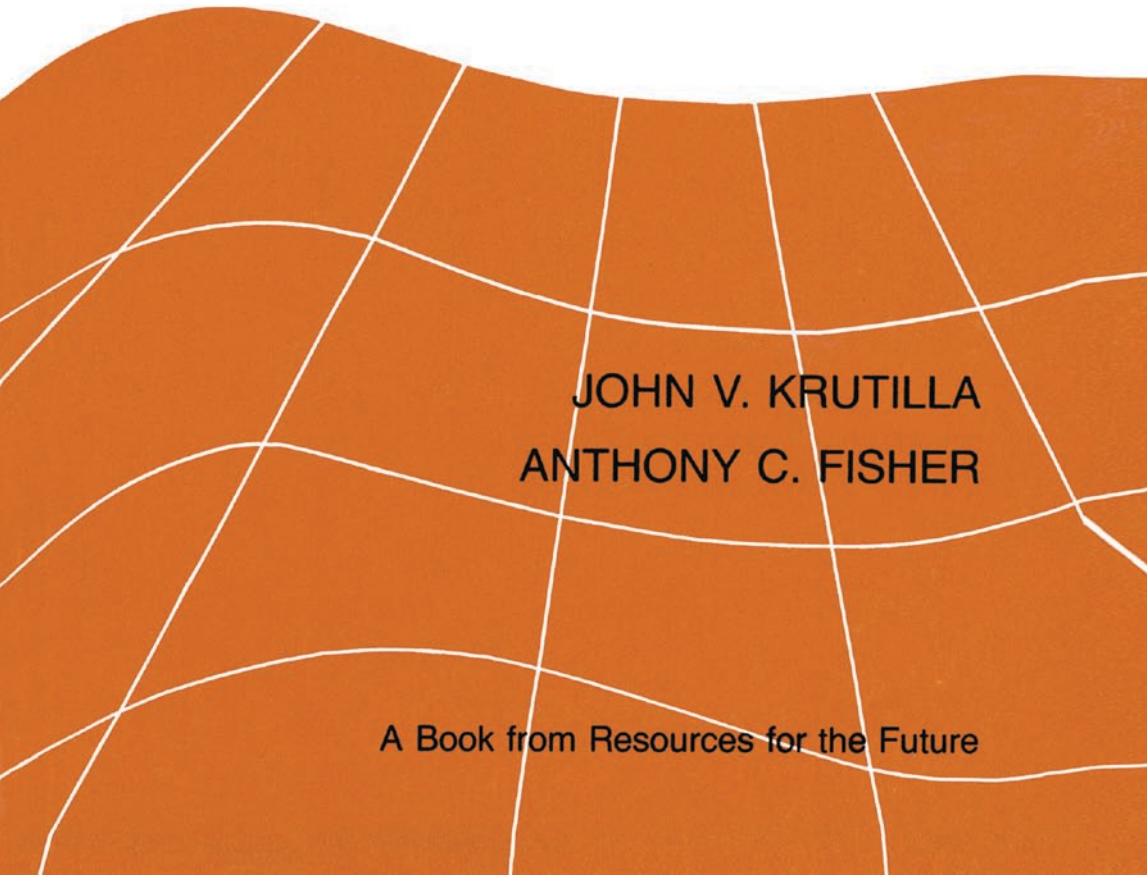
The Economics of Natural Environments

Studies in the Valuation of Commodity and Amenity Resources



JOHN V. KRUTILLA
ANTHONY C. FISHER

A Book from Resources for the Future

THE ECONOMICS OF NATURAL ENVIRONMENTS

JOHN V. KRUTILLA

ANTHONY C. FISHER

The Economics of Natural Environments

STUDIES IN THE VALUATION OF COMMODITY AND AMENITY RESOURCES

RESOURCES FOR THE FUTURE

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RESOURCES FOR THE FUTURE

Resources for the Future (RFF) is an independent nonprofit organization that advances research and public education in the development, conservation, and use of natural resources and in the quality of the environment. Established in 1952 with the cooperation of the Ford Foundation, it is supported by an endowment and by grants from foundations, government agencies, and corporations. Grants are accepted on the condition that RFF is solely responsible for the conduct of its research and the dissemination of its work to the public. The organization does not perform proprietary research.

RFF research is primarily social scientific, especially economic. It is concerned with the relationship of people to the natural environmental resources of land, water, and air; with the products and services derived from these basic resources; and with the effects of production and consumption on environmental quality and on human health and well-being. Grouped into four units—the Energy and Natural Resources Division, the Quality of the Environment Division, the National Center for Food and Agricultural Policy, and the Center for Risk Management—staff members pursue a wide variety of interests, including forest economics, natural gas policy, multiple use of public lands, mineral economics, air and water pollution, energy and national security, hazardous wastes, the economics of outer space, and climate resources. Resident staff members conduct most of the organization's work; a few others carry out research elsewhere under grants from RFF.

Resources for the Future takes responsibility for the selection of subjects for study and for the appointment of fellows, as well as for their freedom of inquiry. The views of RFF staff members and the interpretations and conclusions of RFF publications should not be attributed to Resources for the Future, its directors, or its officers. As an organization, RFF does not take positions on laws, policies, or events, nor does it lobby.

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PREFACE

This volume represents a synthesis of selected work undertaken in the Natural Environments Program at Resources for the Future. It addresses the valuation, allocation, and management of the resources—commercial and otherwise—of natural environments. In particular it seeks to engage the range of amenity resources that, while long recognized in public policies providing, for example, for National Parks, Wildlife Refuges, and Wilderness Areas, have not been explicitly included in economic analyses. In this respect then, the present work represents a "first generation" effort to incorporate the noncommercial, or amenity, resources of natural environments into the body of economic theory and application. At the same time, the analysis of the more conventional, commercial uses of natural environments has been extended to deal with such important issues as how progress in thermal electric power technology will affect the valuation of a site for hydroelectric power production.

An institutional point worth noting here is that observations and remarks in the text generally apply to the management of public lands in the United States. This is because, as suggested by the empirical cases considered in chapters 5 through 10, most of the remaining natural and scenic areas of any great extent, and related resources, are in fact found on the public lands. It hardly needs to be added that most theorems about resource valuation and allocation are not dependent on the ownership status—public or private—of the resource in question, so that most of our results apply to the socially efficient use of any substantial wilderness area currently in private ownership as well.

As an early effort, this volume doubtless raises more issues than it is capable of resolving satisfactorily. Nevertheless, since the value of the resources it addresses is of considerable magnitude, it is hoped that the effort will stimulate others to a wider and more intensive application of analytical inclinations and talent. With this in mind, both theoretical and practical issues are raised and addressed in this volume. The theoretical apparatus has been presented and advanced as far as our capabilities permitted in the time available. There is, nonetheless, much theoretical work

remaining to be done. We have not on that account, however, avoided confronting urgent practical problems of national significance in the applied portions of the study. As a matter of fact, there is scarcely an applied study in any scientific area to which some theoretical objection cannot be interposed at some level. Specific objections to some of our operational procedures are therefore to be anticipated, but should be regarded more as within the tradition of applied analysis than as an exception to it. Moreover, the approaches adopted in these studies, although within the format laid out in the theoretical sections, and drawing on the theory to organize and interpret the available data to the extent permissible, do represent in most instances the type of analysis that might be expected of conscientious resource managers addressing a real and significant resource allocation issue in a relevant time context.

None of the foregoing is to be interpreted as suggesting that the most sophisticated analytical techniques that may ultimately prove useful in problems of this sort are presented in this volume. The authors are the first to concede that much remains to be done on a much wider scale than permitted within the short period and limited resources available thus far. But while we await the desirable advances in methodology and standardization of practices and conventions in applied analysis, we present this volume as a recommended point of departure for site evaluations when the issue of allocating natural environments among incompatible uses needs to be faced.

One other point, and a very important one, deserves mention here. Doubtless it will occur to some, on the basis of certain themes that run through the book, that we have a point of view. This is quite correct. As was stated earlier, our purpose has been to bring the amenity resources of natural environments into an analytical valuation framework comparable to that for the extractive resources. We have sought to do this by applying tools and concepts of conventional economic theory in somewhat unconventional situations. A relevant special feature of a situation, for example, the irreproducibility of amenity resources, is first introduced and explored in detail. It is then set in an appropriate management decision framework and its implications for efficient use of the environment are derived. The empirical studies are loosely tied to the theory in that the theory indicates what data are relevant and how they are to be processed and interpreted.

Where considerations involving amenity resources are put forward with unusual emphasis, the reason is not that we are advocates for one side or the other in a debate over the use of a particular environment. Rather, we are trying to compensate for a history of analytical neglect. In fact, we could turn the argument around and observe that only by proceeding as we have to build the unconventional special features of natural environ-

ments into our economic models can we as economists hope to contribute to the policy debate.

It is hoped that the volume will prove useful to resource managers and related administrative personnel in the field. Indeed, it is intended to be of utility to decision makers since several of the empirical studies have been prepared specifically in response to requests from public officials for assistance in presenting analyses of relative benefits of alternative uses of natural environments. At the same time it is hoped that the format, the level of both theoretical and empirical inquiry, and the relevance of the issues addressed will commend themselves to economists interested in problems of natural and environmental resource use, benefit–cost analysis, and price and welfare theory generally, and to graduate students and upper division undergraduates in these areas. We want to emphasize the accessibility of virtually all of the material presented here to students, including undergraduates. In a few places material is indented to indicate that the discussion becomes more technical. This material may be quickly skimmed, or even skipped without interrupting the flow of the discussion.

John Krutilla is responsible for the outline and general content of the volume, and is primarily responsible for chapters 1, 2, 5, 6, 7, 10, and 11. Anthony Fisher is primarily responsible for chapters 3, 4, 8, and 9. Finally, each has reviewed and participated in the revision of the parts of the manuscript for which the other has been primarily responsible.

Resources for the Future — J. V. K.
January 1975 — A. C. F.

PREFACE TO THE SECOND EDITION

The objectives that motivated the first edition of this volume were first of all to show how economic analysis can be used to address certain vital issues in an area that had been notably neglected by economics; and second, in doing so, to introduce relevant economic information into the debate over how the issues should be resolved. The effort, we believe, has been largely successful. Although all of the issues that were addressed in the first edition have by now been resolved, the tack taken in some cases was sufficiently novel and approach to the problems sufficiently distinctive to continue to serve students in natural resources and environmental economics courses. With a new printing required to keep the volume in print, we felt certain things should be done to bring the volume up to date. Hence, this revised edition.

One matter deals with the theoretical developments that have occurred over the many years since the Arrow-Fisher paper on environmental preservation, uncertainty, and irreversibility—on which chapter 4 of the first edition was partially based—was originally published. Thus, section 3 of chapter 4 has been completely reworked to include these developments.

Another area demanding attention, as suggested by calls from teaching faculty, was: "So what happened next?—The students want to know." This is understandable, given the celebrated set of cases we worked with. It, therefore, seemed a good idea to summarize briefly the outcomes. This we have done in an afterword.

Another reason for providing such a summary is to underscore the fact that a set of studies which meets the standards for use in academic curricula, ought not to be dismissed out of hand as "ivory tower" by program officers who have lost the inclination to read. We are convinced that high quality analysis can also affect the outcome of policy debate. Indeed, it is the only kind that should.

April 1985

J.V.K.
A.C.F.

ACKNOWLEDGMENTS

The research reported in this volume has been undertaken over several years by members of the Natural Environments Program staff of Resources for the Future. We should first of all like to acknowledge with appreciation the general contribution of our former colleagues, Charles J. Cicchetti and V. Kerry Smith, which goes quite beyond the reference in the text to specific debts of gratitude associated with the writing of this volume. Charles Cicchetti also reviewed chapter 10, which is based on his *Alaskan Oil: Alternative Routes and Markets*. Similarly, chapter 9 has been reviewed by Judd Hammack, co-author with Gardner Brown of the study, *Waterfowl and Wetlands: Toward Bioeconomic Analysis,* on which it is based.

A first draft of the manuscript was reviewed by our program colleagues Talbot Page and Kerry Smith, and by Mancur Olson, Anthony Scott, and Vernon Smith. We are most grateful for their perceptive comments and constructive suggestions on both matters of substance and style. We are also grateful to Henry Jarrett and Irving Fox for their valuable comments on a later version of the study. A debt of gratitude is also due Adrian Gilbert and John Butt of the U.S. Forest Service for careful review and detailed comments, particularly regarding chapter 8, which deals with the Mineral King Valley project.

Many individuals have contributed in one way or another to the material presented in the separate chapters. We are indebted to Marion Clawson for a review of chapter 1, and to him and Robert Dorfman for suggestions concerning revision of the content of chapter 2, appearing in *The Governance of Common Property Resources,* edited by Edwin Haefele.

Chapters 3 and 4, as indicated by a number of references, owe much to the work of Kenneth Arrow. Beyond this, the treatment of uncertainty and information is based on collaboration between Arrow and Anthony Fisher. Helpful suggestions by John Brown and Harl Ryder regarding the formulation and solution of the optimal control problem are gratefully acknowledged, as are editorial suggestions by George Borts on an earlier version of some of this material, published in the *American Economic Review.*

The discussion of the intergenerational problem in chapter 4 has been importantly affected by the ongoing work of Talbot Page.

Chapters 5 and 6, the Hells Canyon studies, have benefited from many constructive suggestions by Darwin Nelson, Arnold Quint, and Donald Sander of the Federal Power Commission, and from students and staff of the Natural Resources Institute held at Oregon State University during the summer of 1969. We are also grateful for input to the study by Charles Cicchetti and Clifford Russell, and for comments on drafts of an earlier version by Gardner Brown, Ronald Cummings, Myrick Freeman, and Richard Judy.

Chapter 7 was undertaken in part using information supplied by members of the staff of Region 4 of the U.S. Forest Service. Particular mention needs to be made of the assistance of Fred Wagstaff, regional economist of the U.S. Forest Service, Ogden, in preparing a report with John Krutilla from which this chapter is abstracted. We are also indebted to Don T. Nebeker, study coordinator, White Cloud–Boulder–Pioneer Mountain Area investigations for making numerous arrangements to obtain data and for access to study reports. Acknowledgment of assistance is also due Frank Gunnell, wildlife biologist, U.S. Forest Service; and to William Mellick, Clayton District, and Dan Pence, Clayton District ranger, for much assistance in connection with data and analysis of grazing on the district. To Richard Carter, White Cloud patrolman, we are indebted for testing impressions gained in the field, particularly in connection with estimates of recreational carrying capacity and to Ed Schlatterer, ecologist, U.S. Forest Service, for information regarding ecological carrying capacity in connection with recreational uses. Robert Williams was very helpful, along with Delworth Gardner and Darwin Nielson of Utah State University in assisting with the unit value of grazing permits. To Kenji Shiozawa, staff assistant for landscape architecture and perhaps others in the field of recreation planning at the Ogden office of the Forest Service, we are most grateful for the information on trails, developmental and maintenance costs, and related information on recreational facilities. Acknowledgment is also due Les Pengelly, of the Department of Wildlife Management, School of Forestry, University of Montana, and to Keith Whiting of the American Smelting and Refining Company for information supplied in connection with the study.

Additionally we are indebted to John Merriam, Idaho State University, for a "guided packtrip for John Krutilla through the White Cloud Mountains, and for much on-the-spot information regarding local conditions, as well as for a careful review of an earlier draft of this study. A very special debt of gratitude is due Kerry Smith and Charles Cicchetti for their contribution in adapting for application to the White Cloud Peaks, models developed for their study of the Spanish Peaks Primitive Area.

Chapter 8, as noted in the text, draws on a study by Charles Cicchetti, Kerry Smith, and Anthony Fisher. Comments and suggestions by Anthony Scott and Joseph Seneca on a draft of the study are gratefully acknowledged. Generous assistance in obtaining and interpreting the data on the use of California ski sites, and much information about Mineral King, has been provided by Craig Stanley, and through Stanley, by the U.S. Forest Service, in particular Pete Wyckoff. Programming assistance has been provided by Joseph Tu.

Chapters 9 and 10, as noted above, represent our condensed versions of work done by others (Charles Cicchetti, Gardner Brown, and Judd Hammack) in the Natural Environments Program at RFF, and graciously made available to us for inclusion here.

In revising and editing this volume, it has been our good fortune to work with Ruth Haas of the RFF editorial staff. Although her contributions are too many and varied to list here, much of the credit for the readability of the final product is due to her.

The list of those to whom acknowledgment is due grows long, but it cannot be terminated without reflecting our appreciation for the even-tempered toleration, patience, and perseverance of Rita Gromacki in typing and retyping the manuscript.

Needless to say, while assistance has been rendered by many individuals and organizations, the responsibility for the material included, analysis, and conclusions remain solely with the authors.

Resources for the Future
December 1974

John V. Krutilla
Anthony C. Fisher

PART I

INSTITUTIONAL AND THEORETICAL CONSIDERATIONS

CHAPTER 1

MANAGING NATURAL ENVIRONMENTS

1. INTRODUCTION

There are many dimensions to environmental quality and, thus, many dimensions to the threats to this quality. These may range from minor local disturbances causing physical or psychic discomfort, to large-scale ecological upsets that may affect the length of time man can occupy the earth (Brubaker, 1972). In this study we address issues that cover the entire range of environmental threats.

The theoretical portions of this book are devoted to an abstract, and therefore widely applicable, treatment of the side effects, or externalities, associated with human economic behavior. These range from minor spill-overs that impinge on the amenities of life, to major results of irreversible decisions. The problems taken up in the applied studies, while specific, are important in the models they offer for dealing with environmental considerations that have mostly been neglected in the decision-making process. That is, our empirical work is concerned with the valuation of the opportunity costs of economic activities that can be expressed as loss of amenities otherwise available from a natural environment. It consists of explorations in the relative valuation of amenity and commodity resources.

While the empirical portion of the study does not deal with the gravest environmental threats, it should not be inferred that the problems addressed are of minor significance or little economic consequence. Indeed, the aesthetic dimensions of the environment have been of such profound and persevering concern to the American people that they have occupied an important position in conservation and environmental legislation and policy. It is interesting to note, for example, that the Wild and Scenic Rivers Act preceded the National Environmental Policy Act (NEPA) by a year and the Wilderness Act by several years. In a decade that witnessed the commissioning of a national outdoor recreation resources review, we also saw passage of the Classification and Multiple Use Act of 1964, which required the Department of the Interior to recognize the

amenity aspects of the environment in its management of the public domain. In addition, there was the Multiple Use and Sustained Yield Act of 1960, which required that the amenity services of the national forests be recognized equally with more conventional forest products as valuable and deserving of managerial attention.

The passage of this legislation, which expresses the importance of amenities in the public mind, does not mean that there is no concern for the graver environmental insults. The Federal Water Pollution Control Act and the Clean Air Act obviously reflect a concern about health as well as the aesthetic dimensions of the environment. But it may not be amiss to note that public action taken to preserve the amenities of Yellowstone National Park, for example, predates the establishment of the Food and Drug Administration. America's pioneering role in establishing national parks, a wilderness preservation system, and wildlife refuges, and similar evidences of concern for preserving natural environments attest to the status of these values in the American psyche.

Much of the new legislation seeks to achieve amenity-oriented environmental goals through changes in practices and policies in management of the public lands, and regulation of the nation's use of streams and other bodies of water in which the federal government has a paramount interest. Now, while these policies may be limited largely to actions taken in connection with public lands and waters under federal control, the impact of the new legislation is nonetheless very extensive because of the vast extent of the public lands and the resources represented by them.

In summary, this study seeks to develop and apply some of the theoretical concepts and measurement techniques relevant to the valuation of natural environments. Although the analytical propositions about socially efficient resource use clearly have applications to privately owned natural environments, most of the remaining natural areas of any great extent in the United States appear on the public lands. This chapter is mainly devoted to exploring the association between natural environments and public lands, with particular attention to the problems posed for public land management (and incidentally for research as well).

2. THE PUBLIC LANDS AND COMMODITY AND AMENITY RESOURCES IN THE UNITED STATES

While the United States stands in the forefront among economies that are oriented toward private enterprise and the vestment of property rights in private parties, the federal government simultaneously has vast holdings of public lands and related resources. Indeed, after the Soviet Union, China, and possibly Canada, the U.S. Bureau of Land Management and the U.S. Forest Service administer perhaps the fourth and fifth largest

land holdings in the world. The combined holdings of the two agencies amount to about 650 million acres. This is roughly comparable in area to the eastern European socialist states and equal, similarly, to the combined area of the Common Market countries of western Europe, excluding the United Kingdom. In short, these agencies would rank near the top of the world's largest public enterprises. However, although these lands are publicly owned, their use is often designed to meet the demands of private parties.

A substantial portion of the government-owned land consists of public lands in Alaska, where the settlement of claims in connection with the transition from territorial status to statehood has not yet been completed. Even excepting Alaska, however, the public lands in the coterminous United States represent about a fifth of the total land area, and among some of the western states, where the bulk of the public lands are concentrated, the share is more than half.

While the amount of the land held by the public is relatively large, the share of the total land and land-related resource value may not be proportionate. More precisely, the distribution of resources among these lands differs in character from that among lands in general. Much of the land administered by the Bureau of Land Management is located in the arid West and represents, along with the bulk of the federally owned lands in the Rocky Mountains, Cascades, and Sierra Nevadas, land not suitable for agriculture. Indeed, much of the land remaining in the public domain escaped appropriation by private parties under the Homestead Act and similar land disposal programs because of its unsuitability for agriculture. While National Forest lands are much less the result of neglected private appropriation, having been explicitly reserved under numerous acts of legislation over the years (beginning with the 1891 Act), it is nonetheless true that much if not most of the best timber areas are to be found among the private lands outside the national forests. Many vast areas within the national forests, because of elevation and terrain, in fact do not support stands of merchantable timber. In spite of their immense extent, the public lands thus fall far short of supporting potential silvicultural and agricultural activities at anything approaching the levels that might be obtained from equivalent acreage in private holdings.

The public lands that are the most inhospitable to agriculture and silviculture in many instances are lands valued for their desert or mountain scenery and the wildlife and fish that they support. They may, however, also contain mineral deposits, sites for hydroelectric and other water development, and related extractive industries. It is here that we often find a conflict between exploitation of commodity resources and use of the areas for their recreational amenities.

In recognition of the amenities that natural and scenic environments

provide, the U.S. Congress has over the years reserved nearly 50 million acres to establish national parks (26.6 million acres) and the National Wildlife Refuge System (23.3 million acres). Approximately half of this total, however, consists of the vast Arctic National Wildlife Range of about 9 million acres in the northeast corner of Alaska along with another 9 million in 17 other Alaskan refuges, and the land associated with McKinley National Park. The bulk of the remaining 24 million acres are distributed among the various national parks and wildlife refuges in the coterminous United States.[1] Along with the refuge system and the national parks, the Wilderness System (11 million acres), established pursuant to the Wilderness Act of 1964, represents a "primary purpose" category of land with Congressional intent to exclude uses not compatible with nature preservation and recreation. In addition, but representing a much smaller area in the aggregate are Wild and Scenic Rivers, National Recreation Areas, National Trails, Scenic, Geological, and Research Areas, among the more specialized primary purpose areas.

No specific primary purpose has been designated for the remaining federally owned lands administered by the Bureau of Land Management and the Forest Service.

3. A CRITIQUE OF EXISTING APPROACHES TO PUBLIC LAND MANAGEMENT

The Public Land Law Review Commission, established in 1964 to help resolve the conflicting demands being made on the public lands, after a comprehensive examination of their resources, and the present and potential uses of the lands, had the following to report:

> Although Congress has established goals in the statutes setting aside and providing for the administration of national parks, wilderness areas, and wildlife refuges, it has not provided adequate goals for lands not having a clearly defined primary purpose. It is on these lands, primarily those managed by the Forest Service and the Bureau of Land Management, that the absence of goals has led to major problems. (1970, p. 42)

It is most likely not the "absence of goals" that represents the problem here but rather the absence of a method of evaluating the relative worth of alternative goals, or combinations of goals, to which a given river or tract of wild land can be dedicated.

Since the Wilderness Act requires, among other things, that all roadless areas of 5,000 acres or more on select public lands be reviewed for possible inclusion in the Wilderness Preservation System, the problem of estimating the relative value of such areas when dedicated to alternative pur-

[1] There is also an inconsequential part of this total (220,000 acres) in Hawaii.

poses is quite important. Moreover, a related problem arises in connection with any adequate environmental impact statement (EIS) required under NEPA for any action on the public lands, among others, resulting in a significant modification of the environment.

The problems of multiple uses of an area, particularly where such uses are mutually incompatible, or where one use may be irreparably destructive for another, have been frequently underscored by the controversies, both in the political arena and in the courts, from the time of Hetch Hetchy to the more recent legal maneuvers over the Trans-Alaska pipeline. In recent years, under provisions of NEPA, conservation organizations such as the Sierra Club and the Wilderness Society, among others, have compelled the land management agencies to detail the environmental impacts of their decisions in a manner wholly unanticipated a few years ago. The basis of the challenges has been that many of the unique values of the public lands—the visual or aesthetic character of landscapes, the freedom to float an untrammeled river or enjoy the seclusion of wild places—are not properly safeguarded by the decisions of field level public land managers. This does not necessarily mean that the deficiencies are to be found in the competence of the field level resource manager. The Public Land Law Review Commission makes it clear that while multiple-use authority has been granted by the Congress to the public land management agencies, the guidelines in the statutes have been so ambiguous as to provide no adequate basis for guidance (1970, pp. 44, 48).

The 1960 Multiple Use and Sustained Yield Act for the national forests provides that the relative values of various resources and their uses, and not just the private market values, be taken into account so as to maximize the annual flow of benefits without impairing the basic productivity of the land. The Act is clear that noncommercial as well as commercial values are to be incorporated, and furthermore, that a proper concern for the future—particularly in connection with decisions having irreversible and potentially adverse consequences (impairment of the productivity of land)—be reflected in the actions taken. This legislation, of course, simply reflects the intent of the Congress, and enunciates broad policies. The operational criteria for their implementation, as is inevitably the case, are left to be developed, but somehow seem not to have received the necessary attention.

Similarly in the Classification and Multiple Use Act of 1964, the secretary of the interior was directed to develop criteria to give consideration to all pertinent factors including "ecology, priorities of use and the relative values of the various resources in particular areas." The secretary has published the "criteria," and the Bureau of Land Management has issued instructions to its field personnel. Nonetheless, in the judgment of the Public Land Law Review Commission, which considers the maximization of net social benefits an appropriate objective of public land management,

federal lands are not being administered in a manner consistent with this objective (1970, p. 46).

In addition to the problem of clear criteria for choice in decisions affecting the public lands, the Public Land Law Review Commission has confronted the problem of obtaining data that are relevant to the various choices being made. For example, they note that it is difficult to get information that is truly of value in making many kinds of decisions. They have found it especially difficult to obtain information for use in weighing choices between economic uses of the public land such as timber and forage, and other uses, or protection of environmental values (1970, p. 46).

While the commission's observations are doubtless correct, there appears to run through the report a somewhat naive belief that there are, or ought to be, data which *in general* can be consulted to answer specific questions regarding the relative value of alternative uses of particular tracts of wild land. The problem, however, is not simply one of elusive data. It is rather one of developing adequate and correct procedures of analysis to ensure that welfare maximizing criteria are applied.

There are many facets to the task of expressing the relationship between, say, the value of mineral output from a particular location and the value of recreation in a pristine environment that may be destroyed by such mining activities. For example, how rich is the mineral deposit and how near to developed transport facilities? Or more properly, how much does it cost to mine and refine per unit and thus, what is the net value of the mineral deposit on exploitation? This will vary from one area to another, depending on grades of ore, location, and similarly related conditions. Moreover, the relationship will vary from one allocation problem to another, depending on the significance of the area for the amenity services it otherwise would provide. Are there some highly unusual, if not unique, natural characteristics which are threatened with destruction by the mining operation? If so, are these irretrievably lost if there are no alternative options available? Are there anticipated changes over time in the relative value of the goods or services to be offered by two incompatible uses of the area, and precisely how does this affect the optimal choice between them?

In short, any important decision concerning allocation between incompatible purposes, particularly where one choice would be inconsistent with retention of some valuable attributes of a given natural environment, calls for careful analysis and specific site evaluation using operational criteria for determining "relative preferredness." It is not likely to be usefully addressed by broad "planning criteria" which are ambiguous, if not inconsistent, if their implications are pursued to any length. Nor can we expect that the land management agencies, making records for administrative

purposes, will be generating data which are specifically and directly useful for addressing the question: "What is the relative value of hydro power versus preservation in this particular canyon?" That question is both too technical and too specific for the Public Land Law Review Commission to answer, despite the fact that in its charge it was requested to provide the answer to the aggregate of all of such questions affecting the use of the public lands (1970, p. 19).

What then might we learn from land economics in addressing the problems of allocation, management, and administration of public lands? Unfortunately, at the moment, we cannot learn a great deal in the conventional presentations of land economics. In the general American view no less than among land economists, the belief has persisted until recently that the wilderness, wildlands, and "unimproved resources" had no value. Nash (1967, pp. 40–43) indicates that wilderness represented a negative value in the minds of Americans in the seventeenth and eighteenth centuries and the concept of the "valueless character of land in nature" has persisted into the present and even exists to some extent among resource managers charged with responsibility for the preservation of wildlands and related resources.[2] Among leading contributors to the field of land economics, such as Ely and Wehrwein (1940, p. 144), one may find the statement, "while land as nature has no cost of production, land is *not* a factor of production, or even a consumption good until it has been modified or 'produced'."

Consistent with the belief that land in its natural state has no value, nowhere in the literature on land development costs is there recognition of opportunity costs in the form of the amenity services precluded by improvement or development of wildlands. This is in spite of the fact that in the better textbooks there is a chapter or more on outdoor recreation and the national parks.[3] Several possible reasons can be suggested for this omission. Earlier in the nation's development the wilderness areas and their wildlife populations were vast in relation to the lands under cultivation and the populations of domesticated stock. Under these circumstances, the reduction of the size of wildlands and their wildlife populations represented a transformation of resources that were abundant, and hence of no value *at the margin,* into goods and services of high marginal value in a

[2] An example is the case of the Assistant Chief Park Ranger (a forester by professional training) who, while commenting on the proposed Redwoods National Park in personal conversation with one of the authors, mused that the redwoods were, however, "a resource that should be put to use."

[3] See the detailed and otherwise most complete discussion of the costs of land development in Barlowe (1958), p. 228 ff. The discussion in Ely and Wehrwein of the "Environment and Recreation Land" is fundamentally descriptive rather than analytical and affords no criteria for choice in allocating "land in nature," Chapter X, pp. 315–350.

developing economy. With the wilderness reduced to only about 2 percent of its original extent, and a highly advanced technology that can utilize substitute sources of raw materials, there is no longer any reason wildlands should not be valued.[4]

The puritan ethic impeded the perception of recreational use of leisure time as the consumption of highly valued services of natural resources. Perhaps as much as anything, however, such perception was hindered by the general difficulty in coming to grips with the measurement of values involving preservation of the attributes of natural environments, from genetic stocks to research materials on which advances in the earth and life sciences might depend.[5] It is perhaps for the latter reason that not only have land economists failed to address the question of opportunity costs arising out of the transformation of natural environments by land and extractive resource development, but also those who over the decades of the 1950s and 1960s addressed themselves to the methodology of benefit–cost analysis in resources. While references are made to the values associated with wilderness, parks, cultural heritage and the like, these are treated as intangible values requiring "high policy," rather than analysis for their resolution. In short, they are regarded in the literature as "extraeconomic," albeit recognition is given to their reality even if it is not explicitly measurable as opportunity costs.[6]

A seminal work by Clawson (1959) and an equally imaginative, but less well-known effort by Davis (1963) provided the means for estimating the value of at least a significant part of the amenity service flow, namely that connected with recreational use of the natural environment. Estimates of the recreational value of a site can now be obtained in the same terms and with perhaps equivalent precision as the power values derived from developing a site for electricity generation, or the damage reduction from flood control storage. There is, of course, much room for refinement and improvement in the methodology of recreation resources valuation, just as there is in the development of the hydrology of extreme events in estimates of flood damage reduction, and estimates of firm energy from hydropower resources. While excellent and imaginative work on the estimation of the demand for, and value of, outdoor recreation resources has been done, the history of work in the field is quite recent, and the extent of the work has been limited both by length of time and the restricted auspices under which

[4] For a fuller treatment of these points see Krutilla (1967a, b).

[5] For a discussion of the economic value of natural environments, see Krutilla (1967a); also Gannon (1969) and Smith and Krutilla (1972).

[6] See for example, Subcommittee on Evaluation Standards (1958), p. 44; Krutilla and Eckstein (1958), p. 265, McKean (1958), p. 61, and Hufschmidt, Krutilla and Margolis, with Marglin (1961), pp. 52–53. A possible exception may be found in the unpublished papers of Mason Gaffney.