Multi-Objective Approaches to Floodplain Management on a Watershed Basis

Ecosystem Valuation Methods

REVISED DRAFT
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In Memory of

Andy Lee

Whose Vision For A Wise And Proactive Floodplain Management
Was Only Exceeded By
His Love Of Family, Friends And Colleagues

Andy Lee (center bottom row) and DWR Floodplain Management Branch with
ASFPM Tom Lee Award for Excellence for Pro-Active Floodplain Management Program (Summer 2000)

PREFACE

In October of 1997 the California Department of Water Resources was awarded an EPA Wetlands Protection Development Grant to develop strategies and procedures that will encourage local governments to implement a multi-objective approach to floodplain management on a watershed basis. This federal-state cost-shared study has three distinct components. The Governor's Office of Planning and Research and the California Department of Water Resources have already completed the first--the addition of a separate floodplain management optional element to the State General Plan Guidelines (Appendix C) in November of 1998. The objective of this appendix is to assist local agencies identify flood prone areas within their communities and make appropriate land use decisions for those areas.

The second and most complex component is the development of an economic framework for estimating the benefits and costs of multi-objective floodplain management proposals. The framework addresses a growing concern among floodplain management officials that, for a variety of technical and institutional reasons, economic analyses tend to favor the selection of single-purpose "flood control" solutions rather than multi-purpose proposals that are more likely to include environmental benefits. This framework will enhance traditional benefit/cost analysis by incorporating (1) methods for valuing natural floodplain environmental and societal benefits and (2) recommendations on how to achieve a watershed perspective. It will also address other concerns regarding the economic analysis for floodplain management proposals, such as how to assign benefits for structures removed from floodplains. Four reports have been prepared for this component.

- *Ecosystem Valuation Methods*. Traditionally, economists have been reluctant to assign dollar values to ecosystem resources. However, ecosystems provide a wide range of services that are useful to society. If these services can be identified and quantified, then it may be possible to assign dollar values to them. This report summarizes the advantages and disadvantages of several methods, including those that rely upon revealed willingness to pay (market prices), imputed willingness to pay (circumstantial evidence), and expressed willingness to pay

(surveys). In addition, the use of estimated values developed by other studies (benefit transfers) is also discussed.

- *Natural Floodplain Functions and Societal Values*. Natural floodplains perform a multitude of complex and interrelated functions, which not only provide basic biological support but also provide valuable goods and services to society. This report identifies these functions and their associated societal values and provides monetary examples from other studies. These examples illustrate some of the methods discussed in the *Ecosystem Evaluation Methods* report.

- *Middle Creek Ecosystem Restoration Project Case Study: Benefit and Cost Analysis*. A case study was conducted for the US Army Corps of Engineers proposed Middle Creek habitat restoration project at the north end of Clear Lake in the coastal ranges of northern California. On-site benefits of the restoration project would include restored aquatic, wetland and riparian habitats as well as removing human uses within the floodplain, which are subject to an increasing flood threat. The project is also expected to significantly increase water quality within Clear Lake, which should result in increased recreation. The Corps' Sacramento District has recently completed a feasibility study recommending that this project be implemented.

- *Benefit and Cost Analysis Framework*. Beginning with the Galloway report in 1994, there has been a growing concern among floodplain management officials that economic analyses were favoring single-purpose, structural "flood control" projects. This report presents a comprehensive framework that illustrates (a) how multiple benefits (including environmental) can be incorporated into the analysis, (b) how to address the spatial distribution of benefits and costs within a watershed, and (c) how to account for the different distribution of benefits and costs over time. This framework is then compared to current Corps and Federal Emergency Management Agency benefit/cost guidelines and practices. The report also recommends how the findings of the EPA Study can be adapted to meet current Corps and FEMA planning requirements.

The third study component is the preparation of a NFIP workshop entitled "Comprehensive Floodplain Management: Promoting wise Uses of Floodplains" which will present proactive floodplain management strategies which incorporate multi-objective and watershed planning principles. This workshop will (1) review existing NFIP regulations and recommend No Adverse Impact strategies developed by the Association of State Floodplain Managers and (2) show how the economics tools developed in the second study component can be applied to multi-objective floodplain management projects. The audience for this workshop will include floodplain administrators; local building/planning/public works staffs, local public officials and stakeholders. Work for this workshop and its related materials will be ready by the summer of 2005.

Two advisory committees have assisted with this study. The California Interagency Floodplain Management Coordination Group, which is composed of representatives from federal, state and local agencies, is providing overall coordination and advice. In addition, a multi-disciplinary advisory committee of scholars from the University of California's Centers for Water and Wildlife Resources at Davis provided early input into the study.

In addition to the economics reports described above, the following appendices will also be available:

Appendix A: California General Plan Guidelines (Floodplain Management)
Appendix B: Habitat Restoration Cost Database
Appendix C: Economic Evaluation of Ecosystem Resources: Hamilton City Flood Damage Reduction and Ecosystem Restoration Feasibility Study and Colusa Basin Watershed Management Plan Feasibility Study
Appendix D: Floodplain Management Glossary
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INTRODUCTION

Nationally, there is an increasing focus upon ecosystem restoration, which strives to either restore the structure and functions of damaged ecosystems or protect existing functioning ecosystems from future losses. Billions of dollars are being invested in ecosystem restoration. Within the field of floodplain management, ecosystem restoration is becoming critically important with the increasing emphasis upon *multi-objective* floodplain management. Rather than just focusing upon "flood control" to protect lives and property, proactive floodplain management strives to consider multiple objective actions in order to determine the best overall strategy for any given location.

A critical part of the evaluation process is the economic analysis, particularly the analysis of benefits and costs: does a proposed project's benefit exceed its costs over the expected life of the project? For some objectives, such as flood damage reduction, the economic evaluation is relatively straightforward, requiring the analysis of hydrologic, hydraulic and economic data. However, for ecosystem restoration, the economic evaluation is much more difficult. How can one possibly place a dollar value on ecosystem resources?

Traditionally, many economists have been reluctant to assign dollar values to ecosystem resources. This reluctance has been further institutionalized by the Corps, which requires a cost-effectiveness/ incremental-cost approach (i.e., changes in cost per acre or habitat unit over different sized plans) to evaluating ecosystem outputs.[1] But, this reliance upon only cost-effectiveness has its limitations as well, especially when analyzing multi-objective projects that may affect different types of ecosystems. For example, how can one decide between a riparian restoration project costing

1 Federal agencies involved in land and water resources planning are required to follow the *Principles & Guidelines*. For projects that have environmental quality effects, the *P&G* state (Chapter III) that "During the course of the EQ evaluation, the planner should be aware that contributions or effects that can be measured in monetary terms are to be monetized and included in the NED account." The Bureau seems to have taken this statement at face-value and it is amenable to placing monetary values on ecosystem benefits. The Corps, on the other hand, strictly requires a cost-effectiveness/incremental-cost analysis.

$3,000 per acre versus a wetland restoration project costing $5,000 per acre? Without some common form of measurement of the benefits of both projects the decision is difficult. However, if dollar values could somehow be assigned to the *outputs* associated with these ecosystems, then additional information would be available upon which a decision could be made.

The purpose of this paper is to discuss different techniques for valuing ecosystem resources, focusing upon valuing ecosystem services that are important to humans. This should not be interpreted as an attempt to place an economic value upon the 'total" ecosystem value. Nor should this valuation be viewed as a replacement to current ecosystem cost-effectiveness evaluation techniques but rather a supplement to them. The sections below discuss the basic concepts of economic value, the supply and demand for ecosystem services, and the different evaluation techniques. [2] Ecosystem services specific to floodplains are discussed in the report *Natural Floodplain Functions and Societal Values*, along with examples of dollar estimates from other studies. A suggested framework for performing multi-objective evaluations is included in the report *Benefit and Cost Analysis Framework*.

[2] Much of the information in this paper is adapted from the website http:/www.ecosystemvaluation.org. This website provides good description of the various valuation methods, including step-by-step instructions and examples. This website is written to be understandable for non-economists.

BASIC CONCEPTS OF ECONOMIC VALUE

Although there are many ways to measure value, the use of economic values is important when choices must be made in allocating limited resources among competing programs. The theory of economic valuation is based upon individual preferences and choices. People express their preferences through the choices and tradeoffs that they make, given constraints, such as those on income or time. In economics, the study of values, and particularly changes in those values, is called "welfare economics".

The economic value of a good or service is measured by the maximum amount of other things that a person is willing to give up in order to acquire that good or service. In a barter society, this tradeoff is obvious when a person gives up 3 units of good A in order to obtain 1 unit of good B. However, in market economies, dollars (or other forms of currency) are the accepted indicator of economic value, because the amount of dollars a person is willing to pay for an item indicates how much of other goods and services they are willing to give up for that particular item. This is called "willingness to pay". An alternate approach is called "willingness to accept' which measures how much an individual would accept as payment if they could be induced to forego a good or service. The amount of payment can then be equated to the value of the good or service. Although theoretically WTP and WTA should yield the same answer, often they do not—as discussed below.

Demand Curves and Consumer Surplus. In most cases, people will purchase less of a good or service as its price increases. In economics, this is called the "law of demand." The demand curve for a good can be found by plotting the amount of the good purchased at different prices. Because the purchased quantity generally decreases as price increases, the demand curve slopes downward. It is often assumed that the economic value of a good can be related to the prices paid for that good, however, the market price only indicates the minimum amount that consumers are willing to pay for it. In many cases, people are often willing to pay more for the good, and thus their perceived value for that good exceeds market prices. This value above market prices is called *consumer surplus*. The derivation of demand curves requires data on the

quantity purchased at different prices, plus data on other factors that might affect demand, such as income or other demographic data. Figure 1 illustrates the demand curve and consumer surplus for an individual consumer.

It should be noted that if goods and services have no prices (such as with many environmental goods and services), then there is no price line in Figure 1 and consumer surplus is the entire area under the demand curve.

Supply Curves and Producer Surplus. The above discussion of consumer surplus refers to benefits received by consumers of goods and services. Producers also receive economic benefits, based upon the profits they make from selling goods and services. The supply curve indicates how many units of a good producers are willing to produce and sell at a given price. As prices increases, producers generally want to produce and sell more goods, thus this curve slopes upward. If producers receive a higher price then what it costs to produce the good, then they receive a benefit from the sale—producer surplus. To estimate producer surplus, data on variable costs of production and revenues received from the good are required. The shaded area in Figure 2 illustrates producer surplus for an individual producer.

Total economic value (or welfare) is the sum of consumer and producer surplus, minus any associated production costs. Figure 3 illustrates both consumer and producer surplus based upon the intersection of the demand and supply curves.

Figure 1
Demand Curve and Consumer Surplus

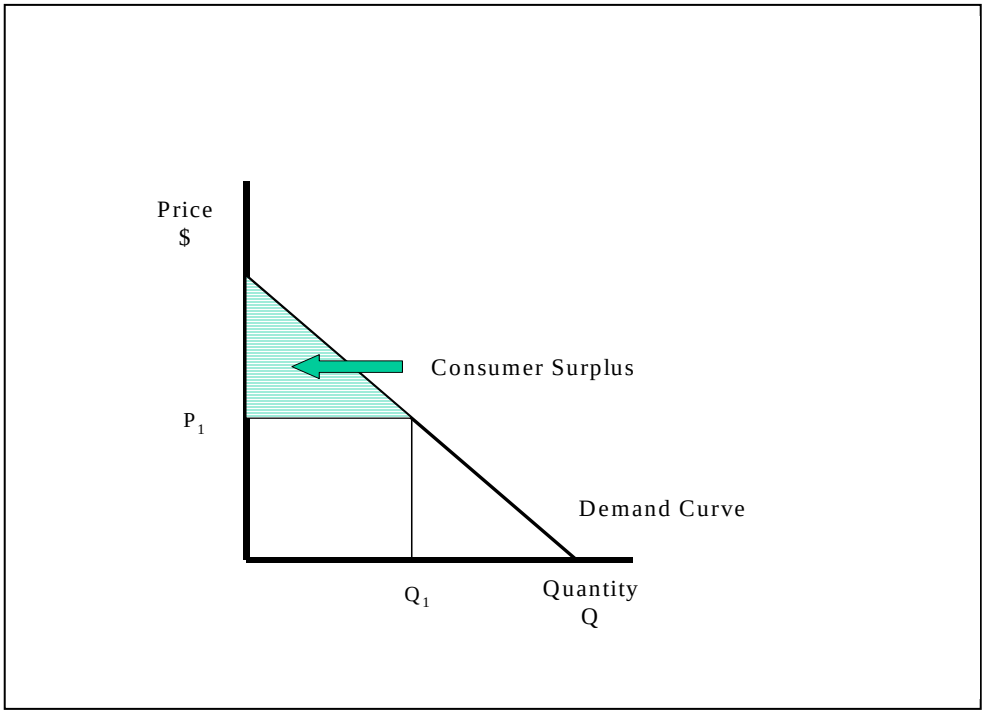


Figure 2
Supply Curve and Producer Surplus

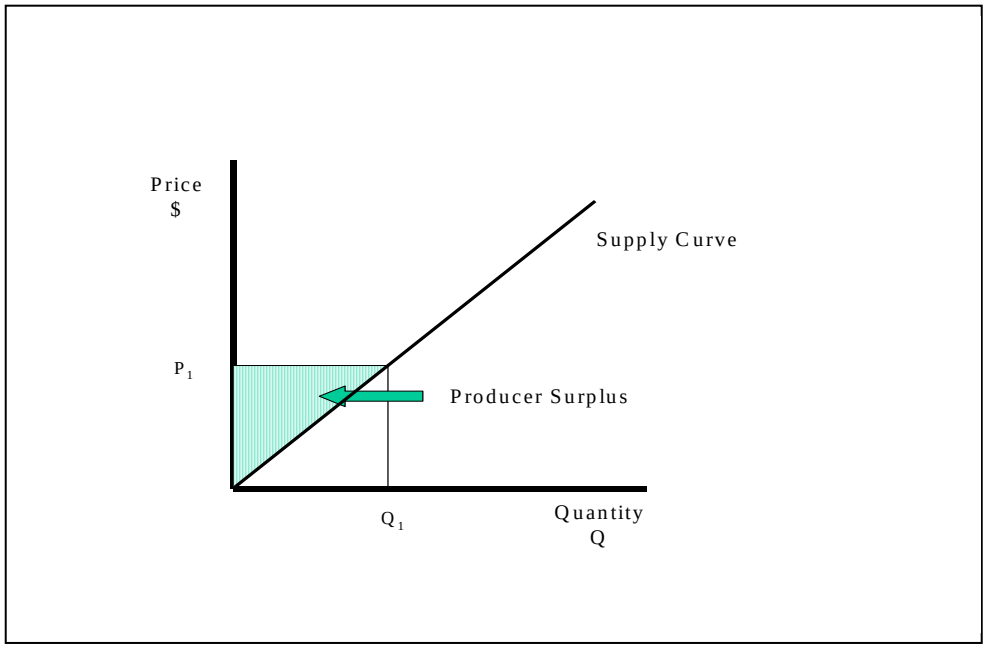
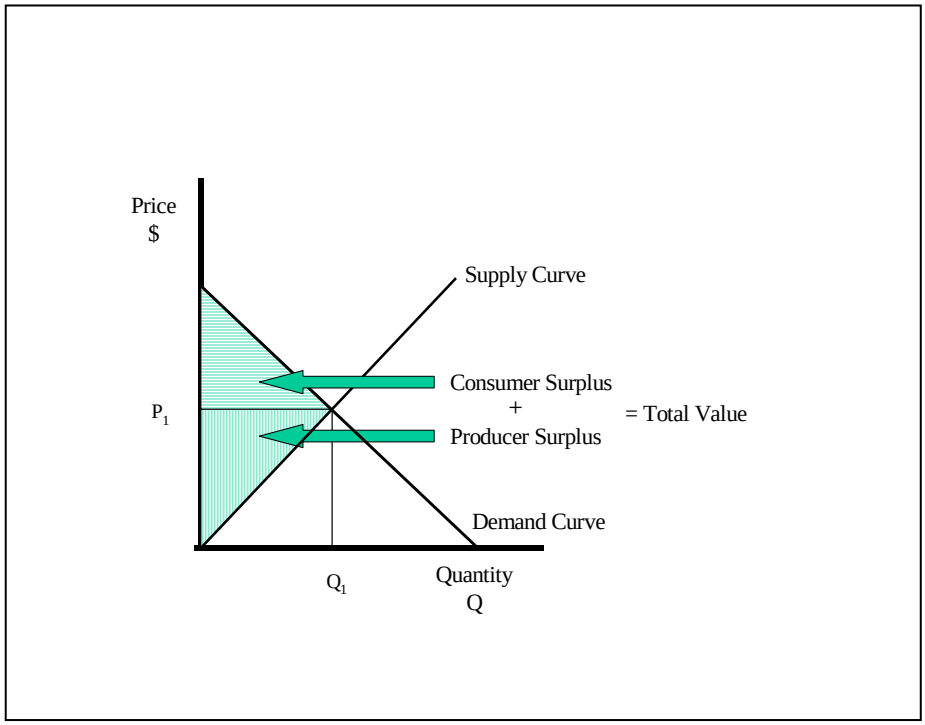


Figure 3
Consumer and Producer Surplus



Changes in Consumer and Producer Surplus. The economic benefit of actions to individuals is measured by *changes* in consumer surplus. For example, if the price of good increases, but a person's willingness to pay remains the same, the benefit received (maximum willingness to pay minus price) will be less than before. Or, if the quality of a good improves, but the price remains the same, a person's willingness to pay may increase thus the benefit will also increase. To estimate changes in consumer surplus, the demand functions for conditions before and after the actions must be determined.

Alternatively, economic values can be affected by changes in the prices or quality of other goods. If goods can be substituted for each other, then if the price of one good declines while prices of other similar goods and incomes remains the same, the consumer can increase their satisfaction by purchasing more of the good which has fallen in price and less of the other goods. For example, if coffee and tea are close substitutes, then if the price of coffee goes up, there may be more demand for tea. The demand curve for tea will shift upward to the right, increasing consumer surplus. Conversely, if goods are complementary, then changes in the economic benefit of one good will lead to changes in the opposite direction for the other good. For example, if sugar is purchased along with coffee, then increases in prices for coffee (and thus reductions in its demand) may also result in less demand for sugar. Thus, consumer surplus for sugar is also decreased because its demand curve is shifted downward to the left.

The economic benefit of actions to producers is measured by *changes* in producer surplus. These changes can occur because of changes in the availability and/or prices of goods and services used in the production process.

Figures 4 and 5 show changes in consumer and producers' surplus resulting from shifts in the demand and supply curves. Economic benefits are a key input into benefit/cost analysis, which (as discussed in the report *Floodplain Management Benefit/Cost Framework*) is used to determine the economic justification of a project.

Figure 4
Changes in Total Surplus: Increased Demand

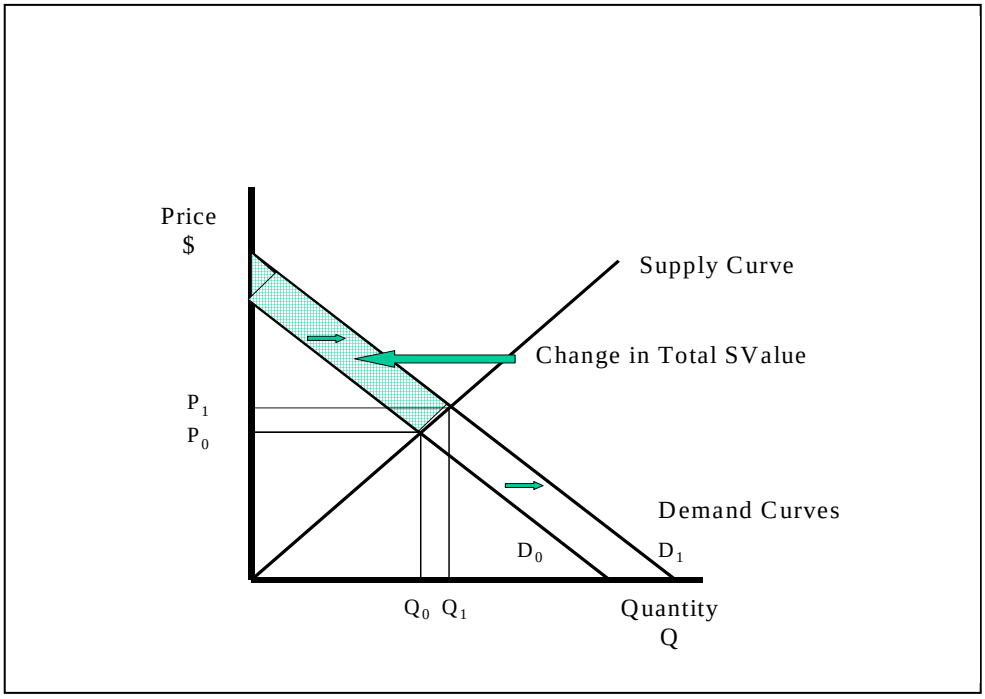
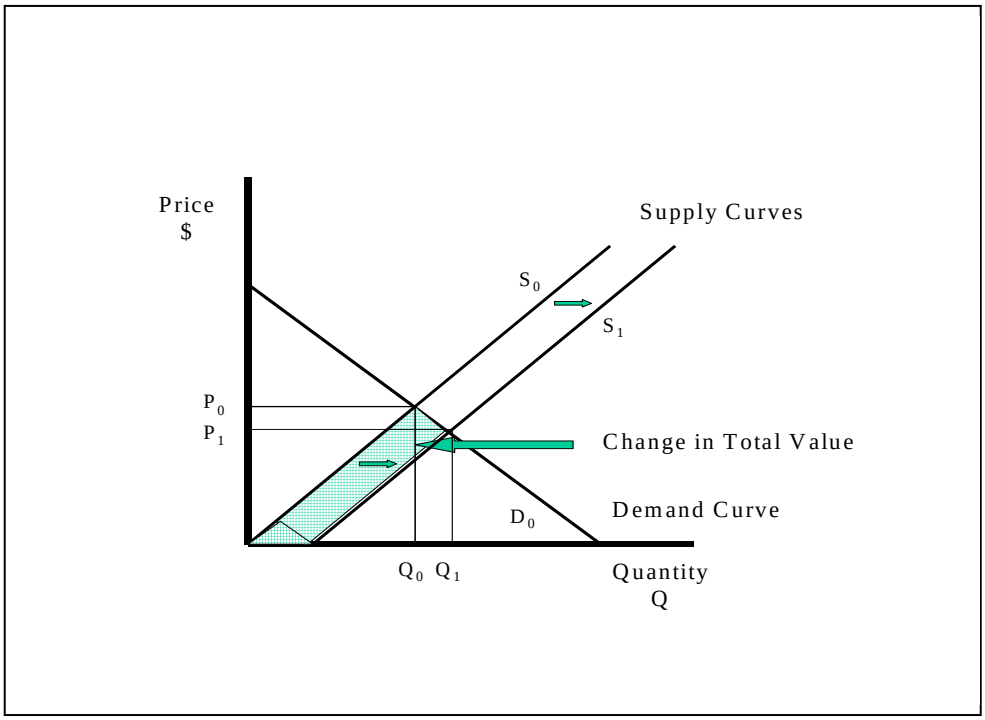


Figure 5
Changes in Total Surplus: Increased Supply



Other Issues. The above discussion of willingness to pay and the related concepts of consumer and producers' surplus were very simplified. In reality, there are a number of issues which can complicate the analysis. Although a full discussion of these issues is beyond the scope of this paper, following is brief description of the more important ones:[3]

- Measuring income and price effects. As illustrated above, shifts in the demand curve result in changes in consumer surplus, which provides the basis in measuring changes in consumer values or welfare. Although the goal is to measure changes in consumer surplus caused by price changes, there is concern among economists that measuring the change in consumer surplus not only includes the effects of these price changes, but also an income effect that occurs along with the price change. Therefore, it may necessary to adjust for the income effect such that only price effects upon consumers are measured, which requires the derivation of "income adjusted" demand curves. This is very difficult to do, and some evidence suggests that there is not that much difference between the "adjusted" and "ordinary" demand curves.
- Income distribution. A consumer's desire for a particular good or service must be backed up with income that can translate that desire into an actual willingness to pay. If the current distribution of income were changed, it is likely that the willingness to pay for different goods would also change because different people would then have the ability to purchase alternative goods and services. For example, environmentally related goods and services may be important to residents in a relatively low-income community, but because of the lower income levels these residents are unable to translate this desire into an actual willingness to pay for these amenities. If the income distribution in this community were somehow changed, then it might be possible to translate this desire into an actual willingness to pay, or benefit. However, economists and other policy makers have no way of determining which income distribution is superior, therefore the current income distribution must be accepted for the benefit and cost analysis.

[3] For more information on these issues, Freeman and Anderson are excellent sources.

- Individual vs. social effects. The above discussion focused upon demand and supply curves of *individual* consumers and producers. However, it is necessary to evaluate the impacts of changes in goods and services (especially public ones) upon society as a whole. Welfare economics is a branch of economics that focuses upon how a society can allocate scarce resources so as to maximize social welfare (economic efficiency). The *Pareto optimality* criterion suggests that an efficient allocation of resources occurs only when there are no possible reallocations that could make at least one person better off without making another worse off. With this criterion, efficiency cannot be achieved by a project if it makes just one person worse off than before, even if many more are made better off. Obviously, this is a very restrictive criterion and reliance upon it would result in very few programs or projects being implemented because most involve tradeoffs among individuals, with some benefiting from those actions while others losing. This is especially true for floodplain management plans that can affect entire watersheds and multiple stakeholders with diverse and competing interests. A less restrictive criterion is called *potential Pareto optimality* which states that an increase in general welfare occurs if those who are made worse off could in principle be compensated for their losses, whether or not this compensation occurs. It is this criterion upon which benefit and cost analysis is based.
- Pure competition vs. other market types. The above graphs of supply and demand illustrate a purely competitive market structure with these characteristics: (a) there are many buyers and sellers and none individually can significantly affect the market price; (b) all the firms produce and sell identical or homogenous products; and (c) buyers and sellers have perfect information and are able to freely enter or leave the market. Obviously there are very few markets that meet these very restrictive conditions. Other market types include oligopoly (few major sellers) and monopoly (one seller). The concepts describe above still apply, although they would be graphed differently for these different market structures. Other market distortions may also be present, such as taxes, subsidies, transfer payments, and externalities.

- Public vs. non-public goods. Many goods and services exist that can be consumed at the same time by more than one consumer and for which it is not feasible to restrict a consumer's access to those goods or services (i.e., there are no markets). These are called "public goods". For example, a floodplain management proposal might include the restoration of natural wetland and riparian habitat, which can be enjoyed by all of the inhabitants of a community. Although there are no traditional markets for habitat, they can provide numerous benefits to society, and as discussed further below, different measurement methods can be used to incorporate these values into a benefit and cost analysis.
- Measuring ecosystem outputs. To successfully place monetary values on ecosystem services, it is essential to be able to first measure the physical outputs from those ecosystems. Unfortunately, measuring the physical outputs from ecosystems can be more difficult than the process of attempting to place monetary values on ecosystem services. The report *Natural Floodplain Functions and Societal Vales* discusses some of the issues involved in measuring the physical outputs of ecosystems.

TYPES OF VALUES

Economists generally classify values as either *use* or *non-use* values. Use values include direct, indirect, option and bequest values. Direct use values contribute to consumer satisfaction or producer profits. For example, a restored wildlife preserve along a river creates values for those who visit the site to view wildlife or to those who harvest natural products (berries, fish, etc.) to be sold to others. Indirect use values are those that contribute to production or consumer utility by supporting other direct activities (or avoiding damages to those direct activities). For example, if the restored wildlife area also acts as a temporary floodwater storage site, then flood damage to downstream residential and commercial properties can be reduced. Option value is the value that people place on having the ability to enjoy something in the future, even though they may not currently use it. For example, a resident in a nearby community may not currently visit the restored wildlife area, but may plan to do so in the future.

Bequest value is the value that people place on something knowing that future generations will have the option to enjoy it. For example, another resident may not be planning on visiting the site, but it has value because to them because their children may be able to visit the site in the future. All of these values assume some sort of use—either now or in the future. However, it is also possible that a resident may value the restored wildlife area even if they fully expect that neither they nor their children will even visit it; it has value simply because "it exists". This is an example of a non-use existence value.

As discussed further in the report *Natural Floodplain Functions and Societal Values*, floodplain ecosystems provide a multitude of services that are valuable to humans. For example, floodplains may directly contribute to the supply of commercially valuable organisms (such as fish and shellfish), or indirectly by providing natural filtering of water supplies or places to store water during flood events (and thereby reducing damage to structures and crops). Floodplains may also have value to individuals who may wish to visit their natural areas in the future to view wildlife or engage in other recreational activities (option value) or preserve these natural areas for future generations to enjoy (bequest value). Finally, individuals may value these floodplains and their ecosystems simply by knowing that they will be protected even if they do not expect to use them (non-use value).

DEMAND INDICATORS FOR ECOSYSTEM SERVICES

Ecosystem restoration projects can potentially increase the quantity and quality of ecosystem services. However, for these services to have the values discussed above, there must be a demand for them. Without a demand for the services, there can be no presumption of "willingness to pay." Establishing demand for ecosystem services can be difficult, especially if the services are not typically traded in competitive markets. The following indicators can be considered in qualitatively assessing the demand for ecosystem restoration projects: [4]

[4] See Cole and Loomis.

- Public access to the on-site or off-site resources. For direct use values to be achieved, people must be able to see or use the restored area that is providing the ecosystem services.
- Regional presence of high demand for the targeted resource. The demand for additional ecosystem services can be demonstrated if there is currently a high demand for existing resources. It is important to determine if a restored resource will attract new users or will redistribute use from existing sites.
- Periodic shortages of resources. Demand for restored resources can be demonstrated if there is past evidence of frequent shortages. The percentage of a site or area capacity that is utilized might be another indicator of demand.
- Legal mandates for services including environmental laws and standards. Often the scarcity and demand for ecosystem outputs or services can be ascertained by court mandates, such as the "no net loss" of wetlands. Court mandates are political indicators of societal demand for these outputs.
- Potential of the restored environment to be used for environmental education. Contacting local school and other organizations to document use of ecosystem resources by these groups and the potential interest in new areas.
- Protection of unique natural resources. Planners should note whether the restored site would provide or enhance populations of regionally unique plants or animals or natural features not found in the region.

VALUATION METHODS

Some of the services provided by ecosystems are priced in competitive markets, and therefore the price paid for that service at least partially reflects the value of that ecosystem service. However, many ecosystem services are not traded in markets because individuals do not own the resources—these are public goods rather than individual goods. The absence of markets does not mean that there is no economic value to the resource. In these cases, nonmarket valuation techniques can be used to estimate economic values.

Because of the market and nonmarket nature of ecosystem services, three general types of methods can be used to estimate willingness to pay: revealed willingness to pay (market prices), imputed willingness to pay (circumstantial evidence), and expressed willingness to pay (surveys). Included within each of these are specific methods that have their own data requirements, advantages and disadvantages. Table 1 summarizes these methods, which are discussed in more detail below. [5]

Revealed Willingness to Pay

Some ecosystem products, such as fish, wood or berries are traded in markets; thus, their values can be estimated using market prices. Other ecosystem services, such as clean water, are used as inputs in production, and their value may be measured by their contribution to the profits obtained from the final goods. However, some ecosystem or environmental services, like aesthetic views or many recreational experiences, may not be directly bought and sold in markets. Even though these services are not bought and sold in traditional markets, it may be possible to estimate their values from prices people are willing to pay in markets for related goods. For example, people often pay a higher price for a home with a view of the ocean, or will take the time to travel to a special spot for fishing or bird watching. These kinds of expenditures can be used to approximate the value of the view or the recreational experience. Methods that rely on some form of market prices include market price, productivity, hedonic pricing and travel cost methods.

[5] Much of the information in this section is based upon the website http//:www.ecosystemvaluation.org. which explains these concepts for non-economists and also provides examples.

Table 1: Summary of Ecosystem Valuation Methods

Valuation Type	Methods	Advantages	Disadvantages
Revealed Willingness To Pay	Market Price	• Price, quantity and cost data are relatively easy to obtain • Uses observed data of actual consumer preferences and behavior • Uses standard, accepted, economic techniques	• Not applicable to many ecosystem services because of the lack of markets • Prices paid do not include consumer surplus • True economic value may not be reflected in prices due to seasonal variations and other effects • Prices may not reflect costs of other resources used to bring ecosystem products to markets
	Productivity	• Required cost and production data may be readily available • Uses standard, accepted, economic techniques	• Limited to those resources that can be used as production inputs • Requires information concerning how the resource used in the production process • If changes in the availability and use of the resource in the production process result in significant changes in the final prices of the final goods, this method becomes more difficult to apply
	Hedonic Pricing	• Uses observed data of actual consumer preferences and behavior • Property markets are good indicators of values • Data on property sales and characteristics are readily available	• Limited to environmental benefits that can be related to primarily housing prices • Will only capture people's willingness to pay for perceived differences in environmental characteristics • Relatively complex to implement and interpret • Requires high degree of statistical expertise
	Travel Cost	• Uses observed data of actual consumer preferences and behavior • On-site surveys may benefit from large sample sizes • Results are relatively easy to interpret and explain	• Complications arise if consumers visit more than one site • Assigning the "opportunity costs" of travel time is difficult • Availability of substitute sites will affect values • Surveying techniques can introduce biases • Requires high degree of statistical expertise

Table 1: Summary of Ecosystem Valuation Methods (Continued)

Valuation Type	Methods	Advantages	Disadvantages
Imputed Willingness To Pay	Damage Costs Avoided	• These methods provide rough indicator of economic value, subject to data constraints or substitutability of related goods and services • It is often easier to measure the costs of producing benefits than measuring the values of the benefits themselves • These approaches are less data- and resource-intensive • Data or resource limitations may rule out other valuation methods	• These methods assume that expenditures to repair or to replace ecosystem services are valid measures of the benefits provided, which may not be true • These methods require information on the substitution between replacement services and the natural ecosystem • Substitute goods are unlikely to provide the same types of benefits as the natural resource • The goods or services being replaced probably only represent a portion of the total value of the natural resource, thus estimated benefits may be underestimated • These approaches are only valid if there is evidence that the public would demand the alternative replacement or substitute project
	Replacement Costs		
	Substitute Costs		

Table 1: Summary of Ecosystem Valuation Methods (Continued)

Valuation Type	Methods	Advantages	Disadvantages
Expressed Willingness To Pay	Contingent Valuation Contingent Choice	• Can be used to estimate the economic value of most goods and services whether they are marketed or not • Commonly used method for measuring the value of non-use goods and services • Most appropriate to use when goods and services can be easily understood by the public and are consumed in discrete units (such as user days of recreation)	• There is much debate whether these methods adequately measures peoples' willingness to pay for improvements to environmental quality • These methods perhaps incorrectly assume that people understand the good or service in question and will reveal their preferences in a "contingent" market just as in a real market • There may be fundamental differences in the way that people make hypothetical decisions relative to the way they make actual decisions (for example, people may not take questions seriously since they will not actually have to pay the stated amounts) • The payment question can be phrased as a "willingness to pay" question or as a "willingness to accept compensation" question in cases where an environmental amenity may be given up. In theory the answers to these questions should be the same but often they are not. • These methods can be very expensive and time consuming

Table 1: Summary of Ecosystem Valuation Methods (Continued)

Valuation Type	Advantages	Disadvantages
Benefit Transfers	• Typically less costly and time consuming than conducting an original valuation study • Method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted	• Method may not be accurate, unless the original site and site its being compared with have similar location and physical characteristics • Existing studies may be difficult to find • It is difficult to assess the adequacy of existing studies • Reporting of existing studies may be inadequate in order to make needed adjustments • Unit use values may be out-of-date

Market Price Method**.** The market price method uses prevailing prices for goods and services traded in markets, such as commercially sold berries or fish. For these goods and services, the standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using market price and quantity data described above. The total net economic benefit, or economic surplus, is the sum of consumer and producer surplus.

Advantages of this method include:

- Price, quantity and cost data are relatively easy to obtain for established markets.
- The method uses observed data of actual consumer preferences.
- The method uses standard, accepted economic techniques.

Disadvantages of the market price method include:

- The true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures.
- Seasonal variations and other effects on price must be considered.
- The method cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service.
- Usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits.
- Market prices may not reflect a greater willingness to pay by consumers (consumer surplus).

Productivity Method. The productivity method is used to estimate the economic value of ecosystem goods or services that are directly used in the production of commercially marketed goods. If a natural resource can be used as a factor of production, then changes in the quantity or quality of the resource will result in changes in production costs and/or increased production, both of which would affect producer surplus. This

method is also called the “factor income” method. For example, increased water quality in a reservoir may result in less water treatment costs for manufacturing firms drawing supplies from that reservoir. Thus, the benefit of improved water quality can be directly measured by the decreased production (treatment) costs. Or, improved water quality may lead to greater agricultural productivity—more crops (or greater yields) can be obtained from the same amount of irrigated lands. In this example, changes in producer surplus will result from the increased income attributable to the increased crop production.

Although the productivity method is relatively easy to use, it can become more complicated if changes in production and/or production costs lead to significant changes in the final prices to consumers. If this occurs, then there may be changes in consumer surplus as well. Thus, the total economic benefit would be the sum of changes in producer and consumer surplus.

Advantages of the productivity method include:

- It is relatively straightforward to use and follows standard economic procedures.
- Data requirements are not extensive and the relevant data may be readily available
- It can be relatively inexpensive to apply.

Disadvantages of the productivity method include:

- The method is limited to valuing those resources that can be used as inputs in production of marketed goods.
- When valuing an ecosystem, not all services will be related to the production of marketed goods. Thus, the inferred value of that ecosystem may understate its true value to society.
- Information is needed on the physical relationships between actions to improve quality or quantity of the resource and the actual outcomes of those actions. In some cases, these relationships may not be well known or understood.

- If the changes in the natural resource affect the market price of the final good, or the prices of any other production inputs, the method becomes much more complicated and difficult to apply.

Hedonic Pricing Method. The hedonic pricing method is used to estimate the value of environmental amenities that affect prices of marketed goods. The method is based on the assumption that the prices people pay for goods are influenced by the set of characteristics that people consider important when purchasing the good. The hedonic pricing method may be used to estimate economic benefits or costs associated with environmental amenities (such as aesthetic views or proximity to recreational sites) or environmental quality (including the effects of air, water pollution, or noise pollution). Most hedonic price applications use residential housing prices to estimate the value of environmental amenities. The price of a house is related to the characteristics of the house and property, the characteristics of the neighborhood and community, and environmental characteristics. Thus, if the non-environmental factors are controlled for (for example, the size, number of rooms, age of the structure, etc.), then any remaining differences in price can be attributed to differences in environmental quality.

To apply the hedonic pricing method, a measure or index of the environmental amenity of interest must be developed (for example, distance to a park or open space from a house). In addition, cross-section and/or time-series data must be obtained concerning property values and property and household characteristics for a well-defined market area. The data set must include homes with different levels of environmental quality, or different distances to an environmental amenity, such as open space or the coastline. The data are typically analyzed using regression analysis, which relates the price of the property to its characteristics and the environmental characteristic(s) of interest. Thus, the effects of these environmental characteristics (such as the distance to a park or greenbelt) on price can be estimated. The regression results indicate how much property values will change for a small change in each characteristic, holding all other characteristics constant.

Advantages of the hedonic pricing method include:

- It can be used to estimate values based on actual market transactions.
- Property markets are relatively efficient in responding to information, so can be good indications of value.
- Data on property sales and characteristics are readily available through many sources, and can be related to other secondary data sources to obtain descriptive variables for the analysis.
- The method can be adapted to consider several possible interactions between market goods and environmental quality.

Disadvantages of the hedonic pricing method include:

- The scope of environmental benefits that can be measured is limited to things that are related primarily to housing prices.
- The method will only capture people's willingness to pay for perceived differences in environmental attributes and their direct consequences. Thus, if people aren't aware of the linkages between the environmental attribute and benefits to them or their property, the value will not be reflected in home prices.
- The method assumes that people have the opportunity to select the combination of features they prefer, given their income. However, the housing market may be affected by outside influences, like taxes, interest rates, or other factors.
- The method is relatively complex to implement and interpret, requiring a high degree of statistical expertise.
- The results depend heavily on model specification.
- Large amounts of data must be gathered and manipulated.
- The time and expense to apply the method depends on the availability and accessibility of data.

Travel Cost Method. The travel cost method is used to estimate the value of recreational benefits generated by ecosystems. It assumes that the value of the site or its recreational services is reflected in how much people are willing to pay to get there. It is referred to as a "revealed preference" method, because it uses actual behavior and choices to infer values. Thus, peoples' preferences are revealed by their choices. The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the "price" of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that people make at different travel costs. This is analogous to estimating peoples' willingness to pay for a marketed good based on the quantity demanded at different prices.

On average, people who live farther from a site will visit it less often, because it costs more in terms of actual travel costs and time to reach the site. The number of visits from origin zones at different distances from the site, and travel cost from each zone, are used to derive an aggregate demand curve for visits to the site, and thus for the recreational or scenic services of the site. This demand curve shows how many visits people would make at various travel cost prices, and is used to estimate the willingness to pay for people who visit the site (whether they are charged an admission fee or not).

To apply the travel cost method, information must be collected about:

- number of visits from each origin zone (usually defined by zip code)
- demographic information about people from each zone
- round-trip mileage from each zone
- travel costs per mile
- the value of time spent traveling or the opportunity cost of travel time

This information is typically collected through surveys—on-site, telephone or mail surveys may be used. In addition, especially for simpler applications, much information may be available from state and county resource agencies, or from federal surveys,

such as the National Survey of Fishing, Hunting and Wildlife Associated Recreation, published every five years by the U.S. Fish and Wildlife Service.

Advantages of the travel cost method include:

- The travel cost method closely approximates the more conventional empirical techniques used by economists to estimate economic values based on market prices.
- The method is based on actual behavior rather than what people say they would do in a hypothetical situation.
- The method is relatively inexpensive to apply.
- On-site surveys provide opportunities for large sample sizes, as visitors tend to be interested in participating.
- The results are relatively easy to interpret and explain.

Disadvantages of the travel cost method include:

- The travel cost method assumes that people perceive and respond to changes in travel costs the same way that they would respond to changes in admission price.
- The simplest models assume that individuals take a trip for a single purpose – to visit a specific recreational site. Thus, if a trip has more than one purpose, the value of the site may be overestimated and it can be difficult to apportion the travel costs among the various purposes.
- Defining and measuring the opportunity cost of time, or the value of time spent traveling, can be difficult. Because the time spent traveling could have been used in other ways, it has an "opportunity cost." This should be added to the travel cost, or the value of the site will be underestimated. However, there is no strong consensus on the appropriate measure—the person's wage rate, or some fraction of the wage rate—and the value chosen can have a large effect on

benefit estimates. In addition, if people enjoy the travel itself, then travel time becomes a benefit, not a cost, and the value of the site will be overestimated.

- The availability of substitute sites will affect values. For example, if two people travel the same distance, they are assumed to have the same value. However, if one person has several substitutes available but travels to a particular site because it is preferred, this person's value is actually higher. Some of the more complicated models account for the availability of substitutes.
- Those who value certain sites may choose to live nearby. If this is the case, they will have low travel costs, but high values for the site will not be captured by this method.
- Interviewing visitors on site can introduce sampling biases to the analysis.
- Standard travel cost approaches provides information about current conditions, but not about gains or losses from anticipated changes in resource conditions.
- The travel cost method it is not well suited for sites near major population centers where many visitors may be from "origin zones" that are quite close to one another.
- As in all statistical methods, certain statistical problems can affect the results. These include choice of the functional form used to estimate the demand curve, choice of the estimating method, and choice of variables included in the model.

Imputed Willingness to Pay

The value of some ecosystem services can be estimated based on the (1) costs of avoiding damages caused by the loss of these services, (2) costs of replacing ecosystem services, or (3) costs of providing substitute services. These methods do not provide strict measures of economic values, which are based on peoples' willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. If people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then

those services must be worth at least what people paid to replace them (circumstantial evidence). Thus, the methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be, made.

Damage Costs Avoided Method. This method uses either the value of property protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. For example, if a wetland protects adjacent property from flooding, the flood protection benefits may be estimated by the damages that would occur if the wetland were not present.

Replacement Cost Method. This method uses the cost of replacing an ecosystem or its services as an estimate of the value of the ecosystem or its services. To continue the above example, perhaps the wetland that might be lost can be replaced with another one upstream, either by purchasing an existing functioning wetland or by restoring a degraded wetland. Then the value of the wetland to be lost can be measured by the costs to acquire and restore alternative wetland sites.

Substitute Cost Method. This method uses the cost of providing substitutes for an ecosystem or its services as an estimate of the value of the ecosystem or its services. In the above example, the flood protection services of the wetland to be lost could be estimated by the cost of structural infrastructure that would be required in the wetlands absence, such as a retaining wall, levee or flood detention basin.

Advantages of the damage cost avoided, replacement cost, and substitute cost methods include:

- The methods may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods.
- It is often easier to determine the costs of producing benefits rather than measure the value of the benefits themselves, especially when goods, services, and benefits are not traded in markets.
- These methods are often are less data- and resource-intensive.

- Data or resource limitations may rule out other valuation methods that estimate willingness to pay.

Disadvantages of these methods include:

- These methods assume that expenditures to repair damages or to replace ecosystem services are valid measures of the benefits provided. However, costs are usually not an accurate measure of benefits.

- These methods do not consider social preferences for ecosystem services, or individuals' behavior in the absence of those services. Thus, they should be used as a last resort to value ecosystem services.

- The methods may be inconsistent because few environmental actions and regulations are based solely on benefit-cost comparisons, particularly at the national level. Therefore, the cost of a protective action may actually exceed the benefits to society. It is also likely that the cost of actions already taken to protect an ecological resource will underestimate the benefits of a new action to improve or protect the resource.

- The replacement cost method requires information on the degree of substitution between the market good and the natural resource. Few environmental resources have such direct or indirect substitutes. Substitute goods are unlikely to provide the same types of benefits as the natural resource, e.g., anglers may not value stocked salmon as much as wild salmon.

- The goods or services being replaced probably represent only a portion of the full range of services provided by the natural resource. Thus, the benefits of an action to protect or restore the ecological resource would be understated.

- These approaches should be used only after a project has been implemented or if society has demonstrated a willingness-to-pay for the project in some other way (e.g., approved spending for the project). Otherwise there is no indication that the value of the good or service provided by the ecological resource to the affected community greater than the estimated cost of the project.

- Just because an ecosystem service is eliminated is no guarantee that the public would be willing to pay for the identified least cost alternative merely because it would supply the same benefit level as that service. Without evidence that the public would demand the alternative, this methodology is not an economically appropriate estimator of ecosystem service value.

Expressed Willingness to Pay

Many ecosystem services are not traded in markets and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for them through their market purchases or actions, nor is there any circumstantial evidence to infer what they might be willing to pay. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario (contingent valuation). Alternatively, people can be asked to make tradeoffs among different alternatives, from which their willingness to pay can be estimated (contingent choice).

Contingent Valuation Method. The contingent valuation method is used to estimate economic values for many ecosystem and environmental services, including use and non-use values. It is the most commonly used--and also the most controversial--method for estimating non-use values. With this method, people are surveyed as to how much they would be willing to spend for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called "contingent" valuation, because people are asked to state their willingness to pay, *contingent* on a specific hypothetical scenario and description of the environmental service.

Contingent Choice Method. The contingent choice method is similar to contingent valuation, in that it can be used to estimate economic values for virtually any ecosystem or environmental service, and can be used to estimate non-use as well as use values. Like contingent valuation, it is a hypothetical method – it asks people to make choices based on a hypothetical scenario. However, it differs from contingent valuation because it does not directly ask people to state their values in dollars. Instead, the contingent choice method asks the respondent to state a preference between one group of

environmental services or characteristics (at a given price or cost to the individual) and another group of environmental characteristics (with a different price or cost). Because it focuses on tradeoffs among scenarios with different characteristics, contingent choice is especially useful to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services.

Advantages of the contingent methods include:

- They are the most widely accepted methods for estimating total economic value, especially for the more difficult to estimate use values (such as option and bequest) and non-use (such as existence) values.
- They are most effective in estimating values for goods and services which are easily identified and understood by users and which are consumed in discrete units (e.g., user days of recreation).
- Although the methods require competent survey analysts to achieve defensible estimates, the nature of these studies and their results are not difficult to analyze and describe. Dollar values can be presented in terms of a mean or median value per capita or per household, or as an aggregate value for the affected population.
- They are commonly used and research is continuing to improve the methodologies, including making study results more valid and reliable with a better understand of their strengths and limitations.

Disadvantages of the method:

- Although these methods have been commonly used for the past two decades, there is considerable controversy over whether they adequately measures people's willingness to pay for environmental quality.
- They assume that people understand the environmental good or service in question and will reveal their preferences in the contingent market just as they would in a real market. However, most people are unfamiliar with placing dollar values on environmental goods and services and they may not have an adequate

basis for stating their “true” value.

- The expressed answers to a willingness to pay question in a contingent valuation format may be biased because the respondent is actually answering a different question than the surveyor had intended. Rather than expressing value for the good, the respondent might actually be expressing their feelings about the scenario or the valuation exercise itself. For example, respondents may express a positive willingness to pay because they feel good about the act of giving for a social good (referred to as the “warm glow” effect), although they believe that the good itself is unimportant. Alternatively, some respondents may value the good, but state that they are not willing to pay for it, because they are protesting some aspect of the scenario, such as increased taxes or the means of providing the good.

- Respondents may make associations among environmental goods that the researcher had not intended. For example, if asked for willingness to pay for improved visibility (through reduced pollution), the respondent may actually answer based on the health risks associated with dirty air.

- Some researchers argue that there is a fundamental difference in the way that people make hypothetical decisions compared to the way they make actual decisions. For example, respondents may fail to take questions seriously because they will not actually be required to pay the stated amount. Responses may be unrealistically high if respondents believe they will not have to pay for the good or service and that their answer may influence the resulting supply of the good. Conversely, responses may be unrealistically low if respondents believe they will have to pay.

- The payment question can either be phrased as the conventional ‘What are you willing to pay (WTP) to receive this environmental asset?” or in the form ‘What are you willing to accept (WTA) in compensation for giving up this environmental asset?’ In theory, the both results should be very close. However, when the two formats have been compared, WTA often significantly exceeds WTP. Critics claim that this invalidates the contingent valuation method.

- Many earlier studies attempted to prompt respondents by suggesting a starting bid and then increasing or decreasing this bid based upon whether the respondent agreed or refused to pay the initial sum. However, it has been shown that the choice of a starting bid affects respondents' final willingness to pay response.
- Non-response bias is a concern when sampling respondents, since individuals who do not respond are likely to have, on average, different values than individuals who do respond.
- Estimates of nonuse values are difficult to validate through other means.
- Properly conducted, these methods can be very expensive and time-consuming, because of the extensive pre-testing and survey work.
- Many people, including jurists policy-makers, economists, and others, do not believe the results of these methods, particularly contingent valuation.

Benefit Transfers

The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. For example, values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study.

The simplest type of benefit transfer is the unit day approach, where existing values for activity days are used to value the same activity at other sites. These estimates are based on expert judgment in combining and averaging benefit estimates from a number

of existing studies. These “unit day values” may be adjusted for characteristics of the study site when they are applied.

A more rigorous approach involves transferring a demand curve from another study. The demand curve statistically relates peoples’ willingness to pay to characteristics of the ecosystem and the people whose values were elicited. When a demand curve is transferred, adjustments can be made for differences in the characteristics between the sites, thus allowing for more precision in transferring benefit estimates between contexts.

Different standards for benefit transfer may be applied in different contexts. For example, a higher standard of accuracy may be required when the costs of making a poor decision are higher. A lower standard of accuracy may be acceptable when costs are lower, such as when the information from the benefit transfer is only one of a number of sources of information, or when it is used as a screening tool for the early stages of a policy analysis.

The benefit transfer method is most reliable when the original site and the study site are very similar in terms of factors such as quality, location, and population characteristics; when the environmental change is very similar for the two sites; and when the original valuation study was carefully conducted and used sound valuation techniques. Although original studies are preferable to benefit transfer, researchers agree that in the absence of funding and resources needed for conduct of such studies; benefit transfer can provide a reasonable valuation of non-market values provided that the above-mentioned factors are met.

Advantages of the benefit transfer method include**:**

- Benefit transfer is typically less costly and time consuming than conducting an original valuation study.
- The method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted.
- The method can easily and quickly be applied for making gross estimates of

environmental values.

Disadvantages of the benefit transfer method include**:**

- Benefit transfer may not be accurate, except for making gross estimates of recreational values, unless the sites share all of the site, location, and user specific characteristics.
- Good studies for the policy or issue in question may not be available.
- It may be difficult to find appropriate studies because many are not published.
- Reporting of existing studies (data, assumptions and methods) may be inadequate to make needed adjustments.
- Adequacy of existing studies may be difficult to assess.
- Extrapolation beyond the range of characteristics of the initial study is not recommended.
- Benefit transfers can only be as accurate as the initial value estimate.
- Unit use recreation value estimates can quickly become dated.

Resource Requirements of Evaluation Methods

In the mid-1990s, the US Army Corps of Engineers' Institute for Water Resources investigated some of the ecosystem evaluation methods discussed above and in one of their reports summarized the resource requirements of those methods. [6] This information, which is summarized in Table 2, was based upon an informal survey of academic economists with experience applying the various methods. As can be seen in the table, many of the methods are data intensive and require primary data gathering through surveys. Many of the methods also require advanced training in economic theory, statistics and econometrics, and applied data management and analysis.

[6] USACE, Evaluation of Environmental Investments Research Program, Monetary Measurement of environmental Goods and services: Framework and Summary of techniques for Corps Planners.

Methods that use surveys also require expertise in survey design and sampling procedures.

Table 2: Resource Requirements for Selected Ecosystem Valuation Methods

Methods	Data	Expertise	Cost Range	Time Range	Comment
Factor Income/ Productivity	Production and price data for the final marketed good and data on the levels of factor inputs used, including the ecosystem factor input	Advanced knowledge of production theory and econometric methods; working knowledge of renewable resource or engineering models	$30 – 50 thousand	2 - 4 months	Cost and time estimates assume that the necessary data are readily available and the main task involves conceptualizing and empriicizing the model
Travel Cost	Data on user visits, characteristics, and distance traveled to regional recreational sites; data on the services provided by and characteristics of regional sites	Advanced knowledge of demand theory, statistics and econometrics, survey design and sampling procedures	$50 – 150 thousand	1 – 2 years	Cost and time estimates assume that regional modeling is needed to obtain the necessary variation in measures of site quality, and to account for possible substitutes. The low ends of the ranges assume that most of the needed data are available and accessible from secondary sources; the high ends assume that primary data gathering using site intercept surveys would be required.
Hedonic Property Value	Data on property prices, lot and neighborhood characteristics, and locational environmental attributes.	Advanced knowledge of demand theory, statistics and econometrics; skilled data manager	$30 – 50 thousand	4 – 6 months	Cost and time estimates assume that the needed data are readily available and computer accessible

Table 2: Resource Requirements for Selected Ecosystem Valuation Methods

(Continued)

Methods	Data	Expertise	Cost Range	Time Range	Comment
Contingent Valuation	Random sample survey of relevant population	Advanced skills in survey design, sampling procedures, and data management; advanced knowledge of demand theory, statistics and econometrics	$50 – 100 thousand	6 – 12 months	Cost and time estimates assume use of a relatively sophisticated questioning format, a mail or telephone survey (or on-site, personal interviews) and a modest sampling level (200-400 sample members)
Benefit Transfers	Data on unit value estimates or valuation models from existing studies. Data on the characteristics of project sites, and the number and characteristics of project site users	Advanced knowledge of nonmarket valuation methods, demand theory and econometrics (required expertise may not be as great as that needed to implement primary studies)	$10 – 20 thousand	1 – 3 months	The low ends of the cost and time ranges assumes use of a unit value transfer and the availability of secondary data on project site users; the high ends assume use of model transfers and some primary data gathering on the number and characteristics of site users.

Source: Apogee Research, Inc.

CONCLUSIONS

Ecosystems provide a wide range of services that are useful to society. Some of these services are priced in competitive markets; therefore the price paid for that service at least partially reflects the value of that service. However, many ecosystem services are not traded in markets because individuals do not own the resources—these are public rather than individual goods. The absence of markets does not mean that there is no economic value to that resource. This report has summarized various methods that can be used to identify the economic values for these services, including those that focus upon revealed, imputed or expressed willingness to pay. In addition, it may be possible to use benefit values developed by other studies ("benefit transfers").

Table 3 illustrates how these methods can be applied to estimate the value of ecosystem services. In the early 1990s, a survey of research was conducted concerning the economic value of California wetlands, focusing upon flood control, water supply, water quality, and recreation services. Values for each of these services were determined differently using some of the methods discussed above. While the dollar estimates presented in this table are certainly subject to considerable debate, the value of the table is not the dollar estimates but rather that it illustrates the application of these methods for different ecosystem services. There is an increasing amount of literature that is focusing upon ecosystem services and the measurement of their value with the methods described above. Some of these studies are described in the report *Natural Floodplain Functions and Societal Values* as they apply to specific floodplain functions.

Table 3: Value of California Wetlands

$1990/Acre

Wetland Function	Low	High	Method
Flood Control	$260	$4,650	Avoided Costs
Water Supply	$6,800	$20,360	Avoided Costs
Water Quality	$3,360	$10,400	Avoided Costs
Recreation	$67	$6,060	Travel Cost
Commercial Fisheries	$38	$877	Net Income
Habitat	$3,337	$8,128	Contingent Valuation
Total Value Per Acre	$13,862	$50,475	

Source: Jeff Allen, et al, "The Value of California Wetlands" (August 1992)

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(Other numerous studies with specific floodplain functions/services examples are included in the *Natural Floodplain Functions and Societal Values* report).