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Environmental Economics for Integrated Coastal Area Management: Valuation Methods and Policy Instruments

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PREFACE

Degradation of the marine environment can result from a wide range of sources. Land-based sources contribute 70% of marine pollution, while marine transport and dumping at sea contribute 10% each. Degradation of the marine environment can also result from a wide range of activities on land. Human settlements, land use, construction of coastal infrastructure, agriculture, forestry, urban development, tourism and industry can affect the marine environment. Coastal erosion and siltation are also of particular concern. Furthermore, coastal erosion is one of the main issues for many developing states, including small islands, in the context of long term sea-level rise. All kinds of marine and coastal degradation require specific actions to control or reduce their social impacts. These actions are costly, and the measurement of costs and social benefits is a very important component of the decision process to prepare national environmental policies for sustainable development and to formulate financial projects to be submitted to relevant development banks and financial institutions concerned with the welfare of human beings.

The **United Conference on Environment and Development** (UNCED, 3-14 June 1992) calls upon countries to undertake activities to meet three fundamental objectives, reflected in Agenda 21, Chapter 8: a) to incorporate environmental costs in the decisions of producers and consumers, to reverse the tendency to treat the environment as a "free good", and to pass these costs on to other parts of society, other countries, or future generations; b) to move more fully towards integration of social costs and environmental costs into economic activities, so that prices will appropriately reflect the relative scarcity and total value of resources and contribute towards the prevention of environmental degradation; and c) to include, whenever appropriate, the use of market principles in the framing of economic instruments and policies to pursue sustainable development.

UNCED recognized also the specifics of the marine environment in Chaper 17 of Agenda 21, and the need to promote the **Integrated Management for the Sustainable Development of Coastal Areas**, and the **Sustainable Use and Conservation of Marine Living Resources**. In particular, the necessity to provide for an integrated policy and decision-making process, to promote the development and application of methods that reflect changes in value resulting from uses of coastal and marine areas, including pollution, marine erosion, loss of resources and habitat destruction and the development of bioeconomic models for the sustainable use and protection of marine living resources. In addition, to strengthen the protection of the marine environment, UNCED recognized the necessity to develop economic incentives, where appropriate, to apply clean technologies and other means consistent with the internalization of environmental costs, such as the "polluter pays" principle, so as to avoid degradation of the marine environment.

The **UNEP Governing Council in its decision 17/33 of 21 May 1993** authorized the Executive Director to implement *inter alia,* the following sub-programmes: Environmental Management of all Kind of Seas and Coastal Area Management (Sub-programme 4), and Environmental Economics, Accounting and Management Tools (Sub-programme 6).

The present document, ***"Environmental Economics for Integrated Coastal Area Management: Valuation Methods and Policy Instruments"***, fits in the overall strategies designed to implement both above-mentioned sub-programmes, and particularly their following components on: **Economic Policy Instruments**, to examine the status of current research

Resource Valuation, to indentify gaps in existing knowledge, by providing developping countries with guidance for decision-making based on economic rationale and principles for environmentally sound and sustainable development; and, to explore how the application of valuation techniques will help ascertain environmental costs and in turn enable developed and developing countries to fulfil their global environmental responsabilities, and to estimate the costs of making the transition to environmentally sound and sustainable development; **Integrated Coastal Area Planning and Management (ICAM)**, to formulate a technical framework strategy for integrated coastal area planning and management with special emphasis on its economic and environmental benefits; **Land-Based Sources of Pollution**, to develop a common methodology to determine the range of cost-effectiveness of protection measures and their overall economic benefits for coastal areas; and **Marine Living Resources**, to formulate integrated management plans for the protection and conservation of coastal and marine ecosystems, critical habitats and/or their living resources, based on ecological, social and economic criteria.

The Oceans and Coastal Areas Programme Activity Centre of UNEP (OCA/PAC) in cooperation with Environment and Economic Unit (UNEP/EEU) initiated in 1993 a programme component on Environmental Economics for Integrated Coastal Area Management to be implemented at the regional and national levels, through the **Regional Action Plans for the Protection and Development of the Marine and Coastal Environment**, in order to assist decision-makers in the implementation of programmes for the economic analysis of marine and coastal issues and the economical formulation of alternative policies for sustainable development, and at the global or multi-regional level, in order to develop recommendations on common methodologies to be applied through the **UNEP Regional Seas Programme** and to make available to decision-makers experience and knowledge accumulated through the Regional Action Plans.

In cooperation with the University of Rhode Island (URI, Department of Resource Economics, Prof. Thomas A. Grigalunas, Prof. James J. Opaluch and Jerry Diamantides, Instructor in Economics) and the University of Washington (Department of Economics, Prof. Gardner M. Brown Jr), UNEP OCA/PAC has prepared a series of reports focusing on methodologies to value goods and services provided by the marine and coastal environment, with a special emphasis on methodologies applicable to developing countries, for the purpose of experts training.

On the basis of these reports, the present document ***"Environmental Economics for Integrated Coastal Area Management: Valuation Methods and Policy Instruments"*** has been prepared to contribute in the implementation of programmes on the Integrated Management of Coastal Areas for national capacity building through training workshops and pilot-studies in some among the thirteen regions covered by the *Regional Seas Programme*. The present document aims at providing background information and case studies for economists well experienced in the field of microeconomics. The first series of activities on environmental economics based on the present document, will be developed in an integrated manner through the West and Central African Action Plan (WACAF) in 1995 in co-operation with FAO.

Professor Thomas A. Grigalunas served as principal investigator and coordinator for this project. He is responsible for Chapter 1, the Introduction, Chapter 5, Stated Preferences, and Chapter 9, Summary and Conclusions. He also co-authored Chapter 7, Other Approaches, and Chapter 9, Policy Instruments, with Jerry Diamantides; and was also a co-author

Brown authored Chapters 3 and 4. These chapters cover the Travel Cost Method and Hedonic Analysis, respectively. Professor James Opaluch was the major author of Chapter 2, Economic Concepts, in collaboration with Professor Grigalunas. He also wrote Chapter 7, on the Productivity Approach. Jerry Diamantides, an Instructor in economics and a Ph.D Candidate at URI, co-authored Chapter 7, Other Approaches, and Chapter 8, Policy Instruments, both with Professor Grigalunas.

A special expression of appreciation goes to Mr. P. Schröder, Director, OCA/PAC, for his continuous support to the development of environmental economics programmes for the integrated management of coastal areas. The authors wish also to acknowledge the enthusiasm, encouragement and intellectual support given, throughout this project, by Dr. Richard Congar, Senior Programme Officer, UNEP OCA/PAC, in charge of projects on environmental economics, and the contribution of Ms. Ruth Batten, Editorial Assistant, for her patient efforts in reviewing, editing and finalizing the document for printing. Special recognition also is due to Mr. Kevin Needham, a research assistant in the Department of Resource Economics at the University of Rhode Island for his contributions, particularly to the chapter on Stated Preferences. Appreciation also is expressed to Stephen Olson who provided comments on the first draft of Chapter 1 and suggested the use of a case study. Thanks also are due to Ms. Clarice Coleman for her secretarial help.

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1. INTRODUCTION

1.1 BACKGROUND

Economic growth is a critical priority for most countries but poses many potential environmental problems. Environmental problems are of special concern for many coastal areas due to:

- rapid increases in population in coastal areas;
- substantial growth in tourism and industry;
- the use of coastal areas as dumping grounds for wastes of all kinds;
- the high level of productivity of the ecosystems at risk (saltmarshes, mangroves, coral reefs, and seagrass beds); and
- the high degree of biological diversity of coastal areas (after Olsen, *et al.* 1989).

Common marine-related environmental problems include reduced abundance and diversity of fish and wildlife due to reduced water quality and loss of habitat and other natural resource functions provided by mangroves, coral formations, and other natural environments. Other coastal area concerns include large-scale deterioration of attractive coastal vistas.

Therefore, those concerned with coastal areas face difficult choices. On the one hand, increased development promises substantial economic benefits. On the other hand, development can lead to many problems, including conflicts between various uses and degradation of environmental and natural resources. In combination, these problems pose threats to those whose livelihood or health depends upon the quality of the environment, and to those who otherwise use or enjoy the services of coastal area resources.

The importance of environmental issues in development has received increased international recognition and spurred efforts to use environmental concepts and methodologies. In the area of environmental economics, major initiatives are underway to integrate environmental costs into economic activity and to include environmental concerns as a central part of benefit-cost analysis and development plans[1]. Additionally, at a broader level, many countries are expanding their existing systems of National Income Accounts using "green" accounting. This is being done to reflect (1) the value of the goods and services provided by environmental and natural resources

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[1] For a general discussion of the growing importance of environmental considerations in development planning, see the Economist (1993). See also The World Bank (1993).

but not reflected in the market and (2) the depletion of natural resource assets (see, Bartelmus, 1993; Repeto, 1993; Gordon and Prince, 1994).

In the international arena, the United Nations in particular has given high priority to environmental issues, including the protection, management, and conservation of marine and coastal areas. Specifically, Chapter 8, Agenda 21 of the United Nations Conference on Environment and Development calls upon countries to undertake activities to meet three fundamental objectives:

(1) To incorporate environmental costs in the decisions of producers and consumers, to reverse the tendency to treat the environment as a "free good", and to pass these costs on to other parts of society, other countries, or future generations (Chapter 8.31a);

(2) To move more fully toward integration of social and environmental costs into economic activities, so that prices will appropriately reflect the relative scarcity and total value of resources and contribute toward the prevention of environmental degradation (Chapter 8.31b);

(3) To include, whenever appropriate, the use of market principles in the framing of economic instruments and polices to pursue sustainable development (Chapter 8.31c).

To help achieve these broad goals, the United Nations Environment Programme (UNEP) is encouraging the development and use of techniques for measuring natural resource and environmental values. UNEP also is supporting the use of environmental policy instruments based on market principles, when appropriate. This Document, which focuses on integrated coastal area management (ICAM), is prepared as part of this UNEP Program.

Our purpose in writing this Document is to provide background, reference materials, and example applications for participants in a planned series of workshops. Our basic goal is to introduce these readers to the rapidly growing economics literature dealing with the valuation of goods and services and to policy instruments for addressing environmental issues, focussing on applications. The intended audience is economists who are concerned with coastal area management. We assume that the audience knows some microeconomic theory but has had little or no formal exposure to environmental economics.

We adopt the view that market failure is a major contributor to coastal area problems and that appropriate policy instruments can help to address many of these problems. Indeed, in many ways, the need for *integrated* coastal area management--as opposed to single sector management--reflects widespread and serious market failure between activities in coastal areas.

At the same time, we recognize that coastal area management is a complex process. Coastal issues often cut across many disciplines, and management decisions occur within a political process. Devising, as well as carrying out policy instruments that meet desirable standards, such as efficiency, cost-effectiveness, and practicality, is very difficult; if this were not so, these measures would already be in place. Resolution of coastal problems does not depend solely on more and better technical economic analyses. Nor for that matter, are solutions likely to be found in technical analyses from any other field. Our basic argument is that the public preferences matter, and that more and better use of valuation methods can contribute to coastal area decision making by providing improved information about the public's preferences for coastal resources and tradeoffs among activities.

Sources of market failure that are important contributors to coastal area management problems include externalities, public goods, and insecure property rights. Common examples of externalities include agricultural runoff and waste discharges from pipelines that impose uncompensated costs on fisheries, recreation/tourism, or other coastal activities. Unless these external costs are internalized, the true costs of the polluting activity will be understated. As a result, production will be excessive, and those who bear the environmental harm will, in effect, subsidize consumers of the polluting product. Public goods include water quality, scenic views, or wildlife diversity enjoyed by the population at large. Since it is often hard or impossible to exclude anyone from benefitting from these goods, few will pay for them voluntarily (the free rider problem). Thus, providing public goods, such as preserving or restoring the services of an estuary, will likely require government action. Lack of secure property rights is a serious problem with fishing and with land use in coastal areas. For example, agricultural landholders will not undertake worthwhile measures to prevent erosion if uncertain property rights may prevent them from capturing the gain from adopting the conservation actions.

A variety of policy instruments are available to address market failure issues, such as those mentioned above. Several factors, however, constrain the selection and effectiveness of these instruments. One is the limited availability of information about non-market benefits and costs for many coastal areas, particularly those in developing countries. Other constraining factors include the cost of implementation, the incentives for correct behavior the instrument provides, and the extent to which other social objectives like policies to expand agriculture conflict with coastal area environmental objectives (e.g., improved water quality). Environmental protection can be very expensive, and resources available to design, carry out, and enforce environmental policies are scarce, particularly for low-income countries. Policies that impose high costs compared with benefits, or that violate standards of cost effectiveness, likely will be rejected. Or, if enacted, such policies may waste scarce resources that could be better used elsewhere.

Use of approaches for measuring non-market benefits and costs can contribute to coastal area management in several ways, including the following as suggestive examples:

- Public debate on proposed policies might be better informed if, beyond narrow commercial costs and benefits, information also was available for non-market costs and benefits. For example, public debate on how best to control discharges might be improved if more was known about the benefits which might result, many of which occur outside the marketplace (Caulkins, 1988).

- Coastal protection can be enhanced by greater use of the Polluter Pays Principle which creates incentives for businesses to reduce the external costs from pollution (Grigalunas and Opaluch, 1988; Tietenberg, 1992). A system of set fees might be used, but if the fee is to approximate actual damages, then non-market valuation techniques must be used.

- Public investments for coastal area improvements might be better targeted, if officials understood better the public's preferences for the attributes of such activities as recreational fishing, diving, or wildlife viewing, (Jones and Stokes, 1987).

- Non-market approaches might also help make difficult development-preservation decisions by providing information on the public's willingness to make required tradeoffs between coastal area resources. For example, approaches which involve asking members of the public to compare and rank alternatives can help policy makers address controversial issues, such as the siting of highways, pipelines, landfills or other locally undesirable facilities (Opaluch, *et al.*, 1993).

Better use of policy instruments might contribute to coastal area management in several ways, for example:

- Use of the Polluter Pays Principle, such as charges or liability for external costs, encourages firms to face the full costs of their actions. This approach provides a market-based incentive for firms to reduce external costs using least-cost approaches, and to adopt new approaches for avoiding external costs (Grigalunas and Opaluch, 1988; Tietenberg, 1992).

- Tradeable permits encourage environmental goals to be met at least cost by allowing firms within an area to pay others to reduce waste discharges. Tradeable permits potentially can work between point sources, or between point sources and non-point sources, reducing the costs for all participants.

- Expanded use of user fees can provide additional funds to maintain marine parks or other areas. And as a side effect, user fees can reduce demand for the site, by that lessening congestion or use-related degradation.

- Careful review of policy instruments might identify and reduce conflicts among instruments (Stavins and Jaffe, 1990). For example, policies that encourage agriculture might lead to more non-point source pollution and be inconsistent with coastal water quality goals.

In summary, rapid development of coastal areas has caused serious conflicts in uses and led to severe environmental and natural resource degradation. Considering these problems, the increased attention being given to environmental problems at the national and international levels is significant. It provides support for governments to consider the pervasive nature of market failures in coastal areas, and it encourages consideration of alternate ways to address market failure through various policy instruments.

We recognize, however, that attempts to integrate social and environmental costs into economic activities or to use market principles to frame economic instruments and policies face serious challenges. One set of difficulties concerns the problems inherent in measuring the value of goods and services that are not traded in markets. Another set of problems arises when critical scientific information establishing cause-and-effect linkages between environmental changes and loss in services to people is uncertain or even unavailable. Other challenges stem from the increasingly complex nature of environmental issues. Further, there is a shortage of pragmatic studies of the relative efficiency of policy instruments for addressing environmental problems in coastal areas.

These challenges are especially daunting for low-income countries. This is due to severe funding constraints, lack of data, absence of well-defined property rights, lack of capital markets, and the frequent absence of an institutional framework for dealing effectively with environmental issues. These and other issues underscore the many difficulties faced when attempting to improve the use of economic analyses or analyses from any other field of environmental issues in coastal area management, particularly in low-income countries.

1.2. PURPOSE, SCOPE, AND ORGANIZATION

Purpose

This Document attempts to contribute to the literature on integrated coastal area management (ICAM) by drawing upon recent work in environmental economics potentially applicable to problems in ICAM. Specifically, (1) we review major techniques available for assessing the economic value individuals' hold for coastal areas goods and services, and (2) we examine policy instruments available to address market failure problems in coastal areas. As noted, the Document was written to provide background information and case studies for a planned series of workshops for economists. We assume that readers have had some training in microeconomics but have had little formal exposure to the field of environmental economics.

Scope

Two major topics are addressed:

(1) concepts, methodologies, and data requirements for valuing marine-related goods and services, emphasizing those that are not traded on markets, and

(2) policy instruments for addressing coastal area environmental concerns.

In keeping with the goal of the Document, we adopt a nontechnical approach to make the materials accessible to a wide audience. Liberal use is made of Figures, with technical material for the most part presented in Appendices. Many examples illustrate the richness of the literature and how the different valuation approaches and policy instruments have been used in various, primarily marine-related applications.

Finally, we emphasize again that this Document provides an *introduction* to a large and rapidly growing literature on valuation and policy instruments. We expose readers to *some* major recent thrusts and controversies in environmental economics. Readers interested in pursuing a particular topic in more detail will want to consult additional sources. To this end, selected references are given at the end of each section. Special reference is made to the works of Walsh, *et al.* (1988), Mitchell and Carson (1989), Braden and Kolstad (1991), Cropper and Oates (1993), Freeman (1993), Tietenberg (1992). These works provide rigorous and comprehensive presentations of many topics presented in this document.

Organization

The Document is organized as follows. First, to make the discussion in the Chapters that follow more concrete, we begin in Section 1.3 by presenting a hypothetical case study of a coastal area, "Challenge Bay". Challenge Bay has problems common to many coastal areas, and we use this case study as a device to lend some specificity to the later discussion of concepts, methods, and policy instruments.

Chapter 2 sets out a conceptual framework that provides a unifying structure for much of the material that follows. Economic value is defined, categories of value and of goods are explained, and market failure is described.

Natural resources and the environment are viewed in Chapter 2 as natural assets (Freeman, 1993). Distinguishing features of assets are that they can provide, over time, a flow of services directly or indirectly valued by people. Direct services include, for example, amenities such as attractive views, clean beaches, and fish harvests. Indirect services include, for example, the natural functions of wetlands and more generally, ecosystems, which support the "production" of fish and wildlife that are, eventually, harvested or viewed by people. These flows of services are sustainable, if the stock of natural assets is maintained. Finally, Chapter 2 considers briefly two alternate approaches used by some to value resource activity: impact analysis and energy analysis.

In Chapters 3-7 major approaches for valuing marine-related environmental resources are reviewed (Table 1.1). These approaches are divided into those that rest on revealed preferences and those based on stated preferences or "constructed" markets (Carson, 1991). Other approaches considered are the productivity approach and benefit transfer.

Revealed Preferences • **Travel Cost Approach** • **Hedonic Analysis** • **Avoidance costs** **Stated Preferences** • **Contingent Valuation** • **Contingent Activity** • **Contingent Ranking** **Productivity Approach** **Benefit Transfer**

Table 1.1. Non-market Valuation Approaches

For each approach, its potential usefulness for coastal area management is suggested and the underlying concepts are reviewed briefly. Then, we outline the methodology and data requirements. Several examples from the literature are given to illustrate application of each approach. Finally, we note some issues associated with the use of each approach. References for further reading are also provided.

Chapter 8 concerns policy instruments ("PIs") that could be used to address coastal area problems. PIs fall into two broad categories: Regulatory Instruments and Economic Instruments (Table 1.2). The characteristics of RIs and EIs are explained and many examples of each type of PI are given. Also, several case studies are used to examine in some detail the application of policy instruments in particular cases.

PIs differ in their relative efficiency, cost-effectiveness and information and transactions cost. PIs also differ with respect to their distributional effects and political feasibility. We do not attempt to suggest which PIs might be "best" suited for particular coastal areas. This is because the choice of PIs will depend upon the specific issues and circumstances facing an area. Instead, we confine ourselves to a discussion of some key features of PIs and of the potential strengths and weaknesses of different PIs.

The final section, Chapter 9, ties together some issues posed by our case study of Challenge Bay and the concepts and methods reviewed in other Chapters. Drawing upon the issues raised in the case study, broad suggestions are made about the kinds of economic studies that might contribute to integrated coastal area management for this prototypical coastal area and, by extension, for other coastal areas.

Regulatory Instruments
Regulations
•technology-based regulations
•conservation/mgmt. practices
•species or resource protection
Zoning
•coastal zone
•parks, sanctuaries & spec. mgmt. areas
Economic Instruments
Polluter Pays Principle
•taxes, penalties & liability
Subsidies
Tradeable Permits
•Offsets & "Bubbles"
User fees
Return/deposit
Criminal Penalties

Table 1.2. Selected Policy Instruments

1.3 CHALLENGE BAY, OCEANUS: A HYPOTHETICAL CASE STUDY

Introduction and Background

Located in a semi-tropical climate, Oceanus is a developing country with an economy that, to date, has relied upon agriculture, small-scale fisheries, small-scale commercial activity and some industrial operations. Tourism is important but thus far is limited to a few, relatively undeveloped coastal and inland areas. These areas are known nationally and internationally for providing quality recreational opportunities, particularly clean beaches, with good coastal water quality and attractive coral reefs with diverse reef fish populations. The coastal area also is known for its natural beauty and contains many marine-related and terrestrial wildlife.

Improving the standard of living of its citizens by promoting economic growth is a high priority of government policy. At the same time, officials and residents are increasingly sensitive to environmental issues. They are aware of the important role that the country's natural resources and environment can play in supporting a higher standard of living for residents.

To help achieve its goals, the government is actively seeking additional foreign investment, including loans from international organizations. As part of this activity, Oceanus is attempting to improve its ability to manage environmental issues. However, environmental laws are weak, and the record for environmental protection is uneven. A strong central government exists, and ministries focus on single-sector issues. Severe budget constraints underscore management problems and hamper developing, carrying out, and enforcing environmental management plans.

Furthermore, environmental groups are not well organized, and little opportunity exists within existing laws and administrative procedures for residents to register their environmental concerns. No studies of resident or visitor preferences have been done. Therefore, little is known about the demand for the services of environmental and natural resources.

We focus on the Challenge Bay watershed as the "planning area". The watershed covers some 1,250 km^2 with Challenge Bay, an estuary covering some 180 km^2, at its center. The watershed is located some 200 kilometers from the capital of Oceanus. Access to the Bay by road is limited to a highway located away from the coast, with small feeder roads to the coast. Some tourists also arrive at an airstrip used by small planes.

Much of the Bay is shallow, although two channels provide access for small craft and occasional larger vessels to villages located along the shore. There are about 600 hectares of mangroves along the estuary, down from 1,200 hectares a decade ago. Seagrass beds, once abundant, have been reduced due to pollution.

Two rivers and several small streams carry rainfall and runoff from throughout the watershed to the Bay. Coastal hills, some very steep, surround the watershed. Some hillsides have been subject to small-scale, slash-and-burn agriculture. The remainder is primary forest comprised largely of hardwood trees.

The population in the watershed is relatively low (400,000 people) but increasing rapidly. Some two million people live in the Province of which the watershed is a part. There are 15 villages in the watershed, although most of the population resides in two municipalities located along the Bay. Substantial growth is anticipated in the next decade, although the scale and pattern of growth depend, in part, on government policies.

Resources and Issues

A preliminary assessment of resources and issues has identified the following information for the Bay and its watershed:

- Fisheries

The Bay has been highly productive biologically. However, the quality and productivity of the Bay have been diminished in recent years and further deterioration could occur due to projected developments described below. Now, the estuary supports some 200 artisanal fishermen and their families who harvest finfish, crab, and shellfish and also 50 commercial fishermen. The productivity of the Bay fisheries is due, in large part, to the high quality of the Bay's waters and the presence of extensive mangroves and wetlands along sections of the shoreline. These natural environments are believed to serve as nursery areas and sources of food for marine life. Loss of seagrass beds is believed to be an important factor contributing to reduced abundance of certain fish species.

- Tourism

Tourists and vacationers have come to the coastal area in rapidly growing numbers in recent years. Several hotels have opened along the estuary and along the ocean-facing coast. Clusters of secondary homes have begun to appear, and many visitors from outside the watershed travel to the Bay and nearby ocean during their holidays. A few thousand people work in tourism-related businesses.

Visitors use the Bay and ocean beaches for swimming, diving, windsurfing, boating, and recreational fishing. The Bay and sections of coastal waters are becoming very popular for diving, due to the abundance and beauty of the coral reef formations and the wide variety of reef fish they support.

Also, some visitors are drawn to the area to view well-known, attractive vistas and wildlife--primarily exotic bird species along the coast and a variety of animals that inhabit the nearby forested and open lands. Some natural and environmental resources of the Bay and its surrounding watershed are of national and international significance. A recent proposal would expand tourism capacity. Developers propose to use an exceptional section of coastal parkland for a new hotel and resort. They say that construction of the hotel would involve temporary employment for about 500 people during the two-year construction period and 400 once operations begin. Purchases in the watershed are estimated to be $5 million per year during construction, and $4 million annually when the facility opens. The developer asserts that each dollar of expenditures will generate $4 of additional expenditures.

Local officials see a strong potential for growth in recreation and tourism, if the quality of the resources that attract visitors is maintained. However, they are concerned about unplanned growth in tourism, projected growth in commercial activity and in the population, and about plans to introduce shrimp mariculture in the Bay. Other issues of worry are plans to expand agriculture and to introduce large-scale forestry operations in the watershed, as is described below.

A major concern is that growth in these other activities will degrade the Bay and coastal waters. This would adversely affect the area's environmental amenities, and, by that, reduce the appeal of the area to visitors and tourists. Already, unattractive development has occurred in some areas, some sections of the Bay and coastal waters are polluted, and debris is beginning to mar sections of the more heavily used shoreline. Underlining this concern is the competitive nature of tourism in the region, with other nations vying to increase their share of the tourism market.

- Agriculture

Sections of upland areas are used by primarily subsistence farmers who grow maize and cotton and some grazing of animals, mostly cattle also occurs. As noted, some agriculture uses the slash-and-burn approach.

Recent events point toward substantial expansion of both small-scale and large-scale agriculture in the watershed and along the Bay. To support large-scale agriculture, dams would be constructed, subsidized by the national government. The dams would divert fresh water from the Bay, changing the oxygen content of portions of the Bay. Expanded agriculture would cause non-point source runoff of pesticides, herbicides and fertilizer into the Bay. Also, of concern is potential runoff of nutrient-rich animal wastes from larger herds of animals. A large expansion in agriculture poses a very serious threat to the Bay and the services it provides to users, unless effective management actions are taken.

- Mariculture

Investors are very interested in using 2,000 hectares of the Bay to raise high-valued shrimp for export. Projections suggest that these operations would employ about 100 people and earn investors a substantial return (economic rent). Preliminary plans suggest that they would like to use the mangrove areas and saltflats These areas are used by artisanal fishermen and others who use the resources of these areas for traditional activities such as wood gathering and charcoal making. Expanded mariculture operations in the estuary also could conflict with recreational uses of the area by some visitors.

Oyster mariculture operations exist. Operators of these facilities are very concerned that possible deterioration in water quality will lower the productivity of their operations and thus threaten their financial viability.

- Forestry

The hardwood forests of upland areas of the watershed contain valuable timber, and commercial interests would like to expand greatly timber harvesting for the export market. About 75 people would be employed, and investors expect to earn large economic rents.

Laws promoting ecologically sensitive silviculture practices are weak, at best. Tourism officials and some residents are concerned about runoff from new roads and activities related to logging. They worry that this runoff will cause serious sedimentation of rivers, streams, and large sections of the Bay itself. This would reduce the productivity of the Bay's fisheries and use of the Bay for tourist and recreational activities. Another concern is that excessive harvesting will render large sections of the upland landscape unattractive and sharply reduce critical habitat for wildlife species important to tourists.

- Other Issues

Increases in population and general development will create important waste management problems. Household wastes are discharged into the ground. In some cases, wastes have infiltrated nearby waters. In other areas, collector pipes carry household wastes out into the estuary, without treatment. Some pollution of Bay waters and of beaches along the Bay has been observed, and incidents of pollution along ocean beaches used by tourists and residents have been reported. A serious concern is that growth will lead to more household wastes. These wastes, if released into area streams and rivers would enter the Bay and nearby ocean, threatening human health, tourism, and fishing. A sewerage facility has been proposed to address these concerns but would be very expensive. Also, increased amounts of refuse and other solid wastes would need disposal to avoid unattractive littering of coastal areas.

Recent and projected growth in light manufacturing raises concerns about discharges of toxic pollutants, conventional wastes, and pathogens and their effects on water quality in the Bay and in some ocean nearshore areas. Also, additional roads, parking areas and other facilities are expected to contribute to additional non-point source pollution. This would result from flushing of oil and grease and other substances into area waters during rainstorms.

An issue of serious debate concerns the best location for a proposed highway system intended to improve road transportation between the watershed and the capital with its large population. Some favor a coastal route. However, sections of the planned route would cut across area wetlands, destroying some wetlands and altering water flows. Further, a coastal route would obstruct the view of the Bay from some locations and degrade the appearance of some areas. Others favor a more upland route along the side of nearby hills. However, this would render the view of the hills less attractive and possibly create erosion problems in some areas. Further controversies with this route stem from the fact that the proposed road would disturb land of great cultural and religious significance to resident populations.

Discussion

This brief sketch of the environment, resources, and issues facing the Challenge Bay watershed suggests several major challenges and questions that must be addressed. Briefly, we note the following:

First, the area provides many benefits due to the quality of the environmental and natural resources of the area. Fisheries and mariculture support many households. Tourism and recreation create a demand for complementary commercial activities, and the benefits received by businesses (economic rent) and their employees are reasonably clear. Much less clear are the non-market valued benefits received by those who engage in the wide range of recreational activities--activities that could be harmed by development. As noted, few mechanisms exist for environmental concerns to become part of the planning process, and little is known about the demand for natural resource and environmental services.

Potential deterioration in the quality of the Bay and surrounding areas is a subject of great concern to many interests. These include not only those engaged in traditional fishing activities, but also those currently earning their livelihood in mariculture operations and in the tourism industry.

Conflicts among resource activities abound--and are likely to get much worse. Expansion in agriculture, mariculture, forestry, and general increases in population and commercial activity pose very serious challenges. The potential benefits from these new activities are important. However, the potential social costs due to externalities from water diversion, non-point source pollution, loss of environmental amenities and habitat, and other potential adverse environmental effects, also must be considered. Other issues concern whether and how policy instruments might be used in an attempt to accommodate growth in area activities. Figure 1.1 summarizes some of the connections between the activities in the watershed, their impact on environmental and natural resources, and the anticipated effects on people.

For purposes of providing information that might be useful for ICAM, three overriding issues are of special concern. One is the need to recognize the important externalities between activities. Unless these externalities are considered, the benefits from environmentally harmful activities will be overstated, and the value of the Bay and the watershed as natural assets will be severely eroded.

A second overriding issue concerns the availability of data necessary to address the issues involved. Attempts to apply economic analysis--or for that matter, *any* socioeconomic analysis--to the problems of coastal area management depend upon the availability of basic scientific information. For example, it would be very valuable to know how changes in water quality or coral cover in the Bay might affect the variety and abundance of fish harvested or viewed by people. Further, the quality dimensions considered must be those which matter to *people*, since data from even the best scientific study will be of little use unless it focusses on environmental services which directly or indirectly are of interest to people. This suggests the need for collaboration--at the outset--among researchers from the social sciences and the natural sciences.

The third overriding issue concerns the institutional setting and the viewpoint of decision makers. In our hypothetical coastal area, we assume that officials want economic development, but they recognize that fisheries, tourism, and other activities depend upon maintaining the quality of the environment. We assume that they are sensitive to the full range of effects of development and want to consider *all* benefits and costs. We also recognize that officials often are very concerned about the distribution of benefits and costs--who gains and loses--and about other social and political issues associated with development, although these are beyond the scope of this document.

In the Chapters that follow we review methods for valuing goods and services not traded in the market place and policy instruments potentially useful for ICAM. We urge the reader to keep in mind the problems faced by Challenge Bay and how the valuation and policy instruments reviewed might be useful for improving coastal area management in this case. Then, in the final Chapter we revisit Challenge Bay and briefly suggest how the valuation methods and policy instruments reviewed might be used to contribute to ICAM for this coastal area--and by extension, for other coastal areas facing similar problems.

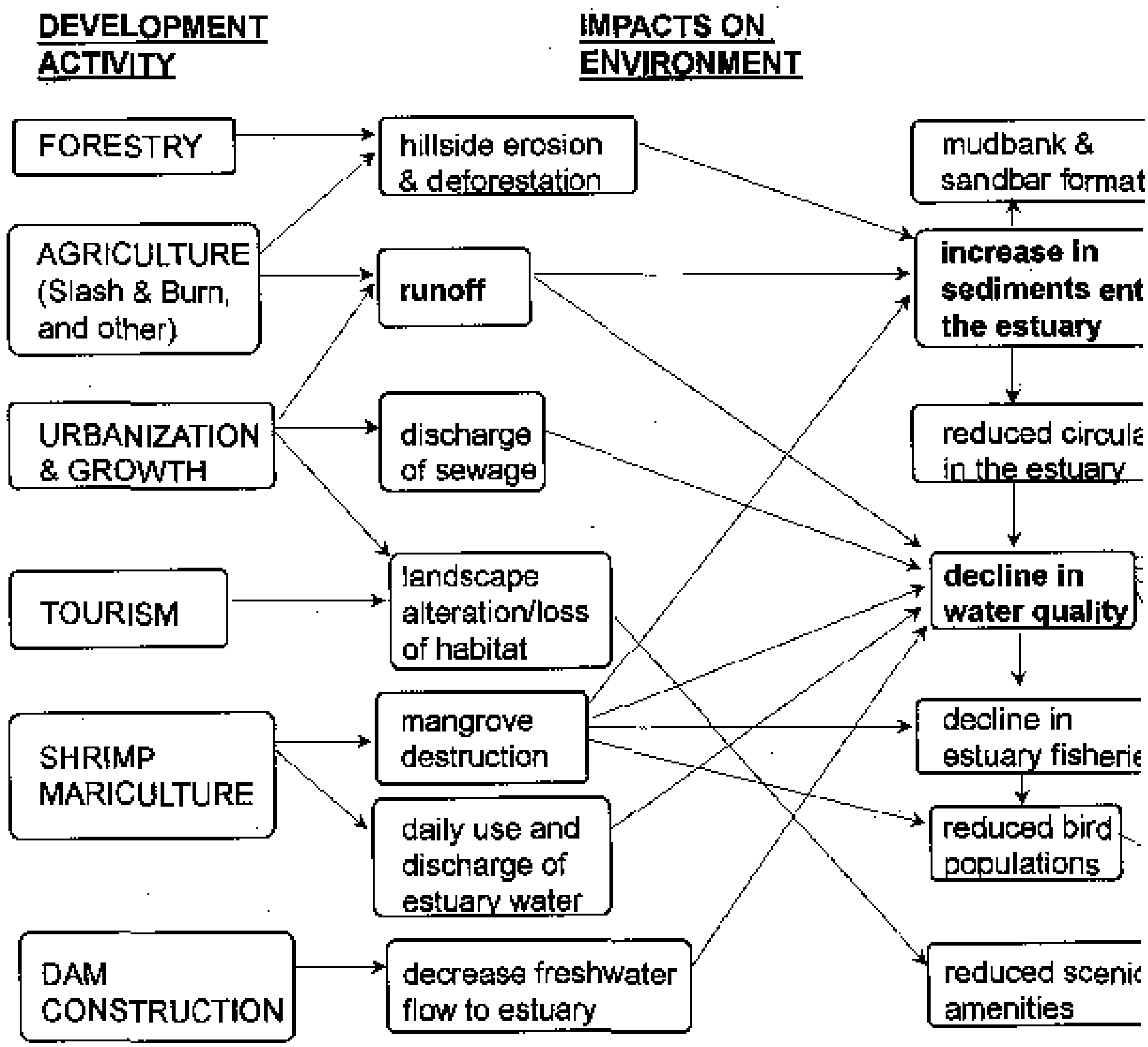

Fig. 1.1 Selected Linkages Among Activities, the Environment, and Lo

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2. ECONOMIC CONCEPTS

2.1 DEFINITION AND CONCEPTUAL FRAMEWORK FOR ECONOMIC VALUE

Introduction

This section provides economic concepts central to addressing many issues in environmental economics relating to coastal area management. The concepts are presented at a level that is accessible to those with little economics training. First we provide a general definition of economic value, followed by a discussion of consumer values. We then provide a brief discussion of the theory of producer values. Different categories of values are described next, followed by a definition of various types of goods. Then, we present conceptual issues which arise when natural resources are viewed as assets providing services over time. This is followed by a discussion of market failure problems--public goods, externalities, and insecure property rights--which underlie many coastal area management problems. Finally, we present a brief discussion of two alternative means of valuation that have been advocated by some: economic impact analysis and energy analysis.

Economic Value

Neoclassical economics focuses on preferences of consumers and profits of firms as fundamental elements that motivate choices. A key concept is economic surplus, which measures gains obtained from a transaction, such as the purchase of a market good. Consumers gain whenever the maximum amount that they would pay for a good is greater than the amount that they are actually required to pay to acquire that good. The difference between the maximum amount that a consumer would pay and the amount that they actually pay, called consumer's surplus, is an unpaid for benefit from use of the good.

Producers gain whenever the revenue that they receive for a good is greater than the cost of producing that good. The difference between the revenues received and the cost of production is producer's surplus. The total gains from trade is the sum of the gains to consumers and producers, which is termed economic surplus.

Measuring Consumer's Surplus

Consider the following example that employs the concept of consumer surplus to place a monetary value on drinking water. Imagine that you are walking through the desert and are dehydrated and very thirsty when you come across a vendor selling drinking water. Given that you are very thirsty, you would be willing to pay a great deal for a glass of water. With each additional glass of water you obtain less and less satisfaction, since the most essential uses of water were fulfilled with the previous glasses. Once the incremental satisfaction that you would obtain from an additional glass of water is less than the satisfaction you could obtain by using the money for something else, you purchase no additional water.

What is the monetary value of the satisfaction you received from purchasing three glasses of water? Suppose that you are willing to pay a substantial sum for the first glass, say $5, given that you are very thirsty. If the price of water was greater than $5, you would continue walking to a nearby town where you know you could get a drink. If the price of water is less than $5, you would purchase the water.

Suppose that the vendor charges $1 for a glass of water. In this case you would purchase the water and obtain a consumer's surplus of $4 ($5 - $1). If you were willing to pay up to $3 for a second glass, you obtain a consumer's surplus of $2 ($3 - $1) for the second glass of water. Now you are much less thirsty, and you would be willing to pay no more than $1.50 for a third glass of water. Given that the price is $1, you purchase the third glass, and obtain a consumer's surplus of $0.50 ($1.50 - $1). The total willingness to pay for three glasses of water is $5 + $2 + $1.50 = $8.50, the total cost is $3, and the total consumer's surplus obtained from purchasing water is $8.50 - $3 = $5.50

Quantity	(1) Willingness to Pay	(2) Cost	(3)=(1)-(2) Incremental Consumer's Surplus
1	$5.00	$1.00	$4.00
2	$2.00	$1.00	$1.00
3	$1.50	$1.00	$0.50
Total	$8.50	$3.00	$5.50

Table 2.1 Total Willingness to Pay and Consumer's Surplus

Thus, consumer's surplus measures value from the maximum amount the individual would be willing to pay for each unit of the good, minus the amount that the individual actually has to pay.[1] This implies that consumer's surplus can be measured from information regarding the quantities of the good that the individual would purchase at various prices, which is simply the demand function.

Specifically, consumer's surplus is measured as the area under the individual's demand function, and above the price of the good (Figure 2.1). In this case, the individual would be willing to pay as much as p_1 for the first unit of the good, p_2 for the second

1 From a more technical perspective, the area under the demand function may serve as an approximation to consumer benefits, that are more properly measured as compensating or equivalent variation. For more details see Currie, Murphy and Schmitz (1971) or Willig (1976).

unit and p_3 for the third unit. However, the individual faces a constant market price of p_1 for all three units, so that the area with diagonal lines in Figure 2.1 represents the amount that the consumer would have been willing to pay for three units of the good, above and beyond the amount that the consumer actually must pay to obtain the good.

■ Valuing Price Changes

The framework presented above can be used to value changes in market prices. In this case, the demand function remains constant, but consumer surplus is affected because the consumer must give up more to purchase each unit of the good. Price increases from P_3 to P_2. This consumer now purchases only two units of the good, and the consumer's surplus is smaller for each unit purchased.

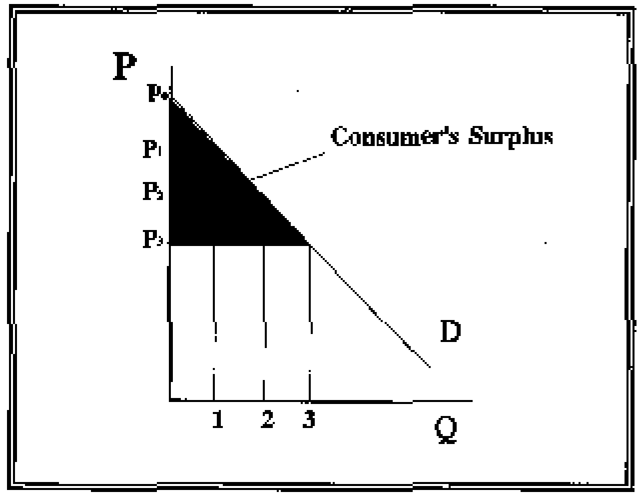

Figure 2.1 Depiction of Consumer's Surplus

The loss in consumer surplus due to the price increase is the appropriate welfare measure, as depicted in Figure 2.2. The cross hatched area in the Figure represents the loss in consumer's surplus due to the price increase.

In the water example, if the price of water from the vendor increased from \$1 to \$2.50, the consumer's surplus from the first glass would be \$2.50 (\$5-\$2.50). The price exceeds the willingness to pay for all other glasses, so that the individual would only purchase one glass of water and obtain a total consumers surplus of \$2.50. Thus, the reduction in consumer's surplus due to the price increase is \$3 (\$5.50 - \$2.50).

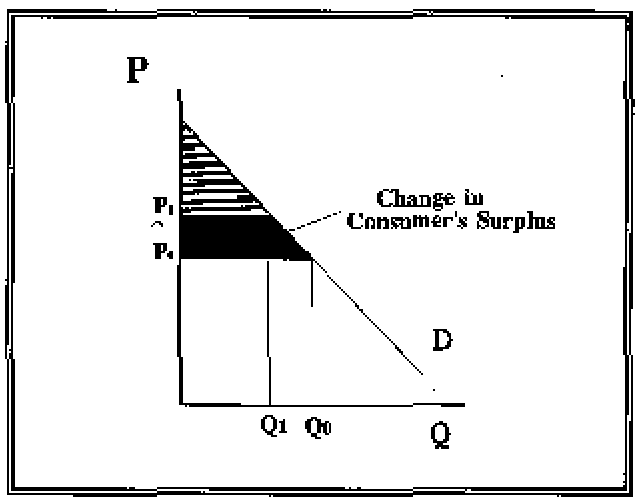

Figure 2.2 Loss in Consumer's Surplus Due to a Price Increase

■ Valuing Quality Changes

Consumer's surplus can also be used to value changes in the quality of the commodity. Consider the case of an increase in quality. If the good is of higher quality, the individual may be willing to pay a greater amount for each quantity, as compared to the case where quality was lower. For example, consumers would likely be willing to pay a higher price for fresh fish than they would for fish that is not so fresh, or consider a case from marine recreation, where recreationists likely would be willing to pay more for a trips to a beach where the quality of the beach use experience was improved by, for example, cleaning up litter along the beach, improving water quality, providing better facilities, or reducing congestion.

The increase in consumer's surplus due to an improvement in quality is depicted in Figure 2.3. Under the lower quality level the demand function is D. Quality then improves to a higher level and demand shifts out to D'. Consumer surplus at the low quality level is equal to the area under D and above the price line, which is represented by the area with horizontal lies. Consumer's surplus after the quality increase is represented by the area below the new higher demand function, D', and above the price line. The change in consumer surplus due the quality change is represented by the cross hatched area in Figure 2.3.

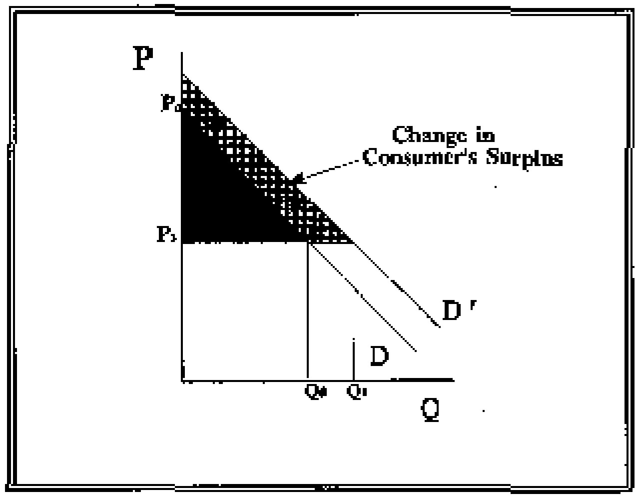

Figure 2.3 Effect of Quality Improvement on Consumer's Surplus

■ Substitutes and Complements

The availability and price of substitute and complementary goods is also an important determinant of the willingness to pay for a commodity, and therefore its economic value. A substitute good is a good that you might purchase instead of the good in question. For example, if you are hungry, you might purchase one type of fish rather than another, or if you are thirsty you might purchase lemonade rather than water. A complement is a good that you might purchase to go along with another good, so that the goods work together and increase the level of satisfaction provided. For example, you might prefer to eat fish with bread, or you might enjoy beach use more after applying sun screen or using sunglasses to block harmful rays from the sun.

An increase in the price of substitutes increases the economic value of the good in question. In the water example, you were willing to pay no more than $5 for the first glass of water, given that you knew there was a town nearby where you could get a drink for free. However, if a drink of water cost $10 in that town, you would likely be willing to pay much more than $5 for a drink of water, knowing that you are dehydrated and have a long walk ahead in the desert before you will be able to get another drink at a lower price. Similarly, if the nearest source of water was 20 miles away you might be willing to pay more than $5 for a drink now. On the other hand, if lemonade or cola is being sold for $.50 from a vendor just ahead, you would not likely be willing to pay $5 for a glass of water from this vendor.

Figure 2.4 demonstrates the effects of availability of substitutes for the demand function for water. Here, the lower demand function, D, represents willingness to pay for water when the nearest alternative source of free water is nearby (say 2 miles). The upper demand function, D', represents willingness to pay for water when the nearest alternative source of water is far away (say 20 miles).

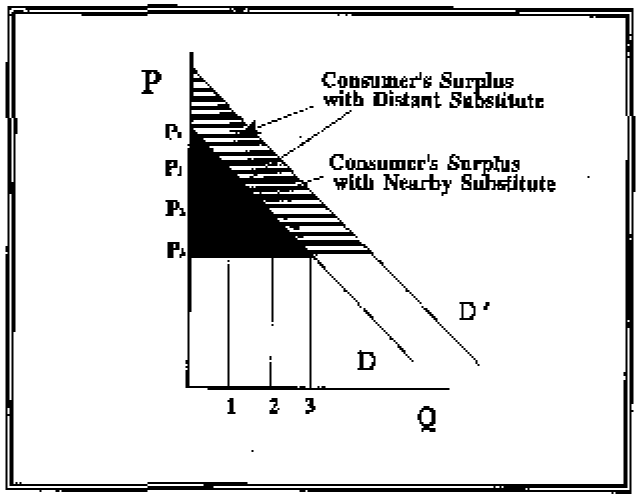

Figure 2.4 Substitutes and Consumer's Surplus

Categories of Value

Economic values can be divided into different categories. One broad distinction is between market-valued goods and non-market (or extra-market) goods. The former includes goods and services bought and sold on organized markets, for example, fish sold commercially. Given that these goods are traded in markets, determining their value is *relatively* straight forward. In contrast, non-market goods are not traded in the market place, for example the value of recreational activities like beach use or visiting a marine park. To measure the value of these goods, resort must be made to one of the non-market valuation approaches described in Chapters 3-7.

The direct use value of a good refers to the value obtained from direct, on-site or physical use of a good. For example, if I spend a day at the beach, I obtain direct use value from the beach. Indirect use value of a natural resource refers to values obtained from using a good that is related to the natural resource. For example, coastal wetlands may contribute to fish and wildlife populations. If I consume fish or view wildlife, then I obtain direct use value from the fish and wildlife and indirect use value from the wetlands. Hence, there is an indirect or derived demand for the ecosystem functions provided by the wetland which result in the "production" of fish and wildlife. Similarly, if I watch a television show about whales, I obtain direct use value from the television show and indirect use value from the whales.

Use values can also be classified other ways. Consumptive use value refers to a case where I obtain use value from a commodity, and in doing so I consume the good, such that it is no longer available for others to use. If I catch and eat a fish, this fish is no longer available to be caught and eaten by others. In contrast, nonconsumptive use value refers to value obtained from using a good, where the good remains to be used by others. If I spend a day at a recreational beach or viewing wildlife at a coastal refuge, the beach and the wildlife are still available for others to use.

Another category of use value has been referred to as incidental use value (Freeman, 1993). For example, while driving down a country road I may unexpectedly see a rare bird species fly overhead. Despite the fact that I did not travel to a specific site to see the rare species, I might be willing to pay (have a value for) viewing the particular bird species.

Nonuse value (sometimes called "passive use value") refers to values obtained with no need to use the resource at all. I may obtain nonuse value from simply knowing that a rare whale species continues to exist, without the need to actually use the whales.
Option value refers to the value that I obtain from maintaining the option of using a resource in the future, even if I do not currently have specific plans on using the good. I obtain option value from conserving a good just in case I should wish to use that good sometime in the future.

Table 2.2. Categories of Economic Value

- Direct Use Value -- Value obtained from direct, on-site use of a good.
- Indirect Use Value -- Value obtained indirectly from a good, where you use another good that depends upon the good in question.
- Consumptive Use - Good is consumed when used, such that the good is not available for others to use.
- Nonconsumptive Use - Good is not consumed through use, such that the good remains for others to use.
- Nonuse Value (sometimes called Passive Use Value) - Value obtained without the need to use the good. For example, one might obtain value merely knowing that a good continues to exist (e.g. whales)
- Option Value - Value obtained by maintaining the option to use the good at some time in the future.

The concept of total value refers to the sum of direct and indirect use value, nonuse value and option value. Generally economists argue that the notion of total value is the appropriate value to employ, and that there is danger in attempting to estimate different categories of value then adding them up (Freeman, 1993). The main problem with summing categories of value is the potential for double counting if some estimates contain more than a single category of value. This is particularly problematic, since it is often not possible to provide a strict dividing line between different categories of value. Consider an example where one enjoys reminising about a past fishing trip. While the fishing trip itself is a use value, it is not clear whether the enjoyment from reminiscing should be considered to be a use value associated with the trip or a nonuse value, since no further direct use has occurred.

Finally, we note that the term "intrinsic value", though sometimes used in popular discussion, does *not* fall under the heading of economic values. This is because goods are defined to have economic value only insofar as they are valued by people. Hence, a good cannot have value in and of itself; it must give rise to a use, nonuse, or option value held by individuals.

In summary, different categories of value may be useful in conceptualizing how individuals place value on goods and services. However, it is usually not very productive to attempt to measure separate components and aggregate them to arrive at total value. It is generally more proper to attempt to estimate the total value associated with the issue relevant to the valuation effort. Nonetheless, as described in later sections of this document, there may be problems with credibly estimating total value, when nonuse value is believed to be a major component of value. The various methods which can be employed to estimate use value, nonuse value and option value are described in Sections 3 to 7.

Categories of Goods

Similarly, we can define different types of goods. A pure public good is one everyone can share without reducing the amount of the good remaining for others to use. In contrast, a pure private good is a good which if one persons uses, that amount less remains to be used by others. For example, aesthetic enjoyment of a clean estuary is a pure public good, in that my enjoyment of the clean estuary does not reduce the amount of clean estuary remaining to be enjoyed by others. In contrast, if I consume a meal of fish, that fish is no longer available to be consumed by others. Hence, pure public goods are characterized by non-excludability, lack of any property rights, and the absence of a market; on the other hand, private goods are often, but not always, distinguished by excludability, well-defined property rights, and the potential for well-functioning markets.

Table 2.3: Categories of Goods

- Public Goods--Goods which if available to one are available to all. Examples: estuary water quality, and viewing wildlife and attractive coastal vistas, nonuse value.
- Private Goods--Use by one individual precludes use by another. Example: fish used consumptively.
- Quasi-private Goods--These include elements of a public good and private good. Examples: recreational beach use, diving, visiting marine parks.

Quasi-private goods are an intermediate case which has elements of both public and private goods. These are goods like recreational beach use, diving, and visiting coastal parks. Use of these goods by an individual does not, within the capactity limits at a site, reduce the amount available to others; yet, individuals in principal can be physically excluded from these activities. However, property rights are often illdefined at recreational sites and markets are generally not used to allocate recreational use, apart from arbitrarily-set and usually below equilibrium user fees.

2.2 PRODUCER THEORY

Firms benefit from a transaction when the cost of producing a commodity is less than the revenue obtained by selling that commodity. Producer surplus is defined as the difference between the cost of producing a commodity and the revenue received by selling the commodity. The supply curve provides the information concerning the production costs. Specifically, the total cost of producing some level of output is equal to the area under the supply function.[2]

The producer's surplus is depicted in Figure 2.5. To maximize profits firms will produce output to the point where the price they receive is just equal to the marginal costs of production. In Figure 2.5, for a price p the firm's profits are maximized at q = 3. Total revenue obtained from producing this level of output is equal to PQ, which is represented by the area below the price line and to the left of Q. Thus, producer's surplus is equal to area indicated by the diagonal lines, below the price line and above the supply function.

The aggregate producer's plus consumer's surplus, as noted, is referred to as economic surplus, and is a measure of the gains from trade between consumers and producers. When markets work well, the economic surplus obtained is the highest available to society--producers and consumers.

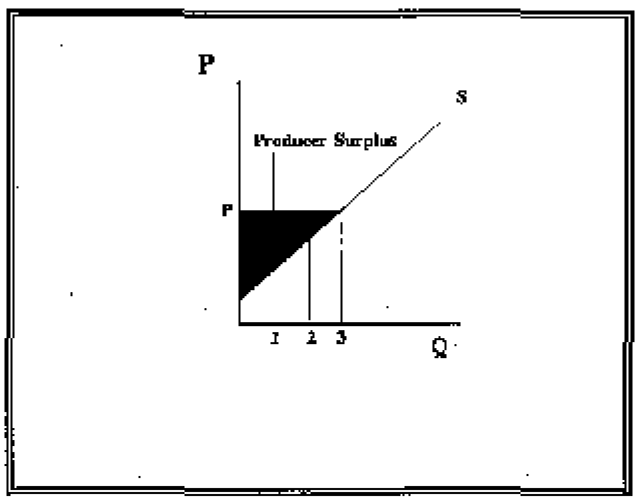

Figure 2.5 Depiction of the Producer's Surplus

2.3 RESOURCE USE OVER TIME: COASTAL RESOURCES AS NATURAL ASSETS

Coastal resources can be viewed as natural assets which, if maintained, can provide services of value to people over time (Kopp and Smith, 1993). For example, the demand for many marine recreational sites

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2 The area under the supply function is actually the variable costs of production, and hence, excludes any fixed production costs. However, fixed costs must be paid whether production occurs or not, and is, therefore, properly excluded from the calculation of producer's surplus. For a more detailed discussion of these issues, see Just, Hueth and Schmitz (1982).

used for diving is due to the presence of healthy coral formations with a diversity of reef fish species. A policy which allows intensive recreational use of these areas might lead to large short-run benefits as measured by consumer surplus. However, intensive use might result in damage to the coral reefs and substantially lower the recreational quality of the site, and hence reduce the present value of the future stream of benefits. Thus, a policymaker interested in maximizing benefits over time would view coral reefs as assets and take into account how the intensity of recreational use at the site would affect recreational benefits over time.

Similar arguments apply to fisheries and to other coastal resources, such as offshore oil. Excessive production today may increase consumer or producer benefits in the current period but lower the discounted value of the services provided by these resources as compared to what they would be with sound management. A *user* cost arises when use of a resource today cause a loss in future value. If property rights to coastal resources are well defined, the owner(s) of resources has a built-in incentive to take user cost into account as a matter of course. However, lack of property rights is a common, major problem with many coastal resources. Again, a policy goal of maximizing the value of coastal resources over time would consider how increased utilization in the present period would affect the value of these assets in future periods.

More generally, estuaries or coastal areas can be viewed as natural assets which directly and indirectly provide a wide range of services to people. These include: habitat and nursery areas and healthy ecosystems which support subsistence, artisanal and recreational fisheries; high levels of water quality necessary for mariculture and for recreational beach use, diving, and other activities; and habitat and nursery areas for wildlife. The value of these assets, measured by the present value of future net benefits, can be substantial. However, measuring the value of natural assets usually is difficult in part because most of the benefits they support are not realized within markets and require the use of the valuation techniques described in Chapters 3-7.

2.4 MARKET FAILURE

Many of the problems in coastal area management arise from, among other things, widespread and severe market failure. Important sources of market failure include public goods, externalities, open access, and lack of secure property rights.

Public Goods

Public goods will not be efficiently produced by a private economy. This occurs because the efficient price for allocating a public good is zero, since enjoyment of the public good implies no cost to society--the full amount of the good remains to be enjoyed by others. However, if price is zero, then private firms will have no incentive to produce the good, since there is no revenue to be obtained from selling the good.

Thus, a competitive market will tend to underproduce pure public goods, since if firms charge a nonzero price in order to cover costs, consumers will not consume enough of the pure public good; if consumers pay a zero price for the public good, firms will have no incentive to produce the good. Hence, at the efficient price there is no incentive for private firms to supply public goods. Public goods will be efficiently provided only through collective action, such as by the government financed, for example, through taxes.

Recall the hypothetical case study of Challenge Bay in Chapter 1. Several important public goods are of concern in this case. These include: improvements in Bay water quality, avoidance of widespread unattractive urban development and unsightly timber harvesting around the Bay, preservation of mangroves and the many services they are believed to provide, and avoidance of loss of wildlife due to habitat destruction and the problems posed by population growth. Given the important public good features of these and other coastal area issues, little incentive exists for individual actions to prevent further deterioration or to pursue improvements.[3]

Externalities

External costs are losses imposed on consumers or firms by other consumers or firms. Typically, externalities are uncompensated side effects stemming from activities by individuals or firms. For example, oil spills from tankers or barges or discharges of wastes from businesses may impose substantial losses on mariculture operations, recreation, and other uses of coastal waters. Unless firms internalize the costs their actions impose on others, the firms' costs will reflect only private costs and not the full costs of its operations which include private costs *plus* environmental costs. Since true costs are understated, firms will produce more than is optimal and will charge too low a price. Those who bear the environmental costs will be subsidizing the consumers of the goods. Refering back to the hypothetical case study of Challenge Bay, important potential external costs to artisanal fisheries, mariculture, and recreation would occur due to runoff of fertilizers and animal wastes from upland agriculture and sedimentation from large-scale timber harvesting. Also, the proposed diversion of water for agricultural use would reduce water quality and hence, productivity in the Bay. A lack of incentives to reduce fertilizer use, to use best-management practices to control runoff from agriculture and timber harvesting, and to pay the full costs of diverted water prevented internalization of these external costs.

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3 To be sure, some community members will undertake environmental actions to avoid further harm or to improve the situation if they judge their private benefit to be greater than their costs, or perhaps they will do so out of public spiritedness. These actions will tend to be limited however, because of the public good/free rider problem.

Lack of Well-Defined Property Rights

Open access, as in the case of fisheries, is a classic problem of lack of well-defined property rights. Unless traditions or customs exists to limit effort, with open access fishing effort will increase as long as economic profits exist in the fishery. Effort will expand until the open-access equilibrium is reached and only normal profits are being made. Under open access, none of the fishermen will have any incentive to conserve fish stocks, since if they do not catch fish, someone else will. This implies that fish populations will be driven down to low levels. Substantial inefficiency results since the same level of catch as in the open access equilibrium can be obtained by applying a lower level of fishing effort, which will allow the population to increase and increase catch per unit of effort.

Lack of well-defined property rights is a particularly serious problem for coastal area management in developing countries not only for fisheries but also for land use. For example, small-scale farmers or residential landholders may not be certain that their ownership rights to property are secure. Individuals with insecure property rights to land may fail to take conservation measures, for example, to reduce erosion if they believe that they cannot capture the gains from their actions.

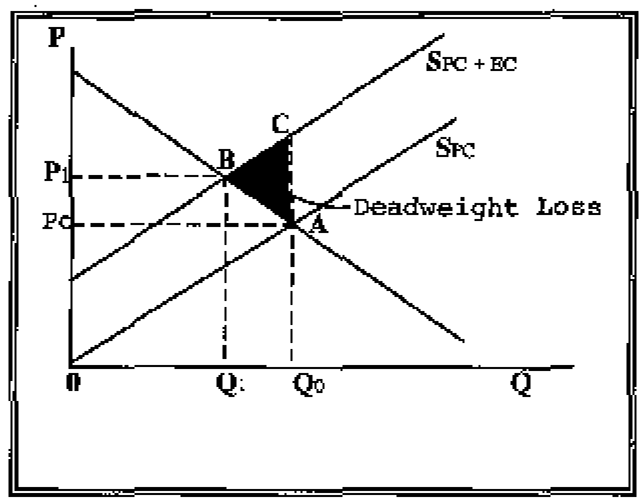

Fig. 2.6. Deadweight loss due to external cost

The consequences of externalities for the measure of economic surplus are illustrated in Fig. 2.6. S_{pc} represents the aggregate marginal cost curve, which is the supply curve in the short run. Since firms are not forced to internalize their external costs, they consider only private marginal costs and produce quantity Q_0 at price P_0. Hence, they ignore the external costs of producing at Q_0, measured by A-C. However, the true costs of the firms' operations include both private costs and external costs. If these external costs of producing Q_0 were internalized, the marginal cost curve would shift up to S_{pc+ec}, price would increase to P_1, and output would decline to Q_1. In this case, failure to internalize the external costs leads to excessive production, too low a price and external costs (referred to as a deadweight loss) indicated by the hatched area. These losses in practice can be substantial; methods to estimate the costs are reviewed in Chapters 3-7.

In summary, market failure is a major source of underlying problems for coastal area management. Many of these market failures involve complex interactions among resource uses and pose challenging issues for natural scientists to sort out cause-and-effect linkages, for example, between erosion or water diversion and the productivity and services provided by an estuary. These scientific issues are outside the scope of this document. Market failures also pose difficult issues for policy makers concerned with devising policy instruments to address problems in the context of coastal area management. Policy instruments which might be useful for addressing some of these sources of market failure are described in Chapter 8.

2.5 ALTERNATIVE MEASURES OF VALUE

Economic Impact Analysis

Above, we discussed the concept of economic surplus as a measure of value. However, other methods of valuing resource-related actions have been proposed. One method that is commonly used to measure value of market related activities is the notion of economic impacts. The economic impact of a project is often described, usually by proponents of development, as the total market expenditures of all actions related to a particular project. For example, in our hypothetical case study, there are proposals to develop a section of an attractive coastal park near Challenge Bay for a tourism hotel. Building of hotels in turn requires production of concrete, leading to demand for machinery, gravel, etc., as inputs to the production of concrete, which in turn requires inputs to the production of gravel and machinery. Once the area is opened to tourists, tourists spend money on hotels, meals, tours, etc. These are the direct effects. In addition, the original expenditure leads to demands for goods and services that serve as inputs to the production of the facilities. This is termed the indirect effects of the original action. However, a portion of the money that goes to employees of these businesses, is in turn spent on food, clothing, housing, etc., and a portion of this money goes to employees of these businesses, etc. This category of economic effect is termed the induced effect, where the original expenditure results in income to employees, which leads to additional expenditures by these workers, resulting in additional income to employees in subsequent rounds of spending[4]. The full economic impact is measured as the original expenditures, plus the indirect and induced effects.

Indirect and induced effects are often calculated using multipliers, which can be calculated as follows. Suppose that employees spend all of their income on goods and services produced locally. Also assume that at each stage, 50 percent of expenditures goes to paying local employees, and that the remaining 50 percent goes elsewhere, like payments of materials or towards profits of the firm. In this case, 50 percent of the original expenditure go to employees, who spend this money on local businesses. In

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[4] Strictly speaking, a full impact analysis would account for other sources of income in addition to wages.

turn, 50 percent of this expenditure goes to employees of these local businesses, who spend this money on other local businesses. The induced effects can be calculated as:

$$.5+.5*.5+.5*.5*.5+\cdots=\sum_{i=0}^{\infty}.5^{i}=\frac{1}{(1-.5)}-1=1$$

Thus, the induced effect is equal to 1 times the direct effect. If the estimated total tourist expenditures from opening an area to tourism is $2 million, the induced effects are estimated to lead to an additional $2 million in economic activity.

Similarly, if 25 percent of the original expenditure goes towards purchase of local inputs, and 25 percent of that, in turn, goes towards purchase of local inputs, etc, then the indirect effect is estimated to be:

$$.25+.25*.25+.25*.25*.25+\cdots=\sum_{i=0}^{\infty}.25^{i}-1=\frac{1}{1-.25}-1=.33$$

Thus, in this example the indirect effect is one third of the direct effect. Thus, given a direct expenditure, the total economic impact is the direct effect plus the indirect effect plus the induced effect, which is 2.33 times the original expenditure. Thus, total economic impact is calculated by using a multiplier of 2.33 times the direct expenditure. If the direct expenditures of tourists is $2 million, the total economic impact - measured as expenditures - is $4.66 million (2.33 * $2 million).

Economic impact analysis can provide useful information to decision makers to be used as part of the planning process. For example, large-scale tourism development may lead to significant population and traffic increases and increased demands for public services which planning agencies will want to take into account. Impact analyses can be useful for these planning purposes. However, there are several problems with economic impacts as a measure of economic welfare or surplus. First, economic impact views the costs incurred as a measure of benefit. Economic impact analysis measures do not look at the value obtained from a project, but only the expenditures needed to carry out a project. Thus, economic impact analysis views costs as benefits. The more costly a project, the higher the economic impact, independent of any benefit that might be obtained from a project. In the extreme, economic impact analysis could imply large positive effects ("impacts") for an extremely expensive project that provides absolutely no benefits whatsoever. Indeed, the logic of economic impact analysis suggests that a project which resulted in substantial environmental harm, for example, a new unregulated chemical plant which required major employment of medical personnel to treat local residents suffering exposure to dangerous chemicals, was good because it resulted in large impacts.

If building a hotel requires gravel to be used to make cement, economic impact analysis views the purchase of gravel as a benefit of the project, not as a cost. However, use of gravel to build hotels can result in environmental damages from removing the gravel from its original site which could result in environmental impacts, such as impacts on fish populations if gravel is obtained from aquatic sources. Economic impact analysis ignores these environmental impacts; in fact, unless supplemented with special studies using the concepts and techniques outlined in the document, impact analysis ignores all non-market valued external costs.

In addition, economic impact analysis ignores the fact that many of the resources that serve as inputs are themselves valuable, and using these resources as inputs to these projects means that the resources are not available for use elsewhere. For example, economic impact analysis implicitly assumes that the laborers hired to work in the hotels would be unemployed and have zero opportunity costs if it were not for this project. If these laborers could obtain other jobs, although perhaps lower-paying, then if the project is not built these laborers would earn a wage doing something else, would spend this smaller sum of money, which in turn generates employment and income to others.

This raises the concept of opportunity cost. The opportunity cost of a resource is the value of the resource if it is put to its best alternative use. If potential employees at the hotel have an alternative of working in agriculture at $60 per week, this defines the opportunity cost of these laborers. If the hotel hires these laborers for $65 per week, they give up the opportunity of working at agriculture, so that their net gain from having the option of working at the hotel is $5 ($65-$60). The benefit derived from working at the hotel is the wage minus the opportunity cost of labor. Unless the hotel hires unemployed labor that has no other productive options, including working at home, the benefit provided by the hotel job is less than the wage. However, calculating the opportunity cost of inputs is not generally an easy thing to do since it is difficult to determine what alternative means of utilization are available. For example, if a hotel hires someone currently working from agriculture, which in turn opens up a job in agriculture for an unemployed individual, then the correct opportunity cost to use is the opportunity cost of the unemployed individual. In general, use of induced effects is more valid when unemployment is high, and is less valid when unemployment rates are low.[5]

Similarly, other resources that are used as part of the project also have opportunity costs. If gravel is used to build a hotel, this could mean that gravel will not be available to build needed roads. Thus, when one attempts to value gravel used to build the hotel, one needs to consider whether that gravel has other productive uses. Only resources that have no other use, including possible future use, should expenditures on

5 Even when unemployment is high, labor will still have an opportunity cost (a shadow value) which should be taken into account.

these resources be viewed as a project benefit. Impact analysis results may be adjusted to take opportunity costs into account using the concept of shadow prices (Squire and van der Tak, 1975).

In cases where inputs are fully utilized, the price is equal to the opportunity cost of the input, so that none of the expenditures on inputs should be counted as project benefits. In this case, indirect and induced effects become zero and input costs are subtracted from gross revenues, which results in producers' surplus being the appropriate welfare measure. Finally, economic impact analysis ignores any consumer benefits that are obtained. In comparison, economic surplus measures benefits accruing as consumer's surplus.

The difference between economic surplus and economic impact as a measure of benefit can be depicted as in Figure 2.7. Here, economic surplus is the sum of consumers' plus producers' surplus, and is the sum of the areas above the supply function but below the price line plus the area above the price line but below the demand function, which is the area with vertical lines in the Figure 2.7. The direct economic impact is the total expenditure, which is represented by the rectangle 0Paq, indicated by the area with horizontal lines in Figure 2.7. The indirect and induced effects are calculated by multiplying the direct economic effect by the multipliers, as appropriate.

Energy Analysis

Another measure of value that has been proposed is energy analysis (Shabman and Batie, 1978) . This approach starts by tracing energy flows within a system in order to calculate the total amount of energy that is embodied in a system, both direct and indirect.

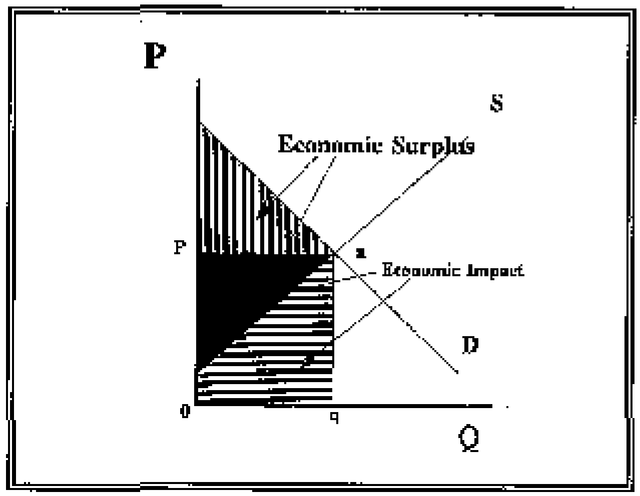

Figure 2.7 Comparison of Producer's Surplus and Economic Impact

For example, the energy embodied in a fish dinner would be equal to the total energy that is needed to produce that dinner. This would include the energy needed to produce the food upon which the fish feeds traced through the entire food chain. In addition, energy is needed to catch the fish, to transport the fish to market, and to prepare the fish for eating. The energy embodied in the fish on a plate is equal to all of the energy needed to sustain each of these components of production.

The energy theory of value calculates the value of this dinner by taking the energy content then multiplying by a price per unit of energy. The price per unit of energy is calculated by dividing total energy use in the country by the gross national product of the country which is generated by that energy use.

The energy theory of value is not based on human values. Rather, it is based on an assumption that energy is the only thing of value, and that energy has a fixed value, independent of its form. Logically, this would imply that a cyclone or an earthquake is enormously valuable. Similarly, a distant star is something of extremely high value. This also implies that a highly polluted eutrophic lake is more valuable than a pristine lake that is less biologically active.

Energy analysis may have uses in tracking energy flows within a system, but it makes no attempt to account for the desirability of the final product that results from energy flow. Clearly, some forms of energy results in highly desirable products, some less desirable, some undesirable. Thus, energy content is not a logical basis for measuring human values and we do not consider this approach further in this document.

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3. THE TRAVEL COST METHOD

3.1 INTRODUCTION

The travel cost method may have been the first non-market approach to value a good. It was discovered as a solution to an urgent practical problem. The state of California was trying to evaluate the economic feasibility of a water project and needed to estimate the benefits of recreation use at a reservoir. It could as well have been a seashore beach, marina, underwater park, or sport fishing at a given area. Consultants working for the state were aware of an evaluation technique recommended by H. Hotelling, the famous economist, in the late 1940s for determining the economic value of U.S. National Park services.

There is a crucial characteristic common to all applications of the travel cost method. Visitors, actual or potential, located at different origins visit a common site at which, it is supposed, no entry fee is charged. As such there is an exceptionally simple driving force in the situation: individuals from different origins bear different costs to enjoy the same good. Therefore rates of participation should differ. This is just what a demand relation is, a quantity response to different "prices" or costs borne by the participant in this case.

While hundreds of travel cost studies have been done to estimate the value of a site, very few actually involve valuing elements of a coastal zone environment. However, it is apparent that the travel cost technique can be used to address such policy questions as:

a. What are the economic benefits of retaining, improving the environmental quality of or creating a site for multiple marine activities (Parsons and Kealy, 1992; Parsons and Needelman, 1992); or fishing (Caulkins, *et al.*, 1986; Kaoru, 1988; Carson, Hanemann and Wegge, 1987; Cooper and Loomis, 1990; Morey, *et al.*, 1991; and Bockstael, *et al.*, 1989). All of these studies are a variety of random utility "nested logit" models, see Appendix A. According to this specification individuals are assumed to make a complex choice in a sequential manner. For example, first they decide which one of many sites to visit. Then they may decide how they want to fish--from a boat, from the shore, then they decide which species to search for. The most elaborated study of this type is that of Carson (1987), the decision tree for which is illustrated in Figure 1.

b. What are the economic costs of having to close a beach or other site because of quality changes? (McConnell, 1987 and in future paragraphs).

The plan in this chapter is to set out the assumptions necessary for conducting a travel cost study, work through the method analytically, work through an example, discuss applications and critically evaluate the method. Useful surveys of the travel cost

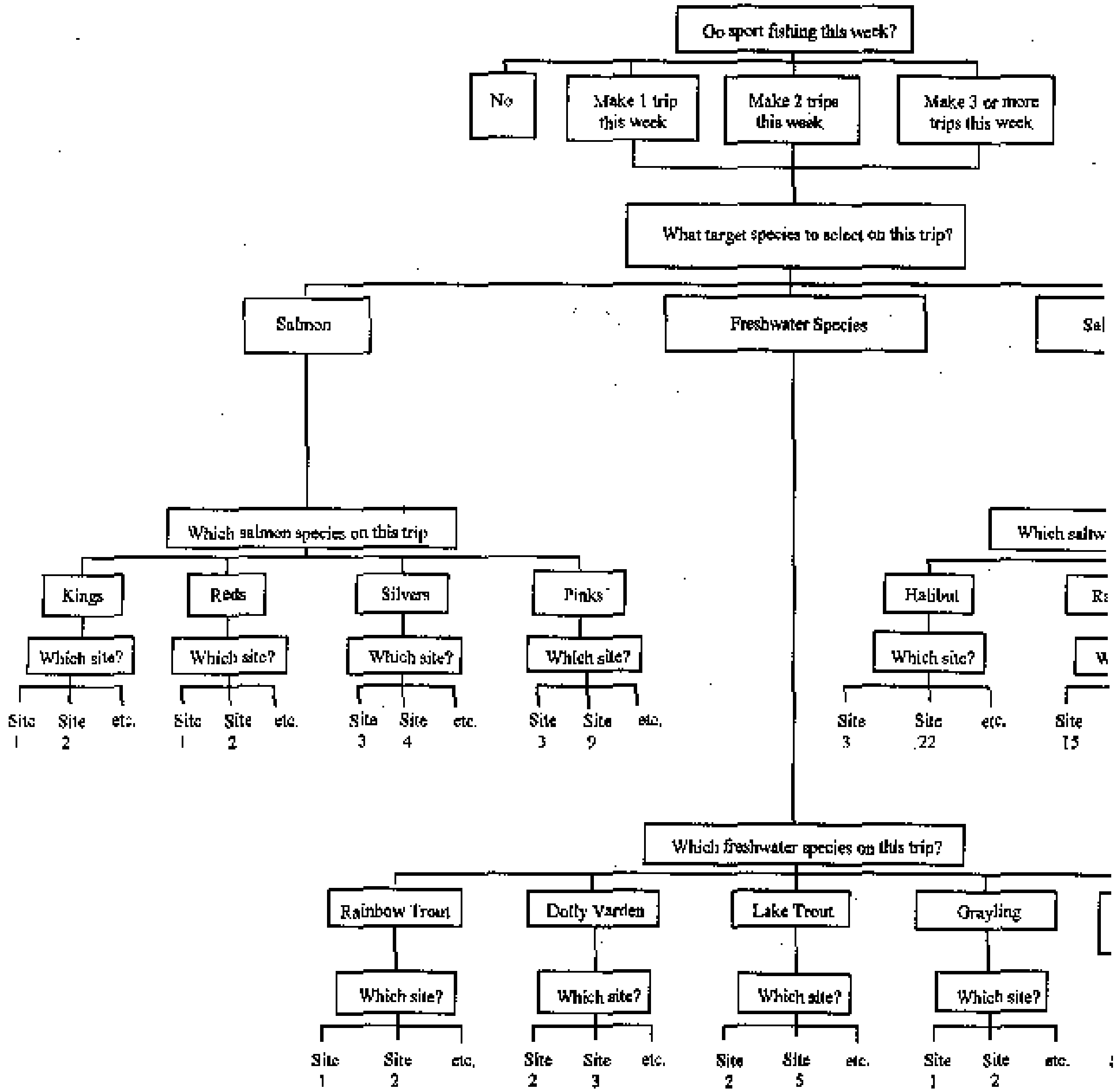

Fig. 1: DECISION TREE FOR RESIDENT ANGLER'S DEMAND FOR SPO

method include Bockstael, *et al.*, 1991; Smith, 1989; and a summary of applications is presented in Walsh, *et al.*, 1988.

3.2 CONCEPTS AND DEVELOPMENT OF METHOD

Basic Assumptions

Assumption 1. Individuals take a trip for a single purpose: to visit a site which we will call a beach.

Assumption 2. Individuals receive no satisfaction from the travel necessary to reach the beach. If they do, then a given travel cost expenditure is satisfying both the taste for travel and for the site, a joint good. Since interest is in valuing the site, the assumption that travel has no value enables the researcher to avoid the problem created by a joint good.

Basic Methodology

The traditional approach is to partition the area around the beach into N concentric zones and to assume that people in any given zone travel the same distance d_i to reach the beach site (Figure 2). In practice, most people may come from a reasonable selection of cities so cities could be the "zones." Alternatively, there may be political subdivisions such as counties in the U.S.

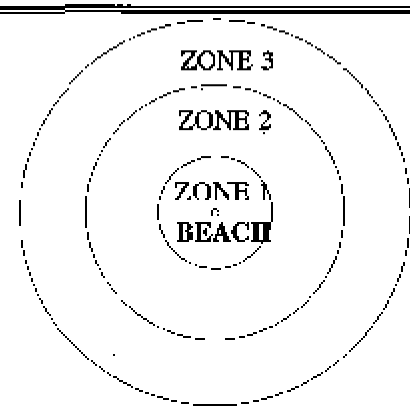

Figure 2: Concentric Travel Zones

Each origin has an estimated number of visitors V_i and population N_i for a given period, say a year. From these data, an adjustment or normalization is made for different sized origins to obtain a visitation rate X_i per unit of population,

$$X_i = \frac{V_i}{N_i}.$$

The next step is to estimate the travel cost from each origin to each destination. As a first approximation, assume that the cost per mile is a constant, c, that does not vary from individual to individual or from zone to zone. This is a strong assumption to which we return in subsequent discussion.

These are all the ingredients necessary for valuing the beach site. Let's solve the problem with the use of figures first. Conceptually, the travel cost method has two stages. In the first stage, the researcher estimates using cross-section (Zone) data, visitation rate as a function of trip cost - cost per mile c, distance d, - and any other demand determinants thought to be important such as income M, or the price of substitutes P_{sub},

$$X = f\ (\ c\ d\ ,\ Income\ \ ,\ P_{sub}\ )\ .$$

In the second stage, the researcher revises the estimates of the first stage to derive a demand curve for the park.

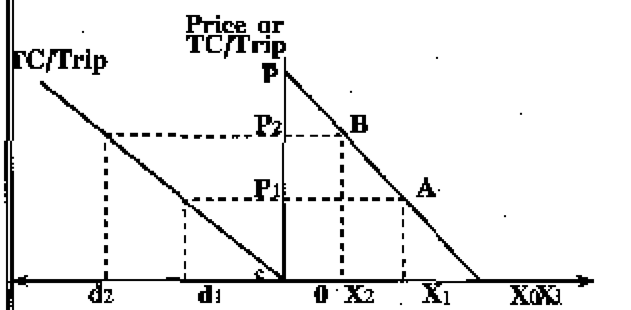

Figure 3: Construction of Travel Cost Demand

The first stage is accomplished in the following way: by assumption the visitors who live next to the beach (in Zone 0) incur no travel cost. See X_0 in Figure 3. The space to the left of the origin in Figure 3 is used to construct the total cost of a trip from each Zone. The total cost of a trip is the product of the constant mileage cost c and the miles d_i for each zone i. Thus the cost of a trip from Zone 1 is cd_1, or P_1. See Figure 3. Total trips or visits is X_1. Point B in Figure 3 is constructed similarly, by matching up the visitation rate for Zone 2 with the trip cost from Zone 2 which is the product of miles d_2 and cost per mile c or P_2.

Estimating the Demand Relation

What is the demand relation for this beach for the people who live at the site? It is P_0X_0. Why? By assumption, people who live at the site have the same tastes, endowment and face the same set of prices, except for the price of a trip to the beach. Alternatively, statistical methods are used to control the differences in socioeconomic variables among individuals in the population. Therefore, if those living at the site were charged an entry fee of P_1, we would expect them to visit the beach at the same rate as those who in fact must incur a travel cost of P_1. They visit the beach at the rate of X_1. This reasoning can be repeated for every other point on the line P_0X_0 where P_0 is interpreted as the reservation price, above which no quantity is demanded. We have, of course, assumed for convenience that, had we chosen any other zones or prices the resulting quantity would fall on the line P_0X_0. What is the demand for the beach for residents of Zone 1? It has height P_0 - P_1 and is exhibited in Figure 4, Panel (ii). Illustratively, incurring a travel cost of P_1 to get to the beach, residents from Zone 1, facing an additional entrance fee of P_2 - P_1, would be expected to purchase trips at the same rate as those who currently pay the same cost P_2 ; i.e., those residents in Zone 2 who purchase X_2. Zone 1's demand for the beach site is exhibited in Figure 4 as are the demand "curves" for the other two zones.

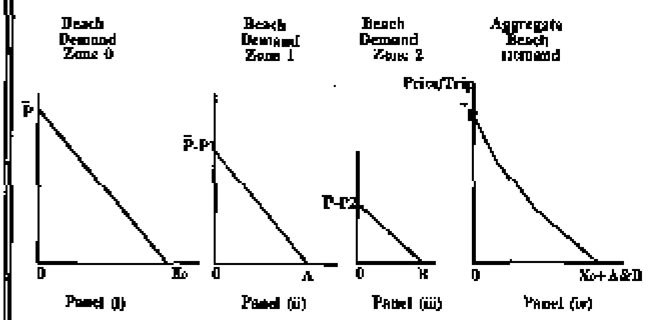

Figure 4: Beach Demand

The aggregate demand curve for the beach site is panel (iv) in Figure 4. It is a simple horizontal aggregation of the individual demand curves--in this case, "individuals" means zones.

Consumer Surplus

What is the economic benefit of the beach site? A useful measure of consumer *economic* benefit is consumers' surplus--the difference between what people are willing to pay and what they do pay (see Chapter 2). In this case the consumer's surplus for those residing at Zone 1 is the difference between what they are willing to pay in Figure 3 and what they do pay in Figure 4, panel (ii), adjusted for population in the zone. Total consumers' surplus for the beach site is therefore the total area under the demand curve *for the beach site* in Figure 4, panel (iv) but adjusted for the population in each zone. This amount is the net economic benefit of the beach site from the individuals' perspective or accounting stance. It is not the *net* economic benefit of the beach site from the perspective of society. For this net benefit, the opportunity cost of society bears of providing the beach services (excluding the individual travel costs already netted out) must be subtracted. Pursuing these opportunity costs takes us beyond the travel cost method.

Valuing an Existing Site

The following example illustrates the travel cost method. Table I summarizes the basic data. Suppose that the vehicle cost per mile for fuel, oil, etc. is \$.20. Left out of the development so far is the fact that there may be an opportunity cost of travel time. Assume for now that it is \$6 per hour and that the automobile travels 60 miles per hour. That is the opportunity cost of time per mile is \$.10. Travel cost for Zone 0 is 0 and for Zone 1 is

$$TC_1 = \$.2d_1 + \frac{Opp.\ Costs}{Hours} * \frac{Hours}{Miles} * d_1$$
$$TC_1 = [\$.2 + \frac{\$6}{60}]\, d_1 = \$.3d_1$$

Consumer's surplus (CS) can be calculated casually by observing Figure 5 and Table 1. Zone 0's CS is the area under its demand curve

$$CS_0 - \frac{1}{2}(Base)(Altitude) = \frac{1}{2}(72)(72)$$
$$CS_0 = 2592$$

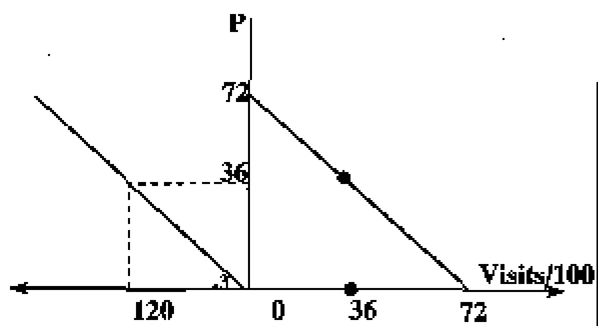

Figure 5: Illustrated Travel Cost Example

TABLE 1: TRAVEL COST EXAMPLE		
	Zone 0	Zone 1
Population N_i in Hundreds	1.00	2.00
Visits, Q_i	72	
Visits/100, X_i	72	36
Miles d_i	0	120
Travel Cost (TC)/Trip (\$) CS/100	1	36

Consumer's surplus/100 for Zone 1 is the area under its demand curve

$$\frac{CS_1}{100} = \frac{1}{2}(36)(36) = 648$$

but the population is 200 so

$$CS_1 = 1296$$

Therefore,

$$CS = \sum CS_i = 3888$$

More formally, from the data in Table 1, a demand function (period in population) can be derived. It is

(1) $$X_i = 72 - P_i .$$

Then from (1), generally,

(2) $$CS_i = N_i \int_{P_i}^{P_0} (72 - P)\, dP .$$

In particular,

(2.1) $$CS_0 - N_0 \int_{0}^{72} (72 - P)\, dP = 2592$$

(2.2) $$CS_1 - N_1 \int_{36}^{72} (72 - P)\, dP = 1296$$

$$CS = \Sigma\, CS_i = 3888 .$$

Notice that the demand function is integrated from the price paid or cost borne P_i up to the reservation price P_0 in (2.1) and (2.2).

Valuing a New Site and the Quality Change at an Existing Site

Consider how to estimate the value of a proposed new site. The function underlying the estimated site demand equation is meant to be general. As long as the new site is believed to be like the old site, then one needs to collect data on travel cost, income and the other independent variables for the zones or population around the proposed new site and plug it into (2) to get the values for the new site. An exceptionally simple formulation illustrates the application to a new site. In the original numerical example, it was assumed that 72 visitors came to the beach site from Zone 1 located d_1 = 120 miles away. Recall that the travel and time cost was $36 because the cost was $.30 per mile. Suppose Zone 1 was in fact two cities A and B, each of population 100 and there were 36 visitors each from two cities. Now suppose that a new beach site just like the old site is proposed one-half the distance from city B to the old beach. No other cities are around. The geography of all this is illustrated in Figure 6. Since the previous analysis was based on visits per 100, it fits in immediately here with no modifications necessary. The people from city A continue to go to the old beach as do those who live at the old beach. Those in city B now can buy the same beach--same by assumption--for one-half the real cost of the old beach or 18. They respond by visiting the beach at the rate of 54 per 100 population because the estimated demand relation (per 100) is

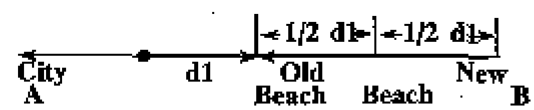

Figure 6: City and Beach Geography

(3) $$X = 72 - P$$

Consumers' surplus is the gain from being able to pay $18 instead of $36 per trip or $810. It is the area under the demand curve between two prices. See Figure 7 or

$$\int_{P_1}^{P_2} (72 - P)\, dP = \int_{18}^{36} (72 - p)\, dP$$

This proposed site is a good idea on economic efficiency grounds if the opportunity cost of the site is less than $810 annually. Other potential origins of visitors to the proposed site can be handled by plugging their relevant socioeconomic data into (1).

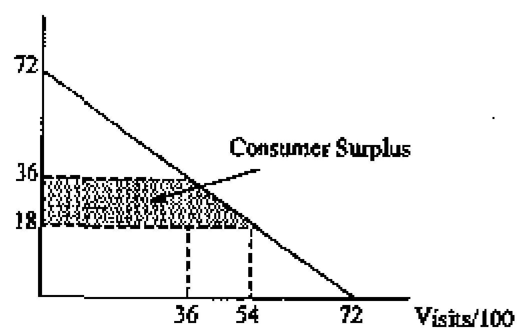

Figure 7: Valuing a New Site

Valuation When Characteristics Differ Among Sites

It is a more complicated task to value a proposed new site if it is not like the old site. Travel cost simply will not work unless the new site is like an old site. We sketch this case briefly. Suppose there are two or N old sites that differ in one dimension such as size, cleanliness of beach or availability of services such as windsailing. The proposed new site will resemble one of the existing sites. Then the researcher does a travel cost study for the two or N sites and obtains a 2 or N dimensional version of (3):

$$X_1 = f\,(P_1,\ P_2,\ K,\ P_N,\ M,\ other\quad socioeconomic\quad variables\ )$$
$$X_2 = f\,(P_1,\ P_2,\ K,\ P_N,\ M,\ other\quad socioeconomic\quad variables\ )$$
$$X_N = f\,(P_1,\ P_2,\ K,\ P_N,\ M,\ other\quad socioeconomic\quad variables\ )$$

Having estimated this system of equations, the researcher then introduces the new site into the suitable equation. Suppose we call old site 1 "small" and old site 2 "big." If the proposed site is *big* then the $X_2 = f\,(*)$ equation for big beaches is appropriate. The first application of this approach was Burt and Brewer (1971) to a series of reservoirs with recreational opportunities and interest was in valuing the recreation benefits of a proposed reservoir.

A variation of the last example is to estimate the fraction of visitors going to each of a set of beaches (Feenberg and Mills, 1980). Caulkins, *et al.*, (1988) did just this and specified that the fraction depended on distance to a beach around the Boston, Massachusetts area, water temperature, water quality as measured by a fecal coliform count in mid-summer and a dummy variable to pick up the distinction between fresh and salt water. The authors used a conditional, multinomial logit estimation procedure to estimate the model. See Appendix A for a discussion of this method. Having estimated the model, one can calculate the value of a given site which depends, in part, on the characteristics of the particular beach, such as its water quality or water temperature. Then it is a simple matter to compute the change in value as a beach quality characteristic is changed.

3.3 EXAMPLE APPLICATIONS TO COASTAL ZONE MANAGEMENT

Estimation of lost recreation value

When authorities discovered hazardous waste in a marine environment in Massachusetts, some activities at some beaches were prohibited, leading to a loss of welfare. The United States government is required to sue for damages. McConnell (1987) estimated the lost recreation value due to decreased beach activity using the travel cost method. A survey was designed and administered by telephone because no usable data existed either on beach attendance before or during the closure. Several beaches were involved and the task was to estimate demand functions for beaches with pollution and demand functions for beaches without pollution. The value to be estimated is illustrated by the area between two demand functions for a representative beach in Figure 8, *dd* and *ba*, where *dd* is the demand curve in the absence of pollution (Polychlorinated Biphenols [PCBs]) and *ba* is the demand curve in the presence of pollution (PCBs).

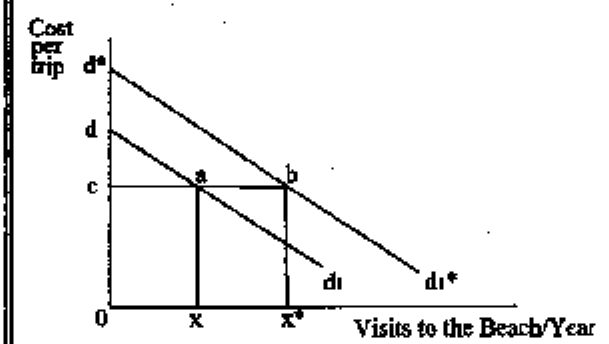

Figure 8

Four beaches are in the study. The contaminated ones are East (which includes another like it in quality and distance), and Fort Phoenix. The substitutes are West Island and Demarest Lloyd.

The demand functions are:

$$X_{ij} = g\,(\,PEB,\ PFTP,\ PSUB,\ PASS\,) + e_{ij}$$

where

X_{ij} = trips by ith household to jth beach;
PEB = cost of getting to East Beach for the household;
PFTP = cost of getting to Fort Phoenix for the household;
PSUB = cost of the cheaper substitute, West Island or Demarest Lloyd;
PASS = 1 if the household has a pass to Fort Phoenix, 0 otherwise.

McConnell used the wage rate net of taxes as the opportunity cost of time and a travel cost of $.08/mile. The demand functions illustrated in Tables 3 and 4 were estimated using a Tobit estimation procedure in recognition that there are a lot of zero quantity observations in the survey data. The Tobit model is described in Appendix B.

Since the beaches would be affected for some years, growth in the absence of pollution had to be estimated, capacity constraints or congestion effects had to be recognized and the sample survey, expanded to the population on a simple proportionate basis. The estimated damages to beach recreation due to pollution was $11 million in 1986 dollars.

TABLE 2

DEMAND COEFFICIENTS FOR PLANNED 1986 TRIPS:
WITH PCBs FROM MCCONNELL (1987)

Variables	Const	PEB	PFTP	PSUB	PASS	Log Liklihd	# Obs
East/West	-23.6 (2.6)	-9.52 (3.4)	-1.9 (.82)	5.62 (2.5)	34.9 (2.7)	-845	495
Ft. Phoenix	-9.2 (3.4)	1.84 (2.2)	-1.38 (1.98)	-.32 (.48)	9.7 (2.4)	-626	495

NOTE: PEB = Travel Cost or Price for East or West Beach.
PFTP = Travel Cost or Price for Fort Phoenix.
PSUB = Travel Cost or Price for the Least Cost Substitute.
PASS = 1 if the Household has a Pass to Fort Phoenix;
= 0 Otherwise.

TABLE 3

DEMAND COEFFICIENTS FOR 1986 TRIPS:
WITHOUT PCBs

Variables	Const	PEB	PFTP	PSUB	PASS	Log Liklihd	# Obs
East/West	-16.8 (1.8)	-13.87 (4.7)	-.33 (.14)	8.99 (3.8)	38.5 (2.65)	-1268	495
Ft. Phoenix	-5.15 (1.4)	1.1 (1.0)	-2.68 (3.0)	1.3 (1.5)	23.4 (4.7)	-1132	495

NOTE: PEB = Travel Cost or Price for East or West Beach.
PFTP = Travel Cost or Price for Fort Phoenix.
PSUB = Travel Cost or Price for the Least Cost Substitute.
PASS = 1 if the Household has a Pass to Fort Phoenix;
= 0 Otherwise.

3.4 EVALUATION

The researcher undertaking a travel cost method should be aware of possible pitfalls.

a. The travel cost method is an application of household production theory. The individual or family combines its own time and travel services with a site to produce a recreation experience. By assuming there is no pleasure in travel to the site, the researcher in effect is attributing all the travel cost to the "purchase" of the site. By this assumption, any consumer surplus associated with the "purchase" will then be attributed to the site. The value of the site will be overestimated in so far as people enjoy the sights along the road and talking with others in the car or train or airplane or other travel mode. Some travel, truly is a means to an end and some travel may be nerve racking in which case the vehicle costs will be an underestimate of true cost. No empirical research to our knowledge has seriously explored this assumption.

b. The much stronger assumption in our judgment is that a trip is single purpose. People from North America may stop in the United Kingdom or Europe on the way to a safari in Africa. People may visit their relations and also go to a beach. People may visit two or more countries in Africa. There is no rigorous way to finesse this problem. The researcher can ask respondents if their trip was multiple purpose and omit all those who respond affirmatively. What then is their value of the site under study? Other things equal, probably less but rarely are other things equal and usually they are unequal in the variables omitted from analysis.

The researcher can ask respondents to allocate their overall satisfaction with the trip over its components. In order to estimate the viewing value of elephants in Kenya, Brown and Henry (1993) asked respondents to allocate pleasure from the trip over wildlife viewing and other facets of the trip. Then they were asked to allocate the enjoyment on the safari over the cats, elephants and other elements. See Table 2. These are average, not marginal values, and the survey question design is controversial because it can innocently elicit inaccurate responses. Another alternative is to use the marginal travel cost from the last destination, but this is a pragmatic strategy.

TABLE 2: ALLOCATING TOTAL VALUE AMONG ITS DETERMINANT

People travel to East Africa for many reasons. Thinking about the pleasure and enjoyment you are experiencing (or have experienced) from your visit, what percentage of your pleasure would you attribute to each of the following? *(Please make your responses add up to 100 percent)*

	Percent
Seeing, photographing and learning about the wildlife	50
Accommodations, staff and services, drivers	20
Observing and learning about Africa and its cultures	10
Rest, relaxation, and shopping	9
Other experiences	2
	100%

Thinking just about the *wildlife* and the pleasure and enjoyment it has or is giving you, what percentage of your enjoyment of the wildlife would you attribute to each of the following?

(Please make sure your responses add up to 100 percent)

Seeing the big cats including lion, leopard, and cheetah	28
Seeing large numbers of a variety of wildlife species	29
Seeing African elephants	25
Learning about the ecology and animal behavior	16
Others (specify):____________________________	2
	100%

NOTE: The share of total value of a safari attributable to viewing elephants is the product of wildlife viewings' share and the share specific to viewing elephants: (50 x .25 = 12.5%).

c. The opportunity cost of time is a critical element in the analysis, yet too little is known about how accurately and practically to deal with it. To see the critical role it plays, just recalculate CS in the above example on the assumption that the opportunity cost of time is 0 and convince yourself that it reduces CS by one-third. Researchers using alternative measures for the opportunity cost of time routinely show that estimated CS is *very* responsive to changes in different assumptions (Cesario, 1976 and Cesario and Knetsch, 1976). Other researchers combine analytical models with statistical techniques such as maximum likelihood estimation, to estimate that implicit opportunity cost of time which best fits the data. The range of estimate is 30 to 60 percent of the wage rate - a fairly large range. (see McConnell and Strand, 1981 and Kealy and Bishop, 1986). In a similar vein, McFadden (1974) used observations on choice of urban travel (to work) to estimate the implicit value of time when individuals chose more expensive but faster modes of travel. The revealed opportunity cost of time was around 40 percent of the wage rate.[1] There has been a tendency in travel cost studies to use a fraction such as 30-45 percent of the wage rate, perhaps in recognition of McFadden's careful estimate of the opportunity cost of time. Researchers should realize that there is then a further untested assumption, that the

1 In response to alarmed, strict neo-classical economists, who wondered why the opportunity cost of time did not approximate the wage rate net of taxes, McFadden said (in a seminar) that travelling to work is the only time individuals can have time to themselves. Evidently commuting time has some positive value.

value of travel time to work equals the value of travel time to a recreation site: The basic question, of course, is opportunity cost. What truly is being forgone when we travel to a recreation site? If one really would have worked, then it is the appropriate disposable fraction of the actual wage earned.

If we should value the opportunity cost of travel time, should we not value the opportunity cost of on-site time? The simple answer is no. It is no if the relevant substitute activity is spending the time on an alternative recreation activity. That seems like a reasonable assumption.[2]

In principle, recreationists vary in the flexibility of their working time. The opportunity cost of one day of leisure time may be low for some and high for others, even if both earn the same wage because one may be able to work as many hours as desired over the relevant range. In practice, it is difficult to sort this out empirically.

d. The travel cost method estimates use values. Any non-use values such as the benefit people might derive knowing that the site exists or that it will be available for others to enjoy in the future are excluded. These are termed existence and bequest values. This omission is likely to grow in importance to the degree that the site in question is unique. In economic terms, it has few close substitutes. If the site is thought to be very unique, a solution is to do a contingent valuation study or some other approach to estimate both use and non-use value simultaneously. Alternatively, one can assume that non-use values are zero. Finally, as a practical expedient only, one can assume that non-use values are approximately equal to use values, a result on average found to be the case in other studies. This, of course assumes that the site is not significantly different from other sites and services investigated in the past and that one is unlikely to improve on the research methods used in these studies.

e. There has been a tendency to measure out of pocket travel costs generously. For example, a long run mileage cost which includes depreciation, repair cost per mile, perhaps even insurance cost per mile can be used. The empirical fact is that cost per mile is not what survey respondents report when asked what their mileage cost is. The difference between reported cost and the researchers imputed long run cost can vary by more than a factor of 2. The correct value is that which is in the recreationist's mind when he/she makes the marginal decision of whether or not to take the trip.

There is also a tendency to include motel, food costs and even the cost of bait in the travel cost component. The tendency may be motivated by a desire to inflate the benefits of the site which is what it does in practice. The tendency should be avoided. Recall the critical ingredient that enables one to go from travel cost to site value--individuals get no satisfaction from travel so we can load its cost-value onto the site.

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2 On-site time costs can be disregarded if the marginal value of time and the time spent on-site are constant across observations (Wilman, 1980).

It is implausible that people obtain no satisfaction from eating the food they do and no enjoyment from the lodging services purchased. That is what the researcher must assume if these expenditures are to be attributed to the site. It makes sense to assume that people pay for what they get and the burden of proof is on the researcher to establish that this working assumption is unacceptably false.[3]

As for expenditures such as bait, their inclusion is in error. Consumer surplus arises from differential expenditures for the same experience. Everyone must purchase bait or ammunition or, in some cases, pay the same charter boat fee. These are necessary for anyone to obtain the service so there should be no difference which can give rise to consumers' surplus.

f. The travel cost method assumes that location of residence is exogenous to the frequency a beach site is used. In other words, recreationists did not choose where to live and bear any opportunity cost in order to be closer to the site in question. If one lives at the seashore and earns a lower wage than is available elsewhere because one likes seashore activities in question, then the opportunity cost of the lower wage will not be captured by the travel cost method. Such an element could be valued in principle by using an hedonic wage model. It captures the implicit value of differences in environmental quality, public services and other amenities that vary across residential locations as revealed by wage differentials for the same job description.

g. Thus far, it has been assumed that price is the only determinant of demand. The demand function can be enriched with all the variables such as income and other socioeconomic variables thought to be important, limited only by the research budget and research design. If zone data are used, then average values for socioeconomic variables have to be used. So, for example, the researcher can collect data on average income M_i for each zone i, the cost of visiting a substitute beach site P_{s_i}, average years of experience E_i, average years of education Ed_i for each zone and use these in a regression analysis to replace (1) with

$$X = \beta_0 - \beta_1 P + \beta_2 P_s + \beta_3 M + \beta_4 E + \beta_5 Ed \qquad (3)$$

One does not have to aggregate data by zones and use averages. Individual observations can be used with zone population or a transformation of zone population as an independent variable (Bowes and Loomis, 1980; Vaughan and Russell, 1982; Strong, 1983; and Rosenthal and Anderson, 1984). For some studies, zone data on independent variables such as income may be available from secondary sources of information. On the other hand, zone data with widely varying populations can lead to problems of heteroscedasticity in the error component of the model of observation

3 Every reader can recall the terrible meals (owing to the price) and lodging experienced enroute. The operational task is to estimate accurately these departures of price from value.

which reduces the efficiency of the estimation. Using individual data has its problems as well. When a lower fraction of a more distant population visits a site, as we would expect, Brown, *et al.* (1983) have shown that individual observation produces a biased estimate of consumers' surplus.

h. Purists will argue that the consumers' surplus estimated in the way described above is biased because the proper measure would emerge from the area under a Hicksian or compensated demand function in which utility, not money income, has been held constant. Fortunately there is no practical relevance to this criticism since Willig, 1976 and Hausman, 1981 have shown that the empirical difference between these two concepts is trivial compared to the noise in the data sets customarily used.

i. The usefulness of the travel cost method is limited by the fact that there is an "all-or-none" aspect to it. The travel cost method was designed to answer questions such as what is the recreation value of a beach as is? The answer contributes to the decision about whether to use the beach for an alternative use inconsistent with recreation.

Lots of policy questions are different. What is the benefit or cost of changing the *quality* of the beach a little bit? What is the value of increasing the success level of fishing by some amount, say by introducing a hatchery? To answer these questions the researcher needs data on the value of what exists now and the value of an alternative circumstance. This is a problem one dimension more complex than the traditional travel cost method is designed to answer.

j. Comments about functional form and good econometric diagnostics made in the chapter on hedonic analysis including omission and commission of variables, and heteroscedasticity also apply here.

It would be wrong to conclude that there are so many difficulties with executing a flawless travel cost study, that it should not be attempted. Rather, the researcher should try to avoid as many of the problems as is feasible with the given budget and illustrate how the value of a site varies under alternative assumptions about the opportunity cost of time and other considerations.

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APPENDIX A

DISCRETE CHOICE: RANDOM UTILITY AND MULTINOMIAL LOGIT MODELS

A recent development in the travel cost literature is the random utility model. This approach begins by assuming that each decision to make a visit involves choosing one site and excluding the others. In the random utility model, this choice takes the form of comparing the utilities from visiting each site and choosing the site that produces the maximum utility. The consumer's choice is not a random one; but if an observer cannot measure all of the determinants of utility, the indirect utility function will have, from the observer's viewpoint, a non-random element and a random error term, or $V = V' + \varepsilon$. The probability that site i will be visited, π_i, is then (again from the observer's viewpoint):

$$\pi_i = Pr\,(V'_i + e_i > V'_j + e_j)\,;\ \ for\ \ every\ \ j \neq i$$

where $V'_i + e_i =$ the utility of visiting site i.

If random variables e_i are independently and identically distributed, extreme value Weibull distributions, π_i , take the form of a multinomial logit model (McFadden, 1974; Maddala, 1988):

$$\pi_i = \left[\frac{\exp\ V'_i}{\sum_{i=1}^{m} \exp\ V'_i} \right]$$

Estimation of the model requires specifying a functional form for V'. Once the parameters of the indirect utility function are estimated, they can be used to generate partial demand systems and partial consumer surplus measures.

The common sense of discrete choice models is made more transparent by simplifying choice to one site. Each person has an underlying utility associated with visiting that site. At a low price, many would visit the site. At a high enough price, none would visit. Put differently, the *fraction* π of people potentially willing to go compared to those that will go is 1 if the price or cost is zero. As price increases, the fraction decreases until it is 0.

Figure B.1 illustrates these ideas. On the x-axis is plotted maximum willingness to pay to visit a site (WTP). Figure B.1 represents a cumulative distribution, but it is for the fraction $(1 - \pi)$ or share that is not willing to go at a given price or WTP. Ten percent would be unwilling to pay 1; alternatively 90 percent would be willing to pay 1 dollar or 80 percent would not pay 10 dollars, etc. The opposite of this, the shaded area, can be interpreted as the area under the demand curve for the site. So at the largest cost, WTP_{max}, no one wants to go. Just rotate the Figure B.1 counter-clockwise

APPENDIX B

The following explanation of the Tobit estimation procedure is drawn from McConnell (1977).

The Tobit model is designed to estimate functions which take only zero or positive numbers. For recreational applications, the model is:

$$
\begin{aligned}
x &= zb - e \\
x &= 0 \\
zb - e &> 0 \\
zb - e &\leq 0.
\end{aligned}
$$

where e, is assumed normal with zero mean, constant variance. This model is explained in detail in Maddala, Ch. 6 (1983). When price gets high enough, quantity demanded is zero. Estimating Tobit models rather than OLS (ordinary least squares) usually results in more elastic recreational demand models. The effect of using a Tobit estimation procedure is illustrated below.

The OLS model will treat the zeroes and positive demands the same, and fit a function which minimizes squared deviations from a line drawn through all the points. The Tobit procedure fits a model which explains whether people take trips at all, and given that they take these trips, what their demand curve is like. The figure shows that the OLS model estimates a slope too steep for participants, and will overestimate consumer's surplus for participants.

Returning to the more formal development, the random utility model estimates the relations between characteristics and visits to a site *conditional* on a visit being made. Consider the antecedent decision of whether or not to make *any* visit. This can be done in two ways: on a day-by-day basis or on a seasonal basis.

The decision to make a visit on a day-by-day basis can be examined by comparing two utilities: the utility of visiting the "best" site and the utility of not making any visit. Given a recreation season that is fixed in length, this model can calculate the expected number of visits per season and the expected number of visits to an individual site, both as a function of individual and site characteristics including the cost of travel.

A difficulty with the day-by-day decision model is the occurrence of zero visits for the entire season by some individuals. Most site characteristics for which data are easily obtained are constant over a season. This means that the decision to visit a particular site or to visit any site will be stationary. Unless the probability of a visit on a given day is uniformly zero across the season, the expected number of visits will be positive; indeed, the probability of zero visits will be very low.

A different means of modeling the visit/no visit decision is on a seasonal basis. This approach is used in Bockstael, Hanemann, and Strand (1986). In their model, an individual chooses the number of visits to make in a season (presumably at the beginning of the season--timing could but does not play a significant role in these models) with zero included as a possible choice. This model can take, for example, the form of a Tobit model:

$$R = h(M, P, Z) + e; \quad \text{if } h(M,P,Z) > 0,$$

$$R = 0; \quad \text{if } h(M,P,Z) \leq 0.$$

The random utility model is probably the closest there is to a "state of the science" travel cost method if the necessary data are available and the decision to participate in recreation at all is included. Complete data are rarely available, however, and the resulting partial estimation may have unknown biases, especially if data on some sites and characteristics are missing. This is a problem that all travel cost methods face, however.

Even with incomplete data, the random utility model has advantages over traditionally estimated travel cost models. It is capable of accounting for zero visits; if the data are available, it can produce exact measures of consumer surplus; and it can estimate the value of changes in access and site characteristics for a number of sites. All of this is accomplished at great cost, we reiterate, in terms of data-gathering and computation.

4. HEDONIC VALUATION

4.1 INTRODUCTION

It has long been recognized that goods are measured both in terms of their quantity and their quality. However, only comparatively recently have economists begun to incorporate the quality dimensions into empirical and theoretical models.[1] The first formal analysis of the characteristics of goods was motivated by the problems created for price indexes by quality changes. Adelman and Griliches (1961) and Griliches (1961) were the first studies to distinguish two sources of changes in the price of a good: those due to changes in the goods characteristics and those due to changes in the price of characteristics. In constructing price indexes one wants to make sure the price refers to a constant quality good or bundle of goods so price change due to quality change must be taken out.

Put simply, hedonic valuation is a means by which the value of a composite commodity traded in a market is divided into its constituent parts. This enables us to value the parts, such as beach quality, which do not have a directly observable market value.

A second area of early empirical work was the analysis of property values. In this case, the focus was on the valuation of characteristics rather than accounting for quality change. Ridker (1967) and Ridker and Henning (1967) were the first authors to focus on the relation between property values and air pollution. They regressed median property values in given census tracts in the St. Louis area in 1960 on each property's housing characteristics, as well as the characteristics of the neighborhood and the house's amenity values including various measures of air pollution. They found that property values varied systematically with air quality levels. The authors did not provide much of a theoretical underpinning for the study. This was supplied by Rosen (1974), building on the work of Becker (1965), Lancaster (1966) and Muth (1966).

There are three basis applications of the hedonic technique: property value studies, wage studies which examine the value of environmental amenities discerned through the labor market, and hedonic travel cost studies which use an approach that combines Rosen's method with travel cost data and attempts to estimate the values of recreation site characteristics. Coastal area management issues addressed by hedonic valuation methods include the value of shoreline and access to beach, long term or chronic damages to the marine environment from oil spills and hazardous waste discharge, benefits of improved water quality, reduced congestion or changes in other qualities of the marine environment. Before presenting these three applications of the hedonic method, it is instructive to get an overall sense of the hedonic concept.

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1 An early exception is Court (1939) who first applied the term "hedonic" to prices.

4.2 CONCEPTS AND DEVELOPMENT OF METHOD

Basic Methodology

In countries where property such as a house are exchanged in a workably competitive market, some houses sell for more than others in the same neighborhood or in the same city at about the same time. If two houses are identical but the lot size is bigger for one, we expect its selling price will be greater. Houses near a park or houses in a low crime neighborhood sell for more than houses in neighborhoods where there are no parks and there is high crime, holding other price determining factors constant, of course. In the United States, it is common to pay more rent for an apartment which is higher up and has a better view than for an apartment with the exact same configuration on a lower floor. Systematic observation of these differences would provide one with the monetary value of average views--the difference between the rental rate with and without a view or the difference between the rental rate on floor 10 versus the rental rate on floor 1, for example.

Suppose a researcher collected samples from three different groups of ocean anglers A, B and C, alike except in the ways illustrated in Table 1.

Table 1: Recreational Data

	A	B	C
Days Fished	10	10	11
Big Fish Harvested	20	21	21
Expenditures ($)	1000	1030	1040

From this idealized data set individuals in group B are exactly like individuals in group A except that they spent $30 more and harvested an extra fish. Assuming away uncertainty for purposes of illustration only, we confidently conclude that the total utility value of the marginal fish must have been worth $30, otherwise why would members in the B group have spent the money? Similarly, groups C and B are alike except members in group C spent $10 more for an extra day suggesting that that is the marginal value of a day. This is the gist of the hedonic approach but it has subtle points which we shall see and they would be dangerous to overlook.

Hedonic Property Models

When the theoretical dust settles, there is a straightforward applied approach to estimating hedonic property values. Suppose the researcher is interested in the value of air quality or clean beaches or some other amenity value. Individuals can register their valuation of these amenity characteristics by bidding up the price of clean properties relative to dirtier ones. Thus rental rates or sales prices should reflect consumers' valuation of these qualities. When we buy a property we are buying many bundled characteristics such as rooms, fireplaces, etc. Thus we use statistical techniques to unbundle the composite good. In general then,

$$\text{(1)} \qquad \textit{Value of house} = f\,(\textit{House}, \textit{Neighborhood}, \textit{Amenity Characteristics})$$

Specifically, the researcher might have selected homes from a given non-segmented (non-discriminating) market and estimated the following statistical regression:

$$V = \beta_0 + \beta_1 \textit{Number of rooms} + \beta_2 \textit{Hectares of open space} + \beta_3 \textit{Distance to beach in neighborhood}$$

where V, is the real price of the house sales price. The interpretation of --- is the marginal economic value of a room:

$$\beta_1 = \frac{\delta V}{\delta \textit{Number of rooms}}$$

We expect that houses located close by beaches are better because one does not have to walk so far so they should sell for a higher price.[2] The regression coefficient, β_3 is designed to capture that gradient,

$$\beta_3 = \frac{\delta V}{\delta \textit{Distance to beach}}$$

Finally β_0 represents the contribution to selling price of the omitted characteristics evaluated at their mean value. Apart from inevitable error, the product of these individual physical characteristics and their marginal dollar values summed overall the characteristics equals the selling price of the house.

Table 2 illustrates results from an hedonic analysis pooled time series data where the value of a house and its characteristics are the observation. In this study, Brown and Pollakowski (1977) were interested in how people valued the open space (set back) around a lake, specifically the *marginal value* associated with *changing* the amount of

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[2] If beaches or parks are rowdy, sometimes the properties nearest the park sell at a discount, reflecting this negative amenity.

open space. For purposes of this paper distance to waterfront (in logs) is highly statistically significant and the width of the open space (in logs) is statistically significant. An average house located near a 300 foot wide set back area would sell for $1,350 more than if it were located near a frontage one-third that size.

Marginal Hedonic Values Are Not Demand Functions

Research reported in the last section indicated that estimated housing value is linearly related to the number of bathrooms. The estimated marginal value of a bathroom is $2,830 (Table 2). This cannot be a market demand for bathrooms because it does not exhibit diminishing marginal utility (diminishing marginal rate of substitution). Whereas the marginal value of bathrooms is constant, the marginal value of distance to the waterfront or the marginal value of open space bordering the nearby lake is not (Table 2). The estimated marginal value of a house as a function of open space does not describe a demand curve for open space, except under a set of implausible assumptions.[3] This should not be surprising. Researchers who estimate demand functions use cross-section or time series data. They do this to pick up variation in supply, i.e., it is shifts in supply which allow econometricians to estimate a demand function. If we draw data from one property market we cannot hope to estimate a demand function except under very special conditions noted above.

In fact, the hedonic relationship is capturing the locus of many individual equilibria. Estimation of a proper demand function for a characteristic will be discussed below. For the moment we must pin down what policy content there is in the hedonic price function. Suppose to make matters simple, an hedonic price equation estimates the value of congestion at a beach (measured as cars parked or people/meter) and it is a negative constant, k. One can imagine that it is the marginal willingness to pay to reduce congestion. If beach authorities were planning to implement a policy which changes marginal congestion, then k is a useful implicit value to use as an indicator of a beach-goer's willingness to pay for relief from congestion. For many purposes, obtaining an estimate of the marginal value of an unmarketed quality is a major achievement and can make a very substantial contribution to policy analysis. Such analysis provides an order of magnitude estimate of the value which may be all that

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3 To obtain a demand function for a characteristic from the first stage estimated hedonic price function, all owners of property must be identical in income and any other socio-economic characteristics, and tastes. The researcher assumes that the data are from a small, open city or region so that economic behavior there does not influence the aggregate market equilibrium. Migration is costless. If income is not the same, then either there must be external information about the income elasticity of 333 for all goods or preference must be homothetic--relative demand for characteristics does not depend on income.

Table 2: Green Lake Area

Left-Hand Variable=Selling Price (deflated to 1967 dollars)

All Observations Weighted By 1/Living Area (N=90)

Variable Error	**Coefficient**	**Standard**
Constant term	15700.00	3400.00
Living area (sq. ft)	3.38	1.17
Age of house	-73.30	15.40
Average room size	-5.51	7.25
Number of fireplaces	1120.00	415.00
Number of car garages	674.00	455.00
Number of rooms 1st story	-311.00	265.00
Number of bathrooms	2830.00	607.00
D=1 of basement	1260.00	464.00
D=1 if dishwasher	2010.00	784.00
D=1 if good or excellent quality	289.00	486.00
D=1 if range and oven	255.00	748.00
D=1 if hot water heating	1040.00	1140.00
D=1 of wall or floor furnace heating	-2220.00	801.00
D=1 if electric heating	-1660.00	903.00
Lot size (sq. ft.)	-0.25	0.20
D=1 if view	573.00	693.00
Log of distance to waterfront	-1770.00	762.00
Log of individual setback size	1230.00	744.00
SR=197	SE=1.66	R^2=.84

Source: Selling Price and structural characteristics: SREA Market Data Center, Inc. (April 1969 to June 1974). Distance to waterfront and setback size: measured on local maps.

is necessary to determine which policy to choose. Wilman (1980) may have been the first researcher to have estimated quantitatively how congested beaches around Cape Cod, Massachusetts, reduce the price owners of guest houses and inns could charge. She also demonstrated that debris on the most frequently used nearby beaches had a statistically negative effect on the price of rented vacation homes. See Table 3.

TABLE 3

RENTED VACATION HOMES: RENTAL PRICE EQUATION

Variable Dependent	**Linear Equation Ave. Monthly Price**
INTERCEPT	1006.38 (4.12)
No. of Rooms	162.39 (5.74)
PHONE	207.18 (2.50)
Distance to Beach	-69.26 (-3.02)
DEBRIS	-221.30 (-2.74)
Distance Nearest Urban Area	-68.22 (-1.72)
R^2	0.35
N	129.00

NOTE: T-statistics are shown in parentheses below the coefficient estimates.

Hedonic Demand Equations

Estimating the demand for a characteristic or an element in a bundled good is a two step process. Since prices do not exist, step 1 requires discovering prices:

Step 1: Estimate a hedonic price equation which contains the characteristic of interest (see (1) above), or

(2) $$V = f(Z_1, K, Z_n)$$

where Z = a selling price or rental rate but could be wage rate or travel cost in subsequent sections. Z_i = characteristic $i = 1.K.N$.

Step 1a: Calculate the marginal value of the characteristics

$$\frac{\delta V}{\delta Z_i} = f_{Z_i}$$

In general the marginal value could be defined as:

$$\Pi_i \equiv f_{Z_i}(Z_i, K, Z_n)$$

but for simplicity assume the relationships are linear so:

$$\frac{\delta V}{\delta Z_i} = f_{Z_i} \equiv \Pi_i \tag{3}$$

Step 2: Estimate the demand function for the characteristic of interest. Suppose it is beach cleanliness denoted by Zi so there is an associated price, Π_1. Then the second stage estimated demand functions for beach cleanliness is

$$Z_1 = f(\Pi_1, \textit{Prices of substitutes}\ (\Pi_s),\ \textit{Income},\ \textit{Age},\ \textit{Family size},\ldots).$$

Data Issues

The critical element here is that data must be collected across markets or over time. That is, separate hedonic price functions must be estimated for a number of cities or resort towns, for example. Palmquist (1984) estimated hedonic price functions for housing characteristics for each of seven cities using 1976 and 1977 individual sales data and housing characteristics. He then performed the second stage analysis and estimated the demand functions for living space (in sq. ft.) and bathrooms, as a function of the own price, hedonic price of other characteristics such as price and year built, price of racial homogeneity of neighborhood, marital status of owner, as well as other variables.

Time series housing data provide an unusually congenial means of estimating marginal value. When a house sells more than once, i.e., repeat sales, most or all of the housing characteristics remain the same (or assessors data on improvements can be used to adjust the data) except age of house in particular and depreciation in general. Under these circumstances, changes in housing value between two sales dates can be attributed to changes in one or more measures of the environment, adjusting of course for overall changes in the value of housing stocks. The nice things about this is that all the errors associated with housing characteristics can be disregarded. No individual housing characteristics are in the estimation procedure because they cancel out. Only the change in an environmental variable and a change in the sale values between dates of sale for the same property are needed. Palmquist (1982) used such an approach and found that as noise levels rose because of increasing traffic, housing values fell.

Repeat sales data were also used in a study by Mendelsohn, *et. al.*, (1992), which was designed to estimate the loss of property value due to the discharge and resulting accumulation of hazardous waste on the floor of New Bedford Harbor, Massachusetts. Independent variables in this study included proximity of residential property to the site, sale date before or after pollution publicly recognized, years between sales, interest rate, per capita income in zone of sale, in addition to variables designed to capture non-pollution source of price change such as overall housing price changes. The authors found that property values fell between $7,000 and $10,000 (1989 dollars) as a result of location near hazardous wastes in the New Bedford Harbor.

The Hedonic Wage Model[4]

Why would a worker in a given skill category accept a lower wage than another worker in the same skill category and each lives in a different city? Suppose the cities are alike in levels of all other prices but the wage rate. In a competitive world, it must be because overall working conditions are better in one city than in another. One city might have been located at the seaside so access to the associated amenities is cheaper and there are no other compensating amenities in the interior city. In a complete model, the labor supply equation depends on the level of amenities which, together with the labor demand equation, produces an equilibrium wage. Such a wage clearly is a function of amenities such as relatively low cost access to fishing, boating, surfing, sailing, etc. In this approach one is addressing the assumption made in the travel cost model that residential location is exogenous. In fact, some chose to live where they do and accept a lower wage rate because of ease of access to desirable recreation sites. Therefore, the hedonic wage model can be used to complement a travel cost model for a given site.

There are fewer studies of the effects of environmental amenities on wages than there are property value studies. Getz and Huang (1978) use a model in which environmental factors affect production and vary across cities. They find that a measure of air pollution is positively related to the wages of only one of the three professions included in their study.[5] Cropper and Arriaga-Salinas (1980) find that air

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4 Some of the material in this section is drawn from Brown and Plummer (1989).

5 The positive relation comes from the compensation workers demand for jobs that expose them to greater pollution (e.g., due to location).

pollution is positively and significantly related to the earnings of eight out of the nine occupations they examine. Clark and Kahn (1989) develop a two-stage model that estimates the equilibrium hedonic wage as a function of city characteristics such as crime rates, unionization, and physician population; and environmental amenities such as miles of ocean beach within 50 miles (of the SMSA) and acres of fishable waters (for the state). They then estimate the demand for specific amenities and use the results from the second stage to calculate the WTP for environmental improvements.

Roback (1982) estimates the effects of several city characteristics on both wages and property values. In her model, city-specific amenities enter both the utility function and the production function; as long as land is consumed by both workers (for their residence) and firms (in production), these amenities should be related to both wages and property values. Her results show a mostly positive relation between particulate levels and wages and no significant relation between particulate levels and property values.[6]

Hedonic wage models have not received as much attention as hedonic property value models, making it more difficult to evaluate the advantages and disadvantages. They clearly also complement property value studies by capturing additional effects of amenity changes on economic values, i.e., wages. Finally, most applications of the hedonic wage model are somewhat incomplete because they do not include a model of firm decision-making. This absence is important because without such a model it is unclear how firms can afford to pay the higher wages that go with lower levels of amenities.[7] Although this shortcoming can be corrected, it complicates the model and increases the data requirements.

The Hedonic Travel Cost Model

A final type of model is a hybrid of the hedonic and travel cost techniques called the hedonic travel cost method. This method was first introduced in Brown, Charbonneau, and Hay (1978) and formalized in Brown and Mendelsohn (1984). Using the Rosen framework, it seeks to estimate the value of recreation site characteristics by using cost information on travel to various sites by recreationists. It is significantly different from the Rosen model, however, in that there are no explicit product prices; instead, as outlined below, travel costs are used in place of these prices.

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6 Roback notes, however, that the property value data are relatively imperfect, suggesting caution in interpreting the property value results.

7 An exception is Roback (1982), mentioned above.

A recreation site is viewed as a bundle of site characteristics, (Z_1, K, Z_n). The cost of travelling from population source j to site i, C_{ij} , constitutes the hedonic price of consuming the services of the site. The first stage of the hedonic travel cost method regresses travel cost, C_{ij}, against the set of site characteristics for each population source/origin:

$$C_{ij} = \alpha_i + \beta_{ij} Z_{i1} + L + \beta_{nj} Z_{1n} \tag{4}$$

where a linear form is used for illustration.[8] The coefficient β_{kj} is then the (constant) marginal price of the kth characteristic for the jth population source/origin.

The second stage follows Rosen's model. The marginal characteristic prices and each individual's chosen levels of characteristics, which are determined by the site chosen, are used to estimate the demand (or inverse demand) for characteristics.

The major study using the hedonic travel cost method is Brown and Mendelsohn (1984), which examines the value of fishing site characteristics in Washington State. Three characteristics are included: scenic value, crowdedness, and the number of fish caught.[9] This study illustrates some of the complications involved in applying this method.

The first step of their analysis involves the estimation of *two* hedonic price functions: a time price and a distance price. To calculate the marginal characteristic prices for the second step, these two price functions are combined using a value of time equal to 30 percent of the wage.[10]

Finally, Bockstael, Hanemann, and Kling (1987) examine the relation between swimming behavior and water quality at Boston area beaches. In the hedonic portion

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8 Brown and Mendelsohn (1984) use two equations, one each for travel out-of-pocket costs and travel time costs.

9 Scenic value and crowdedness are measured by asking the fishermen surveyed to rate a site on a scale of 1 (the worst) to 10 (the best). The rating of a site's characteristic is then the mean assessment by fishermen who used the site or the mean catch for each site.

10 The hedonic travel cost method encounters the same problems in valuing time as does the normal travel cost method. Brown and Mendelsohn experimented with three measures of the value of travel time: 30 percent, 60 percent and 100 percent of an income measured used to proxy wages.

of their study, they focus on two water quality characteristics: a measure of oil and chemical oxygen demand (COD). When a linear form of the hedonic price function is used, the results are mostly unsatisfactory, giving a large number of negative coefficients for marginal characteristic prices and failing to produce a significant negative relation for oil in the second step of estimating the demand for the characteristics. A nonlinear form of the hedonic price function performs substantially better, reducing the incidence of negative prices and generating negatively sloped demand curves.

4.3 EXAMPLE OF AN APPLICATION TO COASTAL ZONE MANAGEMENT

One of the controversial policy decisions in North America centers about whether to restrict development on land adjacent to coastal water. To address this issue from an economic perspective, Parsons and Wu (1991) used hedonic analysis to estimate how property values varied depending on whether it was located on the shore (FRONTAGE), *DISTANCE* to the coast, and whether it had a water *VIEW*. Other variables are listed in Table 4.

The authors found that the best functional form for the regression was double log. The results are exhibited and are illustrated in Table 5. (Dummy variables are not measured in logs). Notice that the three important variables mentioned above are highly statistically significant and have the right sign. From these estimates the authors calculated the average value (1983 dollars) of lost coastal access amenities for the three circumstances listed below:

Houses Losing:	**Lost Value ($)**
Frontage, View and Proximity up to 0.2 miles	82,900
View and Proximity up to 0.2 miles	7,000
Proximity up to 0.2 miles	500

The loss of frontage is very valuable, close proximity to the shore much less so. The authors make assumptions about the forgone level of development for two decades and estimate that zoning laws which restrict development for 0.2 miles from the shore will result in a loss to potential property owners of about 20 million dollars per year for the first 5 years under one scenario and about 4 million dollars annually under an alternative scenario.

TABLE 4

DESCRIPTION OF VARIABLES USED IN THE 1983 REGRESSIONS

Variable	Description
PRICE	Market price of a house
BD	Number of bedrooms
BATH	Number of bathrooms
DINED	Dummy variable (1 = formal dining room)
BASED	Dummy variable (1 = full basement)
AGE	Age of a house (years)
HISTDUM	Dummy variable (1 = historic neighborhood)
GARAGE	Dummy variable (1 = garage or carport)
AIRCON	Dummy variable (1 = central air conditioning)
FRPL	Dummy variable (1 = fireplace)
SF	Interior area of house (square feet)
LOTSZ	Area of lot (square feet)
MONTH	Month the house was sold (1 = January,...,12 = December)
DISTANCE	Linear distance to the nearest point on the Bay or tributary (miles)
DISTCBD	Distance to central business district (miles)
FRONTAGE	Dummy variable (1 = water frontage)
VIEW	Dummy variable (1 = water view)
ED	Percent of block group over 18 years old with 4 years high school education or more
%NWH	Percentage of block group classified as non-white
HHINC	Median household income of block group

The Parson and Wu study resembles an earlier study in which Edwards and Anderson addressed the following policy issue. In response to concern about the impact of development on groundwater levels (the source of water supply) and water quality in salt ponds (the sink for discharge) what would be the economic consequences of increasing the minimum lot size to 2 acres? Such a restriction would reduce the number of residential housing sites by about 800 homes. Edwards and Anderson (1984) estimated an hedonic price equation summarized in Appendix A and concluded that the cost of this down zoning proposal is about $500 per household using the preferred regression equation.

TABLE 5

HEDONIC REGRESSIONS, 1983

Variable	Double-Log
INTERCEPT	4.8(16.5)
BD	.06(2.3)
BATH	.1(4.3)
DINED	.05(4.1)
BASED	.003(0.2)
AGE	-.06(10.7)
HISTDUM	.6(9.3)
GARAGE	.08(6.0)
AIRCON	.05(3.4)
FRPL	.08(6.2)
SF	.4(14.6)
LOTSZ	.1(17.6)
MONTH	.03(3.4)
*DISTANCE	-.07(4.2)
DISTCBD	-.06(7.7)
*FRONTAGE	.4(18.1)
*VIEW	.07(3.5)
ED	.06(3.8)
%NWH	.02(4.2)
HHINC	.2(8.1)
R^2	.79
F-Statistic	275
Observations	1,435

NOTE: *t-statistics are in parentheses.*

4.4 EVALUATION

An advantage of the hedonic travel cost method over the other two hedonic methods is its applicability to non-market settings. The effects of environmental changes are frequently beyond the boundaries of residential property or labor markets. If these effects change non-market behavior, the hedonic travel cost method may be applicable. Unfortunately, this method has substantially greater data costs. Because it is used in non-market settings, existing data sets are rare, and information on individual behavior and site characteristics must then be gathered.

Hedonic analysis works well in property markets because the researcher typically has many observations with substantial variety in the combinations of characteristics observed. The analysis works well in the sense that characteristics believed to be important determinants of value usually are statistically significant and have the right sign. Hedonic analysis works less well in the non-market setting because sites or combinations of characteristics are relatively few and determined by the vicissitudes of nature. One consequence of such data sets is estimates of negative prices for characteristics presumed to have positive value. A possible but not guaranteed way to circumvent this second drawback of the technique is to use discrete choice analysis discussed briefly elsewhere to derive demand functions for characteristics.

The third criticism of hedonic analysis when it is used to estimated demand functions for characteristics is econometric in nature. It is usual to assume that consumers take the price of a good as given. In the realm of recreation services, the consumer has a household production function, in which the consumer chooses certain inputs such as time and one's automobile and a site to produce the characteristics. Then when the hedonic function is non-linear, choice of quantity determines price so that there are endogenous variables on both sides of the demand and supply equations. This problem is addressed by introducing instrument variables as Palmquist (1984) did in the paper summarized above and as Bartik (1987) has done elsewhere. Epple (1987) discusses the econometric assumptions necessary for the estimated coefficients to be unbiased.[11]

As with all econometric studies there are standard errors of omission and commission to avoid. One must be particularly alert to the problem of heteroscedasticity since errors seem to be correlated with the size or value of property. In general, there is no compelling reason, apart perhaps for reasons of simplicity, to use a linear form of regression. The exception is when there is empirical evidence or an analytically persuasive argument that a characteristic of a property is produced under constant return to scale. Then, the unit cost should be constant, regardless of the level of demand or the amount of characteristic. For example, if it costs twice as much to build two fireplaces as one, the marginal cost of a fireplace is constant so the marginal value of a fireplace must be constant in a competitive market. In this instance, number of fireplaces *should* be entered linearly.

A final caution bears on avoiding double counting, hedonic analysis does not capture non-use value but is designed to capture some use value. It should not be used with "stated preference methods" unless they are confined to non-use values.

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11 For example, the hedonic price equation can be estimated by the ordinary least squares procedures if all the characteristics are estimated without measurement error and the demander and the demander characteristics such as income are measured without error. These, of course, are the usual assumptions made at this level of econometric analysis.

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APPENDIX

Edwards and Anderson (1984) identify the variables set forth in Table A.1 as important for explaining housing sales data for 353 single family houses in South Kingston, Rhode Island for 1979-1981.

They experimented with different functional forms for the hedonic price equation using a functional form which is a special case of the more general conditional Box-Cox maximum likelihood procedure set forth by Halvorsen and Pollakowski (1981):

(A.1)
$$P_{h_i}^{(\theta)} = \alpha_0 + \sum_{i=1}^{m} \alpha_i \, Z_i^{(\lambda)} + \epsilon_i$$

where

$$P_{h_i}^{(\theta)} = \frac{P^{\theta} - 1}{\theta} \quad if\ \theta \neq 0,$$
$$= \ln P \qquad if\ \theta = 0$$

and

$$Z_i^{(\lambda)} = \frac{Z_i^{\lambda} - 1}{\lambda} \quad if\ \lambda \neq 0,$$
$$= \ln Z_i \qquad if\ \lambda = 0.$$

Values of λ and θ which meet the maximum likelihood criterion are then estimated. In this case the optimal values of θ and λ are 0.32 and 0.66 respectively. The hedonic equation using these transformations are reproduced in Table A.2.

TABLE A.1

DESCRIPTION AND MEAN VALUE OF VARIABLE

Variable	Definition	Mean
PRICE	Market price adjusted to 1979 values with the national consumer's price index for homeowners.	53188
LOTSIZE	Lot size (sq.ft.) dummy variable for whether the property	[illegible]
WOODED	is within an overall wooded area; 1 = yes, 0 = no.	
MARSH	Dummy variable for whether the property is within a marshy area; 1 = yes, 0 = no.	0.43
VIEWSW	Dummy variable for whether there is a water view of a salt pond or the oceans; 1 = yes, 0 = no.	011
VIEWFW	Dummy variable for whether there is a water view of a fresh water pond or river; 1 = yes, 0 = no.	[illegible]
SWFRONTAGE	Length of water frontage along a salt pond of the ocean (ft.)	150
FWFRONTAGE	Length of water frontage along a fresh water pond or river (ft.)	[illegible]
DSALTPOND	Shortest distance to the nearest accessible salt pond.	1.8
DURI	Shortest distance along streets to the University of Rhode Island (miles).	5.9
DSHOP	Shortest distance along streets to the major shopping district in town (miles).	5.0
DSCHOOL	Shortest distance along streets to the nearest grammar school (miles).	2.5
DENSITY	Population density in the area (numbers per square mi.)	1138
SQFT	Square footage of the house excluding the basement.	1264
BATHRM	Number of bathrooms including half-baths.	1.4
FIREPL	Number of fireplaces.	0.4
AGE	Age of the house (years).	24.5
AGESQ	Age squared.	1604
SWFTBASE	Square footage of finished basement.	88.0
SQFTGAR	Square footage of garage.	188
TIME	Month the house sale was recorded. Values are 1 (Jan., 1979) to 36 (Dec., 1981).	18

TABLE A.2

ESTIMATED HEDONIC EQUATIONS

Variable	**Coefficient**	**Standard Error**
Intercept	89.59*	3.05
LOTSIZE	0.0028*	0.00071
SQFT	0.052*	0.009
BATHRM	6.23*	0.89
AGE	-0.58*	0.10
AGESQ	0.012*	0.004
SQFTGAR	0.046*	0.009
SQFTBASE	0.010	0.008
FIREPL	1.80*	0.38
DENSITY	-0.003	0.005
DBEACH	-0.98*	0.30
DURI	-0.53***	0.38
DSCHOOL	-0.25	0.40
DSHOP	-0.40	0.38
*SWFRONTAGE	0.19*	0.04
FWFRONTAGE	0.05	0.07
*VIEWSW	3.25*	1.07
VIEWFW	1.29	1.60
*DSALTPOND	-0.40	0.45
WOODED	2.68*	0.83
MARSH	-4.07**	2.03
TIME	0.48*	0.08
R^2	0.73	
Observations	353	
θ, λ	(0.32, 0.66)	

* Significant at the 1% level.
** Significant at the 5% level.
*** Significant at the 10% level.

5. STATED PREFERENCE METHODS

5.1 INTRODUCTION

This section reviews approaches that rely upon the creation of a hypothetical or "constructed" (Carson, 1991) market for a commodity within a carefully structured survey instrument. Three approaches are covered: Contingent Valuation, Contingent Activity, and Contingent Ranking. Collectively, these approaches are called Stated Preference Methods and are based upon responses by individuals that are contingent upon the information about the commodity, how it will be provided, and the terms of payment given in the survey instrument.

In the *Contingent Valuation Method* (CVM), individuals may be asked directly about their willingness to pay (WTP) for a specific change in the quality or quantity of the good(s) of interest. For example, users of a coastal beach might be asked the most that they would be WTP to obtain specified improvements in the attributes (e.g., sand cover, debris removal) of the beach. After certain adjustments, which are discussed below, CVM practitioners regard the respondents' statements of WTP as the *economic value* they place on the specific change in attributes described in the survey.

Contingent Activity (CA) surveys, by comparison, ask respondents how they would alter their behavior, in response to a specific change in the quality or cost of using the environmental or natural resources of interest. For example, beach users might be asked how much more they would use a particular beach, if its quality was improved in specified ways. The resulting shift in demand can be used to infer the economic value (Marshallian Consumer Surplus) users attach to the improvement.

Contingent Ranking (CR) surveys ask individuals to compare and rank alternate program outcomes with various characteristics, including costs. For instance, people might be asked to compare and rank several mutually exclusive environmental improvement programs under consideration for a watershed, each of which has different outcomes and different costs. A special case of CR asks participants to compare two alternate situations. This paired-comparisons technique has been used, for example, to examine the public preferences for tradeoffs among environmental resources that arise when considering the siting of locally undesirable facilities at different locations.

Stated Preference Methods have become very popular, due largely to their high degree of flexibility. In principle, one or more Stated Preference methods can be applied to virtually any issue, and it is the only approach available for assessing a new commodity or activity, which by definition, cannot be valued using a Revealed Preference approach. This flexibility makes these methods potentially very valuable for integrated coastal area management. Contingent Valuation is the *only* approach currently available which can provide a monetary estimate for nonuse value.[1]

Many marine-related natural resource issues have been studied with Stated Preference Methods. These include estimates of the value of: (1) specific marine recreational activities, such as beach use, recreational fishing, and wildlife viewing and (2) improvements in water quality and the associated amenities of coastal waters, shorelines, and rivers. Other applications include estimates of the value of: (3) preserving particular resources, such as wetlands, parks, and species and their habitats, and (4) damages due to environmental incidents, such as oil or hazardous substance spills. Table 5.1 below lists selected application of CVM.

Contingent Activity has been used to estimate, for example, the change in the marine recreational use and its value, contingent upon cleaning up contaminated sediments at the site. Example applications of Contingent Ranking include its use to infer: (1) the value individuals attach to the outcomes of different proposals to improve water quality; and (2) scores for environmental and cost attributes, used to help make siting decisions for locally undesirable facilities.

To date, CVM is the most widely used of the three Stated Preference approaches. However, the use of CVM is controversial when, for example, respondents lack familiarity and prior valuation experience with the environmental good of concern; when the issue itself is controversial; or when it generates strong symbolic reactions or responses based on ethical rather than economic motivations. Generally speaking, these issues are most likely to arise when CVM is used to estimate nonuse or "passive use" values (Opaluch and Grigalunas, 1993), for reasons described briefly below in Section 5.4. The CA and the CR approaches are also flexible, and may avoid potential problems attributed to CVM. Hence, these approaches have significant potential, although they have been used much less than CVM. The potential advantages and problems with CA and CR are reviewed below.

Purpose and Scope

This section briefly outlines the concepts underlying Stated Preference Methods, describes the methodology they employ, and provides examples of their use. The examples are meant to provide concrete illustrations of the application of Stated Preference Methods; they are not reviewed critically, since this is outside the scope of the present study. Additionally, we review some issues associated with use of Stated Preference Methods. We emphasize the potential usefulness of Stated Preference Methods in three contexts:

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[1] Recently Larson (1993) has suggested an alternative approach for estimating non-use value using non-CV techniques. An application of this approach to whale watching off the California coast can be found in Larson and Loomis (1993).

Table 5.1. Selected Recent Contingent Valuation Surveys		
RESOURCE / ACTIVITY	**AREA**	**REFERENCE**
Endangered Species and Nongame Wildlife	North Carolina, USA	Whitehead (1993)
Wildlife - Hunting and Viewing	California, USA	Cooper & Loomis (1991)
Recreational Fishing	Wisconsin, USA	Boyle (1989)
Coastal Beaches	New Jersey, USA	Silberman, *et al*., (1992)
Marine Artificial Reef Site	Florida, USA	Milon (1989)
Environ. Improvement-Estuaries	Caribbean & Uruguay	McConnell & Ducci (1989)
Damages - oil spill	Alaska, USA	Carson, *et al*., (1992)
Loss of Access - Tropical Rainforest	Madagascar, Africa	Shyamsundar and Kramer (1993)
Waterfowl Protection	United States	Desvouges, *et al*,. (1991)
Elk Hunting	Montana, USA	Park, *et al*., (1991)
Wildlife Existence Values	United States	Stevens et al. (1991)
Whooping Crane	United States	Bowker & Stoll (1988)
Endangered Species: bald eagle & striped shiner	Wisconsin, USA	Boyle & Bishop (1987)
Potable Groundwater Supply	Cape Cod, MA, USA	Edwards (1988)
Groundwater Protection	New Hampshire, USA	Shulze & Lindsay (1990)
Improved Drinking Water	Nigeria	Whittington et al. (1992)
Scenic River Beauty	Wisconsin, USA	Boyle & Bishop (1988)
Grand Canyon boating	Arizona, USA	Boyle, Welsh, & Bishop (1993)
Wetland Preservation	Kentucky, USA	Whitehead & Blomquist (1991)
Wetland Protection	California, USA	Loomis, *et al*., (1991)
Wetland Protection	Louisiana, USA	Bergstrom, Stoll, & Randall (1990)
River Recreation	Texas, USA	Bergstrom, Stoll, & Randall (1989)
Forest Protection	Southeastern Australia	Loomis, *et al*., (1993)

(2) to estimate, *indirectly*, use value in situations where individuals are asked how their use of a resource would change in response to some hypothetical change in the cost and/or quality of the area or activity (CA);

(3) to rank or value indirectly resources by asking respondents to compare and rank alternatives with different resource and cost attributes (CR).

5.2 CONCEPTS

The theory underlying environmental and resource valuation presumes that individuals have well-defined preferences for goods and services and act in their own best interests. These well-defined preferences are assumed to extend over not only private goods but also over public goods, such as an attractive view or non-consumptive use of wildlife, and over quasi-public goods, for example, use of a beach or a marine park.

Given this familiarity with goods, given the prices of private goods, and given their income and time constraints, individuals are assumed to select private goods and quasi-public goods (e.g., recreation) which makes them best off in their own terms. In effect, individuals are presumed to act "as if" they were maximizing their utility subject to a budget constraint, or minimizing the cost of obtaining goods, subject to a given level of utility.

Economic value as defined in Chapter 2 is the maximum an individual would be willing to pay (WTP) to improve (or to avoid the deterioration of) the quantity or quality of an environmental or natural resource and be no worse off. Alternately, economic value is the minimum a person would be willing to accept as compensation (WTAC) for a reduction in the availability or quality of a resource. These concepts define Hicksian measures of individual welfare change and link with CVM and CR, as explained below.

5.3 METHODOLOGY

Contingent Valuation Method

The CVM approach involves three major steps: (1) design of the survey instrument, (2) survey administration, and (3) data analysis. In the sections that follow, each of these is briefly described. Then illustrative examples of CVM studies are presented and some issues with CVM are reviewed.

- Design of Survey Instrument

A survey instrument contains the following: (a) a description of the commodity of interest and how it will be provided, (b) the means by which the respondent would pay for the commodity, and (c) a means for eliciting the payment. Together, these are referred to as the scenario. In addition, the survey instrument will seek socioeconomic information about the individual and his/her household, such as their income, age, and attitudes toward environmental issues. A brief explanation of each of the above three elements is given next.

a. Commodity Specification

The specific commodity to be valued must be *clearly explained* in terms that are understandable to the respondent. This can be particularly challenging where multiple natural resources are of concern, or where the researcher wants to consider more than one policy alternative. Furthermore, the commodity change and the means of provision must be plausible. Maps, figures, pictures, and other means may be used in addition to carefully worded descriptions to provide information to the respondent. Studies by Carson, *et al.*, (1992) which made considerable use of illustrative figures, and by Opaluch, *et al.*, (1991), which involved showing respondents a brief video about the issue concerned, provide examples of how researchers have tried to convey to study participants information concerning complicated issues. Surveys must also stress the availability of substitute commodities (NOAA Panel, 1993).

Failure to explain the commodity clearly to study participants may result in several problems. For example, respondents may value something other than that which was intended by the researcher, or responses may reflect general sentiment, e.g., for the environment, and not the value of a *specific* commodity. Focus groups, pretests, and pilot studies are used extensively to refine the survey instrument to try to ensure that individuals clearly understand the commodity and its provision.

Particularly serious problems can arise when the population of interest includes sub-groups with different languages and/or cultural values. In such cases, a single survey instrument may not be appropriate to all groups, but translating the instrument and otherwise tailoring it to each group can be quite costly. For example, Carson, *et al.*, (1992) in their CVM study of passive use (nonuse) damages from the *Exxon Valdez* oil spill opted to omit Spanish-speaking households. This was due to the many problems posed by the need to design and administer multilingual surveys. This suggests that use of CV (or any other method) would face many challenges when the population of interest contained, for example, many tribes in a region or country, each with a separate language or dialect.

Furthermore, the commodity described in the survey must match the policy issue being considered. For example, serious mis-specification would occur if a proposed pollution control program would improve water quality and resulting services to people (e.g., swimming and fishing) in a section of a Bay, but the CVM survey instrument erroneously conveyed the impression that the proposed program would improve the quality of the *entire* Bay. Mis-specification of the commodity means respondents are attempting to value the wrong thing. Again, careful survey design is critical.

It is important to state clearly how the commodity will be provided. Respondents who do not believe the scenario may elect not to participate, or will not take the exercise seriously. An example of an attempt to state clearly how a program would be provided is Carson, *et al.*, (1992). They go to some length to explain that escort vessels would prevent another spill with environmental consequences similar to the Exxon Valdez from occurring in Prince William Sound, Alaska, for ten years.

b. Means of Payment

The means of payment ("payment vehicle") refers to how the respondents would pay for the program described in the survey instrument. For example, an increase in a user fee for beach goers might be a reasonable payment vehicle for programs to maintain or improve beach quality for recreational users; and an extra amount paid in water bills may be appropriate for increased services stemming from improved water quality. Choice of a payment vehicle involving payments over time, versus a one-time payment, is particularly challenging in developing countries with poorly-developed credit markets and high inflation rates (McConnell and Ducci, 1989).

Use of inappropriate payment vehicles might cause respondents to reject the survey and not participate. For example, individuals asked to pay for a new program with higher taxes may refuse to participate. They may do so if they think that they already pay too much in taxes or that the government would use the additional revenues wastefully. A variety of payment vehicles have been used in the literature (Table 5.2).

c. Elicitation Methods

The elicitation method is the approach used to attempt to learn *how much* an individual would be WTP for the natural resource or environmental change of interest. Frequently used elicitation methods include open-ended (OE), payment card, (PC), iterative bidding (IB), or take-it-or-leave-it (TILI), and variations of these approaches (Table 5.2).

In the *OE* approach, respondents are asked the *most* they would be willing to pay for the program or policy. This approach has the virtue of not providing any hints about what might be a reasonable value. However, an OE elicitation format confronts respondents with an unfamiliar choice. Few people have experience placing a price

Table 5.2. Survey Techniques, Payment Vehicles and Elicitation Methods of Recent Contingent Valuation Surveys				
RESOURCE/ ACTIVITY	**SURVEY TECHNIQUE**	**PAYMENT VEHICLE**	**ELICITATION METHOD**	**REFERENCE**
Endangered Species and Nongame Wildlife	mail survey	annual payment to Preservation Fund	TILI	Whitehead (1993)
Wildlife - Hunting and Viewing	mail survey	increase in annual trip costs to visit area	TILI	Cooper & Loomis (1991)
Recreational Fishing	mail survey	higher cost licence	open-ended	Boyle (1989)
Coastal Beaches	in-person and telephone survey	one-time contribution	open-ended, iterative bid	Silberman (1992)
Marine Artificial Reef Site	mail survey	one-time contribution to Trust Fund	TILI	Milon (1989)
Damages - oil spill	personal interview	one-time federal tax payment - Protection Fund	iterative bid	Carson, *et al.*, (1992)
Oil Spill Prevention	in-person survey (mall intercept)	higher costs for petroleum products	TILI/open-ended	Desvouges, *et al.*, (1992)
Damages - oil spill	mail survey	higher prices for programs to prevent one oil spill	payment card	Rowe, *et al.*, (1991)
Waterfowl Protection	in-person survey (mall intercept)	higher costs for petroleum products	TILI/open-ended	Desvouges, *et al.*, (1992)
Elk Hunting	mail survey	higher trip costs	TILI	Park, *et al.*, (1991)
Wildlife Existence Values	mail survey	yearly contribution	TILI	Stevens, *et al.*, (1991)
Whooping Crane	mail survey/ in-person survey	Annual membership fee for refuge land	TILI	Bowker & Stoll (1988)
Loss of Access Tropical Rainforest	In-person survey	compensation in rice	TILI	Shyamsundar and Kramer (1993)

Endangered Species		Annual membership to private foundation	TILI	Boyle & Bishop (1987)
Potable Supply of Groundwater		Bond with annual payments	TILI	Edwards (1988)
Groundwater Protection	mail survey	Annual increase in property taxes	TILI	Shultz & Lindsay (1990)
Improved drinking water	in-person survey	Monthly fee for operation of the system	iterative bidding game/ open-ended	Whittington, *et al.*, (1992)
Scenic River Beauty	personal interview	Annual permit fee for river recreation	Iterative bidding/ payment card/ TILI	Boyle & Bishop (1988)
Grand Canyon - boating	mail survey	Higher trip costs	TILI	Boyle, Welsh, & Bishop (1993)
Wetland Preservation	mail survey	Wetland preservation Fund	TILI	Whitehead & Blomquist (1991)
Wetland Protection	mail survey	Annual taxes for Wetland Habitat and Wildlife Program	TILI (double bounded)	Loomis, *et al.*, (1991)
Wetland Protection	mail survey	Yearly income reduction	open ended	Bergstrom, Stoll & Randall (1990)
River Recreation	personal interview with computer	Annual payment for public access and recreation area	iterative bidding	Bergstrom, Stoll & Randall (1989)
Forest Protection	mail survey	Annual Payment into a Trust Fund	open-ended TILI	Loomis, *et al.*, (1993)

on environmental commodities, and studies that use the OE approach have high item non-response rates.

The *PC* provides a number of pre-selected monetary values, where the range of values is determined from focus groups and pretests of the survey. Respondents are asked to pick the value indicated on the card that is closest to their maximum WTP, including zero. "Don't Know" is also an option given. This approach leads to fewer item non-responses than the OE approach. However, range bias may result, if the values provided by the researcher in the payment card influence the respondent.

With *IB*, respondents are asked whether they would be WTP a given amount. If the answer is yes, this amount is raised in pre-set increments until the respondent says that they will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates a willingness to pay the stated amount. Starting point bias is a potential problem with IB. This occurs when the respondent's final WTP depends upon the initial amount offered (e.g., Boyle and Bishop (1988)). This problem is likely to be most serious when individuals do not have well-defined preferences for the good concerned and view the starting point as a clue as to a "reasonable" value.

The *TILI* or dichotomous choice approach is the generally preferred elicitation method. Study participants are asked: "Would you pay $X for the described program, or (in a format that attempts to mimic a public referendum), would you vote for a program if it costs you $X, yes or no?" The amounts are varied randomly across individuals, over a pre-specified range. A "yes" answer is taken to suggest that the item is worth at least the amount stated; a "no" is interpreted to mean that the good is worth less than the indicated amount.

Potential advantages of the TILI approach are several. First, TILI questions are easy to answer - the respondent simply indicates yes or no to the given amount. Second, individuals may be used to voting on public programs, and surveys using the referendum form of TILI have been argued to be similar to a referendum. Third, it is argued that the referendum form of the TILI approach might encourage respondents to be truthful about whether they would pay the given amount.

■ Survey Administration

The final version of the survey instrument is administered to a random sample of the population of interest. Depending upon the issue of concern, the population of interest may be members of a user group, such as beach users or recreationists, the population of the coastal area, or the population at large for an issue of national concern.
Once the sample has been selected, the survey will be administered in-person, by telephone, or through the mail. Choice of the approach will depend on: (1) the complexity of the survey, (2) the available budget, and (3) practicability in particular circumstances.

Long or involved surveys require in-person administration to attempt to convey the information effectively and to maintain the respondent's focus. Brief surveys dealing with uncomplicated issues might be administered by mail or, possibly, by telephone. Cost usually is an important consideration, and will influence the choice of survey administration. In-person surveys are expensive, mail surveys are relatively inexpensive, and telephone surveys fall between the two in terms of cost. In developing countries, a practical concern is that telephone surveys rarely can be used because relatively few individuals have telephones, and even mail surveys may be problematic due to difficulty with the mails (McConnell, 1989). Low literacy rates in the general population also limit the use of mail surveys in developing countries.

Choice of survey administration method also is important due to concern with potential sources of bias. For example, non-response bias occurs when those who take the trouble to complete and return a survey are more interested or concerned about the issue than the average individual. This is of special concern with mail surveys, since those who receive the survey have an opportunity to read it before deciding whether to respond. Consider, for example, a survey of California (USA) residents, which examined WTP for preserving the ecology and scenic resources of a remote lake. In this study, Loomis (1989) found that respondents to the mail survey were much better educated, were older, and had higher incomes than the average state resident. Use of recommended procedures (e.g., Dilman, 1978) may increase survey response rates and decrease the potential of non-response bias.

In-person survey administration is the approach recommended by the NOAA Panel mentioned above. However, in-person interviews may also result in unwanted effects such as compliance and importance bias (Mitchell and Carson, 1989). Compliance bias occurs when respondents' answers systematically overstate or understate their true value to win the approval of the interviewer. Importance bias is present when respondents systematically assign a high value to an issue reasoning that it must be important for the study sponsor to have gone to so much trouble.

■ Data Analysis

Data analysis involves: (1) logging of receipt of survey instruments and careful entering of the data for analysis, (2) "cleaning" the data to eliminate protest and implausibly high WTP bids, (3) statistical analysis of the remaining bids, and (4) expansion of the sample result to the population of concern. Items (2)-(4) are discussed below.

Item 2. Data Cleaning

Respondents to a survey may submit zero WTP bids as a protest, or bids that are "unreasonably" high. In either case, such responses may reflect something other than the economic value of the commodity, which is the fundamental interest to the researcher. Data cleaning attempts to address the issue of protest bids or unreasonably high bids.

Protest bids arise when respondents give a zero WTP because they reject a premise of the study, but give other information suggesting that they have a non-zero value for the commodity. For example, a person could have an economic value for a resource but indicate a zero WTP. They may do this if they feel someone else should pay, for example, the company that caused the problem. Or, they may object to the payment vehicle, for example, taxes, because they doubt its ability to carry out the program successfully. Protest zeros are typically deleted and not treated in the data analysis as zero.

Unreasonably high bids (outliers) may be hard to detect but present a problem because they can seriously distort estimates of the mean. Often, many respondents will indicate a willingness to pay very large amounts (Boyle, *et al.*, 1994) due to, for example, "yea-saying" or a general failure to take the exercise seriously. A common practice has been to exclude WTP amounts greater than some fraction (for example 1%, 5%, or 10%) of household income. More sophisticated approaches also have been employed using multiple criteria (Rowe, *et al.*, 1991), but all approaches for eliminating outliers necessarily involve some *ad hoc* judgments.

Beyond the concern with zero protest bids and very high, outlier bids, it is possible that other bids may not reflect respondents' economic value. For example, a stated WTP even moderate amounts may reflect: (1) yea saying, (2) general environmental sentiments and not the value of the *particular* good of interest, or (3) a sense of responsibility to do one's fair share to fix a problem caused by human activity. These and other potential problems are briefly discussed in Section 5.4.

Item 3. Statistical Analysis

Once the data have been cleaned, the mean or median WTP value will be estimated for the sample. Then, the sample mean or median will be expanded to estimate the total value for the population of interest.

Estimating the mean may be relatively straightforward, but will typically involve fairly extensive statistical analysis. For example, with open-ended WTP data, the simple mean might be used (Hay, 1988a,b). Alternately, more sophisticated econometric approaches may be employed. For example, Rowe, *et al.*, 1990 estimated the relationship between WTP and various explanatory variables (e.g. age, income, degree of environmental concern) using different model specifications.

Different problems arise when the TILI approach is used because individuals are not asked the maximum they would be WTP. Instead, they are asked if they would pay a specific amount, which is varied randomly across individuals. Estimation of mean or median WTP involves two steps. First, it is necessary to estimate the probability that respondents would say "yes" to the monetary amount they are offered. The probability of a "yes" response should decrease with the amount shown, but may also depend upon, for example, income, membership in an environmental group, or use of the resource concerned. Then, it is necessary to estimate the *expected value* of the WTP. A potential problem is that expected value is very sensitive to large WTP amounts, so that it is necessary to cut off (truncate) bids at a given amount, often at the highest bid actually offered to respondents. Alternately, researchers may use the median value, which is less subject to the influence of a few very large values than is the expected value (Hanemann, 1984).

Item 4. Expansion of the sample result

Given an estimate of the mean WTP for the sample, the next step is to expand the result to the population of interest. This generalization may involve simply multiplying the mean from the sample times the number of relevant individuals or households. Or, other more sophisticated weighting procedures may be used (Loomis, 1987). One approach for dealing with potential non-response bias is to assign a zero WTP to all non-respondents when calculating the sample mean.

■ Example Applications of the Contingent Valuation Method

Several CVM studies are summarized below to give concrete illustrations of how the method has been applied in many settings. As noted, it is not within the scope of this document to provide a critical review of the summarized studies.

I. Valuing Environmental Quality in Developing Countries: Two Case Studies Involving Sewerage Treatment in Coastal Areas (McConnell and Ducci, 1989)

Case 1: A Coral Island Country in the Caribbean. Residents' WTP was estimated for construction of a sewerage system and collector lines for handling household wastes. Currently, households on the coral island dispose of wastes into the ground. This is thought to pose a threat to groundwater and to coastal beaches used for recreation (via higher coliform levels), including some beaches near hotels used by tourists and residents. Some believe that continued pollution *may* pose a threat to the reef system surrounding the island, and ultimately induce beach erosion.

After focus groups and pretests, the survey instrument was administered in person to two groups: (1) a sample of residents outside the sewerage district, and (2) a sample of residents inside the district. A TILI approach was used. Participants were asked whether they would pay a specified increment, randomly varied across individuals, in their quarterly water bills to fund the program. One version of the estimated model resulted in a mean WTP of $US11 for residents outside the water district and $US43 for those residing within the district.

Case 2: A Coastal Municipality in Uruguay. Residents' WTP was estimated for construction of sewerage lines to dispose of wastewater. Currently, wastewater from 80 percent of residents in the coastal municipality is collected in a main line and discharged directly into the estuarine waters which surround the city. Affected coastal waters adjacent to municipal beaches have very high coliform counts, and are known to be polluted by area residents who use the beaches.

The proposed project would install more collectors and extend the main wastewater disposal line well out into the estuary. There would be no primary treatment of wastes; the project would simply dispose of untreated wastes farther out in the estuary to avoid pollution of the beaches. Using a municipal tax as the payment vehicle and the TILI elicitation format, the estimated mean WTP per year was about $US14.50.

II. Valuing Loss of Access to Traditional Uses of Tropical Rainforests in Madagascar, Africa (Shyamsundar and Kramer, 1993)

A CVM study estimated the value to rural households in Madagascar of loss of access to tropical rainforests due to establishing a new National Park. There are no human settlements in the Park area, but establishing the Park would preclude populations from nearby villages from foraging in the Park and engaging in swidden (slash-and-burn) agriculture, two primary traditional activities.

Surveys were administered to 351 households in 17 villages around the Park, after focus groups and pretests of a draft survey instrument. Respondents were asked if being given X *vata* (the locally-used unit for rice transactions) of rice per year would make up for their not being allowed to use the forests in the Park. For those who answered "yes" ("no"), the amount was decreased (increased). Rice rather than money was used since the area economy is primarily subsistence, rice is the main crop, and transactions in rice are understood.

Hence, the TILI approach was used, but a follow-up question was employed to attempt to get closer to the "true" value. Note that willingness to accept compensation was used as the measure of value rather than WTP.

Using the approach outlined above, the mean WTAC was 8.03 vata of rice per year. This translates into a mean WTAC of $108.34 per household per year. Aggregated over the relevant population and discounted at 10 % for 20 years, the aggregate net present value of the welfare loss is $673,078.

III. Valuing Wildlife Viewing: Bird Watching in the San Joaquin Valley, California, USA (Cooper and Loomis, 1991).

The value of bird viewing was estimated in the San Joaquin Valley of California using CVM. This information is used with biological data to examine the relationship between agricultural drainage and the recreational demand for wildlife resources in the Valley.

To estimate the benefits of bird viewing, a survey was mailed to 3,000 randomly selected California residents. The response rate was 44%. The survey asked about frequency of outdoor recreational trips and any wild birds they may have seen on these trips during the 12 months before the survey. To estimate WTP, the TILI approach was used. Respondents were asked about their approximate costs for transportation, food, and lodging on their most recent trip when they saw birds. Then they were asked if their annual expenses of visiting that specific site were $X higher, would they still visit that site?

The total value per recreational trip in the Valley in which birds were seen was estimated to be $37.33. Multiplying this by the annual number of trips yielded a total annual value for bird viewing in the Valley of $64.7 million. Using a simulation approach, the authors also presented WTP estimates for other potential levels of bird viewing, reflecting a positive but diminishing relationship between WTP and number of birds seen.

The primary effect of agricultural drainage on waterfowl is the relationship between high concentrations of selenium and embryotoxicity (dead or deformed embryos or chicks). Using embryotoxicity data from one wildlife refuge in the Valley, the authors show that a decrease in selenium from agricultural drainage to nonlethal concentrations results in positive waterfowl population effects, thus increasing viewing values. They suggest that recreational use related to wildlife can be quantified and linked to agricultural contamination issues. However, more precise estimates will require better biological data of contamination effects on migratory birds.

IV. Valuing Scenic River Beauty along the Wisconsin River, Wisconsin, USA (Boyle and Bishop, 1988).

The value of scenic beauty along the lower Wisconsin River was estimated using CVM. Picture boards were used to convey information. The picture boards displayed two columns of photographs of actual scenes along the river. One column portrayed "existing aesthetic landscapes", while the other column portrayed "comparable scenes that contain items that detract from scenic beauty". The photographs selected for the picture boards were the result of two years of survey work to learn what lower Wisconsin River users considered beautiful and what they thought detracted from the landscape. Respondents were presented with a hypothetical scenario asking them to imagine that the lower Wisconsin River is being managed for scenic beauty. Respondents were asked if they would purchase a yearly permit to use the river, and told that the funds raised would be used to maintain scenic beauty.

Data collection involved personal interviews conducted with canoeists and boaters as they completed trips. The estimated mean WTP values for scenic river beauty, for a final sample of 356 observations, ranged from $18.88 to $29.82, depending on the question format.

V. Valuing Wetlands: Wetland Preservation in Kentucky, USA (Whitehead and Blomquist, 1991).

Estimates were made of the WTP for preserving a wetland in western Kentucky, USA. A focus group and pretest were employed to test the use of color photographs to convey information, and to learn the range of values for the final survey instrument. The final survey was mailed to a random sample of Kentucky residents, resulting in 215 usable observations for a response rate of 31 percent.

The survey described functions and benefits of wetlands including waterfowl habitat, alternate uses of wetlands, the current availability of wetlands in Kentucky, and the potential mining of wetlands for coal. Respondents were then introduced to a specific wetland area and potential "Wetland Preservation Fund" (WPF). Using the TILI approach, respondents were asked if they would approve or reject a proposal to purchase the described wetland using the WPF at the cost of $X for each household.

Median WTP estimates ranged from $5 to $17, depending on the information provided. Additional information about substitute goods lowered WTP, while information about complements raised WTP in this experiment.

VI. Oil Spill Impacts: Exxon Valdez Oil Spill Damages Study, Alaska, USA (Carson, *et al.*, 1992)

Carson, *et al.*, 1992 estimated the lost "passive use" (non-use) value due to the 1989 Exxon Valdez oil spill. Extensive use was made of focus groups, pre-testing and pilot studies. The final survey instrument was administered in person to a random sample of households throughout the US "lower 48". Interviews with 1,043 respondents were completed for a 75 percent response rate. Elaborate use was made of maps, figures, and other visual aids. This is likely the most costly CVM study done to date.

The survey instrument described the path of the nearly 11 million gallons of crude oil spilled, injuries to wildlife and shorelines, and the general time to recovery. Participants were told that a similar spill could be expected to occur within the next ten years, unless a special safety program is put in place. The special program would involve use of two specially designed ships to escort oil tankers through Prince William Sound to avoid another large spill like the Exxon Valdez. If such a spill were to occur, special crews and equipment on the escort vessels would be used to prevent the spill from spreading beyond the tanker.

The payment vehicle was a one-time special charge added to their federal taxes. The TILI referendum approach was used, with respondents given three alternatives: they could "vote" for or against the program or they could indicate "not sure". A follow-up question asked respondents who said "yes" ("no") to the initial amount offered whether they would pay more (less). Four versions of the survey were administered by professional survey research firm using trained interviewers, with the only difference among surveys being the dollar amounts used in the WTP question.

The median household WTP for the spill prevention plan was $31. This amounts to $2.8 billion dollars when aggregated across the entire United States. Carson, *et al.*, 1992 believe this to be a conservative or low estimate of damages.

Methodology: Contingent Ranking

This approach is generally similar to techniques often used in marketing to design the attributes of products of appeal to consumers. Individuals are asked to compare and rank alternate outcomes in order of their preference. For example, respondents could be asked to compare and rank alternate programs to improve the quality of a Bay that have different outcomes in terms of environmental effects and the costs respondents would bear to carry out the programs. Individuals are presumed to rank alternatives in the order of the utility they would receive from each outcome. A ranking of these alternatives allows one to infer the tradeoffs among the attributes. Paired comparisons is a special case of CR where only two alternatives are considered.

Respondents could be asked to rank many alternatives; and considerable detail could be used to describe the outcomes of each alternative. However, the greater the number of alternatives considered, and the more detail that has to be absorbed, the more difficult it is for respondents to answer questions meaningfully (Mazzotta and Opaluch, 1994).

CR also has considerable flexibility and can be used in many situations. Another advantage is that it avoids asking individuals to give a monetary value for a proposed change, and instead, asks them to make tradeoffs among outcomes and therefore to balance alternate outcomes.

■ Example Applications of the Contingent Ranking Method

I. Evaluating Public Preferences for Siting Noxious Land Use Facilities: Landfills in Rhode Island, USA (Opaluch, *et al.*, 1991).

A survey was designed to find out public preferences about the potential social and environmental impacts and costs of potential solid waste landfill sites. Respondents were asked to choose between two hypothetical landfill sites described in terms of various attributes. These attributes included: on-site extent of wetlands, woodlands, and farmland, the quality of underlying groundwater, wildlife habitat, number of houses in the vicinity, presence of schools in the surrounding community, and annual costs associated with each site location.

After extensive focus groups and pretesting, the final survey instrument was administered in-person to 1,151 people, of which 1,045 provided usable information. Each survey contained 11 paired comparisons, resulting in a data set of 11,327 usable observations.

The survey data allowed researchers to infer the relative importance that residents place on various, potential attribute impacts related to landfill siting. Results suggest that residents place the highest value on preventing adverse surface water and groundwater impacts. Avoiding detrimental wildlife impacts also ranked highly. Farmland was rated higher than marshland among respondents. As for land use activity around potential landfill sites, school location was rated as the highest consideration, followed by farmland, then parkland. And when selecting a landfill site, residents preferred highway access to local road use, and sparsely populated areas over densely populated areas

Results from the siting survey suggest positive WTP values for resource protection. For example, results suggest that residents are WTP $481 per year in higher taxes or trash disposal fees to select a landfill site with low groundwater quality while preserving a high groundwater quality site, $134 per year to select a site with normal wildlife habitat over a site with unique wildlife habitat.

II. Valuing Improvements in Water Quality: The Monongahela River, Pennsylvania, USA (Smith and Desvouges, 1986).

A CR experiment was used to estimate WTP for different levels of water quality improvement in the Monongahela River. Respondents were presented with four alternate water quality levels and the annual payments associated with achieving these levels. They were asked to rank these based on their present and possible future use of the River. Water quality was described in terms of the types of recreational use possible at different quality levels. These ranged from "no recreation possible" to "boating, fishing, and swimming possible". The payment vehicle was a constant annual increase in taxes and prices.

Of the 301 survey respondents, 213 provided usable information. The CR models were used to estimate option prices associated with incremental changes in water quality. The benefit estimates for a water quality change from boatable to fishable ranged from $35.80 to $85.51, depending on the model selected and the payment level. For a water quality change from boatable to swimmable, benefit estimates ranged from $64.44 to $149.96, depending, again, on model selection and payment level.

III. Evaluation of Natural Resource and Environmental Restoration Alternatives (Mazzotta, Opaluch, and Grigalunas (1994)).

A methodology based on the paired-comparisons approach is described for compensating for loss of natural resources, e.g., wetlands, due to environmental incidents. Respondents would be asked to compare sets of resources that would provide equal satisfaction to those lost. Among the sets of resources that provide equal satisfaction, the least-cost option would be selected, if it is not too costly in relation to the value of benefits to be received. This "resource compensation" approach differs from CVM in that it avoids directly asking respondents to place a monetary value on natural resources and the environment, and instead encourages consideration of tradeoffs among attributes, something which respondents might find easier to do. A major potential advantage is that this approach encourages a cost-effective way for restoring resources while leaving the public no worse off.

Methodology: Contingent Activity

■ Introduction

Contingent Activity involves asking respondents how their behavior would change in response to a proposed change in one or more attributes of an activity. For example, those who engage in wildlife viewing might be asked how many more trips they might make to a site, if the cost of the activity was to change, or if the site of interest was made more accessible, or more attractive to use. Given responses to this type of question, and given information about incremental travel costs and the value of time, a revealed preference method can be used to estimate the value of the change.

The appeal of CA is its flexibility: it can be used to address many issues where changes in the attributes and/or costs of an activity or site are being considered. In addition, it may be easier to answer a CA question about behavioral change than to answer a CVM question concerning WTP for a change in an environmental resource. This can be an important advantage if an issue is controversial or if people are unable to, or object to, placing a dollar value on the environment (Opaluch and Grigalunas, 1993; Opaluch, 1993). The CA approach has been used, for example, to estimate the effects on marine recreational activity in response to a hypothetical clean-up of estuary sediments contaminated with a hazardous substance and the effects on recreational fishing of a reduction in travel costs.

The general methodology is similar to that described for CVM or CR in that a survey instrument must be developed, administered to a sample, and then generalized to the relevant population. However, depending upon the issue, it may not be necessary to provide as much information in a CA study as in a CVM or CR study. For example, if active users of a particular beach are asked how much more they would visit the same beach if the costs were X % lower or higher, it may not be necessary to provide an elaborate scenario. On the other hand, considerable information would have to be given if the researcher is asking users of a given site how often they would use a *new*, substantively different site, or if extensive changes in the attributes of the existing site are being considered.

■ Example Applications of the Contingent Activity Method

I. Estimates of Hunting, Fishing and Non-Consumptive (Viewing, Photographing and Feeding) Use Values for Wildlife in the USA (Hay, 1988a, b).

Data from the National Outdoor Recreation Survey were used to estimate the consumer surplus per trip for several outdoor recreation activities. This Survey is administered every 5 years in each of the 50 USA states by the US Fish and Wildlife Service of the US Department of the Interior. The Survey has two parts. One focusses on hunting and fishing, and one addresses non-consumptive uses, such as observing, photographing and feeding wildlife. As part of each survey, data are gathered which allow for an assessment of economic value using the CA method.

For each outdoor recreational activity, a sample of individuals was asked, first, how many trips they took in 1985 and how much they spent on a typical trip. In principle this gives one point on the individual's (Marshallian) demand curve. Then, they were asked how many trips they would have made, had the cost per trip been higher, assuming that the cost of *other* kinds of recreational activity remained the same. Participants were asked to consider costs 2, 3, and 4 times, respectively, higher than the amount they spent on a typical trip. Hence, these questions were intended to move the respondents up their respective demand curves. Finally, they were asked the most they would pay per trip before they would not make even one trip (i.e., the maximum WTP - comparable to an open ended question).

Given the initial point on the individual's demand curve and the choke price, it is possible to estimate the Consumer Surplus per trip. This calculation was done for each individual, assuming a linear demand function. Then, the results for individuals within a state were used to estimate a state-wide average. The consumer surplus per day, across all states, ranged from $US7 per trip for recreational fishing to $US58 for big game hunting.

II. Recreational Losses Due to Contaminated Marine Sediments in New Bedford Harbor, Massachusetts, USA (McConnell, no date - summarized in Freeman, 1987).

Estimates were made of monetary damages to saltwater sports activity in New Bedford Harbor, Massachusetts, USA, due to contamination of bottom sediments with polychlorinated biphenols (PCBs), a substance believed to cause cancer in animals. To do this, McConnell estimated the decrease in demand due to the contamination. Separate estimates were made for beach use and for recreational fishing, using the results of a telephone survey of a random sample of 545 area residents. For beach use, respondents were asked about their recent use of public beaches in the area and their *planned* visits for the coming season. Then, they were asked how many times would they visit the beaches concerned, if all the PCBs had been cleaned up at the beginning of the year.

This survey revealed that among those aware of the pollution, up to twice as many would have visited the beaches, if the PCBs had been cleaned up. The median number of visits per household would have been increased by from 50 % to 80 % with cleanup.

Using information on travel costs and socio-economic data, demand functions were estimated for the beach areas studied. Separate demand functions for each area were estimated for the existing situation (with contamination) and the "after" situation (all contamination assumed to be cleaned up). The area between these two ordinary demand curves is the Marshallian consumer surplus, taken to approximate the damages due to the contamination (or, alternatively, the benefits due to cleaning up the pollution). The present value of the damage estimate (projected to 2085) was estimated to be \$8.3 to \$11.4 million dollars in 1985.

For recreational sports fishing, McConnell used the telephone survey data to estimate the increase in the number of trips to the closed area which would occur, if the PCBs were cleaned up. In the absence of cleanup, it was assumed that all trips were diverted from the closed area to other, more distant substitute fishing sites. The estimate of damages is measured as the increase in the cost per trip incurred due to the additional travel cost and time to travel to the more distant, substitute site. The present value of these damages (projected to 2085) at a discount rate of 3 % was \$3.1 million dollars in 1985.

III. Comparison of Observed and Contingent Activity Estimates for Recreational Fishing in Nevada, USA (Englin and Cameron, 1993).

The authors sought to compare actual behavior with contingent behavior, using data from a mail survey of recreational anglers. Of 10,000 anglers surveyed by mail, 2,002 responded.

Participants were asked (1) about their actual total trips to engage in recreational fishing and how they were allocated among different sites, and (2) about demographics. They also were asked (3) how many trips the respondent would take if the cost was higher by (a) 25 percent, (b) 50 percent, or (c) 100 percent. Answers to questions (a)-(c) allowed the researchers to estimate the number of trips each respondent would make under the three price scenarios.

The authors concluded that the estimates of consumer surplus using CA may be 50 percent higher than the observed data estimates. Limitations in the research design are noted, and suggestions are given for improving this line of research to enhance comparisons between CA and observed estimates.

IV. Estimation of General Demand Function for Sportfishing for Salmon in Maine, USA (Maharaj, 1995).

The author, in work in progress, estimates a general demand function which could be used to manage a sport fishery so as to provide the best set of conditions which would yield the highest value to the angler. Results of this study also can be used to transfer benefits from one context or location to another context or location.

The study focused on quantifying the economic value (aggregate consumer surplus) of a sport fishery for Atlantic salmon, *Salmo salar*, in New England (USA). From preliminary interviews with Atlantic salmon anglers, it was apparent that this value was dependent on the characteristics of the sport fishing experience. Catch rate, size of fish, location, mode of fishing, congestion, fish type (whether stocked or wild), driving time, and price were all found to be important in determining angler preferences for sites and their choice behavior. Thus demand models were specified to include a range of these characteristics of the sportfishing experience.

A survey was administered, in person, to Atlantic salmon anglers in Maine. Hypothetical sportfishing scenarios were obtained by combining sport fishing attributes using an orthogonal design method. Valuation information was collected through contingent behavior questions. Specifically, anglers were given a description of a hypothetical sportfishing site and asked to indicate first, the likelihood of visiting the site and then, how often they would go in a given season. Answers obtained are used to estimate a general demand function.

5.4. ISSUES

The National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce is developing regulations that will establish procedures to assess the damages to publicly controlled natural resources caused by oil spills. Responsible parties are held liable for restoration costs and all temporary or permanent damages, which have been defined to include nonuse ("passive use") values. Due to the controversy surrounding use of CVM, NOAA established a "Blue Ribbon" Panel of expert economists to examine the use of CVM to estimate non-use value. The Panel focused on several potential problems with CVM. These were: (1) the *hypothetical* nature of WTP, which they concluded leads to exaggerated responses as compared to actual WTP, (2) the potential inconsistency of CVM responses with the theory of rational choice, (3) failure of respondents to consider budget constraints or substitutes, (4) lack of full understanding of the survey by respondents; (5) the concern that responses to CVM questions may reflect the "warm glow" from donating to worthy causes and not the economic value of the specific environmental commodity of interest, and (6) lack of sensitivity of WTP responses to changes in the scale or intensity of the commodity (the "embedding" problem).

The NOAA Panel recommended stringent guidelines for CVM studies to attempt to avoid the problems noted above. These recommendations include: (1) extensive pretesting of survey instruments, including a meaningful scoping test to assess the presence of embedding, (2) probability sampling of affected populations and in-person interviews by professional interviewers, (3) a high response rate (suggested >70 percent); (4) careful pretesting for various potential biases, (5) a referendum TILI valuation question using a willingness-to-pay format, (6) a conservative set of assumptions when carrying out CVM studies, (7) pointed reminders to respondents to consider their budget constraint and the availability of substitute goods, (8) a protocol for reporting of results, (9) an accurate description of the program or policy being "offered", (10) a "No-answer" option in the referendum question, and (11) follow-up questions to help understand YES/NO responses and to test how well respondents understood the survey.

Other issues related to CVM estimates of nonuse value have been mentioned in the literature. One issue is the potential inability of respondents to provide meaningful responses when they are unfamiliar with the good(s) of interest or lack prior decision-making experience. Another issue involves the potential biasing effect of symbolic responses and responses which reflect non-economic motivations, such as a WTP to do one's fair share to help fix an environmental problem that was caused by man. Should these issues arise in a CV study, survey responses would not reflect the *economic* value of the specific good(s) of interest, thus calling into question the validity of that particular study, and of resulting value estimates. For example, Schkade and Payne (1994) used a verbal-protocol approach in which respondents were asked to explain aloud their reasoning while answering survey questions. They concluded that respondents to their CVM study exhibited reasoning similar to that associated with donations to charities and good causes rather than decision-making that is consistent with economic reasoning, i.e., involving tradeoffs consistent with an underlying Hicksian framework.

Finally, in cases where individuals respond to the controversial nature of the issue, or hold vague and exaggerated views of the issue, the validity of the study is called into question. For example, attempts to use CVM to assess damages resulting from oil spills may be severely compromised because the public: (1) views oil spills as highly controversial events, and (2) has exaggerated perceptions of the adverse impacts of spills (Grigalunas and Opaluch, 1993).

Careful survey design, administration, and data analysis, following the NOAA Panel recommendations, may avoid some of the problems noted above. Also, further research will undoubtedly lead to additional improvements in CVM. However, until many of these issues are resolved and a consensus is reached, the use of CVM to estimate nonuse value remains controversial.

It should be noted that Contingent Activity (CA) responses may also suffer "hypothetical bias" effects. For example, respondents to the Englin and Cameron (1993) study were found to overstate by 50% their increase in recreational fishing due to lower costs. Contingent Ranking (CR) can also be problematic, for example, if individuals have difficulty answering CR questions when many alternatives or attributes must be considered. As noted, there have been far fewer applications of CA and CR than of CVM, and much additional research is called for to explore the strengths and weaknesses of these alternatives.

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Appendix A

Contingent Valuation

Assume that the goal is to attempt to measure an individual's (total) value of a well-defined environmental improvement from Q to Q' where Q is a vector of marine-related environmental and natural resources or activities, like recreational fishing; swimming and diving; wildlife viewing opportunities, etc. The person has income Y.

The elicitation methods described in the text can be summarized as follows:

Open ended: What is the most you would be willing to pay for the improvement?

$$U(Q', Y - WTP) = U(Q, Y)$$

Closed ended: Would you pay $X for the improvement?

If yes: $U(Q', Y - \$X) \geq U(Q, Y)$

If no: $U(Q', Y - \$X) \leq U(Q, Y)$

Bidding game: Would you pay $X for the improvement?

If yes: Would you pay $X + Δ ?

If yes: Would you pay $X + 2 Δ?

Repeat until answer is "no".

If no: Would you pay $X - Δ ?

If no: Would you pay $X - 2 Δ?

Repeat until answer is "yes"

Discrete and continuous: Would you be WTP $X? What is the most you would be WTP?

Payment Card: What is the most you would be willing to pay for the improvement?

Don't know_

$0_	$10_	$20_	$30_	$40_
$1_	$11_	$21_	$31_	$41_
$5_	$15_	$25	$35	$45_
$7_	$17_	$27_	$37_	$47_
$8_	$18_	$28_	$38_	$48_

Contingent Choice:

1. Contingent Ranking:

   Rank a group of well-defined alternatives environmental and natural resources: A,B,C...where A, B and C are vectors of environmental and natural resource attributes

   $U(A) > U(B) > U(C)$ ...

2. Paired Comparisons:
   Choose one of two options A or B

   $U(A) > U(B)$

6. PRODUCTIVITY APPROACH

6.1 INTRODUCTION

Natural assets are valued by humans in part because they are productive resources that provide a flow of services over time. In many cases consumers do not use a resource directly, but instead the resource provides various services that contribute to other goods that are consumed and that provide benefits to society.

The productivity approach to resource valuation is based on this notion, whereby a natural resource is viewed as an input into the production of final goods that are valued by society, and the productive capacity of the natural resource is valued in terms of its contribution to production of final goods.[1] For example, wetlands provide habitat and other ecological services that contribute to fish and wildlife populations, which are in turn valued by society. Thus, this aspect of wetlands can be valued by estimating a monetary value on this increment in fish and wildlife populations.

The productivity approach first links the natural resource to the final goods that are produced by the resource. This is analogous to specifying a production technology for the final good, where the natural resource plays the role of an input into production. The increment in value of the final goods that are produced due to the presence of the natural resource then provides an estimate of the value of that aspect of the resource.

The general steps involved with the productivity approach, applied in the context of an environmental incident, such as an oil or hazardous substance spill, are illustrated in Figure 1. Ultimately, we want to link the incident to the consequences for people. To do this, it is necessary to establish links between the incident, injury to natural resources, the resulting loss in services to people, and finally to damages to people measured in monetary terms. Note that we want to allow for behavioral response due to the effects

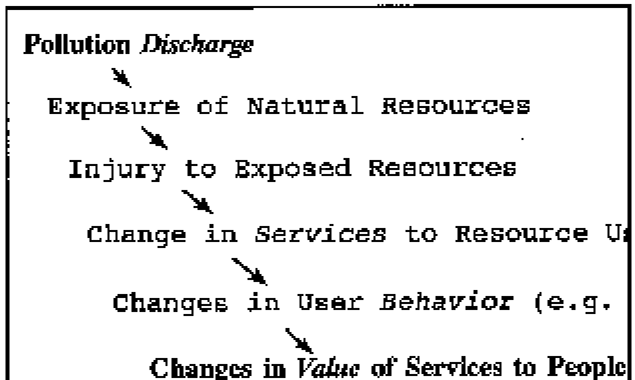

Figure 1: Linkages Between Environmental Damages and Losses to People

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1 In some cases the resource may provide other values, in addition to services to final goods. For example, a salt marsh may provide direct aesthetic values, and conceivably even nonuse values, in addition to productive ecological services to commercial and recreational fisheries. In these cases, the productivity approach could be useful for valuing a component of salt marsh values, but a full assessment would need to consider these additional values.

of an incident. For example, fishermen might move to substitute fishing grounds if an incident harms the productivity of a section of coastal waters, or beach users may visit an alternative site if their first-choice site is polluted with oil or with other wastes.

The productivity approach can be useful when the final product is relatively easy to value and adequate information is available to measure the services provided by the natural resource, but consumers are not fully aware of the services provided by the resource. In the wetlands example, it may be very difficult for people to value wetlands directly, through, say, contingent valuation, since they are not certain how much an acre of wetlands contributes to goods that they value, like fish populations. However, data may be available to estimate the contribution of wetlands to fish catch, and it is relatively easy to value changes in catch.

This method has been applied to a wide variety of resources, including coastal wetlands (U.S. Dept of Interior, 1985) and forests (Bowes and Krutilla, 1989), as well as to negative impacts of environmental degradation due to sedimentation impacts on coral (Hodgson and Dixon, 1992), herbicide impacts on estuarine systems (Kahn and Kemp, 1985), water pollution (Freeman, 1982), oil spills (Grigalunas, Opaluch, Reed and French, 1989), and air pollution (Adams Hamilton and McCarl, 1984).

6.2 CONCEPTUAL BASIS

The productivity approach views natural resources as an input into the production of goods that are utilized by society. This aspect of the resource is valued by measuring the increment in value of the final good that is produced by the resource. Thus, the first stage in the productivity approach is to identify the service flows from the resource, then to quantify the linkages between the natural resource and the production of final goods that are consumed by society.

Consider the case of a coastal wetland that provides nursery habitat for marine fish, and suppose for simplicity that this is the only service provided by these wetlands. In this case wetland acreage enters into the productivity of the fishery, which can be expressed as:

$$X = F(W,E) = X_0 + \beta_1 W + \beta_2 E + \beta_3 E^2 \quad (1)$$

where X is the stock of fish in equilibrium, W is the total acreage of wetlands available, E is the level of effort applied to fishing, and $F(\cdot)$ is a production function that relates the equilibrium stock of fish to the level of wetlands available to enhance the fish stock, and level of fishing effort.

Suppose for simplicity that the level of fishing effort is fixed, independent of catch rates[2]. The value derived from an increment in wetlands through their function as a nursery for this commercial fishery can be calculated by taking the difference between the value of catch with the base level of wetlands, W, and the value of catch with the augmented level of wetlands, $W+\Delta W$. Suppose that catch is determined by:

$$H = q X E$$

where H is harvest or catch, q is a catchability coefficient that relates catch rates to the size of the fish stock for a given level of effort, X is the stock of fish and E is the level of fishing effort. The annual productive value of wetlands in equilibrium for this particular fishery in equilibrium is:

$$P H^1 - P H^0$$

where H^1 is equilibrium catch with the enhanced level of wetlands and H^0 is the level of catch with the initial or unenhanced level of wetlands.[3] This can be expressed as:

$$P q X^1 E - P q X^0 E = P q E (X^1 - X^0).$$

Using Equation (1)

$$PqE[F(E,W+\Delta W) - F(E,W)] = PqE[X_0 + \beta_1(W+\Delta W) + \beta_2 E + \beta_3 E^2 - [X_0 + \beta_1 W + \beta_2 E + \beta_3 E^2]] = PqE\beta_1 \Delta W.$$

Thus, the contribution of wetlands to the value of catch is equal to the price of fish times the change in catch that results due to wetlands availability. By observing catch rates for different levels effort and wetlands we can potentially estimate the contribution to the value of the fishery obtained from an increment in wetlands. Below we will present some case studies that demonstrate how this can be estimated empirically.

6.3 CASE STUDIES

This section describes four case studies which apply the productivity approach to valuing natural resources. Each case study uses different means to implement the productivity approach. The first case study applies statistical methods to relate acreage

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2 For example, the level of fishing effort in a lobster fishery might be independent of catch if there is a binding constraint on the allowable number of lobster traps.

3 If the change in catch is large, the increase in wetlands could affect the fish prices. In this case the value of the change in catch rates is $P^1H^1-P^0H^0$. The remainder of the analysis follows.

of coastal wetlands to catch of blue crab, using a method similar to that described above. The second case study uses expert judgement regarding production relations and available valuation studies (benefit transfer) to estimate wetlands values. The third case study uses a simulation approach to estimate losses in natural resource productivity due to oil spills. Case study 4 uses a statistical analysis to estimate the impacts of sedimentation on coral reef fish diversity and abundance in the context of assessing conflicts among multiple resource uses of a coastal area.

Case Study 1: Coastal Wetlands and the Production of Blue Crab

In the first case study, Lynne, Conroy and Prochaska (1981) use the productivity approach to value coastal wetlands as an input to the production of blue crab in Florida. Below we briefly sketch the approach employed by Lynne, *et al.* Readers interested in the details are referred to the original paper.

Blue crab in the Florida Gulf Coast move onshore and along the coast, and spawn near marsh and estuarine areas. Lynne, *et al.* quantify losses in socially valued good by establishing a statistical relationship between acres of coastal wetlands and catch of blue crab. They use a stock-adjustment model, where the stock of blue crab in some year depends upon the stock in the previous year, catch over the previous year, and production of new crab since the previous year. Thus, catch in some particular year will depend upon catch in the previous year, the level of fishing effort in the current year, and marsh acreage, which is a determinant of crab production.

In order to estimate the model, Lynne, *et al.* collected data on blue crab catch and effort for the years 1952 - 1974 and they collected data on marsh acreage from aerial photos. They employed regression analysis to estimate a model of the form:

$$C_{it} = \beta_0 + \beta_1 \ln(M_{i\,t-1})E_t + \beta_2 \ln(M_{i\,t-1})E_t^2 + \beta_3 C_{i\,t-1} + \epsilon_{it}$$

where C_{it} represents catch at time t, β_0 through β_3 are estimated parameters, $M_{i\,t-1}$ is the acreage of marsh in county i in the previous year, E_t is the level of fishing effort, measured in terms of the number of traps laid, and ϵ_{it} is an random error term, assumed to be distributed normally with mean zero.

This regression resulted in parameter estimates shown in Table 1. The key parameters are significant at about the 90% level. Also, the equation shows reasonable

Table 1 Regression Results from Lynne, et al (1981)

Variable	Parameter Estimate	t-Stat
Intercept	-6594.	-1.43
$\ln(M_{i\,t-1})\ E_t$	48.2	2.03
$\ln(M_{i\,t-1})\ E_t^2$	-0.48	-1.69
C_{t-1}	0.40	2.17
R^2=0.78	DW = 2.05	
Sample Size = 22		

explanatory power, with an R^2 of .78. Using these estimated parameters, the estimated marginal value of an acre of marsh translates to a capitalized value of about $3 per acre in 1975 dollars (about $7.62 expressed in 1993 dollars). The low value estimate is attributed by Lynne, *et al.*, in part, to low profits in the blue crab fishery due to the common property aspect of the resource. Annual profit to the blue crab fishery is estimated by Lynne, *et al.* to be on the order of $300 thousand. Also, it must be kept in mind that this represents the value of only one service provided by wetlands, as a spawning habitat for blue crab. Inclusion of other services of course would increase the value per acre.

Case Study 2: Value of Coastal Wetlands

The second case study applies the productivity approach to value coastal wetlands using expert judgement to provide a perspective on the value of services lost due to erosion of coastal wetlands from offshore oil development throughout the United States. Benefit estimates from available studies are used to place a monetary value on lost services. This work was done as part of a large policy analysis effort by the Mineral Management Service (MMS) of the US Department of the Interior (1987)

Within the context of this study, it is not possible to identify specific wetlands areas that would be lost, given that this study is done on a broad national basis, using large planning areas, prior to development of specific oil and gas leasing plans. Thus, this study attempted to use available studies of wetlands values to place a general perspective on the order of magnitude of lost wetlands values, rather than calculate values of any particular set of wetlands.

The wetland services that were valued include flood control, wildlife habitat, contributions to commercial and recreational fisheries, and open space. To assess the contribution of wetlands to commercial and recreational fisheries, they assume that coastal wetlands are critical habitat for all species of marine fish, and that a 1% loss in wetlands would result in a 1% loss in both commercial and recreational catch. This is equivalent to assuming that the production relationship described above is of unitary elasticity. Using available estimates of current wetlands acreage and MMS estimates of potential wetlands losses due to offshore development, they calculate the percentage loss wetlands for each region of the country.

Government estimates of commercial and recreational fishing are used to estimate lost catch. Losses in commercial catch are valued using market prices, and an available study of the value of change in catch rates (Norton *et al.*, 1983) is used to estimate the value of lost recreational catch.

Next aesthetic and flood control benefits per acre of wetlands are estimated using an available study (Gupta and Foster, 1975). Gupta and Foster estimate per acre annual values of aesthetics and flood control to be an average of $270 and $80, respectively, in 1972 dollars. The value of wetlands for wildlife habitat is estimated using the price for which lands were purchased by state wildlife agencies within the specific OCS region. These values range from $50 to $2,000 per acre. Mid-points of the range of expenditures are used for the estimated value wildlife value for each OCS region. The estimated values of wetlands for each OCS region are presented in Table 2.

OCS Region	Value per Acre
North Atlantic	$28,454
Mid Atlantic	$15,059
South Atlantic	$12,826
Strait of Fla	$12,468
Eastern Gulf of Mexico	$12,110
Central Gulf	$13,847
Western Gulf	$14,270
Southern California	$24,610
Central California	$20,898
Northern California	$58,280
Washington & Oregon	$26,381
Alaska*	$11,610-$11,852

Table 2: Estimated Value of Wetland for Each OCS Region

* Alaska was separated into 10 planning areas, with values within the indicated range.

Case Study 3: Oil and Hazardous Substance Spill Damages

The Natural Resource Damage Assessment Model (NRDAM) was developed for the US Department of Interior to measure liability for natural resource damages from spills of oil and hazardous substances under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (Grigalunas, *et al.*, 1988). An updated version of the model has been proposed for measuring liability from oil spills under the Oil Pollution Act of 1990 (OPA). Under CERCLA and OPA responsible parties are liable for damages to natural resources from spills of oil and hazardous substances. It is recognized that in many cases the costs of a spill-specific natural resource damage assessment could easily exceed the damages that result from the spill. For example, the 1985 ARCO Anchorage oil spill was estimated to have caused $32 thousand in damages, but the damage assessment effort cost over a quarter of a million dollars. Hence, there is a need to develop simplified methods for assessing damages from relatively small spills, in addition to developing protocols for incident-specific methods for assessing damages from major incidents.

The NRDAM model measures loss in productivity due to oil spills by simulating the loss of socially valued resources and their recovery over time. The model simulates the spreading of a substance in the environment, biota exposed to the substance, subsequent injury to natural resources, recovery of resources over time, lost services to society (for example, lost fish catch or beach use) and translates these lost services into a dollar measure of damages.

The model is made up of three integrated components: the physical fates, biological effects and economic damages submodels (Figure 2)[4]. The user inputs into the model information describing the incident, such as the substance and amount spilled, the spill location, water depth, wind speed, the amount cleaned up, etc. Given this information, the physical fates submodel retrieves characteristics of the substance from the chemical data base, such as the solubility, specific gravity, etc. Using this information on the substance and on conditions of the environment where the spill occurred, the physical fates submodel simulates the dispersion and decay of the substance through the environment over time. The output of the physical fates submodel is a time series of concentrations of the substance in the sediments and in the water column, and the size of the surface slick, if appropriate. This information is then passed to the biological effects submodel.

The biological effects submodel contains a database on average concentrations of biota of various species groups like sea birds, anadromous fish, etc. in different seasons and environment types (e.g., a sandy bottomed estuary in the Northeastern United States). Given the output of the physical fates submodel and the data on the presence of biota, the biological effects model calculates the number of biota of different species groups that are exposed to the substance. Time of exposure is linked with the toxicity of the substance from the chemical data base, using standard dose-response relationships, to determine mortality due to the spill. The model also uses a simple model to determine losses in biota which occur through the food web.

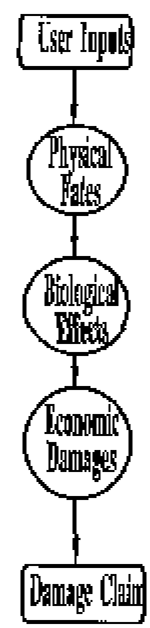

Figure 2

The output of the biological model is the reduction in populations of various species due to the spill and their recovery over time. This information is passed on to the economic damages submodel. In addition, the user specifies the length and duration of public beach closure, if any. The economic damages submodel determines monetary losses due to reduced services in commercial and recreational fishing, bird watching and recreational beach use. Values from the literature

4 Note that Figure 2 is an application of the general framework set out in Figure 1, presented in the introduction to this chapter.

(benefit transfer) are then used to place a value on these lost services. The output of the economic damages submodel is the actual damage claim that is presented to the responsible party.

Case Study 5: Sedimentation Damage to Coral Reefs and Fisheries

Hodgson and Dixon (1992) evaluated alternative development plans for Bacuit Bay in the southwest Philippines where two industries, tourism and fisheries, are in competition with a third, the timber industry. Bacuit Bay is a relatively remote, very attractive area which supports artisanal and commercial fisheries as well as tourism operations focussing on scuba diving. The high quality of the water, extensive coral reef formations, and an abundance of reef fish make this a very attractive destination for scuba diving.

Construction of roads and skid trails to support timber operations along the Bay's drainage basin have created serious sedimentation problems and reduced coral cover and the diversity and abundance of reef fish species. Sedimentation from logging is exacerbated by the topography of the area which is characterized by steep slopes which pose an erosion hazard. Coral grows slowly, and loss of living coral cover would likely take many years to replace. Hence, logging could impose significant, long-term external costs on fishing and tourism.

Regression analysis was used to estimate the dependency of fish abundance and diversity on living coral reef. Briefly stated, this analysis established: (1) that every additional 400 tons/km^2 of annual sediment deposition in the Bay decreased coral cover by 1 percent; (2) that one coral species was lost (extinct) in the Bay per 100 ton/km^2 annual sediment deposition; and (3) that for each 1 percent annual decrease in coral cover, fish biomass decreased by 2.43 percent.

The above estimated productivity relationships were used to examine two policy options: (1) continuation of logging versus (2) banning of logging. For each of these two options, total revenues for fishing, tourism and logging were estimated over a ten-year period, using a variety of assumptions concerning the growth in tourism and fishing and sediment loading from logging. Hodgson and Dixon found that the present value of total revenues (using a 10 percent discount rate) for the three activities was four times larger with the policy banning logging versus the policy of continuing logging ($25.5 v. $6.3 million in 1986 US dollars).

6.4 SUMMARY

The productivity approach estimates the value of a natural resource by linking the resource to services provided by the resource, then placing a monetary value of the services. Thus, the approach proceeds as follows. First, services provided by the natural resource are enumerated and quantified to the extent possible. Next each service is valued, either by carrying out a valuation study or by using value estimates from available studies. In many cases it is difficult to quantify services precisely or to estimate the value of the services precisely. However, in numerous cases reasonable orders of magnitude can be specified, or a range of values can be indicated using reasonable upper and lower bounds. For many policy issues, these sorts of bounds can shed light on the desirability of actions, and are the best that can be achieved given limitations in our scientific understanding of service flows provided by resources, and/or in valuing those service flows.

In many cases, the productivity approach may be useful for quantifying only a subset of the values provided by a resource. Resources may have other values, including nonuse values, that are not included in a particular analysis. In these cases, it is important to recognize that some values are excluded in the analysis, and those values need to be considered in other ways, including qualitatively.

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7. OTHER APPROACHES

7.1 INTRODUCTION

This Chapter briefly presents two alternative approaches for valuing coastal resources not traded on markets: averting behavior and benefits transfer.

7.2 AVERTING BEHAVIOR MODELS

This method estimates benefits using information on behavior by individuals undertaken to avert injury. The method assumes that individuals carry out avoidance behavior to escape the expected disutility of exposure to pollution. For example, people may incur costs or take actions to avoid the disutility from illness due to drinking unclean water or breathing polluted air. Conceptually, the averting behavior model can be used to estimate a lower bound on benefits from environmental improvements, but practical impediments described below limit its application (Courant & Porter, 1981 and Bartik, 1988).

Averting behavior takes many forms. Individuals may avoid experiencing disutility by avoiding contact with the polluted medium, through substitution, such as buying bottled water in the case of unsafe drinking water. Or, people may relocate to avoid exposure to adverse local conditions. The individual may also come in contact with the polluted medium and avert the disutility through remedial measures. This might involve taking medicine to relieve symptoms aggravated by pollution, or by increased cleaning or painting of property to decrease losses from air pollutants. The level of averting behavior is expected to increase for higher levels of perceived risk.

The averting behavior model can be used to estimate the value of an environmental amenity such as water quality improvements. This assumes that the willingness to pay (WTP) for the environmental amenity can be divided into an amenity component which reflects the increased utility derived from the quality improvement itself, and a health-related component which reflects the reduction in disutility resulting from illness (Freeman, 1994). If the amenity component is relatively small, the WTP for improvements in amenity quality are the expenditures made to avert the illness that would occur in the absence of the environmental improvement. Under ideal modelling conditions, an individual's expenditures on symptom-specific medicine taken to relieve the pollution-caused symptom would indicate that person's minimum WTP to prevent the level of pollution that causes the illness.

However, several factors limit the usefulness of the averting-behavior model for resource valuation. Perhaps the most significant problem is the occurrence of joint products. In order for averting expenditures to indicate a lower bound of WTP for an environmental improvement, the individual must gain no other utility from the improvement. In the case of joint products, the individual gains utility from the reduction in illness and from an associated product of the averting expenditure. An often-used example is the case of the air conditioner. The individual reduces illness by filtering the air, but also enjoys the utility of a cool room on a hot day. In this case, the averting behavior model yields no information on the relative size of the health and amenity components of utility (Freeman 1994). Although the amenity benefits may be assumed to be relatively small, this remains an empirical question.

Another factor complicating the application of the averting behavior model involves the lack of variation in the costs of averting behavior. Ideally, the costs of averting behavior would vary with the reduction in injury or perceived risk of injury. This variation would allow the optimal levels of cost and amount of averting behavior to be found. However, in actual applications the costs of averting behavior may not vary much. Consider the extreme case of a polluted drinking water well. The only averting behavior available to the individual in this case is to build a new well. The cost of averting behavior in this case does not vary with the level of protection. There is no indication that the cost of the well, discounted as required, is indicative of the WTP for an improvement in water quality because it has not been established that the cost of the well is the minimum the individual would pay for the same improvement in water quality. The individual may have been satisfied with a level of water quality below that provided by the well. However, in this case there exists no mechanism for the individual to obtain the preferred level of lower water quality at a lower cost.

7.3 BENEFIT TRANSFER

Benefit transfer occurs when resource values, such as consumer surplus per trip or per day, from an existing study (the *study site*) are applied to another site (the *policy site*) (Brookshire and Neill, 1992). Benefit transfer can be very useful when the benefits due to a policy affecting environmental amenities need to be estimated, but an original study of benefits is not feasible due to limited budgets or time constraints. The benefit transfer process may include information from one or numerous study sites to obtain an estimate of values at the policy site, as is explained below.

As an example of a situation that requires benefit transfer, consider a municipality that is deciding where to place a solid waste facility. One potential location offers positive attributes such as proximity to major roads and low cost of acquisition, but runoff and seepage is expected to affect commercial and recreational shellfishing and beach use. There has never been an economic study of the value of shellfishing or beach use in the area, and the municipal budget does not allow for an original valuation study. In this case, benefit transfer may supply useful estimates of resource values for the policy site. This assumes the researcher can find appropriate studies of recreational shellfishing and can identify the site-specific attributes of both the study and policy sites that will affect the reliability of transferred values.

As indicated above, benefit transfer may be applied when an original benefit study of the policy site is not practical. However, benefit transfer is not applicable if the level of accuracy of the transfer is not appropriate to the circumstances. In large part, the level of accuracy required depends upon the costs of being wrong. Various policy settings require different levels of accuracy for resource valuation. The highest level of valuation accuracy is required for natural resource damage assessments performed under liability proceedings in which the responsible party must pay a specified level of damages. A lower level of accuracy may well be acceptable in a preliminary policy analysis used to obtain a first-cut review of benefits and costs, where valuation information will be considered subjectively along with many other factors, or where valuation information is used to rank projects. Benefit transfer may be very useful for small proposed projects, which would not justify the costs of an original study.

It is not uncommon to find that different policy contexts require different levels of accuracy. For example, a hierarchy of accuracy requirements is institutionalized in the United States where criminal proceedings require that findings satisfy the accuracy criteria of "beyond a reasonable doubt". Civil proceedings require "a preponderance of evidence", or in the case of rebuttable presumption as awarded trustees in natural resource damage assessments, "a preponderance of evidence to the contrary"; and government agency decisions which must meet the criteria of being neither "arbitrary or capricious" (Opaluch and Mazzotta, 1992). Although applications of benefit transfer purposely sacrifice accuracy for expediency, there is a point at which it is better to admit that reliable values for the resources in question do not exist rather than utilize study values that are incompatible with the policy site.

Despite the potential for misuse and the occasional misguided notion that "some value is better than none", benefit transfer is regularly used in policy analysis. The actual transfer of benefits may take place by transferring point estimates, that is by simply setting the resource value at the policy site equal to the resource value estimated for a study site, or equal to an average of study site values. However, this practice is generally discouraged because it ignores known differences between the study and policy sites that would affect value estimates (Grigalunas, *et al.*, 1993).

Another approach to transferring benefits is to transfer the function that estimated values for the study site to the policy site and input as much policy site information as available into the transferred function. Although transferring the whole function is generally preferred to simply transferring a point estimate, there remains considerable potential for gross inaccuracy, not the least of which is the assumption that the study-site function holds for the policy site as well.

A third approach to benefit transfer is known as meta-analysis (Smith and Kaoru, 1990; Walsh, *et al.*, 1992). This consists of incorporating information from numerous previous studies to estimate a function that explains resource value estimates across studies as a function of the attributes of the resource(s) in those studies. Given measures of the similar attributes of the policy site, it might be possible to use the meta analysis results to estimate a value for the policy site. Ideally, a researcher could take meta-analysis one step further by pooling the original data utilized in the original studies to generate a function that estimates policy site values. Unfortunately, there are many obstacles to this type of pooled data analysis. For example, the estimated functions and parameters of existing studies may be available, but often the underlying data are not available.

Many benefit transfer models have been developed in the United States for the purpose of expediting the resource valuation process. These models are used in policy analysis and natural resource damage assessment. In natural resource damage assessments, these models are used for estimating damages for relatively small cases when the cost of performing an original study cannot be justified. The natural resource damage assessment model, described in Chapter 6, is an example of how benefit-transfer has been used to estimate damages as a simplified approach for relatively minor pollution incidents. In policy analysis, benefit transfer models often are used to provide input into benefit-cost analysis. The low cost and speed of performing benefit transfer provide important advantages over performing an original study when the project in question and the resource impacts are relatively small.

Any benefit transfer study, regardless of its application, is subject to three criteria that directly impact the study's reliability. The first criterion concerns the quality of the value estimates of the study site, that is, how well does the original study estimate the true value of the resource. The second criterion is the level of similarity or dissimilarity between the resources at the study and policy sites. In our shellfishing example, one can imagine that the abundance, quality, and size of the shellfish may differ between the study and policy sites. But, there may be other significant differences between the sites as well, such as congestion, access, scenic attributes, and availability of substitutes that affect the value of recreational shellfishing at the site. The third criteria concerns the differences between the preferences, behavior, and socioeconomic profile of those sampled at the study site and the population at the policy site. For example, if individuals at the study site had access to only one type of shellfish, but individuals at the policy site have access to a variety shellfish types, it may be that individuals at the policy site have a lower value for the common shellfish near the proposed solid waste facility due to the availability of substitutes.

Failure to address adequately any of the these criteria can cause severe problems for the reliability of the benefit transfer study. If the underlying studies are of poor quality, then transferring those values to the policy site only compounds the errors of the original work. It is also important to note that standards of quality for valuation studies change over time so that a state-of-the-art study done ten years ago may not meet acceptance standards today. Significant differences between sites, or between the resources being valued, reduces the reliability of the benefit transfer study. The larger the differences between resources or activities, the less reasonable it is to expect individuals to hold the same values for them. Similarly, the larger the differences between the characteristics of the human populations in question, the less likely it is that they have the same tastes and preferences that yield similar resource values.

The three reliability criteria categorize the effects of error factors that contribute to the reliability or unreliability of the benefit transfer. Some of the error factors can be identified, such as measurable differences in resource quality, some can be identified and controlled for in the estimation process, such as differences in income or education, and some error factors will remain unknown. In cases where the benefit transfer consists of simply applying a point estimate from the study site to the policy site, no attempt is made at even identifying potential error factors. By transferring the value function from the study site, the researcher attempts to control some of the error factors by utilizing some policy site data with the study site function. However, in this case there is no systematic way to judge how well the parameter estimates of the study site function approximate relationships at the policy site. Meta-analysis and data pooling can further control for the impacts of some identifiable error factors, but these approaches are often not feasible and do not systematically address unidentified error factors. Further research is needed in this area to identify error factors and explicitly model the way data is adjusted to control for their effects (Cameron, 1992).

The application of benefit transfer offers the important advantages of low cost and timeliness, but many conditions restrict its use. First and foremost is the frequent lack of appropriate studies to transfer benefits from. The transfer of point estimates is often not appropriate, but reliable benefit transfer may require more information than is available in the published study. The missing information may include raw data, survey questions, variable definitions, etc. Recently, more attention has been given to designing benefit studies in to make information more available for benefit transfer. Another restriction on benefit transfer is the lack of biological or physical science information needed to make the link between a policy action such as reducing effluent into a body of water and the change in services provided by the body of water that affects resource values. For example, if recreational fishing valuation studies provide changes in benefits resulting from changes in catch rates, the link must be made between the proposed reduction in effluent, increased fish populations, and increased catch rates. There is, overall, a lack of scientific baseline studies from which resource value changes can be determined.

A major concern for benefit transfer applications in developing countries is that most resource valuation studies have taken place in the United States and Europe. Relatively few resource valuation studies are available for developing countries (see references at end of Chapters 3-6). There are many concerns about the application of benefit transfer of resource values estimated in a developed country to a developing country. Apart from the reliability criteria applicable to any benefit transfer, cultural differences may make cross-cultural benefit transfers untenable. Low income levels in some countries may make the concept of WTP an unreliable indicator of benefits. Similarly, the transfer of elasticities from high income to low income countries may not be justified.

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8. POLICY INSTRUMENTS

8.1 INTRODUCTION

Coastal area management problems reflect, among other things, pervasive market failure as externalities and public goods and a lack of secure property rights. For example, in our hypothetical case study sketched in Chapter 1, agricultural runoff, sewerage from a growing population, and poor forestry practices threaten water quality. A loss of habitat, nursery areas and storm protection for coastal structures may result from loss of mangroves or coastal wetlands. The visual appeal of some areas of the watershed is at risk due to unattractive housing and commercial development and accumulation of debris along beaches and coastal areas. These external effects of coastal area development, singly and collectively, pose threats of losses to fishermen, to owners and operators of tourism-related businesses, and to coastal residents and visitors.

Environmental Policy Instruments (PIs) are the mechanisms used to attempt to correct market failures, such as those mentioned above. PIs generally encompass Regulatory Instruments (RIs) or Economic Instruments (EIs). RIs typically seek to achieve environmental objectives by imposing direct restrictions on activities. Examples include zoning land or nearshore waters for particular uses, limiting permissible waste discharges, or establishing acceptable practices for agriculture or forestry. EIs, on the other hand, are incentive-based approaches that use decentralized, market-type mechanisms to guide activity toward desirable ends. Examples of EIs include user fees, taxes and subsidies, liability, and tradeable permits.

In practice, use of RIs and EIs is not an either-or proposition and they often are used in combination. For example, RIs may prescribe *ex-ante* limits on the discharge of a substance from a business; but the operator may be assessed under EIs *ex-post*, for damages or compelled to pay a fine or penalty if the discharge limit is exceeded. Therefore, RIs and EIs can be complementary (Kolstad, Ulen, and Johnson, 1990). Brown and Johnson (1984) identified the advantages of a RI/EI-mixed schemes in a study of the German system of water quality regulations. They cite the ability to adjust regulations over time and the potential for decentralized control as advantages of a mixed system.

PIs correct market distortions by internalizing the external costs of development activity so that individuals and businesses face the full costs of their operations, that is, the private costs of production plus environmental costs. As described in Chapter 2, if external costs are not considered, the price of goods is artificially low, too much of the good is produced, and those who bear the environmental costs in effect subsidize those who use the products of environmentally-damaging activities.

Important criteria for selection of PIs include economic efficiency and cost-effectiveness. Efficiency refers to the relationship between the benefits and costs of carrying out a PI. Cost-effectiveness takes benefits as a given and addresses whether a PI achieves an environmental objective at least cost, or obtains the highest level of an environmental good for a given cost. Efficiency and cost-effectiveness clearly are important concerns when considering PIs for coastal area management. This is especially true for developing countries where environmental projects must compete with other beneficial public projects for severely limited resources.

Other important factors in selecting PIs include transactions and information costs and distributional effects. Transactions and information costs encompass all of the costs necessary to design, carry out, monitor, and enforce PIs. These costs can be substantial. Distributional effects refer to how the gains and losses from adoption of PIs are divided between affected individuals and groups. Policies proposed for coastal areas, e.g., zoning and limits on waste discharges, can impose substantial costs on, and create large gains for, different parties. The resulting interplay among interest groups and government agencies over who gets the benefits and pays the costs often determines how - and even whether - a policy will be adopted and then implemented (OECD, 1994; Zeckhauser, 1985; Downing, 1981; Opaluch and Kashmanian, 1985; see also, Olsen, 1989; Coello, Praoño-Leroux, and Robadue, no date).

The transaction costs and distributional effects of PIs are of special concern in coastal area management since the market failure which drives the demand for policy usually occurs within a multi-jurisdictional system of governments. Transaction costs often are important, for example, when trying to develop policy approaches for controlling agricultural runoff, sewerage discharges, or pollution discharges from industrial sources. These releases into the environment typically originate in a multitude of upland watershed communities. Eventually they enter an estuary, and reduce the productivity of the estuary and by that the many services it provides to people in many other communities. Negotiating and implementing approaches for addressing such problems among many independent government units in the watershed can be costly, given the many interests involved. Further, the costs and benefits from introduction of PIs often will be distributed unequally, which raises important distributional issues.

In summary, many coastal areas face similar kinds of management issues; but each area will have a unique institutional setting, policy objectives, and financial, political, and perhaps other constraints. Further, many PIs might, in principle, be applied, each in various ways; and each may have different consequences with respect to important criteria, including not only economic efficiency and cost-effectiveness but also transactions and information costs and distributional effects. Hence, in practice many tradeoffs must be made, and no simple checklist can be used to choose the "best" PI without reference to the circumstances relevant to each issue and coastal area.

8.2 PURPOSE, SCOPE, AND ORGANIZATION

This Chapter reviews some policy instruments potentially useful for coastal area management. We do not indicate which of the PIs reviewed might be "best" suited for particular coastal management issues. This is because, as noted, the choice of PIs will depend upon the circumstances of particular areas. Instead, we adopt a pragmatic approach in which we confine ourselves to reviewing the principal characteristics and the potential strengths and weaknesses of major PIs.

We focus on PIs generally devised and carried out by governments and ignore voluntary negotiations among affected parties. In individual cases negotiations may be possible when the number of parties is small so that the transaction costs of negotiating are low. However, most important coastal area management problems, for example, water quality issues, involve numerous sources and victims. These problems do not lend themselves to negotiations as in Coase (1960).

Our review draws upon the available literature, and we attempt to capture some the major issues identified in theory and in practice. Given the generic approach of this Document, the treatment is necessarily general. Readers interested in a more extensive treatment of particular topics can consult publications included in the list of references.

Our aim is to explore the range of instruments and their application. First, we define the two broad categories of policy instruments, RIs and EIs, discuss the basic rationale behind their application, and comment upon the way they affect behavior. Then we provide an overview of major policy instruments, highlighting their strong and weak points. We also provide examples of their use, after which we review some practical conditions that influence the effectiveness of PIs. The discussion concludes with some brief case studies illustrating how PIs have been used, or proposed for use, in practice.

8.3 POLICY INSTRUMENTS: INTRODUCTION

Regulatory Instruments

RIs are the most common PIs used in environmental policy. As noted earlier, RIs are designed to affect directly the behavior of firms or households by dictating what is allowable and what is not (OECD, 1989). RIs designed to control pollution include discharge permits, discharge level standards, and technology standards. Other types of RIs are designed to control the use of land, coastal waters and other resources and include zoning requirements, licensing, and protection of species and resources.

The political appeal of RIs is, in part, due to the direct nature of regulatory control that allows policy makers to be (or appear) decisive and effective. The political feasibility of RIs targeted at industry discharges may also be enhanced when full implementation is delayed lowering the level of short-run costs to constituents (Zeckhauser, 1985). Another factor is that the distribution effects of RIs may often not be as easily discerned compared to the distribution effects of economic instruments, such as charges. Thus, RIs may meet less political resistance (Bohm and Russell, 1985). The environmental agency may also prefer RIs that give the agency flexibility in the timing of implementation and direct control over specific characteristics of the regulation.

The effectiveness of RIs in reducing discharges from pollution sources depends upon the influence the regulation has on the motivation of the owners and operators. Those owners and operators concerned only with maximizing their economic returns will balance the cost savings they can expect from not complying with regulations against the costs they will face if their operations are monitored and found in violation (Hartford, 1978 and Russell, 1988). Therefore, pollution source owners or operators will consider the costs of complying, the probability of being monitored, the probability of being penalized, if found to be in violation, and the size of the penalty for failing to comply.

In practice, monitoring often is limited and, often, self-monitoring is used, and the polluter is expected to report violations (Russell, 1990). There is also uncertainty in the size of the penalty, which can be reduced or suspended once assessed (EPA, 1992). It follows that in considering the use of RIs, the environmental objective may be difficult to achieve when there are high costs of compliance, imperfect monitoring, and when penalties for violations are low or uncertain. However, motivations other than profit maximization, such as a sense of responsibility, also may be important (Wasserman, 1993). In the United States, for example, nearly one thousand companies have agreed voluntarily to reduce air pollution emissions of high priority toxins by 347 million pounds (US GAO, 1993). This suggests that there are many potential motivations for compliance, in addition to economic incentives. For example, one analysis of voluntary programs in the US found that large firms with high pollution volume listed in widely available public information documents were more likely to engage in voluntary reductions. The implication is that these firms are sensitive to their public image and consumer response to pollution information (Arora and Cason, 1994).

Regulations protecting species and other special resources are based on national laws and international treaties which, for example, prohibit the consumptive use of endangered species, the destruction of wetlands or coral formations, or the killing of migratory birds. For example, endangered species legislation in many countries prohibits the taking, trading, or even possession of members of endangered species. In No. America, the Migratory Bird Treaty Act protects marine birds from hunting or other causes of mortality, and many nations have laws and subscribe to conventions restricting or prohibiting the killing of marine mammals. Many countries also restrict the destruction of coral, wetlands, and other natural habitats.

Economic Instruments

EIs attempt to create market-type incentives for avoiding pollution incidents and discharges by using individuals' private interests to promote public purposes (Schulze, 1975). However, a common objective of EIs also is to raise revenues for pollution prevention, for cleanup, for operation of public facilities, and for restoration (Anderson, *et al.*, 1977; Grigalunas and Opaluch, 1988; OECD, 1989; and US GAO, 1993). EIs designed to affect prices directly are effluent, product, and user charges or taxes, subsidies, and refund-deposit systems. EIs designed to create a market that promotes pollution reduction at least cost are tradeable permit systems. EIs, such as systems of transferable development rights, can promote habitat preservation and desirable land use alternatives. EIs that transfer society's risks to the polluter are liability rules and performance bonds.

Growing interest in EIs stems, in part, from the concern that RIs impose unnecessarily high costs, which hinder efficiency and competitiveness. The appeal of EIs is their anticipated efficiency and cost effectiveness, the incentive they provide for technical innovation, and their potential for revenue generation.

The effectiveness of EIs stems from the financial incentives they impart to the firm by forcing firms to internalize costs (the Polluter Pays Principle). Lacking environmental regulations, profit-maximizing firms will not consider the damages caused by its actions. Unregulated firms will produce goods, and pollution, until the revenue from the last unit of the good produced is equivalent to the private costs of producing that unit. Under a regulatory scheme that uses EIs, the costs that the firm considers include private costs plus the social costs of its pollution output. The perfectly operating EI thus transfers the costs of bearing the pollution injury from society to the firm that generates it. In this way, EIs create an incentive for the firm either to reduce the level of pollution or its effects. In practice, the true social costs of pollution may be hard to know, and the EI may or may not fully transfer the social costs of pollution to the firm. However, the general effects of the incentive mechanism remain the same when firms are assessed for their discharges, and the firm will want to reduce pollution if the gains from reducing discharges exceed the cost of doing so.

8.4 OVERVIEW OF MAJOR POLICY INSTRUMENTS

Regulatory Instruments

Examples of RIs available are given in Table 8.1. The characteristics, strengths and weaknesses of these and other RIs are described in the sections which follow.

■ Discharge Standards

Discharge Standards define the allowable discharge levels of a point source of air emissions or effluent. For example, the United States Environmental Protection Agency ("EPA") has identified 126 priority toxic chemicals and has set national effluent guidelines concerning water quality standards for categories of industries. The EPA also designs the numerical criteria for water quality standards expressed as chemical concentration levels that are administered at the state level (GAO, 1991). The strongest argument for using standards occurs when there is a threshold beyond which discharges are very harmful and the source of the discharge is readily identifiable, for example, a point source such as industrial plant discharge pipe.

Table 8.1 Regulatory Instruments: Examples

Discharge Standards
Numeric discharge limits
Technology Standards
Effluent pre-treatment requirements
Best available control technology requirements
Zoning
Land use restrictions
Density requirements
Permits and Licenses
Set authorized releases & activities
Criminal Sanctions
Imprisonment

Generally, discharge standards are not a cost-effective way of achieving society's environmental objective. For one thing, all firms must achieve the same discharge levels, though the marginal cost of abatement may differ substantially among firms. Therefore, potential gains from trade are not exploited. Further, the costs to the agency of defining, revising, and monitoring discharge standards decrease their effectiveness. Evidence of the difficulty of implementation is indicated by the fact that in 1991, only 24 out of 50 states in the US could set up fully the numeric criteria for discharges as outlined by the EPA. Lack of resources at the state level was a significant reason for the limited application (GAO, 1991). If this is true in wealthy countries, like the

U.S., the feasibility of effectively implementing discharge standards is likely to be especially problematic in developing countries.

■Technology Standards

Technology standards dictate the type of abatement or production technology to be used by the firm or treatment facility. Regulations can require firms to use the best available technology (BAT), which might involve new, potentially high-cost approaches, or the somewhat relaxed requirement of the best practicable technology (BPT). Technology standards may also be indirectly applied as with Maximum Achievable Control Technology (MACT) standards, which are discharge standards based on the best demonstrated control technologies. It is also possible to design flexibility into technology standards. For example, the US EPA's Coastal Nonpoint Pollution control Program requires local authorities to choose among various technical solutions to nonpoint source problems. As an illustration, the EPA recommends and gives guidance for the application of storm water and effluent runoff control technologies for five types of animal feedlot operations. The methods of control include various technical specifications for diversions, settlement basins, retention ponds, and effluent disposal (EPA, 1993).

The possible advantages of technology standards are low transaction costs (for some costs) and certainty of the level of discharges. Low transaction costs stem from the avoided information costs among firms, if a technological standard is set by a government agency. Further, monitoring costs may be lower if use of the approved technology is regarded as in compliance. However, the technology mandated by the agency likely will not be the efficient choice for all firms (Bohm and Russell, 1985). Similarly, monitoring costs may not be reduced and discharge levels may not be certain, if the abatement equipment is bypassed or not fully operable. In short, even the presence of the appropriate technology does not ensure that firms will reduce discharges or that the outcome will be efficient or cost-effective.

■Zoning

Zoning attempts to protect specified areas from a variety of human activities and is used often in coastal area management. Commonly used zoning practices include a prohibition on locating heavy industry, minimum lot size for residential development, or outright prohibition of development, e.g., on unstable barrier beaches or in designated preservation areas. Other examples include establishment of special management areas and sanctuaries to protect unique shoreline or marine areas; or in a related vein, state or national parks may be set aside and reserved for limited public uses. Through the outright restriction of the categories or scale of activities, government may reduce the threat of externalities due to unattractive development, habitat destruction, or other adverse ecosystem effects caused by harmful discharges or activities, for example.

Zoning can be effective in protecting coastal area resources, by that maintaining the environmental benefits that these resources provide to people. However, zoning also can have substantial costs. Perhaps the largest of these is the opportunity cost or foregone benefits when land development is precluded (Parsons, 1991). Other costs arise if the diversion of development activity from coastal areas to other, substitute locations causes adverse environmental effects at the substitute locations.

The efficiency of zoning regulations depends upon the benefit from limiting development as compared to the costs associated with these actions. These benefits depend upon the attributes of the area or the productivity of the natural environment. For example, some of the benefits of increasing minimum allowable lot sizes show up in higher property values, which can be captured by hedonic analyses, as described in Chapter 4. The costs of zoning, as noted, are comprised of opportunity costs and possible environmental externalities at sites to which precluded coastal area development is diverted.

Another application of zoning for environmental goals is to group polluting firms together in a specified area so that wastes can be treated by a common treatment facility. Grouping firms in an industrialized zone may reduce the waste treatment costs to the individual firm, if scale economies exist for waste treatment For example, Opaluch and Kashmanian (1985) found that the Rhode Island jewelry industry, located along Narragansett Bay, could realize considerable cost savings through centralized waste treatment, even when the costs of hauling wastes from the plants to the centralized facility were included.

■Permits and Licenses

Permits and licenses are a standard component of regulatory control and are often used with other forms of regulatory and economic instruments. Permits and licenses are administrative mechanisms that authorize discharges, land use, resource use, etc. which allow government to monitor and to some extent control, activity. They are generally granted for a limited period, and must be renewed. Permits and licenses can be withdrawn for noncompliance and can be an effective part of enforcement. Permit and license fees are also sources of revenue.

For example, the US EPA's title V permit program is a major element of the agency's recent efforts to control air pollution from stationary sources. Each source must obtain an operating permit that will list all the air quality requirements for that source. The availability and certainty of this information should simplify and speed up enforcement (US GAO, 1994).

Permits and licenses also are used to allocate scarce wildlife experiences. For example, a permit may be required for hunting or fishing, which might limit the number of fish or game birds that can be harvested. Or, permits or licenses might limit the number of individuals who can camp or use natural environments at a given time.

■Criminal Sanctions

Criminal sanctions pose the threat of imprisonment, community service, financial penalties, or other restrictions on individuals found guilty of breaking environmental laws. Criminal sanctions influence the individual's behavior, even when the individual is acting in the corporation's behalf. The effectiveness of criminal sanctions is largely dependent on the level of enforcement. In the United States, criminal enforcement is the fastest growing component of the EPA's enforcement effort (EPA, 1993)

Criminal sanctions may be expensive to carry out and the outcome is uncertain. Their political appeal stems from the classification of infractions of some environmental laws as criminal behavior, giving the appearance of high governmental priority for environmental objectives. However, knowledge about the relative effectiveness of this set of instruments is limited (see, however, Segerson and Tietenberg, 1992; and Cohen, 1993).

Economic Instruments

Many EIs are available and may be useful for addressing particular coastal area problems (Table 8.3). Below we describe important features of these EIs, including strengths and weaknesses.

■Discharge Fees or Charges

Discharge fees or charges are costs imposed on the firm for the discharge of pollutants. To the extent these charges approximate marginal damages attributable to the release, they internalize the externality and force the discharger to account for the costs of using scarce environmental resources. However, in practice these charges may not be based on actual emissions, which can be costly to monitor. Instead, they may be based on some proxy measurement such as hours of operation, energy consumption, or may even be imposed as a flat fee that does not reflect the actual level of discharges at all (OECD, 1989)

Discharge fees and charges are the most widely used EIs in both the number of countries that use them and the range of applications. They have most often been set at a rate too low to induce a financial incentive for pollution reduction. Instead, fees and charges raise revenue for the subsidization of abatement costs or funding of common treatment facilities. However, they also reduce pollution through the financial incentive provided when the charges are set high enough, such as in the Netherlands system of effluent charges (Hahn, 1989). Potential difficulties with discharge fees and charges have been noted by Brown and Johnson (1984), particularly the strong political opposition to effluent fees when they were initiated in Germany. Another potential problem is that they may cause the firm to shift pollution output from one environmental medium to another (US GAO,1993).

Table 8.2 Economic Instruments: Examples

Discharge Fees or Charges	
	Fee per unit of discharge
Product Charges	
	Fee on undesirable material
User Fees	
	Volume charges on water use
	Access fees
Subsidies	
	Grants & tax allowances
Tradeable Permits	
	Point source / point source
	Point source / non-point source
Transferable Develop't Rights	
	Land trusts
Deposit & Refund Systems	
	Beverage & pesticide containers
Performance Bonds	
	Prepay't of landscape rehabilitation
Fines & Penalties	
	Remediation & restoration costs
Liability	
	Damages & restoration

■Product Charges

Product charges or taxes are levied on the marketable product of the production process or on inputs. Product charges are often used when the product itself is the source of pollution and there is no common discharge point, or when pollution is due to a specific input of the production process. The product charge is generally a surtax at the consumer level since the harm to the environment is caused by the consumption or perhaps the disposal of the product. Common examples of product charges are fees on pesticides, fertilizers, and non-rechargeable batteries (OECD, 1989)

The financial incentive created by a product charge is based on the relative prices of substitute goods. If the product charge sufficiently raises its relative price, consumption of the undesirable product should decrease. Of course, with inelastic demand for a product, a product charge would be unlikely to be effective in reducing consumption or use.

Similar to the application of discharge fees and charges, product charges are generally used to raise revenues and are not set high enough to influence behavior (OECD, 1989). A notable exception occurred in Austria. A small tax on pesticides and fertilizers had the unintentional result of decreasing their use by 30 percent over a two-year period (US GAO, 1993). A major concern in the application of product charges is that producers might shift to more economical but equally hazardous substitute inputs or use unregulated inputs or processes (Macauley, Bowes, and Palmer, 1992).

■User Charges

User charges can take the form of entry fees, waste-water fees, development fees, or fees for hunting and fishing. Entry fees are a practical way to fund operation and maintenance of recreational sites. If set high enough, entry fees also reduce the quantity demanded and may help avoid congestion at heavily used sites. On the other hand, residents may view user fees as unfair, unless residents are assessed lower fees than visitors. Waste-water charges primarily are used to pay for the costs of sewerage treatment facilities. However, these charges may discourage some water use, if the cost is tied to the volume of water used.

Other variations of user fees include development fees. For example, communities may levy a fee on developers to help defray the costs of administering permits and perhaps mitigating some undesirable consequences of development. Licenses and their associated fees for hunting and fishing provide funding for government agency activity for these resources and restrict catch or use.

■Subsidies

The use of subsidies as an EI for environmental protection is common practice although the funding sources are varied. In France, subsidies generally transfer the revenues raised by discharge fees or product charges to support a desirable activity, such as pollution abatement or waste treatment. In other countries, such as the United States, Germany, and Sweden, subsidies for construction of new waste treatment facilities or abatement research have come from general revenues and are not tied to charges (Opschoor and Vos in OECD, 1989). In the United States, the cleanup of hazardous wastes is partially subsidized and partially funded through revenues from taxes on petroleum, chemical feedstocks, and a corporate environmental tax (Probst and Portney, 1992).

Subsidies can also take the form of tariff reductions. For example, in the Philippines half of the tariff on pollution control equipment is waived. In the former Yugoslavia, pollution control equipment was exempt from custom duties (Bernstein, 1993).

However, in some situations, subsidies unrelated to pollution control may have adverse environmental consequences. Mahar (1989) cites subsidized farm credits and investment tax credits as significant causes of the deforestation of Brazil's Amazon Region. It is not uncommon for price distortions resulting from input subsidies to hinder achievement of environmental objectives. For example, subsidies for fertilizer use in Korea, on pesticide use in Indonesia, and on energy consumption in Taiwan encourage their use (Bernstein, 1993). Similarly, subsidies for sewerage treatment facilities encourage large, capital-intensive systems, while reducing incentives for water conservation.

Subsidies also may involve using differentials in property taxes to encourage socially desirable land uses. For example, some countries assess lower taxes on land used for agricultural purposes rather than tax the land valued for its most profitable use, which might be as commercial or residential property. Use of a tax differential encourages the preservation of open space and a rural way of life. However, it likely is of limited effectiveness where pressures for development are substantial due to the high opportunity cost of agricultural land preservation.

On the other hand, the removal of environmentally detrimental subsidies can have beneficial effects on the environment. For example, Kramer and Shabman (1993) found that policy reforms, which denied program benefits to farmers growing crops on lands drained after a certain date, and phased out government-supplied technical assistance for draining wetlands, helped to slow the environmentally detrimental conversion of bottomland hardwood wetlands to agricultural uses in the Mississippi Delta (USA) region.

■Tradeable Permits

Tradeable permits are a relatively new type of EI and have not yet been widely used, with most examples occurring in the United States (Opschoor and Vos in OECD, 1989). Under a tradeable permit system, the agency decides the total discharge level for a particular pollutant in a certain geographic area. Individual discharge permits are distributed to the pollution sources in the area. The sum of discharges allowed by these permits is set to the agency's environmental objective. The initial distribution of permits is an important issue. Permits may be distributed free to polluters, based on historical discharge levels, or auctioned, by that transferring potential gains to the government. Once distributed, permits can be bought and sold, which tends to equalize the marginal cost of pollution abatement across all participants.

A well-functioning tradeable-permits system promotes cost effectiveness in that the environmental objective, i.e., the aggregate level of discharges set by the agency - is achieved at the lowest cost. This result occurs because firms with high abatement costs will want to have higher discharge levels and will purchase discharge permits from firms with lower abatement costs. The aggregate costs of achieving the environmental objective are minimized when all firms face the same marginal cost of abatement, and are free to choose the type of abatement equipment and their discharge level. The level of discharges across firms will vary according to the trading of permits in the market.

Trading can also take place within a single firm. *Netting* occurs when a new pollution source at an existing facility uses discharge permits saved by reducing emissions at another source within the same facility. *Offsets* occur when a new pollution source at a new facility produces less pollution than allowed by the discharge permits saved by retiring an existing source. Offsets allow for new sources outside existing facilities to replace existing sources, provided there is a net loss in discharges. Offsets may also involve trading among different firms. *Bubbles* allow the firm to aggregate the discharge permits of all the existing sources at a single facility and distribute discharges among those sources as it wants, provided the total allowable discharge level for the facility is not exceeded. *Banking* allows firms to save emission reductions beyond current discharge levels for future use.

In practice tradeable permit systems have led to substantial cost savings, but have not achieved maximum potential savings. Most of the trading has been internal, so the full cost savings resulting from industry-wide minimum abatement costs have not been realized. External trading has been hampered by regulatory instruments that coexist with the tradeable permit system (Hahn, 1989). On the other hand, the administering agencies have incurred the costs of providing the institutional setting that promotes active trading (Opschoor and Vos in OECD, 1989). These costs derive from efforts to approve and monitor trades and to enforce the changing allocation of permits so that each firm's level of discharges matches its permit allocation. Another concern for a tradeable permit system is political opposition arising from groups opposed to selling or giving firms the "right to pollute"; and from the constituents of "hot spots" where the local level of pollution has risen due to the re-allocation of permits.

- Transferable Development Rights

A system of transferable development rights (TDRs) provides incentives for land preservation by allowing the transfer of foregone development capacity to a more-developed target area. In a TDR system, owners of real estate in the preservation area sell the right to develop their property to others who can apply those rights towards development in the target area. The preservation area contains desirable attributes or provides amenities, such as species habitat, natural resources, or recreational and agricultural uses, which would be lost under commercial or residential land use development. The target area is generally an area where development has already occurred and where a market for increased development exists.

Transfers of development rights are driven by the desire of developers to increase development in the target area beyond normal zoning limitations. Increased development in the target area occurs through use of the transferred development rights as "bonus" zoning allowances for the target area. Compensation is provided to the preservation area land owner through the sale of TDRs to a developer. The market determines the price of TDRs. In part, the price is determined by the expected increase in the developer's profits due to increased density (Small and Derr 1980).

The government plays a significant role in the design, implementation, and monitoring of a TDR system. In designing a TDR system, the government must define both the preservation and target areas, and the transfer ratio - how many units of preservation area development rights are required to allow for one unit of density increase in the target area - the initial distribution of TDRs. Additionally, the government must decide whether the system will be voluntary or mandatory. Defining a coastal zone as a preservation area can be problematic as there may be greater pressure to develop the coastal zone than an inland transfer zone, by that diminishing the incentive to purchase TDRs (McGilvray, et al., 1985). The initial distribution of TDRs can be based on either the size of the parcels, i.e., per unit of area, or on the estimated development value of the land. Distribution of TDRs according to estimated development value would acknowledge the heterogeneity of parcels within the preservation area. Based on the idea of just compensation, a voluntary TDR system may be more feasible than a mandatory system. In the U.S., mandatory systems have been challenged for providing unjust compensation due to the uncertainty of TDR price and demand (McGilvray, *et al.*, 1985).

The compensation provided land owners in the preservation area has also been subject to criticisms based on fairness and uncertainty. The compensation to land owners is determined in an unstable market that is sensitive to the design decisions of the government (Barrows and Prenguber 1975). Questions also arise whether land owners in the preservation area should receive compensation, which is an unearned increment in value, due to public action such as the creation of TDRs (Field and Conrad 1975, Barrows and Prenguber 1975). Another major criticism of TDR programs is that the costs of preservation borne by purchasers of TDRs are not related to the benefits of preservation, such as recreational use and nonuse values. The resulting preserved acreage may not approximate the optimal level (Small and Derr, 1980).

A variation of a TDR system in common practice in the U.S. is the "land trust" system. Under a "land trust" system either the government or a non-governmental organization purchases the development rights of land in the preservation area and retires them. The land trust may also promote preservation through ownership of land or through easement acquisition. Public and private land trusts have been active in the U.S. preserving farmland, habitat, and natural resources. In 1990, there were over eight hundred active land trusts in the U.S. protecting over two million acres (US Department of Agriculture, 1994).

- Deposit and Refund Systems

Deposit and refunds are used most often as a financial incentive for the proper disposal of a consumer product. At the time of purchase the buyer pays a deposit refunded when the product or its residual is disposed of in the pre-specified manner. For example, the disposal of beverage containers has been successfully controlled by deposit and refund systems in the United States, Canada, Germany, France, and Switzerland. The disposal of car hulks has also been successfully controlled by deposit and refund systems in Norway and Sweden (Opschoor and Vos in OECD, 1989). Deposit and refund systems have been used to control the disposal of potentially hazardous wastes such as car batteries and pesticide containers (Bernstein, 1993). These systems have also been recommended for toxic substances such as chlorinated solvents and brominated flame retardants (Macauley, Bowes, and Palmer, 1992). Potential problems in the application of deposit and refund systems to hazardous wastes are that hazardous wastes are often not precisely defined or measured. Also, refunds may also not be large enough to discourage illegal disposal (Hahn, 1988).

- Performance Bonds

Performance bonds are similar to deposit-refund systems in that payment is made prior to any actual environmental damage to ensure that potential damage is avoided. Performance bond payments are intended to cover the full cost of any potential damages or restoration and are refunded when predetermined conditions are met. For example, performance bonds are used in regulating the Australian mining industry as an incentive to rehabilitate fully former mining sites (Opschoor and Vos in OECD, 1989). In the United States, performance bonds are recommended by the EPA as an innovative approach to encourage the use of coastal nonpoint pollution control (EPA, 1993).

The advantage of performance bonds is that they fully protect society from the risk that the polluting firm may become bankrupt before fulfilling its restoration commitments. Performance bonds also relieve the potential risks associated with innovative new processes.

■Fines and Penalties

Fines and penalties are often levied on firms for violations of environmental regulations. However, they are not always set high enough to act as incentives for compliance with environmental regulations (Bernstein, 1993). Arbitrarily set or flat rate fines and penalties likely will produce little incentive for compliance and will have no relationship to damages. Fines and penalties that are larger than the profits gained from non-compliance are compatible with the Polluter Pays Principle and have been successful in OECD countries (Opschoor and Vos in OECD, 1989). Under US EPA guidelines (EPA, 1984) assessed penalties should include the defendants' economic gains from noncompliance and a substantial monetary component that reflects the gravity of the violation.

Beyond fines and penalties, Supplemental Enforcement Projects (SEPs) are being used in the United States. SEPs provide additional environmental benefits beyond traditional penalties and relief through the courts. Under the 1991 Policy On the Use of Supplemental Environmental Projects in EPA Settlements (EPA, 1991) the defendant may undertake projects or programs other than those required to correct the violation in exchange for a reduction in the assessed civil penalty. The EPA requires that SEPs maintain an appropriate relationship to the original violation and that SEPs in no way reward firms by subsidizing legally required compliance. SEPs can promote pollution prevention, pollution abatement, environmental restoration, and environmental auditing. The total estimated value of SEPs in the United States increased from $48 million in fiscal year 1992 to over $73 million in fiscal year 1993 (EPA, 1994).

■Liability

Liability serves the twin purposes of providing an incentive for due care to avoid environmental harm and compensating those who suffer losses. Liability for environmental damages generally requires the party responsible for the environmental injury to pay damages. These damages are for the lost services caused by the injury to the natural resource and for the costs of restoring the resource. To learn the value of a claim, a damage assessment must be done. The damage assessment establishes the linkages between the injury to the environment and the lost services to people provided by the resource. The assessment also determines the value of the lost services, and the costs of restoration. Recent policy developments and technical advances enhance the potential applicability of liability as a useful policy instrument in certain situations (Grigalunas and Opaluch, 1988; Kopp and Smith, 1993).

Theoretically, liability is akin to a tax on potential environmental losses. The threat of liability provides an incentive for potential polluters to exercise care, since it must bear the costs of any damages. The potential polluter will use the level of expected damages as a gauge to decide the appropriate level of precaution (Grigalunas and Opaluch, 1988; Tietenberg, 1989).

Use of liability as an EI requires that cause-and-effect linkages be established between an incident and a money measure of damages. These linkages extend from a spill (or other environmental disturbance), to a deterioration in ambient conditions in the affected environment (e.g., concentration of a pollutant in the water), to injury to particular natural resources (e.g., loss of fish or birds), to a loss in services to people (e.g., lost catch of fish), which ultimately results in damages to people measured in monetary terms.

In practice, however, a system based on liability for environmental damages faces severe problems. This is because of difficulties in quantifying damages in dollar terms and the high cost of legal proceedings (Cootner, 1991). However, use of liability as an EI is much more practical often due to recent developments, which provide a legal and administrative framework for this approach. For example, in the US simplified approaches have been developed to estimate damages from relatively minor oil and hazardous substance spills in coastal and marine environments. Two types of simplified approaches are available. One relies on use of an integrated, interdisciplinary computer model that simulates spills and their consequences, given information about the spill and the affected coastal environment (Grigalunas and Opaluch, 1988). The second simplified approach employs "look-up tables" or a simple formula to arrive at an estimate of a claim against a polluter. For example, several states employ a formula, based on expert judgment and qualitative considerations, which specifies the claim as:

$$\text{Dollar Claim} = (\$/\text{volume}) \times T \times P \times ES \times (\text{Volume spilled})$$

where

$/volume is a basic dollar charge per unit spilled
T = an index of the toxicity for the substance spilled
P = an index of persistence for the substance spilled
ES = an index reflecting the environmental sensitivity of the affected area
Volume = amount spilled

Other factors might be added to reflect the amount cleaned up, the season of the spill, or other considerations. Ideally, the formula would approximate the "true" damage function[1]. Of course, learning the base monetary damage per unit spilled

[1]The U.S Department of Commerce, National Oceanographic and Atmospheric Administration (1993) has recently proposed regulations which use simple formula for assessing damages from oil spills up to 50,000 gallons. Separate formula are given for different oil types, spill sizes, environment types and seasons. Repeated applications of an interdisciplinary computer model were used to generate the formula.

is problematic and remains a critical issue with use of a simplified formula such as that indicated above.

8.5 POLICY INSTRUMENT EFFECTIVENESS

Introduction

The preceding section describing the various policy instruments suggests that certain instruments are better suited to some applications than others. This section explores some practical conditions that influence the effectiveness of PIs. These conditions can often be manipulated to increase the effectiveness of PIs either through mixed use of RIs and EIs or through other policy reforms. Achievement of environmental objectives requires that environmental PIs (1) are compatible with other policy objectives; (2) have broad-based support; and (3) provide the appropriate incentives to firms and individuals. Specific conditions that influence the effectiveness of PIs include:

- compatibility with the environmental objective
- compatibility with existing government policies
- administrative feasibility
- political feasibility
- compatibility with other government objectives
- cost effectiveness
- gains from technological change
- per unit discharge costs

Each of these is briefly reviewed.

Factors Influencing Effectiveness of PIs

<u>Compatibility with the Environmental Objective</u>

A policy instrument may be incompatible with some facets of the environmental policy objective. For example, a system of tradeable permits that allows the creation of "hot spots", i.e., sources that have increased discharge levels through purchasing permits, may be incompatible with local air quality objectives. In some instances, it may be possible that the local firm can legally discharge more under a system of tradeable permits than under a command and control regime, even though aggregate levels of pollution in the region is lower.

The tradeable permit system designed to enhance air quality in the Los Angeles Basin addressed this incompatibility, i.e., the presence of "hot spots", in two ways. First, the tradeable permit system co-existed with a command and control regime that limited discharges at each source according to technology-based standards. Second, trading reforms were initiated that only allowed sales to downwind trading partners (Foster and Hahn, 1993).

Compatibility with Existing Government Policies

The effectiveness of a PI may be restricted due to other existing regulations or institutional practices. For example, conservation-oriented, land-use restrictions under the administration of the federal Institute of Forestry Development prohibited landowners from clearing more than one-half of their land holdings in the Amazonia region of Brazil. Simultaneously, the National Institute for Colonization and Agrarian Reform maintained a policy by which deforestation was considered a suitable land improvement qualifying a homesteader for rights of possession (Mahar, 1989).

The practices of a country's legal institutions may also inhibit the effectiveness of some policy instruments. If property rights are not firmly established, or are unenforced, policy instruments that depend on property rights such as zoning, licensing, and liability will be unsuccessful. Similarly, if the local courts do not enforce civil penalties or collect taxes, a policy that relies on these courts to enforce environmental regulations and collections will meet with limited success.

The Amazonia region of Brazil can again be an example. The rural land tax was created in part to encourage productive land use and to reinforce the 50 percent conservation rule by not taxing that portion of the holding. However, collection of this tax relied on self reporting of land use and production. Similarly, capital gains on the sale of land were also based on self-reported sales prices. This absence of tax enforcement subsidized land speculation that significantly contributed to the deforestation of the region (Mahar, 1989).

Administrative Feasibility

The administrative feasibility of a policy instrument depends on the costs of administering the PI. These costs include the research and testing required to design standards, monitoring costs, and enforcement costs, including legal expenses. These costs can have a significant impact on the administrative feasibility and, therefore, the effectiveness of PIs. For example, in the United States the 1987 Water Quality Act amendments to the Clean Water Act required the states to adopt numeric guidelines provided by the EPA for water quality standards and list all waters that did not meet established water quality standards for toxic pollutants. The EPA was required to begin almost immediately publishing a biennial schedule for the periodic review and revision of existing effluent guidelines.

A review of the progress of these initiatives three years later found that few states had adopted the numeric guidelines. This was in part because the guidelines were not methodologically sound, were outdated, and their use would incur large legal expenses by the states. Most states after three years had monitored less than half of their surface waters. And only 29 percent of the nation's river miles had been monitored for toxic pollutants at that time. Also, the EPA was unable to maintain the mandated guideline revision schedule. It was found that 19 of the 35 major guidelines had not been revised in over five years and 9 of those had not been revised since the 1970s. The administrative infeasibility of this purely RI approach to water quality caused the report to conclude by recommending effluent fees for raising revenues and providing incentives for emission reductions (US GAO, 1991).

Political Feasibility

The anticipated distribution of the costs and benefits resulting from the implementation of the policy instrument will directly effect the political approval of the policy instrument and its effectiveness (Zeckhauser, 1985). However, the benefits from a policy instrument may not be easily identified. For example, small businesses in the Los Angeles Basin were initially concerned about switching from a command and control regime to a system of tradeable permits. They thought that they would be at an unfair disadvantage compared with larger firms. An empirical study of the furniture manufacturing industry in the region which is composed of small businesses showed the industry's fears to be unfounded in that there would be a net annual gain to the industry of $31 million dollars by switching to a tradeable permit system (OECD, 1994).

The same study by the OECD (1994) reviews the findings of the few empirical analyses on the distributional impacts of EIs. Pollution control costs were regressive, but pollution control benefits were pro-poor. The report also finds that both emission taxes and trading programs can cause large transfers of wealth, but the distribution varies widely according to the specifics of each program. Generally, the report warns against making mistaken distributional assessments that are not based on empirical analysis.

Compatibility with Other Government Objectives

Governments commonly subsidize firms to promote policy objectives in areas of trade, employment, and development. However, subsidies may also conflict with and, therefore, reduce the effectiveness of economic instruments for environmental protection. An economic instrument designed to provide a financial incentive to reduce an environmentally undesirable practice is undermined by a subsidy scheme that promotes greater output. In West Java, for example, soil conservation policies discouraging monocropping of cassava are ineffective due to the Government of Indonesia's export and pricing policies (Barbier, 1990).

Consider an agricultural example in which the environmental objective is the maintenance of water quality in a particular watershed. The environmental policy instrument is a product charge levied on fertilizer. It is designed to reduce fertilizer use, by that reducing fertilizer runoff into the watershed. The government also has the objective of increasing employment in the region. The employment policy instrument reduces the price of land through subsidized leasing. Farm employment increases as more farmland is brought into production. Hence, a conflict between the two policies arises. This conflict may be serious where, for example, marginal lands that require proportionately more fertilizer and are more prone to erosion are brought into production by the lease subsidies. Using these lands for farming increases fertilizer runoff into the watershed. Although the usage of fertilizer on any individual farm is reduced due to the product charge, the adverse environmental effects of the employment policy hinder achievement of the environmental objective.

Achievement of the environmental policy objective generally is more difficult and more costly when the financial incentive of economic instruments competes with market distorting subsidies. Removal of these subsidies is a significant point of the OECD's Recommendation of the Council on the Use of Economic Instruments in Environmental Policy (OECD, 1993).

Cost Effectiveness

Environmental protection imposes costs on firms, even when the net benefits to society are positive. Pollution abatement equipment, alterations of the production process or use of inputs, and restrictions on potential plant locations are all costly. The firm will be subject to some or all these costs in its compliance with the government's environmental policy. The cost of environmental protection is not insignificant and reduces the funds available for other productive uses. Conflicts between applying scarce resources for environmental protection and other productive uses intensify when countries are poor.

A cost-effective policy instrument allows the firm to realize a least-cost strategy and reduces incentives for non-compliance. A commonly cited advantage of a tradeable permit system is that the environmental objective can be achieved with large cost savings over other PIs (Tietenberg, 1980; O'Neil, *et al.*,1983; Opaluch and Kashmanian, 1985; and Hahn, 1989). Perhaps the most successful program in this respect has been the lead credit trading program carried out in the United States to reduce the lead content in gasoline. The estimated cost savings to the industry from this program were over $228 million. The success of this program has been largely attributed to the ease in which lead content could be monitored through the existing regulatory system and to the widespread support for the environmental objective (Hahn, 1989).

Gains From Technological Change

Policy instruments vary in the level of incentive to promote technological change that they provide. Milliman and Prince (1989) learned that PIs as direct controls, such as discharge level standards, discouraged innovative behavior. Innovation is discouraged because gains to the firm are restricted to only the reduction in the direct costs of producing the allowable level of discharges. They also found that emission taxes and auctioned marketable permits provided greater incentives than emission subsidies and free marketable permits. This finding is based on the potential for significant gains for the firm once the innovation has been employed under these PIs. The rationale is that the existence of these potential gains will cause the firm to explore innovative technologies. The regulating agency can also positively effect innovation by making its response to innovation known with certainty (Milliman and Prince, 1989).

Per Unit Costs of Pollution

Policy instruments that impose costs (penalties) for discharges greater than the allowable limit without imposing costs (fees or taxes) for discharges below that limit provide no incentive for discharge reductions below the allowable level. The firm gets no financial benefit from reducing discharges below the standard because there are no costs associated with discharges below the standard and therefore, no cost savings. Instead the incentive is to produce the allowable discharge limit at the least cost.

On the other hand, an emissions charge applied as a financial incentive would attach a fee to each unit of discharge. The per-unit emissions charge provides an incentive for the firm to reduce continuously discharge levels. Empirical analysis and surveys of polluters and agency officials supports this finding (Hahn, 1989). Hahn (1989) refers to the results of a 1986 study by Brown and Bressers that analyzes the effluent charge system in the Netherlands. This system of charges has been in place since 1969. The results of this empirical analysis are that pollution measured in population equivalents has decreased by 90 percent between 1969 and 1985. Of course, reducing discharges below the allowable limit presumably are justified only if there is a sound reason, based on benefit cost analysis of another reasoned criteria, for doing so.

8.6 CASE STUDIES

Introduction

This section describes case studies of actual uses of economic instruments. These studies were chosen for their relevance to coastal area management issues and because they represent *actual* applications of economic instruments as opposed to simulations. The first case study concerns the use of liability for damages to natural resources in the United States. The next case study is a review of a combination of studies portraying the use of point source/non-point source trading to control water quality. The third case study discusses the effects of agricultural policies on water quality based on examples from Java and the United States. The fourth case study discusses the use of supplemental environmental projects (SEPs) as policy instruments used in the United States. The potential for use of economic instruments in environmental policy has been well documented. However, few studies exist of the frequency and effectiveness of economic instruments used for coastal zone management. These studies are presented to offer some insight into the application of policy instruments whose use is more complex than the familiar emissions and product charges.

Case I: Liability

In the United States, liability for damages, restoration, and remediation of injuries to natural resources is a significant and at times controversial environmental policy instrument. The significance stems from the potentially huge dollar values of damages, restoration, and remediation costs. The controversy stems from the means of assessment of dollar values for natural resource damages and the use of retroactive, strict, joint and several liability rules used in the determination of responsible parties. Liability for damages in case of injuries to public natural resources caused by hazardous substances is provided by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The Outer Continental Lands Act of 1978 (OCSLA) and the Oil Pollution Act of 1990 (OPA) addresses liability and related issues upon injuries to natural resources occurring from oil spills. Although CERCLA, OCSLA, and OPA are the laws governing liability issues, the application of these laws occurs through regulations promulgated by designated federal government agencies.

The strict, joint and several liability provisions of CERCLA give strong economic incentives for cleaning up active hazardous waste disposal sites and for preventing harmful situations in the future. The retroactive liability provisions of CERCLA place the costs of rectifying abandoned and inactive hazardous waste disposal sites with those that benefited from past harmful activities. Under retroactive, strict, joint and several liability any firm that disposed of hazardous wastes at a facility in the past, despite the level of care taken then and despite the volume of waste deposited, is liable for all remediation and restoration costs at that site. If a causal link is established the firm may also be responsible for all natural resource damages (Anderson 1993; Kenison, 1993). The effect of these liability provisions is that the government, acting as trustee of public natural resources, pursues large firms able to pay substantial sums toward site remediation. In many cases disposal sites were used by a single firm, but in many other cases there were multiple contributors of hazardous waste at a site. Pursuing only the largest firm(s) under the joint and several provisions of CERCLA in instances of multiple contributors deviates from the polluter pays principle. Smaller waste contributors that are unable to pay substantial portions of remediation costs are not sharing in the burden of remediation and transaction costs (Probst and Portney 1992).

Many criticisms have been made of the effectiveness of CERCLA, in encouraging cleanup of hazardous waste sites and affecting future waste management practices. In 1991 the US EPA estimated that it would take an average of eleven years between the time a site was placed on the National Priorities Listing to the time that remediation was completed. However, the pace of site identification and clean up through 1991 indicates that it may take as long as 18 years between identification and full remediation (Probst and Portney, 1992). Delays in the performance of cleanups are due to many factors. The most prevalent are disputes over the level of clean up required, the level of scientific study required to learn the appropriate clean up process, and the agency's policy choice to pursue litigation before cleaning selected sites.

Another severe criticism of current practices under CERCLA and OPA is the high level of transaction costs associated with the pursuit of liability claims. Under CERCLA there are numerous avenues of litigation that are taken. These include litigation by the government against the potentially responsible party, litigation between potentially responsible parties, litigation between potentially responsible parties and their insurers, litigation between insurers, and settlement negotiations between the government meet and the potentially responsible parties (Probst and Portney 1992). Transaction costs increase further when each party to the litigation hires its own technical experts to provide analyses on their behalf. One survey of transaction costs estimated that in 1989, transaction costs were 41 percent of CERCLA outlays for litigation concerning multi-party sites. The same survey found that insurers spent 90 percent of their CERCLA-related outlays on active claims on transaction costs such as legal fees and technical support (Probst and Portney 1992). Under OPA and CERCLA, natural resource damage assessments also significantly add to the level of transaction costs.

The high cost of doing natural resource damage assessments has led to attempts to streamline and systematize assessment efforts. Examples of this approach are the Type A models for the estuarine and marine and Great Lakes environments in the U.S. These computer models use biologic, oceanographic, and economic information to assess damages to natural resources based on historical estimates of significant parameters. This approach is used for relatively small spills or where damages are too small to warrant a site-specific study.

The effectiveness of liability rules in inducing firms to take the appropriate level of care is difficult to determine. One study of the incentives provided by liability rules by Opaluch and Grigalunas, 1984 shows that offshore oil producers in the United States reduced bids for offshore leases because of perceived liability exposure in case of spill or other incident. Bids for leases in areas that were more vulnerable to injury due to a spill were lower than bids for areas of less vulnerability, other things being equal. The implication is that firms are internalizing the potential environmental costs of pollution by offering a lower lease price where potential damages are higher.

Overall, it appears that liability rules under CERCLA and OPA provides some incentive for increased levels of care in the disposal and transport of hazardous materials. However, the level of incentive is unclear due to the uncertain nature of litigation outcomes. The effectiveness of liability rules under CERCLA and OPA may also be limited by the high transaction costs and by the abilities of scientists to assess accurately environmental injury and economic damages.

Case 2 - Point source/Nonpoint source Trading

This case study reviews the application of point source/nonpoint source trading schemes in various locations in the United States. Simulation models find that trading between point sources lowers the cost of reducing effluent discharges (Hanley 1993; Opaluch and Kashmanian, 1985). These results are supported by studies of point source trading to achieve air quality goals (Foster and Hahn, 1993). However, controlling nonpoint source discharges through trading with point sources has been applied only infrequently. A major impediment to the application of point source\nonpoint source trading schemes has been the stochastic nature of, and difficulty in measuring, nonpoint loading (Malik et al. 1993). Other impediments are the level of information and modeling required and the institutional requirements to ease trading.

Nonpoint sources of water pollution are a significant cause of water quality degradation. Estimates are that full compliance with all technology based discharge requirements by point source dischargers would still leave 18,000 bodies of water in the U. S. below designated water quality standards due to the effects of nonpoint source pollution (Apogee 1992). The US EPA has identified five major categories of non-point pollution sources that pose a significant threat to coastal waters: (1) agricultural runoff, including pesticides, herbicides, and soil erosion; (2) urban runoff including erosion, on-site disposal systems, roadway runoff, and construction runoff; (3) forestry runoff including pesticides, fertilizer, and erosion; (4) marinas and recreational boating including marina runoff, waste disposal, fuelling and maintenance practices; and (5) channelization and channel modification, dams, and shoreline erosion (EPA, 1993).

Trading discharges between point sources and nonpoint sources allow for overall water quality improvements, reduces nonpoint source discharges, and provides a mechanism for firms or waste treatment plant operators to choose lower cost pollution abatement solutions. The motivation for establishing a trading scheme may be the improvement of overall water quality in a body of water when point source discharges are already achieving discharge standards. Alternatively, a point source may want to increase discharges while under a requirement to maintain the current level of overall water quality. Point source/nonpoint source trading may also ease the introduction of new point sources of pollution without degrading overall water quality, if adequate nonpoint reductions can be made.

Under a point source/nonpoint source trading scheme, the point source would reduce nonpoint loading to avoid having to increase its own abatement activity. Actions to reduce nonpoint loading may be taken directly by the firm. For example, the firm might build anti-erosion structures, or the firm may make payments into a fund that supports nonpoint pollution reduction efforts. A point source/nonpoint source trading scheme is not viable under many restrictive conditions. The body of water in question must have a measurable input of nonpoint source pollution loading, and the effects of reducing that loading on overall water quality must be known with some certainty. If reducing the volume of nonpoint loading will have the desired effect on overall water quality, there must be a sufficient difference in the marginal cost of abatement between the point source and the nonpoint source to induce trading. The cost to the firm of a unit reduction in point source discharges must be greater than the cost of a unit reduction in nonpoint source reduction including the trading rate multiple. The trading rate multiple reflects the stochastic nature of nonpoint loadings due to external factors such as rainfall, time of year, etc. In a point source/nonpoint source trading scheme, the trading rate multiple (also known as the trading ratio) specifies the number of nonpoint loading units that are the trading equivalent of a single point source loading unit. The trading rate multiple may be greater than one to account for anticipated development of new nonpoint sources. A significant requirement for a point/nonpoint trading scheme is an institutional structure that provides enforcement, monitoring, and a mechanism for carrying out nonpoint source loading reduction activities.

A few water quality point source/nonpoint source trading schemes are in effect in the United States. A point source/nonpoint source trading program is being introduced to achieve water quality improvements in the Albemarle-Pamlico Estuary in North Carolina. This estuary system is one of the largest in the country with a surrounding watershed of over 5,400 square miles. The environmental objective is a 200,000 kg/yr reduction of nutrient loading in the estuary to be achieved according to a declining schedule of load allowances. Estimates are that almost 80 percent of nutrient loading was attributable to nonpoint sources, making achievement of the environmental objective extremely costly for point source contributors. The estimated capital cost of compliance by point source contributors exceeded $50 million (Apogee, 1992). The trading program alternative allows point source contributors to achieve nutrient reduction goals by funding relatively low cost agricultural best management practices that reduce nonpoint loading.

Point source contributors formed an Association that includes twelve publicly-owned waste-water treatment facilities grouped together for loading allocation purposes. The trading rate multiple is 3:1 for cropland best-management practices and 2:1 for animal best-management practices. Point source reduction credits earned by funding nonpoint reductions are valid for ten years. Funds targeted for nonpoint source loading reductions go to a state agency responsible for overseeing agricultural best management practices (Apogee 1992).

Trading is allowed only after Association members optimize existing facilities. To date, no trades have taken place. This is because loading reduction targets have been met through efficiencies realized at existing facilities. However, the Association has spent over $1 million developing agricultural best management practice demonstration projects to ensure that nonpoint reductions can be achieved when trading commences.

At Chatfield Basin in Colorado, a program in the planning and modeling stages will facilitate point source/nonpoint source trading of phosphorus effluent to maintain water quality in the Chatfield Reservoir. The models being developed will predict monthly and annual phosphorus loads from point and nonpoint sources. Other models will figure out the economically optimal phosphorus discharge allocations among sources under the constraint of limited total phosphorus loading in the reservoir. Point source/nonpoint source trading will be available to achieve water quality goals at least cost; however, this program is not yet in effect (Apogee 1992).

At the Cherry Creek Reservoir, also in Colorado, a point source/nonpoint source trading program has been developed and is in effect although trading has not occurred yet. At the aforementioned reservoir, nonpoint sources of phosphorus loading were the largest contributor of phosphorus into the reservoir. To maintain water quality during anticipated population growth in the watershed, a trading program was developed. The program would allow point sources to earn loading allocation credits by setting up nonpoint source phosphorus loading controls. Trading has not yet occurred, mainly because actual population growth has been less than anticipated (Apogee 1992). A third reservoir in Colorado, the Dillon Reservoir, set up the first point source/nonpoint source trading program in the United States. However, point source/nonpoint source trading has not occurred due to increased operating efficiency of the point source technology allowing for low cost reductions in point source loading (Apogee 1992).

Point source/nonpoint source trading programs show much promise as a cost-effective means of achieving water quality objectives. Trading programs may be particularly applicable to areas where increasing development is expected to overload existing waste-water treatment facilities and nonpoint sources are significant contributors to pollution loading. However, the institutional, informational, and modeling requirements for a successful point source/nonpoint source trading program may often be difficult to fulfill.

Case 3 - Agricultural Policies

Agricultural policies can have intended and unintended effects on water quality. Agricultural policies can effect levels of fertilizer and pesticide use, crop choice, and the amount of acreage under cultivation. Each of these items can affect water quality through resulting levels of runoff and erosion. Subsidies are often used as agricultural policy instruments yielding water quality effects. Beneficial water quality effects of agricultural subsidies may occur when highly erodible cropland is removed from cultivation as a part of a soil conservation program. Agricultural subsidies may also have degrading effects on water quality if subsidies encourage excessive fertilizer and pesticide use or when price supports keep highly erodible land under cultivation. Pesticide subsidies of various types have been prevalent in developing countries encouraging excessive use and resulting in many costly externalities including water quality degradation (Farah 1994).

The three cases reviewed here examine the water quality related effects of soil conservation efforts and agricultural policies in Java, soil conservation polices in the U. S., and policies affecting wetland conversion to cropland also in the U.S.. In a study of soil conservation practices on the Indonesian island of Java, Barbier (1990) discusses several economic influences on the land management behavior of subsistence-level, upland farmers. This study does not address the potential water quality implications of soil conservation, but the incentives influencing soil management behavior here parallel a soil conservation program aimed at water quality improvements. A notable conclusion of this study is that farmers may not adopt soil conservation practices, though there may be substantial long term benefits, if short-term economic incentives are not in place.

Disincentives to adoption of soil conservation practices may result from physical attributes of the farm and from government policies concerning crop price supports and fertilizer subsidies. The physical disincentives cited by Barbier include the depth of topsoil and the amount of labor required to build bench terraces. On many of the farms in question in Java, the depth of the volcanic topsoil is so great that despite the high volume of erosion that occurs, the farmer's harvest is not affected and there is no immediate economic incentive to conserve soil. The preferred soil conservation practice in the upland area is bench terracing which is very labor intensive to construct. The average farmer working throughout the dry season would only be able to terrace a small fraction of the farm in a single season. Another impediment to terrace building is that most farmers do not have the cash or available credit to hire labor. Subsistence farmers choosing the most productive use of their time face high opportunity costs with bench terracing. These opportunity costs are due to lost income from either off-farm employment or reduced crop production (Barbier, 1990).

The disincentives to adoption of soil conservation measures resulting from government policies are based on the effects of those policies on the farmer's profits. For example, bench terracing increases the moisture content of the soil allowing farmers to switch to traditionally higher valued crops. However, the presence of government price supports for lower valued crops such as cassava provide incentive for farmers to forego terracing and monocrop cassava, which causes high levels of erosion. Government subsidies for fertilizer use in Indonesia have encouraged reliance on increased fertilizer input to maintain crop yields rather than on more expensive soil conservation practices. Barbier also cites the lack of secure land tenure as a disincentive to investment in soil conservation practices. For example, in Srigonco, East Java, poor land management practices were most prevalent on leased farms were tenure was unstable (Barbier, 1990).

Ribaudo (Ribaudo, 1989) examines the economic efficiency of water quality improvements from the Conservation Reserve Program in the United States. This program allows farmers to take highly erodible farmland out of production for soil conservation. The government pays the farmer 50 percent of the cost of establishing permanent ground cover and rental payments for the duration of the contract period. Although many benefits besides water quality improvements arise from this program, there has been encouragement to use this program for enhancing water quality nationwide. Under this program objective, the specification of water quality targets influences the distribution of enrollment in the program and the economic value of water quality benefits achieved (Ribaudo, 1989).

Three different specifications of water quality goals were compared for effects on the overall economic value of water quality improvements and on enrollment patterns. Under the three scenarios, water quality goals are specified according to (1) the physical characteristics of the water including concentration levels of phosphorus, suspended sediments, and nitrogen; (2) the economic damages per ton of erosion (a proxy for economic benefits); (3) and economic damages per acre of cropland enrolled (a proxy for economic benefits). The two damages scenarios used available estimates of offsite erosion damages for each region of the country. The damages per ton scenario, however, include the implicit and false assumption that removing an acre of cropland will result in the same level of erosion reduction whatever the region. Defining water quality goals according to damages per acre of cropland avoids this problem by allowing differences in topography, climate, and soil type to effect the level of economic damages. Under the damages-per acre scenario, regions with similar levels of damages per ton can have significantly different levels of damages per acre depending on regional differences in per acre erosion levels.

Ribaudo's conclusions emphasize the importance of incorporating economic benefits into the goals of a soil conservation program aimed at improving water quality. The estimated benefits of the damages-per ton and damages-per acre scenarios were both approximately 34 percent higher than the level of economic benefits resulting from a program aimed at improvements in physical characteristics. Enrollment patterns

also varied widely across scenarios reflecting different water uses and benefit levels in different regions.

A third case concerns the effects of agricultural policy on economic incentives for environmental management. The role of taxes and price policies on wetland conversion to cropland on the Mississippi Delta region of the United States is examined. In the two hundred years before 1980, the continental U. S. is estimated to have lost 53 percent of its original freshwater and estuarine wetlands. Since 1937, the Mississippi Delta region lost 80 percent of its bottomland hardwood forests to cropland conversion (Kramer and Shabman, 1993). Historically, tax and price policies and government supported channelization and drainage projects encouraged the conversion of wetlands into cropland for soybeans, cotton, rice, and wheat. Kramer and Shabman, 1993 analyze the effects of policy reforms on the land owner's incentive to convert bottomland hardwood forests into cropland.

Bottomland hardwood forests can produce marketable timber, leaving the ecological functions of the wetland area relatively intact. The landowner must decide the most profitable use of the land. This involves comparing the potential discounted future income of the cropland in question to the costs of converting the land, and the discounted foregone timber income. Government policies and programs have affected this land-use decision by stabilizing farm income, and subsidizing wetland conversion. Before the 1980s the United States Department of Agriculture's Soil Conservation Service supported wetland conversion by providing technical assistance to farmers installing wetland drainage systems. The risk of future farm income was reduced by U. S. Dept. of Agriculture programs that set minimum prices on crops and supported income levels of farmers who kept acreage out of production. The government also subsidized crop insurance against yield losses due to natural causes. Recent polices have reversed some of these incentives by removing technical support for new drainage and removing price and income supports for crops grown on recently converted wetlands (Kramer and Shabman, 1993).

Federal income tax law also provided economic incentives for wetland conversion until the mid-1980s. Previously, farmers could reduce net farm income by the amount spent on land clearing and drainage installation up to a percentage limit of gross farm income. Positive tax incentives also existed for timber harvesting and management as well, however, tax favored management practices did not apply to bottomland hardwood forestry. Preferential tax treatment of wetland conversion was removed by the Tax Reform Act of 1986. Kramer and Shabman did a simulation analysis on the net present value of the conversion investment to decide whether current policies will continue to provide a disincentive for wetland conversion. Their results suggest that the new policies provide disincentives to wetland conversion. However, they also acknowledge other factors, such as environmental policies aimed specifically at wetland conservation and that converting remaining wetlands may require more extensive engineering than previously converted wetlands (Kramer and Shabman, 1993).

Case 4 - Supplemental Environmental Projects:

In recent years, the United States has greatly increased the use of civil fines and criminal penalties as economic incentives for compliance with environmental regulations. In fiscal year 1993, $115.1 million in civil penalties and $29.7 million in criminal fines were assessed (EPA, 1994). One firm paid over $5 million in fines and penalties for unauthorized discharges of pollutants into a bay; improper storage and handling of hazardous materials; and inadequate record keeping and training of personnel. Criminal sanctions have also increased yielding 135 convicted defendants in fiscal year 1993, 57 of whom were imprisoned (EPA, 1994). The environmental benefits that result from monetary fines and criminal sanctions are revealed by the increased level of care taken by firms and individuals in response to the enforcement initiative. These benefits increase when the assessed fines and penalties are used in environmentally beneficial programs.

Supplemental Environmental Projects provide environmental benefits beyond the restoration and compliance measures normally required of environmental regulation offenders. All SEPs must be approved by the Assistant Administrator for Enforcement (EPA) and the Assistant Attorney General for the Environment and Natural Resources Division (Department of Justice). Although not economic incentives in themselves, since the penalty may be reduced by the value of the SEP, these projects allow for direct environmental benefits to accrue from noncompliance of environmental regulations. This brief review highlights the innovation and potential for generating environmental benefits that occur in this program.

The EPA requires that SEP "furthers the Agency's statutory mandates to clean up the environment and deter violations of the law". More specifically, "All supplemental projects must improve the injured environment or reduce the total risk burden posed to the public health or the environment by the identified violations" (EPA, 1991). This language indicates and the agency contends that there must be a connection between the original violation and the SEP. A vertical link between the SEP and the violation occurs when the SEP reduces pollution loadings to offset the excess loadings of the same pollutant into the same medium discharged during the violation. A horizontal nexus exists when the SEP provides relief for a different medium at the same polluting facility or provides relief for the same medium at a different facility. In this instance, it is important to the agency that the SEP either reduce the risk to public health or the environment or reduce the likelihood of a similar violation occurring at a different facility or in a different medium. However, a SEP may not be used to resolve violations at facilities other than the facility at which the original violation occurred since this would remove the deterrence incentive (EPA, 1991).

The EPA uses SEPs as opportunities to promote pollution prevention, reduce waste generation, and generate environmental benefits (EPA, 1994). There are five categories of allowable SEPs: pollution prevention, pollution reduction, environmental restoration, environmental auditing, and enforcement related public awareness. Pollution prevention projects attempt to reduce pollution through new technologies, input substitution, or adjusted operating procedures. Pollution reduction projects reduce the discharge of pollutants through increased abatement efforts. Environmental restoration projects go beyond restoration of the area injured by the violation and enhance the area. Environmental auditing projects are allowable when the project goes beyond general good business practices or focuses on the correction of potential violations. Public awareness projects promote industry wide compliance or provide public services such as distribution of innovative pollution reducing technologies. Public awareness projects are not held to the "connection" requirement.

The following examples of actual SEPs illustrate the variety of applications and costs associated with SEPs. These examples are drawn from the Fiscal Year 1993 Enforcement Accomplishments Report (EPA, 1994). In one case a company that owned most railroad yards signed a consent decree for alleged violations of the Clean Water Act (CWA). The company agreed to pay $3 million in civil penalties and do four SEPs at a cost of $4 million. The SEPs require a National

Pollution Discharge Elimination System (NPDES) permit-audit at 21 active yards owned by the firm; a risk-assessment audit at 61 inactive yards; an environmental awareness program for company managers; and the development of a best management practices manual and a seminar on storm water runoff. In another case, a tile making firm also signed a consent decree for alleged violations of the CWA. The decree required the firm to pay $493,000 in civil penalties and to construct a new storm water drainage system to remove the violation. The consent decree also includes two SEPs. One is a pollution prevention project that identifies a plan to reduce the zinc oxide levels used in tile glazes. The other SEP will construct a zero discharge stormwater management system on company owned property that is not subject to NPDES permit requirements. The combined cost of these SEPs is $333,930.

The following two cases concern violations by public entities. In one case the Port Authority of a U. S. west coast city posed a hazard to human health and the marine environment by unpermitted toxic discharges. The consent decree requires a civil penalty of $92,000 and two SEPs valued at $58,000. The SEPs include an analysis and removal of contaminated sediments near stormwater drains. Another western U. S. city was found violating its NPDES permit by not properly carrying out and enforcing federal pretreatment regulations. The city had to correct the deficiencies and pay a civil penalty of $45,000. The city was also required to do three SEPs that will develop a household hazardous waste program, an on-site assistance program for small communities, and a workshop on pollution prevention assessment and waste minimization for treatment plant operators.

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9. SUMMARY AND CONCLUSIONS

9.1 INTRODUCTION

Coastal areas are under severe pressures due to rapid population growth, development, and the generally high degree of biological productivity and the fragile nature of the natural environments of these areas. In the international arena, the United Nations Environmental Program and others have emphasized the importance of environmental concerns in general and coastal and marine issues in particular, and have encouraged the use of valuation methods and market-based policy instruments to help address environmental issues.

This Document attempts to contribute to the emerging literature on integrated coastal area management (ICAM) by examining non-market valuation methods and policy instruments, emphasizing applications. We view market failure in the form of externalities, public goods, and insecure property rights as major contributors to coastal area management problems. In fact, the existence of widespread externalities is perhaps a central argument for *integrated* coastal area management as compared with single-sector management.

We recognize that coastal area management problems occur within a complex political process and necessarily involve issues which cut across many disciplines. We also are mindful that solutions to coastal management problems will not be based solely on technical economic analyses - nor for that matter, will they be based only on analyses from *any* single field. Fundamentally, we take the position that public preferences matter and that non-market valuation techniques can improve our understanding of the public's preferences for the resources of coastal areas and, by that, help select among policy instruments to be used for ICAM .

In this Document the concepts underlying non-market techniques were reviewed, the methodology and data requirements were outlined, and many marine-related examples were given. Also, many of the issues and challenges to be faced when attempting to apply each approach were noted. We also reviewed many regulatory and economic policy instruments and gave examples of their use. A hypothetical case study, "Challenge Bay", was used as a device to make the discussion of valuation methods and policy instruments concrete. Below we return to the issues facing Challenge Bay and indicate briefly how the non-market valuation methods and policy instruments reviewed in Chapters 3 through 8 might be used to address some of the issues faced in this coastal area.

9.2 CHALLENGE BAY REVISITED

Our hypothetical coastal area faces many problems. Non-point source runoff from agriculture and urbanized areas threaten to degrade coastal waters. A proposed dam would divert water to agriculture and decrease oxygen levels and increase salinity levels in sections of the Bay. Household wastes are entering the Bay and affecting sections of coastal waters, threatening fishing, mariculture, tourism, and public health.

In addition to the above, unattractive development is degrading the scenic amenities of the area. A new highway has been proposed, which endangers the ecosystem and attractiveness of some parts of the area. A new tourism hotel and resort complex would lead to loss of much of a marine shoreline park, a popular destination for many visitors. Some public recreation areas are suffering from congestion, and debris has begun to mar some beaches. Proposed logging would result in sedimentation in the Bay, reducing coral cover, and by that reducing the appeal of diving, a popular tourist attraction. Figure 9.1, which is a reproduction of Figure 1.1, illustrates some of the many linkages among development activities, environmental impacts, and impacts on people. These and other problems described in Chapter 1, (Section 1.3) confront Challenge Bay - and many other coastal areas.

Next, we suggest ways in which valuation methods and policy instruments might be used to assist in the ICAM of the Challenge Bay watershed. These ideas are intended to be suggestive of the rich variety of valuation methods and policy instruments which might be employed; it is not intended to be a carefully conceived research strategy. Clearly, in a particular case, it would be necessary to consider carefully the cost of the studies concerned and how the added information would improve decision making. The benefits, costs, and feasibility of the policy instruments also would be important concerns.

To address conflicts between agriculture and environmental quality, attention might be drawn to the subsidy provided for water use and to the external effects of agricultural activity. If agricultural operators are to face the full costs of their activities, the use of a subsidy to promote water use must be called into question. To help control runoff, approaches such as technical assistance and subsidies might be used to encourage best management practices. These could include, for example, use of an undeveloped buffer zone along waterways, improved tillage practices, and restrictions on cultivating certain areas. Further, assistance to help farmers adopt least-cost approaches for controlling runoff of animal wastes may well be in order.

The problem of insecure property rights might hinder adoption of conservation measures. Although these are fundamental and difficult issues that extend beyond coastal area management, suggestions to develop clearer titles to ownership and to improve leasing arrangements might be worth pursuing as a broad policy. The literature also points out that the lack of long-term capital to finance conservation measures might be as important a problem as insecure property rights in hindering the adoption of soil conservation methods (Lutz, *et al.*, 1994). Again, as a broad policy concern, it may be worthwhile to examine ways to provide long-term financing for conservation measures for coastal and other areas, for example, through government programs.

Tourism and recreation issues are of great importance. To begin to address the issues of serious congestion and degraded facilities at public beaches, parks, and diving sites, introduction of a user fee might be considered. A user fee would have the goal of improving maintenance operations and, as a side effect, reducing overcrowding and overuse of the site, perhaps shifting demand to less heavily used, substitute sites in the watershed. An example of how a user fee was introduced for these purposes is the case of Bonaire Marine Park in the Caribbean (Dixon, *et al.*, 1993). Debris problems might be reduced by encouraging the use of deposit and recycling schemes together with a broadly publicized and enforced penalty for littering.

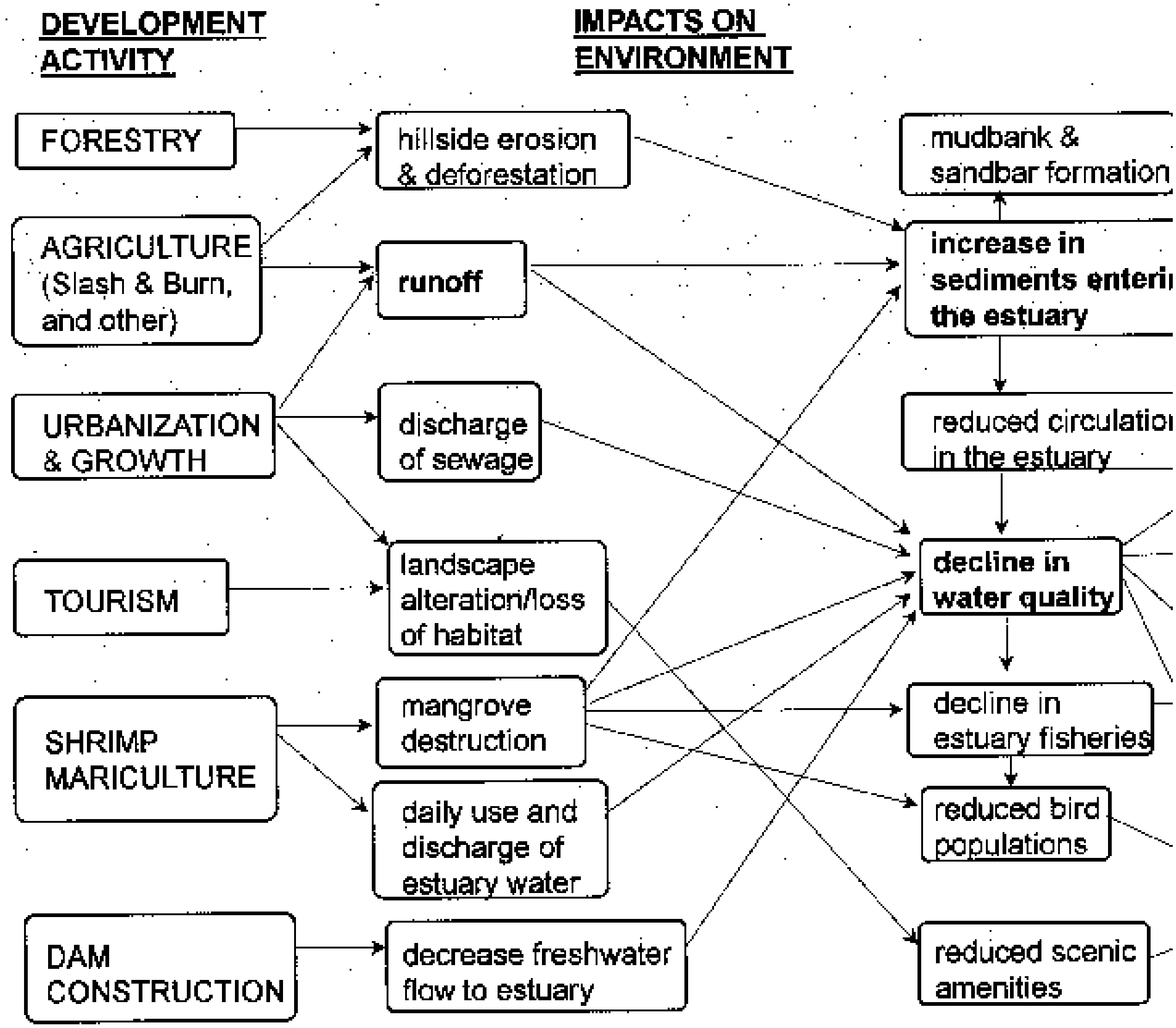

Fig. 9.1 Selected Linkages Among Activities, the Environment, and Loss

To contribute to the debate concerning the proposed hotel resort complex which would be located on a popular public shoreline park, a travel cost framework might be used to gain some insight into the economic value of the site to recreationists. This information would allow public officials to appreciate use of the site and the value that recreational participants place on the site. Beyond this, to appreciate fully what would be lost if the site was developed, the travel cost study results might be used to estimate the *asset value* of the site by calculating the present value of the benefits to recreationists, if the site was maintained in its current use. This estimate would represent an opportunity cost of developing the site, which should be taken into account if private market decisions are to reflect all of their costs. An example of this type of analysis is given in Leeworthy (1990). He used the results of travel cost, contingent valuation, and market value studies (Chapters 2, 3 and 5) for marine activities in Florida (US) to calculate the asset value of environmental and natural resource activities. Applying techniques like those given in Leeworthy for use in Challenge Bay might lead to the conclusion that the asset value of the site as a public park is quite large. This information, in turn, might provide valuable input to decision making concerning the benefits of preservation of the site as a park versus development. Or, this information might suggest ways to accommodate development by altering the location or scale of the proposed hotel and resort complex.

Another important set of issues related to the proposed hotel and resort complex concerns the accuracy of statements made by the developer about the benefits (economic impacts) from the proposed development. The developer's use of gross expenditures and crude "multiplier effects" as a measure of the project benefits exaggerates the true economic benefits due to the project. As explained in Chapter 2, the developer's argument ignores the alternative uses the resources dedicated to the project (land, labor, and other resources), the costs (e.g., public services) the development might impose, and any undesirable environmental consequences that might result from the development. Given the importance of this development-no development decision, a careful, objective analysis of the net benefits of the development is in order.

For recreational activities occurring at multiple sites, such as beach use, diving, or recreational fishing, a more sophisticated approach might be used. This could involve studies to establish how the attributes of different sites (for example beaches, diving areas, wildlife viewing sites) affect recreationists' participation at these sites. This type of an approach would yield information about the factors affecting use of the sites and the market and non-market benefits of use. This type of analysis also could be used to examine how *changes* in the quality of the activity at the sites might affect participation, choice of sites, and benefits. To the extent officials can improve the quality attributes at different sites though policy actions (e.g., better access; improved facilities), it would be possible to use the results of non-market valuation studies to compare the benefits and costs of undertaking the improvements. A study by Carson, *et al.*, (1987), mentioned at the outset of Chapter 3, provides a detailed example of how this approach was used to study marine recreational fishing at multiple sites in south central Alaska.

As an alternative, contingent behavior approaches might be used. For example, recreationists may be asked how their use of a site for diving or for wildlife viewing would be affected, if specific quality attributes of the site and/or the costs of using the site were changed in specified ways. This approach would be particularly useful for studying new facilities or activities, or for dramatic changes in existing activities. Examples by McConell, and Maharaj, described in Chapter 5, illustrate how this approach might be used.

Hedonic analysis appears to be of limited use in this case. However, as noted in the case study description, pollution problems have begun to affect some areas where a seasonal residential community has grown. If information on purchase prices or rentals is available for a sufficiently large number of homes, it may be possible to use the hedonic framework, described in Chapter 4, to estimate the implicit value attached to water quality.

The infiltration of household wastes to groundwater reservoirs and the Bay poses major potential problems, particularly in view of the anticipated rapid growth in the population. It may be possible to estimate the benefits of reducing household waste releases, in which case benefit-cost analysis might be used to evaluate the feasibility of investments or to help prioritize these investments. Alternatively, if benefits cannot be credibly estimated, technical assistance and perhaps subsidies, might be provided to identify cost-effective waste treatment facilities appropriate to the area (General Accounting Office (GAO), 1994).

The productivity approach might be used for several issues. For example, to attempt to address the effect of changes in salinity on oyster catch, a framework similar to that of Kahn and Kemp, described in Chapter 6, might be used. Or an approach like that used by Hodgson and Dixon might be employed to project the effects of sedimentation on coral cover and the diversity and abundance of reef fish.

It might also be possible to do a benefit-cost analysis of proposed seagrass or other restoration, using the productivity approach. The cost of restoration efforts (labor, supplies, plantings, etc.) is relatively easy to establish, but the benefits of this investment are difficult to estimate. It may be possible to use the productivity approach to help with this issue. For example, it might be feasible to use cross section data to examine the relation between seagrass and fishery population levels, similar to the approach described in Hodgson and Dixon or in Kahn and Kemp (see Chapter 6). With this information it would be possible to estimate the change in the asset value of seagrass due to restoration, information which could be compared with the costs. Of course, many other factors may affect fishery populations, and it may be very difficult to remove their influence. Obviously, well-focused, multidisciplinary research which could shed light on links between environmental change and changes in abundance in the cases described would be very useful for informing coastal area decisions.

As an alternative, a simulation approach might be used. For example, the integrated interdisciplinary model described in Chapter 6 simulated food web effects and the associated productivity of various coastal environment types. It may be possible, for example, to compare the indirect use value of sea grass bed (the "with" alternative) with the alternative state of the environment (the "without" alternative) using a simulation approach. Of course, an elaborate simulation is costly and may not be feasible; but perhaps a less sophisticated and less costly adaptation of this approach could provide adequate information for a cost-benefit analysis.

Location of the proposed highway to connect the Challenge Bay watershed to the population center in the capital city of "Oceanus" poses very difficult problems. The highway could have serious amenity effects, and could have ecological consequences as well due to the elimination of large sections of wetlands and alteration of water flows. One alternative to aid decision making is to use a paired-comparison approach, described in Chapter 5. Individuals could be asked to indicate which of two routes they prefer, where each route differs with respect to its resource and other effects (e.g. effect of open space, water resources, forests, proximity to housing). Use of this approach forces individuals to make tradeoffs among resource impacts rather than being asked directly to come up with a monetary estimate of the value of a resource change, something they may have trouble doing. Hence, use of paired comparisons rather than contingent valuation (CV) may make it possible to include public preferences in an important decision, while avoiding many of the potential problems with CV described at the end of Chapter 5. However, very difficult issues are posed by the archeological, cultural, and religious concerns with the upland highway location. How does one take into account the strong cultural and religious concerns?

Finally, the use of tradeable permits also could be explored. As noted there are several firms are discharging similar industrial wastes into the Bay. To the extent these firms have different marginal costs of abatement, there is an incentive to explore trading. Similarly, it may be useful to explore how trading of permits might be done among some farms and the proposed sewerage treatment plant to achieve nutrient discharge goals for the Bay at least cost. However, tradeable permits may not be practical if prevailing laws and administrative practices impose high transactions costs on potential participants.

In summary, ICAM raises many difficult challenges. Particularly serious challenges arise due to widespread market failure in coastal areas, the fact that many coastal environmental goods and services are not traded in organized markets, and the absence of policy instruments that create built-in incentives to avoid environmental harm. As described in this Document, and in the case study of Challenge Bay, economic methods can contribute to public policy for coastal area management by providing information on the public's preferences for market and non-market coastal area resources and by helping to select between policy instruments for coastal management.

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