PART

ONE

Introduction: The Economy and the Environment

CHAPTER FOCUS QUESTIONS

- What major environmental issues do we face in the twenty-first century?
- How can economics help us understand these issues?
- How do economic and ecological perspectives differ, and how can we combine them to address environmental issues?

CHAPTER **1**

Changing Perspectives on the Environment

Economics and the Environment

Over the past three decades, we have become increasingly aware of environmental problems facing communities, nations, and the world. During this period, natural resource and environmental issues have grown in scope and urgency. In 1970, the Environmental Protection Agency was created in the United States to respond to what was at that time a relatively new public concern with air and water pollution. In 1972, the first international conference on the environment, the United Nations Conference on the Human Environment, met in Stockholm. Since then, growing worldwide attention has been devoted to environmental issues.

In 1992 the United Nations Conference on Environment and Development (UNCED) focused on major global issues including depletion of the earth's protective ozone layer, destruction of tropical and old-growth forests and wetlands, species extinction, and the steady buildup of carbon dioxide and other "greenhouse" gases causing global warming and climate change. Eight years later, the United Nations Environmental Programme (UNEP) report *Global Environmental Outlook 2000* found that "environmental gains from new technology and policies are being overtaken by the pace and scale of population growth and economic development." And in 2002 the follow-up report *Global Environmental Outlook 3* stated that, while in the years following the 1972 Stockholm conference "the world has made great strides in placing the environment on the agenda at various levels from international

to local . . . the level of awareness and action has not been commensurate with the state of the global environment today; it continues to deteriorate."[1]

With the exception of ozone depletion, an area in which major reduction in emissions has been achieved by international agreement, the UNEP reports offer evidence that the global environmental problems identified at UNCED in 1992 have continued or worsened. In addition, UNEP points to nitrogen pollution in freshwater and oceans, exposure to toxic chemicals and hazardous wastes, forest and freshwater ecosystem damage, water contamination and declining groundwater supplies, urban air pollution and wastes, and overexploitation of major ocean fisheries. Underlying all these problems is global population growth, adding more than 70 million people a year. The world population, which had passed 6 billion by the year 2000, is expected to grow to around 8 billion by 2030.

Scientists, policymakers, and the general public have begun to grapple with questions such as What will the future look like? and Can we respond to these multiple threats adequately and in time to prevent irreversible damage to the planetary systems that support life? One of the most important components of the problem that rarely receives sufficient attention is the economic analysis of environmental issues.

Some may argue that environmental issues transcend economics and should be judged in different terms from the money values used in economic analysis. Indeed, this assertion holds some truth. We find, however, that policies for environmental protection are often measured—and sometimes rejected—in terms of their economic costs. For example, it is extremely difficult to preserve open land that has high commercial development value. Either large sums must be raised to purchase the land, or strong political opposition to "locking up" land must be overcome. Environmental protection organizations face a continued battle with ever-increasing economic development pressures.

Often public policy issues are framed in terms of a conflict between development and the environment. The battle over logging of old-growth forest in the U.S. Northwest was typified as "jobs versus owls." Opponents of international agreements to reduce carbon dioxide emissions argue that the economic costs of such measures are too high. Supporters of increased oil production clash with advocates of protecting the Arctic National Wildlife Refuge. In developing nations, the tension between the urgency of human needs and environmental protection is even greater.

Does economic development necessarily require a high environmental price? Although all economic development must affect the environment to some degree, is "environment-friendly" development possible? If we must make a tradeoff between development and environment, how shall we decide the proper balance? Questions such as these highlight the importance of environmental economics.

Two Approaches

In this book we describe two approaches in addressing natural resource and environmental economics. The first, or traditional, approach uses a set of models and techniques

[1]UNEP, 1999, 2002.

rooted within the standard *neoclassical mainstream* of economic thought[2] to apply economic concepts to the environment. The second approach, known as **ecological economics,**[3] takes a different perspective. Rather than applying economic concepts *to* the environment, ecological economics seeks to place economic activity *in the context of* the biological and physical systems that support life, including all human activities.

The Traditional Economic Approach

Several models in economic theory specifically address environmental issues. One important application of neoclassical economic theory deals with the allocation of **nonrenewable resources** over time. This analysis is important in understanding such issues as depletion of oil and mineral resources, and also has applications to **renewable resources** such as agricultural soils. Economic analyses also address **common property resources** such as the atmosphere and oceans and **public goods** such as national parks and wildlife preserves. Because these resources are not privately owned, the economic principles governing their use differ from those affecting goods traded in the market.

Another central concept in neoclassical economic analysis of the environment is that of **externalities,** or **external costs and benefits.** The theory of externalities provides an economic framework for analyzing the costs of environmental damage caused by economic activities or the social benefits created by economic activity that improves the environment. Externalities are also sometimes referred to as **third-party effects,** because a market transaction that involves two parties—for example, someone buying gasoline from a filling station—also affects other people, such as those exposed to pollution from producing and burning the gas.

Modern environmental economic theory, built on this foundation, addresses many issues ranging from overfishing to fossil fuel depletion to parkland conservation.[4] In this text we will investigate how these economic concepts can help frame environmental questions and provide guidance for environmental policymaking.

The Ecological Economics Approach

Ecological economics takes a broader perspective in framing environmental questions by incorporating laws derived from the natural sciences. For example, to understand the collapse of many important ocean fisheries, ecological economics refers to population biology and ecology as well as to the economic view of fish as a resource for production.

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[2]Neoclassical price theory, based on the concepts of marginal utility and marginal productivity, emphasizes the essential function of market price in achieving an equilibrium between supply and demand.

[3]For an overview of many key articles in ecological economics, see Costanza, 1991, and Krishnan et al., 1995.

[4]See Bromley, 1995; Grafton et al., 2001; Markandya, 2001; Markandya and Richardson, 1993; Stavins, 2000; and van den Bergh, 1999, for collections of articles on environmental economics.

Ecological economics theorists emphasize the importance of energy resources, especially fossil fuels, in current economic systems. All ecological systems depend on energy inputs, but natural systems rely almost entirely on **solar energy.** The rapid growth of economic production during the twentieth century required enormous energy inputs, and global economic systems will make even greater energy demands in the twenty-first century. Energy availability and environmental implications of energy use are central issues for ecological economics.

A fundamental principle of ecological economics is that human economic activity must be limited by the environment's **carrying capacity.** Carrying capacity is defined as the population level and consumption activities, whether of humans or animals, that the available natural resource base can sustain without depletion. For example, when a herd of grazing animals exceeds a certain size, rangeland overgrazing will diminish the potential food supply, leading inevitably to a population decline.

For the human population, the issue is more complex. The issue of food supplies is certainly relevant as the world population, more than 6 billion by 2000, grows toward a projected 8 to 10 billion. But ecological economists also point to energy supplies, scarce natural resources, and cumulative environmental damage as constraints on economic growth. They argue that the standard theory gives these factors insufficient weight, and that major structural changes in the nature of economic activity are required to adapt to environmental limits.

In this text we will consider insights from both the standard and the ecological versions of environmental economics. Sometimes the theories show significant agreement or overlap, and sometimes they produce widely differing implications. The best way to judge which approaches are most fruitful is to apply them to specific environmental issues, as we do throughout this book. First, however, we must understand the relationship between the economic system, natural resources, and the environment.

A Framework for Understanding the Ecological Perspective

How can we best conceptualize the relationship between economic activities and the environment? One way is to start with the traditional **circular flow** diagram, used in most economics courses to depict the economic process.

The Circular Flow Model

Figure 1-1 shows a simplified model of relationships between households and business firms in two markets: the market for goods and services and the market for factors of production. Production factors are generally defined under the headings of land, labor, and capital. The services these factors provide are "inputs" to the production of goods and services, which in turn provide the basis for households' consumption needs. Goods, services, and factors flow clockwise; their economic values are reflected in the flows of money used to pay for them, moving counterclockwise. In both markets the

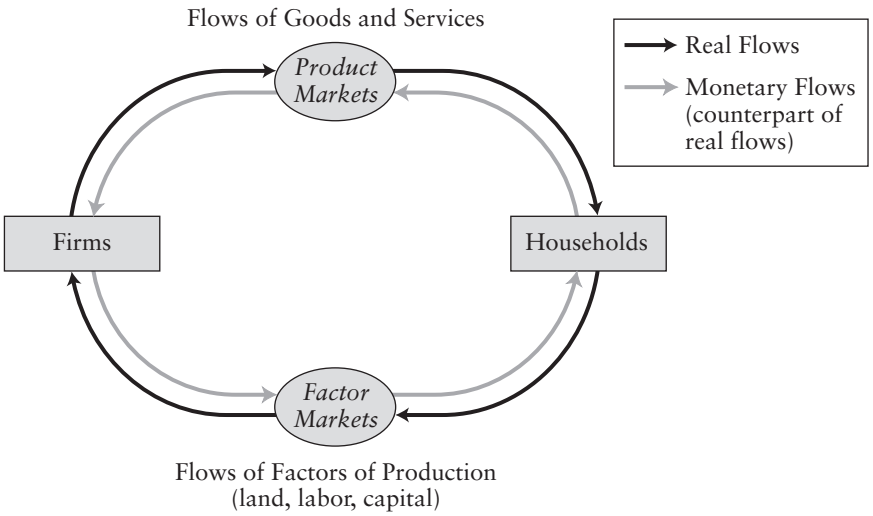

FIGURE 1-1 *The Standard Circular Flow Model*

interaction of supply and demand determines a market-clearing price and establishes an equilibrium level of output.

Where do natural resources and the environment fit in this diagram? **Natural resources,** including minerals, water, fossil fuels, forests, fisheries, and farmland, generally fall under the inclusive category of "land." The two other major production factors, labor and capital, continually regenerate through the economic circular flow process, but by what processes do natural resources regenerate for future economic use? To answer this question, we can construct a larger "circular flow" that takes in ecosystem processes as well as economic activity (Figure 1-2).

Taking this broader view, we notice that the standard circular flow diagram also omits effects of wastes and pollution generated in the production process. These wastes from both firms and households must somewhere flow back into the ecosystem, either through land disposal or as air and water pollution.

In addition to the simple processes of extracting resources from the ecosystem and returning wastes to it, economic activities also affect broader natural systems in more subtle and pervasive ways. For example, modern intensive agriculture changes the composition and ecology of soil and water systems, as well as affecting nitrogen and carbon cycles in the environment.

Figure 1-2, although still quite simple, provides a broader framework for placing the economic system in its ecological context. As you can see, the ecological system has its own circular flow, determined by physical and biological rather than economic laws. This broader flow has only one net "input"—solar energy—and only one net "output"—waste heat. Everything else must somehow be recycled or contained within the planetary ecosystem.

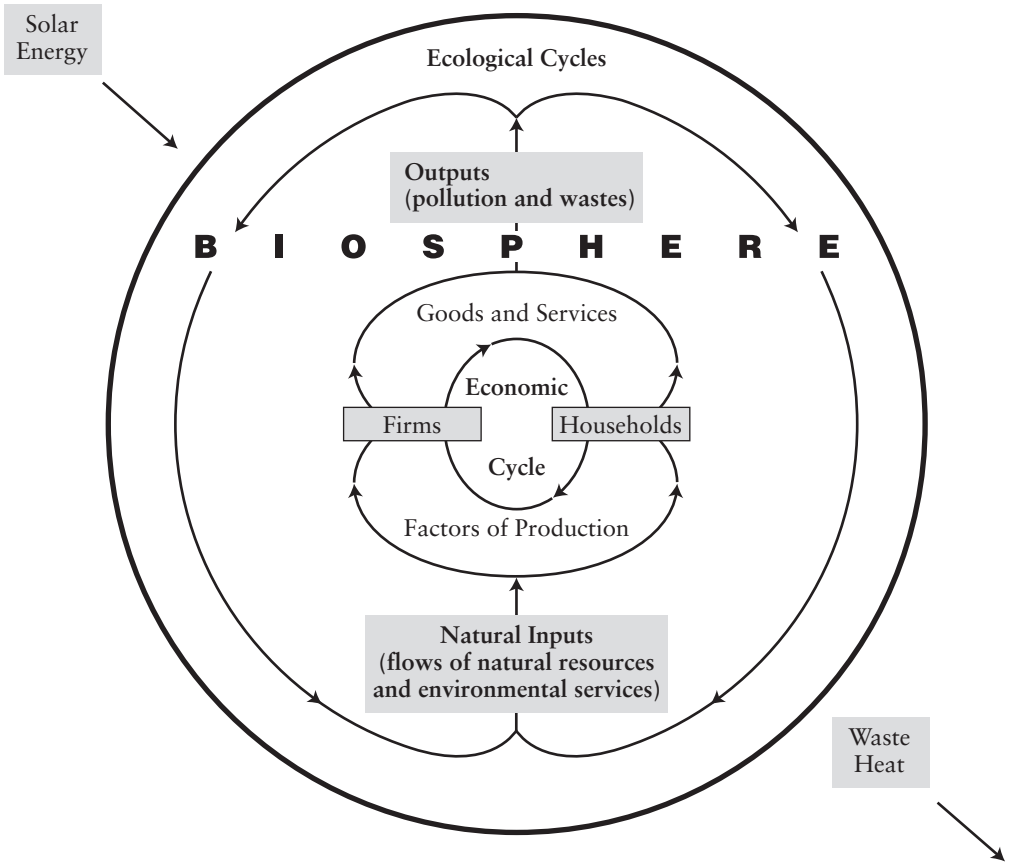

FIGURE 1-2 *A Broader Circular Flow Model*

Points of Contact Between Economic and Ecological Flows

Understanding the relationships between economic systems, natural resources, and the environment begins with defining the different functions natural systems serve.

- The environment's **source function** is its ability to make services and raw materials available for human use. Degradation of the source function can occur for two reasons: (1) **Resource depletion:** the resource declines in quantity because humans have drawn on it more rapidly than it could be regenerated; and (2) **Pollution:** contamination of the resource reduces its quality and usefulness.
- The environment's **sink function** is its ability to absorb and render harmless the waste by-products of human activity. The sink function is overtaxed when waste volume is too great in a given time period or when wastes are too toxic. When that happens, aspects of the environment on which we depend (most often soil, water, and atmosphere) become damaged, polluted, or poisoned.

These relationships between human activity and the environment define the points of contact between the inner circle of economic flows and the outer circle of ecological flows. Natural resource and environmental economics analyzes the relationships between the two circular flows: the economic system and the ecosystem.

The Economic Valuation Approach

The traditional economic approach to analysis of natural resource and waste flows uses the same kind of **economic valuation** applied to factors of production, goods, and services. This analysis seeks to put a price on each natural resource and environmental input to the economy, including an estimated price for inputs not usually included in market transactions, such as clean air and water. Economic techniques can also be used to assess the money value of damages done by pollution and waste disposal.

By placing a money value on natural resources and environmental functions, we can include them in the inner, or economic, circular flow. This is the goal of much standard resource and environmental analysis. As we will see, a variety of methods can serve this end, including redefining or reassigning property rights, creating new institutions such as markets for pollution permits, or implicit valuation through surveys and other techniques. If we can be satisfied that these pricing mechanisms accurately reflect the "true value" of resources and of environmental damages, we can relatively easily include these factors in a market-oriented economic analysis.

The Ecological Economics Approach

The ecological economics approach views the economic system as a subset of the broader ecosystem. In this perspective, an economic valuation expressed in prices can only imperfectly capture the complexity of ecological processes, and indeed will sometimes result in serious conflict with ecosystem requirements.

Ecological economists have often argued that standard economic pricing and valuation techniques must either be altered to reflect ecosystem realities, or must be supplemented by other forms of analysis focusing on energy flows, the carrying capacity of the environment, and the requirements of ecological balance. As we will see in our discussion of analytical techniques and of specific issues in population, energy, resources, and pollution, the standard and ecological economics perspectives will sometimes have similar practical implications, but in other cases the two approaches may lead to significantly different conclusions about appropriate resource and environmental policies.

For example, in dealing with the problem of global climate change (discussed at length in Chapter 18), a standard economic approach involves balancing the costs and benefits of avoiding future climate change. Damages caused by rising sea levels or stronger heat waves are estimated in economic terms and then compared to the costs involved in lessening climate change through reducing fossil fuel use and other measures. Policy recommendations are then formulated to maximize net economic benefits. An ecological economics approach, by contrast, looks first at the physical requirements

for a stable climate, in particular the limitation of carbon dioxide and other heat-trapping gases in the atmosphere. Once the physical requirements for a stable climate are determined, the economic measures necessary to achieve this are analyzed.

Application of a standard economic approach to the problem of global climate change often results in a recommendation for more limited policy action, to avoid excessive economic costs. The ecological approach usually suggests more drastic action to preserve atmospheric balance. Cost minimization is also a concern for ecological economists, but only after the basic biophysical requirements for ecosystem stability have been met.

Environmental Microeconomics and Macroeconomics

Another way of viewing the difference between standard and ecological approaches is in terms of a tension between microeconomic and macroeconomic perspectives on the environment.

Standard environmental economic analysis relies largely on microeconomic theory. **Environmental macroeconomics,** however, can help place the economic system in its broader ecological context.

A microeconomic perspective focuses on individual resource and environmental issues. The macroeconomic view is concerned with the interrelationship of economic growth and ecosystems.

Microeconomic and Valuation Techniques

To the extent that we can succeed in putting a price on natural resources and the environment, extensions of standard microeconomic theory can help explain the process of achieving equilibrium in markets for natural resources and for **environmental services**—the capacity of the environment to absorb wastes and pollutants, capture solar energy, and in other ways provide the basis for economic activity. Analytical techniques that play an important role in **environmental microeconomics** include

- *Measuring external costs and benefits.* This means, for example, estimating a money value for damage caused by acid rain pollution. This value can then be compared to the costs of correcting the problem through pollution control technology or reduced output of polluting activities. We can **internalize externalities** through, for example, a tax on the polluting activity.
- *Valuing resources and the environment as* ***assets,*** *whether privately owned or public.* This involves considering **intertemporal resource allocation,** the choice between using a resource now or conserving it for future use. The standard economic technique to balance present and future benefits and costs is to use a **discount rate.** In this technique, a present benefit or cost receives a somewhat higher value than a future benefit or cost—how much higher depends on the discount rate employed and on how far into the future the comparison extends.

In complex ecosystems such as rainforests, solar energy drives the cycles of life. Many such ecosystems are threatened by expansion of human activities.

- *Devising appropriate* ***property rights*** *rules for environmental resources and establishing rules for use of common property resources and for provision of public goods.*[5] For example, a fishery may be privately owned, or it may be public with access limited by government sale of fishing licenses. Similarly, a wildlife preserve may be privately owned and managed or may be maintained as a public park.
- *Balancing economic costs and benefits through some form of* ***cost-benefit analysis.*** This often involves a combination of values observable in the market, such as values of land or goods, and estimates of nonmarket values, such as natural beauty and maintenance of species diversity. For example, deciding whether or not to permit construction of a ski resort on a previously undeveloped hillside would require some estimate of the recreational value of skiing, the value of alternative land uses, as well as less easily quantifiable concerns such as impact on water supplies, wildlife, and on the rural character of the area.

[5]*Public goods* are resources and goods available to the public without restriction. For a more precise definition, see Chapter 4.

In the context of the double circular flow shown in Figure 1-2, the above analytical techniques are derived from the smaller "economic" circle: in effect, they apply pricing concepts drawn from the economic system to the intermediate flows of natural resources and wastes that connect the two circles. These approaches seem most appropriate when we focus on a specific, quantifiable problem, such as figuring the appropriate fee to charge for a license to cut timber on government land or appropriate limits on factory air pollutant emissions.

Environmental Macroeconomics

Valuation techniques are less effective in handling important unquantifiable values such as aesthetics, ethical issues, and **biodiversity** (the maintenance of many different interrelated species in an ecological community). They may also fail to capture the scope of **global environmental problems** that have become increasingly important in recent years. Issues such as global climate change, ozone depletion, loss of species, widespread degradation of agricultural lands, regional water shortages, forest and ocean ecosystem damage, and other large-scale environmental issues require a broader perspective. For this reason, ecological economist Herman Daly has called for development of an environmental macroeconomics,[6] which requires a different approach from the standard economic techniques discussed earlier.

Developing such a macroeconomic perspective on environmental issues requires placing the economic system in its broader ecological context. As Figure 1-2 shows, the economic circular flow is really part of a larger ecological circular flow. This ecological flow is actually made up of many cycles. **Ecological cycles** include

- The *carbon cycle,* in which green plants break down atmospheric carbon dioxide (CO_2) into carbon and oxygen. The carbon is stored in the plants, some of which are eaten by animals. Carbon is recombined with oxygen by animal respiration and by decay or burning of organic matter and is thus returned to the atmosphere.
- The *nitrogen cycle,* in which soil bacteria "fix," or chemically combine nitrogen from the atmosphere with oxygen and make this essential nutrient available for plant growth.
- The *water cycle,* including precipitation, runoff, and evaporation, which continually make fresh water available for plant and animal life.
- Other *organic cycles* of growth, death, decay, and new growth whereby essential nutrients are recycled through the soils to provide a continuing basis for plant and animal life.

All of these cycles rely on solar energy and operate in a complex balance that has evolved through millennia.

Seen in this context, economic activity is a process of speeding up the **throughput** of materials from the ecological cycles. The term "throughput" denotes the total use of energy and materials as both inputs and outputs of a process.

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[6]See Daly, 1991.

Modern agriculture, for example, applies vast quantities of artificially derived nitrogen fertilizer to obtain higher crop yields. Runoff of excess nitrogen creates environmental problems and water contamination. Both agriculture and industry make heavy demands on water supplies. Together with household use, this demand can exceed the capacity of the natural water cycle, depleting reservoirs and underground aquifers.

The most important way of speeding up resource throughput is using more energy to drive the economic system. More than 80 percent of the energy used in the global economic system is derived from fossil fuels. Carbon emissions from burning these fuels unbalances the global carbon cycle. Excessive amounts of CO_2 accumulate in the atmosphere, alter the processes that determine the planet's climate, and thereby affect many global ecosystems.

As economic growth proceeds, the demands of the economic system on the ecological cycles grow. Energy use, resource and water use, and waste generation increase. Thus the environmental macroeconomic issue is how to balance the size of the economic system, or **macroeconomic scale,** with the supporting ecosystem. Viewing the problem in this way represents a significant paradigm shift for economic analysis, which until recently has not usually considered overall ecosystem limitations.

Implications of Ecologically Oriented Economics

An ecologically oriented macroeconomics involves new concepts of national income measurement that explicitly reckon environmental pollution and natural resource depletion in calculating national income. In addition, ecological economists have introduced new forms of analysis at both microeconomic and macroeconomic levels. These new analytical techniques are based on the physical laws that govern energy and materials flows in ecosystems. Applying these laws to the economic process offers a contrasting perspective to the standard microeconomic analysis of environmental issues.

Seeking a balance between economic growth and ecosystem health has given rise to the concept of **sustainable development** (discussed in detail in Chapter 2). Forms of economic development that preserve rather than degrade the environment include renewable energy use, organic and low-input agriculture, and resource-conserving technologies. On a global scale, the promotion of sustainable development responds to the many resource and environmental issues outlined at the beginning of the chapter, viewing these issues in terms of ecosystem impacts rather than as individual problems.[7]

A Look Ahead

How can we best use these two approaches to economic analysis of environmental issues? In the following chapters we will find out by applying the tools and methods of each to specific issues. In preparation, Chapter 2 provides an overview of the

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[7]For surveys of the relationship between environmental economics and sustainable development, see Opschoor et al., 1999, and Harris et al., 2001. For a discussion of global ecosystem impacts of human activity, see World Resources Institute, 2000.

relationship between economic development and the environment. The microeconomic elements of resource and environmental economics are explored in detail in Chapters 3–6. Chapters 7–9 cover the concepts of ecological economics, environmental accounting, and ecosystem modeling.

In Chapters 10–18, we apply techniques of standard economic analysis and of ecological analysis to the major issues of population, food supply, energy use, natural resource management, and pollution control. Chapters 19 and 20 bring together many of these topics to focus on questions of trade, economic growth, and development as they relate to the environment.

SUMMARY

National and global environmental issues are major challenges in the twenty-first century. Response to these challenges requires understanding the economics of the environment. Policies aimed at environmental protection have economic costs and benefits, and this economic dimension is often crucial in determining which policies we adopt. Some cases may require tradeoffs between economic and environmental goals; in other cases these goals may prove compatible and mutually reinforcing.

Two different approaches address economic analysis of environmental issues. The standard approach applies economic theory to the environment using concepts of money valuation and economic equilibrium. This approach aims for efficient management of natural resources and proper valuation of waste and pollution impact on the environment. The ecological economic approach views the economic system as a whole as a subset of a broader biophysical system. This approach emphasizes the need for economic activity that conforms to physical and biological limits.

Much of the analysis drawn from the standard approach is microeconomic, based on the workings of markets. Variations of standard market analysis can be applied to cases where economic activity has damaging environmental effects or uses up scarce resources. Other economic analyses provide insight into the use of common property resources and public goods.

Environmental macroeconomics, a relatively new field, emphasizes the relationship between economic production and the major natural cycles of the planet. In many cases, significant conflicts arise between the operations of the economic system and these natural systems, creating regional and global problems such as global climate change from excess carbon dioxide accumulation. This broader approach requires new ways to measure economic activity, as well as analysis of how the scale of economic activity affects environmental systems.

This text outlines both analytical perspectives and draws on both to help understand the major issues of population, food supply, energy use, natural resource management, and pollution. The combination of these analyses can help to formulate policies that address specific environmental problems as well as promote a broader vision of environmentally sustainable development.

KEY TERMS AND CONCEPTS

assets
biodiversity
carrying capacity
circular flow
common property resources
cost-benefit analysis
discount rate
ecological cycles
ecological economics
economic valuation
environmental macroeconomics
environmental microeconomics
environmental services
external costs and benefits
externalities
global environmental problems
internalizing externalities
intertemporal resource allocation
macroeconomic scale
natural resources
nonrenewable resources
pollution
property rights
public goods
renewable resources
resource depletion
solar energy
source and sink functions
sustainable development
third-party effects
throughput

DISCUSSION QUESTIONS

1. Do economic growth and sound environmental policy necessarily conflict? Identify some areas where a choice must be made between economic growth and environmental preservation and others where the two are compatible.
2. Can we put a money price on environmental resources? How? Is this impossible in any cases? Identify specific situations of valuing the environment with which you are familiar or have read about.
3. In what ways do the principles of ecological circular flow resemble those of the economic circular flow? How do they differ? Consider specific examples in the areas of agriculture, water, and energy systems.

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WEBSITES

1. **http://www.worldwatch.org/** The homepage for the Worldwatch Institute, an organization that conducts a broad range of research on environmental issues. The Worldwatch annual "State of the World" report presents detailed analyses of current environmental issues.
2. **http://www.ncseonline.org/** Website for the National Council for Science and the Environment, with links to various sites with state, national, and international data on environmental quality.
3. **http://www.emagazine.com/** Website for E/The Environmental Magazine. The site includes many archived articles on all environmental topics.
4. **http://www.unep.org/geo/geo3/** Website for the Global Environment Outlook-3, a United Nations publication. The report is an extensive analysis of the global environmental situation.