly, climate is valued as an amenity. People are drawn to conditions of weather and climate that they find pleasant or attractive. In the United States, for example, there has been a major migration flow during the past half century. Millions of people have left the Snow Belt of the Northeast and moved to the Sun Belt. They have been attracted by warmer temperatures in the South and Southwest. Many retirees, too, have sought the amenity of a warmer climate in which to live. After all, one cannot play golf or enjoy an outdoor barbecue 365 days a year in the Snow Belt.

WEATHER HAZARDS

Throughout history, most of the greatest natural disasters have been weather related. Floods have taken a terrible toll on human life and property. In fact, four of the five greatest disasters ever recorded have been flood related. In 1931, up to 4 million people died from flooding of China's Huang He ("Yellow" River). In 1970, an estimated half million people lost their lives in low-lying Bangladesh, when the country was swamped by flood waters from a cyclone. Indirectly, drought has taken an even greater toll. In India, the summer monsoon winds failed to bring desperately needed rainfall during a two-year period in the late 1870s. The drought caused a massive crop failure that resulted in widespread famine and the death of some 25 million from starvation.

A very important point is revealed by the data appearing in Table 1. Nearly all of the major "natural" disasters occurred in very densely populated places. In fact, six of the eight catastrophic events happened in people-packed Asian countries. Many places are more susceptible to hazardous weather-related events than are the record-holding places listed. But they have many fewer people to suffer from the ravages of nature on a rampage.

Most places in the world experience some kind of weather-related hazard(s). By and large, people become adapted to such conditions. That is, they learn to take steps to avoid at least the worst of what nature throws at them. In many hurricane-prone areas (including in the United States), for example, houses may be built on stilts. This allows treacherous wind-pushed surges of water to pass beneath structures. In America's "Tornado Alley," most homes have basements or storm cellars. Unfortunately, as populations grow, more and more people are forced

TABLE 1. WORST WEATHER-RELATED NATURAL DISASTERS BY CATEGORY

Event	Location	Date	Deaths
Avalanche (snow)	United States (Stevens Pass, WA)	1910	96
Blizzard	Iran	1972	4,000
Drought	India	1876–1878	25,500,000
Flood	China	1931	<4,000,000
Hail	India	Ninth century	600
Heat wave	Europe	2003	37,451
Tornado	Bangladesh	1989	1,300
Tropical storm	Bangladesh	1970	<500,000

MAKING CONNECTIONS

OUR POLLUTED ATMOSPHERE

During the 1970s, the author lived for a while in the southeastern United States. Thousands of miles away, on the southern margin of North Africa's Sahara Desert, a severe drought gripped the land. The event affected mainly the Sahel region (*Sahel* means "shore," in this case, the edge of the Sahara). It turned millions of acres of agricultural (crop and grazing) land into desert. Fierce winds swept up the exposed red earth and carried it high into the atmosphere. Upper atmospheric winds then carried the clouds of dust across the Atlantic Ocean. Can you imagine the shock felt by millions of southerners when the sky turned red and red rain fell in places? Atmospheric pollution is global in both origin and distribution.

Recently, scientists have begun to study the nagging haze that often hangs over coastal Washington state and other areas along the West Coast. They were in for a surprise. The pollution, they found, is caused mainly by smoke from China's coal-burning industries. Industrial pollution from factories in northwest Europe causes acid rain and other forms of pollution in central Europe. Lakes and forests in much of New England also have suffered from acid rain. The pollutants come from industries around the Great Lakes in both the United States and Canada. (Sudbury, Ontario, boasts the world's second tallest chimney, a towering 1,247-foot [380 m] stack that boosts toxic smoke high into the atmosphere.)

Few places on Earth are free from atmospheric pollution. And increasingly, pollution from one source can foul the atmosphere of distant places. Conduct research to determine whether your area experiences atmospheric pollution from some distant source. What affect does it have on your area? Does your community or region contribute to atmospheric pollution? If so, how? Are steps being taken to reduce the pollution?

to live in hazardous places. When nature strikes, more people are there to experience its fury. In the United States, however, many people seek such locations by choice. They want to live along the Gulf or Atlantic coast because of the scenery and other amenities of a coastal location. They do this knowing that a hurricane can strike at any time during the storm season. Property and lives are placed in jeopardy even though people are aware of the risk.

CLIMATE CHANGE

Climate change—particularly the threat posed by "global warming"—is a cause of major concern for many people, businesses, and governments. What is happening? Is Earth warming? And if it is, are humans the cause? If the planet is getting warmer, will the consequences be as catastrophic as the media, many politicians, and others would like us to believe? Three short decades ago, many of the same people and agencies also were spreading panic. They were terrified that Earth was on the brink of another Ice Age and we were all going to freeze!

Twelve thousand years ago the author would not have been sitting in this location while writing. Eastern South Dakota was buried beneath a mile-thick sheet of glacial ice. On the other hand, fossil remains, including pollen and other historical records, clearly show that at times past, the weather was much warmer than it is now. Climate changes. It changes repeatedly. And it will continue to change. Like a seesaw, it goes up and down—warmer and colder, wetter and drier. Earth's atmosphere is incredibly complex. Many factors combine to influence its conditions and changes. Throughout human history, people have adapted to change. Certainly we shall continue to do so whether Earth is now warming or—as recent drops in temperatures suggest—is entering another long cold spell.

LAND FEATURES

Lithos is a Greek word meaning "stone." In this chapter, we will investigate the "stony" part of Earth's surface, its land features and soils, which combined form the lithosphere. Only 29 percent of the planet's surface is composed of dry land. Yet it is this small portion of Earth that we call "home." It is where we live and on which most of our economic and other day-to-day activity takes place.

Geo (earth) and *logy* (science) are also Greek words. Geology is the science of the earth, the study of its origin, age, and structure. Geomorphology, closely related to geology, is the science of landforms. A geomorphologist, for example, might study a mountain range. First, she would want to identify the structure itself; what kind of mountain is it? Second, what is its stage of development; is it a young mountain or very old? Finally, what processes formed the mountain and what agents have worked to wear it away?

Earth's land features and soils vary greatly from place to place. In the small South Asian country of Nepal, Mount Everest, the crown jewel of the Himalaya Range, towers 29,035 feet (8,850 m) above sea level. Several thousand miles distant, sandwiched between Jordan and Israel, is the small Dead Sea. At 1,378 feet (420 m) below sea level, its shoreline is the lowest spot of dry land on Earth.

Differences in elevation are even greater on the ocean floor. Mount Everest is the world's highest mountain above sea level. But Hawaii's Mauna Kea is the tallest mountain as measured from bottom to top. It rises 20,000 feet from the ocean floor to an elevation of 13,796 feet (4,205 m) above sea level—a total of 33,796 feet (10,301 m).

And in the western Pacific Basin, the Challenger Deep in the Marianas Trench plunges to a depth of 35,838 feet (10,923 m). If Mount Everest rose from the bottom of the Deep, its peak would still be more than a mile (1.6+ km) below the ocean's surface.

Terrain—the form of the land—makes a huge difference in terms of human activity. Fertile plains can easily be farmed by large equipment. They are easy to travel and build upon. Most of Earth's transportation networks and cities are located on plains. Mountains, on the other hand, often serve as barriers. Few routes cross ranges such as Asia's Himalayas or South America's Andes. But mountains do offer spectacular scenery and many recreational opportunities that attract millions of people. Majestic mountains tower above sprawling plains on every continent. In between the extremes of mountains and plains, hills and plateaus offer diverse natural landscapes.

All landform regions offer some opportunity for human activity. Many of the flattest and most boring plains rank among our very best agricultural areas. Excellent soils are found on most coastal plains, river valleys, and interior plains areas. The most rugged terrain offers scenery, recreational opportunities, and for some people, even protection. Let's begin our investigation of Earth's land features with a close look at the various types of landforms.

MAJOR LANDFORMS

Landforms come in many sizes and shapes. How does such diversity occur? The answer lies in the various processes that create them. Some forces build land features. Others work to wear them away. Every spot of dry land on Earth's surface is affected by one or more of the agents of change. Space does not allow a detailed discussion of each land feature. Here, attention is given only to the major landforms and the forces that shape them. Each continent, someplace within its territory, has examples of the four major landform features—plains, hills, plateaus, and mountains.

Plains

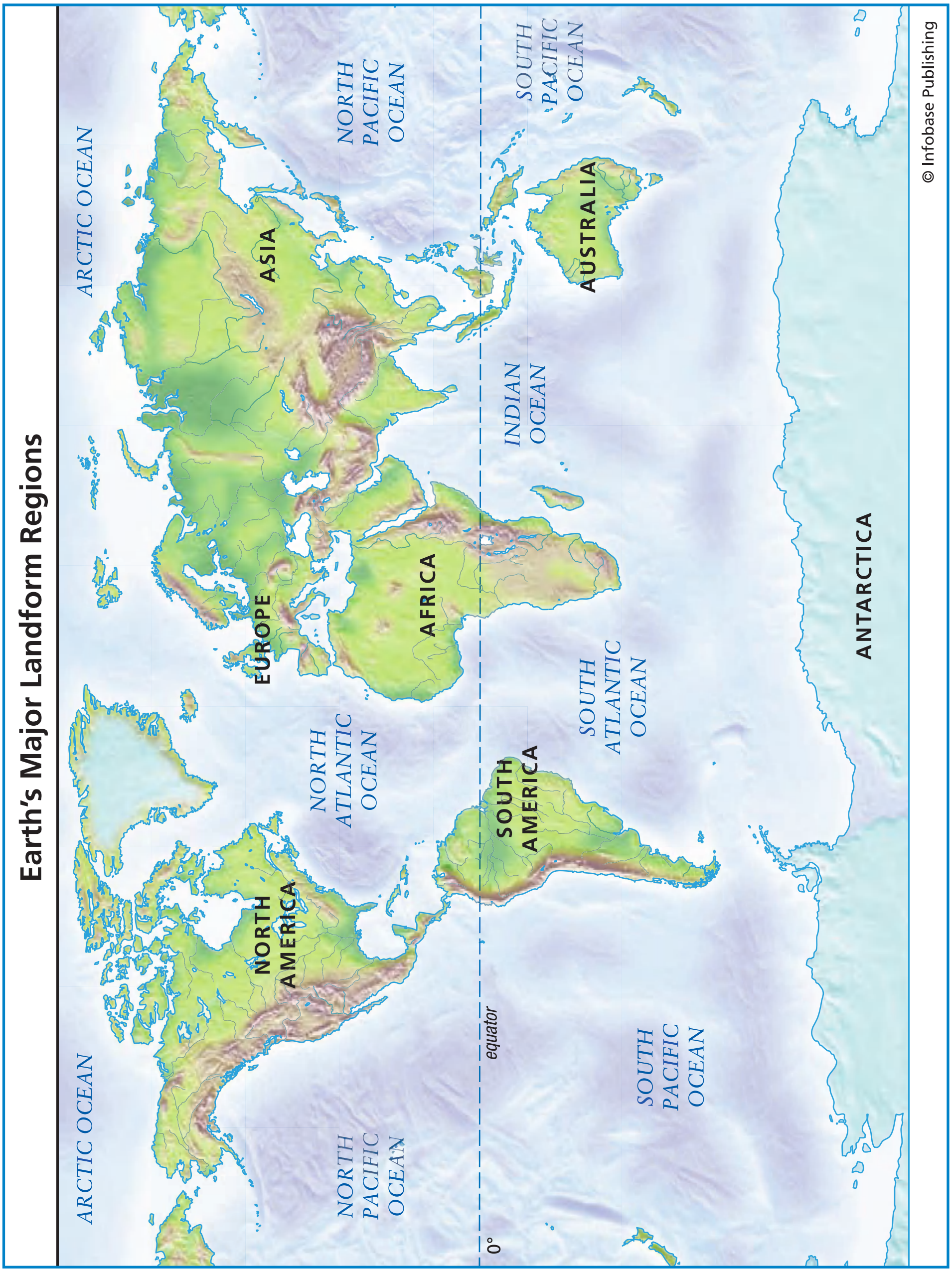
Plains are large areas of relatively flat land. They may be low in elevation. The Amazon Basin, West Siberian Lowland, and Gulf Coastal Plain of the United States are examples of large, flat, low-lying plains. Denver, Colorado, on the other hand, is called the Mile High City, and it is located on the western margin of the North American Great Plains. South America's Altiplano (high plain) is perched at elevations of about 12,000 feet (3,658 m) in the central Andes.

Hills

Hills are uplands that are not as high as mountains. This definition may seem a bit vague. Many people, after all, want features to be arbitrarily defined. But in reality, this rarely works. For example, the highest elevation in the United States and Canada east of the Rocky Mountains is 7,242 feet (2,207m), in the Black *Hills* of South Dakota. On the other hand, the highest elevation in Louisiana is 535-foot (163-m) high *Mount* Driskill. Clearly, whether a feature is a hill or a mountain depends upon the eye of the beholder (and the person who named it).

Plateaus

A plateau is a large tableland. Mesas and buttes are similar but smaller in area. Like a plain, a plateau has a relatively flat



surface. But what sets plateaus apart is that they must have steep escarpments (slopes) on one or more sides. Examples in the United States include the Colorado Plateau in the Southwest and the Columbia Plateau in the Pacific Northwest. Both regions feature spectacular cliffs and deep canyons. In some cases, the bordering slopes go upward. One example is Mexico's high Central Plateau, at the south end of which is Mexico City, one of the world's largest urban areas. This plateau is bordered on three sides by high mountain ranges. The high Plateau of Tibet is also bordered by rising slopes of the Himalayas and ther ranges.

Mountains

Mountains are the highest and usually the most rugged landform features. Some mountains stand as lone sentinels. In the United States, many such peaks are scattered about the Basin and Range physiographic region of the Southwest. Others are part of much larger ranges (*sierras* in Spanish). In the United States, these include:

Mountain peak	Mountain range	Elevation
Mount Mitchell (NC)	Appalachians	6,684 ft. (2,037m)
Mount Elbert (CO)	Rocky Mountains	14,433 ft. (4,399m)
Mount Whitney (CA)	Sierra Nevada	14,494 ft. (4,418m)
Mount Rainier (WA)	Cascades	14,410 ft. (4,392m)
Mount McKinley (AK)	Alaska Range	20,320 ft. (6,194m)

The world's longest mountain range is in South America. The Andes stretch some 5,500 miles (8,850 km) from the southern tip to the northern tip of the continent. In elevation, no range comes even close to matching South Asia's towering Himalayas. In fact, seven of the world's 10 highest peaks—including Mount Everest—are located in one small Himalayan country: Nepal.

BUILDING LAND FEATURES

Have you ever noticed how different various land features look? Take mountains, for example. Some look like smooth-sided cones, while others resemble the jagged teeth of a saw. Some, like Japan's beautiful and sacred Mount Fuji (Fujiyama), are symmetrical. Others have one very long slope and another slope that plunges steeply. Such differences are basically the result of two sets of agents that constantly work in opposition to one another. One group of agents—the tectonic forces—work to build land features upward. The other—agents of weathering and erosion—work to tear them down.

Various forces work from within the earth to build land features. These are called the tectonic forces. Plate tectonics is the theory that huge segments of Earth are moving about. Imagine that you are driving a giant bulldozer (a plate) moving earthen material. As it slams into a mass of rock and dirt, what happens? *Voila!* You have just created the Himalayas! The range was formed as the Indo-Australian Plate plowed into South Asia beginning millions of years ago.

Faulting also creates mountains and other features. A fault is a zone along which movement of earth material occurs. It can take place very slowly, as in the building of a mountain range. When movement occurs rapidly, it is called seismic activity—an earthquake. In your mind, take a shoe box and place it on the table before you. Now lift the right hand (eastern) side of the box. What do you have? There is a long, gentle slope on the left (west) and a very steep slope on the right (east). You have just formed California's Sierra Nevada, a gigantic upward-tilted fault block range. The highest point, very near the sharp peak of the shoe box, is Mount McKinley.

Now take a piece of paper. Hold it horizontally before you. Push both hands toward one another several times. What happens to the paper? Sometimes a rounded upward fold will form; on other occasions, depending upon how you apply pressure, the paper folds downward. You have just created the Appalachians, a folded range of mountains. From the air, the parallel ridge-and-valley terrain of the Appalachians looks much like the folds in an accordion.

Have you ever heard of the Pacific Ring (or "Rim") of Fire? It is a belt of geologic instability that surrounds the Pacific Basin. This zone is formed by the collision of numerous tectonic plates. These slow but violent clashes around the Pacific result in most of the world's volcanoes and earthquakes. Volcanic action can also create mountains. In the United States, the Cascades, which stretch from northern California into Washington State, are volcanic in origin. Most recently, the 1980 eruption of Mount Saint Helens served as a violent reminder of the Cascades' volcanic origin!

TEARING LAND DOWN

Again, natural forces constantly work against one another. Tectonic forces try to build land features upward. Other forces, those of weathering and erosion, are constantly at work trying to wear them away.

Weathering of Rock Material

Have you ever noticed a pile of rock rubble at the base of a cliff or a large crack in a sidewalk or driveway? Weathering is the process by which natural forces break rock material into smaller pieces. Thanks to weathering, once massive rocks eventually become smaller stones and, ultimately, particles of sand, silt, and dust. Space does not allow a detailed explanation of how weathering occurs. Many agents are responsible. Some of them cause rock to break apart. This is mechanical weathering. Others take rock into solution. This process is chemical weathering. Caves, for example, are caused when chemicals (in water) come into contact with limestone rock. Gradually, the chemical action eats away at the soluble rock, which dissolves, leaving a hollow spot, or cavern.

Agents of Erosion

Erosion is the transport of weathered rock materials from one place and their deposition in another. It is a process that has gone on since the beginning of time. In nature, erosion and deposition are the work of several agents. Gravity moves materials down slope. Sometimes the movement is very slow. Earth material, for example, can creep slowly down a hillside, perhaps moving only an inch or two a year. At the other extreme, land—whether mud, dirt, or rock—can move very rapidly. Such events include mudflows, landslides, and avalanches. (These events are discussed further in the section on hazards.)

The most common erosional features are those that result from action of ice, water, and wind. Some of the world's most spectacular scenery is the result of erosion. And some of the most fertile lands were formed by deposition.

Continental Ice Sheets

A large portion of Earth's middle and poleward latitudes has been shaped by glacial ice. On four separate occasions during the Pleistocene (the past million or so years of geologic history, also called the Ice Age), huge ice masses covered large areas of the northern United States and most of Canada. Much of Europe and Asia were also buried beneath ice. Remnants of the Ice Age exist today in Greenland and Antarctica.

These were continental glaciers, or ice sheets. They moved like gigantic graders, rounding off and tearing away everything in their path. An estimated 90 percent of the world's lakes were formed by glacial action. Ice sheets scoured depressions that, as they receded, filled with meltwater. North America's Great Lakes system is an example of their work. But so, too, are the hundreds of thousands of smaller lakes that dot the landscape of formerly glaciated areas. All of the glacial debris had to be deposited somewhere, usually at the outer margin of the glacial ice. Much of the soil of the U.S. Midwest, for example, was formed upon glacial till (debris) that was carried southward and deposited. Today, it forms the rich soils of the Corn Belt.

Mountain Glaciers

Mountain or "alpine" glaciers are a second type of glacial feature. As their name suggests, these are ice masses that form at high elevations. You have probably noticed that snow and ice often appear on the peaks of many high mountains. This is because temperatures drop with increasing altitude. Surprisingly, perhaps, glaciers can be found on higher peaks on or near the equator in South America, Africa, and the island of New Guinea.

Unlike continental glaciers that tend to level and round off terrain, mountain glaciers tend to increase relief (vertical distances). Much of the spectacular mountainous terrain in northern portions of the United States (including Alaska) and in Canada is the result of glacial erosion. Examples in the United States include Glacier National Park (MT), Grand Teton National Park (WY), Rocky Mountain National Park (CO), and, of course, all mountains in Alaska. Europe's spectacularly rugged Alpine peaks also owe their jagged features to glacial erosion.

Water Erosion

Have you ever looked closely at a stream and noticed sand moving along its bottom? Certainly you have seen silt carried in a stream that makes its water look dirty. Each particle of earth came from somewhere and will be deposited someplace else. Stream action can have a profound impact on the landscape. It is a very important erosional agent, the work of which happens any place water is in motion and something is present to erode.

Waves eat away at shorelines. They erode land in one place and deposit sand elsewhere to form beaches and other coastal features. Rivers are the major agents of water erosion. Near its mouth, the Mississippi River is a very dirty stream. It should be. The "Mighty Mississippi" transports sand and silt from 31 U.S. states and two Canadian provinces! Louisiana has been called a "gift of the Mississippi." Nearly all of the state (and portions of other states that border the Mississippi in its lower course) was formed by the river's deposition of silt.

Many places in the United States have breathtaking scenery created by water erosion. None is more spectacular than the various erosional features on the Colorado Plateau. There, more than a dozen national parks and monuments showcase landscapes created by water erosion. None is more spectacular than the Grand Canyon, gouged in the plateau's surface over millions of years by the erosive force of the Colorado River.

Work of the Wind

Of the four agents that wear away land features, the work of the wind is the least significant. The most visible aeolian (wind-created) landforms are sand dunes. Even in desert regions, however, dunes cover only a small area. Examples include the Algodones Dunes in southeastern California, Great Sand Dunes National Monument in south-central Colorado, and White Sands National Monument in southern New Mexico. Surprisingly perhaps, some of the greatest expanses of dunes are found in humid areas. Large dunes, for example, occur along the coasts of Oregon and North Carolina's Outer Banks.

Human Impact

Humans have a major impact on both creating and protecting land features. Our effect is both intentional and unintentional. In places throughout much of the world, the land has been permanently scarred by mining activity. In the United States, huge open pits scar the landscape of many western states. Not only does mining result in gaping holes in the ground, it also leaves man-made mountains of tailings (waste material). The West is not the only area of the United States that has been affected by surface mining. Vast areas of land have been stripped away in Minnesota's Iron Range and in coal-mining regions of Appalachia.

In parts of Asia, the Central Andean area of South America, and elsewhere, mountain sides have been terraced to create

This image of Utah's Bingham Canyon Pit illustrates the impact human activity can have on Earth's lands. The copper mine reduced an 8,000-foot mountain to the world's largest human-made hole.

land suitable for farming. Throughout much of the world, land has been stripped away for the construction of buildings and other structures. Many low-lying areas, on the other hand, have been built up with landfill so they can accommodate construction. The next time you take a road trip, notice places where earth was either cut away or filled in to create a relatively smooth roadway.

HUMAN ADAPTATION TO LAND RESOURCES

It may seem strange to think of land as a natural resource. After all, it is not like oil, iron ore, coal, or timber. Yet we use land and it has value to us; therefore, it is a resource. Think for a moment about the area in which you live. Are most farms, transportation routes, and communities on relatively flat land? Are there rugged uplands in your area? If so, are they developed economically? For example, are there communities or parks that draw tourists to ski, camp, enjoy cooler summer temperatures, or just view the scenery?

Does any land feature serve as a barrier to transportation? The author once worked on the Glen Canyon Dam project on the Colorado River near the Arizona-Utah border. At that point, the canyon was about 700 feet (213 m) deep. Its 1,200 foot (366 m) width was spanned by a narrow footbridge. To drive to the other side of the narrow gorge, however, was a trip of more than 200 miles (322 km). You might ask, "If the canyon is a barrier, how is it a resource?" Look at a map of the region. How many national parks and national monuments can you locate in the area that have "canyon" as a part of their name? How many millions of people and billions of dollars are attracted to the area each year to view its scenic canyon land wonders?

For obvious reasons, most transportation routes, towns and cities, and farmlands are located on plains. In fact, an estimated 90 percent of human settlement and economic activity takes place on relatively flat lands. There are exceptions. In hot equatorial latitudes, many people prefer to live in cooler highlands. In the tropical Andean region, from Venezuela to Bolivia, most of the population is clustered in high mountain valleys. Temperatures are much cooler and the highlands are relatively free of tropical diseases. Today, in economically developed countries, many people choose to live in rugged upland areas because of their scenery. Mining, administration, recreation (such as skiing), and military ventures can all draw people into hills, plateaus, and mountains.

People tend to cluster in areas where nature offers them some advantage. Many American cities owe their origin and subsequent growth to good natural harbors. They include Boston, New York, San Diego, San Francisco, and Seattle. In mountainous areas, cities are often located at the end of a mountain pass. Examples include Salt Lake City (UT), Denver (CO), and Albuquerque (NM).

Terrain can also offer a refuge—a place for oppressed groups to hide away. The Caucasus Mountains offer a splendid example. The range is located between the Black and Caspian seas on a portion of the border between Europe and Asia. The surrounding region has long been a cauldron of cultural antagonisms and conflicts. Today, in an area about the size of Kansas, several hundred different languages are spoken. Various groups sought protection in the mountains, some perhaps thousands of years ago. They remain there today.

SOILS

If you like to eat, you can thank soils for nearly all of your food. It certainly ranks as one of our most important and useful natural resources. Soil is more than just "dirt." It is a combination of earth material and organic matter. The type of soil found in a particular location is a product of several factors. This includes the rock material from which the soil was formed (called parent material). Climate is also important. In a dry location, few soil nutrients will be lost by leaching (the washing out of minerals).

Many regions that receive less than 40 inches (100 cm) of precipitation have quite fertile soils. Humid tropical regions, on the other hand, are notorious for the infertility of their soils. Most of the

MAKING CONNECTIONS

A DEADLY EVENT WITH WIDESPREAD CONNECTIONS

On December 26, 2004, a huge earthquake jarred the ocean floor just off the Indonesian island of Sumatra. The jolt to the ocean floor resulted in a huge tsunami, one of the largest ever and certainly the most devastating. From its spot of origin, it spread out across the Indian Ocean at speeds of about 500 miles per hour (800km/h). It struck with deadly impact in low-lying areas of Indonesia, Thailand, Sri Lanka, and southeastern India. The huge waves also swept across many low islands in the Indian Ocean Basin. An estimated 230,000 people lost their lives directly as a result of the event. It ranks as the seventh most deadly, and certainly one of the most costly, natural disasters of all time.

Particularly hard hit were vacation resorts along Thailand's coast. Because the earthquake and tsunami occurred a day after Christmas, it struck during the peak holiday season. Certainly a geologic event that occurred in deep ocean water off the coast of an Indonesian island had an awesome reach in terms of the lands and people it affected.

Do some research on the Indian Ocean earthquake and tsunami of 2004. The earthquake itself occurred at coordinates 3°18'58"N latitude and 95°51'14" E longitude.

But how far did its influence spread? In how many different ways were people's lives changed (or lost)?Can you think of other ways that land features and other natural hazards affect people far beyond their location? (Don't forget soils and the crops they produce.)

nutrients have been washed away (leeched). Vegetation cover is also important. It is what contributes to the humus (decomposed organic matter) contained within a soil type. Some of the world's richest soil formed beneath a grassland cover. The sod (thickly matted roots of grasses) added valuable nutrients to the upper layers of soil. This is what happened in the prairie and steppe grassland areas that today are the world's major "breadbaskets." They include the interior plains of North America, the Pampas of Argentina, and the Black Earth Belt of interior Eurasia.

No doubt you have always heard that erosion is very bad, particularly for farming. Well, the answer to this common bit of wisdom is both "yes" and "no." Many of the world's most fertile agricultural lands are in river valleys and coastal plains. Soils are fertile because they are alluvial, that is, water deposited. Such soils form from material that was eroded someplace upslope or upstream. They eventually were deposited in their present location. Nearly all of the world's tropical plantations, for example, are located on alluvial soils. Tropical soils that formed in place are notoriously infertile. Because of the high amounts of rainfall, they have been leached of nearly all of their nutrients. But periodic flooding and deposition of silt, as in the ancient Nile Valley, renews the fertility of alluvial soils.

LAND-CAUSED ENVIRONMENTAL HAZARDS

Some of the world's greatest disasters have been caused by earthquakes, volcanic eruptions, and landslides. Additionally, tsunamis can be caused by any of the foregoing events if they occur on the ocean floor. They, too, have taken a terrible toll of human life and property. In the Western Hemisphere, nine of the ten greatest natural disasters as measured by loss of life have been caused by earth-related hazards (see Table 2).

Earthquakes

Worldwide, six earthquakes have resulted in more than 200,000 deaths each. Three of them occurred in densely populated China.

TABLE 2. MAJOR LAND-RELATED DISASTERS IN THE WESTERN HEMISPHERE			
DATE	**EVENT**	**LOCATION**	**DEATHS**
1970	Earthquake and avalanche	Peru	69,000
1797	Earthquake	Ecuador	40,000
1902	Volcanic eruption	Martinique	30,000
1868	Earthquake and tsunami	Chile	25,674,
1985	Volcanic eruption and mudflow	Colombia	25,000
1976	Earthquake	Guatemala	23,000
1780	Hurricane	Caribbean Islands	22,000
1812	Earthquake	Venezuela	20,000
1939	Earthquake	Chile	20,000
1999	Mudslides	Venezuela	10,000–30,000

In 1556, an estimated 830,000 Chinese were killed by an earthquake that remains the most catastrophic such event in history. Areas facing upon the Pacific Rim are particularly prone to earthquake (and volcanic) activity. You will note that 8 of the 10 major land-related disasters in the Western Hemisphere happened in countries bordering the Pacific Ocean.

The most deadly tremor in the United States was the San Francisco earthquake of 1906. As many as 3,000 lives were lost, and about 80 percent of the city was destroyed. Surprisingly, perhaps, most destruction of property was caused by fire. The tremor ruptured gaslines throughout the city, starting more than 30 fires. The raging inferno destroyed some 25,000 structures in an area of nearly 500 city blocks.

Anchorage and a number of other Alaskan communities were devastated by a terrible earthquake in 1964. It measured 8.4 on the Richter scale (used to record earthquake intensity), making it the second strongest tremor ever recorded. The resulting tsunami (incorrectly called a tidal wave) was also the second highest ever measured. One hundred thirty-one people lost their lives. Many of them died when they were washed away by the tsunami that in places exceeded 70 feet (21 m) in height. Most tsunamis, in fact, are caused by seismic (earthquake) activity.

Volcanic Eruptions

Explosive volcanic eruptions can also take a dreadful toll of life and property. Indonesia, an island country in Southeast Asia, is particularly vulnerable to devastating volcanic events. In fact, 4 of the top 10 most deadly eruptions have occurred in Indonesia.

TREACHEROUS TERRAIN

The Southeast Asian island country of Indonesia is home to more than 400 volcanoes, about 100 of which remain active. Since 1600, the country has experienced about 70 eruptions, including some of the world's most violent volcanic events. During the past thousand years, Earth has experience 23 volcanic disasters that resulted in the loss of 1,000 or more lives. Nine of them have occurred in Indonesia.

A volcano, it might seem, can really influence only its immediate environment. But is this really true? Two of history's most violent volcanic eruptions occurred in Indonesia. In 1815, the Tambora volcano erupted violently. An estimated 12,000 people living near the mountain lost their lives in the explosion. Another 80,000 Indonesians died of starvation because crops were destroyed beneath layers of volcanic ash.

The effects of the Tambora eruption, however, reached far beyond the islands. Ash from the eruption was blown high into the atmosphere. There, it formed a blanket that blocked some of the sun's energy. As a result, temperatures dropped by up to 5 degrees (about 3°C) worldwide, causing widespread crop failures and famine in many locations.

A volcanic eruption can kill and destroy property in at least three ways. First, the explosion itself can be devastating. The force of the blast can cause widespread destruction. A shower of rock and other debris adds to the devastation near the eruption. Searing hot gases and ash can create deadly pyroclastic flows. Second, if the eruption occurs within an ocean basin, it can create a tsunami. These huge, fast-moving, often deadly waves can wreak havoc hundreds, or even thousands, of miles away.

Finally, volcanic ash can cause a drop in the global temperature. Cooler temperatures, in turn, can result in crop

In 1883, another Indonesian volcano, Krakatoa (Krakatau), erupted with catastrophic results. On August 26, residents of a small island on the eastern edge of Africa heard a strange rumbling sound, much like distant thunder. They had no way of knowing that what they heard was the sound of a violent volcanic explosion nearly 3,000 miles (4,800 km) away.

The explosion destroyed two-thirds of Krakatoa (the island formed by the volcano). Debris was blown nearly 17 miles (23 km) into the atmosphere. Where there had once been a volcanic island, the ocean was up to 1,000 feet (300 m) deep. The explosion was just the beginning. It created a giant tsunami up to 120 feet (40 meters) high that spread throughout Southeast Asia's coastal region. The raging waves destroyed 165 coastal villages and killed an estimated 37,000 people. Ash and gases were blown into the upper atmosphere, causing sunrises and sunsets to be much more colorful for several years. And as happened with the Tambora eruption, global temperatures dropped—about 2 degrees (1.2°C)—and five years passed before temperatures returned to normal. And, again, crop failures in many midlatitude countries caused hunger and starvation for millions of people.

failures that cause famine and death by starvation. In 1600, Peru's Huaynaputina volcano exploded violently. Some scientists believe that the eruption caused a temperature drop that resulted in the coldest year in six centuries. Throughout the mid- and northern latitudes of the Northern Hemisphere, crops failed. In Russia, alone, some 2 million people died of starvation. Many others starved to death elsewhere.

The United States is not immune to deadly volcanic eruptions. About 7,700 years ago, a volcano in the Cascades exploded to create what is today Oregon's Crater Lake. A similar, although less explosive, event occurred in 1980, when Washington's Mount St. Helens erupted violently. The blast devastated the surrounding area for many miles and resulted in 57 fatalities. Fortunately, very few people lived in the area of the eruption, or the death toll would have been much higher.

Landslides and Mudflows

You do not often hear about landslides or mudflows. Explosive volcanic eruptions and violent earthquakes seem to get much more media attention. Yet many of the most devastating natural disasters have been landslides and mudflows. Earth moves in various ways, including rock avalanches, landslides, and mud flows. Movement can be rapid and violent, and can result in widespread devastation. This happens frequently in Southern California, where many wildfires occur during the dry summer and early fall months. Fire destroys the hillside vegetation, leaving slopes bare. When the rainy season begins in late fall, the exposed earth can become saturated. When this occurs, it can flow as mud or as huge masses of solid earth. Either way, property located downslope can be washed away or buried in debris.

An avalanche caused the Western Hemisphere's worst natural disaster. In 1970, a strong earthquake shook the area of Peru's highest peak, 22,204-foot (6,768-m) Mount Huascarán. The tremor broke loose a huge piece of the mountain, along with the snow and ice that covered its peak. This mixture of debris careened wildly into the valleys and unsuspecting villages scattered below. The provincial capital of Yungay and more than a dozen other communities lay in its path. In an instant, they were buried beneath a blanket of mud and stone. An estimated 69,000 people were killed, 140,000 were injured, and more than one-half million people were left homeless.

WATER FEATURES

Our very existence depends upon water. Have you seen close-up photographs of bone-dry Mars or the moon? Even if they had a suitable atmosphere, life as we know it would be impossible in their parched environments. Earth has been called the Blue Planet. As seen from space, water dominates its surface. Nonetheless, many experts believe that the twenty-first century will experience growing conflict over the planet's limited water resources.

THE HYDROSPHERE

Have you ever heard the statement "Water, water everywhere, but not a drop to drink"? Seventy-one percent of Earth's surface is water covered. But, surprisingly perhaps, only about 2.4 percent of it is freshwater. And of that amount, nearly 80 percent is locked up in glacial ice. This means that it is located thousands of miles from thirsty people, farms, and industries. Only a fraction of one percent of Earth's freshwater is easily accessible to humans (see Table 3). Yet that small amount of freshwater is humankind's lifeblood.

Originally, all freshwater begins in the global sea. Through a process called the hydrologic (or water) cycle, moisture is evaporated from the ocean (see Figure 4). When transported over land by winds, it falls as salt-free precipitation. On land, much of it is stored as polar region ice. Some of it sinks into the ground, where it is stored. A small portion of it remains on the surface in lakes or rivers. Ground and surface water supplies are the source of nearly all water used by humans.

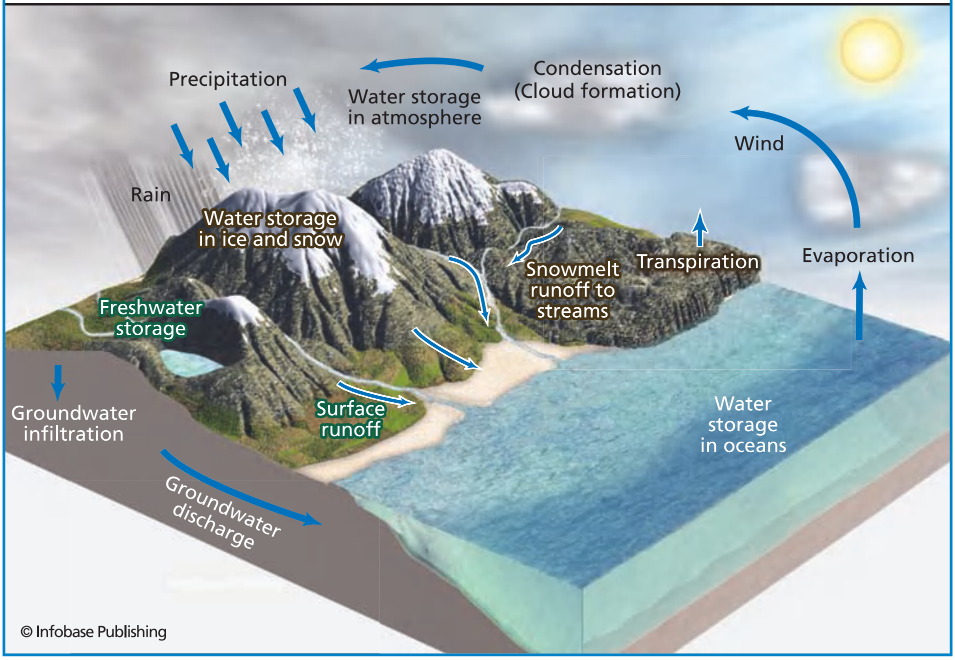
Oceans

Oceans are the major physical feature of Earth's surface. All landmasses combined could be placed within the Pacific Ocean Basin alone, and an area of ocean the size of North America would still remain. The Pacific itself occupies about one-third of the globe. At its widest point, it spans about 180 degrees of longitude, halfway around the world.

Some disagreement exists over the number of oceans. For several thousand years, the number seven has been sacred. As a result, we have many groups of seven, including seven

TABLE 3. EARTH'S WATERS	
Oceans (salt water)	**97.60%**
Freshwater	**2.40%**
Distribution of freshwater resources (2.40%)	
Glacial ice	78.51%
Groundwater (aquifier)	20.64%
Soil moisture	.44%
Lakes	.38%
Rivers	.01%
Atmospheric moisture	.01%

Hydrologic Cycle



continents, seven Wonders of the Ancient World, and according to some people, seven seas. It is easy to identify four oceans. The Pacific, Atlantic, Indian, and Arctic oceans occupy fairly well-defined basins. To expand the number to seven, some people simply add the South Pacific, South Atlantic, and South Indian oceans. Others have added a fifth ocean, the four mentioned above plus an Antarctic Ocean. This idea, however, fell into disfavor. Today it is being reborn under a new name: the Southern Ocean. Its boundary is disputed but is often placed at 60 degrees south latitude. The author, a geographer, continues to recognize four oceans: the Pacific, Atlantic, Indian, and Arctic.

Surface area, alone, is not the only "Wow!" fact about the global sea. For example, were all ocean water held as a spherical mass, it would have a diameter of about 850 miles (1,368 km). Looked at another way, the average elevation of Earth's land surface is about 2,000 feet (610 m). The average ocean depth is about 13,000 feet (3,962 m). If Earth's surface were level, it would be covered by about two miles of ocean water.

Seawater, of course, is saline with a salt content of about 3.5 percent. Salinity, however, varies from place to place. In the semi-enclosed Baltic Sea, into which many rivers flow, salt content is about 2.7 percent. In the Red Sea, also semi-enclosed but subject to very high evaporation and with no year-round source of freshwater, the average is about 4.5 percent. Amazingly, if all oceanic salt were converted to solid form, it would cover the entire Earth with a layer 400 feet (122m) deep!

Oceans are important to us in countless ways. You have already seen how the hydrologic cycle influences precipitation. In this process, it also takes salty seawater and changes it to freshwater. Oceans also play a major role in influencing temperatures. Coastal areas do not experience the ranges of temperature extremes that occur at inland locations. And ocean currents, like the warm Gulf Stream and North Atlantic Drift, keep Western Europe extremely warm for the latitude at which it lies. We depend upon the sea as a major source of food and other resources. Historically, it was a primary route for explorers that led to the discovery of new lands and ultimately their colonization by European powers. Today, the sea is a major route of trade and transportation. And who does not dream of taking a leisurely and relaxing recreational oceanic cruise?

Freshwater

Relative to salty seawater, useful freshwater is little more than a "drop in the bucket," so to speak. And most of this 2.4 percent of Earth's water is not easily accessible for human use. In fact, only about one-half of one percent of the planet's total water is available in freshwater lakes, streams, or groundwater. Unfortunately, these resources are not evenly spaced or easily accessible to everyone. Seven of the world's 10 largest rivers flow through areas of low population density. These include the Amazon, the

Congo, and the various rivers that flow into the Arctic Ocean in Siberia. The same holds true for many large lakes. Let's take a brief look at each of the sources of freshwater.

Glacial Ice

Nearly 80 percent of all freshwater is in the form of glacial ice, most of which is stored in the thick Antarctic and Green-

MAKING CONNECTIONS

OCEANIC GARBAGE DUMPS

On the Internet or elsewhere, look up "oceanic gyres," the "great Pacific garbage patch," "oceanic pollution," "red tide(s)," and "dead zones." Because the global sea covers so much of Earth's surface, people have long used oceans as a dumping ground for waste. Because there is so much water, they thought, the wastes would simply disappear. Well, they haven't! Increasingly, the oceans are becoming dangerously polluted and often with disastrous results. Toxic red tides and dead zones affect coastal waters throughout much of the oceanic world. The gigantic swirls (gyres) in both the Atlantic and Pacific oceans have turned into huge garbage dumps. In the Pacific, there are floating masses of garbage as large as the United States!

Where are the huge oceanic garbage dumps located? Where does the trash come from? (Don't forget wrecks of huge petroleum-carrying supertankers, such as the Exxon *Valdez*.) Whom does the pollution affect and how? What marine life, including fish, shellfish, and crustaceans, is affected and how? Find out about the red tides and dead zones that affect coastal waters of the United States. How do people in the U.S. heartland contribute to pollution in the Gulf of Mexico? Make a list of the ways you believe that oceanic pollution is a problem with global connections.

land ice sheets. Were this ice to melt, sea level would rise an estimated 300 feet (100 m). This, of course, would have catastrophic consequences. Nearly one-half of the world's population lives on low-lying coastal plains. These lands, settlement, and economic activity would be threatened by a significant rise in sea level.

Ground Water

The second largest store of freshwater, about 20 percent of it, is locked up in aquifers, or as groundwater. To understand how an aquifer works, fill a glass to the top with sand or gravel. Then slowly begin to fill the container with water. You will be amazed at how much water it can hold, even though it is "full." This, basically, is how an aquifer works. The top level of an aquifer is called the water table. Groundwater exists throughout most of the world. In humid areas, it is very close to the surface. The surface of a lake, for example, is a local water table. In some places, like many desert areas, the aquifer and water table may lie at a depth of more than 1,000 feet (300 m).

Many communities and rural homes in the United States and Canada depend upon groundwater supplies. In some areas, artesian conditions allow water to reach the surface under its own pressure. Most groundwater, however, is brought to the surface either by hand (in less developed areas) or pumping. Increasingly, groundwater supplies are being polluted and/or rapidly depleted in many locations. In the United States, depletion is occurring to the huge Ogallala aquifer that extends from South Dakota to the Texas Panhandle. Much of the agriculture in the Great Plains depends upon its water for irrigation. Yet the aquifer's water table continues to drop at an alarming rate. When gone, how will it be replenished? What will happen to the region's agricultural economy? And if the economy declines, what will happen to the Great Plains population?

Lakes

About 90 percent of all natural lakes were formed by glaciers. There are very few natural freshwater lakes in nonglaciated areas of the world. In the United States, nearly all natural lakes are located in an area north of the Missouri and Ohio rivers. (These stream courses represent the southernmost extent of continental glaciation during the Ice Age). In the western United States, many lakes are found at high elevations, where they were scoured by mountain glaciers.

In the United States, the Ice Age ended about 10,000 to 12,000 years ago. The farther north one travels in North America (or Eurasia), the healthier most lakes are and the cleaner their water is. This is because as the glaciers receded, lakes were first created at their southern margin; hence, they are older. Because of their age, many former lakes are little more than richly organic "muck" soil, or shallow, dirty, reed infested wetlands.

The Great Lakes, shared by the United States and Canada, form the world's largest lake system. They are drained by the St. Lawrence River. Canada has its own group of large lakes and perhaps a million smaller freshwater bodies, all a gift of glacial action. Lakes also dot the landscape of northern Eurasia. Not surprisingly, because of their glacial origin, there are very few lakes in less glaciated Africa, South America, or Australia.

Some lakes occupy trenches caused by deep faults within Earth's crust. These include long, deep, narrow lakes of East Africa's Great Rift Valley. There, Lake Tanganyika reaches a depth of 4,823 feet (1,470 m), making it the world's second deepest. In southern Siberian Russia, Lake Baikal (Baykal) plunges to a depth of 5,371 feet (1,637 m). It is not only the world's deepest lake, but also the oldest, having been formed some 25 million years ago. And because of its great depth, it holds more water than any other lake in the world. In fact, although Lake Baikal is about the size of Lake Erie, it holds more water than all of North America's Great Lakes combined.

Lakes should not be confused with reservoirs, water bodies often formed artificially behind dams. This can be confusing because so many reservoirs have "Lake" as a part of their name.

Rivers

Rivers, more than any other form of freshwater, are useful in a great variety of ways. They provide water for domestic, industrial, and agricultural use. They have long been major arteries for travel. Rivers have deposited some of the world's most fertile soils. When harnessed by building dams and creating reservoirs, they become a major source of electrical energy. And many streams add great beauty to the landscapes through which they flow. To understand the importance of rivers, look at a good atlas. Can you find a single large city any place in the world that is not located on a river? (Of the world's capital cities, only one—Mexico City—is not located on a river.)

South America's giant Amazon is far and away the world's largest river. In fact, it carries about 20 percent of all river flow. There are places along its course where one cannot see across the river. Over its last 2,000 miles (3,220 km), the Amazon's average depth is greater than the deepest spot in North America's largest river, the Mississippi.

Some rivers with headwaters in humid regions flow year-round across desert areas. These "exotic" streams, as they are called, have an importance much greater than their actual size. In North America, the Colorado and Rio Grande rivers are examples. They are the lifeblood of those areas in both the United States and Mexico that they pass through. So much of their flow is used by communities and farmers that both rivers often are bone dry near their mouths. Egyptians have depended upon Nile water for thousands of years. Because of its reliable flow, they were able to develop a great civilization in its fertile valley. Today, most of Egypt's 82 million people live along the Nile.

(continues on page 78)

THE MISSISSIPPI RIVER: MORE THAN JUST A BLUE LINE ON THE MAP

A river is many things to many people. To some, it is little more than a blue line on a map—a lifeless abstraction. To others, particularly people who live along and in many ways depend upon rivers, they are much more. Let's look at the mightiest stream in the United States, the Mississippi River, and see how many roles it fulfills.

- The Mississippi is a flowing body of water beginning in northern Minnesota's Lake Itasca. With its longest tributary, the Missouri River, it flows some 3,988 miles (6,418 km) to the Gulf of Mexico. It is the world's third longest river, behind the Nile and Amazon.
- The Mississippi and its tributaries form a basin that drains 41 percent of the United States, including all or part of 31 states and 2 Canadian provinces.
- The river is the source of alluvial deposits that have, over millions of years, "built" the state of Louisiana and much of the low-lying land south of the juncture of the Mississippi and Ohio rivers. Deposition continues today at a rate of about 15,000 railroad cars filled with sediment each day, or the equivalent of a train 150 miles (241 km) long. Weight of the sediment has caused a geosyncline (huge down warp of the Earth's crust) 30,000 feet (9,144 m) deep in the area of its delta.
- Periodic shifts in the lower river course have caused the location of the delta to change repeatedly, including at least five changes during the past 2,000 years. These shifts have left southern Louisiana with many bayous (former river channels), stranded levee systems, and offshore islands. Had the Corps of Engineers not stepped in, the Mississippi River would have shifted its course into the Atchafalaya River system in the mid-1960s.

- Historically, the river served as a major barrier to east-west land travel and transportation. In Louisiana, the first bridge to span the river was opened in 1935 (in New Orleans).
- The river is a major transportation artery: Major seaports are New Orleans (125 miles [201 km] upstream, number 3 port in the United States) and Baton Rouge (the head of navigation for ocean-going vessels, 250 miles [402 km] from the delta and the number 9 ranking port in the country). Barge traffic occurs upstream to Minneapolis-St. Paul, Minnesota.
- The Mississippi is of great historical importance in terms of exploration, early travel, commerce, and settlement in the nation's interior.
- The Mississippi forms a natural political boundary for all or part of 10 states, and its tributaries define the borders of many others.
- The river is a vast open industrial, agricultural, and domestic sewer.
- The Mississippi is a source of industrial and domestic water.
- It is an ecosystem for fish and wildlife.
- The river is an important recreational resource, particularly in its upper course.
- It is a potentially dangerous environmental hazard.
- The Mississippi is a source of driftwood and sand and gravel deposits; a breeding ground for mosquitoes; a baptismal basin for some; a landmark for aerial navigation; and much more.

(continued from page 75)

In Asia, tens of millions of people depend upon the Indus, Tigris, and Euphrates rivers, and even the tiny Jordan River for their water supply. As with the Nile, a complex and highly advanced early civilization developed in each of the areas through which these streams flow. In parched Australia, the Murray-Darling is the country's largest river system. Its water is so important to the region's agriculture that most, if not all, of its flow is used for irrigation.

HUMAN USE OF WATER RESOURCES

Water is essential to life. An unlimited supply of clean, fresh water is something that most readers take for granted. Has your water supply ever been shut off? If so, do you remember the great inconvenience that it caused? We turn on a tap and a seemingly unlimited supply of clean water—flowing both hot and cold—is there for us. As a result, we tend to waste, misuse, and even pollute our water supply. Most of the world's people, however, cannot afford such a luxury. In fact, it is estimated that around 20 percent of the world's population, about 1.2 billion people, lack access to a safe and reliable source of drinking water. How is water used? The answers may surprise you.

Domestic Use

Only about 4 percent of all water is used domestically. The amount varies greatly from country to country, and even within countries. In the United States, for example, individuals use an average of 60 to 400 gallons (227 to 1,514 liters) of water daily. The wide range of consumption is based upon such factors as availability, cost, and individual lifestyle and need. Actual consumption accounts for but a very small amount of water use. The average human drinks about 2 quarts (1.9 liters) of liquid each day. Other domestic uses include bathing, laundry and dishwashing, toilet flushing, cooking, and landscaping and yard watering. There are many others.

Industry

Various industries account for about 44 percent of all water use. This figure, too, varies greatly from country to country and place to place within a country. Depending upon the industry, water is used to wash, flush wastes, and cool. It is also used as an additive and converted to steam. To make one ton of steel requires 65,000 gallons (250,000 liters) of water. An average-sized oil refinery uses as much water in a day as does a city of one million people. For this reason, nearly all refineries are located near an abundant and reliable water supply. Industries are also the major contributors to water pollution. Fortunately, in the United States, Canada, and Western Europe industrial pollution has been greatly reduced during recent decades.

Irrigation

Agriculture is far and away the major user of water, accounting for more than half of all consumption worldwide. In the U.S. about 80 percent of all water is used for irrigation. Only about 16 percent of the nation's crops are grown under irrigated conditions, but they account for about half of the value of all crops marketed.

Irrigation has been practiced since the dawn of agriculture. In fact, most early civilizations depended upon irrigated farming. These hydraulic societies included such early high cultures as those of Mesopotamia, Egypt's Nile Valley, the Indus Valley, and even the Inca and Aztecs in the Americas.

Water Power

Water has been used as a power source for several thousand years. In most cases, energy is harnessed without waste, pollution, or changing water to some other form (as steam).

The importance of stream locations suitable for harnessing their energy potential is suggested by the name of many communities in the United States. How many place names can you find on a map that include words such as "mill," "falls," or "rapid(s)"?

Water-powered mills, of course, depended upon a rapid flow. Therefore, falls or rapids were ideal sites at which to build a mill around which a community sprung up.

Roughly 20 percent of the world's electricity is water generated. Many dams in the United States were built primarily as producers of clean, inexpensive electrical power.

Transportation

For thousands of years, water bodies have been important routes for transportation. Humans first reached the island continent of Australia perhaps 50,000 years ago. This involved crossing a span of open sea. A growing number of scientists now believe that the earliest Americans also may have traveled at least part of the way from Asia by water.

Five hundred years ago, adventurous explorers from Spain, Portugal, England, and elsewhere sailed out and discovered the New World. Political control, trade, and massive human migration soon followed—all using sea routes. For centuries, much of the world's trade had been waterborne. How many of the world's great cities can you identify that grew as ports dependent upon oceanic travel and trade? Inland, rivers have long been major arteries of travel. In many places, canals were built to link nature's water routes. If differences in elevation interfered, humans constructed elaborate locks to raise and lower vessels.

Source of Food

Since the dawn of human history, people have depended upon the sea, lakes, and rivers as a source of food. Fish, shellfish, crustaceans, and even seaweed are dietary mainstays for many people around the world. So popular have they been, in fact, that today many of these food resources are severely threatened. Populations of many oceanic species, for example, are in sharp decline. There is an urgent need to implement and adhere to strict conservation methods. If this is not done, there soon will be a day when seafood is no longer available.

Mineral Resources

Today, an increasing amount of petroleum and natural gas are coming from offshore fields. The United States and Mexico have long exploited oil resources in the Gulf of Mexico. For more than 30 years, a chief source of American petroleum has been from the treacherous waters of northern Alaska's Prudhoe Bay. Europe's largest producing oil field is in the North Sea off the continent's northwest coast. There are offshore fields in the Caspian Sea and Persian Gulf in Southwest Asia. In South America, most of Venezuela's oil comes from Lake Maracaibo. Currently, Brazil has plans to develop oil fields far from its coast and at depths of up to 4.35 miles (7 km). Several African countries also have offshore production.

Every mineral found on land is also found in the sea. The problem is that concentrations are so low that they cannot be reclaimed, at least economically. Salt, of course, is an exception. The sea is a major source of this abundant, inexpensive, yet essential commodity.

Recreational and Other Uses

There are many other uses of water as a vital natural resource. Who doesn't enjoy a visit to some sea or lake shore? Water bodies draw millions of visitors who come to swim, boat, water-ski, or just enjoy a leisurely summer afternoon. Some enjoy fishing or hunting waterfowl. Many others enjoy camping. Judging from whopping property values, people are willing to pay a premium price to live near a water body.

WATER-RELATED PROBLEMS

There are many problems associated with Earth's waters. Some of them, such as depleted oceanic and freshwater fisheries, have been discussed elsewhere. Basically, there are two major problems with water: quantity and quality.

Water Quantity

A number of experts believe that access to water will be a major source of conflict during the twenty-first century. This may well be true. Already, there are a considerable number of heated disputes over this precious resource. Yet, ironically, there is more than enough freshwater to satisfy the world's need many times over. The daily flow of the mighty Amazon River could easily supply the world's entire water needs. But the Amazon is in South America. How could its water be distributed to places throughout the world where water is in short supply? In the United States, more than enough water flows into the Gulf of Mexico via the Mississippi each day to supply the country's needs. Again, the problem is one of distribution.

Huge areas of the world are water deficient. This is particularly true for much of Africa, most of Australia, and vast areas of Central and Southwest Asia. Much of the United States also faces water problems. This is particularly true of California and most of the country's arid to semiarid western interior. But some humid regions, such as large areas of the Southeast, also experience periodic and often severe water shortages.

If a country is economically developed, it has options. Some countries, like Israel, get a portion of their freshwater by desalination—removing salt from seawater. Others, such as the United States and Libya, have built elaborate aqueduct systems that move water over large distances. In California, Nevada, and Arizona, water is diverted from the Colorado River. California also taps other water supplies. For example, the state built a lengthy aqueduct that transports water from the northern part of the state to densely settled Southern California.

The world's most ambitious water project is in Libya, an oil-rich North African country. According to some estimates, it is

In Libya, an ambitious engineering project known as the "Great Man-Made River" brings fresh water to the coastal region.

the largest and most costly engineering project ever undertaken. The "Great Man-Made River" begins with a series of more than 1,300 wells that tap water from deep beneath the Sahara Desert. A 2,500-mile-long (4,000 km) underground network of pipes then transports the water to the Libyan coastal region, where the population is clustered and most agriculture and industry are located. You might wonder how vast freshwater resources accumulated beneath the sands of the Sahara. Thousands of years ago, during the Ice Age, conditions in that part of the world were much wetter. It was during this time that the aquifer formed.

Water Quality

In developing countries, about 80 percent of all illnesses and a huge proportion of related deaths are associated with an unclean water supply. Clean water is a luxury enjoyed by a minority of the world's people. Even in well-developed countries, including the United States and Canada, water use for humans must be treated to ensure its purity. When traveling in developing countries, the number one bit of advice visitors usually receive is "Don't drink the water."

Pollution comes from countless sources. Human and animal wastes are just the beginning. In industrial regions, various kinds of pollutants enter both surface and ground water supplies. Agriculture and mining activities contribute to pollution in many places. Cleaning up the world's water supply is one of the greatest challenges facing humankind. It will be extremely costly. But the health and well-being of a substantial portion of the human population depends upon its being done.

WATER HAZARDS

Water and water-related events cause many environmental hazards. Drowning is one of the leading causes of accidental death. Although figures are difficult to pin down, hundreds of thousands of people drown each year. (Floods are the leading cause of deaths directly related to an environmental disaster.) Tsunamis, or "tidal waves," are water-related disasters caused by geologic events. They pose a threat to low-lying coastal zones throughout most of the world.

PLANT AND ANIMAL LIFE

Plants are essential to all animal life. And, of course, both flora (plants) and fauna (animals) are indispensable to human survival. Plants and animals vary greatly from place to place on Earth's surface. Each environment is unique in its own way. There are dense tropical rain forests, parched desert landscapes, and the barren expanses of Arctic tundra. Different environments, in turn, are home to their own distinct "community" of animals, birds, insects, and other fauna.

The biosphere (all living organisms) has been shaped by many factors, both natural and human. Worldwide, weather and climate play the most important role in determining a region's natural vegetation. Soil type, slope and exposure to sunlight, and the availability of moisture are also important. Humans also have had a major hand in shaping the biosphere. Used and cared for properly, flora and fauna are renewable resources that can sustain human needs indefinitely. Occasionally, plants or animals strike back. Like all other aspects of nature, they can pose hazards to human health and well-being. In this chapter, you will learn about these and other aspects of Earth's biosphere.

THE BIOSPHERE

Plant and animal life differs greatly from place to place on Earth's surface. Obviously there are huge differences between saltwater, freshwater, and land-based flora and fauna. On land surfaces, variations of temperature, moisture, and other physical factors account for vast differences in flora and fauna. Such differences can exist in very small areas—even drops of water or a square inch of lawn. Here, our attention is limited to the "big picture." Before progressing further, it is important that you know several key terms and their meaning.

Ecology is the study of the interrelationships that exist between an organism, either plant or animal, and the environment in which it lives. Some animals, like squirrels, live in woodlands. Others are adapted to grassland environments, as is the case with much of Africa's abundant wildlife. (Can you picture a giraffe walking through a dense forest?)

An ecosystem is a community of organisms and the environment in which they live. A puddle of water is an ecosystem; so is the prairie and steppe grassland region of interior North America, or the Sahara Desert.

Biome is another important concept that relates to the biosphere. It is very similar to an ecosystem and, in fact, the two terms are often used interchangeably. But there is a slight difference. "Ecosystem" is used in reference to the total interrelated environment, including flora and fauna, weather and climate, soils and land features, water, and so forth. "Biome," on the other hand, refers to the plant and animal life found within a particular ecosystem.

Finally, each form of life has biological limits. Each can survive only within certain environmental conditions. Very few freshwater life-forms, for example, can survive in salty seawater.

Most oceanic species, on the other hand, cannot live in freshwater. Many animals can live where it is warm and moist. Few, however, are adapted to areas of severe cold. Yet animals such as caribou and reindeer thrive in the frigid north. And penguins are right at home in ice-covered Antarctica. Of Earth's life-forms, only the pesky mosquito seems to be at home almost anywhere. The environment within which a plant or animal can survive is its natural habitat.

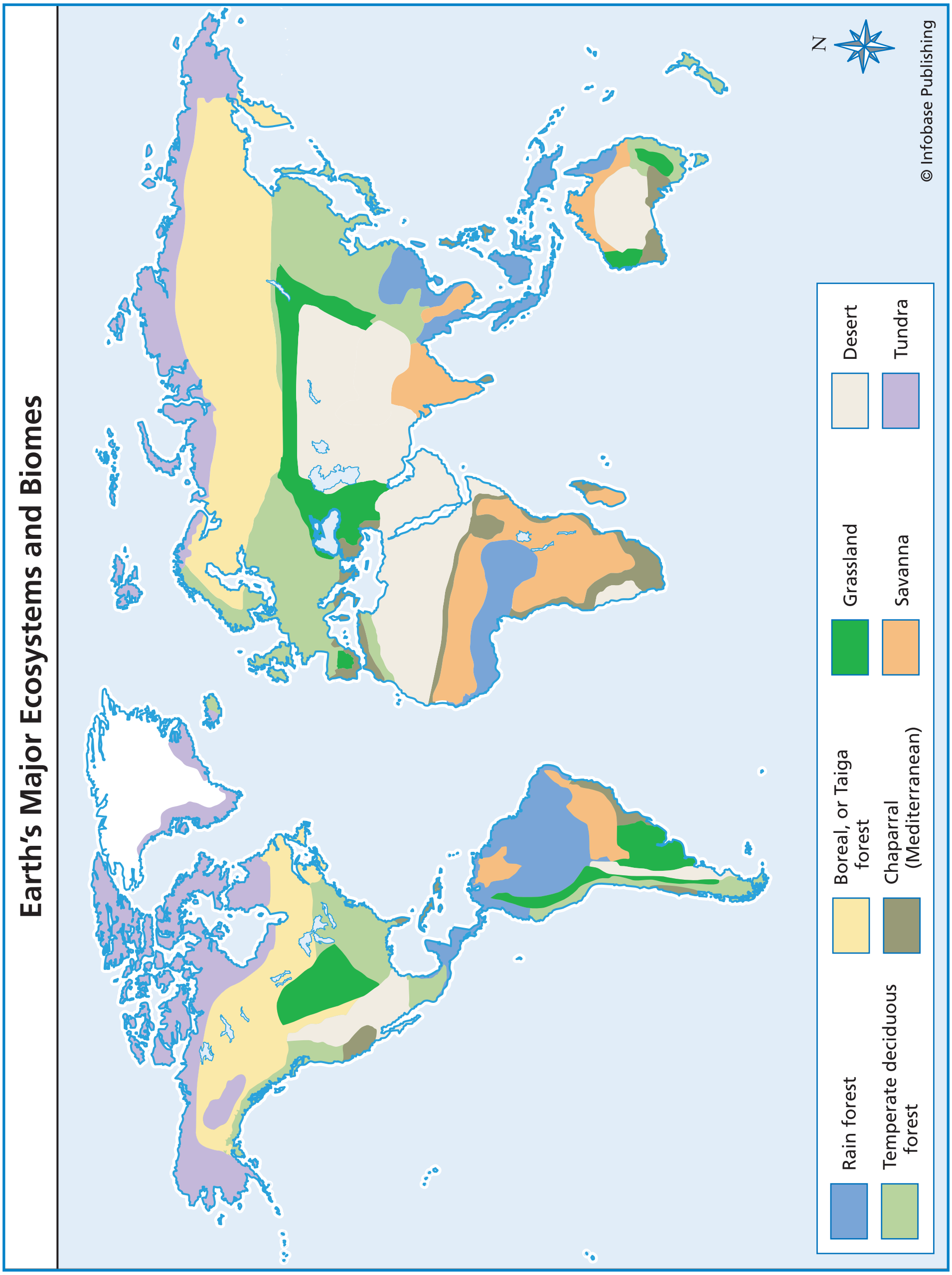
MAJOR ECOSYSTEMS

At the most basic level, Earth's ecosystems can be divided into those found on land and those that thrive in water. Each of them, in turn, can be further divided. Land-based ecosystems include forests, grasslands, deserts, and tundra. Those found in aquatic environments include oceanic (saltwater) and freshwater systems. Each of those categories also can be subdivided, in some instances into many subgroups.

Forests

Forests cover about one-third of Earth's land surface. At one time, the area was much greater. Much of the original forest cover has been removed. Land has been cleared for human settlements, transportation linkages, and farmland. Forests have also been cut over to provide fuel (including charcoal), building material, and pulp and paper.

The world's two largest forested areas are the vast taiga woodlands that stretch across northern portions of North America and Eurasia. Combined, these woodlands (also called boreal forest) cover about 8 percent of Earth's land surface. The taiga is dominated by needle leaf species, most of which are evergreens. Because they occupy a cold area with poor soils, trees are relatively small. Therefore, most species are not well-suited for use as lumber. Increasingly, however, the taiga is being harvested for pulp and paper. The northern woodlands are home to many types of wildlife. Large animals include bears, elks, moose, deer, caribou, and wolves. Because human populations are generally low, the taiga is the least disturbed of all woodland biomes.



The second-largest area of woodland cover is found in the equatorial belt of Southeast Asia, Africa, and portions of Latin America. This year-round hot, humid environment is home to the dense tropical rain forest. The world's third-largest wooded area is the vast rain forest of South America's Amazon Basin.

Overall, these forests cover about 17 percent of Earth's land surface. By a wide margin they are the planet's most diverse ecosystem. In fact, it is estimated that up to 80 percent of all land-based plant and animal species are native to this ecosystem. Several hundred tree species and hundreds of thousands of other plant forms may occupy a single square mile. The same holds true for animals, birds, insects, and other forms of fauna. Strangely, however, very few large animals inhabit the dense rain forest.

In many places, the rain forest ecosystem is under attack. In Indonesia and tropical Africa, much of it has already been cut over. During recent decades, millions of acres of Latin America's tropical forests have been stripped away, mainly for farming and grazing. Most tropical trees are softwoods and have little commercial value. Those few that are valuable for their beautiful hardwood, such as teak and mahogany, are threatened.

Midlatitude woodlands cover about 8 percent of Earth's surface. They vary greatly in composition. Some are needle leaf, coniferous, evergreens such as pine, cedar, spruce, and fir. Others are broad leaf, deciduous species that lose their leaves seasonally. Throughout much of the world, midlatitude forests have been destroyed or severely cut over. This is because much of the world's population, agriculture, and industry are located in this temperate zone. So is the need for fuel, building material, and paper.

Grasslands

Grasslands of different types cover about 20 percent of Earth's land surface. The largest expanse is the tropical savanna. This ecosystem is located at roughly 10 to 25 degrees north and south latitude. It is sandwiched between the tropical rain forest on the equatorial side and deserts on the poleward side. Savanna occurs in areas of wet-and-dry tropical climate. During the wet season, plant life flourishes, but during the dry period it becomes dormant. The coarse, dead grasses and shrubs are a nuisance, so for millennia, people have burned the savanna during the dry season. This has resulted in the region's unique vegetation—tall grasses and scattered trees that are resistant to fire. Because of the abundant grass cover, this ecosystem is home to many of the world's large herbivores (grazing animals). They, in turn, are prey to carnivores (meat-eating animals). Various carrion-eating birds, such as vultures, serve as the "clean-up crew" feasting on leftovers.

Midlatitude grasslands are found in most areas that receive 10 to 20 inches (25 to 50 cm) of precipitation annually. Tall grass prairies exist on the wetter margin and steppe grasslands on the

In a savanna region in Africa, a jackal guards a lion's freshly-killed giraffe. Vultures wait their turn to feast.

drier margin. Today, much of the world's natural grassland has been changed by human activity such as farming or livestock herding.

Desert

Deserts are areas in which there is not enough moisture to support a solid stand of plant life. Deserts occupy about 20 percent of Earth's surface. Most desert lands are in a band between 20 and 30 degrees north and south latitude on the western side, or in the interior, of continents. Some, such as the Great Basin of the United States and deserts of interior Asia, are located in the middle latitudes. The largest desert region, North Africa's Sahara Desert, spreads over an area about the size of the United States. Large expanses of desert surface occur in every continent except Europe and Antarctica.

Because of their aridity, vegetation is sparse and few animals exist. Both must be adapted to a lack of moisture in order to survive. Through time, both plants and animals have developed traits that allow them to survive in this parched environment. Plants, for example, may have very deep root systems and very small leaves that reduce water loss by transpiration. Many desert animals are nocturnal, coming out only during the cooler nighttime period. Population densities can be quite high in oasis sites, places where good water is available by any means.

Tundra

The barren tundra is the northernmost and perhaps most harsh of Earth's inhabited ecosystems. It occupies about 5 percent of Earth's land surface in northernmost North America and Eurasia. Flora is confined to mosses, lichens, sedges, and clumps of grass. Trees, where they exist, are stunted and widely scattered. Herds of reindeer and caribou graze on the tundra's scant vegetation. Predators include wolves and arctic foxes. Many migratory birds flock to the tundra during summer months. What any visitor to

(continues on page 94)

MAKING CONNECTIONS

THE "COLUMBIAN EXCHANGE"

In the wake of Christopher Columbus's epic voyage, one of history's greatest swapping events began. The "Columbian Exchange" refers to a massive transfer of plants, animals, and diseases between the Americas and the Old World (Afro-Eurasian landmass). It is a process that continues today. These exchanges of flora and fauna forever altered Earth's biosphere. Humans gained many more options from which to select. But the exchanges also gave us many of our most noxious pests.

From the Old World came a flood of useful items. Animals, most of which came from Asia, include cattle, horses, swine, goats, sheep, and poultry. Many if not most of our important foods also came from across the sea. They include wheat, rice, barley, oats, and millet. Asia was also the source of nearly all of our fruits and vegetables.

Recently, have you been plagued by a little insect that looks like a ladybug, but isn't? It is the *Asian* beetle. Is the *English* sparrow, or perhaps the *European* starling, your most common neighborhood bird? Does anyone in your family enjoy hunting the *Chinese* ringneck pheasant? Has the *Dutch* elm disease destroyed many of the stately old trees in your community?

Southerners, have you heard of "the vine that ate the South"? There is even a syndicated cartoon named for it—(Japanese) kudzu. And what about the several kinds of (Asian) carp that seem to be taking over your streams and lakes? Don't blame just Asia. From Latin America came those nasty little fire ants. So did the beautiful, but noxious, water hyacinth that clogs your streams, and the large aquatic rodent pest, the nutria.

Midwesterners, has the green ash borer begun to take its toll on the region's most common tree species. If you live near the Great Lakes, how many of the 180-some exotic (foreign) species that infest their waters can you name? Some, like the lamprey eel and zebra mussel, have caused millions of dollars in damage.

The list goes on and on. There are slimy snakeheads (a skinny fish) in several states. Walking catfish and giant Burmese pythons now inhabit South Florida. Asian tiger mosquitoes and the mosquito that transmits the deadly West Nile virus now threaten much of the United States. Forests throughout the country have been destroyed by the Dutch elm disease, the Asian long-horned beetle, the green ash borer, and other imported insects. Recently, a scientist has even suggested that Formosan (Taiwan) termites may have been the primary cause of the devastating floods in New Orleans following Hurricane Katrina! Evidently, the ravenous insects ate the material that filled the expansion joints in the levees, thereby weakening them.

Space does not allow a region-by-region discussion of invaders. No location in the country, however, is free from them. Some invaders, such as kudzu, water hyacinth, and nutria, were introduced deliberately. So were the crops and domesticated animals. But the great majority of exotic species entered the country unintentionally and often with devastating results.

Conduct research on the invasive species in your area. Find out what they are and if possible where they came from. How and when did they arrive? Which of the "guests" are beneficial and why are they welcome additions? Which of them are unwanted guests? What damage do they cause and what is their estimated financial drain on your area? (Don't forget weeds; in many states, all 10 plants on the "noxious weeds" list were introduced from the Old World.)

(continued from page 91)
the tundra most remembers, however, are the swarms of mosquitoes, gnats, black flies, and other buzzing pests.

Oceanic

Oceans occupy 71 percent of Earth's surface. In many respects, oceanic ecosystems are as varied as those on land. Flora and fauna abound in the briny waters of the global sea. All marine life-forms must be adapted to the ocean's 3.5 percent average salinity. For centuries, most people believed that the oceanic ecosystem was far too immense to feel the impact of human activity. We now realize that it is just as vulnerable as land-based environments to pollution and overharvesting of its resources. Much if not most of the global sea has become dangerously polluted. And many of the world's most important fishing grounds have been severely depleted of their former catch.

Freshwater

Freshwater ecosystems also teem with plant and animal life. As is true on land surfaces, conditions tend to vary depending upon weather and climate. Tropical waters, for example, have much different flora and fauna than do lakes in the far north.

HUMAN USE OF THE BIOSPHERE

Some people believe that the biosphere is the most important of Earth's natural conditions. In so doing, they fail to recognize that Earth's natural environment is a closely interrelated *system*. In nature, as well as human life, everything seems to be dependent upon everything else. And everything is important! Could you live without air to breathe or water to drink? What about the soils in which plants grow or the sunlight that is the source of nearly all energy? In nature, each of the "spheres" has its place and is essential to life. So it is with the biosphere.

From the dawn of human history, plants and animals have provided us with many if not most of our essential needs. From flora and fauna, we obtain food and beverages, fiber, energy, and building materials. From both, we have gained additional mobility. Biomes create varied landscapes to which we are attracted, or perhaps repelled. Both plants and animals contribute to human recreation, aesthetics, and other pleasures. There are, of course, also plant and animal pests.

Think for a moment: If there were no plants or animals, what would you eat? Other than water or a shake of salt on your food, can you think of anything that you eat or drink that does not come from a plant or animal? Ah, so you are a vegan. No animal products in your diet! Have you considered the role of bees in pollinating the plants upon which your diet depends, or worms aerating the soil in which plants grow?

Eating and drinking are not the only ways we put the biosphere to use. How many articles of your clothing were made from cotton or some other plant? Are your shoes and belt made of leather? Are the souls of your shoes made from rubber (the sap of a tree)? Do you sleep on a feather pillow? Many of us live in houses made all or in part from lumber. The pages of this book were processed from wood pulp. And more than half of all medicines are made from plant or animal extracts. The biosphere even comes to your aid when you are ill.

HUMAN IMPACT ON THE BIOSPHERE

Since the very first humans roamed Earth's surface, the biosphere has been changed by human activity. Some changes come from direct human impact. Initially, we hunted and gathered for our food and used wood or animal skins for our shelter, tools and weapons, and clothing. Land was cleared of vegetation for our settlements and trails. Later, some plants and animals became domesticated. In the process, things that previously grew wild were now under our control. Domestication made them much more accessible, productive, and useful to us. Soon, much of Earth's surface began to show the impact of land clearing for farms or livestock grazing. Forests were felled to provide fuel, building material, mine timbers, rail ties, and many other useful items.

Through time, nearly all of Earth's ecosystems were changed in some way by human activity. The vast interior plains of North America were once home to endless grasslands and huge herds of American bison (buffalo). Today, grasslands and animals still dominate the regional landscape. Various cultivated grasses (such

PUTTING PLANTS AND ANIMALS TO WORK

Perhaps ten thousand years ago humankind's relationship with the plant and animal kingdom began to change. This change, called the Agricultural Revolution, put plants and animals to work for us. The process, which continues today, is called domestication.

Domestication involves three fundamental features. To become domesticated, a plant or animal must: (1) be of use to humans; (2) be genetically different than its wild ancestor; that is, it is changed in physical form; (3) be deliberately raised and cared for.

Because domesticated plants and animals are useful to humans, the physical changes usually make them even more useful. Plants, for example, become more productive and have a much higher yield.

Early maize (corn) had very small ears, only an inch or two long, and contained a small number of kernels. Today's ears can reach 12 inches (30 cm) in length and contain up to 400 kernels. Through careful selective breeding, different strains of corn have been created to fulfill different purposes. Major differences exist, for example, between sweet corn, popcorn, corn fed to livestock and poultry, and the corn used in manufacturing ethanol as fuel for automobiles. Dogs, we now know, all evolved from the wolf. Yet consider how many different types of dogs there are—each "designed" for a particular purpose. The same holds true for cats, horses, cattle, and all other animal domesticates.

as wheat), however, have replaced the native grasses. And cattle now graze where bison once roamed. Not all natural changes, you must remember, are "bad" for the environment.

Many scientists believe that human activity in some form is evident every place in the world. Even in Antarctica, ice cores show evidence of atmospheric pollution. Through time, fire has been humankind's primary tool of environmental change.

Some people believe that domestication was "invented" in response to human hunger. Actually, common sense should suggest that this was not the case. If you are starving and have a sack of grain, are you going to eat it or plant it and wait for several months to harvest a crop? It is now widely believed that plant domestication first happened among sedentary people who had a reliable food source. Only if people lived in one place for a long time and had plenty of food could they experiment with plants and animals in their surroundings. Such conditions existed in a few places. The earliest evidence of domestication is found in Southwest Asia, Southeast Asia, and portions of Central America (particularly southern Mexico and Guatemala). Traditionally, women were always the gatherers. It was they who gathered, processed, and prepared plants for human consumption. Almost certainly it was women who were first involved in plant domestication.

The first animal domesticates—dogs and sheep—may have been camp followers. They became familiar with the human environment, were tamed, and became pets. Soon, humans controlled their reproduction. Through time, different breeds of dogs, sheep, and all other domesticated animals were "designed" deliberately to create more useful forms.

Nearly all domesticated animals and many of our domesticated plants originated in Asia. In fact, only a single domesticate had its origin in what is now the United States and Canada: the Jerusalem artichoke, a species of sunflower with an edible tuber.

Human-caused fires have changed the makeup of most if not all biomes. Grazing animals, logging, farming, and other activities have also taken a toll on the biosphere. Some experts even suggest that there is no such thing as "natural" vegetation anyplace in the world today.

The greatest human impact upon the biosphere has come from agriculture. Vast areas of Earth's surface have been cleared for raising crops or grazing domesticated animals. The crops and animals themselves represent a change from their wild ancestors. Good pasture land can be destroyed by overgrazing, such as occurred throughout much of the western interior of the United States. Millions of acres of once nutritious grasslands have been replaced by mesquite, sagebrush, and other scrub plants.

HAZARDS WITHIN THE BIOSPHERE

Although perhaps not as destructive as floods, massive earthquakes, or destructive winds, the biosphere is not without its own hazards. In February 2009, Australia suffered its worst fires in the country's history. More than 1,200 square miles (3,000 sq. km) of woodland was burned. The wildfires charred nearly 2,000 homes and killed as many as 300 people. It is estimated that more than one million animals—kangaroos, wallabies, koalas, and others—were killed. Countless others died because their habitat was destroyed. Wildfires pose an omnipresent threat to people and property throughout most of the world.

When one thinks of dangerous fauna, deadly snakes, fierce animals such as lions and tigers, and powerful-jawed sharks and piranhas may come to mind. The greatest threat to humans, however, comes from insects and microscopic disease-causing organisms. The world's number one disease is malaria, which is transmitted by a mosquito. Numerous other deadly diseases are passed to humans by insect bites or stings. And don't forget about the microorganisms—bacteria and germs—that can also be killers.

MINERALS AND FOSSIL FUELS

Have you ever played the guessing game in which players can ask for a clue, “Animal, vegetable, or mineral?” You guessed it: A mineral is anything in nature that is solid and neither animal nor vegetable. Minerals have been used as resources from the moment the earliest human picked up a rock and used it as a tool or weapon. A very strong link exists between rocks (or stones; they are the same) and minerals and human development. In fact, our use of minerals is one of the most common systems of classifying stages of cultural evolution:

Stone Age This period includes most of human history, during which humans used stones for making tools and weapons (often divided into Old, Middle, and New Stone Age, based primarily upon different stone-working techniques).

Copper Age	In its native form, copper is malleable and can be fashioned into different usable items. Its use first appeared in Southwest Asia during the fifth millennium B.C.
Bronze Age	This is a period during which bronze, a blend of copper and tin, began to be used to make tools, weapons, armor, and ornaments. It appeared in Southwest Asia as early as the fourth millennium B.C.
Iron Age	Around 1200 B.C., iron began to replace bronze as the metal of choice. It, too, was first used in Southwest Asia.

Most minerals are used to make things. Fossil fuels, on the other hand—coal and petroleum—provide much of the energy that makes many things work. We are highly dependent upon both.

Think for a moment of the various items around your home. How many of them are made from some kind of metal? Was brick or stone used to build your home? Of what material is your street, driveway, or sidewalk paved? Do members of your family have jewelry made of gold, silver, or some other precious metal or gemstone? How is your home heated? Does the electricity in your area come from a plant powered by some fossil fuel or perhaps nuclear energy? How would your life and those of family members and friends be different were it not for petroleum products to power vehicles? Do you use chemicals—fertilizers, pesticides, or herbicides—on your lawn (or fields if you live on a farm)? All of these and countless other examples point to the importance of minerals and fossil fuels in our daily lives.

TYPES OF MINERALS, ROCKS, AND FOSSIL FUELS

The difference between minerals, rocks, and fossil fuels can be rather confusing. Here, our focus is mainly on their use, rather than specific properties. Basically, a mineral is an inorganic (nonliving) substance formed from a single compound or element. Many minerals are useful because of their particular chemical makeup. Useful metals include iron, lead, copper, gold, and silver. Some minerals are valued for their unique appearance. These include diamonds, rubies, topaz, and other gemstones. Today, about 80 minerals are considered essential.

A rock is a combination of two or more minerals fused together. Geologists classify rocks by their formation. Igneous rocks form when molten magma or lava cools. When rock material is broken down and reformed as deposits of water, glaciers, or wind, sedimentary rocks are formed. Metamorphic rocks are those formed from minerals that have been changed in texture and composition by high temperatures and pressure.

Fossil fuels were created from plant and animal life millions of years ago. They include coal, petroleum, and natural gas. (Uranium is also a source of energy, but it is a metal, not a fossil fuel.)

MEASURING CULTURAL DEVELOPMENT

How can cultural development be measured with any degree of validity? It is a difficult and highly controversial task. Yet people have tried to classify groups on the basis of their relative "development" for centuries. (Here, "development" is used in a quantitative sense. In other words, we are measuring culture traits—what a people know, have, and are able to do. No qualitative judgment, such as "primitive" or "advanced" is attempted.) Through time, many different criteria have been used. The author's favorite (of unknown origin) is "The amount of inconvenience and frustration a society experiences when the power goes out." Think about it. Not bad!

If exercises of this nature are to have any validity whatsoever, the criteria on which they are based must be measurable. That is, hard data must support the conclusion. With this in mind, some social scientists have turned to the per capita use of energy as a measure of cultural development.

EARLY HUMAN USES

Stones have been used since the dawn of human history. Initially, we can imagine that as weapons, rocks were thrown at the intended target. Much later, they were sharpened and tied to the end of spears or arrows. As tools, stones were used to pound, grind, and when sharpened, to cut and scrape. Eventually, rock was used to build sturdy shelters. Thousands of years ago, in some parts of the world, people began to quarry stone. Even in

ENERGY AND CULTURE

In 1949, anthropologist Leslie A. White made a bold suggestion. He put forward the idea that cultures develop or decline on the basis of the per capita energy consumption. In other words, the more energy a culture uses the more developed it will be. Some people, of course, have challenged White's theory. Most critics make a very common mistake; they are thinking in qualitative, rather than quantitative, terms. White never attempted to rank cultures in qualitative terms such as "good" or "bad."

Why don't you test White's theory? Make a list of traits (things people know, have, or are able to do) that you believe are important. For example, you might include per capita gross national product (GNP), life expectancy, and literacy. Once your list is made, it is time to start working like a social scientist. Select 10 countries you consider to be well developed. Then identify 10 countries you consider to be less developed. Place them in what you think is rank order.

Now, find data for the various categories that you selected for each of your countries. Many data lists are available online; for example, the CIA World Factbook (https://www.cia.gov/library/publications/

ancient times, huge rocks were cut away and used to build some of Earth's most amazing structures. How this was done and how huge pieces of rock were moved over long distances remains a mystery. Examples include the gigantic stones used in building the ancient Egyptian pyramids and England's mysterious Stonehenge monument. The mysterious giant stone heads of Easter Island were quarried from stone. So were the huge stone heads carved by Mexico's Olmec people. In Peru, the Inca made many structures from cut stone. None is more spectacular than the massive stone fortress of Sacsayhuaman that overlooks the city of Cusco.

Metals appear to have first been used around 7,000 years ago. Southwest Asia appears to be the area in which people first

the-world-factbook/index.html) has many categories of information (by country, or "Guide to Rank Order Pages").When this is done, find a list of per capita energy consumption by country. Wikipedia has such a list: (http://en.wikipedia.org/wiki/List_of_countries_by_energy_consumption_per_capita).

Now, compare these rankings with the Human Development Index (http://en.wikipedia.org/wiki/List_of_countries_by_Human_Development_Index).

This will give you a glimpse of the links that exist between your selected criteria, per capita energy consumption, and human well-being. Based on your research, do you agree, or disagree, with Leslie White's theory?

How did the United States fare in your analysis? The country is home to about 5 percent of the world's people, yet we use about 25 percent of all energy. Today, the United States has the world's most highly developed culture (as measured by the number of culture traits and their complexity). Where do Americans stand on the Human Development Index? Can you think of reasons that help explain this standing?

began to use copper, bronze, and iron. Not surprisingly, this also is the cradle of Western Civilization. Cultures that developed metallurgy had an advantage over others. They could make much more effective weapons and tools.

The use of fossil fuels as a source of energy is quite recent. In the thirteenth century, Marco Polo returned from China with tales of a rock that burned. This was the first mention of coal in Europe. It was not until the mid-1700s that coal was first mined and used in the United States. Where available at the surface, petroleum was used for centuries. In Mesopotamia, it was used in building walls and towers as early as the second millennium

One of the earliest known materials used in building weapons, tools, and shelter, rocks also were used in the creation of some of the world's most mysterious structures and monuments. Above, Easter Island's famous Moai statues, carved out of volcanic rock sometime around 1250–1500 A.D., remain a popular tourist attraction.

B.C. Around the same time, Persians used oil for medicinal purposes and as a fuel for lighting. By 347 B.C., the Chinese were drilling oil wells up to 800 feet (240 m) deep to obtain fuel to burn.

IMPORTANCE OF MINERALS, ROCKS, AND FOSSIL FUELS TODAY

Imagine a world without minerals, rocks, or fossil fuels. What a strange and different place it would be! Even in their simplest form, such basic resources as stone, gravel, and sand play a vital role in our everyday lives. Used in concrete, they pave many of the surfaces on which we drive, walk, park, and play. Concrete is also used in many other structures, including buildings, dams, and fortifications.

Minerals, particularly metals, have essential uses too numerous and too obvious to mention. Where would we be without basic metals such as iron, copper, lead, or zinc? And don't forget the importance of the various minerals used to make alloys (mixtures of two or more minerals that create a metal with desired physical properties, such as additional strength). Gemstones, of course, are used mainly for jewelry and other ornaments. Because of their hardness, some diamonds are used in industry. Initially, many minerals were found in almost pure form. Today, much of the ore mined is found in small amounts contained within other rocks. It is removed and concentrated by a series of processes that include smelting.

Brief mention should be made of mineral fertilizers. Without nitrate, phosphate, limestone, and various other minerals, much of the world's soil would be less productive. Improved fertilizers have been one of several factors responsible for the huge gains in crop production during the past century.

Fossil fuels include coal, petroleum, and natural gas. Coal is unique in that it is both a rock and a fossil fuel (it is not a mineral). Uranium is a mineral that can be used as a fuel. Today, much of the global economy depends upon fossil fuels. Worldwide, coal is the most widely used source of energy in industry. Petroleum, whether gasoline or diesel, powers most forms of transportation. Natural gas is used in heating and the generation of electrical energy. Where developed, nuclear energy is also used to create electrical power. As you would expect, because of its importance, many of the world's political issues and conflicts are rooted in the need to secure reliable sources of energy.

We will never run out of rock. But many people are worried that Earth's reserves of valuable minerals and fuels are disappearing at a rapid pace. Others are less concerned. They look to the past and take heart in the fact that alternative sources or new deposits of vital resources have always been found. Both sides have valid points. The future certainly will bring changes in the resources upon which we depend. But there seems to be little likelihood that humans will suddenly be without metals and sources of energy.

HUMAN IMPACT

When natural resources are extracted from the earth, a scar of some type is left. It may be little more than a mine shaft with rotting timbers that can be covered and forgotten. At the other extreme, huge open pits and strip mines forever alter the landscape. Millions of tons of rock are dug from the ground, leaving huge holes. The overburden (rock without ore) and rock remaining after the ore has been extracted are left as huge mountain-like piles. Eventually, things made with metal wear out and are abandoned. Many landscapes are littered with rusting vehicles and other metallic objects.

There are many other impacts. Today, many people are deeply concerned over what some scientists and others believe to be a rapidly warming Earth. They point to our burning of fossil fuels as the culprit. Carbon dioxide is a byproduct of burned coal and petroleum. In turn, this pollutant creates an atmospheric "blanket" that, in turn, causes a greenhouse effect. Basically, the blanket keeps heat in the lower atmosphere, rather than allowing it to radiate back into space. As a result, they believe Earth's temperature is warming.

Even mineral (and other) fertilizers are creating environmental havoc. Tons of fertilizer applied to fields within continental interiors are washed away into streams. Streams then transport the nutrients into the global sea. There, algae thrive upon the

MAKING CONNECTIONS

THE GLOBAL TANK OF GAS

Where does gasoline come from? Well, "The gas station!" you say. But filling your tank is a bit more complicated than that. How did the gas arrive at the station? Was it delivered by a tanker truck? Where did the tanker truck go to fill up? Was the gas delivered by rail tank cars? Did a pipeline transport the gas from a refinery? Where was it refined? Where are refineries located in the United States, and what factors influenced their location? How did crude oil get to the refinery? What are the major routes by which petroleum enters the United States? From what countries do we import oil? Upon which countries do we most depend for our supply? What problems exist in the various foreign lands that might disrupt our supply? What would be the consequences of a severe reduction in oil imports?

In order to answer as many of these questions as you can, conduct research to learn more about our vital gasoline supply. Talk to a gas station owner or a trucker who delivers gas to the station. Find information about petroleum production, refining, and distribution in your library or online. It is important for all citizens to know just how complex the gasoline industry is. Few of our necessities are more dependent upon a very complex global network of connections.

This area where the Mississippi River empties into the Gulf of Mexico is one example of a "dead zone," created when fertilizer washes into the water supply. The negative impact of this human activity threatens marine ecosystems and the livelihoods of people who rely on it.

nutrients. As their numbers grow, they deplete oxygen in the water. With oxygen depleted, nothing can survive. Today there are several hundred such dead zones. The largest is in the Gulf of Mexico off the mouth of the Mississippi River. But they exist in waters off all continents except Antarctica.

ENVIRONMENTAL HAZARDS

Rocks, minerals, and fossil fuels do not directly present a hazard to humans. Indirectly, of course, they can. Rock avalanches, earthquakes, and volcanic eruptions take a heavy toll of life and property. But these destructive forces are not created by the rock itself.

Some minerals, such as lead, arsenic, and mercury, can be deadly poisonous. Mercury, for example, is used in gold mining in Brazil (and elsewhere). But heavy rains wash the toxic metal into the Amazon River and its tributaries. There, it is beginning to show up in fish which, in turn, are eaten by humans.

Most hazards associated with minerals and fossil fuels are indirect. That is, their use pollutes the environment. Environmental concerns ranging from possible global warming to acid rain are caused by the use of coal and petroleum. One solution to atmospheric pollution is the use of nuclear energy. But it, too, has many associated potential problems. Nuclear waste can be safely stored. The United States has a major facility designed for this purpose at Yucca Flats, Nevada. The primary problem, and one that concerns many people, is the safe transporting of radioactive waste. And, of course, many people do not want such a facility in their neighborhood.

8

ENVIRONMENT, RESOURCES, AND THE FUTURE

Nearly everyone is concerned about the natural environment. People are worried about growing pollution. Is the burning of fossil fuels causing our planet to warm, perhaps beyond the critical point? We read that the populations of many whale species are in sharp decline. Much of Africa's famous wildlife is vanishing. Poachers hunt for bush meat, ivory, rhino horns, or anything else of value. The Amazon rain forest is vanishing, as trees fall to the ax of economic development. Drought plagues many areas of the world and affects hundreds of millions of people. We need petroleum to fuel our economy, but at what cost to the environment?

In regard to the natural environment and its resource potentials, three things are certain. First, we will never run out of land, air, water, flora, fauna, or minerals. Second, many future resources will still be available, but in diminished quality or quantity. Finally, viewpoints pertaining to the environment and use of resources will always be sharply divided.

Matter, as we know, can neither be created nor destroyed. It can only be changed in form. Water can turn to ice or vapor. Iron can rust away. A dense virgin forest can be changed into a stand of useless scrub brushland. Earth's primary elements—lithosphere, atmosphere, biosphere, and hydrosphere—will always exist. The primary question and concern is *in what form and in what quantity*?

Through time many environmental elements and resources have been and will continue to be changed by human exploitation. Some resources experience a decline in quantity. The American bison (buffalo) was once the most prevalent large animal in North America. It is estimated that between 60 million and 100 million of the huge, shaggy beasts once roamed the plains. By the mid-1880s, they were nearly extinct. At one time there were an estimated 5 billion passenger pigeons in the United States. The bird was the most abundant noninsect fauna on Earth. By 1914, it was extinct. In the case of both the bison and passenger pigeon, because they were so common, no one believed that they could be overhunted.

Today, a similar situation exists with many resources. Water becomes increasingly scarce in some locations. Elsewhere, it becomes increasingly polluted. Deposits of valuable ores eventually play out. Petroleum will eventually disappear entirely. Forests are cleared and replaced by crop or grazing lands.

Quality also diminishes through use and time. Tree species in secondary forests are rarely as useful as those in uncut woodland. A century ago, many metals were found in nearly pure concentrations. Today, most of the world's mines extract ores in minute amounts, often no more than a percent or two. This greatly increases the cost of processing and, therefore, finished products manufactured from the metal. A visit to the grocery store reminds us that good seafood—fresh shrimp, fish, and shellfish—is increasingly scarce and costly.

Today, issues relating to the environment and resources have taken on an added dimension. On one side are those who believe the environment and its resources should be developed. They want abundant and inexpensive lumber, manufactured goods, food, and fuel. On the other side of the conflict are those who want to preserve or restore the environment. In this context, one reality stands out: Only an affluent society can enjoy the luxury of a "clean" environment. Most of the world's people depend upon the environment and its resources for their livelihood and very survival. But in a wealthy society, people can decide *not* to develop a resource. They place a greater value on an undisturbed environment than they do on the resources that it could provide.

In the United States and Canada, there are many examples of "green" values at work. Should we stop using coal and petroleum as our primary fuels? Is the burning of fossil fuels changing

As the once plentiful American bison was hunted to near extinction, so too may some of our most valuable natural resources become depleted.

Earth's climate in a critical way? Should northeastern Alaska's rich petroleum deposits be tapped to reduce our reliance on foreign oil? Or should the caribou herds and other animals of the Arctic National Wildlife Refuge (ANWR) be protected from pipelines, roads, and other intrusions? We need lumber, pulp, and paper. Should dense forests of the Pacific Northwest be harvested? Or should the rare spotted owl be protected? Questions such as these should not be taken lightly. Both sides have very valid points.

Return for a moment to the image of Earth from space. How small we are! And how closely we are connected to one another.

WOULD YOU LIKE TO JOIN?

MAY WE LIVE LONG AND DIE OUT

Phasing out the human race by voluntarily ceasing to breed will allow Earth's biosphere to return to good health. Crowded conditions and resource shortages will improve as we become less dense.

The foregoing plea appears on the Web site of the Voluntary Human Extinction Movement (VHEMT). To the author, it seems to be a bit extreme! Something, however, must be done. Today's 6.7 billion population is expected to soar to around 9 billion by mid-century. Where will the natural resources to sustain them come from? Will there be enough water to go around? Will air, water, and land become increasingly polluted?

Most readers of this book will be alive in 2050. What would you like the world to be like by then? What things can you do to help reduce environmental pollution? Can you take steps to reduce your "footprint" (your environmental impact) on Earth's surface? Are there things that you could do to reduce your use of energy, space, or other resources? Remember, it is *your* world. Take good care of it!

In terms of environment and resources, imagine the flow of water, air, food, fuel, and other resources with which you come in contact during a single day. Can you imagine the flow of each across Earth's surface—global connections—as you gaze at our planetary spaceship?

GLOSSARY

culture The totality of the way of life practiced by a people. It includes everything they know, believe, possess, and are able to do.

ecology The science that studies interrelationships between an organism and its environment.

ecosystem An interrelated ecological community and its environment (such as a pond, desert, or tropical rain forest).

Human Development Index (HDI) A United Nations ranking of countries from number 1 to number 177 in terms of human well-being based upon such factors as life expectancy, education, literacy, and standard of living.

natural resource Natural elements found to be of use to a particular culture.

overpopulation More people than a cultural system, including environmental, economic, political, and social conditions, can provide for adequately.

sustainable Describes a practice that can be continued indefinitely. For example, if used properly, soils will permanently retain their fertility.

BIBLIOGRAPHY

Lomborg, Bjorn. *The Skeptical Environmentalist: Measuring the Real State of the World.* New York: Cambridge University Press, 2001.

McGrath, Susan. “Attack of the Alien Invaders.” *National Geographic*. 207:3 (March 2005): pp. 93–117.

“Troubled Waters.” *The Economist,* Supplement (January 3, 2009): p. 18.

White, Leslie A. “Energy and the Evolution of Culture,” *The Science of Culture.* New York: Farrar, Straus, 1949, pp. 363–393.

FURTHER RESOURCES

Calhoun, Yael. *The Environment in the News*. New York: Chelsea House Publishers, 2007.

Casper, Julie Kerr. *Forests*. New York: Chelsea House Publishers, 2007.

Casper, Julie Kerr. *Lands*. New York: Chelsea House Publishers, 2007.

Casper, Julie Kerr. *Water and Atmosphere*. New York: Chelsea House Publishers, 2007.

Desonie, Dana. *Humans and the Natural Environment*. New York: Chelsea House Publishers, 2008.

Gritzner, Charles F. *Deserts*. New York: Chelsea House Publishers, 2007.

Gritzner, Charles F. "Farewell to Bongo, Ahab and Iglook." *Journal of Geography*, 101:4 (July–August 2002), pp. 176–178.

Gritzner, Charles F. *Polar Regions*. New York: Chelsea House Publishers, 2007.

Gritzner, Charles F. *Population*. New York: Chelsea House Publishers, 2009.

Gritzner, Charles F. *The Tropics*. New York: Chelsea House Publishers, 2007.

Sonneborn, Liz. *The Environmental Movement*. New York: Chelsea House Publishers, 2007.

PICTURE CREDITS

Page

10: Courtesy of NASA Goddard Space Flight Center; Image by Reto Stockli

21: Greg Sousa/AP Images

26: Emilio Morenatti/ AP Images

34: © Barry Sweet/Landov

38: © Infobase Publishing

43: © Infobase Publishing

51: © Infobase Publishing

58: © Bettmann/CORBIS

70: © Infobase Publishing

83: © AFP/Getty Images

88: © Infobase Publishing

91: © Peter Johnson/CORBIS

104: © Carlos Barria/Reuters/ Landov

108: © NASA-GSFC-digital version copy/Science Faction/CORBIS

112: © JA.J. Sisco/UPI/Landov

INDEX