The Economics of Non-Market Goods and Resources

Patricia A. Champ
Kevin J. Boyle
Thomas C. Brown *Editors*

A Primer on Nonmarket Valuation

Second Edition

Springer

The Economics of Non-Market Goods and Resources

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Acronyms

CE/CEs	Choice experiment(s)
EA	Equivalency analysis
GIS	Geographical information system
i.i.d.	Independent and identically distributed
RUM	Random utility model
TCM	Travel-cost model
VSL	Value of statistical life
WTA	Willingness to accept
WTP	Willingness to pay

Use only in Equations

ACS	American community survey
MLS	Multiple listing service
NB	Net benefits
PIN	Parcel identification number
RDC	Research data center
TC	Transaction costs

Chapter 1
Valuing Environmental Goods and Services: An Economic Perspective

Kathleen Segerson

Abstract Nonmarket valuation, i.e., valuing environmental goods and services that are not traded in a market, has been increasingly used in a variety of policy and decision-making contexts. This is one (but not the only) way that researchers and practitioners have sought to define and measure the values that individuals assign to environmental goods and services. The idea of putting a dollar value on protecting the environment has been controversial, but often because the economic approach to valuation has not been well-understood. This chapter provides a nontechnical overview of and rationale for the economic approach to valuation, starting from a broad conceptualization of values versus valuation. It summarizes the economic concept of value and its key features. It then discusses the use of economic valuation in decision making, followed by an overview of the steps involved in the valuation process and important issues that arise in implementing that process. Finally, it identifies and briefly summarizes the principal non-market valuation methods used by economists. In doing so, it sets the stage for the more detailed chapters on theory and methods that follow.

Keywords Preferences · Market failure · Externalities · Ecosystem services · Held versus assigned values · Substitutability · Economic versus commercial values · Economic impacts versus values · Valuation process · Aggregation · Discounting · Uncertainty · Valuation methods

1.1 Making Choices

As Jean-Paul Sartre put it, "we are our choices." Choice is a fundamental part of our lives. We are constantly making choices, often individually or among friends but also collectively. Some individual choices are routine (e.g., about how to spend our income or time on a given day), but others involve major decisions (e.g., about

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houses, families, jobs, or careers). We make collective choices about, for example, the establishment of laws and regulations or the use of publicly owned resources. These collective decisions can be made directly through collective choice mechanisms such as voting or through elected or appointed representatives who make those choices on our behalf.

All choices, whether individual or collective, involve evaluating alternatives so that a choice among those alternatives can be made. Imagine, for example, that you have three hours of uncommitted time and you are trying to decide how to spend it. Suppose you narrow your options down to two: going hiking in a nearby forested area or going to a museum. Assuming that the cost of both alternatives (including travel cost and any entry fee) is the same (say $20), your choice will presumably hinge on which option you prefer. An alternative way to think about this same choice is to ask yourself whether, given $20, would you choose to spend it going hiking, or would you rather keep the $20 and maintain the option of using it for something else, such as going to the museum? Either way of framing the choice—choosing between two activities of equal cost, or choosing between spending the money on hiking or keeping it for some other use—highlights the inherent trade-off involved in nearly all choices, i.e., the fact that choosing one alternative means giving up the other(s).

We can think about collective choice in a similar way, although the choice problem is more complex. Imagine, for example, that $20 million in tax revenue is available for use either to preserve a forested area for hiking or to build a museum. Which option is preferred? Similarly, we could ask whether preserving the forested area is collectively *worth* the $20 million it would cost, or whether instead the money should be used for an alternative, such as the museum. Again, the decision involves a trade-off because using the money for one option means giving up other option(s). Based solely on their own preferences, some individuals might prefer the forested area while others might prefer the museum, so neither is likely to be the preferred choice for all individuals. Thus, collective choice requires not only a comparison and evaluation of the options from the perspective of affected individuals, but also some means of combining disparate individual views into a single collective choice.

Because making choices requires assessing preferences over different options, observing people's choices can reveal information about their preferences. For example, if you face the above choice and choose to go hiking in the forested area, then presumably this implies that you felt that the hiking experience was "worth" the $20 it cost you. Equivalently, through that choice you have revealed that you prefer the hiking to the alternative that the $20 could have bought (a trip to the museum).

The topic of this book, nonmarket valuation, is fundamentally about individual choices and the preferences that underlie those choices. The methods described in the following chapters are all based on the premise that, when faced with a set of options, individuals evaluate those options based on their preferences (and other circumstances) and choose the option that is most preferred, recognizing that choosing one option (e.g., hiking) precludes the other options (e.g., visiting the museum). The information that is obtained about individual preferences can then be used for a variety of purposes, such as informing collective decisions about similar options. For example, information about individuals' preferences regarding use of forested areas can be used by policymakers when making decisions about devoting public funds to preserve those areas or to evaluate the loss that individuals would experience if the forested area were damaged or destroyed.

While nonmarket valuation is fundamentally about individual choices, it is focused on a particular type of choices, namely, those that are not fully captured by purchases or sales in a market. Many choices involving environmental goods and services, including natural amenities such as wilderness and open space, fall into this category. When individuals directly purchase goods and services (such as food or cars), their purchase decisions directly reveal information about their preferences for these items. However, individuals do not typically make a direct purchase of environmental goods and services such as clean air or clean water (although they might purchase a trip to a wilderness area). For goods that are not directly for sale in the market, individuals cannot express their preferences through their purchases. The nonmarket valuation methods described in this book are designed to elicit information about those preferences through other means.

1.2 Choices and Market Failure

When individuals make choices based on their preferences and self-interest, the outcomes that result can be good for society as a whole as well. This is the essence of Adam Smith's observation in "The Wealth of Nations," published in 1776, that individuals are led by an "invisible hand" to unintentionally promote broader social goals. However, in many cases, the invisible hand does not work, i.e., individual decisions based solely on self-interest do not lead to outcomes that are best for society. The invisible-hand argument rests on the assumption that markets exist for all the goods and services that individuals care about, thereby creating a means for buyers to express their preferences in the marketplace. However, as noted above, for many environmental goods or services, markets do not exist.

The lack of markets for many environmental (and other nonmarket) goods has important implications for resource allocation.[1] In particular, a purely market-based economy will tend to underprovide nonmarket goods relative to what would be socially optimal.

We can think about the problem in two alternative (but equivalent) ways. The first views environmental improvements as goods or services that would be supplied by individuals or firms, if only a market existed. For marketed goods and

[1]The reasons that markets do not exist can vary. In many cases, the market failure arises because the environmental good or service is a public good. For example, air quality in a city is a pure public good because all individuals living in the city will benefit from an improvement in the city's air quality and no one in the city can be excluded from enjoying the benefits of the improvement. Public goods suffer from the "free-rider" problem, which can impede the development of a market for the good. Markets can fail to exist for other reasons as well, including ill-defined property rights, information asymmetries, and difficulty in defining and monitoring tradable units.

services (e.g., food and housing), suppliers provide these goods in exchange for payments that cover their costs of providing them. In contrast, when there is no market for an environmental good, individuals or firms who could supply that good will not have an incentive to do so because they will not receive a payment to cover the associated costs. For example, private landowners will not have an incentive to keep some of their land as protected habitat if they have no way of recouping the foregone profits by selling the environmental services that would result. So, unlike with marketed goods, even if the benefits (to society) from providing those services exceed the corresponding cost (i.e., the foregone profit), the landowner is not likely to supply the protected habitat.

The second way to think about the undersupply of environmental goods is based on the concept of externalities, i.e., unintended (and uncompensated) positive or negative impacts that one individual's or firm's decisions have on others. Environmental degradation is a classic example of a negative externality. By engaging in activities that, as a byproduct, degrade the environment, individuals or firms impose environmental damages on others. When no market exists in which those individuals must purchase the right to impose those damages, the individuals will face only their own private costs of engaging in the activity rather than the full social cost (which includes the environmental cost). As a result, they will tend to overengage in the environmentally degrading activity. For example, an electric utility that generates carbon dioxide emissions as a byproduct of electricity production will pay for the labor, capital, and fuel it uses in that production, but it will not typically pay for the cost of the pollution it generates. Because emissions are not costly to the utility, it has no incentive to try to reduce its emissions and, therefore, will typically pollute too much (i.e., undersupply environmental protection).

The undersupply that results from missing markets creates the opportunity to improve outcomes from society's perspective by (1) facilitating the creation of those markets, if possible, or (2) seeking to provide the good through means other than markets, such as through laws/regulations requiring or restricting certain activities or through direct provision by the government. In either case, information about the value of the environmental goods and services that would be supplied can help in addressing and overcoming the market failure, and nonmarket valuation can play a key role in providing that information. Consequently, the need for nonmarket valuation often arises in the context of missing markets or market failure.

1.3 Development of Nonmarket Valuation

Most nonmarket valuation techniques first appeared in the U.S. in the 1950s, primarily for use by federal agencies in benefit-cost analyses of proposed water resource projects such as dam construction. In the years that followed, environmental and natural resource economists refined and improved these techniques and applied them in a wide variety of contexts. Progress was spurred on in the early 1980s with two federal actions. One was Executive Order 12291 (issued in 1981), requiring benefit-cost analyses of all proposed major regulations (see Smith 1984). The other was passage of the Comprehensive Environmental Response, Compensation and Liability Act (passed in 1980), requiring an assessment of damages to natural resources from releases and spills (Kopp and Smith 1993; Portney 1994). These and subsequent actions in the U.S. and elsewhere focusing on public land management and environmental protection led to many applications of nonmarket valuation methods, primarily to assess the environmental and health benefits of environmental regulation, to estimate compensation for damages suffered as a result of spills or other types of contamination, and to inform land and water management decisions (see, for example, Smith 1993; Adamowicz 2004; Carson 2012).

Interest in the use of nonmarket valuation techniques among non-economists is more recent and stems to a large extent from the growing understanding that the natural environment generates "ecosystem services" that sustain and enhance human well-being and the recognition that those services are being significantly degraded or threatened by a wide variety of activities across the globe (Daily 1997; Millennium Ecosystem Assessment 2005). In addition, ecologists realized that these critical services were being given little, if any, weight in policy decisions because their contributions to individual and collective well-being were not being estimated and included along with other considerations in evaluating choices. This led to increased interest in valuing ecosystem services and including those values in decision-making (National Research Council 2005; Carpenter et al. 2006; Brown et al. 2007).

An early attempt to place a monetary value on the contributions of the world's ecosystems estimated the mean annual value to be $33 trillion (Costanza et al. 1997), suggesting that global ecosystem services were "worth" more than the annual global production of marketed goods and services at that time. While the methods and results used in this analysis were heavily criticized by economists (see, e.g., Toman 1998; Bockstael et al. 2000), this early work and the discussion it spurred highlighted the importance of considering ecosystem services in individual and collective decisions and the role that nonmarket valuation techniques could play in ensuring that consideration. It also highlighted the need to understand and apply those methods appropriately. This book is designed to meet the growing demand for the use of nonmarket valuation techniques and to provide the necessary foundation for understanding and appropriately applying those techniques.

1.4 Values Versus Valuation

Nonmarket valuation is often described as a means of "valuing" the environment (or environmental goods and services). However, the concept of "value" or a person's "values" encompasses a wide range of ideas, and there is often confusion over what exactly is meant when we refer to valuing something (see Brown 1984; Dietz et al. 2005). For example, individuals can value certain types of behavior (such as loyalty), certain end states (such as freedom), and certain qualities (such as beauty). Brown (1984) refers to these end states and other ideas of what is good or preferable as *held* values. In contrast, he refers to the values that individuals place on an object as *assigned* values, which, importantly, are "not a characteristic of the object itself but rather the standing of the object relative to other objects" (Brown 1984, p. 233). The value that an individual assigns to an object (relative to other objects) will depend on a number of factors, including "(1) the person's perception of the object and all other relevant objects, (2) the person's held values and associated preferences, and (3) the context of the valuation" (Brown 1984, p. 235), where context is broadly defined to include the external and internal circumstances of the valuator, the way in which values are expressed, and whose interests the valuator is representing (e.g., pure self-interest or a broader constituency).

The distinction between held values and assigned values is critical in understanding nonmarket valuation as a means of "valuing" the environment (or environmental goods and services). Individuals may have held values related to environmental protection, i.e., they may feel that environmental protection is an important and desirable type of behavior or end state. These values can be based on a number of possible grounds, such as spirituality, bioethics, or aesthetics (e.g., beauty). However, they are not by themselves directly measurable in economic terms, so they are not the focus of nonmarket valuation.

Nonmarket valuation seeks to measure assigned values, which are influenced by held values but distinct from them. Rather than seeking to value environmental protection as a general principle, it seeks to measure the value that individuals assign to particular environmental quality (or natural resource) outcomes *relative to* some alternative. For example, it is focused on the value an individual would assign to having air quality at level A instead of having air quality at some alternative level, say B. In this case, the *object* to which the value is assigned is the *change* in air quality (from A to B). Thus, the values measured by nonmarket valuation are always relative in the sense of being assigned to *changes* from one outcome or scenario to another.

It is important to note that nonmarket valuation does not seek to identify (let alone measure) the underlying held values that are manifested in the assigned value for a given change. For example, it does not seek to identify whether an individual values an improvement in air quality or preservation of a wilderness area based on spiritual, bioethical, aesthetic, or some other grounds. In other words, it does not seek to identify, understand, judge, or explain the *reason* that an individual assigns a particular value to the change and does not involve a process designed to influence the underlying held values (Polasky and Segerson 2009). Regardless of the underlying philosophical basis or reason, nonmarket valuation simply seeks to measure the values that individuals assign to a given change based on their preferences over alternative outcomes and the trade-offs they are willing to make. In brief, it seeks to measure what changes people care about and how much they care, independent of *why* they care.

Although held values can be stated in terms of general principles (e.g., "I value my health"), assigned values must be stated in terms of some scale that allows a direct comparison to determine whether one object or change is valued more, less, or the same as another. The term "valuation" refers to the process of measuring individuals' assigned values using a given scale. Fundamentally, this process involves two primary components: determination of the relevant change(s) to be valued and estimation of the value of the change(s) based on a given scale.[2] Different scales or means of expressing assigned values exist (Brown 1984), and there are different views on the importance of the factors that influence those values. These views tend to vary across scholarly disciplines. For example, economists generally emphasize the importance of (fixed) preferences and income, while psychologists and sociologists focus on other internal and external factors, such as perceptions, social/cultural influences, and framing effects. As a result, different disciplines tend to view valuation somewhat differently, employ different methods for eliciting assigned values, and express those values using different measures or scales (Dietz et al. 2005; U.S. Environmental Protection Agency 2009).

This book focuses on an economic approach to valuation. As mentioned, it is one (but not the only) way that researchers and practitioners have sought to define and measure the values that individuals assign to environmental goods and services.[3] Although economic valuation does not necessarily capture all relevant dimensions of assigned value in a given context and may not be appropriate in all circumstances, it is based on a well-developed theoretical foundation and has proven to be very useful in practice as a means of ensuring that the environmental or health impacts (either positive or negative) of individual or collective choices are considered when those choices are made.

1.5 The Economic Concept of Value

Standard economic theory defines value in terms of the trade-offs that individuals are willing to make. The value of something, such as an improvement in environmental quality (call this change X), is the maximum amount of something else (call this good Z) that an individual would be willing to give up in exchange for the change that is being valued.[4] This presumes that, for any reduction in the quantity of some good or service, there is an increase in the quantity of some other good or service that would leave the individual at the same level of well-being ("utility") as before.

Two fundamental implications of this definition are: (1) the more of good Z that an individual is willing to give up to get X, the more the individual values X; and

[2]Most theoretical discussions of economic values and nonmarket valuation methods focus on valuing a single change (e.g., a change in ambient air quality). However, most real-world valuation contexts involve changes in multiple environmental goods or services and multiple impacts on human well-being. The need to consider multiple changes or impacts raises questions about interconnectedness and aggregation and clearly complicates the valuation process. See National Research Council (2005, Chapter 5) for a useful discussion of valuing changes in multiple ecosystem services.

[3]An important research question is whether alternative ways to define and measure assigned values yield consistent information about underlying preferences. The limited evidence that exists on this is mixed. See, for example, Cooper et al. (2004) and Spash (2006).

[4]See Chap. 2 for a more formal definition.

(2) if the maximum amount of Z the individual is willing to give up to get X is greater than the maximum amount he or she is willing to give up to get Y, then the individual values X more than Y. The scale used to measure (and compare) values is therefore the maximum amount of Z the individual would be willing to give up. Note that nothing in this definition of value precludes X from being something to which the individual assigns a negative value. For example, if X represents a given amount of environmental degradation, then the amount of some beneficial good Z that the individual would we willing to give up to get X would be a negative number, meaning that the individual would actually require compensation (i.e., more Z) to accept X.

This concept of value does not require that values be expressed in monetary terms, i.e., that Z be money. Any other good that individuals care about could be the basis for the expression of economic values. For example, the economic value of reducing one type of risk (such as fatality risk from natural disasters) can be expressed in terms of the increase in another type of risk (such as fatality risk from traffic accidents) that the individual would be willing to accept (Viscusi 2009). Values expressed in these terms are generally called "risk-risk trade-offs."

In principle, Z can be anything individuals care about, but in practice, economists typically seek to measure values in monetary terms, i.e., Z is taken to be an amount of money an individual would be willing to give up to get X (i.e., the individual's "willingness to pay" [WTP] for X) or the amount of monetary compensation he would require to give up X (i.e., the individual's "willingness to accept" [WTA] compensation for not getting X).[5] When X represents something the individual views as beneficial (i.e., he or she would prefer having it to not having it and so would prefer not to give it up) and Z is money, economists refer to the assigned monetary value as the *benefit* of X, representing what X is *worth* to the individual. Thus, while in everyday language the word "benefit" is broadly used to refer to something beneficial (e.g., a benefit of improved air quality is reduced infant mortality), in the context of economic valuation, the term "benefit" has a much more specific meaning based on the economic concept of assigned value, a meaning that is not only quantitative but monetary as well. Having values (benefits) expressed in monetary terms allows for a simple means of aggregating values across individuals and comparing them to costs.

The economic concept of value reflects four key features:

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[5]Because people regularly use money to buy things and accept money when they sell things, the idea of trading money for goods and services is familiar to them (although they may never have traded for the specific good or service being valued). Nonetheless, some individuals may feel that certain things, such as changes in health or environmental quality, should not be "commodified" and sold in markets. This does not, however, mean that providing those things does not involve trade-offs. As emphasized, economic values are fundamentally about the trade-offs individuals would be *willing* to make. Even individuals who object to the idea of buying or selling nature exhibit a willingness to make trade-offs related to health and the environment in their everyday lives (for example, every time they travel by car).

1. The values that individuals assign depend on their preferences over different outcomes, which are assumed to be stable and consistent (in the sense of not being unduly influenced by issues such as framing, presentation, or elicitation method).[6] Because individuals assign the values, they are anthropogenic, i.e., they are derived from humans and are not defined independently of the individuals who assign them.
2. Although economic values are agnostic on the reason(s) individuals care about and hence value something, they do assume there is some (finite) substitutability between what is being valued and other things the individual cares about. In other words, they assume that individuals care about multiple things (such as environmental quality, health, food, and leisure time) and are willing to make trade-offs among these, at least over certain ranges. Held values that are absolute and do not allow for *any* substitutability (e.g., "freedom at all costs") preclude measurement of assigned values in economic terms.
3. As noted, values are assigned to *changes*. These changes can be purely hypothetical or actual realized or predicted changes. They can be expressed in absolute terms (e.g., 100 additional acres of wetlands), percentage changes (e.g., a 10% reduction in ambient concentration of particulates), or as a with-or-without scenario (e.g., with or without an old-growth forest area). However, the changes must be feasible. This implies that when using a valuation technique that involves asking people about hypothetical changes, the changes must be meaningful to the individuals asked to value them. For example, asking individuals to assign values to the entire global ecosystem is not meaningful because it requires that individuals envision the world without that ecosystem, which is probably an impossible task, in part because it is an impossible change.
4. In general, economic values will depend not only on preferences but also on how much Z an individual has available to trade. When measured in monetary terms, this means that values (benefits) depend on an individual's income. This feature is not problematic when comparing values for a given individual. For example, if an individual is willing to pay more of his income to get X than to get Y, then presumably he values X more than Y, regardless of the amount of income he has. However, comparisons are less clear when made across individuals because two individuals with identical preferences but different incomes could express different values for the same X. As a result, if a wealthy person expresses a higher willingness to pay for X than a poor person, this would imply that the benefit of X as defined by economic value is greater for the wealthy person than the poor person, even though it does not in a broader sense imply that X is more important to the wealthy person or that the wealthy person cares more about X than does the poor person (see Sect. 1.8.2 for further discussion).

Although economic values are typically expressed in monetary terms, as already mentioned, economic valuation is *not* limited to goods and services that are bought

[6]In contrast, some psychologists believe that preferences are *constructed* through the elicitation process. See, for example, Lichtenstein and Slovic (2006).

and sold in markets. In fact, the purpose of nonmarket valuation is to elicit information about the values individuals would assign to things that are *not* bought and sold in markets. As long as an individual cares about something, regardless of whether it can be bought and sold and regardless of the reason the individual cares, he or she will presumably assign a nonzero value to it. Consequently, the economic concept of value is fundamentally different from and should not be confused with the concept of commercial value. While commercial values often reflect economic values, very frequently they do not. In particular, goods that are not sold in markets typically have no commercial value even though the economic value individuals assign to them can be very large. For example, people might assign very high values to improvements in their health or reductions in their risk of getting cancer even though these cannot be directly purchased in a market. Similarly, they might assign very high values to an increase in biodiversity even though biodiversity cannot generally be directly bought or sold for money. Therefore, economic values reflect a much broader notion of value than commercial values.

Figure 1.1 illustrates a standard classification of economic values that highlights the breadth of what the concept covers (National Research Council 2005). In particular, it shows that the total economic value of a natural resource or environmental good includes not only the benefits individuals get through use of the good (use values) but also the value they place on the good even if they do not actually use or come in contact with it (passive-use or nonuse values). The latter values arise when an individual values the *existence* of a species or preservation of a natural environment for reasons such as bioethics, cultural heritage, or altruism toward others (including future generations). For example, empirical evidence suggests that passive-use values exist for the protection of not only charismatic species (such as grizzly bears and bighorn sheep; see Brookshire et al. 1983) but also marine habitats (McVittie and Moran 2010) and even moss (Cerda et al. 2013).[7]

Use values arise as a result of use of or physical contact with the environmental good. Use can be either consumptive or nonconsumptive. Consumptive use implies that use by one person precludes use by another. Examples include the harvesting (and use) of timber or the taking of a pheasant while hunting. With nonconsumptive use, one individual's use does not diminish the amount available for others. For example, bird watching by one individual does not diminish the potential for others to enjoy the same viewing, and swimming or boating in a lake by one individual does not preclude others from enjoying the same recreational experience. These are examples of direct nonconsumptive use, where the individual directly benefits from the environmental good or service. Nonconsumptive use can also be indirect, such as when we benefit from climate regulation provided by forests or storm protection provided by wetlands.

[7]However, see Common et al. (1997) for evidence suggesting that the assumption of substitutability that underlies the economic notion of existence value may not hold in all contexts.

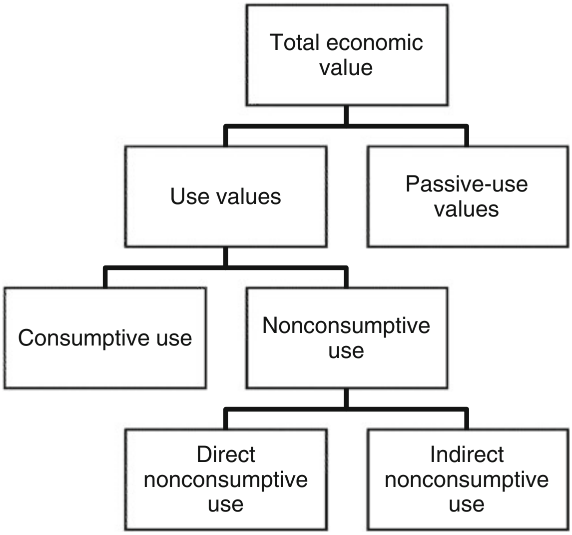

Fig. 1.1 Classification of economic values

Thinking about economic values using a categorization like the one illustrated in Fig. 1.1 helps in recognizing the types of values that are included and in ensuring that some types of values are not overlooked. In addition, it helps to avoid double counting values, which would lead to an overestimation of total economic value. Suppose a resource manager seeks to estimate the benefits of a program designed to improve the marine habitat that supports a commercial fishery. It would be double counting to include in a measure of total economic value both the consumptive-use value of the increased fish catch and the indirect-use value from the habitat improvement that in turn allows the increased catch because the two are just different manifestations of the same benefit. A careful delineation of the types of benefits using a categorization such as the one in Fig. 1.1 helps to ensure that all components of total economic value are included, but each is included only once.

The above discussion focuses on what the concept of economic value includes. It is equally important to recognize the factors that are *not* valid components of economic value. In particular, it is important not to confuse the concept of economic value (benefits) with the concept of economic impacts. Consider again a program designed to improve marine habitat that supports a commercial fishery. If the program is successful in improving fish catch, it could lead to an increase in economic activity in the region, which could in turn generate additional jobs and income. While the impact on regional employment and income could be an important consideration when evaluating the program, these impacts are *not* measures of the economic benefit of the program. More specifically, they are not a measure of the amount individuals would be willing to pay for the program or the amount they would require in compensation to give it up.

As an illustration of why impacts do not measure benefits, consider the impact of an oil spill that threatens to destroy marine habitat. Cleanup of the spill can generate jobs and income, but clearly this does not mean the spill was beneficial. In fact, the labor needed to clean up the spill is part of the cost of the spill, not a benefit of the spill. As a second example, consider a regulation that restricts the type of gear that can be used in a fishery in order to reduce bycatch of a protected species. If, as a result of the regulation, it now takes more labor to catch a given amount of fish, employment in the industry may increase. However, this increased labor requirement is a measure of the cost of the regulation, not the benefit of the regulation. The regulation is costly because, among other things, it now takes more effort to produce the same amount of harvest. The benefit of the regulation would come from the value of the species protection, not from the employment impacts of the regulation.[8] These examples illustrate why, although economic impacts might be an important consideration in evaluating alternatives, they should not be confused with economic benefits.

1.6 Use of Economic Values

Information about the economic values that individuals assign to environmental changes can help improve decisions in a wide variety of contexts (e.g., Adamowicz 2004). These include decisions about (1) public policies (at the local, regional, or national level), (2) resource allocation and priorities, (3) compensation for losses, and (4) design of environmental markets.

When making public policy decisions regarding, for example, laws and regulations, policymakers can use a number of different criteria or decision rules. One possibility is to base decisions on an explicit comparison of benefits and costs.[9] Of course, the use of a benefit-cost criterion requires a monetary measure of benefits. However, even if a strict benefit-cost criterion is not used, information about benefits (and costs) can be very helpful in evaluating alternatives (Arrow et al. 1996). Even if decisions are based on sustainability or precautionary principles, information about benefits can help in identifying the trade-offs implied by those decisions, especially when they involve conflicts regarding different environmental goals or ecosystem services (e.g., timber production versus carbon sequestration).

Similarly, resource managers who need to allocate fixed budgets across different projects, programs, or initiatives can use information about economic values to ensure that resources are targeted in a way that maximizes benefits. For example, in making

[8]Under some conditions, it is possible to value a change in output by aggregating the payments to the owners of the inputs used to produce the additional output. For example, with perfectly competitive markets and constant returns to scale, the value of additional agricultural output can be measured as the sum of the payments to the laborers, landowner, fertilizer producers, etc., who supply the inputs used to increase production. In this case, the income paid to farm workers can be used as part of the measure of benefits. However, including both the payments to the inputs and the revenue from the sale of the additional output as measures of benefits would be double counting. Benefits can be measured as the value of the inputs or the value of the output but not both.

[9]The theoretical foundations of benefit-cost analysis as a basis for public policy are well established and described in detail in Just et al. (2004).

land purchases to protect open space or habitat, the available funds can be allocated to the purchase of parcels that give the greatest benefit per dollar spent. Identifying those parcels requires information about the benefits that preservation of specific parcels would generate based on their environmental and other characteristics.

Measures of the economic value of environmental losses can be used in damage assessments and in the determination of the amount of monetary compensation that would be necessary to restore the well-being of affected individuals to their pre-loss levels. Information about benefits can be useful even if compensation is in-kind rather than monetary. For example, if wetland losses in one location are offset by wetland restoration elsewhere, measures of the benefits generated by wetlands in the two locations can be used to determine the amount of restored area needed to compensate for the loss in well-being resulting from the original reduction in wetland area.

In addition to policymakers, government officials and resource managers, private parties and nongovernmental organizations (NGOs) might also want to use information about economic values in setting priorities and designing initiatives. For example, there is increasing interest in the development of markets for environmental goods and services such as ecotourism, carbon sequestration, and habitat preservation for biodiversity (see Daily and Ellison 2002; Heal 2000; Brown et al. 2007). Information about the benefits associated with these services can be used to determine payments or contributions that individuals would be willing to make for the purchase of these services. In addition, it can be used to target specific groups for contributions or to design conservation and other programs to align with preferences of specific constituencies, such as donors.

1.7 The Valuation Process

Although economic values may be used in various decision contexts, in all cases the basic process for environmental valuation is essentially the same. The key steps are listed in Table 1.1 (adapted from U.S. Environmental Protection Agency 2009).

As an example, consider the process of estimating the benefits from a restoration project that would increase or restore stream flow and/or fish passage in a river with a dam.[10] Step 1 would identify the possible alternatives under consideration (such as full removal of the dam, partial removal of the dam, installation of fish ladders, etc.). Each alternative could generate a number of biophysical changes (identified in Step 2) that might be important to individuals either because of use value (for example, increased fish abundance increases catch rates in recreational or commercial fishing) or because of passive-use values (for example, individuals may value the existence of a more viable population of native fish in the river or the wildlife that depend on those fish for food). Once these potential sources of value have been identified (Step 3), the relevant impacts can be quantified (Step 4) and valued (Step 5).

[10] For an example of nonmarket valuation in this context, see Johnston et al. (2011).

Table 1.1 Steps in the valuation process

Step 1	Identify the decisions that need to be made and the options to be considered. This step is often referred to as "problem formulation"
Step 2	Identify the significant environmental or biophysical changes that could result from the different options
Step 3	Identify the types of impacts these biophysical changes might have on human well-being and so could be important to individuals
Step 4	Predict or hypothesize the quantitative magnitude of environmental changes in biophysical terms that are relevant to human well-being and hence can be valued
Step 5	Estimate the economic values that individuals would assign to these changes using appropriate valuation methods
Step 6	Communicate the results to the relevant decision-makers

Source U.S. Environmental Protection Agency (2009)

Although Table 1.1 depicts the valuation process as linear, in fact it is an iterative process because information generated by later steps might imply a need to revisit some previous steps. For example, in the process of estimating the values individuals assign to the various impacts, some unanticipated sources of value might be discovered. In the above example, it might be discovered in Step 5 (perhaps through survey responses or focus groups) that in addition to the relevant impacts already identified, individuals value the overall ecological condition of the river, which would be affected by the restoration project. This would necessitate going back to Step 4 to quantify the resulting change in ecological condition in units or measures that relate directly to what individuals value and then revisiting Step 5 to estimate this additional value.

This book focuses, of course, on methods that can be used in Step 5. However, it should be clear from the discussion above that Step 5 is part of a broader valuation process that requires a close collaboration between natural scientists and social scientists. For example, an interdisciplinary team should be involved in Steps 1-3 to provide the different perspectives and expertise needed to ensure that the remainder of the valuation process (Steps 4-6) is focused on the impacts that are most important in terms of their contribution to human well-being. Otherwise, natural scientists can end up predicting biophysical changes in terms that cannot be readily valued by individuals (such as impacts on phytoplankton), or social scientists can end up valuing changes that are not closely related to the biophysical impacts of the alternatives that are being considered.

1.8 Some Additional Issues

In moving from conceptualizing the valuation process described above to actually estimating values (benefits) in Step 5 using nonmarket valuation, a number of issues can arise. These include: (1) whose values to include, (2) how to aggregate across individuals, (3) how to aggregate across time, and (4) how to treat uncertainty.[11]

[11]For more detailed discussions of these and related issues, see, for example, Freeman et al. (2014).

1.8.1 Whose Values to Include

Critical in determining how much individuals value a particular change in environmental goods and services is defining the relevant population of individuals. While the answer to this might seem to be that anyone who values the change should be included, the relevant population actually depends on the valuation context. For example, in a context where valuation is designed to estimate the compensation to pay to individuals who are harmed by environmental degradation from an oil spill, the relevant population is typically the set of individuals who are impacted *and* legally entitled to compensation. If the damage payment is designed to compensate the public for kills of wildlife species that have existence value (such as birds or seals), the question is how the "public" is defined, i.e., whether it includes the existence values across *all* individuals (i.e., the global population) or some more locally defined public. The amount of compensation would clearly be greater in the former case than in the latter.

Similarly, in evaluating the costs and benefits of a national policy to reduce greenhouse gas emissions and slow global climate change, should the benefits that are included be just the benefits realized by individuals within that country, or should benefits be measured at a global scale? Again, the measure of benefits will be much higher if it includes benefits to people everywhere and not just those within the country considering the policy. Whether a global or more local measure of benefits is appropriate depends on how the policy decision will be made. For example, if policymakers are willing to adopt the policy as long as global benefits exceed the costs that the country would incur (even if local benefits do not), then the benefit measure should be at the global scale. However, if policymakers will base their decision on whether their country will realize a net benefit, i.e., the benefits within the country exceed the costs, a more localized measure of benefits is needed.

1.8.2 Aggregating Values Across Individuals

When the relevant population has been identified, estimating total value across that population requires a means of aggregating values across individuals. Individual values measured in monetary terms are typically aggregated by simply adding these values over the relevant individuals.[12] This sum is typically unweighted, implying that the values of all individuals receive the same weight in the calculation of the

[12]As an alternative, preferences could be aggregated across individuals simply by counting the number of individuals who prefer one option to another. This approach underlies decision rules based on standard voting procedures. A key drawback to using votes as a means of aggregating preferences to determine outcomes is that the resulting decisions do not reflect the intensity of individual preferences for one option over another. For example, in a three-person vote, an option that is only slightly preferred by two individuals would win over an option that is strongly preferred by the third individual.

total, regardless of the characteristics or circumstances of those individuals.[13] The aggregate benefit measures used in benefit-cost analyses use this approach,[14] where the objective is to identify options that generate the greatest good for the greatest number.[15]

While equally weighting benefits across all individuals may seem fair in the sense of implying equal treatment for all, it is important to understand its implications. Recall that in general for any good or service, including environmental goods, the value an individual assigns to an increase in that good (for example, the amount the individual is willing to pay for that increase) will depend on his or her income. This implies that, for two individuals with identical preferences, in general the one with the higher income will place a higher value on (have a greater willingness to pay for) an increase in the good than the person with the lower income. In other words, when all else is equal, benefits will typically be higher for wealthier people. This implies that equally weighting benefits does not actually give equal weight to the preferences of all individuals.

To see this, consider a change (call it X) in an exclusive good that is valued by two individuals with identical preferences but different incomes. Assume Person 1 has the higher income and the income difference causes Person 1 to place a higher economic value on X than Person 2 does. Assume Person 1 is willing to pay \$100 for X, while, because of lower income, Person 2 is only willing to pay \$50. As a result, the good would be viewed as generating greater benefits if it were consumed by Person 1 than if it were consumed by Person 2. More generally, with equal weighting and when all else is equal, options that generate value for the wealthy

[13]Occasionally, a weighted sum will be used in an effort to incorporate distributional concerns, i.e., to give more weight to the benefits that accrue to one group of individuals than to another (see, for example, Johannsen-Stenman 2005). However, most economists do not advocate the use of a weighted average as a means to incorporate distributional concerns; rather, they advocate providing decision-makers with an unweighted measure of total benefits along with information about the distribution of benefits across relevant subpopulations. See, for example, Arrow et al. (1996).

[14]This is based on the compensation principle that underlies benefit-cost analysis. For a detailed discussion, see Just et al. (2004).

[15]Note, however, that maximizing aggregate net benefits or aggregate income is not generally equivalent to maximizing the sum of utility across all individuals. The two will be the same *if* coupled with a redistribution of income that equates the marginal utility of income across all individuals. Absent that redistribution, a change for which benefits exceed costs could actually reduce aggregate utility. To see this, consider a choice *x,* where an increase in *x* generates an increase in income (i.e., a benefit) for Person 1 and a decrease in income (i.e., a cost) for Person 2. Let $Y_i(x)$ be income for Person i (where $i = 1$ or 2) and let $u_i(Y_i(x))$ be i's utility. Then, if $\frac{\partial u_1}{\partial Y_1} < \frac{\partial u_2}{\partial Y_2}$ and there is no actual compensation, it is possible to have $\frac{\partial Y_1}{\partial x} + \frac{\partial Y_2}{\partial x} > 0$ (i.e., the gain to person 1 exceeds the loss to person 2) even though $\frac{\partial u_1}{\partial Y_1}\frac{\partial Y_1}{\partial x} + \frac{\partial u_2}{\partial Y_2}\frac{\partial Y_2}{\partial x} < 0$ (i.e., aggregate utility decreases). While it might be reasonable to assume that direct mechanisms (such as taxes) are available to address income distribution within a given generation, this assumption is much more questionable for income redistribution across generations. For this reason, differences in the marginal utility of income across individuals are often not explicitly considered when aggregating benefits and costs at a given point in time, while differences in the marginal utility of consumption across generations play an important role in aggregation across time (see discussion in Sect. 1.8.3).

will yield higher economic benefits than those that generate value for low-income groups. As such, although in nonmarket valuation it is standard practice to use an unweighted sum of benefits across individuals to measure the aggregate benefit across the relevant population, the implications of this approach need to be borne in mind when interpreting these measures.

1.8.3 Aggregating Across Time

In many contexts, such as climate change, the benefits of a particular policy or action extend across many years. A measure of the total benefit of such an action should include not only benefits in the current period but also future benefits that would result from the current action. In principle, it is possible to think about the total benefit to an individual simply as the total amount the individual would be willing to pay today for the policy change, recognizing the stream of impacts it would have over time.[16] In practice, however, benefits are typically measured separately for each time period and then aggregated over time. Accordingly, when benefits extend across time, estimating total benefits typically requires some means of aggregating over time. The standard approach used in economics is to weight benefits that occur at different points in time using a discount factor and then add the weighted measures of benefits across all time periods to get a measure of the total (discounted) benefit. Usually this is done using a constant discount rate, defined to be the rate at which the weights change over time. However, uncertainty about the appropriate discount rate to use can provide a rationale for use of a discount rate that declines over time.[17]

Discounting future benefits can be controversial and has important implications for measures of total benefits, making it important to understand the economic rationale for discounting. One rationale stems simply from the ability to earn a return on investments. As an example, if you can earn interest at a rate of 5% on your investments, then you should be indifferent between receiving a payment of $100 today (and investing it, so that you have $105 in the next period) and receiving a payment of $105 in the future period. Similarly, if you instead receive $100 in the next period, it is worth less to you than if you had received $100 today because of the lost investment opportunity. This means that payments received in the future should be discounted when compared to payments received today to

[16]However, to the extent that current decisions affect future generations, the individuals in those generations are not around today to express the values they would assign to the relevant changes. Thus, in practice it is the current generation that must express values on behalf of future generations.

[17]A simple example illustrating this result is provided in Cropper (2012). A declining discount rate is also consistent with some forms of nonstandard preferences, such as those that exhibit hyperbolic or quasi-hyperbolic discounting. See, for example, the discussion and references in Benhabib et al. (2010).

account for this lost opportunity. Of course, this simple example ignores real-world complications associated with investments (such as uncertainty regarding the return on most investments and taxes on investment income), but it illustrates an investment-based rationale for discounting.

There is also a possible consumption-based rationale for discounting, based on either of two considerations about consumption over time. First, individuals may simply value current utility more than future utility and as such put more weight on increases in current consumption than increases in future consumption. Second, if an individual expects his or her income (and, therefore, consumption) to rise over time and the marginal utility of an additional dollar's worth of consumption decreases as income increases, then additional consumption dollars in the future will give less utility than those in the current period simply because of the difference in income. Assuming growth in the individual's income over time, both considerations imply a positive discount rate.

The consumption-based rationale for discounting becomes more complicated, however, when the benefits accrue well into the future, as will occur for decisions with long-term impacts that last for generations (such as those related to climate change). In this case, the issue of aggregating over time is confounded with the issue of aggregating across groups of individuals (generations). Now, the values placed on current versus future utility are no longer simply a reflection of an individual's preferences. Rather, if used in policy decisions, these values reflect society's judgment about whether the well-being of one group (e.g., the current generation) should receive more weight than the well-being of another group (e.g., a future generation). If, as many argue, there is no reason to believe that the well-being of one generation is more important than the well-being of another, then the well-being of all generations should be weighted equally in aggregating well-being across generations (see, for example, Heal 2005, 2009).

However, this does not necessarily imply that benefits to future generations should not be discounted. For example, as with the case where benefits accrue to the same individual over time, if, other things being equal, the marginal utility of consumption diminishes as consumption increases, then benefits should be weighted differently for the different generations, based solely on their consumption levels (not on when they live). If future generations are expected to have a higher consumption level (due to economic growth), then even if the utility of all generations are weighted equally, the discount rate should be positive, implying that benefits to future generations receive less weight than those that accrue to the current generation.[18] This implies that choice of the appropriate discount rate to use in aggregating benefits across generations is not simply a question of *picking* a discount rate; rather, the rate used should reflect a number of considerations, including how society chooses to weight the utilities of different generations (based

[18]A negative discount rate might arise, for example, in the context of ecosystem services where those services are becoming scarcer (rather than more abundant) over time. See, for example, Heal (2005, 2009) and National Research Council (2005).

on intergenerational equity) and information about the rate at which consumption is expected to change over time. Because of the difficulty of determining a single *correct* discount rate, aggregate measures of benefits are often computed for a range of discount rates.

1.8.4 Uncertainty

In many (if not most) cases, valuing environmental changes will involve uncertainty. Uncertainty can arise either in predicting the magnitude of the environmental changes to be valued or in assigning values to those changes.

Consider, for example, a policy to reduce greenhouse gas emissions in an effort to mitigate climate change. Valuing the benefits of such a policy first requires an estimate of the changes that will result. Predicting those changes will involve many sources of uncertainty, including uncertainty about how the policy will affect emissions, how the change in emissions will affect the climate, and how the resulting change in climate (e.g., the distributions of temperature and precipitation at various locations) will affect environmental, health, and other outcomes.

Models are often used to predict these impacts, and there is uncertainty about both the appropriate model structure and the model parameters (National Research Council 2005). In addition, we may be uncertain about our own future circumstances (such as future preferences and income) and/or the preferences of future generations. The values assigned to the predicted changes will reflect these uncertainties as well.

Methods exist to address uncertainty in valuation—both theoretically and in practice. The theory that underlies the economic concept of value described above can be extended to define values in terms of the trade-offs individuals are willing to make *given the uncertainty* associated with the impacts and the factors that affect values, as long as it is possible to identify all possible outcomes and the probability of each occurring. This generalization can incorporate not only uncertainty but also the possibility of learning (and hence reducing uncertainty) over time (Zhao and Kling 2009). Of course, because economic values are defined in terms of trade-offs that would hold an individual's well-being constant, in the presence of uncertainty the values are typically defined in terms of trade-offs that would hold the *expected value* of an individual's well-being ("expected utility") constant. Such measures of economic values reflect not only the individual's preferences over alternative outcomes but also his or her preferences over different amounts of risk, i.e., the extent to which the individual is averse to risk, enjoys risk, or is indifferent to risk. Therefore, while the basic concept of economic value remains the same with or without uncertainty, the values that individuals assign to a given change will reflect additional considerations when uncertainty exists.

In practice, uncertainty about the changes to be valued can be addressed through use of techniques such as sensitivity analysis or Monte Carlo simulation, which can provide information about the distribution of possible outcomes (see National

Research Council 2005). Survey methods can also be used to elicit information about values that explicitly reflects uncertainties about environmental outcomes (see, for example, Brookshire et al. 1983).

Furthermore, in some cases, the explicit goal of a policy or other action might be a reduction in a specific health or environmental risk.[19] For example, a reduction in air pollution can reduce the risk of contracting an illness such as asthma. It can also reduce mortality rates, particularly for infants (e.g., Currie and Neidell 2005; Agarwal et al. 2010). Thus, the benefits of reductions in air pollution include reductions in these health risks. Values must be placed on the risk reductions to estimate these benefits. As with other types of benefits, the basic concept of economic value can be applied to the value of these risk reductions as well, for example, by estimating the amount that individuals would be willing to pay to reduce these risks (e.g., Cameron and DeShazo 2013).[20]

Therefore, when the risks or uncertainties can be quantified and are borne by the individuals assigning values, the standard approach to nonmarket valuation can be modified to explicitly incorporate uncertainty. To date, however, efforts to incorporate uncertainty into nonmarket valuation have been primarily limited to the valuation of health-related risks. The valuation of other types of environmental risks, particularly those that are long term, geographically broad, and potentially catastrophic, remains a significant challenge.

1.9 Valuation Methods

As noted, this book is primarily about nonmarket valuation methods that can be used in Step 5 of the valuation process depicted in Table 1.1. A number of nonmarket valuation methods exist. Most of them have a long history of use within the field of environmental and natural resource economics, while others (such as the experimental methods discussed in Chap. 10) are newer. All of them seek to estimate the economic values individuals assign to goods and services that are not traded in markets (such that values cannot be directly inferred from market prices).

Although all of the methods described in this book seek to estimate economic values, they differ in a number of ways, including the following:

[19]Although some authors distinguish between "risk" and "uncertainty" based on whether the probabilities of the possible outcomes can be quantified, in economics, the two terms are typically used interchangeably. We follow this convention here. For example, when talking about either the uncertainty associated with future preferences or the health risks from exposure to pollution, we assume that all possibilities can be identified and each can be assigned an objective (or possibly subjective) probability of occurring.

[20]Such estimates are often expressed in terms of the "value of a statistical life" (VSL). However, this terminology has led to confusion and unnecessary controversy about the concept being measured, prompting some to argue that the term VSL should not be used (e.g., Cameron 2010).

Table 1.2 Major nonmarket valuation methods

Revealed preference	Stated preference
Travel cost	Contingent valuation
Hedonics	Attribute-based methods
Defensive behavior	
Substitution methods	

1. Revealed preference methods estimate values by observing actual behavior that is linked in some way to an environmental good or attribute (such as visits to a recreational site or the purchase of a home), and then inferring values indirectly from that behavior. Stated preference methods estimate values by asking individuals survey questions related to their preferences and inferring values from their stated responses. As a result, the types of data used differ across methods. Revealed preference methods rely on observed data, which may include data collected through surveys related to behavior or market outcomes (for example, data on visits to sites or house prices). In contrast, stated preference methods require surveys that use hypothetical questions designed specifically to elicit information about values (for example, questions about willingness to pay or questions that require a choice among hypothetical alternatives). Table 1.2 categorizes the major nonmarket valuation methods based on this distinction.
2. Methods also differ in terms of the components of total economic value they can capture. For example, revealed preference methods can only capture use values, while stated preference methods can (in principle) estimate both use and passive-use values. Likewise, specific revealed preference methods capture only certain kinds of use value. For example, hedonic methods capture only use values that are capitalized into prices of related goods or services (such as housing), while travel cost methods capture only the value of goods that require travel to a site.
3. The resources (both time and money) needed to do the valuation can also differ, depending on the method chosen. This implies that some methods might be more feasible or appropriate (depending on information needs) in some contexts than others. For example, major regulations might warrant the significant expenditures involved in doing an original valuation-related survey, while minor regulations or less significant decisions might be able to rely on less resource-intensive benefit transfers.
4. Finally, in some contexts, methods might differ in terms of their perceived acceptability as a reliable means of estimating values. For example, regulatory impact analyses might need to rely primarily on methods that have been deemed acceptable or are explicitly preferred by those with authority/responsibility for regulatory review.[21] Similarly, there continues to be debate about acceptability of

[21]For example, the U.S. Office of Management and Budget's Circular A-4, which governs federal regulatory impact analyses, explicitly states: "Other things equal, you should prefer revealed preference data over stated preference data because revealed preference data are based on actual