

Kneese
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Editors

**HANDBOOK OF
NATURAL RESOURCE
AND ENERGY
ECONOMICS**

VOLUME II

HANDBOOK OF NATURAL RESOURCE AND ENERGY ECONOMICS

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HANDBOOKS IN ECONOMICS

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KENNETH J. ARROW
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**HANDBOOK OF NATURAL RESOURCE
AND ENERGY ECONOMICS
VOLUME I**

INTRODUCTION TO THE SERIES

The aim of the *Handbooks in Economics* series is to produce Handbooks for various branches of economics, each of which is a definitive source, reference, and teaching supplement for use by professional researchers and advanced graduate students. Each Handbook provides self-contained surveys of the current state of a branch of economics in the form of chapters prepared by leading specialists on various aspects of this branch of economics. These surveys summarize not only received results but also newer developments, from recent journal articles and discussion papers. Some original material is also included, but the main goal is to provide comprehensive and accessible surveys. The Handbooks are intended to provide not only useful reference volumes for professional collections but also possible supplementary readings for advanced courses for graduate students in economics.

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PREFACE TO THE HANDBOOK

Natural resources have been studied by economists from the earliest days of the profession. They have been seen as providing a basis for national prosperity, power, and wealth. The ability to harness energy in new ways has been recognized as a major, if not the major, factor underlying the industrial revolution. Because forests, fisheries, and agricultural land are fundamental to food supplies, these resources have been long studied.

Yet only relatively recently have there been developed broad theories specific to the fields of natural resources and energy economics. Previously, examination of these fields relied upon the general economic theories being utilized for analysis of other commodities. More recently, however, it has been recognized by economists that certain special characteristics of natural resources have required theories which explicitly accounted for these characteristics.

Agricultural land, forest, and fisheries have been seen only in the last generation to be usefully described as renewable resources. Such resources are self-renewing at a limited rate which may itself depend upon the size of the stock in existence at any given time and upon the extent and nature of human intervention into the stock dynamics.

Minerals and many energy commodities are now seen as depletable or nonrenewable resources. These are resources for which only a limited concentrated stock exists for allocation over all time. For these resources, a central issue involves *when* they should be extracted, since a decision to utilize a given portion of the stock at one moment of time precludes the opportunity of using that portion at another time.

Even more recently have the environmental resources—air, water, open space—been also seen as renewable or even in some cases depletable resources. The image of environmental resources, fisheries, and wild animal stocks as common property resources owned by everyone and hence by no one is also of relatively recent development. And even more recently, economists have systematically incorporated concepts of materials balance into theories of the flow of physical materials from the natural environment, through the economy, and back into the natural environment.

And it has been only since the early 1970s that energy resources have been given particular attention as a matter for theorizing, empirical testing, and policy-making.

Thus, there now exists a set of concepts which unite the field of natural resource economics. While these concepts are also finding application in other branches of economics, their formalization has been motivated by the need to better understand natural resource issues.

Also uniting the study of natural resource issues is the growing realization that most important energy and natural resource issue are inherently interdisciplinary. The interdisciplinary nature requires applied work to integrate information from some combination of physics, engineering, chemistry, biology, ecology, political science, and law.

To a lesser extent the current theories also reflect this interdisciplinary reality. Materials balance concepts from physics are now fundamental to economic theories of the environment. Population dynamics concepts from biology and ecology are intertwined with economic concepts in renewable resources theories. Thermodynamic concepts and concepts of energy conservation are fundamental to theoretical work on energy economics. Legal concepts of property rights and ownership greatly influence analysis of environmental economics.

The study of resource economics has thus required and motivated researchers to reach out beyond their own disciplines and to integrate ideas from other fields into their own disciplines. Presumably this integration will influence not only resource economics but also other areas within economics.

The three volume comprising the *Handbook of Natural Resource and Energy Economics* examine the current theory and sample current application methods for natural resource and energy economics. Volumes I and II deal with the economics of environmental and renewable resources. Volume III, which is still in preparation and whose outline is included in this volume, will deal with the economics of energy and minerals.

Volumes I and II are divided into six parts. Part 1, which deals with basic concepts, consists of five chapters. The first chapter discusses environmental issues and welfare economics. Among the more penetrating developments in the short history of environmental economics is a wedding of the concepts of economic general equilibrium, materials balance, and common property resources into a single unified theory. This model offers a systematic explanation of the occurrence of pollution-type environmental problems and an opportunity to explore the welfare economics of suggested remedies. In Chapter 1, Karl-Göran Mäler uses a version of this model to provide a general theoretical framework for the field of environmental economics.

Chapter 2 attests to the interdisciplinary character of both environmental and renewable resource economics. In it James Wilen explains the bioeconomic models pertinent to these fields. The response of biological systems both to insults

and to management actions is a central concern in many natural resource problems. Often, models simulating these responses are an integral part of the economic analysis of such problems.

In much of economics the spatial relationships among economic activities can be safely ignored. In environmental economics these relationships can rarely be ignored. Environmental effects of human action occur in and through space; neglect of this fact can lead to serious error. Space is involved in such matters as the degradation of residuals in the environment, the effects of airborne residuals on visibility, and the efficiency of alternative environmental policies. Moreover, environmental economics must address problems of interregional and international trade. In Chapter 3, Horst Siebert explores the spatial aspects of environmental economics.

Conservation of natural resources is a long-standing human concern. But in the last two decades there has been active economics research addressing the problems related not to scarcity of resource commodities, but rather to the protection of natural areas. This research has concerned itself with such issues as irreversibility, option values, and asymmetric technological change. In Chapter 4, Anthony Fisher and John Krutilla address these new conservation issues.

The final chapter in Part 1 deals with ethics and environmental economics. The theoretical underpinning of benefit–cost analysis, one of the basic tools of natural resource economics, is welfare economics. Welfare economics, in turn, can be viewed as an enormous elaboration and adaptation of an ethical theory: classical utilitarianism. But there are other valid ethical systems. And these other systems might imply quite different outcomes if applied to natural resources problems. For example, issues such as the long-term storage of nuclear waste and changes in climate resulting from resource use raise ethical issues perhaps more strongly than is usual in economics. These concerns are addressed in Chapter 5 by William Schulze and Allen Kneese.

Part 2 deals with methods and applications of economics to environmental problems. In Chapter 6, A. Myrick Freeman reviews methods for assessing the benefits of environmental programs. One of the most challenging areas of environmental economics, development of methods for estimating benefits of environmental improvements, has also been one of the most active areas of research in recent years. The interest results, in part at least, from increased pressure to demonstrate benefits from the costly environmental improvement and protection programs put into place by governments of industrialized countries in recent years.

Another major area of environmental economics, pursued especially actively in the 1970s, is the application of quantitative (usually linear) economic models to environmental questions. Such models have been applied to analyze effects of alternative policies on residuals generation and on control cost at both the industrial and regional level of detail. For regional analysis transfer functions

which translate emissions at various points into ambient concentration at other receptor points – are often embedded directly into economic models. David James reviews both industrial and regional models and their applications in Chapter 7.

An important class of linear models applied to environmental problems is that of national input–output models. When outfitted with residuals generation coefficients and residuals control options such models can be utilized to analyze indirect, as well as direct, effects on the environment of economic growth, changes in product mix, and alteration of other variables of interest. In Chapter 8, Finn Førsund describes the use of national input–output models, with special application to the economy of Norway.

Part 3 of the Handbook includes two chapters on the economics of environmental policy. Chapter 9, by Gregory Christainsen and Tom Tietenberg, reviews what is known about the distributional and macroeconomic consequences of environmental policy. How, if at all, does environmental policy contribute to inflation or to unemployment? How are the costs and benefits of environmental policy distributed among income groups? This chapter describes methods of addressing such questions and offers a set of conclusions.

Chapter 10, by Peter Bohm and Clifford Russell, provides a comparative analysis of environmental policy instruments. While the idea of effluent fees as a policy instrument flows naturally from abstract economic reasoning, most governments have chosen not to follow economists' advice and have resorted to command and control strategies. Also advocated by some economists, and partially implemented, are tradeable permits to emit residuals. Deposit-and-return systems are also applied to some environmental problems and may have potential for dealing with others. This chapter reviews what the last twenty years of economic research have shown about the strength and weaknesses of these various approaches.

Part 4 deals with uses of renewable resources other than simply as recipients of residuals. Water resource development and use has probably received more attention from economists than any other natural resources subject except agriculture. There are at least three reasons for this attention. Because federal water resources agencies have long practiced benefit–cost analysis in the evaluation of water resources, there has been much opportunity for economists to develop and use theoretical concepts, methods, and data for such evaluations. Second, the development of river systems for multiple purposes has provided interesting opportunities for the application of systems analysis, that close relative of microeconomics. Third, market processes have played some role in the allocation of scarce western water. Chapter 11, by Robert Young and Robert Haveman, reviews economic and institutional aspects of water development.

The remaining two chapters in this part, Chapter 12 by Michael Bowes and John Krutilla, and Chapter 13 by Alan Randall and Emery Castle, deal with land

use, although not in the traditional manner as a factor of production in agriculture or yielder of a single product, wood, in forestry.

Chapter 12 deals with the management of wildlands. Recognizing that wildlands yield not only timber but also recreational and aesthetic values, this chapter integrates theory derived from the forestry literature with that from the multipurpose firm literature. Chapter 13 also departs from the conventional view of land, using an asset pricing model to analyze land markets. The chapter includes an in-depth study of rent determination, examining influences of macroeconomic changes and of growing alternative demand for land on land prices, and in turn examines the reaction of land prices to increasing rents. The chapter also explores implications for land use planning and regulation and examines the role of land in the evolution of economic thinking.

Part 5 deals with the economics of renewable resource goods or services provision. Chapter 14, by Anthony Scott and Gordon Munro, treats commercial fishery economics. Commercial fishing has fascinated natural resources economists because this activity uses a common property resource as an essential input. The common property nature of the resource in a free market leads to decisions which produce economic inefficiency. Free access can lead to excessive depletion of the resource and to excess investment, both phenomena eliminating any net economic returns that would, under optimal management, be available from this resource. The chapter reviews these issues and spells out implications for public policy and international cooperation.

Chapter 15, the final one in this part, by Kenneth McConnell, treats the economics of outdoor recreation. It surveys conceptual and empirical approaches, problems, and solutions encountered in applying economics to the provision of natural resources for recreational purposes. It also shows how the evolution of the economics of outdoor recreation was influenced by the distinctive nature of markets for outdoor recreation.

Part 6 concludes Volumes I and II with two case studies dealing with environment and renewable resources in socialist systems. The first, by Marshall Goldman, focuses upon the Soviet Union, and the second, dealing with China, is by Shigeto Tsuru.

Since in socialist states all means of production are owned by the state, a superficial view might suggest that all externalities would be internalized and that, therefore, there would be no incentive to generate excessive residuals or overuse renewable resources. Goldman, in his study, shows that for the Soviet Union this impression is very far from the truth. He argues that the incentives for abusing resources are at least as large as in market economies and, possibly, much larger. Tsuru's study of China suggests that the situation may be somewhat different there. China is a developing economy and resources for environmental protection are accordingly limited. There is, however, explicit recognition of the environmen-

tal problem, and there is a public policy aimed at the comprehensive recycling of wastes. Presumably, this recycling is motivated by the scarcity of resource inputs as well as by a desire for control of residuals.

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