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Natural Resource and Environmental POLICY ANALYSIS

Cases in Applied Economics

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Chapter One

The Role of Economics in Natural Resource and Environmental Policy Analysis

George M. Johnston

Natural resources are broadly defined as specific attributes of the environment that are valued or have proven useful to humans. The space we occupy, air we breathe, and water we drink are essential life-supporting natural resources. Energy and raw materials support human production and consumption. In judging the human condition, we must consider (both qualitatively and quantitatively) our use of environmental elements such as sea coasts, mountains, and wild species of plants and animals.

Problems

The two primary sources of global pressure on natural resources are increasing human population and the increasing per capita consumption of resources by that population. These problems exist in both industrialized and industrializing economies. Industrialized economies consume a dwindling and finite stock of oil, while the use of timber for fuel in the industrializing economies of Africa, Asia, and South America is leading to deforestation and seriously exhausting that renewable resource. Relatively affluent societies will be able to cope better with increasing scarcity, but the need for careful choices is critically important to poor societies where unrestrained population growth often strains the resource base.

Exhaustion of resources, destruction of environments and ecosystems, and the effects of residuals (air and water pollution) are neither new phenomena nor insurmountable problems. Nevertheless, concern over these issues has grown considerably in the last several decades. One reason for this change is that knowledge and understanding of the interdependence between various life-forms and other natural resources have multiplied within the biological and earth sciences, especially ecology. Although scientists have known about acid rain and the greenhouse effect for some time, there are now efforts to measure these relationships and show causality. As a result of this burgeoning knowledge as well as expanding public awareness, the preferences and, hence, the demand for preserving or improving natural environments has dramatically increased. Preferences for environmentally sensitive policies also have grown because more affluent communities are better able to change production modes and consumption patterns as a means to protect the environment.

Policy Questions

A common element of resource use decisions is their long-term effects. The policymaking issue is usually not one of hoarding resources but one of deciding upon the rate of resource use—the intertemporal dimension. How much do we use now and how much do we leave for future use? At what rate do we exhaust depletable resources, thereby affecting the endowment for future generations? In what condition do we leave the environment? What current actions have irreversible effects on resource availability and the assimilative ability of the environment? The intertemporal element permeates economic analyses of natural resource and environmental issues. This preoccupation with present and future outcomes of resource use includes concerns with efficiency, equity, conservation, preservation, environmental quality, and economic growth.

This chapter will explore a conceptual model of natural resource policy analysis. Ultimately the process of determining the boundaries of a conceptual model and defining concepts therein is one of individual choice. My view of how the pieces fit together should not necessarily be interpreted as either the best view or as the only view. I have made an effort to define commonly used economic concepts in a way acceptable to many, but no claim to universality is made or is even possible.

THE TASK OF ECONOMIC ANALYSIS

Economic and Scarcity Defined

Economics is a social science whose central focus is the process and institutions involved in weighing alternative uses of scarce resources. A resource is considered scarce when demand exceeds supply at zero price. Scarcity forms the basis of human interdependence concerning natural resources and the environment; scarcity involves both the amount available and how society allocates that amount.

The concept of opportunity cost—the value of a forgone alternative—follows directly from the assumption of resource scarcity: Every choice has an alternative and a cost reflecting the value of the opportunity sacrificed. Much of economic analysis, including benefit-cost analysis, is an extension of this concept. As the quantity of resources or the quality of the environment decreases, their opportunity cost increases, other things being equal.

A Framework for Policy Analysis

Broadly speaking, analysis involves the resolution of a complex issue into its parts in order to clarify the nature of the issue and to facilitate problem solving. The application of economics to resource policy analysis requires that the analysis proceed by identifying (1) key characteristics of the resource; (2) realistic policy constraints; (3) relevant participants and institutions; (4) behavioral responses of participants under different institutional arrangements and policy structures; and (5) current and future outcomes affected by policy options.

Natural systems have physical characteristics that affect the kinds of institutions likely to be useful in coping with or changing undesired outcomes. Socioeconomic characteristics such as the degree of excludability also affect resource use. Institutions, in turn, affect human production, consumption, and land use behavior. The outcomes or consequences of policy choices affected by institutions and behavior include residuals, resource availability now and in the future, the quality of life, and other concerns. From this core knowledge, the economist identifies behavioral results that suggest how policy alternatives affect various outcomes. Economists pursue the problem-solving nature of policy analyses with various degrees of theoretical abstraction and empirical evaluation, but these five steps are common elements in much of their work.

RESOURCE CHARACTERISTICS

Economists depend upon the physical and life sciences to provide information on physical traits of resources: rate of exhaustion of a depletable resource; capacity and extraction limits for a renewable resource; kind and rate of waste discharge; and other physical and biological traits of relevance to a particular policy issue. Changes in characteristics also become, in effect, outcomes—intentional or unintentional, direct or indirect—of policy decisions.

Some resource characteristics shape the policy debate over their use. The stock of specific natural resources can be classified as either depletable or renewable within a humanly relevant time period (McInerney, 1981). Some resources are depletable; their quantity is finite, and their current use reduces that quantity in the future. Oil, virgin natural habitat, natural gas, and minerals are all examples of depletable resources. The quantity of other resources is renewable at biological or biochemical rates, mostly out of human control. Timber, fish, wildlife, and most groundwater are examples of renewable resources. The current stock of both depletable and renewable resources may be consumed; renewable resources, however, have the potential of adding to their stock by a measurable amount if consumption does not exceed depletion. Issues associated with depletable resources center on intergenerational allocation and possible substitutes for these finite stocks; issues associated with renewable resources center on maintaining a sustainable flow of the resource. At the limit, the maximum physical flow of the resource that can be maintained in perpetuity is called the maximum sustainable yield. Both depletable and renewable resources can be exhausted through human use. There is thus an intrinsic issue of intertemporal allocation and distribution of such resources between current use and use by future generations.

Resources must be used for investments that will produce goods for future generations. But the use of natural resources can also alter or destroy environmental and ecological systems, thereby threatening future generations. Destruction of wetlands, for example, has dramatically affected a large number of wild species and the genetic foundation of many animal and plant resources. Such resource issues often arise when we make decisions about the use of land. Land use decisions are important because of the varied and interdependent attributes of land. The most important of these attributes is land's unique spatial and geographic features. The use and value of land often depends upon proximity to cities and towns; land close to or in urban areas is geographically unique and commands location or economic rents. Rents are defined as returns above costs of production resulting from natural limitations of supply.

Other attributes of land include soil productivity, mineral deposits, wildlife habitat, and scenic amenities. There are many cases of complementary land uses—forestry and some recreational and wildlife uses, for example—but land use decisions often involve choices between incompatible uses. Land can be used for urban housing *or* for agriculture. In some cases, land may have unique scenic, geographic, or biological traits whose loss, as a result of incompatible uses, would be irreversible.

Using natural resources for human production and consumption has physical consequences deriving from the principles of thermodynamics. Extraction and transformation of natural resources leads to conversion from a concentrated to a dispersed form or a residual that is then deposited back into the environment. These residuals can either overload the absorptive capacity of the environment or be of such an exotic nature as to cause severe long-term harm. Common examples of such residuals are air and water pollution from energy and mineral use. The alarming effect of residuals on the environment ultimately focuses our attention on natural resource use and results in public debates about the trade-offs between various forms of energy, soil conservation practices, and the use of pesticides and fertilizers, to name a few of the many questions to be addressed.

In addition to the physical characteristics of resources just discussed, there are social and economic characteristics that influence how society controls any resource. Four of these characteristics are incompatible use, joint impact, exclusion traits, and group size (Schmid, 1978).[1] These characteristics exist in various degrees in many natural resource and environmental issues.

Assuming scarcity, when a resource has two or more potential uses that are incompatible, one person's use means that the resource is unavailable to another. In the main, resource ownership determines resource use, buttressed by common, trespass, and nuisance law. In Western societies, private ownership and the market are the principal institutions used to determine resource use, but land use regulations and public ownership of land, energy sources, and minerals are also common. Further government concern with incompatible uses centers on maintaining a degree of competition in order to prevent monopoly conditions. Incompatible use also applies across generations. Current use of depletable resources, renewable resources being used beyond their carrying capacity, and permanent changes in environmental and ecological systems all create incompatible use between current and future peoples.

Within limits, some resources can be shared by two or more compatible users without subtracting utility from any one user. In economic terms, the marginal cost of an additional user is zero or close to zero. These are called joint-impact goods.[2] In terms of access to users, clean air, clean water, abundant wildlife, and other factors contributing to the quality of human life, have, in effect, a marginal cost of zero. These are joint-impact goods up to the point a threshold for the absorptive or replacement rate is exceeded. A central institutional issue associated with joint-impact traits is how the costs of providing these resources are shared. Providing good water quality or an electrical grid system will often be hindered if the cost-sharing issues are not resolved. Thus issues often arise about who will pay for these goods.

Regardless of whether a resource has incompatible-use or joint-impact traits, the ease of access or, conversely, the difficulty of excluding others from access or exposure to the good affects resource use and provision decisions. When exclusion costs are low, the control of access allows the resource owner to charge for the use of the resource. This is the case for an incompatible-use good such as land or a joint-impact good like electrical lines.

When exclusion costs are high, the access or exposure to the resource will be difficult to police or, in some cases, avoid. Nominal private ownership of incompatible-use resources such as migratory wildlife or some ocean fisheries would be of little value because access by nonowners is relatively easy and therefore difficult to police. Joint-impact goods with high-exclusion costs abound in the environment; air, water, and other qualitative features affected by residuals are prime examples. When a few individuals are affected and wish to change the situation, organizational possibilities exist to have this group engage in strategic bargaining within the market because the group can perceive its gains from involvement. When many are affected, which is often the case with air and water quality problems, the "free rider" situation arises. In this case, each air or water user knows that if these resources are made cleaner, no one can be excluded, even if they as individuals make no contribution to help clean up the resource. Pure market institutions are thus unlikely to provide these goods. Even should the good be provided, the joint-impact, cost-sharing issue would still exist with many goods. How would you charge a price for the good? Who would pay?

Group size can affect the ease or difficulty in dealing with high-exclusion cost situations. Individuals in a large group are less likely to perceive an ability to affect an outcome such as improving air or water quality. All affected individuals in a small group, in contrast, may be able to perceive the returns from collective action. For example, smaller, inshore fisheries are more often successfully managed than international fisheries because a smaller group with more uniform interests is involved.

Incompatible-use, joint-impact, exclusion, and group size traits do not exhaust the list of resource characteristics shaping human interdependence and resource use. These traits, however, combined with physical information relating to resource depletion, carrying capacity (the population that an area will support without deteriorating), and the incidence of residuals, provide a basis for predicting the effects of various institutional arrangements on the outcomes of the policy alternatives.

INSTITUTIONS AND TRANSACTIONS

Institutions include both formal and informal rules and procedures governing behavior (Wandschneider, 1986) and include the range of laws, administrative codes, customs, organizations, traditions, and their interactions as they affect the way in which society deals with complex resource issues (Buse and Bromley, 1975). Property rights refer to that subset of institutions that specify the rules and procedures governing the relationships among individuals with respect to their access to, and control over, resources. "Rules-of-the-game" connotes a specific set of institutions and property rights relevant to a particular problem and is the focus of policy analysis. Institutions establish the particular rights and rules that affect market, administrative, and traditional transactions. Institutions guide and condition the behavior of individuals and groups and ultimately affect resource outcomes. But this process requires the recognition of the complexity and subtlety of the relationship between resource characteristics and institutions.

Three institutional subsets often discussed by economists exhibit different types of transactions. Briefly, markets involve exchanges between legal equals, administrative transactions are between a superior and inferior, and traditional transactions are internalized standards of behavior or customs (Schmid, 1978). Natural resource and environmental problems often involve a complex mixture of transactions.

Market Transactions

Analysis of market institutions is central to resource and environmental issues because such institutions often determine the use of resources. Prices, mirroring supply-and-demand conditions, and substitutes play a critical role in natural resource use decisions. Market prices reflect the processing of large quantities of information about production and consumption while also serving as incentives to produce, consume, or conserve. For example, if a natural resource becomes scarcer, either as a result of diminishing supply relative to constant demand or to increasing demand relative to a constant supply, its price is likely to rise. The opportunity cost of the resource increases, and behavioral responses could include conservation, substitution of other resources, greater exploration for the now more valuable resource, increased research and development in search of technological changes, and recycling, among other responses.

Economists often prescribe rules that affect prices and the costs and returns available to firms as policies to avoid environmentally harmful residuals. Examples of such policies include emission charges, taxes, penalties, and tradable emission rights. Charges, taxes, or penalties are applied to actual levels of pollution, an action that increases the production cost to the firm and hence provides an incentive to reduce emissions. These policies, as well as other market approaches to resolving environmental issues, including marginal cost-price and tradable emission rights, while popular with economists, are much less in evidence than administrative rules and regulations.

Administrative Transactions

Legal, administrative, or regulatory systems of control are the general institutional devices that govern the environment in which individuals exchange goods and services. Through changes in laws, regulations, administrative procedures, adjustments are made in the nature of ownership of resources. For example, although market transactions and institutions predominate in land use decisions, administrative transactions are also involved via zoning, taxes, and the provision of public services. There are also many resources in the United States and Canada, including extensive land, timber, and mineral resources, that are owned by the federal governments. Furthermore, marine resources are now publicly regulated within 200 nautical miles of the coast.

Environmental residuals are managed by means of a predominant set of rules that include standards. These set rules regulate behavior by designating acceptable levels of ambient or effluent discharge or for specific technologies required of those companies discharging residuals. Many economists favor charges over standards because of perceived cost-effectiveness and ease of policing. Standards, nevertheless, are the most common form of transactions imposed because they are a more easily understood control device and because they allow the regulator to be more specific in determining the admissible level of emissions.

Traditional Transactions

Internalized standards of behavior or prescribed social and family obligations can have a major effect on natural resource use. Examples of such behavior are land stewardship, altriusm in provision of high-exclusion and joint-impact goods, and grants for posterity by the present generation. When a person contributes or donates land for a public park, the returns to that individual in terms of personal benefits are exceeded by the value of the gift to others. Many individuals are involved in group efforts such as the Nature Conservancy and the World Wildlife Fund, where the same process is at work. Provision for posterity at either the individual, group, community, or government level also reflects internalized beliefs of social obligations or stewardship. This type of action reflects the divergence that often exists between private or individual returns and benefits that accrue to the larger community.

Transaction Costs and the Boundary Issue

Regardless of the type of transactions, there are costs associated with changing or attempting to change resource use. Transaction costs arise both from resource characteristics and property rights. When there are large groups and high-exclusion costs, organizing either a market bid or even an administrative transaction will be difficult. Those affected by widely dispersed air pollution will find it difficult to organize to change the situation. In this case, assembling individuals into a cohesive group and assessing the magnitude of the total injury is an expensive proposition. Information and uncertainty affect the ease or difficulty in making a transaction or decision. Political activity and class action suits provide a means for short-circuiting this process. The ability to acquire information, to influence the flow of information, or to cope with uncertainty are unevenly distributed among the population and, therefore, affects resource use.

In order to understand resource use decisions, it is critical to examine the relationship between the physical, social, and economic boundaries of environmental problems and the political boundaries of the jurisdictions responsible for addressing those problems. Political jurisdictions and the resource/environmental decisions made by those jurisdictions seldom match the boundaries of those affected by the decisions. The "boundary issue" arises when the costs and benefits of an activity or decision affecting resource use are not contained solely within the jurisdiction making the decision. Solutions to problems arising from such a situation, if such solutions are to consider all parties affected, will require transactions between political entities. A few examples of boundary issues involving jurisdictions both within countries and between countries are river basin management; migratory wildlife management; marine fisheries management, particularly of migratory species such as tuna and salmon; and ambient air quality problems such as acid rain.

BEHAVIOR

Behavior that affects resource use is defined as the calculated and noncalculated response to resource, environmental, and institutional situations. These responses incorporate both current values and habits as well as the learning process, which results in changes in those values and habits. Well-posed problems with clear value choices, objectives, and expected outcomes can be aided by static economic analyses. Economists have provided a rich literature on market, production, and consumption behavior. This behavior includes accepting "reasonable" but not optimal criteria—"satisficing"—as well as accepting behavioral rules such as standard operating procedures. The insights of economists are brought to bear in various aspects of resource and environmental analyses: for example, the role played by the market and prices in the resource substitution process; the impact of uncertainty, expectations, and options on our behavior; time preferences and interest rates, which affect future generations; and the role played by social traps and common property. The following discussion addresses the behavioral issues that impact resource and environmental issues.

Substitution, Exploration, and Technological Change

Prices play an important role in determining resource use and chages in use. Prices result from and affect behavior through the interaction of supply and demand. Thus, as in other forms of incentives, humans are influenced by the consequences of their own behavior.

Substitution implies shifts to other resources as well as recycling (Howe, 1979). As relative prices increase (or decrease), there will be a shift to (or from) other resources. The ease and rate of this process will depend upon the availability of substitutes and preferences for those substitutes. A small change in relative prices can trigger a significant change in resource use if substitution is easy. If substitution is not easy, then it will take a larger change in relative prices to trigger the shift to other resources.

Price changes can also result in reuse of some resources. However, recycling of materials, primarily minerals, will not save the materials ad infinitum. Minerals are ultimately, in an economic sense, depletable because following each round of use some quantity is not recoverable. The costs of recycling, especially transportation, limit its application, and some rules, such as depletion allowances, favor the use of raw materials rather than recycling. Property rights also often favor disposal of residuals from production and consumption as the cost of disposal to the resource user is zero or subsidized (Pearce and Walter, 1977).

Prices or other factors that improve the returns to a resource can stimulate increased exploration for new resource sources. From the point of view of the firm, an increase in marginal revenue may provide the incentive to bear the larger marginal costs involved in exploration and discovery of the resource. The firm will find that expanding exploration is profitable whenever expected marginal revenue is greater than marginal cost, and the firm will continue to expand until marginal revenue equals marginal cost. The relative ease of exploration, discovery, and extraction will determine how much of a price increase will be needed to trigger such a response. Rapid increases in oil prices in the early 1970s resulted in greater investments in exploration and extraction of less accessible deposits. In other cases, exploration and discovery have become easier as a result of technological changes that have made locating and quantifying both depletable and renewable resources easier.

Improved technology can reduce the cost of extracting, transporting, processing, and using resourses. A search for such technology can be a purposeful response to increased extraction costs or improved revenues. Technological improvements can increase output per resource unit through new resource discoveries, utilization of lower grade resources that are easily accessed, or greater use of substitute resources (Baumol, 1986). Technology can also lead to more uses of a depletable resource or the possibility of exceeding the carrying capacity of a renewable resource. Technological change, triggered by competition for an open access resource, has, for example, allowed per unit costs of harvesting some marine fisheries to drop dramatically to the point of near destruction of the fishery. On the other hand, as the cost of pumping groundwater has increased because of declines in the water table, technology in agricultural uses has increased the productive efficiency of the water.

Uncertainty, Expectations, and Option Values

Uncertainty "is the gap between what is known and what needs to be known" in decisionmaking (Mack, 1971). Uncertainty permeates economic issues. It may be relatively small, when total knowledge is not quite possible, as is the case in many land use decisions. It may be extensive, when the type or direction of results, such as the greenhouse effect, is unknown.

Uncertainty exists over the following range of issues: the stock of depletable resources; the stock and carrying capacity of renewable resources; the short- and long-term effects of residuals; and the future demand for natural resources, a clean environment, and natural environments that have been lost due to irreversibilities in current decisions. The scope and nature of uncertainty will vary from issue to issue. The behavioral responses to uncertainty will depend upon the relative situation of the individual or group. Some may respond to uncertainty with a conservative approach, limiting the number of alternatives considered. Others may ignore the issue. For example, if there is no certainty about the cumulative effects of pesticides or the rate of groundwater pollution, their effects are easier to ignore.

We deal with the "gap" between the known and unknown by forming expectations. What one thinks about the likelihood of a future outcome depends upon many factors including the quality of information, past experience, the current situation, and one's mood on a particular day. Although expectations can change quickly, if acted upon, they can also have enduring, profound effects. For example, expectations of increasing farmland prices accentuated the increase in those prices in the 1960s and 1970s. The decline in farmland prices in the early and mid-1980s was also accentuated by expectations of continued price declines.

Expectations can also lead to a conservative attitude. Expectations on the success of exploration may affect the rate of depletion of the known resources. Fewer chances for success in exploration lead to slower depletion of known reserves. Thus, nonoptimizing concepts of behavior, including seeking satisfactory versus optimal outcomes, will be likely to predominate in the face of greater degrees of uncertainty. Finally, because future demands are uncertain, the present generation may perceive a value to maintaining an option for future uses of the resource (Krutilla and Fisher, 1975). Whether altruistic or self-serving, this behavior, especially directed at potentially irreversible resource losses, has affected resource decisions.

Time Preferences and Interest Rates

The current generation makes resource choices for future generations, like it or not. Current use of resources affects opportunities in the future by changing what will be available and, among other things, by improving knowledge of how to use resources. But extraction of depletable resources also represents a forgone future output, and use of a renewable resource can exceed the replacement rate. These are in effect intergenerational opportunity costs.

Time preferences gauge the degree to which concern for future generations is taken into account by the present generation. Uncertainty about the future results in a bias toward current use because the latter is more certain. Other factors affecting time choices are present and expected future income, perceived needs, age, education, and altriusm. For example, people with high incomes are able to defer some consumption more often than poorer people, who may lack even the most basic items and who therefore cannot defer consumption. Communities and governments are able to take a longer view. The degree to which they do also depends upon their relative income, uncertainty, and so on.

Interest or discount rates provide a means for comparing different streams of benefits and costs through time. The rates provide a means for weighting outcomes that occur at different points in time so that they have present value equivalents. Lower interest rates put greater weight on future outcomes; higher interest rates favor current consumption. With a lower interest rate, the opportunity cost of waiting is reduced. Clearly, there is a great deal of variety in time preferences and, hence, interest rates among individuals, groups, and societies. Interest rates chosen for appraising the benefits and costs of public projects are a value-weighting device and as such are subject to debate among groups holding different time preferences. The choice of interest rates will affect the choice of projects to be undertaken. A higher interest rate will restrict projects to those having fairly rapid recovery costs.

Social Traps and Common Property

Social traps (Platt, 1973; Schmid, 1978) exist when individuals or groups do something for their individual, marginal advantage that is collectively damaging to themselves, and/or the group as a whole, in the long term. Although individuals might be aware of the long-term consequences of their actions, they, of need, are trapped into responding to short-term situations and constraints. Even if individuals try to act differently, the outcome will not change unless there is collective action by all of the resource users. Social traps are often intractable but certainly not insolvable. Common property institutions will serve as an example of social traps and also provide an example of a method of analysis for breaking the trap.

As population growth and increased economic activity lead to greater resource scarcity, existing institutional arrangements like common property may induce behavior that can destroy that resource. Common property problems exist when the following conditions are present (Ostrom and Ostrom, 1977):

1. Property rights to the resource are unclear or held in common.
2. A large number of users have unrestricted access.
3. Collective action is needed to solve the problem.
4. Total demands upon the resource exceed the supply or carrying capacity.

Common property is an institutional arrangement that can coincide with a large variety of both physical and socioeconomic resource characteristics. Common property resources often represent incompatible uses because the marginal cost of an additional user is not zero. But common property can have either high- or low-exclusion costs, and its use can be affected by small or large groups. Examples of common property include international fisheries, fugitive wildlife resources, some underground oil and water pools, and ambient air and water systems. Adverse effects of human activity include exhausting the resource or polluting it with residuals.

An examination of international fisheries and issues of the freedom of the seas demonstrates the social-trap characteristics of common property institutions. Freedom of the seas permits unrestricted access to international fisheries. The number of users of a given fishery can, therefore, be quite large. In some cases, the demands placed upon the fishery have exceeded its production capacity and diminished or destroyed the fishery. As the fishery resource becomes smaller, the resource users will increase their effort to catch fish and/or invest in improved fishing gear in order to maintain the quantity of their catch. There will be no individual incentive to conserve because the bulk of the benefits of this behavior would pass to others. Everyone else will be in the same position unless some sort of collective action is undertaken to relieve the social trap. In the case of international fisheries, territorial limits have been either unilaterally or multilaterally extended as an effort to remedy some of the depletion problems. Other institutional solutions will depend upon the resource traits such as exclusion, group size, and international boundaries.

OUTCOMES

Outcomes are the consequences resulting from the interaction of resource characteristics, institutions, and human behavior. As such, they are the indicators of the impacts of institutions on resources and humans. They become defined within specific issues and problems. Outcomes may be measured by physical units, monetary units, or both, and can be defined for the individual, group, or government. Three broad categories of economic concepts relevant to understanding and judging outcomes are externalities, efficiency, and equity.

Externalities

In the broadest sense, externalities are the outcomes or effects of an action that are not accounted for by the actor and that therefore do not influence his or her decisions (Heyne, 1973). They can be either positive or negative. Three kinds of externalities are discussed here: technological, pecuniary, and political.

Technological externalities, called simply externalities by most economists, are the unaccounted-for physical consequences of a decision or resource use. Off-site effects of pollution on air and water, soil erosion, and losses and gains in wildlife habitat are physical effects caused by an individual or group not bearing the full costs or benefits of the act.

Pecuniary externalities are the unaccounted-for positive or negative monetary effects of an action. They are changes in relative prices that work their way through the market to enhance or detract from the value of assets held by others. Responses to technological externalities often create pecuniary externalities and vice versa (Baumol and Oates, 1975). If a steel mill's pollution is abated by regulations, thus "internalizing" the technological externality, the resulting pecuniary externalities can include higher prices for steel or lower profits for the steel firms. Similarly, efforts to change relative prices lead to changes in resources used in production or consumption activities.

Political externalities arise when the actions of a governmental unit affect citizens of other units of government. The boundary issue is an example of a political externality. However, the effects of political choices on those outside the choice process are measured by technological and/or pecuniary effects. The land-use zoning decisions of one jurisdiction can affect the housing demands made on other jurisdictions: Restrictive zoning to preserve agricultural uses will force housing developers to look and bid in other, more receptive jurisdictions and will raise the price of housing by limiting supply.

Technological, pecuniary, and political externalities provide concepts for categorizing the outcomes of given institutions on resource use and the environment. They also help to isolate the effects of market, administrative, and traditional transactions on resources. Externalities, as used here, become a way of tracking human interdependence in resource use decisions.

Efficiency

Efficiency measures how well inputs are combined in the process of making outputs. It is used by economists as a social norm, based upon the perfectly competitive model, to judge resource use. As with all outcome measures, the type of efficiency considered depends upon the units of measurement. Four kinds of efficiency are explained here—technical, price, allocative, and intertemporal (Freshwater and Appin Associates, 1985).

In technical efficiency, the physical combination of inputs to outputs is such that no greater output can be produced with the given inputs. Further, "technical efficiency is concerned with the physical determinants of 'ideal' output" (Bromley, 1984). This includes, for example, the physical relationship between grazing and watershed protection or timber production and grazing.

Price or private economic efficiency is measured by looking at how an individual or firm adjusts the ratio of inputs to outputs depending upon their relative prices. Prices serve as indicators of value derived from market transactions. They adjust to reflect changing tastes, levels of income, resource availability, and so on, when markets work well. Prices signal a set of production decisions that equate selling prices to their marginal production cost, assuming profit maximizing behavior.

Allocative efficiency is defined as the maximum consumption of goods and services given the available amount of resources. Prices provide the link between the production decisions of the firm and individual consumption decisions. It implies an allocation of resources, at the societal level, to produce a collection and allocation of goods and services that results in a situation where no individual can be made better off without another being made worse off. Allocative efficiency requires that individuals equate the marginal benefit of the last unit of every type of good obtained by that individual. In this sense, it is a measure of the opportunity cost of consumption of a particular good. For the individual, maximum welfare is achieved if the ratio of prices paid for the goods equals the ratio of the marginal utility provided by the goods. From the production side, the output mix is such that the social values between any two products are equal to the rate at which one is sacrificed for the other (Bromley, 1984).

Intertemporal efficiency conceptually applies the Pareto Optimality through time, acknowledging that a particular set of goods produced and distributed at one point in time will change in the future. As particular resources become scarcer, population grows, and consumption patterns change, efficient outcomes will change.

Economic calculations of efficiency assume, indeed require, that the conditions necessary for a perfectly competitive market be met. Efficiency also assumes a status quo distribution. When there are significant technological externalities, high-exclusion and joint-impact traits, or intertemporal depletion effects (Page, 1981), a perfectly competitive market does not exist, and, therefore, resources are not efficiently allocated by markets. In cases where there are many deviations from the perfect competition requirements, partial policy measures that eliminate some but not all deviations do not necessarily improve "social welfare." Efficiency, however, in a less technical sense, is still used as a rough measure of opportunity costs, focusing on the "reasonable" trade-offs involved in policy choices.

Equity

Equity in access and use of resources is an important, if not transcendent, policy determinant. Indeed, policy prescriptions based solely on economic efficiency criteria, which assume the status quo distribution, may receive little attention if they do not coincide with the values of the decisionmakers (Shabman, 1984; Bromley, 1984). Policy analysis, therefore, usually entails a description of the distributional consequences of choices being considered.

Equity or fairness issues have been discussed largely in an intertemporal dimension, but in practice, intratemporal distributions of wealth and access to resources often dominate the policymaking process. The policies adopted and institutions considered depend to a considerable extent upon who is involved in the decisions. As in the case of political externalities and the boundary issue, if you are not involved in the decisionmaking, your interests may not be considered even if you are affected by the decisions.

The distribution of resources also significantly affects the behavior and potential options open to various segments of society. We are not equal in our abilities to respond to price changes, use technological changes, respond to uncertainties, and save for the future. Policy issues are therefore often focused on changing the access to resources by various groups. Distributional issues also arise because of the joint-impact nature of many environmental issues. The marginal cost of additional users is effectively zero once clear air and water are provided. The issue then becomes allocating the cost in an "equitable" manner. Additionally, as previously mentioned, regulating pollution, a technological externality, has monetary effects on the value of assets associated with the pollution.

As no universal criteria for equity exists, economic policy analysts can only incorporate the distributional effects of policy choices into their analysis, eschewing a declaration of the "best" distribution. Because natural resource and environmental issues have inherent intertemporal choices, current economic analysis often reports, in some form, the effect of choices made today on resource availability and environmental conditions for the future.

Evaluating Outcomes

Externalities, efficiency, and equity are central to natural resource and environmental problems. Resolving a problem invariably involves choosing among policy prescriptions that are not value neutral and may result in the creation of an externality. Incorporating these issues into the analysis of a problem is often the major task for an economist involved in applied work.

Nevertheless, for many economists efficiency is the key criterion used to judge the desirability of outcomes. A more efficient solution is one that increases the aggregate quantity of output available to the consumer. In a perfectly competitive world it follows that equating marginal revenue with marginal cost will result in a distribution of goods and services in which nobody can be made better off without someone else being made worse off. Although this is a powerful result, it is restricted in it legitimate applications.

If the requirements of perfect competition are not met, making changes that lead to equating marginal revenue with marginal cost in individual markets will not necessarily lead to improved social welfare. Thus, in the presence of technological externalities, for example, moving a single market to a point where marginal conditions are satisfied need not improve our collective well-being. Further, the perfectly competitive model is silent on issues of distribution. If more is produced or less inputs are consumed this is a desirable outcome. Thus, making the wealthy even richer, providing that no poor people are made worse off, is just as desirable in a competitive model as making the poor wealthier and leaving the rich no poorer. As noted in the discussion on equity, more than efficiency enters the determination of which outcomes are the most desirable.

Despite these limitations, efficiency can be a useful criterion for economists. In many cases the gains from a more efficient solution are such that losers are compensated for the change, and thereby a clear benefit results. When this is the case, an argument for a more efficient solution is hard to refute, providing compensation takes place.

Even in cases that are less clear it may be useful for an economist to advance the case for efficient solutions, particularly if, in developing the argument, allowance has been made for the presence of externalities. In such cases economists must recognize that they are now advocates of particular outcomes and cannot claim that their position represents a value-neutral argument. Efficiency arguments may not be germane in all cases, but they may improve the discussion leading to the ultimate decision.

CONCLUSION

In analyzing the interaction of resource characteristics, policy constraints, institutions, human behavior, as well as the outcomes of policy options, economics can make a significant contribution to natural resource and environmental policymaking. This chapter has presented a framework used in various degrees by economists for analyzing natural resource and environmental issues. Many economic and physical concepts have been defined. Although most of the definitions should be acceptable to most economists, the points emphasized and the groupings of concepts reflect my perception of how the tools of economics can be applied to resource policy issues. The authors of the chapters that follow will expand, elaborate, or adjust this framework as befits their needs and approaches. The intent of this chapter is to provide an overview of important concepts; the diverse approaches to economic analysis represented in the case studies should provide the reader with a more specific understanding of how economics can be usefully applied to natural resource and environmental issues.

NOTES

1. The terminology used in this section is taken from Schmid (1978) because it allows greater precision in analysis. This terminology is not widely used among economists but other terms are less clear. For example, see Randall (1981).

2. In economics literature, high-exclusion cost, joint-impact goods are often called public goods. However, public goods are at various times defined as either high-

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exclusion, joint-impact, or goods that the public should provide. Given this confusion in the literature, the term is not used here.

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A solid presentation of economic theory for advanced students.

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