1 Visions of the Future

From the arch of the bridge to which his guide has carried him, Dante now sees the Diviners . . . coming slowly along the bottom of the fourth Chasm. By help of their incantations and evil agents, they had endeavored to pry into the future which belongs to the almighty alone, and now their faces are painfully twisted the contrary way; and being unable to look before them, they are forced to walk backwards.

—Dante Alighieri, *Divine Comedy: The Inferno,* translated by Carlyle (1867)

Introduction

The Self-Extinction Premise

About the time the American colonies won independence, Edward Gibbon completed his monumental *The History of the Decline and Fall of the Roman Empire.* In a particularly poignant passage that opens the last chapter of his opus, he re-creates a scene in which the learned Poggius, a friend, and two servants ascend the Capitoline Hill after the fall of Rome. They are awed by the contrast between what Rome once was and what Rome has become:

> *In the time of the poet it was crowned with the golden roofs of a temple; the temple is overthrown, the gold has been pillaged, the wheel of fortune has accomplished her revolution, and the sacred ground is again disfigured with thorns and brambles. . . . The forum of the Roman people, where they assembled to enact their laws and elect their magistrates is now enclosed for the cultivation of potherbs, or thrown open for the reception of swine and buffaloes. The public and private edifices that were founded for eternity lie prostrate, naked, and broken, like the limbs of a mighty giant; and the ruin is the more visible, from the stupendous relics that have survived the injuries of time and fortune. (Vol. 6, pp. 650–651)*

What could cause the demise of such a grand and powerful society? Gibbon weaves a complex thesis to answer this question, suggesting ultimately that the seeds for Rome's destruction were sown by the Empire itself. Although Rome finally succumbed to such external forces as fires and invasions, its vulnerability was based upon internal weakness.

The premise that societies can germinate the seeds of their own destruction has long fascinated scholars. In 1798, Thomas Malthus published his classic *An Essay on the Principle of Population*, in which he foresaw a time when the urge to reproduce would cause population growth to exceed the land's potential to supply sufficient food, resulting in starvation and death. In his view, the most likely response to this crisis would involve rising death rates caused by environmental constraints, rather than a recognition of impending scarcity followed either by innovation or self-restraint.

Generally, our society seems remarkably robust, having survived wars and shortages, while dramatically increasing living standards and life expectancy. Yet, actual historical examples suggest that Malthus's self-extinction vision may sometimes have merit. Example 1.1 examines two specific cases: the Mayan civilization and Easter Island.

EXAMPLE 1.1

A Tale of Two Cultures

The Mayan civilization, a vibrant and highly cultured society that occupied parts of Central America, did not survive. One of the major settlements, Copán, has been studied in sufficient detail to learn reasons for its collapse.

After A.D. 400 the population growth began to bump into environmental constraints, specifically the agricultural carrying capacity of the land. The growing population depended heavily on a single, locally grown crop—maize—for food. By early in the sixth century, however, the carrying capacity of the most productive local lands was exceeded, and farmers began to depend upon more fragile parts of the ecosystem. Newly acquired climate data show that a 2-century period with a favorable climate was followed by a general drying trend lasting four centuries that led to a series of major droughts. Food production failed to keep pace with the increasing population.

By the eighth and ninth centuries, the evidence reveals not only high levels of infant and adolescent mortality but also widespread malnutrition. The royal dynasty, an important source of leadership, collapsed rather abruptly sometime about A.D. 820–822.

The second case study, Easter Island, shares some remarkable similarities with both the Mayan case and the Malthusian vision. Easter Island lies some 2000 miles off the coast of Chile. Current visitors note that it is distinguished by two features: (1) its enormous statues carved from volcanic rock and (2) a surprisingly sparse vegetation, given the island's favorable climate and conditions. Both the existence of these imposing statues and the fact that they were erected at a considerable distance from the quarry suggests the presence of an advanced civilization, but current observers see no sign of it. What happened? According to scholars, the short answer is that a rising population, coupled with a heavy reliance on wood for housing, canoe building, and statue transportation, decimated the forest (Brander and Taylor, 1998). The loss of the forest contributed to soil erosion, declining soil productivity, and, ultimately, diminished food production. How did the community react to the impending scarcity? Apparently, the social response was war among the remaining island factions and ultimately, cannibalism.

We would like to believe not only that in the face of impending scarcity, societies would react by changing behavior to adapt to the diminishing resource supplies, but also that this benign response would follow automatically from a recognition of the problem. We even have a cliché to capture this sentiment: "necessity is the mother of invention." These stories do point out, however, that nothing is automatic about a problem-solving response. Sometimes societies not only fail to solve the problem but their reactions can actually intensify it.

Sources: Webster, D., Freter, A., & Golin, N. Copan: The rise and fall of an ancient maya kingdom. (2000). Fort Worth: Harcourt Brace Publishers; Brander, J. A., & Taylor, M. S. (1998). The simple economics of Easter Island: A Ricardo-Malthus model of renewable resource use. *The American Economic Review, 88*(1), 119–138; Turner, B. L., & Sabloff, J. A. (2012). Classic period collapse of the central Maya lowlands: Insights about human–environment relationships for sustainability. *Proceedings of the National Academy of Sciences, 109*(35), 13908–13914; Pringle, Heather. (9 November 2012). Climate change had political, human impact on ancient Maya. *Science*, 730–731.

Future Environmental Challenges

Future societies will also be confronted by resource scarcity as well as with accumulating pollutants. Many specific examples of these broad categories of problems are discussed in detail in the following chapters. This section provides a flavor of what is to come by illustrating the challenges posed by one pollution problem (climate change) and one resource scarcity problem (water accessibility).

Climate Change

Energy from the sun drives the earth's weather and climate. Incoming rays heat the earth's surface, radiating energy back into space. Atmospheric "greenhouse" gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy.

Without this natural "greenhouse effect," temperatures on the earth would be much lower than they are now and life as we know it would be impossible. It is possible, however, to have too much of a good thing. Problems arise when the concentration of greenhouse gases increases beyond normal levels, thus retaining excessive heat somewhat like a car with its windows closed in the summer.

Since the Industrial Revolution, greenhouse gas emissions have increased, considerably enhancing the heat-trapping capability of the earth's atmosphere. According to the Intergovernmental Panel on Climate Change National Research Council, 2010, "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia." It also noted that based upon multiple lines of evidence "Human influence on the climate system is clear."

As the earth warms, the consequences are expected to affect both humans and ecosystems. Some damage to humans is caused directly by increased heat, as shown by the heat waves that resulted in thousands of deaths in Europe in the summer of 2003. Human health can also be affected by pollutants, such as smog, that are exacerbated by warmer temperatures. Rising sea levels (as warmer water expands and previously frozen glaciers melt), coupled with an increase in storm intensity, are expected to flood coastal communities with greater frequency. Ecosystems will be subjected to unaccustomed temperatures; some will adapt by migrating to new areas, but many others are not expected to be able to adapt in time. While these processes have already begun, they will intensify slowly throughout the century.

Climate change also has an important moral dimension. Due to their more limited adaptation capabilities, many developing countries, which have produced relatively small amounts of greenhouse gases, are expected to be the hardest hit as the climate changes.

Dealing with climate change will require a coordinated international response. That is a significant challenge to a world system where the nation-state reigns supreme and international organizations are relatively weak.

Water Accessibility

Another related class of threats is posed by the interaction of a rising demand for resources in the face of a finite supply. Water provides a particularly interesting example because it is so vital to life.

According to the United Nations, about 40 percent of the world's population lives in areas with moderate-to-high water stress. ("Moderate stress" is defined in the U.N. Assessment of Freshwater Resources as "human consumption of more than 20 percent of all accessible renewable freshwater resources," whereas "severe stress" denotes consumption greater than 40 percent.) By 2025, it is estimated that about two-thirds of the world's population—about 5.5 billion people—will live in areas facing either moderate or severe water stress.

This stress is not uniformly distributed around the globe. For example, in parts of the United States, Mexico, China, and India, groundwater is already being consumed faster than it is being replenished, and aquifer levels are steadily falling. Some rivers, such as the Colorado in the western United States and the Yellow in China, often run dry before they reach the sea. Formerly enormous bodies of water, such as the Aral Sea and Lake Chad, are now a fraction of their once-historic sizes. Glaciers that feed many Asian rivers are shrinking.

According to U.N. data, the continents most burdened by a lack of access to sufficient clean water are Africa and Asia. Up to 50 percent of Africa's urban residents and 75 percent of Asians are estimated to lack adequate access to a safe water supply.

The availability of potable water is further limited by human activities that contaminate the remaining supplies. According to the United Nations, 90 percent of sewage and 70 percent of industrial wastes in developing countries are discharged without treatment. And climate change is expected to intensify both the frequency and duration of droughts, simultaneously increasing the demand for water and reducing its supply.

Some arid areas have compensated for their lack of water by importing it via aqueducts from more richly endowed regions or by building large reservoirs, but this solution can promote conflict when the water transfer or the relocation of people living in the area to be flooded by the reservoir is resisted. Additionally, aqueducts and dams may be geologically vulnerable. For example, in California, many of the aqueducts cross or lie on known earthquake-prone fault lines (Reisner, 2003). The reservoir behind the Three Gorges Dam in China is so vast that the pressure and weight are causing tremors and landslides.

Meeting the Challenges

As the scale of economic activity has proceeded steadily upward, the scope of environmental problems triggered by that activity has transcended geographic and generational boundaries. The nation-state used to be a sufficient form of political organization for resolving environmental problems, but is that still the case? Whereas each generation used to have the luxury of being able to satisfy its own needs without worrying about the needs of generations to come, intergenerational effects are now more prominent. Solving problems such as poverty, climate change, ozone depletion, and the loss of biodiversity requires international cooperation. Because future generations cannot speak for themselves, the current generation must speak for them. Current policies must incorporate our obligation to future generations, however difficult or imperfect that incorporation might prove to be.

International cooperation is by no means a foregone conclusion. Global environmental problems can result in very different effects on countries that will sit around the negotiating table. While low-lying countries could be completely submerged by the sea level rise predicted by some climate change models, arid nations could see their marginal agricultural lands succumb to desertification. Other nations may see agricultural productivity rise as warmer climates in traditionally intemperate regions support longer growing seasons.

Countries that unilaterally set out to improve the global environmental situation run the risk of making their businesses vulnerable to competition from less conscientious nations. Industrialized countries that undertake stringent environmental policies may not suffer much at the national level due to offsetting increases in income and employment in industries that supply renewable, cleaner energy and pollution control equipment. Some specific industries facing stringent environmental regulations, however, may well face higher costs than their competitors, and can be expected to lose market share accordingly. Declining market share and employment resulting from especially stringent regulations and the threat to outsource production are powerful influences. The search for solutions must accommodate these concerns.

The market system is remarkably resilient in how it responds to challenges. As we shall see, prices provide incentives not only for the wise use of current resources, but also for promoting innovations that can broaden the menu of future options.

Yet, as we shall also see, market incentives are not always consistent with promoting sustainable outcomes. Currently, many individuals and institutions have a large stake in maintaining the status quo, even when it poses an existential threat. Fishermen harvesting their catch from an overexploited fishery are loath to reduce harvests, even when the reduction may be necessary to conserve the stock and to return the population to a healthy level. Farmers who depend on fertilizer and pesticide subsidies will give them up reluctantly. Coal companies resist any attempt to reduce carbon emissions from coal-fired power plants.

How Will Societies Respond?

The fundamental question is how societies will respond to these challenges. One way to think systematically about this question involves feedback loops.

Positive feedback loops are those in which secondary effects tend to reinforce the basic trend. The process of capital accumulation illustrates one positive feedback loop. New investment generates greater output, which when sold, generates profits. These profits can be used to fund additional new investments. Notice that with positive feedback loops, the process is self-reinforcing.

Positive feedback loops are also involved in climate change. Scientists believe, for example, that the relationship between emissions of methane and climate change may be described as a positive feedback loop. Because methane is a greenhouse gas, increases in methane emissions contribute to climate change. The rise of the planetary temperature, however, could trigger the release of extremely large quantities of additional methane currently trapped in the permafrost layer of the earth; the resulting larger methane emissions would further increase temperature, resulting in the release of more methane, and so on.

Human behavior can also intensify environmental problems through positive feedback loops. When shortages of a commodity are imminent, for example, consumers typically begin to hoard the commodity. Hoarding intensifies the shortage. Similarly, people faced with shortages of food may be forced to eat the seed that is the key to more plentiful food in the future. Situations giving rise to this kind of downward spiral are particularly troublesome.

In contrast, a negative feedback loop is self-limiting rather than self-reinforcing. Perhaps the best-known planetary-scale example of a negative feedback loop is provided in a theory advanced by the English scientist James Lovelock. Called the *Gaia hypothesis* after the Greek concept for Mother Earth, this view of the world suggests that the earth is a living organism with a complex feedback system that seeks an optimal physical and chemical environment. Deviations from this optimal environment trigger natural, nonhuman response mechanisms that restore the balance. In essence, according to the Gaia hypothesis, the planetary environment is characterized by negative feedback loops and, therefore, is, within limits, a self-limiting process.

As we proceed with our investigation, the degree to which our economic and political institutions serve to intensify or to limit emerging environmental problems will be a key focus of our analysis.

The Role of Economics

How societies respond to challenges will depend largely on the behavior of human beings acting individually or collectively. Economic analysis provides an incredibly useful set of tools for anyone interested in understanding and/or

Ecological Economics versus Environmental Economics

DEBATE 1.1

Over the last decade or so, the community of scholars dealing with the role of the economy and the environment has settled into two camps: ecological economics (http://www.ecoeco.org/) and environmental economics (http://www.aere.org/). Although they share many similarities, ecological economics is consciously more methodologically pluralist, while environmental economics is based solidly on the standard paradigm of neoclassical economics. While neoclassical economics emphasizes maximizing human welfare and using economic incentives to modify destructive human behavior, ecological economics uses a variety of methodologies, including neoclassical economics, depending upon the purpose of the investigation.

While some observers see the two approaches as competitive (presenting an "either-or" choice), others, including the authors of this text, see them as complementary. Complementarity, of course, does not mean full acceptance. Significant differences exist not only between these two fields, but also within them over such topics as the valuation of environmental resources, the impact of trade on the environment, and the appropriate means for evaluating policy strategies for long-duration problems such as climate change. These differences arise not only over methodologies but also over the values that are brought to bear on the analysis.

The senior author of this book has published in both fields and has served on the editorial boards of the leading journals in both fields, so it probably will not be surprising that this book draws from both fields. Although the basic foundation for the analysis is environmental economics, the chapters draw heavily from ecological economics to critique that view when it is controversial and to complement it with useful insights drawn from outside the neoclassical paradigm, when appropriate. Pragmatism is the reigning criterion. If a particular approach or study helps us to understand environmental problems and their resolution, it has been included in the text.

modifying human behavior, particularly in the face of scarcity. In many cases, this analysis points out the sources of the market system's resilience as embodied in negative feedback loops. In others, it provides a basis not only for identifying the circumstances where markets fail, but also for clarifying how and why that specific set of circumstances supports degradation. This understanding can then be used as the basis for designing new incentives that restore a sense of harmony in the relationship between the economy and the environment for those cases where the market fails.

Over the years, two different, but related, disciplinary approaches have arisen to address the challenges the future holds. As shown in Debate 1.1, both ecological economics and environmental economics can contribute to our understanding.

The Use of Models

All of the topics covered in this book will be examined as part of the general focus on satisfying human wants and needs in light of limited environmental and natural resources. Because this subject is complex, it is better understood when broken into manageable portions. Once we master the components in individual chapters, we will be able to coalesce the individual insights into a more complete picture.

In economics, as in most other disciplines, we use models to investigate complex subjects such as relationships between the economy and the environment. Models are simplified characterizations of reality. For example, although a road map by design leaves out much detail, it is nonetheless a useful guide to reality. By showing how various locations relate to each other, a map gives an overall perspective. Although it cannot capture all of the unique details that characterize any particular location, a map highlights those characteristics that are crucial for the purpose at hand.

The models in this text are similar. Through simplification, less detail is considered so that the main concepts and the relationships among them become clear.

Fortunately, models allow us to study rigorously issues that are interrelated and global in scale. Unfortunately, due to their selectivity, models may yield conclusions that are dead wrong. Details that are omitted may turn out, in retrospect, to be crucial in understanding a particular dimension. Therefore, models are useful abstractions, but the conclusions they yield depend on the structure of the model. Change that structure and you are likely to change the conclusions. As a result, models should always be viewed with some skepticism.

Most people's views of the world are based on models, although frequently the assumptions and relationships involved may be implicit, perhaps even subconscious. In economics, the models are explicit; objectives, relationships, and assumptions are clearly specified so that the reader understands exactly how the conclusions are derived.

The validity and reliability of economic models are tested by examining the degree to which they can explain actual behavior in markets or other settings. An empirical field known as econometrics uses statistical techniques, primarily regression analysis, to derive key economic functions. These data-derived functions, such as cost curves or demand functions, can then be used for such diverse purposes as testing hypotheses about the effects of policies or forecasting future oil prices.

Examining human behavior in a non-laboratory setting, however, poses special challenges because it is nearly impossible to control completely for all the various factors that influence an outcome beyond those of primary interest. The search for more control over the circumstances that provide the data we use to understand human behavior has given rise to the use of another complementary analytical approach—*experimental economics*, as discussed in Example 1.2. Together, econometrics and experimental economics can provide different lenses to help us understand human behavior and its impact on the world around us.

EXAMPLE 1.2

Experimental Economics: Studying Human Behavior in a Laboratory

The appeal of experimental economics is based upon its ability to study human behavior in a more controlled setting. During the mid-twentieth century economists began to design controlled laboratory experiments with human subjects. The experimental designs mimic decision situations in a variety of settings. Paid participants are informed of the rules of the experiment and asked to make choices. Perhaps, for example, in an experiment to mimic the current carbon trading market, the participants are told how much it costs to abate carbon emissions and they are asked to place bids to buy carbon allowances. The team running the experiment would then calculate the resulting market price as well as how many allowances each successful participant would acquire, based on all the bids.

To the extent that the results of these experiments have proved to be replicable, they have created a deeper understanding about the effectiveness of markets, policies, and institutions. The large and growing literature on experimental economics has already shed light on such widely divergent topics as the effectiveness of alternative policies for controlling pollution and allocating water, how uncertainty affects choices, and how the nature of cooperative agreements affects the sustainability of shared natural resources.

While experiments have the advantage of being able to control the decision-making environment, the artificiality of the laboratory setting raises questions about the degree to which the results from laboratories can shed light on actual human behavior outside the lab. While the degree of artificiality can be controlled by careful research design, it cannot be completely eliminated. Over the years, however, this approach has provided valuable information that can complement what we have learned from observed behavior using econometrics.

Sources: Cummings, R. G., & Taylor, L. O. (2001/2002). Experimental economics in natural resource and environmental management. *The International Yearbook of Environmental and Natural Resource Economics* (H. Folmer and T. Tietenberg, Eds). Cheltenham, UK: Edward Elgar, 123–149; Smith, V. L. (1998). Experimental methods in economics. *The New Palgrave Dictionary of Economics*, Volume 2, J. Eatwell, M. Murray , & P. Newman, Eds. London, UK: The Macmillan Press Limited, 241–249.

The Road Ahead

Are current societies are on a self-destructive path? In part, the answer depends on whether human behavior is perceived as a positive or a negative feedback loop. If increasing scarcity results in a behavioral response that involves a positive feedback loop (intensifies the pressure on the environment), pessimism is justified. If, on the other hand, human responses serve to reduce those pressures or could be reformed so as to reduce those pressures, optimism may be justified.

Not only does environmental and natural resource economics provide a firm basis for understanding the behavioral sources of environmental problems, but also this understanding provides a firm foundation for crafting specific solutions to them. In subsequent chapters, for example, you will be exposed to how economic analysis can be (and has been) used to forge solutions to such diverse areas as climate change, biodiversity loss and water scarcity. Many of the solutions are quite novel.

Market forces are extremely powerful. Attempts to solve environmental problems that ignore these forces run a high risk of failure. Where these forces are compatible with efficient and sustainable outcomes, those outcomes can be supported and reinforced. Where the forces diverge, they can be channeled into directions that restore compatibility. Environmental and natural resource economics provide a specific set of directions for how this compatibility between goals and outcomes can be achieved.

The Issues

The two opposing visions of the future identified in Debate 1.2 offer not only rather different conceptions of what the future holds but also dissimilar views of what policy options should be chosen. They also suggest that to act as if one vision is correct, when it is not, could prove to be a costly error. Thus, it is important to examine these two views (or some third view) as a basis for forging your own view.

In order to assess the validity of these visions, we must address some basic issues:

- Is the problem correctly conceptualized as exponential growth with fixed, immutable resource limits? Does the earth have a finite carrying capacity? If so, how can the carrying-capacity concept be operationalized? Do current or forecasted levels of economic activity exceed the earth's carrying capacity?
- How does the economic system respond to scarcities? Is the process mainly characterized by positive or negative feedback loops? Do the responses intensify or ameliorate any initial scarcities?
- What is the role of the political system in controlling these problems? In what circumstances is government intervention necessary? What forms of intervention work best? Is government intervention uniformly benign, or can it make the situation worse? What roles are appropriate for the executive, legislative, and judicial branches?
- Many environmental problems involve a considerable degree of uncertainty about the severity of the problem and the effectiveness of possible solutions. Can our economic and political institutions respond to this uncertainty in reasonable ways or does uncertainty become a paralyzing force?
- Can the economic and political systems work together to eradicate poverty and social injustice while respecting our obligations to future generations? Or do our obligations to future generations inevitably conflict with the desire to raise the living standards of those currently in absolute poverty or the desire to treat all people, especially the most vulnerable, with fairness? Can short- and long-term goals be harmonized? Is sustainable development feasible? If so, how can it be achieved? What does the need to preserve the environment imply about the future of economic activity in the industrialized nations? In the less-industrialized nations?

The rest of this book uses economic analysis to suggest answers to these complex questions.

What Does the Future Hold?

DEBATE 1.2

Is the economy on a collision course with the environment? Or has the process of reconciliation begun? One group, led most notably by Bjørn Lomborg, President of the Copenhagen Consensus Center, concludes that societies have resourcefully confronted environmental problems in the past and that environmentalist concerns to the contrary are excessively alarmist. As he states in his book, *The Skeptical Environmentalist*

> *The fact is, as we have seen, that this civilization over the last 400 years has brought us fantastic and continued progress. . . . And we ought to face the facts—that on the whole we have no reason to expect that this progress will not continue.*

On the other end of the spectrum are the researchers at the Worldwatch Institute, who believe that current development paths and the attendant strain they place on the environment are unsustainable. As reported in that institute's *State of the World 2012* report

> *In 1992, governments at the Rio Earth Summit made a historic commitment to sustainable development—an economic system that promotes the health of both people and ecosystems. Twenty years and several summits later, human civilization has never been closer to ecological collapse, one third of humanity lives in poverty, and another 2 billion people are projected to join the human race over the next 40 years.*

These views not only interpret the available historical evidence differently, but also they imply very different strategies for the future.

Sources: Lomborg, B. (2001). *The skeptical environmentalist: Measuring the real state of the world*. Cambridge, UK: Cambridge University Press; The Worldwatch Institute (2012). *The state of the world 2012*. Washington: Island Press.

An Overview of the Book

In the following chapters you will study the rich and rewarding field of environmental and natural resource economics. The menu of topics is broad and varied. Economics provides a powerful analytical framework for examining the relationships between the environment, on one hand, and the economic and political systems, on the other. The study of economics can assist in identifying circumstances that give rise to environmental problems, in discovering causes of these problems, and in searching for solutions. Each chapter introduces a unique topic in environmental and natural resource economics, while the overarching focus on development in a environment characterized by scarcity weaves these topics into a single theme.

We begin by comparing perspectives being brought to bear on these problems by economists and noneconomists. The manner in which scholars in various disciplines view problems and potential solutions depends on how they organize the available facts, how they interpret those facts, and what kinds of values they apply in translating these interpretations into policy. Before going into a detailed look at environmental problems, we shall compare the ideology of conventional economics to other prevailing ideologies in the natural and social sciences. This comparison not only explains why reasonable people may, upon examining the same set of facts, reach different conclusions, but also it conveys some sense of the strengths and weaknesses of economic analysis as it is applied to environmental problems.

Chapters 2 through 6 delve more deeply into the economic approach, highlighting many of the tools used by environmental economists including cost-benefit analysis, discounting, and methods available for monetizing nonmarket goods and services. Specific evaluation criteria are defined, and examples are developed to show how these criteria can be applied to current environmental problems.

In Chapters 7 through 13 we turn to some of the topics traditionally falling within the subfield known as natural resource economics. The topics covered in these chapters include depletable and renewable energy resources, recyclable resources, water, and land, as well as forests, fisheries and other ecosystems.

We then move on to an area of public policy—pollution control—that has come to rely much more heavily on the use of economic incentives to produce the desired response. These chapters reveal the unique aspects of local and regional air pollution, global problems such as climate change and ozone depletion, vehicle air pollution, water pollution, and toxic substances as well as the effectiveness of the various economic approaches used to control these pollutants.

Following this examination of the individual environmental and natural resource problems and the successes and failures of policies that have been used to ameliorate these problems, we return to the big picture by assembling the bits and pieces of evidence accumulated in the preceding chapters and fusing them into an overall integrated response to the questions posed in the chapter. We also cover some of the major unresolved issues in environmental policy that are likely to be among those commanding center stage over the next several years if not decades.

Summary

Are our institutions so myopic that they have chosen a path that can only lead to the destruction of society as we now know it? We have briefly examined two points of view that provide different answers to that question. The Worldwatch Institute finds that the path is destructive, while Lomborg strikes a much more optimistic tone. The pessimistic view is based upon the inevitability of exceeding the carrying capacity of the planet as the population and the level of economic activity grow. The optimistic view sees initial scarcity triggering sufficiently powerful reductions in population growth and increases in technological progress bringing further abundance, not deepening scarcity.

Our examination of these different visions has revealed questions that must be answered if we are to assess what the future holds. Seeking the answers requires that we accumulate a much better understanding about how choices are made in economic and political systems and how those choices affect, and are affected by, the natural environment. We begin that process in Chapter 2, where the economic approach is developed in broad terms and is contrasted with other conventional approaches.

Discussion Questions

1. In his book *The Ultimate Resource*, economist Julian Simon makes the point that calling the resource base "finite" is misleading. To illustrate this point, he uses a yardstick, with its one-inch markings, as an analogy. The distance between two markings is finite—one inch—but an infinite number of points is contained within that finite space. Therefore, in one sense, what lies between the markings is finite, while in another, equally meaningful sense, it is infinite. Is the concept of a finite resource base useful or not? Why or why not?
2. This chapter contains two views of the future. Since the validity of these views cannot be completely tested until the time period covered by the forecast has passed (so that predictions can be matched against actual events), how can we ever hope to establish *in advance* whether one is a better view than the other? What criteria might be proposed for evaluating predictions?
3. Positive and negative feedback loops lie at the core of systematic thinking about the future. As you examine the key forces shaping the future, what examples of positive and negative feedback loops can you uncover?
4. Which point of view in Debate 1.2 do you find most compelling? Why? What logic or evidence do you find most supportive of that position?

Self-Test Exercise

1. Does the normal reaction of the price system to a resource shortage provide an example of a positive or a negative feedback loop? Why?

Further Reading

Batabyal, A. A., & Nijkamp, P. (2001). Introduction to research tools in natural resource and environmental economics. In A. A. Batabyal & P. Nijkamp (Eds.), *Research tools in natural resource and environmental economics*. Hackensack, NJ: World Scientific Publishing. An introduction to the most frequently used theoretical, empirical, experimental, and interdisciplinary research tools in natural resource and environmental economics.

Delbeke, J., Klaassen, G., van Ierland, T., & Zapfel, P. (2009). The role of environmental economics in recent policy making at the European Commission. *Review of Environmental Economics and Policy*, *4*, 24–43. This article examines how environmental economics has been used at the European Commission in climate change, energy, and air pollution policy.

Repetto, R., Ed. (2006). *Punctuated equilibrium and the dynamics of U.S. environmental policy*. New Haven, CT: Yale University Press. A sophisticated discussion of how positive and negative feedback mechanisms can interact to produce environmental policy stalemates or breakthroughs.

Stavins, R., Ed. (2012). *Economics of the environment: Selected readings* (6th ed.). New York: W. W. Norton & Company, Inc. An excellent set of complementary readings that captures both the power of the discipline and the controversy it provokes.

Additional References and Historically Significant References are available on this book's Companion Website: http://www.routledgetextbooks.com/textbooks/9780133479690