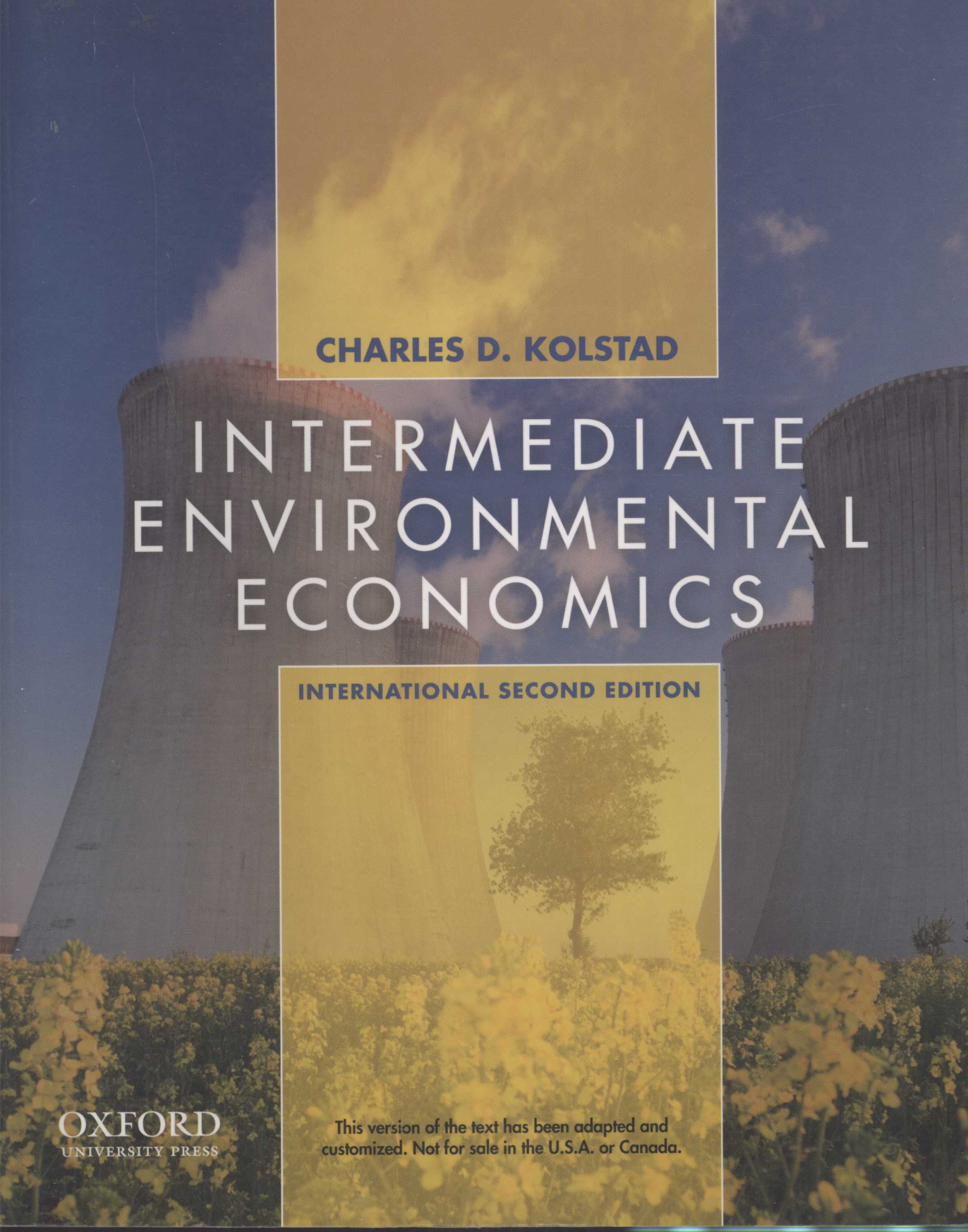

CHARLES D. KOLSTAD

INTERMEDIATE ENVIRONMENTAL ECONOMICS

INTERNATIONAL SECOND EDITION

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INTERMEDIATE ENVIRONMENTAL ECONOMICS

To Valerie, Jonathan, Kate, Katrina, Christine, Luis,
and the memory of George

PREFACE

THIS IS AN ECONOMICS TEXTBOOK CONCERNED WITH A FIELD OF ECONOMICS—ENVIRONMENTAL economics. This book is entitled *Intermediate Environmental Economics* to reflect the fact that it is neither an advanced graduate text nor a beginning undergraduate text. It is intermediate, written at a similar level as most intermediate microeconomics texts.

Most of the standard fields of economics (e.g., public, labor, industrial organization) have texts aimed at three different levels: beginning (with few or no prerequisites), intermediate (with a prerequisite of intermediate microeconomics), and advanced (for PhD students). There are two major reasons for producing this book at the intermediate level. One is to underscore the fact that environmental economics is a field of economics that can and should be studied by advanced undergraduates. The other reason is that there is a real shortage of intermediate-level texts in environmental economics. There are many good introductory texts aimed at students without much preparation in economics. And there are a few good graduate level texts. But little in between.

The field of environmental economics has grown significantly since its beginnings in the 1960s. And just as the world has changed dramatically over that period (and continues to change), the challenges for environmental economics continue to evolve. One of the remarkable features of environmental economics is the international scope of the field. Many scholars work in the field in Europe, North America, Japan, and Australia. It has also been gratifying to see the growth in the field in countries such as India. I am frequently approached by an Indian national who tells me he or she used the Indian version of my text for a class in India. It gives me great satisfaction for my book to be offered at low cost in many areas of the world—something Oxford University Press does very well.

A real effort has been made to make the text of this book read as if it were written from a global perspective, not just from a U.S. or European perspective. Environmental economics is one of the most international of all fields of economics, with active practitioners in the developed and developing world. To what extent this internationalization has been achieved is best judged by readers from around the world.

There is more material in the book than can be covered in the typical one-term class (of 25 to 35 student-contact hours). When I teach from the book, I try to cover all chapters but pick and choose the subsections of each chapter. In this way, students are exposed to the important components of the field of environmental economics.

It should be emphasized that this book makes a distinction between environmental policy and environmental economics. Environmental policy receives short shrift here, primarily because it is such a broad topic. Additionally, this book emphasizes environmental economics at the expense of resource economics. Excluded are topics of natural resources in which there is not a dominant market failure. Thus fisheries are covered at an

elementary level but exhaustible resources are not. This is consistent with the course division at the University of California, Santa Barbara, where we have one ten-week course in environmental economics and one ten-week course in resource economics.

Although the book is targeted at undergraduates studying economics, it may also be useful for graduate students, particularly those pursuing a master's degree in economics or environmental management. Again, at the Bren School of Environmental Science & Management at the University of California, Santa Barbara, we use the text as a supplement for a master's level course entitled "Economics for Environmental Management."

I welcome comments from users of the book, both students and teachers. It is always gratifying to receive feedback, even when it involves an error in the text!

Finally, let me say that this book would not be possible without the support and encouragement of my extended family, to whom I dedicate this book.

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ECONOMICS AND THE ENVIRONMENT

Tell someone you study environmental economics and the usual response is a look of puzzlement and the query "Just what is that?" A natural reaction, particularly considering the common belief in some circles that economics is the root of the "environmental problem."

Environmental economics is concerned with the impact of the economy on the environment, the significance of the environment to the economy, and the appropriate way of regulating economic activity so that balance is achieved among environmental, economic, and other social goals. What distinguishes a morally neutral chemical such as sulfur dioxide from the pollutant sulfur dioxide is the economy. The polluters who emit sulfur dioxide do so because it is a by-product of producing some good the public wants; consumers want the good associated with sulfur dioxide but at the same time obtain disutility (damage) from the sulfur dioxide pollution. The essence of the environmental problem is the economy—producer behavior and consumer desires. Without the economy, most environmental issues are simply research questions of concern to chemists or biologists with no policy significance.

There is no question that today environmental protection is recognized by societies and governments around the world, in both developed and developing nations, as being a top public policy and quality-of-life issue. Although people have been concerned about environmental quality for decades, or even centuries, the widespread societal recognition of the importance of environmental protection is a relatively recent phenomenon.

In this chapter we first consider the discipline of environmental economics, a subfield of economics. We then turn to a broad treatment of environmental problems and policy approaches that have been taken to provide society with higher levels of environmental quality.

I. ENVIRONMENTAL ECONOMICS AS A DISCIPLINE

For most goods and services in a modern economy, we rely on markets to match producer costs with consumer demands to yield the "right" amount of production (and

thus consumption). The problem with pollution is that markets do not work to yield the socially desirable amount of pollution. This illustrates the breadth of problems that need answers: What are the incentives for the generation of pollution? What are the costs of cleaning up pollution? What are the societal gains from pollution control? What is the right balance between costs of control and gains from control? What regulatory mechanisms can be designed to ensure the right balance between costs and gains? Sometimes these issues are straightforward; othertimes they are exceedingly complex.

Although the field of environmental economics probably dates to the late 1950s and early 1960s with the important contributions emerging from the "think tank" Resources for the Future,[1] the field really took off in the 1970s and has been booming ever since. In the 1990s the payoff began to be seen in terms of influence on environmental policy. Marketable permits for pollution control are now widely embraced, valuation methods are an integral part of environmental prevention, environmental valuation is being used to make decisions concerning major public projects with environmental impacts, and environmental economics is playing a major role in the current climate change debate. Now, as the world works to develop regulatory means to control climate change, a very large proportion of proposed regulatory approaches involve markets for emission rights.

In the sections that follow we will more fully develop several of these dimensions of environmental economics. We first consider how environmental economics relates to environmental policy. Next, we examine how environmental economics meshes with the larger discipline of economics. We then discuss two related terms that have emerged in the academic and policy world—ecological economics and environmental economics. How do they differ? Environmental economics is also closely related to resource economics. What is the connection and what are the distinctions between them? Finally we consider several important issues, currently the subject of much research and debate, that confront the field of environmental economics.

A. Environmental Economics and Environmental Policy

Concern with the environment is not a passing fad but a deep-seated concern, brought on in large part by the coincidence of high incomes and high population density. If there were few people in the world, the earth's environment would be very forgiving and capable of absorbing most of what humans throw at it, cleansing itself automatically. The days of low population on the earth have passed; the total number of people on the planet and particularly the density of people in some parts of the planet magnify the size of environmental insults, overloading the capacity of the earth for self-cleansing. Income is also important, not only because rich people tend to consume more and thus generate more pollution, but also because the environment is often viewed as a luxury good. For the poor who struggle to keep food on the table, environmental issues often take a backseat to other more pressing needs related to survival. As people become wealthier, they turn their attention increasingly to the quality of their living environment, which ultimately is the planet. Thus if recent trends toward increasing wealth for the people of the world continue, we can expect concern for the environment to increase over time.

What are the typical issues facing most countries of the world with regard to environmental policy? In developed countries, pollution and the preservation of natural environments (e.g., wilderness areas) are major concerns. Pollution problems usually involve

two major issues—what is the right amount of pollution and how can we get polluters to control their emissions?

Determining the right amount of pollution is not easy. Pollution is generated as a by-product of producing goods. To determine the costs of pollution control it is necessary to understand the structure of goods production and how costs will differ for different levels of pollution. Contrary to what most people might think, this is not an engineering question. Although it is easy to find out how much it would cost for a piece of equipment that is placed on a smokestack to reduce pollutants in the smoke (a "scrubber"), to an economist that is only the tip of the cost iceberg. Faced with the prospect of having to reduce pollution levels, the firm has many options. These include end-of-pipe treatment, modifying the production process, modifying the characteristics of the product, relocating the productive activity to reduce damage, and investing in research and development to find new ways of controlling pollution. If a pollution permit market exists, the firm has the additional choice of buying permits to emit, rather than reducing emissions. Consumers can also reduce consumption of the polluting good. Thus characterizing costs at a conceptual level, as well as measuring these costs empirically, is a complex question without easy answers. It is also the domain of environmental economics.

Determining the right amount of pollution also involves determining damages from pollution. The words "damages from pollution" deceptively suggest that this is a natural science question, such as counting the dead fish on a polluted lake or determining the level of pollution at which people begin to get sick. This is an oversimplification of the multitude of ways pollution affects people and the relative seriousness of these effects to people. Air pollution in an urban area can cause physical irritation (itchy eyes, running nose), reduced visibility, degraded visibility (a brown pale), soiled clothes, decreased lung capacity, worry about adverse effects, increased susceptibility to illness, and of course illness itself. Some of these effects are tangible, others are very intangible. Economics is accustomed to condensing this variety of effects into a single measure—the willingness to pay to reduce pollution. If pollution is bad, people are willing to devote some of their resources to eliminating the pollution. Leaving aside the fact that most people think the polluter should pay, one way of measuring the overall magnitude or importance of pollution reduction to a person is through his or her willingness to give up something valuable in exchange for improved personal environmental quality. Measuring this willingness to pay is not easy and is the subject of much research in environmental economics.

Having characterized the importance of pollution reduction to individuals (their willingness to pay), it is possible to sum up individual preferences to obtain a societal willingness to pay to reduce pollution. It is then easy to combine this with the cost of pollution control to determine the socially optimal amount of pollution reduction. But how to obtain this? The government could tell each polluter how much to emit, but this would be analogous to central planning in the old Soviet Union—we know it works up to a point but has severe problems, particularly when there are many firms and polluters involved. It is difficult to determine the best way for the government to intervene in the economy ("regulate") to yield the right amount of pollution control without excessive administrative costs or control costs while at the same time providing the right incentives to undertake research to reduce costs for the future.

So the "simple" job of fixing the problem of pollution is not so easy at the policy level and can involve hard-to-solve problems, many in the domain of environmental

economics. The examples we have used are from developed economies but a very similar analysis could apply to a developing country. Air pollution is a big problem in many cities of the developing world. Water pollution is probably the most severe environmental problem in many developing countries: water contaminated by human waste kills millions of people annually. The same issues of costs, demand for clean-up, and how to regulate apply equally to this question.

Another important type of policy question is the preservation of natural environments, broadly defined. This could involve preserving wild and scenic areas from development or protecting animal and plant species from extinction. Here the primary issue is providing balance between the forces of development that threaten these environmental resources and the social value of preservation. How can both sides of this equation be quantified to help policymakers when they are confronted with very specific decisions (such as whether to allow logging in a virgin forest)?

These examples could go on and on. The point is that environmental protection usually involves the intervention of governments in the economy and it is often difficult to decide on the proper extent and nature of that intervention. Environmental economics as it is applied to real environmental problems can be invaluable in helping make those important decisions.

B. Positive versus Normative Perspectives

There are two fundamental uses of economics. One is to try to explain what we see in the economy around us. Another is to try to explain how we would wish the economy to allocate and distribute goods and services. The terms positive and normative are used to distinguish these two perspectives. Positive economics is more value free, aiming to explain economic behavior: why markets and institutions have evolved as they have and how they work. Examples are understanding why the price of gasoline increases when OPEC meets to restrict output and how the spatial distribution of pollution emissions changes when a marketable permit system is established to regulate sulfur emissions.

Normative economics, on the other hand, attempts to use economic tools to design government policies to intervene in the marketplace. Inevitably the question arises as to the "best" way of intervening in the marketplace. Clearly, this requires a way of defining what is best—a much more value-laden process than merely explaining why the economy works as it does. Normative and positive examples from climate change are explored in some detail in Chapter 2.

Unfortunately, when working with environmental problems it is not possible to restrict attention solely to positive economics. Fundamental to environmental economics is the notion of market failure. Repairing that market failure typically requires government intervention. What kind of government intervention? That is a normative question. And that is often the question that environmental economists are asked to help answer. In developing the normative theory of regulation to correct market failure or the public provision of nonmarket goods, we will try to make clear when value judgments enter the process of policy formulation. The practicing environmental economist should always be aware of the problems of venturing into the territory of normative analysis. This is one reason we turn in Chapter 3 to the question of social choice—the process of making societal decisions.

C. Environmental Economics and Economics

Economics is a well-developed discipline with an extensive body of theory, a paradigm associated with how the economic world works, strong empirical tools, and a number of branches, or fields of study, associated with pieces of the economy.

The fundamental building blocks of economics are contained in microeconomics—the theory of the consumer, the theory of the firm, and the theory of market interaction. This forms the basis for nearly all of economics. Related to microeconomics is the branch of statistics applied to economic phenomena—econometrics. Microeconomics permeates all of economics and econometrics permeates all of applied economics.

Branching out from basic microeconomic theory are the several fundamental fields of economics. These would include macroeconomics (the study of aggregate as opposed to individual phenomena), public finance (the study of goods not provided by the market and the study of taxation), industrial organization (the in-depth study of how firms interact with each other and with consumers and organize themselves into industries), and international trade (concerned with how distinct and independent economies interact). Each of these major fields is concerned with major portions of economic activity and each has unique contributions to make to the overall study of economics.

There are a number of applied fields of economics that draw on all of the basic fields as well as microeconomics. These would include labor economics, health economics, monetary economics, experimental economics, development economics, international finance, law and economics, and environmental economics. Each of these applied fields draws heavily on microeconomics and the basic fields of economics. For the most part, each of these fields has contributed in some way to understanding economics outside of its own narrow set of interests. For instance, labor economics has been the source for many innovations in econometrics that have found application across economics. The primary contribution of environmental economics has been in the area of nonmarket valuation, i.e., methods for measuring demand curves for goods when there is no market (or, equivalently, measuring the willingness to pay or willingness to accept compensation for nonmarginal changes in environmental quality). Other important components of environmental economics involve adapting tools developed in other parts of economics to questions regarding the environment.

The categorization above is by no means unequivocal. I would expect many economists in one or another of the fields mentioned above to dispute how their field has been categorized and placed in relation to other fields. To an extent they would be right: there are many different ways of summarizing the different fields of economics. The point that is being made is that environmental economics is an applied field, like many other applied fields in economics. Much of environmental economics involves adapting concepts developed in other branches of economics (particularly public finance and industrial organization) and applying them to environmental problems. Some aspects of environmental economics are unique to the field (such as valuation, mentioned above) and have potential use in economics outside of the environmental economics field.

D. Environmental Economics and Ecological Economics

This book is concerned with environmental economics. There is another field of study that largely has grown out of systems ecology called "ecological economics." These two

fields take quite different perspectives, but are ultimately concerned with helping make social decisions about environmental problems. Unfortunately, in many non-English speaking countries the distinction between the two fields is lost in the translation because of the similarities between the words "environmental" and "ecological."

A simple distinction between the two fields arises from the fact that environmental economics tends to involve economists who have extended their discipline and paradigm to consider the environment, whereas ecological economics tends to involve ecologists who have extended their discipline and paradigm to consider humans and the economy. Another distinction between the fields is that ecological economics is very multidisciplinary. In contrast to environmental economics, which is a branch of economics, ecological economics welcomes and embraces practitioners from a wide variety of fields who wish to study the environment–society interface. But this is history; the appropriate question to ask is how do the two fields approach environmental problems and how do they differ?

Ecological economics (as well as conventional economics) is difficult to succinctly define. One of the leading ecological economists defines the subject as a "field of study that addresses the relationships between ecosystems and economic systems in the broadest sense."[2] The emphasis is on the very long-term health of the ecosystem, broadly defined (i.e., with humans as part of it). In a 2007 invited lecture to the European Society of Ecological Economics, Malte Faber argues that an interest in "nature, justice and time constitutes the defining characteristic of ecological economist."[3] He argues that the economy must be considered a part of nature, that doing what is just must be a central tenet of the field, and that the issue of time is oversimplified in conventional economics.

It follows that ecological economics tends to be normative, indicating what society *should* do, rather than positive, describing what society actually does (as discussed earlier). And one major distinction between the two fields is associated with value and thus the way in which social decisions are made that depend on measures of value of the environment. Conventional economists believe that value to society derives from the individual values held by human members of society. Ecological economists take a more biophysical view of value. For instance, some ecological economists measure value in terms of embodied energy content. Thus in comparing a typewriter to a computer, the appropriate question is which took more energy to create? Less energy is better. This is a direct extension of ecological theories that ecosystems operate to minimize the throughput of energy. To these researchers, minimizing the energy content of delivered goods and services should drive public policy. The criticism leveled at this "energy theory of value" by environmental economists is that there are many resources in short supply, including land and skilled people. Reducing the value of a good to the embodied content of any factor is an oversimplification. Environmental economists believe the value of a good stems from its embodied content of multiple scarce factors (including energy) as well as how much value individual people place on the final good. In other words, value cannot be reduced to a simple physical metric.

A recurring theme among some ecological economists (but not all) is the notion that economic growth is undesirable. Further, these practitioners argue that a central tenet of economics is that growth is desirable. To a large extent, this stems from a misunderstanding of growth. Technological progress and education, as well as population growth, have in fact led to economic growth. But it is not inevitable that this growth be at the expense of the environment. Consumption can be of material goods (such as steel or motor vehicles) or it can be of aesthetic goods (such as art or literature).

However, the greatest distinction between the fields emerges when considering environmental problems with very long-time horizons, such as global warming or disposal of nuclear wastes. As some environmental economists will readily admit, economics has a difficult time analyzing problems in which costs and benefits span long time horizons. For instance, storing nuclear wastes can involve potential risks that extend for a quarter of a million years. The benefits of the storage are reaped by the present consumers of nuclear power; the costs, if any, are borne by future generations that must live with the nuclear repositories. The conventional economic approach to this is to add up all of the costs and benefits, whenever they may occur, but to apply a discount factor to reduce the importance of future costs in the sum. Inevitably, this means that what happens a century from now has very little effect on the decisions that are made today. To many people, this is disquieting. Ecological economists have proposed other ways of dealing with the intertemporal decision problem, particularly the notion of sustainability. They argue that we should never undertake any action that is not sustainable in the long run. In the nuclear waste example, they would ask: Can we continue to bury waste forever and ever and be satisfied with the world that results? If the answer is no, then the action is not sustainable. It is not a matter of balancing costs and benefits. There is some intuitive appeal to such a philosophy.

Over the past decade, the lines between environmental economics and ecological economics have become more blurred, at least based on the content of the journal *Ecological Economics*, where environmental economists (as well as ecological economists) regularly publish. As a case in point, the first edition of this textbook cited no articles from the journal, whereas the current edition of this textbook cites several. The distinctions are clearly evolving.

E. Environmental Economics and Resource Economics

Nearly all textbooks combine the treatment of environmental and resource economics. In fact, most graduate programs that have a specialization in the area combine environmental and resource economics into one field. Undoubtedly this is because both concern the natural world. Environmental economics involves questions of excessive production of pollution by the market or insufficient protection of the natural world, due to market failure. Resource economics, on the other hand, is concerned with the production and use of natural resources, both renewable and exhaustible. Renewable resources would include fisheries and forests. Nonrenewables would include minerals and energy as well as natural assets such as the Alps and species of plants and animals.

So we see the distinction between the two areas but we also see the overlap. Typically, environmental economics is concerned with issues of market failure regarding the natural world—for a variety of reasons, markets do not function correctly, and as a consequence there is too much of some things (such as pollution) or too little of other things (such as wild and scenic areas). These problems may be essentially static, where time is not particularly important; in other cases, long time horizons are the essence of the problem. For instance, time is not really an issue in deciding on the right amount of air pollution in an urban area such as London.

Much of resource economics on the other hand is concerned with dynamics. Time is what makes renewable and exhaustible resource questions interesting. If we log a forest slowly enough, the forest can regenerate itself and we can continue logging indefinitely.

How fast we extract an exhaustible resource will determine its scarcity in the future, and thus its price in the future. It is time, rather than the failure of markets to operate properly, that is the essence of this logging example.

There are overlaps between environmental and resource economics. The management of a fishery to deal with overfishing is a good example in which the failure of markets is important (the fact that fishers may freely enter the market) as well as dynamics (growth and regeneration of the fishery is what makes it a renewable resource). Global warming is an example of a pollution problem with a very long time frame. There are other overlaps, primarily in the preservation of natural environments. These issues involve time so they could be relegated to resource economics. On the other hand, damage to natural environments is often the incidental result of economic activity with a different primary purpose. Species loss is usually the result of conversion of habitat to human use.

So we see that many environmental economics problems (but not all) are static, whereas many resource economics problems are dynamic.[4] Most environmental economics problems involve market failure, whereas many resource economics problems (but not all) do not. In other words, there is overlap between the fields. For the most part, in this book we are concerned with environmental problems involving market failure. As such, we cover pollution problems but also discuss the management of fisheries.[5]

II. THE QUALITY OF THE ENVIRONMENT

There are many comprehensive assessments of the state of the world's environment.[6] It is unnecessary to offer another review here. What we would like to do is provide some indication of the breadth of problems that are deemed environmental and to gain an appreciation for what problems are being solved and what problems remain difficult to solve and are likely to be a focus of attention in the coming decades.

Pollution problems are not new to mankind. There are records of the Romans complaining about the "stink of smokey chimneys."[7] Pollution control laws in other parts of Europe date from the Middle Ages. It has always been the case that urban areas have bad pollution problems, primarily because of the large concentrations of people. People are associated with emissions as well as being the reason pollution is damaging. But outside of cities, historically the earth's size has been vast enough to dissipate even the most serious environmental threat. What is new is the magnitude of the problem and the fact that the world is no longer infinite compared to the ability of people to pollute it. In the 1960s and 1970s many people around the world were galvanized into doing something to curb environmental degradation. In most countries, significant movements to protect the environment date from this period.[8] To a very large extent, the enormous size of our current world's population and the high standard of living of portions of the population are responsible for the pressures on the environment. A larger economy generates more pollution, all other things being equal; richer citizens usually demand higher levels of environmental quality. And as long as the world becomes more populated and wealthier, the pressures will only increase. This is not to say environmental problems cannot be solved, only that it will become increasingly difficult to protect the earth's environment.

We focus on four main categories of environmental problems: air pollution, water pollution, toxic emissions, and ecosystem health. This is not to suggest that this is a comprehensive list, just that these are four major categories that encompass many of the major environmental problems faced by man today.

A. Air Pollution

Air pollution is primarily a by-product of energy consumption. Impurities in fuels lead to emissions of sulfur dioxide and particulate matter. It is a basic fact of chemistry that burning carbon-based fuels leads to emissions of oxidized carbon—carbon dioxide, a major greenhouse gas. Because our atmosphere contains significant amounts of nitrogen in addition to oxygen, burning fuels inevitably leads to emissions of nitrogen oxides. Tropo-spheric ozone is not directly emitted from fuel combustion but results chemically from high concentrations of nitrogen oxides (from fuel combustion) and organic vapors (from paint drying and gasoline evaporating, among other things), in the presence of sunshine. It has proved to be very difficult to control ozone in many urban areas of the world.

To a large extent, air pollutants are at their worst in urban areas, due to concentrations of people, both as sources of the pollution (directly or indirectly) and as victims of the pollution. Air pollution can lead to health problems, including sickness as well as physical irritation and reduced human performance. The young and those weakened by other illnesses may be particularly susceptible to the effects of urban air pollutants. Urban air pollution also damages materials (such as buildings), increases the cost of maintenance (such as increased cleaning requirements), and degrades aesthetics (no one likes to live in a brown haze).

At a regional level, air pollutants may damage crops (though some sulfur and carbon pollution can help crops). Acid deposition is a regional problem in many parts of the world. Deposition of sulfur and nitrogen-based acids can harm forest and aquatic ecosystems. Regional haze from nitrogen and sulfur pollutants is also a problem in areas with less rainfall. Carbon dioxide is a global pollutant in that overall levels in the earth's atmosphere lead to increases in the heat-trapping capacity of the atmosphere, which leads to global warming. Controlling the precursors of climate change is the subject of intense current international debate.

Some urban air pollutants have been curbed with some success, though not without cost and not in all parts of the world. Sulfur dioxide emissions in Western Europe, North America, and the rest of the developed world have been the subject of significant control over the past two decades. Aggregate emissions appear to have peaked and are now declining. Table 1.1 shows a twenty-five-year time series for three pollutants for three countries, one in transition from poor to middle-income (China), one rich (Japan), and one in between (Iran). Note the dissimilarity among the three pollutants represented. Carbon dioxide emissions, which lead to global warming, have been increasing over the period and are higher in wealthier countries. Sulfur dioxide is almost the opposite. In fact, sulfur dioxide seems to be particularly troubling for the middle-income country, Iran. With money (income), the problem can be solved, as the Japan data demonstrate. Suspended particulates (soot) are worse in lower income countries and tend to be less of a problem as income levels rise. The story Table 1.1 tells is that not all air pollutants are the same; nor are the same pollutants always the most problematic across countries.