Handbook for Estimating Economic Benefits of Environmental Projects

For Inclusion in Benefit-Cost Assessments of Projects Proposed for funding Under California Propositions 84 and 1E

Prepared for the North Bay Watershed Association

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Sarah Reich, Ann Hollingshead, and Ed MacMullan of ECONorthwest completed this project under contract to the North Bay Watershed Association. ECONorthwest is solely responsible for its content.

ECONorthwest is the oldest and most comprehensive economics consulting firm in the Pacific Northwest. We have a staff of 40 in offices in Portland and Eugene, Oregon and Boise, Idaho.

We gratefully acknowledge the assistance of the many individuals who provided us with information and insight, but emphasize that we, alone, are responsible for the contents of this handbook. We have compiled the information based on our general knowledge of environmental valuation methods, our review and application of the California Department of Water Resources' Guidelines and Proposal Solicitation Packages for Propositions 84 and 1E, information derived from government agencies, the reports of others, interviews of individuals, or other sources believed to be reliable. ECONorthwest has not independently verified the accuracy of information developed by others but cited here, and makes no representation regarding its veracity or completeness. Any statements nonfactual in nature constitute the authors' current opinions, which may change as more information becomes available

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Introduction and Background

The California Department of Water Resources (DWR) administers grant programs to fund projects designed to meet the goals of Integrated Regional Water Management Plans (IRWMPs). These grants are funded through resources authorized by the voters of California. In 2006, voters passed two measures:

- Proposition 84 (P84), to invest in safe drinking water, water quality and supply, flood control, and river and coastal protection, and
- Proposition 1E (P1E), to invest in flood prevention and stormwater management.[1]

DWR's funding program allocates funds based partly on information that project sponsors provide about their projects' economic benefits and costs. DWR provides guidelines for conducting benefit-cost analyses in the Proposal Solicitation Packages (PSP) for each grant program.[2] DWR updated these guidelines in 2012 to address, in part, challenges project sponsors faced in the past. The challenges partly involved quantifying some types of economic benefits—especially those associated with environmental enhancement projects, such as wetland restoration, habitat improvement, and green stormwater control.

The North Bay Watershed Association (NBWA) recognized a need among sponsors of these types of environmental enhancement projects for additional technical information to help project sponsors satisfy the economic components of the P84 and P1E grant applications. As a consequence, the NBWA, on behalf of communities proposing projects through the Bay Area Integrated Regional Water Management Plan (IRWMP), asked ECONorthwest (ECONW) to create additional guidance materials for these project sponsors.

This handbook is the product of the NBWA's request. We developed it with a non-technical audience in mind. We expect the information this handbook contains will help project sponsors better understand and describe the full range of economic benefits of their projects. Used together with guidance from DWR, we expect project sponsors will use the information in this handbook to develop a more comprehensive valuation of their projects' benefits.

This handbook does not, however, provide a step-by-step guide to completing the benefit-cost analysis required in the funding application. We expect that many project sponsors without a background in economics may require further assistance from technical experts to complete the full benefit-cost analysis as

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[1] California Department of Water Resources. 2012. *Integrated Regional Water Management Grants, IRWM Grant Program.* Retrieved November 10, 2012, from http://www.water.ca.gov/irwm/grants/index.cfm

[2] California Department of Water Resources. 2012. *Integrated Regional Water Management Grants, Guidelines.* Retrieved November 10, 2012, from http://www.water.ca.gov/irwm/grants/guidelines.cfm

outlined in the PSP. For those interested in undertaking this process themselves, we provide recommendations for additional in-depth resources on environmental valuation and benefit-cost analysis in Section 4 of this handbook.

ORGANIZATION OF THIS HANDBOOK

We have organized this handbook into five sections:

Section 1 provides a general framework for identifying the benefits and costs of environmental enhancement projects. We introduce and explain concepts, such as total economic value, ecosystem goods and services, and non-market valuation, to shed light on how economists think about and value environmental benefits.

Section 2 uses descriptions of common project activities to illustrate how economic benefits arise for different types of projects. We start with a description of the biophysical effects that projects generate, and demonstrate how those effects interact with other biophysical, social, and economic systems to generate a broad range of economic benefits. Across the six examples we provide, we address the range of economic benefits that environmental enhancement projects commonly generate.

Section 3 describes in more detail how to quantify the value of or, alternatively, describe qualitatively from an economic perspective, each of the benefits identified in Section 2. We describe each benefit, identify applicable values and valuation methods, and detail the several categories of information that should be included to constitute a complete description of the benefit within DWR's guidelines.

Section 4 provides recommendations for additional resources that build on the information presented in this handbook, including in-depth instruction on the valuation methods and analytical techniques used in benefit-cost analysis.

Section 5 presents complete citations for the studies we reference in Section 3.

We encourage the reader to start with Section 1 to gain an overall understanding of the framework and principles guiding the information contained within the rest of the handbook. Sections 2 and 3 can be used together to explore specific types of projects and the benefits they generate. If you already know the types of benefits your project likely generates, you might rely primarily on Section 3.

Throughout the handbook, we offer additional information, examples, elaborations, and clarifications in sidebars to the main text. We also provide cross-references in the sidebar to connect the dots between similar concepts in different locations throughout the handbook. We encourage the reader to explore the pages of this handbook, rather than reading from cover to cover.

1: Framework and Principles

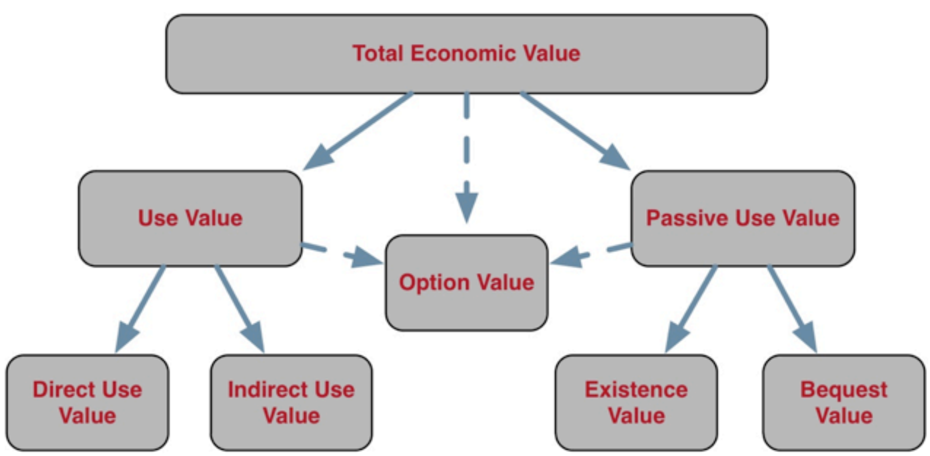
Proposals submitted under Proposition 84 must include detailed information on the economic **benefits**[3] and costs of proposed projects. As we describe in the previous section, the purpose of our report is to provide information that will help project proponents better understand, and hence describe, how their projects would benefit the supply of **ecosystem services**, and associated **economic values**. In this section we describe the framework and economic principles for conducting such analyses.

We begin by describing the range of categories of **economic values** associated with projects that enhance the environment. Our description includes a brief summary of the methods that economists use to measure these values. Next, we address, from an economic perspective, the relationship between **natural resources** and the **ecosystem services** that those resources provide. **Ecosystem services** is a mainstream concept used to describe how natural resources interface with and benefit human society. We end this section with a list of the general principles for estimating values of benefits associated with the changes in ecosystem services that would arise from actions, such as a habitat-restoration project, submitted to DWR for funding.

A. TYPES OF ECONOMIC VALUES

Society derives a range of **economic values** from projects that enhance the environment and generate **ecosystem goods and services**.[4] We depict these values in Figure 1.1 below.

Figure 1.1. Economic Values Associated with Ecosystem Services



Source: ECONorthwest

[3] Definitions of bolded terms may be found in the glossary on page 4.

[4] We use the terms "ecosystem services" and "ecosystem goods and services" synonymously.

Glossary

Glossary terms are bolded in the text.

Benefit. The well-being people derive from capital inputs, whether through active or passive consumption or appreciation merely through awareness.

Benefit-Cost Analysis. A systematic process for calculating and comparing benefits and costs of a project or policy. Also referred to as Cost-Benefit Analysis.

Bequest Value. A desire to preserve the environment for the benefit of future generations. See also passive-use value.

Built Capital. A stock of man-made physical resources, such as buildings; equipment; schools; roads; etc. See also, Capital.

Capital.Resources commonly used to produce things people value. See also, Human Capital, Built Capital, Natural Capital, and Social Capital.

Demand. Consumers' desire and willingness to pay for a specific good or service.

Discounting, Social. Renders benefits and costs that occur in different time periods comparable by expressing their values in present terms. It reflects the fact that people prefer consumption today to future consumption.

Economic Value. A monetary measure of the benefit a person gains from a good or service.

Ecosystem Goods and Services. The aspects of ecosystems enjoyed, consumed or used, either actively or passively, to produce human well-being.

Existence Value. The benefit people derive from knowing a resource exists, e.g., knowing that the population of bald eagles hasn't gone extinct. See also passive-use value.

Human Capital. A stock of man-made knowledge resources, including: information; education; data; etc. See also, Capital.

Marginal. One additional unit of something.

Marginal Analysis. An examination of the additional benefits of an activity compared to the additional costs of an activity.

Market Benefit. The value of a good or service that is traded on a market (e.g., has a price assigned as people buy and sell the good or service).

Monetized Benefit. A benefit whose value is expressed in dollars.

Natural Capital. A stock of environmental and natural resources, such as forests, soil, air, and water. See also, Capital, Natural Resources.

Natural Resources. Elements of the natural world, such as forests, soil, air, and water. Commonly used to refer to those resources that can be used for economic gain. See also, Capital, Natural Capital.

Non-Market Benefit. The value of a good or service that is not traded on a market, but that contributes to people's well-being, e.g., a scenic view.

Non-Monetized Benefit. A benefit whose value is not expressed in dollars.

Option Value. The benefit people place on a future ability to use the environment, even if they are not currently using it.

Passive-Use Value. The benefit people derive from natural resources that they do not directly or indirectly use. These include existence value and bequest value.

Social Capital. A stock of man-made intangible resources, such as relationships; cultural, spiritual, and religious norms and values; and laws and regulations. See also, Capital.

Supply. The quantity of a certain good or service that producers are willing and able to sell at a given price. May also relate to the amount of an ecosystem service available at a given time and place.

Total Economic Value. The total value of a good or service. Includes Use Value, Passive-Use Value, Bequest Value, and Option Value.

Use Values. The benefit people derive from using natural resources. These can include direct use values, such as catching and eating a salmon and indirect use values, such as groundwater recharge that eventually provides drinking water.

Willingness to Pay. The amount a person would be willing to pay or exchange in order to receive a desirable good or to avoid something undesired.

The **total economic value** is made up of several components. **Use value** is perhaps the clearest type of value. Use values include **direct use value,** which describes the value associated with direct use of a resource, such as breathing clean air or drinking clean water. **Indirect use value** describes the value associated with **ecosystem services** that are necessary to produce economic benefits. Soil fertilization, for example, promotes vegetative growth which, in turn, plays a role in air purification.

Passive use values are less obvious, but in some instances are greater than **use values**. They include existence value, which describes an individual's **demand** for the existence of a particular object or condition, and **bequest value**, or an individual's **demand** for the future existence of a particular object. Typically, these values are described in terms of an individual's **willingness to pay** for a resource's current or future existence. For example, if an individual is willing to pay a positive sum of money to prevent a species from going extinct, then she likely is placing **existence value** on the species. Similarly, if she would be willing to donate a positive sum of money to a conservation fund aimed at maintaining bald eagle health into the future, she likely is placing bequest value on the species.

Option value fall into either the use or passive use categories. It describes the value of keeping the option open to use a resource or service in the future. For example, some people may not have visited salmon spawning habitat, but want to know it exists in California in case they decide to visit such areas in the future.

Economists measure values of ecosystem services using the following methods.[5]

- Market Valuation — This relies on prices set by the buying and selling of a particular good or service. Established markets exist for some **ecosystem services**. For example, wetland-mitigation banks are publicly or privately managed lands that allow a developer or government agency to purchase mitigation credits that offset damage caused by construction projects elsewhere.
- Replacement Cost — Some benefits of projects that affect environmental resources can be estimated in terms of the costs society would have incurred without the projects. For example, a municipality may have in the past tapped a river for drinking water with little or no chemical treatment because high-quality riparian areas in the city's watershed maintained water quality. Over time, development degraded the watershed's riparian areas, which negatively affected water quality. As a result the municipality upgraded its water-treatment plant to filter and chemically purify the water. The additional filtration and purifying costs represent the replacement cost of the water quality services provided previously by natural riparian areas.
- Avoided Cost — Avoided costs represent the costs a community or some individuals would no longer incur if a project restores the ability of the environment to provide services or if the source of pollution is removed. For example, when a watershed's floodplain functions are restored and the risk of severe floods decreases, a community can benefit by avoiding damages to its properties.
- Hedonic Analysis — The basic premise of hedonic analysis is that the price of a good is related to its characteristics, or the services it provides, including environmental amenities. This method is commonly used to calculate that portion of a property's value attributed to the property's proximity to an environmental amenity, e.g., stream, forest, scenic view.
- Travel Cost — The fundamental principle of the travel cost method is that we can infer the value that people attache to an environmental asset based on the costs people will incur to access, use and enjoy the asset. For example, a travel cost analysis of a recreational fishery would calculate the value of the fishery based on fishing-related costs including: access fees, license costs, travel costs to and from the fishing site, costs of fishing equipment, etc.
- Contingent Valuation — This method estimates the economic value of a non-market benefit by directly asking a sample of consumers about their

[5] For more information on these methods see, King, D.M. and M. Mazzotta. 2003. "Ecosystem Valuation." Retrieved November 10, 2012, from http://www.ecosystemvaluation.org.

willingness to pay for a change in the level of an ecosystem good or service.

- Benefits Transfer — The benefit transfer method calculates the values of ecosystem services at a site (referred to as the policy site) based on the results from hedonic analysis, contingent-valuation, travel cost, or other studies conducted at a different location (referred to as the study site or sites).

The valuation descriptions provided in Chapter 3 rely primarily on just a few of these approaches: market valuation, replacement cost, avoided cost, and benefits transfer of values estimated in other studies. These other studies may derive value through hedonic analysis, travel cost, or contingent valuation. These more sophisticated economic-valuation approaches are generally too time-consuming and expensive to deploy to estimate environmental values in the context of DWR's cost-benefit analysis requirement.

B. ECOSYSTEM SERVICES AND ECONOMIC VALUATION

In 2005, the Millennium Ecosystem Assessment (MA), a pivotal work involving over 1,300 scientists coordinated by the United Nations, formalized a definition and classification of **ecosystem services** that is widely recognized across the world. The MA defined ecosystem services as "the benefits people obtain from ecosystems,"[6] and grouped them into four major categories of services that support human well-being: supporting, provisioning, regulation, and cultural.

The MA framework has become the basis for many studies of the economic value of ecosystem services.[7] While many economists have generally accepted the MA framework's basic organization, its complexity leads to difficulties in translating biophysical effects into economically relevant benefits and costs. To address these difficulties, several economists have proposed modified or alternative frameworks to guide economic analyses of ecosystem services.[8]

Figure 1.2 illustrates a simplified framework that draws elements from the MA framework and alternative approaches and grounds **ecosystem services** in an economic context. The framework centers around the notion that **ecosystem services** exist at the nexus of the **supply** of natural resources and **demand** from

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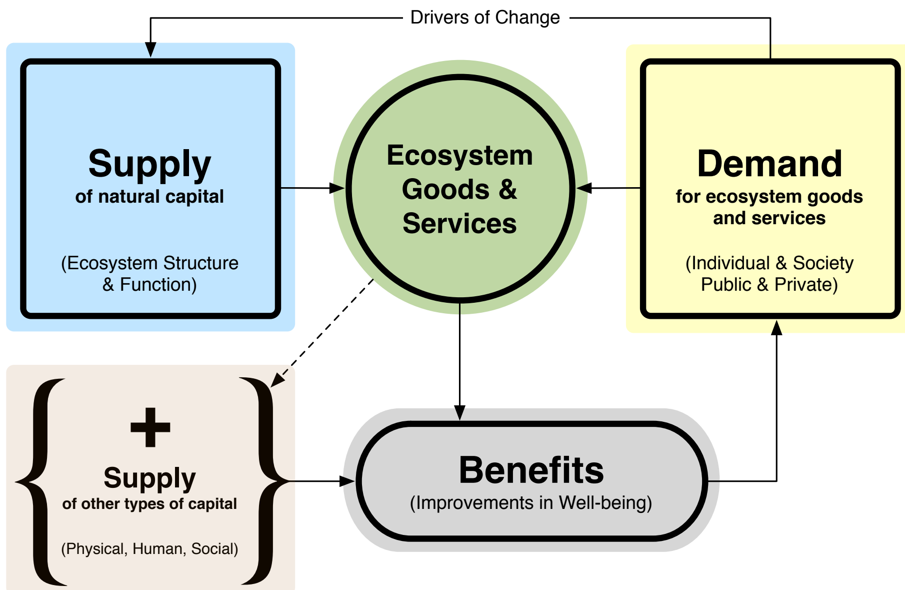
[6] Millennium Ecosystem Assessment. 2005. *Millennium Ecosystem Assessment*. Washington, D.C.: Island Press. Page v.

[7] See, for example, U.S. Environmental Protection Agency, Office of the Administrator, Science Advisory Board. 2009. *Valuing the Protection of Ecological Systems and Services: A Report of the EPA Science Advisory Board.* Report No. EPA- SAB-09-012. May.

[8] *See,* for example, Fu, B., C.H. Su, Y.P. Wei, I.R. Willett, Y.H. Lu, G.H. Liu. 2011. "Double counting in ecosystem service valuation: causes and countermeasures." *Ecological Research* 26(1):1-14.; Fisher, B., K. Turner, M. Zylstra, R. Brouwer, R. De Groot, et al. 2008. "Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research." *Ecological Applications* 18(8): 2050-2067; Wallace, K. 2007. "Classification of ecosystem services: problems and solutions." *Biological Conservation* 139:235-246.; Nahlik, A.M., M.E. Kentula, M. Fennessy, D.H. Landers. 2012. "Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice." *Ecological Economics* 77:37-35.

individuals and communities. It recognizes that most **ecosystem services** only produce **benefits** that improve human well-being when combined with other inputs (e.g.,**built capital**, such as pipes or fishing rods; knowledge; and skills). It also indicates that demand can influence the ecosystem (**supply**) and the **benefits** available from a given ecosystem can shape **demand**.

Figure 1.2. Ecosystem Services — Benefits Framework



Source: ECONorthwest

Supply of Natural Capital

Our understanding of **ecosystem services** begins with **natural capital**, represented by the blue box on the left of Figure 1.2. **Natural capital** describes the inventory of nature's basic building blocks, such as vegetation, water, wildlife, soils, and gases. Some types of natural capital have value as stand-alone goods, such as a tree or a fish. Most **natural capital**, though, has value primarily through its many symbiotic relationships with other units of **natural capital** that, through the complex functions and processes of an ecosystem, provide goods and services of value to society. Carbon sequestration is an example of an ecosystem service that depends on inputs of natural capital (vegetation and gasses) but requires various chemical and biological processes to occur.

Demand for Natural Capital

Ecosystem goods and services exist because people **demand** them. If people didn't exist, the ecosystem would persist, but there would be no need to describe the additional layer of meaning that **ecosystem goods and services** imparts on the natural system. Human **demand** is what transforms the **supply** of **natural capital** and ecosystem processes and functions into **ecosystem goods and services**. **Demand** for **ecosystem goods and services** arises from individuals and society, and

The Four Forms of Capital

Economists use the term capital to describe resources commonly used to produce things people value (e.g., different types of goods and services).

Classifications vary, but most economists generally recognize four types of capital:

Natural capital refers to the components of nature, e.g., water, trees, and soil, and the interactions between these components.

Built capital refers to water-delivery infrastructure, roads, buildings, and other tangible goods and infrastructure.

Human capital refers to the knowledge and skills embodied in people.

Social capital refers to the access to goods and services we obtain through social relations; it includes social networks, cultural norms, laws, and political systems.

is represented by the yellow box on the right-hand side of the Figure 1.2. Some types of demand for ecosystem services are obvious and routinely recognized within an economic framework: demand for trees to produce wood to build things, or demand for fish and fishing opportunities to entertain and sustain. Humans also demand other types of ecosystem services without explicitly recognizing them: clean air to breathe, for example.

Ecosystem Goods and Services

The green circle in Figure 1.2 represents **ecosystem services**. To summarize, an ecosystem service exists if the ecosystem supplies something that people want. Ecosystem services only exist insofar as there is human demand for their supply. The set of ecosystem services in an area can expand or contract depending on human preferences over time and across geographic areas.

Benefits

Ecosystem goods and services are precursors to, but distinct from **benefits**, which are represented in the gray oval in Figure 1.2. This is a subtle, but important distinction, fundamental to an economic perspective. Benefits represent improvements in human well-being. To achieve improvements in well-being, humans typically combine ecosystem services with other types of inputs. Ecosystem services rarely, if ever, produce changes in human well-being independent of other inputs.

Supply of Other Types of Capital

Benefits are produced when human demands are satisfied by the ecosystem's production of goods and services, married with other factors of production. These other factors of production are represented by the tan box in Figure 1.2, which represents the supply of other types of capital. In addition to natural capital, economists distinguish three categories of capital:

- **Built Capital** (e.g., our houses, offices, cars, and other tangible manufactured goods)
- **Human Capital** (e.g., the knowledge and skills embodied within people)
- **Social Capital** (e.g., relationships, institutions, cultural norms and values)

In most cases, people combine different forms of capital to produce a good or service they want. For example, an individual may enjoy recreational fishing (a benefit) within a lake that provides habitat for fish (ecosystem services), but would also require a fishing pole (physical capital), knowledge and skill to tie fly or bait a lure (human capital), and a fishing license (a product of social capital). Even non-use benefits derived from ecosystem services may require inputs of other forms of capital. Improvements in well-being from simply knowing that fish populations will exist in the future usually requires knowledge of the importance of the fish and its place in the ecosystem, and may be intertwined with cultural or social notions of morality and spirituality, which are formed and maintained through social capital.

Feedback Relationships

The framework emphasizes the feedback relationships that exist in this system. While ecosystem goods and services, in combination with other forms of capital, produce improvements in human well-being, humans drive changes in the natural world that produce changes in natural capital and ecosystem functions and processes. These changes can occur indirectly, through demographic, economic, and sociopolitical changes, or directly, through changes in local land use and land cover, species introduction or removal, or climate change.

Ecosystem goods and services are already well-integrated into our communities and economies: we all depend on them, whether or not we recognize them explicitly. This framework helps decision-makers identify and incorporate ecosystem service values into decisions. By doing so, they are better-able to account for the full range of benefits and costs associated with projects and actions.

C. GENERAL PRINCIPLES FOR ECONOMIC VALUATION

The general principles guiding estimation of the benefits and costs associated with impacts to ecosystem good and services are no different from those required for any other type of economic analysis. Economists have developed clear guidelines for conducting economic analysis.[9] These guidelines define an analytical framework that includes a variety of essential components, which we describe below. DWR provides guidance about adopting assumptions for some of these principles—where it does, we note that in the text and sidebar.

Define Appropriate Geographic and Temporal Boundaries

In conducting an economic analysis of a project or proposal that affects the use and allocation of natural resources, the analyst must clearly define the geographic and temporal boundaries of the study area. The definition should be broad enough to capture the effects on all relevant resources, communities, and stakeholders, but narrow enough to describe the effects in sufficient detail.

Geographic Boundaries

Depending on the natural resources and stakeholders the project is likely to affect, the geographic boundaries of analysis may be broad or narrow. Defining multiple geographic boundaries to capture different types of effects at different scales might be appropriate. Specific to Proposition 84 projects, the appropriate geography for the economic analysis includes both local and statewide geographies.[10] *That is, the analysis should identify and describe benefit that extend beyond the immediate area of the project*. For example, the benefits of a restoration project that benefits salmon habitat near the headwaters of a stream may extent downstream to coastal communities that benefit from salmon harvests. The geography of the economic

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[9] See, for example, U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses. EPA Report No. 240-R-10-001*. Retrieved November 14, 2012, from http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html

[10] California Department of Water Resources (CDWR). 2012. *Draft Proposal Solicitation Package, Proposition 84, Implementation, Round 2.* Page 50.

analysis should capture both the benefits local to the restoration project, and the benefits in coastal communities.

Temporal Boundaries

As with geographic boundaries, project-specific conditions dictate the appropriate time horizon across which to conduct an economic analysis. DWR recommends setting a period of analysis consistent with the life cycle of the project.[11] For environmental enhancement projects without a lifespan defined by engineering constraints (e.g., a wetland restoration), costs are often incurred for several years during construction and maintenance, while benefits accrue in perpetuity. The appropriate period of analysis for these types of projects would be long, to capture both the active construction and maintenance costs incurred in the initial years and the stream of benefits that accrue over time (in some cases in perpetuity).

There isn't one time period that fits all circumstances. Federal and professional guidance for conducting benefit-cost analyses, including guidance from the Office of Management and Budget (OMB) suggests tailoring the time frame to capture all important benefits and costs likely to arise from a project or regulatory action.[12] In its Guidelines for Preparing Economic Analyses, the U.S. Environmental Protection Agency (EPA) recommends the time horizon of an analysis to coincide with the time span of the physical effects that arise from a project or action.[13] Moreover, EPA emphasizes that the "time horizon should be long enough that the net benefits for all future years (beyond the time horizon) are expected to be negligible when discounted to the present."[14] For projects with ecological effects, longer time horizons—perhaps 50 to 100 years—are usually required to satisfy this.

Identify Effects by Comparing With-Project and Without-Project Conditions

To value a project's effects on ecosystem services, it is important to identify each change attributable to the project or action, taking into account differences in the environment and human systems with the project versus without it (economists refer to these as **marginal** changes). To do this, economists define and then compare the total values associated with two scenarios:

1. Current and expected future conditions **without** the project.
2. Current and expected future conditions **with** the project.

The "without scenario," or the baseline, provides an important reference point. It describes future conditions, including a given allocation of natural resources, likely to develop if no project were implemented. *The without scenario requires the analyst to anticipate likely future conditions and is therefore distinct from a simple description of*

[11] CDWR 2012, page 49.

[12] U.S. Office of Management and Budget (OMB). 2003. *Circular A-4: To the Heads of Executive Agencies and Establishments Regarding Regulatory Analysis*. September 17.

[13] U.S. EPA 2010.

[14] U.S. EPA 2010, Pp. 5-6.

Period of Analysis for Environmental Enhancement Projects

DWR suggests the following period of analysis for projects submitted under P84 or P1E processes:

The economic analysis will be based on a project life cycle specified by the applicant which shall include the construction period and operational life. (CDWR 2012, pg. 49)

For environmental enhancement projects, this guidance may not be as clear-cut as for an engineered improvement (e.g., a new reservoir or a piece of technology that has a defined engineering life span). The intent of most restoration projects is to provide self-sustaining long-term improvements that continue to generate benefits for decades or centuries to come.

For this reason, EPA and others recommend longer time horizons—50 to 100 years—to capture these lasting benefits. If you decide to use a long period of analysis, be sure to include any project-related costs that might occur over the same period. If the restoration will require human attention to maintain the same stream of benefits, you need to include those costs. Alternately, you might reduce the benefits to levels you can reasonably be assured will occur without human intervention.

Be sure to describe how natural variability over time may make long-term benefit estimations more uncertain, especially over long time horizons.

Making Assumptions about the With and Without Project Conditions

Sometimes we don't have a clear picture of what would happen in the future with or without a project. Nobody can predict the future, but a good analysis requires the analyst to make some educated guesses about how things will turn out.

Wherever possible, support your projections with credible information. Sources may include engineering reports, field reports, evaluations of similar projects elsewhere, or best-expert opinions from biologists and other scientists.

Even with supporting information, uncertainty may still exist about future conditions. Don't be afraid to make assumptions about what might occur. Just describe those assumptions clearly.

Discount Rates and Discount Factors

Projects submitted to DWR must use a discount rate of 6 percent. An easy way to discount is to use discount factors, which you simply multiply by your dollar values for the appropriate year. DWR provides discount factors to use in your analysis in the PSP (CDWR 2012, page 49).

For example, if you expect a project to generate $1,000 worth of benefits in 2020, you would multiple $1,000 by 0.672. The discounted value of $1,000 occurring in 2020 is worth $672 today, assuming a 6-percent discount rate.

current conditions. Consistent with the ecosystem services framework presented in the previous section, the without scenario should describe both the supply of natural resources and the demand for natural resources without the project.

The "with scenario" provides information on the future conditions likely to happen with a project over the same geographic boundaries and period of analysis, including changes in the supply of and demand for natural resources. *The differences in conditions between those expected in the baseline scenario and those expected with the project provide the basis for determining the change in value associated with a particular set of natural resources.*

Discount Future Benefits

Economists use **discounting** to account for time preferences, that is, the preference for benefits or money earlier rather than later. Part of this preference is due to the opportunity cost of committing money and other resources to a strategy that generates benefits in the future, and losing the opportunity for interest and other means of growing resources and benefits over time. Discounting entails reducing values that would materialize in the future by a percentage over time to standardize values occurring at different times to their equivalent, present value (which may be the current year or another year). *Projects submitted to DWR must use a 6 percent discount rate.* Discount rate and associated discount factors are presented in the PSP.[15]

Address Risk and Uncertainty

Risk and uncertainty have important implications for quantifying benefits provided by natural resources. Consider potential sources of risk and uncertainty both within the natural environment and arising from human actions that affect natural systems. At a minimum, incorporate the potential for risk and uncertainty to affect your estimate of benefits by identifying the source and pathway of the risk and/or uncertainty, the potential magnitude of the effect, and the timing and duration of the effect. If you are able to quantify the probabilities associated with unpredictable but certain events, incorporate these probabilities into your benefits calculations. With increasing risk and increasing uncertainty, expected benefits generally decline. Given the potential for long-term and uncertain effects on ecosystem quality, particularly in the face of climate change, this cautious approach is warranted in determining how impacts to natural capital might ripple through an ecosystem, and how valuable the impacts to ecosystem-service benefits might be.

Identify Beneficiaries and Address Distributional Effects

Projects may produce benefits for just one beneficiary, or multiple beneficiaries. If the same amount of benefits accrue to one or many, the economic importance of those benefits from a social perspective may differ. DWR recommends project proponents clearly describe who benefits from the project. *If the project benefits*

[15] CDWR 2012, page 49.

disadvantaged communities (DACs) or communities that rely on bay-delta ecosystems, these should especially be noted.

Identifying beneficiaries also facilitates a discussion of the distributional effects of a project. Distributional effects explicitly acknowledge that the people who bear the costs of an action aren't always the people who enjoy the benefits, and vice versa. Describing distributional effects involves describing the allocation of the project's benefits and costs across individuals, organizations, and communities. When the allocation of benefits and costs is uneven, it has economic importance independent of the simple difference between the project's costs and benefits. Discussing the distribution of effects helps decision-makers better-understand the full range of economic effects of an action.

2: Identifying Benefits of Projects

This section describes the categories of economic benefits associated with some common types of environmental enhancement projects. These projects illustrate a wide range of potential projects that generate economic benefits through improvements to natural capital and ecosystem services, and through investments in other forms of capital. Together they capture a range of benefits that may arise from environmental enhancement projects. We describe how to value the categories listed as “potential economic benefits” in Section 3.

Through the sketches described on the next few pages, we outline the conceptual logic of translating biophysical effects of environmental enhancement activities into economic terms. Benefits can arise through improvements to any of the four forms of capital described in Section 1. We focus primarily on improvements to natural capital, although we include benefits arising from improvements to built, human, and social capital as well, because without them, the description of the economic value of the project would be incomplete.

As we outline in Section 1, the first step in describing benefits in economic terms is to generate a complete description of the biophysical effects of a project. Doing this requires:

1. **Defining geographic and temporal boundaries** of analysis that capture a project’s direct effects on the environment and the ripples the effect generates through other social and economic systems.
2. **Describing the conditions within those boundaries *without* the project,** which involves anticipating what the future might look like assuming nothing is done, and quantifying the relevant parameters (e.g., fish populations, maintenance activities, etc.) where data allow, and qualitatively where data don’t allow.
3. **Describing the conditions within those boundaries *with* the project,** which involves describing the effects of the project on the same parameters, quantitatively where possible, and qualitatively where data don’t allow.

Once the biophysical description of the project’s effects is in hand, the process of translating biophysical effects into economic benefits can begin. The important thing to remember is that **benefits are highly site specific.** Remember from Section 1, an ecosystem provides a benefit only if there is demand for that ecosystem service. So part of the process of identifying benefits involves understanding the demands for the ecosystem services in the relevant geography and time period.

Once you identify a set of economic benefits of a project, proceed to the valuation instructions in Section 3.

Using this Section

The following pages describe the benefits of common types of environmental enhancement projects.

The green-shaded boxes and table columns highlight the benefit categories that are presented in more detail in Section 3.

For projects that improve environmental resources, it is often difficult to separate out the effects that are biophysically important from those that are economically important. The tables help to do this by showing the linkages from:

1) Changes in Natural Capital, to
2) Changes in Ecosystem Services, to
3) Economic Benefits (e.g., changes in people’s well-being).

The cost-benefit analysis should only quantify and describe the benefits (category 3).

The changes in categories 1 and 2 should be included as part of the description of the biophysical effects of the project, and are necessary for justifying the benefits.

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

Stream Channel Restoration

This project would reconstruct a degraded stream channel, using a new restoration technique to stabilize and widen the stream channel and floodplain. The stream historically served as important habitat for ESA-listed salmonids, and restoration activities would create 2 stream miles of new spawning habitat. The project would involve planting 2 acres of forest vegetation. The project would be monitored for 10 years to observe the effects of the restoration. Restoration and ongoing monitoring efforts would engage local high schoolers and community organizations.

Project Benefits Related to Changes in Natural Capital

This stream channel restoration project has the potential to produce a wide range of economic benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital		
Change in Natural Capital (Biophysical Effect)	**Ecosystem Service**	**Potential Economic Benefit**
Increased forest vegetation	Carbon sequestration	- Avoided costs of climate change
Increased spawning habitat	Salmonid population maintenance	- Value of salmonid populations (commercial, recreational, and existence)
Improved water quality parameters (e.g., DO, temperature, PM, etc.)	Production of clean water	- Reduced costs to downstream water users - Reduced compliance costs for TMDLs - Higher quality water recreation opportunities - Improved aesthetics
Improved hydrologic infiltration	Improved water supply through groundwater recharge	- Value of increased water supply - Reduced groundwater pumping costs
	Increased base flows during dry season	- Value of increased water supply for environmental purposes
Increased flood storage capacity	Flood control	- Avoided costs of flood damage

Potential Economic Benefits of Changes in Human Capital and Social Capital

Reduced costs of future projects.

Improved well-being of students.

Improved well-being of community.

Project Benefits Related to Changes in Human Capital

By using a new restoration technique, the project **invests new skills in local labor and volunteers**, which may reduce the costs of future restoration projects. **Investing in the skills and interests of high-school students** may influence graduation rates and improve academic achievement now and in the future.

Project Benefits Related to Changes in Social Capital

By engaging community organizations and local land owners, the project strengthens the relationships among members of the community, increasing capacity to address other challenges, and improve the community's resilience in addressing future conflicts.

Rainwater Harvesting

This project would install five cisterns for collecting rainwater on a farm. The rainwater would provide enough water to substitute for 2 acre-feet of irrigation withdrawals during the dry summer season from a nearby creek that provides habitat for salmon. A legal agreement would ensure the farmer and other water users downstream do not withdraw the water and it remains available for environmental purposes. It would reduce the quantity of untreated stormwater runoff from the farmer's land, improving water quality in receiving waterbodies. The farmer would no longer need to pump water and maintain water conveyance equipment from the stream to the land being irrigated.

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

Project Benefits Related to Changes in Natural Capital

This rainwater harvesting project produces several benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital		
Change in Natural Capital (Biophysical Effect)	**Ecosystem Service**	**Potential Economic Benefit**
Increased base flow during dry season	Increased instream flow	- Value of increased water supply for environmental purposes - Higher quality water recreation opportunities
Increased spawning habitat	Salmonid population maintenance	- Value of salmonid populations (commercial, recreational, and existence)
Improved water quality parameters (e.g., DO, temperature, PM, etc.)	Production of clean water	- Reduced costs to downstream water users - Reduced compliance costs for TMDLs - Higher quality water recreation opportunities - Improved aesthetics

Project Benefits Related to Changes in Built Capital

The project's investment in new built capital (i.e., the rainwater storage tanks) would save the farmer continued investments of money and time in older irrigation pumping equipment. This would avoid costs associated with electricity, labor, and operation and maintenance (e.g., parts).

Potential Economic Benefits of Changes in Built Capital

Avoided costs of electricity

Avoided carbon emissions

Avoided costs of labor

Avoided costs of operation and maintenance

Culvert Replacement on Fish-Bearing Stream

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

This project would reconstruct a culvert on a stream with 5 miles of stranded salmonid spawning habitat. The new culvert would allow fish to access this habitat. In the process of rebuilding the culvert, the road would be regraded and stabilized, and 2 acres of forest habitat would be replanted. These restoration activities would prevent 1 ton of sediment from entering the stream each year.

Project Benefits Related to Changes in Natural Capital

This culvert replacement project has the potential to produce a wide range of economic benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital

Change in Natural Capital (Biophysical Effect)	Ecosystem Service	Potential Economic Benefit
Increased forest vegetation	Carbon sequestration	- Avoided costs of climate change
Increased spawning habitat	Salmonid population maintenance	- Value of salmonid populations (commercial, recreational, and existence)
Reduced sediment deposition	Production of clean water	- Avoided costs of sediment deposition
Improved other water quality parameters related to sediment (e.g., DO, temperature, PM, etc.)	Production of clean water	- Reduced costs to downstream water users - Reduced compliance costs for TMDLs
Improved bank stability	Flood regulation	- Avoided costs of flood damage

Potential Economic Benefits of Changes in Built Capital

Avoided maintenance costs

Avoided costs of catastrophic failure

Project Benefits Related to Changes in Built Capital

The project's investment in new built capital (i.e., the culvert) would reduce the annual maintenance costs associated with an older culvert design. It would also reduce the risk of the culvert plugging and washing out the road, causing a catastrophic road and culvert failure, which would require emergency repairs and potentially require detours, costing travelers additional time and fuel.

Road Reconstruction for Sediment Reduction

This project would reconstruct 10 miles of dirt road prone to washing out throughout a small rural watershed. The work would stabilize road beds and surface material, reducing sediment deposition into the watershed's salmon-bearing creeks by 20 tons per year. A community downstream of the road improvements pulls its drinking water from the stream. Because the water is cleaner, especially immediately following storms, the community would experience less wear and tear on its pumps and uses less treatment chemicals. Stabilizing the roads also would lead to fewer road closures affecting residents traveling on the roads. The state has been in the process of developing a TMDL limit for sediment on the stream. This project would reduce sediment loads enough that the watershed would fall below threshold levels for regulation.

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

Project Benefits Related to Changes in Natural Capital

This road reconstruction project has the potential to produce a wide range of economic benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital		
Change in Natural Capital (Biophysical Effect)	**Ecosystem Service**	**Potential Economic Benefit**
Improved spawning habitat	Salmonid population maintenance	- Value of salmonid populations (commercial, recreational, and existence)
Reduced sediment deposition	Production of clean water	- Avoided costs of sediment deposition (general) - Reduced drinking water treatment costs - Reduced compliance costs for TMDLs - Higher quality water recreation - Value of improved aesthetics

Project Benefits Related to Changes in Built Capital

The project's investment in new built capital (i.e., roads built to modern construction standards) would reduce the annual maintenance costs associated with roads in poor condition. It would also reduce the risk of a catastrophic road failure, which would require emergency repairs and potentially require detours, costing residents additional time and fuel.

Potential Economic Benefits of Changes in Built Capital

Avoided maintenance costs

Avoided costs of catastrophic failure

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

Wetland Ecosystem Restoration

This project would restore 10 acres of existing wetlands and reconstruct 20 acres of new wetlands on a site that had been drained and converted to farmland long ago. The wetlands would provide habitat for birds and wildlife, provide flood storage capacity, and provide groundwater recharge in an area experiencing depletion of groundwater. By recharging groundwater, it would extend the timing of summer flows in a creek, providing, on average, two additional weeks of flows. A 2-mile interpretive trail would be constructed on the site.

Project Benefits Related to Changes in Natural Capital

This wetland ecosystem restoration project has the potential to produce a wide range of economic benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital		
Change in Natural Capital (Biophysical Effect)	**Ecosystem Service**	**Potential Economic Benefit**
Increased native vegetation	Wetland habitat and biodiversity	- Value of wetland habitat - Value of nature-based recreation
Increased flood storage capacity	Flood control	- Avoided costs of flood damage
Improved hydrologic infiltration	Improved water supply through groundwater recharge	- Value of increased water supply - Reduced groundwater pumping costs
	Change in timing of summer flows	- Value of increased water supply for environmental purposes

Potential Economic Benefits of Changes in Built Capital

Value of nature-based recreation (also listed in table)

Project Benefits Related to Changes in Built Capital

The project's investment in new built capital (i.e., the trail and signage) would interact with the changes in natural capital to produce benefits from increased recreational opportunities.

Potential Economic Benefits of Changes in Human Capital

Improved well-being of community.

Project Benefits Related to Changes in Human Capital

Both the project's investments in built and natural capital would have the potential to produce additional investments in human capital, assuming people use the trail and learn about their natural environment.

Urban and Suburban Stormwater Infiltration

This project would construct several small-scale stormwater and rainwater infiltration structures on residential parcels in the upper elevations of a watershed. Infiltration installations would include downspout dry wells, vegetating ditches, and bioswales designed for detention and retention. The bioswales include subsurface infiltration ditches at the base to increase water storage and absorption into the soil and wetland plant species native to the area in landscaped zones along the bed and at the edges of the swale. The watershed is prone to flooding that closes roads and damages streamside properties. Groundwater over-pumping for residential and agricultural use is also a concern. The main stream and its tributaries support threatened salmonid populations and are listed as impaired for sediment.

This description is hypothetical and illustrative only. The with and without project descriptions should include more detail.

Project Benefits Related to Changes in Natural Capital

These infiltration installations have the potential to produce a wide range of economic benefits related to improvements in natural capital and ecosystem services. These are shown in the table below.

Project Benefits Related to Changes in Natural Capital		
Change in Natural Capital (Biophysical Effect)	**Ecosystem Service**	**Potential Economic Benefit**
Increased native vegetation	Wetland habitat and biodiversity	- Value of wetland habitat - Value of improved aesthetics
Increased flood storage capacity	Flood control	- Avoided costs of flood damage
Improved hydrologic infiltration	Improved water supply through groundwater recharge	- Value of increased water supply for residential and agricultural users
	Change in timing of summer flows	- Value of increased water supply for environmental purposes
Improved spawning habitat	Salmonid population maintenance	- Value of salmonid populations (commercial, recreational, and existence)
Improved water quality parameters (e.g., DO, temperature, PM, etc.)	Production of clean water	- Reduced costs to downstream water users - Reduced compliance costs for TMDLs - Higher quality water recreation opportunities - Value of improved aesthetics

Project Benefits Related to Changes in Built Capital

The project's investment in new built capital (i.e., the constructed bioswale and dry well) would save the nearby municipality costs associated with stormwater capture and treatment. This would avoid costs associated with electricity, labor, and operation and maintenance.

Potential Economic Benefits of Changes in Built Capital

Avoided costs of electricity

Avoided carbon emissions

Avoided costs of labor

Avoided costs of operation and maintenance

3: Quantifying Benefits of Projects

Using this Section

The following pages describe how to quantify (or, alternately, how to describe qualitatively) the benefits of projects.

The benefits are grouped by ecosystem service categories. So if you're looking for benefits related to a project's effects on salmon populations, for example, you'll see those benefits all together.

Use the table on the following page to quickly locate a benefit within this section.

This section describes the economic values of benefits that environmental projects can generate. Benefits that arise from investments in natural capital are grouped by ecosystem service. Several additional categories describe benefits that arise from investments in built, human, and social capital.

For benefits that we can assign a dollar value, we provide the unit value and information necessary to understand and apply the value to a project's biophysical effects. We also describe the sources of uncertainty and risk inherent in the unit value and describe the beneficiaries of the benefit.

For benefits for which we cannot assign a monetary value, we indicate the types of information that should be included in the description. This information frames the effect in economic terms and provides evidence that, while it is not quantifiable given available information, it likely has economic importance that should be accounted for in the project evaluation. This approach is consistent with guidance from the U.S. EPA and the U.S. Office of Management and Budget in its guidelines for conducting benefit-cost analyses.[16]

Wherever possible, we selected values from the existing literature conducted in the relevant geographic location, i.e. the Bay area, Northern California, California, or the Pacific Northwest. In all cases, we have taken care to ensure that there are no dollar values presented here that would be inappropriate in the context of proposed projects through the Bay Area IRWMP.

All values in the following pages are in 2012 dollars.

The table on the following page shows a summary of all the benefits highlighted in this chapter and their page number, for easy skimming.

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[16] U.S. Office of Management and Budget (OMB). 2003. *Circular A-4: To the Heads of Executive Agencies and Establishments Regarding Regulatory Analysis*. September 17.; U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses. EPA Report No. 240-R-10-001*. Retrieved November 14, 2012, from http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html

Relevant Projects

Road reconstruction

Culvert replacement

Wetland restoration

Stream habitat improvement

Water quality improvement (e.g., reduced dissolved oxygen, sediment, etc.)

See Also

Improvements in Salmonid Populations

Improvements in Water-Based Recreation

Production of Clean Water

Avoided Cost of Sediment Deposition

If the project reduces the volume of sediment in a waterway, it provides a benefit equal to the sum of the costs avoided from the decrease in sediment.

Potential Biophysical Units: Tons per year; cubic yards per year

Potential Economic Unit Value: Up to $10.35 per ton of sediment (Hansen and Ribadu, 2008). See the table below for use-specific avoided costs. Only use the aggregate value if there are a broad base of downstream beneficiaries. If you are calculating other benefits from a sediment removal project, avoid double counting with this category by carefully selecting the appropriate categories of avoided costs from the table below.

Alternate Valuation Method: It is also possible—actually, desirable if sufficient information exists—to estimate the value of avoided sediment deposition by estimating the avoided costs associated with sediment removal. For example, if a dredging effort has been completed recently downstream of the project site and the project will eliminate the need to dredge in the future, use the costs of the recent dredging project to estimate the value of avoided sediment deposition in the future. For most sediment-removal projects, you can scale the avoided costs of past projects to the current project by dividing the total sediment removal cost of the project by the tons of sediment it removed, then multiply the unit cost by the number of units (e.g., tons of sediment) your project will address.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and the assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. If this value does not reflect many potential benefits, such as goods and services derived from potential impacts on

Avoided Costs Associated with Reduced Sediment in the San Francisco Bay Watershed

Benefit Type	Description	Value
Water-based recreation	cleaner fresh water recreation	$5.02
Irrigation ditches and channels	reduced cost of removing sediment from irrigation channels	$1.10
Road drainage ditches	less damage to and flooding of roads	$0.21
Municipal water treatment	lower sediment-removal costs for water treatment plants	$0.50
Flood damage	reduced flooding and damage from flooding	$0.35
Marine fisheries	improved catch rates for marine commercial fisheries	$0.45
Marine recreational fishing	improved catch rates for marine recreational fishing	$0.53
Municipal and industrial water use	reduced damages from salts and minerals dissolved from sediment	$0.18
Steam power plants	reduced plant growth on heat exchangers	$0.04
Soil productivity	reduced losses in soil productivity	$0.43
Dust cleaning	decrease in cleaning due to reduced wind-borne particulates	$1.22
Reservoir services	less sediment in reservoirs	$0.29
Navigation	shipping industry avoidance of damages from groundings	$0.03

wetlands and endangered species, it may underestimate the total benefit from sediment reductions. These may be reflected in other benefit categories, however. The value above embodies the uncertainty inherent in the individual study as well as from applying results from past research to future conditions.

Beneficiaries: Depends on the categories of value included in the total economic unit value. Insofar as each of these categories are included, the beneficiaries could include a combination of those benefiting in the table below: general public, irrigators, municipal water treatment operators and ratepayers, etc.

Reduced Drinking Water Treatment Costs

If the project decreases the amount of treatment required to produce drinking water, it provides a benefit equal to the value of avoided water treatment costs.

Potential Biophysical Units: Gallons treated per year; Acre-feet treated per year

Potential Economic Unit Value: **Average cost per unit of water requiring reduced treatment.** Average cost should be the difference between what it would have cost to treat the water without the project and what it would cost with the project. This value requires agency-specific inputs. The mid-range cost of drinking water treatment in the San Francisco area is $65 per acre-foot per year (Chen et al. 2008). The value used here should be somewhat less than this value, and will depend on the differences in inputs in the water-treatment process with the project.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. If using the mid-range cost of drinking water treatment, the value would represent an overestimate of the true per unit cost if agency costs are lower than the average or an underestimate if agency costs are higher than the average.

Beneficiaries: Drinking-water plant operators, customers, and ratepayers in the system.

Reduced Stormwater Water Treatment Costs

If the project improves the quality of stormwater by providing natural filtration through improved riparian corridors, it provides a benefit equal to the value of avoided water treatment costs—in this case, the construction of a stormwater treatment plant.

Potential Biophysical Units: Gallons treated per year, acre-feet treated per year

Potential Economic Unit Value: **Average cost per unit of water requiring reduced treatment or not needing treatment.** Using the cost of a constructed facility that would be required to treat stormwater, but would be avoided with the project may be appropriate to estimate the value of natural stormwater treatment in many cases. Care should be taken to scale the cost of the constructed facility to the effects of the project. Threshold issues are important in applying values here: if the project wouldn't actually avoid a treatment project, the full value of the project

Thresholds

Sometimes a biophysical effect occurs, but it is so small that it is economically meaningless. A good example of this is benefits related to TMDL compliance requirements, arising from improvements in water quality. A certain level of biophysical effect must occur before this benefit may be realized, and in most cases, on project will not exceed the threshold. If it is likely, provide strong documentation that the biophysical effect will translate into an economic benefit.

should not be used, and applying a partial value can be problematic, because you can't build part of a treatment plant. That said, if such information is available, it's usually best to use it and describe the sources of potential over or underestimating in the discussion of uncertainty and risk. One example of the cost of a stormwater treatment plant comes from Riley (2009) who estimated that replacement a treatment plant with 4,000 to 5,000 lineal feet of functional riparian corridor provides treatment equivalent to a constructed facility, built by the City of Santa Monica, which has annualized costs of about $1.3 million per year (assuming a time period of 50 years and a 6 percent discount rate). Extrapolating this value to a larger project could overestimate the avoided costs, because construction costs of water treatment plant for larger treatment amounts may benefit from economies of scale.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. Describe the potential reasons why the valuation may over or underestimate the actual value (see discussion above).

Beneficiaries: Stormwater management agency customers and ratepayers in the system, or taxpayers.

Reduced Costs Associated with TMDL Compliance

If the project improves water quality to the point that TMDL regulation is no longer required, it may reduce costs to taxpayers and property owners and water users in the affected water body.

Potential Biophysical Units: Threshold–does the project affect TMDL regulation?

Potential Economic Unit Value: Cost of TMDL regulation. Work with agency or local officials to determine what these costs might be. They likely vary considerably from watershed to watershed. This benefit can be very difficult to quantify, for a variety of reasons, including that TMDL regulatory costs may not be tracked in a way that ties them to a specific action, and environmental effects may occur over a longer period, making cause-and-effect relationships difficult to substantiate. For this reason, if effects are expected, it may be easiest to describe qualitatively

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. These costs are particularly contingent on threshold effects, which are uncertain both on a biophysical and an economic sense. To the extent that the agency is not able to accurately predict the future costs associated with TMDL compliance, both with and without the project, the value presented here may be an over- or underestimate of the true cost.

Beneficiaries: Taxpayers and property owners/water users in the watershed.

Improved Water Supply/Groundwater Recharge

To estimate the value of effects on water supply, we focus on water for environmental purposes. Environmental enhancement projects may also increase water available for agricultural and municipal purposes, either through surface augmentation or groundwater recharge but these benefits are likely to be smaller than projects intended specifically to augment these water supplies.

Increased Instream Flow for Environmental Purposes

If the project increases the volume of instream flow available for environmental purposes, it provides a benefit equal to the market value of environmental water purchases.

Potential Biophysical Units: Acre-feet per year

Potential Economic Unit Value: Where possible, project proponents should use the cost of raw water purchases from, for example, DWR water projects. If no site-specific values are available, use $80 per acre-foot per year (Brown 2007). This value represents the median price paid in California water markets for water purchased for environmental protection. This value should be applied to the increase in the volume of instream flow (acre-feet per year) for environmental purposes.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. To the extent that the water is used multiple times as it flows downstream—for hydropower production, then ecosystem enhancement, then municipal use, for example—applying a single value may underestimate the water's total value if left instream. The value above embodies the uncertainty inherent in the individual study as well as from applying results from past research to future conditions. There is, however, no obvious reason to conclude that the estimate systematically overestimates the true marginal value of water for environmental purposes in the region. As human populations and incomes grow in California, the marginal value of wild salmonid populations and other benefits derived from instream flows for environmental purposes is likely to increase, as will the value of stream flows that support their continued existence.

Beneficiaries: Several groups of stakeholders including commercial fishermen and recreational anglers in both marine and freshwater fisheries, residents who benefit from increased groundwater recharge in relevant areas, recreational users of water, such as kayakers and wildlife watchers, Californians who place a non-use value on maintaining sufficient instream flows for environmental purposes, and other water users, such as irrigators, who bear increased regulatory pressure and costs to increase instream flows by reducing their own use of water.

Relevant Projects

Wetland restoration

Stream habitat improvement

Water quality improvement (e.g., reduced dissolved oxygen, sediment, etc.)

See Also

Improvements in Salmonid Populations

Improvements in Water-Based Recreation

Increased Water Supply for Municipal, Agricultural, and Industrial Purposes

If the project increases the volume of water available for agricultural or municipal purposes (ether by surface augmentation or groundwater recharge, it provides a benefit equal to the market value of water for those purposes.

Potential Biophysical Units: Gallons per year; Gallons per minute; Acre-feet per year.

Potential Economic Unit Value: **Market value of water for agricultural, municipal, or industrial purposes.** Check with the beneficiary of this benefit to determine what they would have paid for water without the project. This could be the cost of bulk or wholesale water purchases. This valuation method applies even if the end user of the water ends up paying nothing for the water—its value is still equivalent to the value they would have to pay to secure an equivalent alternate source.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. For benefits that would accrue over long time periods, describe how the value used today may not reflect the value in the future. This is especially relevant for water in California, as demand is likely to continue to grow faster than supply.

Beneficiaries: Potentially any one of: municipal water users, ratepayers, and operators; industrial water users; agricultural water users.

Additional Benefits Associated with Groundwater Recharge

Increased groundwater recharge may augment water supplies, which you should value based on the descriptions above, depending on the ultimate use of the water. Groundwater recharge may produce other benefits that are more difficult to quantify for most projects:

- Reduced pumping costs by increasing the level of the aquifer or avoiding drawdowns that increase costs to well-users in the future.
- Reduced risk of subsidence, which would avoid damage to property associated with subsidence, and which could limit future aquifer storage capacity and resulting in future water-supply development costs.

If any of these benefits are likely to occur, you are able establish cause-and-effect relationship between the project and the effect, and you are able to quantify in biophysical terms, then there are approaches to monetize the benefits. Most of the time, however, these benefits are too difficult to quantify biophysically. Nevertheless, they should be described with as much detail as possible.

Maintenance of Salmonid Populations

Individuals derive value from increases in fish populations in two ways: some (e.g., recreational anglers, commercial fishermen, people who consume fish) derive benefits by catching, selling, and/or eating the fish. Others (including some from the former group) derive value from the salmon solely based on the salmon's existence. Studies have shown that regardless of direct interaction with salmon populations, many Californians hold a positive willingness to pay to ensure the long-term survival of salmon (Loomis, 2006).

Value of Increase in Salmonid Populations

If the project increases populations of endangered fish populations, it provides a benefit equal to the value Californian's are willing to pay to improve the fish population. (See the next benefit for cultural and spiritual value).

Potential Biophysical Units: # of additional fish per year (may increase over time)

Potential Economic Unit Value: **$ per additional fish per year** (See specific values in the table on the following page). Individuals derive value from increases in salmonid populations in two ways: some (e.g., recreational anglers and commercial fishermen) directly interact with salmon populations and derive benefit by catching and consuming the fish, others (including some from the former group) derive value from the salmon solely based on the salmon's existence. Studies have shown that regardless of direct interaction with salmon populations, many Californians hold a positive willingness to pay to ensure the long-term survival of salmon (Loomis 2006).

Several studies have attempted to estimate the passive use value of increases in salmonid populations among households in California and neighboring states. Passive use value, in this case, refers to the benefit individuals derive from knowing that healthy salmonid populations exist, regardless of their intent to directly interact with salmon and steelhead through fishing or some other means. These studies have estimated households' average willingness to pay to implement policies that would increase salmon populations.

At the per-salmon level, these studies reveal that households are willing to pay only fractions of a penny for increases in salmon populations. When summed across a region, however, the total value Californians are willing to pay for increases in salmon populations can become several thousands of dollars per fish (See table on the following page). According to the 2010 U.S. Census, there are about 12.6 million households in California. Applying the results of three studies that have estimated household willingness to pay values for increases in salmon populations to the number of households in California suggests that, in total, Californians (in the aggregate) would be willing to pay between $500 and $9,300 per fish per year (see table on the following page). In eliciting willingness to pay estimates from respondents, these studies told respondents that hypothetical policies would increase salmon populations by 2.5 million, 300,000, and 165,000, respectively.

Relevant Projects

- Fish passage improvement
- Culvert replacement
- Stream habitat improvement
- Water quality improvement (e.g., reduced dissolved oxygen, sediment, etc.)
- Increased instream flows

The Importance of Population Size

Economic studies agree that respondents' willingness to pay per fish for an increase in salmon populations decreases as the hypothetical increase in salmon stocks increases. In other words, the smaller the increase in salmon populations, the higher the willingness to pay, per fish. Many of the proposed projects may yield small potential increases in salmon populations, relative to the size of existing populations, and to the hypothetical increases posited in the valuation studies. Hence, the value per additional fish resulting from the proposed projects likely will resemble the upper end of the range of estimates rather than the lower end. On the other hand, if the proposed project yields a large potential increase in salmon populations, relative to the existing population and the hypothetical increases in the studies, the value per additional fish likely will resemble the lower end of the range of estimates.

Potential Annual Economic Value of Increases in Salmonid Populations	
Value Per Fish	**Source**
$500	Olsen, Richards, and Scott 1991
$4,200	Loomis 1996
$9,300	Bell, Huppert, and Johnson 2003

The studies agree that respondents' willingness to pay per fish for an increase in salmon populations decreases as the hypothetical increase in salmon stocks increases. In other words, the smaller the increase in salmon populations, the higher the willingness to pay, per fish. The proposed projects would yield small potential increases in salmon populations, relative to the size of existing populations, and to the hypothetical increases posited in the valuation studies. Hence, the value per additional fish resulting from the proposed projects likely will resemble the upper end of the range of estimates rather than the lower end. **Nonetheless, to address concerns about not overestimating the benefits, we suggest employing a value of $2,000 per additional fish per year as a rough estimate of the benefit of those projects that would increase salmon populations.**

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. Applying a value derived from studies conducted elsewhere in the Pacific Northwest may over or underestimate Californian's willingness to pay for salmon. Use caution when calculating and aggregating these values (see Sidebar). They are highly dependent on project specifics, and are not generally linear.

Beneficiaries: Californians who value the survival of healthy ESA-listed fish populations in California, which includes those who may never fish or directly interact with those populations.

Cultural and Spiritual Value Associated with Increases in Salmonid Populations

If the project increases populations of fish with special cultural values to Native Americans, some of whom rely on the fish for subsistence, cultural identity, and spiritual significance, it provides an additional cultural value (Kass 2009) that has economic importance and is not reflected in the general willingness-to-pay values presented in the previous benefit.

Potential Biophysical Units: # of additional fish per year (may increase over time)

Potential Economic Unit Value: **Not Monetized.** Unlike many Californians who ascribe a monetary willingness to pay to protect salmon, even if they never intend to directly fish or watch them, many Native Americans recognize the importance of salmon outside the cultural framework and economic terms western society often imposes (Malloy 1992). Accordingly, they reject the validity of applying a dollar value to fish that constitute a core element of their cultural and spiritual well-being.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on.

Potential Beneficiaries: Members of Native American tribes, both within and outside of the California, who believe the continued existence of salmonid populations and their habitat is essential to cultural and spiritual well-being. Identify specific tribes as local beneficiaries, if relevant.

Relevant Projects

Sediment reduction

Stream habitat improvement

Water quality improvement (e.g., reduced dissolved oxygen, sediment, etc.)

Trail creation or maintenance

Consumer Surplus Value of Recreation

A recreational activity is valuable insofar as individuals are willing to pay to participate in it. In most cases, individuals typically would be willing to pay some greater sum of money to participate in a recreation activity than they actually pay. The difference between the amount they would be willing to pay and the amount they actually pay is called consumer surplus. The table shows these values associated with several types of recreation.

These represent the net value associated with a day spent participating in different recreational activities (not including the costs of participating in the activity). Generally, increases in quality of recreational opportunities are not quantifiable.

Expenditures on Recreation

These values do not account for expenditures associated with recreation. In general, expenditures transfer value from the recreationist to a business, so they are not, by definition, benefits (i.e., there is no net value created for the economy). Expenditures may be important in gaining the support of local businesses and stakeholders, however.

Provision of Natural Capital for Recreation

Improved Quantity or Quality of Recreation

If the project increases the number of days individuals spend participating in recreation activities or the quality of their recreation, it provides a societal benefit equal to the total increase in the value of the consumer surplus associated with the increased or enhanced recreation days.

Potential Biophysical Units: Number of additional recreation days, by type of activity.

Potential Economic Unit Values: Consumer surplus value of recreation, per person, per day (See table below; Loomis 2005). Researchers have also valued beach recreation specifically, which may be particularly important to projects the region. One such study found the value of a trip to North Carolina beaches is worth $178 per trip for individuals or $1,697 per trip per household (Landry and Liu, 2009).

Sources of Uncertainty and Risk: One of the challenges of estimating the value of recreation is determining whether the project results in a *net increase* in recreation, or just shifts recreational users from one location to another. Estimating the value of recreation by counting people on a trail, for instance, may overestimate the value they gain from the trail because without it, they may have hiked elsewhere. Applying a value derived from studies conducted elsewhere in the United States may over or underestimate the total economic value of increases in quantity or quality of recreation.

Beneficiaries: Individuals that participate in recreation in the area as well as businesses that provide goods and services associated with recreation in the area.

Net Economic Value (Consumer Surplus) of Recreation in the Pacific Region

Activity	Value per person per day
Camping	$128
Fishing	$54
Hiking	$28
Mountain Biking	$61
Picnicking	$79
Sightseeing	$25
Swimming	$33
Wildlife Viewing	$89
Floating/Rafting/Canoeing	$34

Improved Wetland and Riparian Habitat

Increased or Improved Habitat

If the project improves the functionality of or increases the acreage of a particular type of habitat, it provides a benefit equal to the value of the habitat provided by the improved functionality or increased acreage.

Potential Biophysical Units: Acres of habitat type

Potential Economic Unit Value: Economic value of increases in habitat, by land cover type, per acre, per year. *See Table below for specific habitat types.* These values represent estimates of the total annual economic value associated with riparian and wetland habitat. If, for example, a project creates 0.5 acres of riparian habitat, the value of that benefit would be $60 per year (half of the per-acre value of riparian habitat). If a project improves the functionality of an existing habitat (e.g., by removing invasive species), apply the value proportional to the increase in function. For example, if a project improved the functionality of an acre of freshwater wetland by 75 percent, use a value of $126–$1,300 per acre per year.

Potential Annual Economic Value of Increases in Habitat, by Land Cover Type (National Average)		
Land Cover Type	**Value per Acre per year**	**Source**
Riparian	$120	Chiabai et al. (2009)
Freshwater Wetland	$168–$1,735	Woodward and Wui (2001)
Coastal Zone Wetland	$222-$403	Kazmierczak (2001)

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. Applying a value derived from studies conducted elsewhere in the United States may over or underestimate the total economic value of increases in certain types of habitat. The values described above estimates society's total willingness to pay for one fully restored acre of each type of habitat in North America. They are generally applicable to habitats found in California. Insofar as this estimate considers only passive use values, it likely underestimates the total economic value of restoration because direct users of the restored habitat likely are willing to pay more for its restoration. It also likely underestimates the value because, as human populations and incomes grow in California, the marginal value of natural landscapes probably will increase, as will the value of restoration efforts. Use caution when calculating and aggregating these values. They are highly dependent on project specifics.

Beneficiaries: Individuals in California who value the continued existence of these forms of habitat.

Relevant Projects

Stream habitat improvement

Riparian restoration

Wetland restoration

Coastal marsh restoration

Open space acquisition

Rare Habitat Types

The more specialized or rare the habitat is, the more likely people are willing to pay more to increase the amount of it in a given area. Exceptions may apply, if people don't understand or appreciate the services the rare habitats provide, or if they simply do not provide many ecosystem services that people rely on, consciously or not.

The economic literature does not contain a comprehensive set of values for all types of habitat, especially some of the rarer or more specific habitats found in California (e.g., sycamore riparian woodlands, or alkali sinks).

If your project improves a particularly unique habitat type, it's best to describe why these values may underestimate the actual value, and provide the reasons why people might be willing to pay more for this habitat and the ecosystem services it produces, rather than inflating values documented in the literature.

Relevant Projects

Sediment removal / reuse
Levee improvements
Floodplain enhancements
Fish passage improvements
Stream habitat improvement
Riparian restoration
Wetland restoration
Coastal marsh restoration
Culvert replacement

Flood Regulation

Avoided Flood Damage Costs

If the project decreases the frequency and/or magnitude of potential future flood events, it provides a benefit equal to the value of avoided flood damages.

Potential Biophysical Units: Area and type of land protected; Change in flood probabilities.

Potential Economic Unit Value: Project specific. Calculate expected annual damage following DWR's instructions and using a relevant model.[17] The avoided damages usually captured in the modeling effort include those to residential and commercial structures and public infrastructure. The model may also calculate costs associated with road closures due to flooding. The models typically do not capture other, less easily quantifiable, benefits related to avoiding flood events. W describe these in more detail below.

Sources of Uncertainty and Risk: These benefits are dependent on proper estimation and modeling of flood risk reduction. Insofar as modeling or past flood events are not representative of future events, they may over or underestimate the actual value.

Beneficiaries: Individuals and businesses that avoid damage to physical assets, loss of functions, health, and safety. Taxpayers that avoid expenses related to emergency response and cleanup.

Other Benefits Related to Avoided Flood Events

If the project decreases the frequency and/or magnitude of potential future flood events, it produces benefits in a variety of other categories, related to the disruption of public and private activities and services during flood events.

Potential Biophysical Units: Description of the types and extent of past flood damage, and related impacts. For example, along with avoiding physical damage, the economic costs associated with expected annual damage may also include avoided costs associated with loss of functions; avoided emergency response and cleanup; and avoided, but unquantifiable, public safety and health impacts. Descriptions of these disruptions (e.g., number of days emergency workers address flooding disruptions instead of other normal duties, number of flood-related injuries, etc.).

Potential Economic Unit Values: Project specific or not quantifiable. Consult with municipal officials on estimates of the cost of public safety and public works disruptions. For other avoided effects, it is likely best to describe qualitatively, but not attempt to put a dollar value on the effect.

[17] Such as U.S. Army Corps of Engineers HEC-Flood Damage Assessment or the Flood Rapid Assessment Model (F-RAM).

Climate Regulation

Avoided Costs of Climate Change from Carbon Sequestration or Avoided Carbon Release

If the project increases the amount of vegetated area, it provides a benefit equal to the social cost of carbon equivalent, increasing over time, multiplied by the volume of carbon dioxide equivalent sequestered in natural vegetation over time.

If the project results in less emissions of carbon dioxide, by reducing electricity use or other fuel use, it provides a benefit equal to the social cost of carbon, increasing over time, multiplied by the volume of carbon dioxide equivalent not released into the atmosphere each year.

Potential Biophysical Units: Acres of vegetation planted by type of habitat for these types of habitat: fir-spruce-hemlock stands; western oak stands. Both habitat types are specific to the Pacific-Southwest region and are appropriate to use in California if your project addresses similar vegetation communities. The table on the following page show the annual amount of carbon sequestered per acre year over 100 years for each type of habitat.

If you have a specific estimate of carbon sequestration for a different type of habitat, the units needed to apply the unit value below would be volume (tons) of carbon dioxide equivalent sequestered per year.

For emissions reduction projects, use the volume of carbon dioxide equivalent not released into the atmosphere per year.

Potential Economic Unit Value: $13 per ton of carbon dioxide equivalent sequestered or avoided being released (Shaw et al., 2009), increasing at a real rate of 2.5 percent per year (Nordhaus 2008). The table on page 37 shows the value as it increases over the next 100 years (these values are inflated at a real rate of 2.5 percent, but are not discounted).

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. The actual amount of sequestered carbon dioxide is dependent on many variables including but not limited to the precise mix of species planted, the density of the saplings, the age of the saplings, climate patterns, and the surrounding vegetation and land uses. In 2009, a literature review submitted to the California Energy Commission suggested that the social cost of carbon dioxide emissions is $9 to $40 per ton of carbon dioxide (Shaw et al. 2009). If the true social cost of carbon dioxide lies closer to the upper or lower end of the range, this unit value would be an under or overestimate.

Beneficiaries: All residents in California.

Relevant Projects

Riparian habitat restoration

Wetland restoration

Tree planting

Any project that reduces electricity or fuel use (e.g., from pumping)

Social Cost of Carbon

Economists use what's known as *the social cost of carbon* to estimate the value of changes in greenhouse gas emissions.

The social cost of carbon represents the full global cost today of emitting an incremental unit of carbon at some point of time in the future, and it includes the sum of the global cost of the damage it imposes on the entire time it is in the atmosphere. (Shaw et al. 2009)

Annual Carbon Sequestration (Live Trees) - Tons of CO2 Equivalent per Acre per Year					
Year	Fir-Spruce-Mountain Hemlock	Western Oak	Year	Fir-Spruce-Mountain Hemlock	Western Oak
1	1.052	0.890	51	2.913	5.461
2	1.052	0.890	52	2.913	5.461
3	1.052	0.890	53	2.913	5.461
4	1.052	0.890	54	2.913	5.461
5	1.052	0.890	55	2.913	5.461
6	0.769	0.485	56	3.358	4.207
7	0.769	0.485	57	3.358	4.207
8	0.769	0.485	58	3.358	4.207
9	0.769	0.485	59	3.358	4.207
10	0.769	0.485	60	3.358	4.207
11	0.769	0.485	61	3.358	4.207
12	0.769	0.485	62	3.358	4.207
13	0.769	0.485	63	3.358	4.207
14	0.769	0.485	64	3.358	4.207
15	0.769	0.485	65	3.358	4.207
16	1.537	0.526	66	3.641	3.479
17	1.537	0.526	67	3.641	3.479
18	1.537	0.526	68	3.641	3.479
19	1.537	0.526	69	3.641	3.479
20	1.537	0.526	70	3.641	3.479
21	1.537	0.526	71	3.641	3.479
22	1.537	0.526	72	3.641	3.479
23	1.537	0.526	73	3.641	3.479
24	1.537	0.526	74	3.641	3.479
25	1.537	0.526	75	3.641	3.479
26	1.982	3.560	76	3.803	2.872
27	1.982	3.560	77	3.803	2.872
28	1.982	3.560	78	3.803	2.872
29	1.982	3.560	79	3.803	2.872
30	1.982	3.560	80	3.803	2.872
31	1.982	3.560	81	3.803	2.872
32	1.982	3.560	82	3.803	2.872
33	1.982	3.560	83	3.803	2.872
34	1.982	3.560	84	3.803	2.872
35	1.982	3.560	85	3.803	2.872
36	2.589	5.623	86	3.924	2.346
37	2.589	5.623	87	3.924	2.346
38	2.589	5.623	88	3.924	2.346
39	2.589	5.623	89	3.924	2.346
40	2.589	5.623	90	3.924	2.346
41	2.589	5.623	91	3.924	2.346
42	2.589	5.623	92	3.924	2.346
43	2.589	5.623	93	3.924	2.346
44	2.589	5.623	94	3.924	2.346
45	2.589	5.623	95	3.924	2.346
46	2.913	5.461	96	4.005	1.942
47	2.913	5.461	97	4.005	1.942
48	2.913	5.461	98	4.005	1.942
49	2.913	5.461	99	4.005	1.942
50	2.913	5.461	100	4.005	1.942

Source: Smith et al. 2006

Social Cost of Carbon With Real Annual Increase of 2.5%			
Year	$/ton of carbon dioxide equivalent	Year	$/ton of carbon dioxide equivalent
2012	$13.33	2062	$45.80
2013	$13.66	2063	$46.94
2014	$14.00	2064	$48.12
2015	$14.35	2065	$49.32
2016	$14.71	2066	$50.55
2017	$15.08	2067	$51.82
2018	$15.45	2068	$53.11
2019	$15.84	2069	$54.44
2020	$16.24	2070	$55.80
2021	$16.64	2071	$57.20
2022	$17.06	2072	$58.63
2023	$17.48	2073	$60.09
2024	$17.92	2074	$61.60
2025	$18.37	2075	$63.14
2026	$18.83	2076	$64.71
2027	$19.30	2077	$66.33
2028	$19.78	2078	$67.99
2029	$20.28	2079	$69.69
2030	$20.78	2080	$71.43
2031	$21.30	2081	$73.22
2032	$21.83	2082	$75.05
2033	$22.38	2083	$76.92
2034	$22.94	2084	$78.85
2035	$23.51	2085	$80.82
2036	$24.10	2086	$82.84
2037	$24.70	2087	$84.91
2038	$25.32	2088	$87.03
2039	$25.95	2089	$89.21
2040	$26.60	2090	$91.44
2041	$27.27	2091	$93.72
2042	$27.95	2092	$96.07
2043	$28.65	2093	$98.47
2044	$29.37	2094	$100.93
2045	$30.10	2095	$103.45
2046	$30.85	2096	$106.04
2047	$31.62	2097	$108.69
2048	$32.41	2098	$111.41
2049	$33.22	2099	$114.19
2050	$34.05	2100	$117.05
2051	$34.91	2101	$119.98
2052	$35.78	2102	$122.97
2053	$36.67	2103	$126.05
2054	$37.59	2104	$129.20
2055	$38.53	2105	$132.43
2056	$39.49	2106	$135.74
2057	$40.48	2107	$139.13
2058	$41.49	2108	$142.61
2059	$42.53	2109	$146.18
2060	$43.59	2110	$149.83
2061	$44.68	2111	$153.58

Source: Shaw et al. 2009 and Nordhaus 2008

Relevant Projects

Water supply augmentation

Culvert replacement

Road Reconstruction

See Also

Avoided cost of climate change from carbon sequestration or avoided carbon release (page 34)

Benefits of Investments Built Capital

Avoided Electricity Costs

If the project decreases the amount of energy used to pump, convey, or treat water, it provides a benefit equal to the value of avoided energy costs.

Potential Biophysical Units: Energy units (kWh) per year; Acre-feet of water pumped per year.

Potential Economic Unit Value: $ per kWh per year. As of October 2012, the average price of electricity (per kWh) in the San Francisco-Oakland-San Jose, California Metropolitan Area was $0.218 (Bureau of Labor Statistics 2012). This area includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma Counties in California.

If information on the project-specific change in electricity use is available, it can be multiplied by local electricity prices over the appropriate time frame to estimate the value of the benefit.

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value. If the actual price of electricity differs with the estimate and varies over time, this benefit could be an over or underestimate of the true value.

Beneficiaries: The irrigators and municipal, commercial, or industrial water-service ratepayers who would pay less in electric costs each year.

Decreased Operation and Maintenance Costs

If the project decreases any operation and/or maintenance costs not accounted for in other benefit categories, count those benefits here. The value of the benefit is equal to the avoided operation and maintenance costs per year.

Potential Biophysical Units: Project specific.

Potential Economic Unit Value: Avoided costs associated with labor and capital. If information on the project-specific change in operation and maintenance activities is available, it can be multiplied by the cost of those units over the appropriate time frame to estimate the value of this benefit. If no information on the project-specific wages associated with labor for operations and maintenance is available, use area- and industry-specific median hourly wage rates listed by the Bureau of Labor Statistics. For example, the median hourly wage for general maintenance and repair workers in the San Francisco-Oakland-Fremont MSA is $21.19 (BLS 2011).

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value.

Beneficiaries: The operators and ratepayers in each system.

Avoided Costs Associated with Catastrophic Failure and Emergency Repairs

If a project decreases the frequency and/or severity of potential future emergency repairs, it provides a benefit equal to the costs of those avoided repairs.

Potential Biophysical Units: Project specific.

Potential Economic Unit Value: **Avoided costs associated with labor and capital to make the emergency repair.** If the project avoids costs associated with emergency repairs, the value of those costs may be included as a benefit. To calculate this benefit, you must have information on the project-specific change in the probability of the necessity for emergency operation and maintenance activities. Given this information, you can multiply these units by their probability-weighted costs over the appropriate time frame to estimate the value of this benefit. If no information on the project-specific wages associated with labor for operations and maintenance is available, use area- and industry-specific median hourly wage rates listed by the Bureau of Labor Statistics. For example, the median hourly wage for general maintenance and repair workers in the San Francisco-Oakland-Fremont MSA is $21.19 (BLS 2011).

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value.

Beneficiaries: The operators and ratepayers in each system. Other potential beneficiaries include taxpayers at the state and federal level, who incur costs through disaster relief agencies such as FEMA, and other emergency-service entities, for example the Red Cross.

Avoided Costs of Road Maintenance

If the project improves roadway conditions resulting in a decrease in future road-related maintenance costs, it provides a benefit equal to the value of the avoided maintenance costs.

Potential Biophysical Units: Miles of road; Avoided maintenance costs.

Potential Economic Unit Value: Avoided costs associated with labor and capital for road-related maintenance.

To avoid double-counting with previous maintenance-related benefits, the value of this benefit should reflect only those additional avoided costs.

If no information on the project-specific wages associated with labor for operations and maintenance is available, use area- and industry-specific median hourly wage rates listed by the Bureau of Labor Statistics. For example, the median hourly wage for general maintenance and repair workers in the San Francisco-Oakland-Fremont Area is $21.19 (BLS 2011). The median hourly wage rate for paving, surfacing, and tamping equipment operators in the San Francisco-Oakland-Fremont MSA is $30.65 (BLS 2011).

Sources of Uncertainty and Risk: Describe the robustness of biophysical estimates and what assumptions they are based on. Sources of uncertainty that apply to biophysical units also apply to economic value.

Beneficiaries: The land managers and other property owners responsible for the maintenance of the roads and/or the operators and ratepayers in each system.

Benefits from Investments in Human Capital

Reduced Costs of Future Projects

This benefit reflects efficiencies gained when people who complete projects refine skills and knowledge required to complete an activity. This might range from engineers employing innovative channel reconstruction techniques to volunteers planting trees—people who know what they are doing and do it well save time and money.

Potential Biophysical Units: N/A

Potential Economic Unit Value: **Not monetized.** Describe the skills or knowledge the project will help people develop or refine. Describe challenges that might be encountered and overcome. Provide as much detail as you can. Look to past projects to provide examples of when this has occurred, and explain why it is likely to occur in this project.

Sources of Uncertainty and Risk: This is a difficult category of benefit to quantify in either physical or monetary terms. Sometimes the benefits of a project aren't fully understood until a project is completed.

Beneficiaries: Sponsors of future projects; taxpayers.

Improvements in Participants' Well-Being

This benefit reflects improvements in well-being people experience by working on restoration projects, whether through a volunteer experience, educational curriculum, or other form of engagement.

Potential Biophysical Units: N/A

Potential Economic Unit Value: **Not monetized.** Describe the ways the project may enrich people's lives, including who might benefit and how they might benefit. These descriptions might take the form of anecdotes, but if you have data demonstrating tangible effects (e.g., better educational outcomes, increase in overall volunteer rates) include those.

Sources of Uncertainty and Risk: This is a difficult category of benefit to quantify in either physical or monetary terms. Sometimes the benefits of a project aren't fully understood until a project is completed.

Beneficiaries: Volunteers, project participants, and others in the community that participate or are exposed to the project as well as the communities within which they live; project participants, and others who gain new skills to market

Relevant Projects

Any project that involves innovative techniques, new approaches, volunteers, education, or citizen engagement has the potential to produce these benefits.

Relevant Projects

Any project that involves extensive facilitation or stakeholder involvement, addresses contentious issues through cooperation, or emphasizes building new connections between community members may produce these benefits.

Benefits from Investments in Social Capital

Reduced Costs of Future Projects

This benefit reflects efficiencies gained when investments in facilitation and networking result in stronger relationships between stakeholders. Building or strengthening these relationships through on project may result in future projects being completed at lower cost (either through reduced facilitation costs or faster completion times).

Potential Biophysical Units: N/A

Potential Economic Unit Value: Not monetized. Social capital is valuable in that it enhances the capacity of community members to engage in and complete future projects. They may include activities in which volunteers, project participants, or others in the community connect with each other in workshops, forums, or committees. Describe the ways the project might build new relationships or strengthen existing networks in ways that lead to greater capacity to solve problems or undertake new projects. Provide as much detail as you can. Look to past projects to provide examples of when this has occurred, and explain why it is likely to occur in this project.

Sources of Uncertainty and Risk: This is a difficult category of benefit to quantify in either physical or monetary terms. Sometimes the benefits of a project aren't fully understood until a project is completed.

Beneficiaries: Sponsors of future projects; taxpayers; residents of communities where relationships are strengthened.

Avoided Water Resources Conflicts

If the project provides opportunities for public involvement in water management, avoids or resolves existing conflict as evidenced by recurring fines or litigation, or helps meet an existing state mandate, it provides avoided conflict benefits.

Potential Biophysical Units: N/A

Potential Economic Unit Value: Not monetized. Describe and quantify potential conflicts and how this project may avoid them through investments in social capital.

Sources of Uncertainty and Risk: This is a difficult category of benefit to quantify in either physical or monetary terms. Sometimes the benefits of a project aren't fully understood until a project is completed.

Beneficiaries: Sponsors fo future projects; taxpayers; property owners where conflicts might arise.

Other Potential Benefits Related to Human Well-being

There are many ways environmental projects can lead to improvements in people's well-being besides those listed on the preceding pages. It is very difficult, however, to establish credible cause-and-effect relationships that tie a specific project to a specific outcome in an individual. That doesn't mean these effects don't exist or that their value is zero in an economic sense, only that they are currently beyond our ability to thoroughly understand and assign a specific value to them.

If you think your project will have some of these effects, describe them and their specific relationship to the project, using specific data (e.g., number of people likely affected) whenever possible.

Human health improvements: Researchers have linked access to green spaces, improved air quality, and scenic views to better mental and physical health through studies of specific populations (e.g., hospital residents, depressed individuals, asthma suffers). Some of these effects, such as improved air quality, have been quantified in both biophysical and economic terms. It is very difficult, however, to establish a cause-and-effect relationship between the effects of a small improvement in air quality from an environmental enhancement project, which is required before quantifying economic benefits. It is easier to do this for large projects with substantial reductions in pollutants across large populations.

Cultural heritage and sense of place. The special features of ecosystems, such as rivers, mountains, or an individual tree or animal species can hold important cultural values that positively affect individual well-being by reinforcing social capital and providing motivation and space for building human capital. For example, some species of fish reinforce special cultural values for Native Americans who rely on the fish for subsistence, cultural identity, and spiritual significance. We address this with Salmon populations above, but it applies to other elements of the landscape as well as more general notions of place.

How do I account for benefits that occur at different times, or at different intervals, within the period of analysis?

That depends. Benefits and costs do not always start immediately after a project is completed, and some benefits may not occur every year. You may not even be sure when a particular benefit might materialize.

The timing of a benefit matters, because of discounting (benefits that materialize later in time will be worth less today), so it's important to put a little bit of thought into when your benefits might actually occur.

There are three basic ways benefits can materialize over time. Use this guide to select the appropriate categorization for calculation.

Benefits that occur one time in one year. Benefits can occur in a single year, either now or in the future. For example, a project that avoids a sediment reduction project would avoid costs in one year (the year in which that project would have occurred).

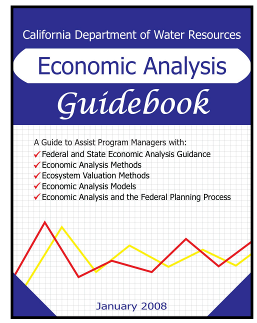
Benefits that occur predictably over a number of years. Some benefits may materialize predictably over a number of years. For example, a project that increases instream flows would generate benefits for each year those flows are increased over the base flow. This might be every year continuously, or once every 10 years. Calculate this benefit by including the value in each year when it would occur, starting with the first year the benefits will accrue and extending over the life span of the project or the final year the benefit would occur (these don't necessarily need to be the same).

Benefits that likely would occur, but the timing is uncertain. Some benefits arise from events whose timing is naturally unpredictable. For example, a project that would protect local residents from property damage given a flood event would only result in benefits if the flood occurs. Calculate this benefit by multiplying the total annualized benefit (e.g., the value of avoided flood damages) by the percentage probability of the event occurring in a given year. For example, if a project is expected to reduce flood damages by $100,000 during every 100-year flood, you would multiply the expected benefit by 1% and count it every year. Do this before you apply a discount factor.

4: Additional Resources

These resources provide more detailed descriptions and methodological instructions for how to value environmental benefits and conduct benefit-cost analyses. They build on the information presented in this handbook to provide in-depth instruction on the valuation methods and analytical techniques used in benefit-cost analysis.

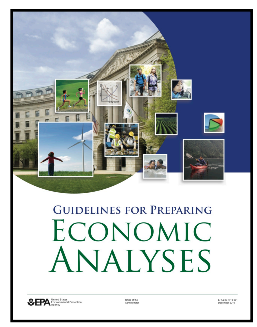
DWR's Economic Analysis Guidebook



DWR adopted, maintains, and periodically updates its own guidelines for conducting economic analysis that is consistent with federal guidelines, but with specific applications and examples for California. DWR developed the *Economic Analysis Guidebook* to assist economists in performing economic analyses and to explain economics concepts, methods, and tools to non-economist staff, program managers, and management within DWR.

California Department of Water Resources. 2006. Economic Analysis Guidebook. January.

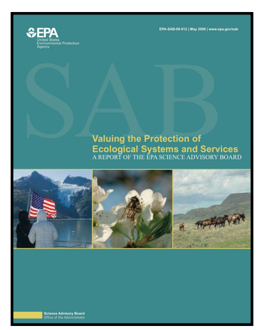
U.S. EPA's Economic Analysis Guidebook



The U.S. EPA's Guidelines for Preparing Economic Analyses establish a sound, nationally accepted framework for performing economic analyses. The Guidelines provide instructions for analyzing the benefits, costs, and economic impacts of regulations and policies. The general framework and instructions detailing methods and assumptions are applicable to any application of economic analysis.

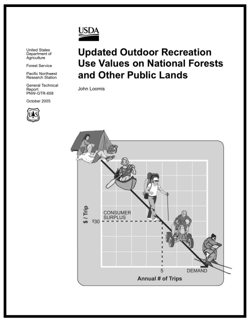
U.S. Environmental Protection Agency. 2010. Guidelines for Preparing Economic Analysis. December.

U.S. EPA's Valuing the Protection of Ecological Systems and Services



The EPA's Science Advisory Board created the Committee on Valuing the Protection of Ecological Systems and Services, which put together this report. It describes and reviews the best practices and state of the science for ecological valuation. It also provides recommendations to the Environmental Protection Agency for improving the current approach to ecological valuation and for supporting new research to strengthen the science base for future valuations.

U.S. Environmental Protection Agency Science Advisory Board. 2009. Valuing the Protection of Ecological Systems and Services. May.



Outdoor Recreation Use Values

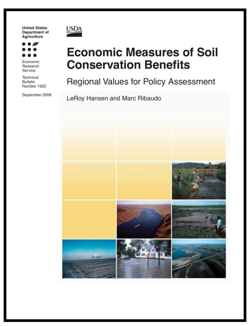
This report summarizes and analyzes the literature on economic value of outdoor recreation on public lands. The report provides average willingness to pay or consumer surplus per day for 30 recreation activities at the national level. The report also presents values per day by recreation activity by census region of the United States. These values are generally applicable, using the recommended approaches, to outdoor recreation on any public lands.

Loomis, J. 2005. Updated Outdoor Recreation Use Values on National Forests and Other Public Lands. U.S. Department of Agriculture. Forest Service Pacific Northwest Research Station. October.

Economic Value of Streamflow: Evidence from Markets

The report uses evidence from water market transactions to report the quantities, prices, buyers and sellers, and applications of water purchases by state throughout the western U.S. The report summarizes statistics of these transactions over time to draw general conclusions about the value of instream flows for different purposes and geographies.

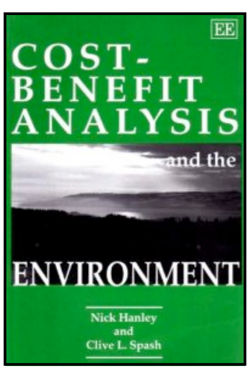
Brown, T. 2007. The Marginal Economic Value of Streamflow from National Forests: Evidence from Western Water Markets. U.S. Forest Service Rocky Mountain Research Station.



Economic Measures of Soil Conservation Benefits

This report describes data and methodologies that the Economic Research Service has used to apply monetary values to changes in soil erosion and deposition. The report presents regional benefit values in dollar-per-ton measures for 14 different categories of soil conservation benefits.

Hansen, L. and M. Ribaudu. 2008. Economic Measures of Soil Conservation Benefits: Regional Values for Policy Assessment. U.S. Department of Agriculture Economic Research Station.



Cost Benefit Analysis and the Environment

This book provides a discussion of the key issues surrounding the incorporation of environmental factors into modern cost-benefit analysis. The book also uses a number of case studies to reinforce its concepts.

Hanley, N. and C. Spash. 1995. Cost-Benefit Analysis and the Environment. Edward Elgar Pub.

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