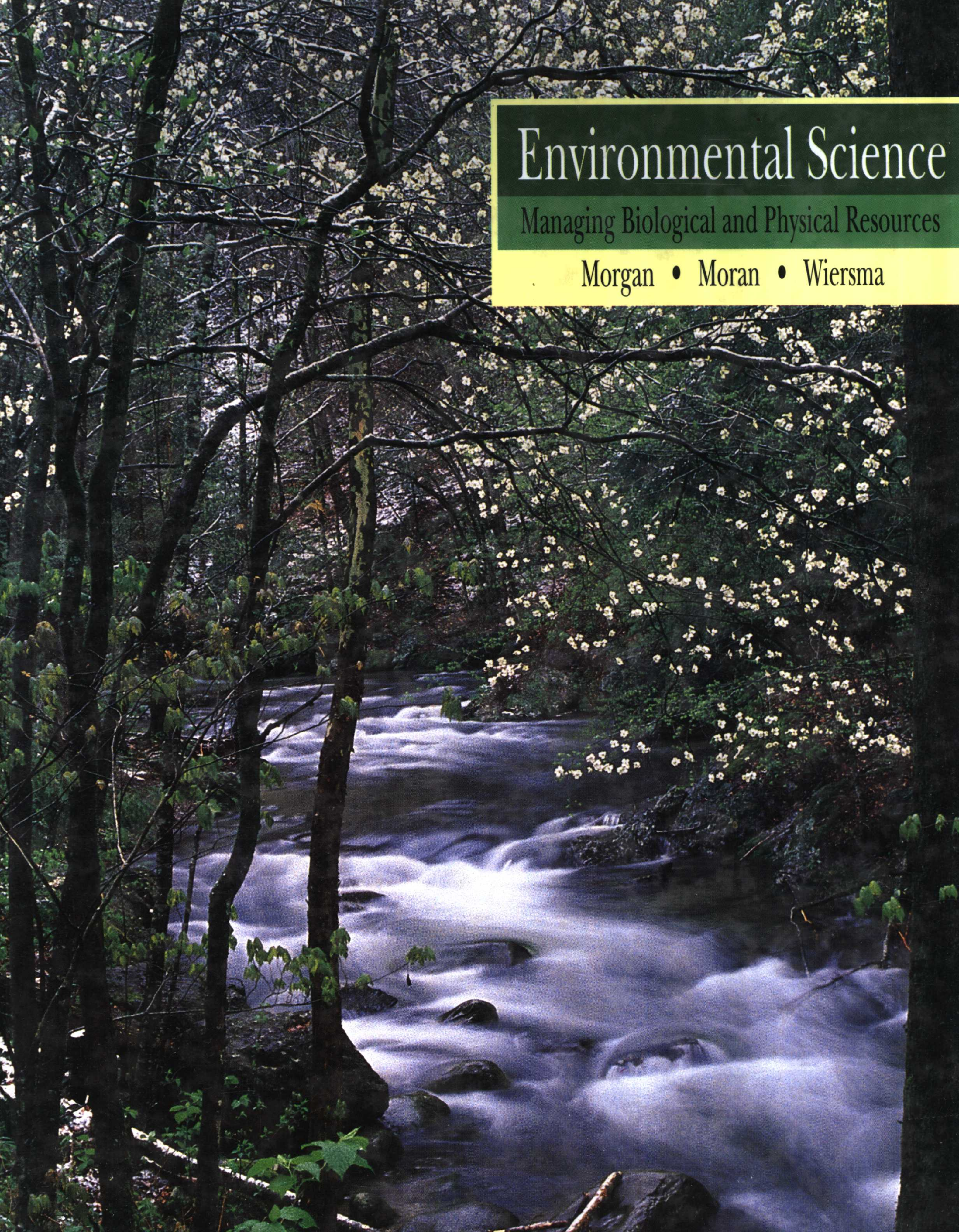

# Environmental Science

## Managing Biological and Physical Resources

Morgan • Moran • Wiersma

# Environmental Science

## Managing Biological & Physical Resources

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A roaring mountain stream, trees bursting forth in blossom, and plants emerging on the forest floor attest to the dynamism of the environment.

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The combination of abundant rainfall, ceaseless spray from the falls, and the shade of an overhanging cliff promotes the luxuriant growth of this community of ferns.

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Around the world, humans exploit a variety of biological resources. In these Montana foothills, upper slopes are managed for livestock grazing while hay for winter forage is grown on the valley floor.

**Volume III: Environmental Science: Managing Physical Resources:**
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In view of the adverse environmental impacts of human exploitation of nonrenewable physical resources, there is increasing interest in less disruptive and sustainable alternatives such as this wind farm.

Copyedited by Nick Murray

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# Guided Tour through the *Environmental Science* Learning System

## Chapter Outlines

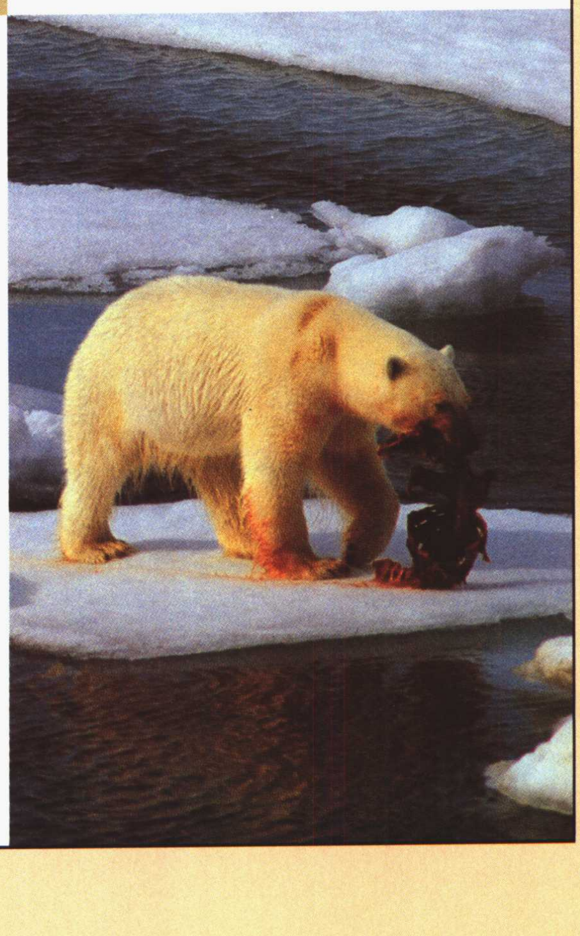
Chapter outlines offer the student a quick overview of key topics and how they are organized within the chapter.

Chapter 3

# Ecosystems

*Energy Flow and the Cycling of Materials*





This scene of a feeding polar bear illustrates one step in the flow of energy within an ecosystem.
© Jack Stein Grove/Tom Stack & Associates

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## Boldfaced Terms

Important terms are boldfaced within the narrative when they are initially introduced. They are also defined within the context of the sentence and are again listed at the end of the chapter and in the glossary.

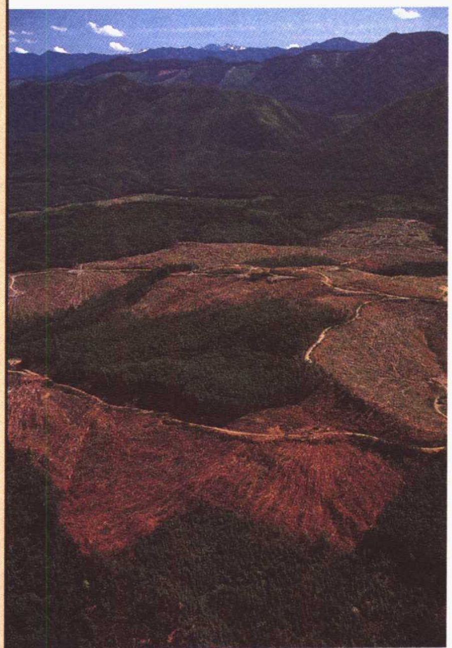

Figure 10.6 A close clustering of large, clearcut plots can lead to a loss of species diversity and accelerated soil erosion.
© Jack Swenson/Tom Stack & Associates

closely clustered clear-cut plots on steep slopes are subject to severe soil erosion and stream sedimentation.

After clearing, a clear-cut plot may reseed naturally. Increasingly, however, the plot is planted with seedlings selected for high growth rates. Clear-cutting thus eventually leads to establishment of an even-aged stand, often composed of only one or two species of trees. Such plots are more vulnerable to pest outbreaks, fires, and perhaps even to climate change.

**Partial cutting** covers a continuum of activities that range from selectively cutting only a few trees (by desired size and species, for example) to harvesting most but not all (typically 85% to 90%) of the trees on a site (fig. 10.7). In the latter situation, the remaining trees serve as seed sources and as refugia from which species can invade the surrounding developing forest as it becomes established and matures. Aggregating partially cut sites reduces habitat fragmentation and thus helps maintain species diversity. Furthermore, soil erosion is usually less of a problem than on clear-cut sites.

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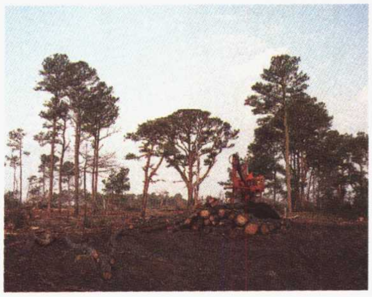

Figure 10.7 Partial cutting of a forest stand leaves behind trees that serve as seed sources.
© Milton H. Tierney, Jr./Visuals Unlimited

The Forest Service is now officially planning to make the transition from a timber/grazing/watershed/mining orientation to one with more emphasis on fisheries, wildlife, recreation, and environmentally friendly resource use. However, transferring such strategic planning to actual forest management will be most challenging. These new initiatives require significant additional funding, which will be difficult to obtain from Congress. The forest-products industry remains a powerful economic and political force, and many people within the Forest Service remain strongly committed to timber production. Furthermore, if timber harvests are to be reduced, retraining should be made available to those in the timber industry who will lose their jobs. There is a consensus that forestry practices must be more ecologically based and that the Forest Service must achieve a better balance in its management of the diverse resources on NFS lands. However, progress will be slow as research and management evolve to enhance the compatibility of multiple resource uses and to ensure a long-term, sustained supply of resources from National Forest Service lands.

### National Rangelands

**Rangelands** are essentially unsuited for rain-fed crop cultivation or forestry. Grasses or shrubs such as sagebrush (fig. 10.8) dominate these arid and semiarid tracts. Essentially all of the rangeland in the United States is west of the Mississippi River. About one-third of it is publicly owned, most of that land is managed by the Forest Service or the Bureau of Land Management (BLM).

Federal rangelands are primarily managed for livestock production. In 1989, ranchers leased nearly 108 million hectares (267 million acres) of federal land for grazing their livestock. Although grazing has long been the traditional use of federal rangelands, management of public rangelands primarily for this single purpose is coming under increasing fire from conservation groups.


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## Special Topics

Throughout the text, special topic boxes highlight additional topics at a more extended level. Students will find them a lively and interesting feature as they investigate the process of science.

**Special Topic 5.1**

### *Mutualism: Species Helping Each Other*

Mutualism—an interaction between species that is beneficial to each—occurs widely and is important to many populations. Such an interaction can benefit a species in several ways, including (1) nutrition, either through the digestion of food for the partner or the synthesis of vitamins or proteins for the partner; (2) protection, either from enemies or from environmental change, or (3) transport, such as the dispersal of pollen or the movement of materials from unsuitable to suitable environments.

Interactions between ruminants (e.g., cows and sheep) and the microorganisms that inhabit their stomachs are good examples of nutritional mutualism. A ruminant's diet consists mainly of cellulose, but like most animals, ruminants do not produce the necessary enzymes to break down cellulose. Unlike most animals, however, they have microorganisms in their stomachs that can digest cellulose. Furthermore, these microorganisms can also synthesize proteins from ammonia and urea that are present in the stomach. Some of these microorganisms are subsequently digested, thus providing the ruminant with protein. They can also synthesize all of the B-complex vitamins and vitamin K. Hence microbial activity enables ruminants to gain additional energy and nutrients. The microorganisms, in turn, benefit from free food and good housing—the warm, wet interior of the stomach provides a favorable environment for their growth and reproduction.

In their mutualistic relationship, these red ants obtain nourishment from aphids and protect the aphids from predators. © Hans Pfletschinger/Peter Arnold, Inc.

The head of this bronzy hermit hummingbird is about to be dusted by pollen as it feeds upon nectar from a passion flower. © Michael Fogden/Animals Animals

We, too, have a complex assemblage of mutualistic microorganisms residing in our digestive systems. Unlike those of ruminants, our microbes cannot digest cellulose, but they do synthesize the B-complex vitamins and vitamin K.

Many organisms provide protection from enemies and in turn may be provided with food, protection, housing, or all of these. In East Africa, for instance, certain ants live in the swollen thorns of acacia trees. The thorns provide an ideal shelter and a balanced and almost complete diet for all stages of ant development. The ants, in turn, serve as protectors. As soon as a branch is touched by a browsing animal or some other organism, the ants feel the vibrations and respond by pouring out of their holes in the thorns and racing toward the ends of the branches. Along the way, they release a repulsive odor that usually drives the enemy away.

Ants are also involved in protective mutualisms with sap-feeding insects, such as aphids. Plant sap often contains too much sugar for the aphids to utilize. Consequently, aphids extrude a sugary solution, called *honeydew*, which serves the ants as a major source of food. In return, ants protect the aphids by attacking and driving away predators (left photo).

Flowering plants and their pollinators exemplify transport mutualism. A wide variety of animals (e.g., butterflies, beetles, hummingbirds, and bats) visit flowers to obtain food (right photo). Flowers produce pollen, which is rich in protein, and nectar, a nutritious sugary fluid. As the visitors feed, they brush against the male structures (which produce pollen), and their bodies are dusted with pollen. When they visit another flower, the pollen from the first flower is transferred inadvertently to the female structures of the second flower. This pollination process may then lead to fertilization and the production of seeds and fruits. Several advantages accrue to flowering plants from pollination by animals. Because the animals move directly from one flower to another, less pollen is wasted than in pollination that depends on the random movements of the wind. Furthermore, when plants are relatively few and widely scattered, the food-seeking activities of pollinators make pollination more likely than it is with wind pollination.

How do mutualistic interactions form? Are the mutualistic microbes that live in us the descendants of microbes that were once intestinal parasites in our ancestors? Are mutualistic interactions stable, or do they frequently break down? For example, instead of protecting their partners, do aphid-tending ants sometimes turn on the aphids and devour them? Ecologists still have much to learn about these fascinating population interactions.

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## Issues

Issue boxes offer case studies that touch upon many of the controversial subjects in environmental studies.

**Issue**

*Fire Management Policies in National Parks*

The year 1988 brought national attention to the National Park Service in general and to Yellowstone National Park in particular. The spectacular Yellowstone fires that summer produced such headlines as "A Legacy in Ashes," "Yellowstone Destroyed," "Valuable Timber Lost," and "Survival of Yellowstone in Jeopardy." These headlines along with sensational video footage of wildfires roaring through Yellowstone gave the public the erroneous impression that the entire park had been reduced to cinders. Such media exposure also reinforced the popular notion that all fires are destructive. Because Yellowstone National Park had a fire management policy that under certain conditions allowed lightning-started fires to burn out on their own, the Park Service was blamed for the conflagration. In fact, many of the major fires were human-caused, and some originated on adjacent U.S. Forest Service lands (fig. 10.18). Nevertheless, federal, state, and local politicians, business people of the gateway towns on the park's perimeter, and some members of the media severely criticized the Park Service for its fire management policy. Let us evaluate the ecological basis for this policy.

The legislative mandate of the National Park Service is to maintain, as near as possible, a primitive ecological situation. Ecologists have known for some time that naturally caused fires are among the factors that have shaped the evolution of vegetation and wildlife for millennia. The aftermath of the Yellowstone fires of 1988 supports this perspective.

Contrary to popular opinion, less than 1% of the park experienced the high-intensity fires that left little more than ashes. In fact, as the fires progressed, they produced in their wake a mosaic of burned, partially burned, and nonburned areas. As a result, new habitats were created that will follow various pathways of ecological succession. The fires increased the heterogeneity (patchiness) of the landscape, which sustains greater species diversity.

Plant growth began almost immediately after the fires. Less than 1% of the soil was subjected to heat extreme enough to penetrate more than 2.5 centimeters (1 inch). Thus, the fires left most seeds unharmed, and many germinated when soil moisture conditions became favorable. Furthermore, the fires released billions of seeds of the lodgepole pine, a species that provides nearly 80% of the forest cover in Yellowstone. Lodgepole pines produce two types of cones. Some shed seeds when they reach maturity. Others are sealed with a resin coating and will not open until they are exposed to high temperatures from a fire. Hence, they may remain unopened for years, but they release millions of seeds within a few days after a fire. Following the 1988 fires, densities of lodgepole pine seeds in some areas of the park ranged from 50,000 to 100,000 seeds per acre. While many of these seeds nourished birds, mice,

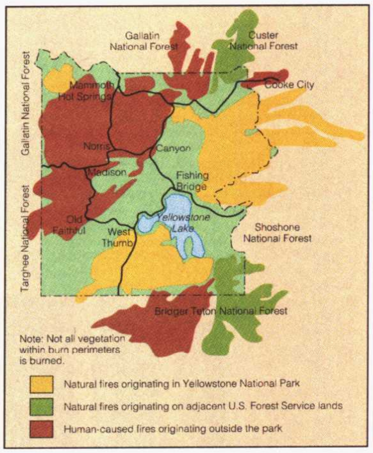


**Figure 10.18** Extent of natural and human-caused fires in the Greater Yellowstone Area in 1988. Not all vegetation within burn parameters was burned.

Source: *Yellowstone Fire*, 1988, National Park Service.

and squirrels, some escaped predation, germinated, and will eventually produce forests that are much like the ones that burned. Other plants, such as willows and grasses, quickly resprouted from underground structures that were not harmed by the fires. Thus, within only one or two growing seasons, the charred forest floor was replaced with herbaceous plants, shrubs, and the seedlings of tomorrow's forests (fig. 10.19).

Rather than destroying the vegetation of the park forever, the fires actually spurred a renewal of life in Yellowstone. Prior to the fires, plant growth had slowed considerably on some sites where the soils are inherently infertile. The relatively dry and cool summer weather in Yellowstone, which slows decomposer activity, also contributes to low soil fertility. Without fire, most of the nutrients are tied up in living and dead vegetation. The fires of 1988 triggered a resurgence of plant growth because they released plant nutrients in the form of ash and because they exposed the previously shaded forest floor to the sun. Herbivores flourished after the

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## Visual Aids

A wide array of beautiful photos and informative illustrations are featured throughout the text, including numerous graphs that convey analytical information in an easy-to-read format.

(a) (b)

**Figure 5.17** Differences in the structural adaptations of (*a*) the hairy woodpecker and (*b*) the downy woodpecker enable them to exploit somewhat different food sources. This reduces competition between the two species.
(*a*) © John Gerlach/Animals Animals. (*b*) © Rod Planck/Photo Researchers, Inc.

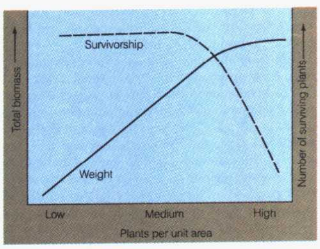


**Figure 5.18** As plant density increases, total biomass production increases until a maximum production level is reached. Increasing plant density also eventually results in lowered survivorship.

that were previously occupied by bluebunch wheatgrass. Although ranchers prefer to graze cattle on wheatgrass, it has been almost impossible to reestablish wheatgrass, even where grazing has been eliminated.

Field and laboratory experiments indicate that cheatgrass can exclude wheatgrass for several reasons. The seeds of both species germinate at approximately the same time, during the fall, when the soil is moist. Then during the winter, wheatgrass becomes dormant, while cheatgrass continues to grow. As a result, the extensive root system of cheatgrass grows deeper and gains control of the soil before the wheatgrass seedlings can become better established. Also, cheatgrass matures four to six weeks earlier than wheatgrass, so it withdraws most of the water from the soil before the wheatgrass has a chance to tap it. During the typically hot and dry summers, wheatgrass seedlings usually succumb to severe soil moisture deficits. Hence in places where summers are relatively dry, cheatgrass excludes wheatgrass by out-competing it for soil moisture. In areas where plentiful rain falls in the summer,

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## Tables

Tables are strategically placed throughout each chapter to offer important data in an accessible manner.

**Table 8.1** Sources and deficiency symptoms of some important vitamins

| Vitamin | Major Sources | Deficiency Symptoms |
|---|---|---|
| A | egg yolk, green or yellow vegetables, fruits, liver, butter | night blindness; dry, flaky skin |
| $B_1$ (thiamine) | pork, whole grains | beriberi: fatigue, heart failure, indigestion, nerve damage |
| $B_2$ (riboflavin) | milk, eggs, liver, whole grains | inflammation and cracked skin, including lips; swollen tongue |
| $B_6$ (niacin) | whole grains, liver, and other meats | pellagra: cracked skin, digestive disorders, mental changes |
| Folic acid | liver, leafy vegetables | anemia, digestive disorders |
| C | citrus fruits, tomatoes, green leafy vegetables, potatoes | scurvy: bleeding of gums and skin, slow healing of wounds |
| D | fish oils, liver, fortified milk and other dairy products, sunlight on skin | rickets: defective bone formation |
| K | synthesis by intestinal bacteria, leafy vegetables | bleeding, internal hemorrhaging |

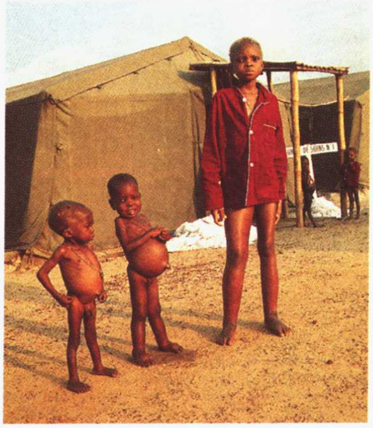

**Figure 8.6** Children in Nigeria suffering from a form of protein-calorie malnutrition called *kwashiorkor*.

© Dourdin/Photo Researchers, Inc.

Protein malnutrition is perhaps the greatest single cause of human disease in the world. **Kwashiorkor** (a form of protein malnutrition) occurs in many less-developed nations where young children receive insufficient protein to support their rapidly growing bodies. Symptoms of this devastating illness include lethargy, depressed mental abilities, failure to grow, hair loss, and swelling caused by accumulation of fluids beneath the skin (fig. 8.6). Kwashiorkor commonly develops when a child is switched from highly nutritious mother's milk to a diet of mostly cereals or roots, such as sweet potato and cassava—foods rich in carbohydrates, but poor in essential amino acids. Fortunately, permanent retardation can be avoided if a child is put on a balanced diet soon enough.

To maintain good health, humans also require about twenty vitamins, most of which the body's cells cannot manufacture. Deficiencies of each vitamin are associated with specific metabolic effects. Table 8.1 lists some of the essential vitamins, their major food sources, and associated deficiency symptoms. Vitamin A deficiency, for example, results in dry, flaky skin that is susceptible to invasion by microorganisms. Vitamin A deficiency also reduces the ability of the eye to respond to light. Mild deficiencies usually lead to an inability to see at night (night blindness). In extreme cases, blindness may occur. Vitamin A is also known as an anti-infection vitamin. People with insufficient Vitamin A are more prone to infections in the eyes, kidneys, or respiratory tract. Severe deficiencies in children dramatically increase deaths due to diarrhea, measles, and other maladies.

Recall from chapter 3 that we also require a variety of minerals for proper nutrition. Among these are iron, a component of hemoglobin, which carries oxygen in the blood; calcium, a component of bones; and potassium, required for transmission of nerve impulses and for muscle contraction. Table 8.2 lists these and other minerals and their sources. Iodine is an example of an essential mineral that is lacking in the diet of some regions. Iodine is a component of the hormone thyroxin, which is produced by the thyroid gland. Without sufficient iodine, thyroxin production declines, and the thyroid gland, located in the neck, swells to form what is known as a *goiter*. Because thyroxin stimulates metabolism, other symptoms of low thyroxin production include mental and muscular sluggishness and extreme lethargy. A victim often sleeps 14-16 hours a day. In extreme cases, people develop deafness and arteriosclerosis (hardening of the arteries). Goiters and associated symptoms are common in mountainous regions of Asia, Africa, and Latin America, where

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Molds that grow on seeds and fruits of food plants synthesize a variety of natural toxins, including carcinogens, that apparently help the molds to survive, and some of these carcinogens find their way into food. Aflatoxin, one of the most potent carcinogens in laboratory rats, is formed by molds that grow on corn, wheat, and nuts and thus enters the human food chain. For example, peanut butter marketed in the United States contains on average about 2.0 ppb aflatoxin. Because of their potency, mold toxins may be one of the most important sources of carcinogens in our food supply. The concern is even greater in less-developed nations, where poor storage facilities and warm, humid climates greatly enhance mold growth. In more-developed nations, modern storage facilities that use fungicides greatly reduce mold contamination.

From our discussion of risk assessment, it is clear that we still have much to learn about exposure to chemicals, especially carcinogens, mutagens, and teratogens. Research suggests that for society as a whole, pollution only contributes minimally to the cancer hazard compared to background levels. This does not mean that we should be complacent about pollution, but it does indicate that we need a more equitable balance between the fear of exposure and the actual risk. Currently, the possibility of exposure to even minute quantities of almost any chemical is stringently controlled by regulations that make compliance costly for industry. In many cases, these costs provide society with no tangible benefits. On the other hand, there still remain many occupations in the United States where lifetime exposure to the chemicals of the trade can result in permanent illness and a shortened life span.

## Conclusions

We have examined human exposure to chemicals in an effort to understand the risks we face from continual exposure to synthetic and naturally occurring toxins. Some species are significantly more sensitive to toxins than we are, while other are more tolerant. For all organisms, we know that the severity of symptoms increases as the dose of noncarcinogenic toxins increases. The sensitivity of organisms varies because species differ in their ability to detoxify toxins.

When risks from activities such as driving a car, jaywalking, or sunbathing are compared to risks from chemical exposure, we see that today's society perceives risks from many toxins as being much higher than they actually are. The result has been strict regulation of activities that involve exposure to toxins. We will apply the fundamental concepts of toxicology again when we examine the impact of water and air pollutants (chapters 14 and 16) and the management of hazardous waste (chapter 20).

## Key Terms

| | |
|---|---|
| toxicology | oncogene |
| toxins | promoter |
| heavy metals | suppressor gene |
| bioaccumulation | mutagen |
| acute exposure | mutation |
| chronic exposure | teratogen |
| toxicity | detoxification mechanisms |
| enzymes | metabolites |
| no-observed-effect level (NOEL) | risk |
| $LD_{50}$ | individual risk |
| $LC_{50}$ | societal risk |
| carcinogen | risk assessment |
| initiator | |

## Summary Statements

Toxins enter organisms via four possible routes: inhalation, absorption, ingestion, and injection. Inhalation is the most frequent route of human exposure to toxins.

Normally, we ingest only minor amounts of toxins. The amounts we ingest from animals and plants contaminated with toxins through bioaccumulation are exceptions.

Short-term, or acute, exposure to toxins involves exposure to high levels of toxins with almost immediate symptoms. Long-term, or chronic, exposure to toxins involves exposure to low levels of toxins over lengthy periods, usually with long-delayed symptoms and illnesses.

The response to most toxins is dose-dependent; higher doses produce more severe symptoms.

The $LD_{50}$ value, the dose required to kill 50% of a test population, is one way to express the toxicity of a substance.

A carcinogen is a substance or radiation that causes cancer. Carcinogens include initiators and promoters that act on DNA.

Mutagens are substances that cause heritable changes in genes.

Teratogens cause defects between conception and birth.

The body defends against toxins by excreting or metabolizing them. The liver is the primary organ for metabolizing toxins.

Risk is a measure of the likelihood of something going wrong. People vary in their response to risk; typically, they underestimate the risk associated with familiar activities and overestimate the risk associated with unfamiliar activities or highly publicized risks.

Toxicological data are used to determine the allowable levels (risk) of exposure of humans to toxins.

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## Key Terms

A list of key terms for each chapter will help students identify and review important terms.

## Summary Statements

Summary statements offer students a synopsis of each chapter's key topics for quick study reference and for emphasis of important concepts.

## Conclusions

Every chapter ends with statements that reiterate key concepts and present corollaries that are relevant to students' lives.

Expanded use of biofuels as an energy source is possible, but large-scale expansion would require tremendous amounts of land, which, in turn, would aggravate environmental problems.

Wind generation of electricity by moderate-sized windmills is economically competitive with conventional electric generation methods but is unreliable because winds are highly variable.

The United States has used approximately 42% of its favorable hydroelectric dam construction sites. Construction of new dams is highly controversial because dams cause social and environmental disruptions and are expensive to build.

In some regions it is possible to extract energy from geothermal resources, particularly for generating electricity. Some favorable sites cannot or should not be used because extraction of energy might jeopardize geothermal features in public parks. Geothermal sites produce pollutants that must be dealt with.

Nuclear fusion yields enormous quantities of energy. Development of nuclear fusion technology that will permit sustained generation of electricity is technologically challenging, and thus, extremely expensive. Its ultimate development is still highly questionable.

The mix of fossil fuels, nuclear fuels, and renewable resources will change somewhat by the year 2010, with coal and renewable sources picking up most of the increase (25 quads) in demand.

### Questions for Review

1. List the top three energy-consuming activities in the average household.
2. What measures are some utilities taking to reduce the demand for electricity in their service areas?
3. What passive features can be incorporated into a new home to cut its energy consumption? Which of these features could be incorporated into existing buildings?
4. How much more efficient are the new screw-in-fluorescent bulbs than ordinary incandescent bulbs?
5. List six ways to conserve energy in your home or apartment. Rank them in order of pay-back time and the likelihood of implementation.
6. Why is fuel efficiency in automobiles of primary concern? What are some of the factors that keep fuel efficiency from reaching its full potential?
7. How can a community increase the efficiency of its transportation network? How could you cut the amount of energy you use for personal transportation?
8. Cite reasons why car and van pools are not used more widely. Suggest some ways to overcome some of the barriers to their use.
9. Give two examples of passive and active solar collection systems.
10. Use figure 19.6 to determine the seasonal variation in the amount of solar radiation in your region. What are some of the more common methods used in your region to take advantage of solar energy?
11. What are photovoltaic cells? Why are they considered to be an ideal solar energy collection device. What are some of their limitations?
12. How are biofuels used to supplement traditional energy sources? Can the use of biofuels be expanded?
13. Identify the advantages and disadvantages of harvesting the sun's energy using the following methods: solar collectors, solar photovoltaic cells, windmills, hydroelectric dams, and biofuels. Which systems work best for homes? Which systems work best for large-scale applications?
14. Summarize the arguments of those who favor and those who oppose expansion of hydroelectric power in the United States.
15. Describe why geothermal energy should be considered a nonrenewable resource.
16. Peak electrical demand in most communities occurs at about 4 P.M. each day. On an annual basis, peak demand occurs during the summer. What are the advantages of reducing peak demand? Suggest some policies that would lower peak demand.
17. More efficient energy use during the last decade is the result of substantially higher energy prices. If energy costs continue to rise, will it be possible to conserve as much energy as was conserved in the 1980s?
18. Distinguish between nuclear fission and nuclear fusion.
19. What efforts are underway to make nuclear fusion a viable technology?
20. What changes in the energy delivery system are possible for the United States over the next two decades? Are these changes likely to be controversial?

### Projects

1. Locate a solar home in your community, and obtain some data on its performance. Report on changes that might make it even more energy-efficient.
2. Do you think mandatory performance standards imposed by federal or local governments for vehicles, appliances, and new buildings are a good idea? Explain why you agree or disagree with them.
3. Contact your local electric utility and determine which energy conservation measures they are attempting to implement in your community. What types of incentives are they using to reach their energy conservation goals?

### Selected Readings

Abelson, P. H. "Energy Futures." *American Scientist* 75 (1987):584-93. A discussion focusing on why energy policies must change if the United States is to avoid severe shortages of liquid fuels.

Conn, R. W., V. A. Chuyanov, N. Inoue, and D. R. Sweetman. "The International Thermonuclear Experimental Reactor." *Scientific American* 266 (April 1992):102-10. A discussion of efforts underway to build a single large experimental nuclear fusion reactor.

Dostrovsky, I. "Chemical Fuels from the Sun" *Scientific American* 265 (Dec. 1991):102-7. A description of fuels that could be produced using sunlight and then transported to the point of use.

Echeverria, J. et al. *Rivers at Risk: The Concerned Citizen's Guide to Hydropower.* Covelo, Calif.: Island Press, 1989. Discusses how to become involved when a hydroelectric generating dam is proposed for a scenic area.

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## Projects

To encourage active participation in environmental awareness, students can choose one or more of the projects that appear at the end of most chapters.

## Selected Readings

For further reference on specific topics, students can use the list of selected readings from current journals and texts.

## Questions for Review

Each chapter ends with Questions for Review to help students test their mastery of terms and concepts and to promote critical thinking and writing skills.



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# Preface

This book introduces the college nonscience major to the principles and issues of environmental science. It was written for a one-semester course, but is comprehensive enough for most two-semester courses. In it, we demonstrate how environmental issues relate to the reader's everyday life, illustrate scientific principles by building on worldwide and familiar examples, and encourage students to become personally involved with solving environmental problems. So while we cover large-scale or global issues, we encourage students to act locally as well.

Over the past twenty years, we have coauthored five textbooks on the environment. Each of us brings to this work the experience of teaching undergraduates for more than twenty-two years and the complementary perspectives of different scientific backgrounds. One of us is an ecologist, one a meteorologist, and the other an environmental chemist. Through team-teaching and collaboration, we have learned much from each other, giving our writing a genuine sense of interdisciplinary instruction, a writing style nonscience students with diverse backgrounds should find appealing.

The study of environmental science is dynamic, and we have attempted to keep pace with rapid advances in the field. This text reflects the continued maturation of environmental science, which is characterized by an improved scientific understanding of how environmental systems work and a better ability to predict the consequences of human and nonhuman disruptions of the environment. In addition, this book responds to the renewed public interest in environmental quality by providing a solid scientific basis for understanding and demonstrating how various environmental issues are linked.

Improper disposal of toxic and hazardous wastes, deterioration of groundwater quality, the buildup of greenhouse gases and the resulting possibility of global climatic change, and the thinning of the stratospheric ozone layer are among the major environmental concerns we discuss. The linkage between human population growth and environmental deterioration is appropriately emphasized as well. Increased demand for resources, which threatens the quality and availability of adequate fresh water, food, energy, and living space, is also fully discussed. On the positive side, significant progress is frequently cited in air quality issues, the reclamation of surface-mined land, recycling, the preservation of wilderness, protection of endangered species, and greater energy efficiency.

We have tried to meet the challenge of writing not just a *timely* environmental science textbook but a *timeless* one by emphasizing scientific principles and the natural functioning of the environment. Although the importance of certain environmental issues may wax and wane with time, the underlying principles that govern physical and biological systems do not change. Hence, the readers' grounding in basic ecological concepts provides them with the interpretive skills and flexibility needed to analyze new environmental issues as they arise.

We have made every effort to describe and analyze environmental problems as objectively as possible. While we convey the seriousness of those problems, we do not editorialize. Rather, we encourage readers to become personally involved in solving environmental problems and to form their own opinions on controversial issues.

## Important Features of the Text

Highlights of this text include the following:

A unique, three volume organization based on the three basic elements of most courses: economics and ecology, biological resources, and physical resources. The latter two should allow instructors with backgrounds in either biological or physical science to move through the text more efficiently. Because each part may be adopted individually in paperback "separates," instructors can customize the book to their particular course needs.

Extensive treatment of ecological principles and application to environmental issues.

Separate chapters on the nature of environmental science (chapter 1) and economic and public policy aspects of environmental issues (chapter 2).

Two chapters on human population growth (chapters 6 and 7) precede discussion of environmental problems.

An analysis of various strategies to enhance food production and of the future role of sustainable agriculture (chapter 8).

Chapter-length treatment of pest management (chapter 9).

Chapter-length coverage of the management of public lands (chapter 10).

Extensive application of ecological principles to managing biodiversity (chapter 11).

An entire chapter on environmental toxicology (chapter 12).

Concise treatment of contemporary concerns in water quality (chapters 13 and 14) and air quality (chapters 15 and 16) that is based upon physical principles.

An extensive treatment of mining, land reclamation, and management of rock and mineral resources (chapter 17).

Thorough analyses of present energy sources and future energy options (chapters 18 and 19).

A chapter on waste management that combines coverage of nonhazardous, hazardous, and radioactive wastes (chapter 20).

A unique look at land-use conflicts in the context of coastal zone management, geological hazards, and urban growth (chapter 21).

Color photographs and illustrations. Ninety - five percent of the book's visuals are in full color.

- Inclusion of two types of readings called "Issues" or "Special Topics."

Metric and British units of measure are used throughout text.

Many case studies and practical examples.

Numerous suggestions for individual action.

Includes key pedagogical aids such as key terms, summary statements, questions for review, suggestions for projects, and an annotated bibliography.

An epilogue entitled "Toward a Sustainable Environment" that summarizes numerous themes developed throughout the text. It appears at the end of the full text or at the end of Parts II and III, if adopted as "separates."

A complete glossary.

An appendix addressing some of the special environmental concerns of Canada, Mexico, and Hawaii.

## Organization and Content

*Environmental Science: Managing Biological and Physical Resources* remains both a basic science text and a text on environmental issues. This approach is evident throughout the book and is reflected in the basic organization of its twenty-one chapters. The organization is based upon suggestions of reviewers and an in-depth survey of potential adopters.

## Volume I: Economics and Ecology

**Part I** consists of two introductory chapters. Chapter 1 introduces the reader to environmental science, how scientists do science, and the successes and limitations of scientific inquiry. Many of the ideas presented in chapter 1 (such as scientific models) are woven through the entire text. Chapter 2, authored by Richard J. Tobin, covers the economic and policy-making dimensions of environmental issues.

Basic principles of ecology are treated in **Part II** (chapters 1 – 5). We consider the flow of energy and cycling of materials within the environment, the nature of environmental disturbance and pollution, how organisms and ecosystems respond to environmental change, and the various biological and physical factors that govern population growth. These fundamental ecological principles are applied to a wide variety of environmental issues throughout the text.

**Part III** (chapters 6 and 7) focuses on human population growth. Exponential growth of global human population and the consequent soaring demand for resources are at the very core of many environmental problems. Hence, we treat this topic extensively and introduce it prior to our discussion of environmental issues.

## Volume II: Managing Biological Resources

**Part IV** (chapters 8 – 12) deals with problems of environmental quality and management that are primarily biological in nature. Thus, we describe the challenge of meeting the food requirements of a soaring human population, pest management strategies, management of public lands in the face of pressures from visitors and resource developers, and threats to biodiversity. This section closes with a chapter on environmental toxicology, reflecting the importance of assessing the risks and response of humans and other organisms to toxins.

## Volume III: Managing Physical Resources

**Part V** (chapters 13 – 21) covers environmental issues that are chiefly, but not exclusively, physical. Thus, we consider water quality, air quality, exploitation of mineral resources, energy supply and demand, waste management, and land-use conflicts and natural hazards. For each problem area, we describe the natural functioning of the environment, the nature of the problem, and how that problem is managed.

The text closes with an epilogue that underscores the need for sustainable development and the role of the individual in environmental problem solving and with an appendix on the special environmental concerns of Canada, Mexico, and Hawaii.

The three-volume organization of the text provides the instructor with considerable flexibility in course planning and can provide students with significant price savings. For example, a course that emphasizes biological problems may opt for a packaging of Chapters 1 – 7 plus 8 – 12, or volumes I and II, while a course with a greater emphasis on physical science might utilize a packaging of Chapters 1 – 5 plus 13 – 21, or volumes I and III. Chapters in volumes II and III may be covered in any order, and any topic may be dropped without loss of continuity.

## Ancillaries

An ***Instructor's Manual*** and ***Test Item File,*** prepared by Barry Wulff, is available free to adopters as additional support material. The instructor's manual provides a list of key terms/concepts, a chapter outline, learning objectives, and ideas/activities for each chapter. The test item file contains 30 – 40 objective questions for each chapter that can be used for exam purposes. (ISBN 0 – 697 – 10833 – 3)

A ***Student Study Guide,*** prepared by Michael Morgan and Joseph Moran, is available to students as a resource for extensive self-testing of basic scientific concepts and environmental issues. (ISBN 0 – 697 – 10834 – 1)

Also available to instructors is ***TestPak,*** a computerized testing service that includes a database of objective questions and a grade-recording program. Disks are available in IBM, Apple, and Macintosh formats. If a computer is not available, the instructor can choose questions from the *Test Item File* and phone or FAX in their request for a printed exam, which will be returned within 48 hours.

There are 100 two- and four-color overhead ***Transparencies*** available free to adopters. These acetates feature key illustrations from the text that will enhance your lecture or course outlines. (ISBN 0 – 697 – 10835 – X)

***Transparency Masters*** are also available in the instructor's manual. These can be used to prepare handouts or to project as overhead transparencies, depending on the instructor's needs. (ISBN 0 – 697 – 16358 – X)

***You Can Make a Difference,*** by Judith Getis, is a short, inexpensive supplement that offers students practical guidelines for recycling, conserving energy, disposing of hazardous wastes, and other environmentally sound practices. It can be shrink-wrapped with the text, at minimal additional cost. (ISBN 0 – 697 – 13923 – 9)

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If we may be of assistance to you in utilizing this book, or if you have suggestions or comments, please feel free to contact us at the University of Wisconsin—Green Bay, College of Environmental Sciences, Green Bay, WI 54311. FAX: 414 – 465 – 2376; VOICE: 414 – 465 – 2371.

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# Brief Contents

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