SPECIAL BENEFIT FROM ECOSYSTEM SERVICES

ECONOMIC ASSESSMENT OF THE KING CONSERVATION DISTRICT

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Contents

Tables and Figures

Abbreviations

BMP	Best Management Practice
ESV	Ecosystem Service Valuation
GIEE	Gund Institute for Ecological Economics
GIS	Geographic Information System
KCD	King Conservation District
PV	Present Value
WRIA	Water Resource Inventory Area

Executive Summary

King Conservation District (KCD) programs and activities are vital to empowering landowners with knowledge, tools and methods for personal gain from ecosystem conservation. KCD programs and activities are also vital for securing and enhancing the common wealth that healthy lands, waters and ecosystems provide, special and irreplaceable benefits for the greater community. The District is particularly integral to the improvement of several key ecosystem services in the area: soil formation and retention, water regulation and supply, nutrient regulation, waste treatment, habitat functions, aesthetic value and other services providing special benefit to landowners and other stakeholders in the community.

Although rendered for free in terms of market price, these services have a high economic value. The majority of economic value, or special benefits, provided by ecosystem services is produced as economically non-excludable services for landowners as well as members of the general public. This report estimates the economic value of conservation programs and activities that provide extensive special benefits to landowners and the general community. This case is made using ecosystem service valuation, the best available scientific method for quantitative analysis of the relationships between ecosystem health and economic benefit.

From this analysis, it is clear that KCD programs and activities are integral to maintaining and increasing landowner and community benefit. This report presents a preliminary economic case for several recommendations:

- Maintain a $10 per parcel Special Benefit Assessment rate funding the KCD and other conservation efforts.
- Increase the KCD portion of this rate to $3 per parcel due to the cost-effectiveness of KCD conservation work.
- Evaluate potential private and public economic value of a moderate 15-20% increase in these rates by 2010.

From our analysis, it is evident that increasing this rate will more than proportionately increase the economic value of special benefits received by landowners and other community members. This proposed change in the per parcel assessment rates ultimately amounts to a relatively small increase that is would result in significant increases in short and long term return on investment in natural capital.

The following points summarize estimates of the economic benefit from conservation activities. These estimates show vast value previously not considered by economic valuation methodologies. This analysis is only recently available through work by Earth Economics with the extensive research support of the Gund Institute for Ecological Economics at the University of Vermont.

1. Parcels assessed within the KCD cover 712,336 acres (532,640 individual parcels and 53,859 condominium units), for a total assessment of $2,932,495 at the pre-2006 Special Benefit Assessment rate of $5 per parcel; $586,499 of this funded KCD conservation programs and activities in 2005.

2. KCD ecosystems provide ecosystem services with an economic value of $8.70-32.3 billion annually.

3. These ecosystems can be managed as natural capital assets providing ongoing service and special benefits to public and private stakeholders. As such, they are conservatively estimated to have a minimum present value, discounted (rate noted) and calculated in perpetuity, of $124 billion (7%), $173 billion (5%), or $247 billion (3.5%).

4. Long-term value providing special benefits to current and future generations from ecosystems in the KCD is estimated to have a total economic present value of $867 billion-3.2 trillion (100 years), $2.1-8.0 trillion (250 years), $4.3-16.1 trillion (500 years), with no discounting of benefits to future generations.

5. The current annual Special Benefits Assessment of $10 per parcel is still less than .003% of the total annual value of special benefit from ecosystem services produced by these natural capital assets.

6. Built capital asset management budgets commonly include 5-10% of total asset value in annual maintenance expenses. This rule of thumb would support a minimum budget of $6.2 million, over $10,500 per parcel, in annual combined public and private conservation investment within the District area until those ecosystems are at a healthy state that does not require conservation maintenance.

7. A rapid partial appraisal of the value from KCD programs and activities in 2005 estimates the direct net special benefit after costs of $18,221-$494,538 in the first year alone. Indirect special benefit from landowner implementation of Best Management Practices results in an estimated value of $4.5-$16.4 million, again in the first year alone and not considering landowner investment.

8. The long-term present value of special benefit from KCD programs and activities in 2005 is projected in perpetuity to have an estimated value of $4.8-$6.7 million directly from KCD activities. An additional $90.5-$327.3 million is estimated as the indirect special benefit resulting from landowner implementation of Best Management Practices.

9. KCD programs and activities are very cost-effective, as measured by a ratio of total special benefit to total costs. A high return on investment is evident from the 2005 Special Benefit Assessment rate of $1 per parcel for the KCD: $4.22-$5.95 of value from direct special benefit, more in indirect benefit.

10. Current and proposed future rates of Special Benefit Assessment are expected to demonstrate the same rate of return on investment with minimal variance: a return of $8.44-11.90 per parcel in long-term value is estimated for the $2 per parcel funding the KCD in 2006 and $12.66-17.85 per parcel in long-term value is estimated from the proposed $3 per parcel assessment fee allocation to KCD.

11. Any increase or decrease in KCD funding would result in a corresponding gain or loss of at least 422-595% as much in economic value of special benefits from ecosystem services enhanced by KCD programs. Combined with grant programs for landowners, such highly cost-effective conservation activities multiply the economic benefit for landowners as well as the general community.

12. Over 98% of the special benefits from ecosystem services are produced as economically non-excludable services, providing beneficial value to landowners and the general public. Market valuation methods provide no quantification of this value.

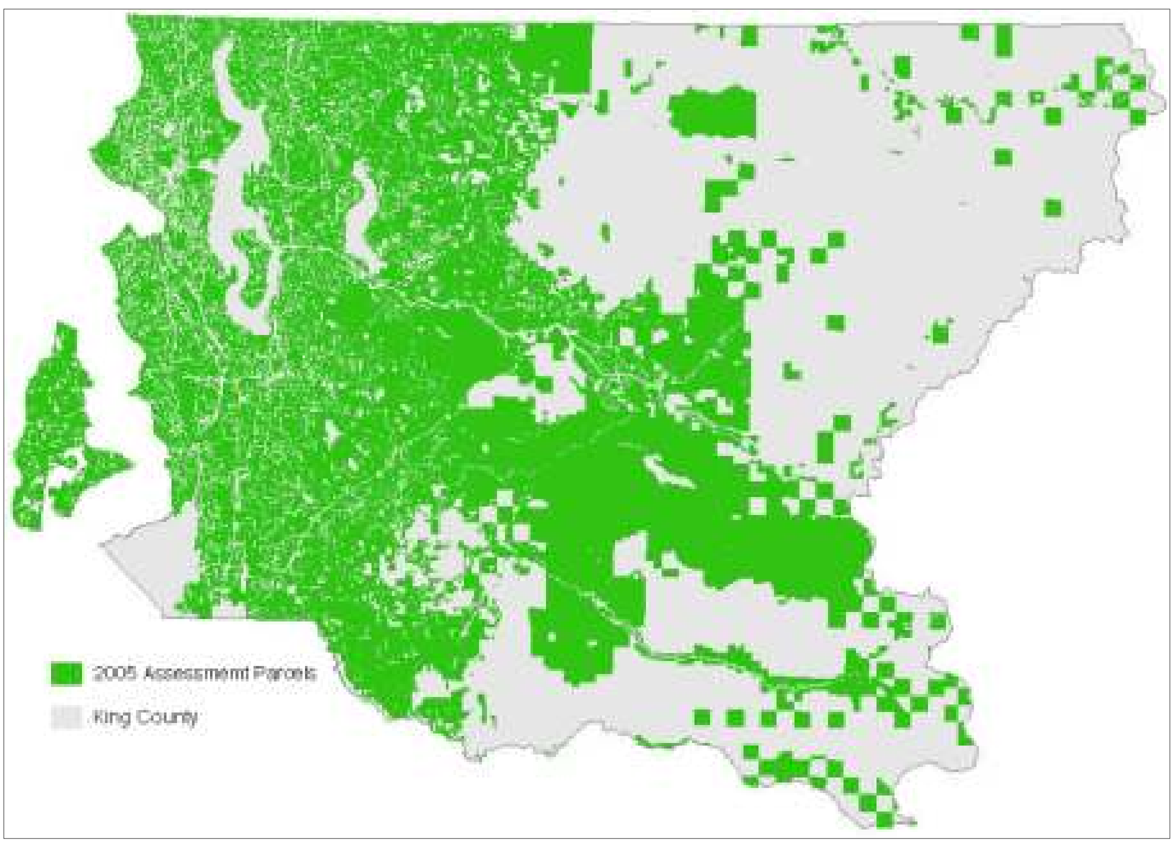
13. The benefit from KCD activities cannot be captured with the current methods for formal appraisal of real estate value. In some cases, close proximity to healthy ecosystems in public open space increases property values by as much as 8-20% (Crompton, 2001). The total economic value of ecosystems is only recently being understood.

Introduction

This report analyzes the special benefits arising from ecosystems in the King Conservation District by using an economic methodology for valuation of the ecological goods and services. The King Conservation District Assessment Area has a large wealth of valuable natural capital assets in the form of thousands of acres of healthy ecosystems. These natural capital assets provide extensive value in terms of special benefits; these benefits are best understood as services provided by the ecosystems. The current assessment of $10 per acre (RCW 89.08.400) funds conservation programs and assistance activities provided by the KCD, WRIAs, and individual municipalities help maintain and improve the quality and economic value of ecosystem services. This funding creates a cost-effective conservation economy of scale that in turn provides value to landowners and the community.

This report shows that this Special Benefit Assessment is only a fraction of a percent of the total economic value provided to individual landowners and the greater community. Economic assessment of the economic value of ecosystems and conservation efforts is important for setting a scale to appropriate public and private funding; particularly since RCW 89.08.400 states that "the special assessments to be imposed on any land will not exceed the special benefit that the land receives or will receive from the activities of the conservation district." Scientists focused on environmental and ecological economics are only recently developing adequate assessment tools.

The total number of parcels subject to the Special Benefits Assessment fee, referred to in this report as the District's "assessment area," is significantly smaller than the larger King County as a whole due to several categories of land removed from the assessment. These include but are not limited to the United States Department of Agriculture Forest Service and other federal lands, Washington State Department of Natural Resources lands, several municipalities (Enumclaw, Federal Way, Skykomish, Pacific, Milton) and various other landowners who have legally opted out of the assessment. The map below shows in



green those parcels that are subject to the assessment fee funding the KCD and other regional conservation activities.

In order to analyze the economic value of ecosystems, this report uses a natural capital approach to policy and asset management; identifying and estimating the value of those goods and services produced by natural capital. This report builds on the following recent work completed by Earth Economics: the Water Resource Inventory Area 9 (WRIA 9) Steering Committee and the King County Department of Natural Resources in support of salmon habitat restoration (Batker et. al., 2005), the Seattle Public Utilities Tolt River Watershed Asset Management Plan (Earth Economics, 2005), and a General Technical Report currently in press for the United States Department of Agriculture Forest Service Pacific Northwest Research Station.

While ecosystem and resource management decisions typically focus on "built capital" and financial efficiency, the communities comprising the KCD are critically dependent not only on built capital but also on "natural capital" for provision of water, drainage, electricity, flood protection, and other benefits. Watersheds and other ecosystems are capable of providing a full range of the 23 identified categories of ecological goods and services. A better understanding of the relationships between watershed ecosystem health and the provision and value of these goods and services can inform conservation planning and implementation.

The next section describes the key concepts for including natural capital in conservation planning and implementation decisions and the study approach followed by the results of our analysis in the King Conservation District Special Benefits Assessment area or of KCD programs and activities.

1. Key Concepts

The science of economics has advanced significantly in recent years improving our ability to quantify the value and impacts of resource management actions. Research since 1985 has developed and refined methods, tools, and techniques for measuring the value produced by natural systems. These include new concepts such as "natural capital" and new techniques including ecosystem service valuation. This section gives an overview of these concepts as a foundation for understanding the analysis results.

1.1. Special Benefit Assessment

Special benefit assessment for natural resource conservation is outlined in the Revised Code of Washington State Title 89 Chapter 89.08 Section 400. This legislation establishes that "activities and programs to conserve natural resources, including soil and water, are declared to be of special benefit to lands and may be used as the basis upon which special assessments are imposed." This legislation does not provide a complete definition of special benefit, nor does it provide adequate means for summarizing the total economic value of special benefit resulting from natural resource conservation activities, in part because of the aforementioned limitations of conventional economic valuation methods. Ecosystem service valuation provides a classification and valuation methodology suitable for estimating the special benefit that results from natural resource conservation.

1.2. Natural Capital and Asset Management

In the past, ecosystems and natural resources, or natural capital, have been viewed as free and virtually limitless compared to human-built capital, therefore of no value. Given the increasing scarcity of healthy ecosystems, the valuation of natural capital helps decision makers identify costs and benefits, evaluate alternatives, and make effective and efficient management decisions. Scientific methods for estimating the economic value of natural capital helps decision makers identify otherwise hidden costs and benefits, evaluate alternatives, and make effective and efficient management decisions. Excluding natural capital in asset management can result in significant losses, increased costs, and decreases in efficiency and community benefit.

1.2.1. Understanding Natural Capital

Natural capital is comprised of geology, nutrient and water flows, native plants and animals, and the network of natural processes that yield a continual return of valuable benefits (Daly and Farley 2004). Natural capital contributes to our economy and quality of life in many ways that are not currently included in policy considerations. This includes provision of water, natural water filtration, energy production, flood control, recreation, natural storm water management, biodiversity, and education. Consideration of the King Conservation District Assessment Area and other ecosystems as natural capital helps provide a more complete view of ecosystem health and the production of valuable benefits.

1.2.2. Economics of Natural Capital

Healthy ecosystems are self-maintaining, they have the potential to appreciate in value over time and provide an ongoing output of valuable goods and services in perpetuity. In contrast, built structures and other man-made capital have the tendency to depreciate in value over time and require significant financial inputs for operation and maintenance. By incorporating natural capital with conservation planning and implementation, the KCD can expand the capacity of ecosystems to produce economic value and community benefit.

Public and private landowners have a unique opportunity to understand the full economic importance of ecosystems in services. The provision and filtration of water is a good example. New York City in 1997 acted to enhance natural capital rather than invest in greater built capital for drinking water provision. New York City consumes over one billion gallons of water each day. Facing degraded drinking water quality, New York City weighed the option of building a water filtration plant at a cost of over $7 billion or investing $1.5 billion to restore the health of the watershed and allow natural ecosystems to filter the water to meet drinking water standards. The City decided to invest in watershed restoration. That option was a less costly and less risky for providing one billion gallons of water and meeting drinking water standards. It also had a higher rate of return on investment.

Ecosystems in the King Conservation District Assessment Area can be managed in a way that optimizes the aggregate value of goods and services with potential to benefit present and future generations. This requires ongoing assessment of KCD programs and activities in terms of the economic value of these conservation improvements on special benefit from ecosystem services.

1.3. Ecosystems and Value Production

Ecosystems are composed of individual structural components (trees, forests, soil, hill slopes, etc.) and dynamic processes (water flows, nutrient cycling, animal life cycles, etc.). These components and processes create functions (water catchment, soil accumulation, habitat creation, etc.) generating ecological goods and services (salmon, timber, flood protection, recreation, etc.). Figure 1 below summarizes these relationships in a simplified diagram. Ecosystem infrastructure is comprised of the particular physical components within given boundaries of the ecosystem. The infrastructure itself is dynamic, as biotic structures migrate and abiotic components flow through the watershed, often via air or water. These functions vary widely in spatial boundaries (oxygen migrates globally, spawning habitat is locally confined). Thus ecosystems may provide benefits that extend globally (carbon sequestration) or locally (drinking water production). These structures, processes, and functions combine to produce economically valuable goods and services.

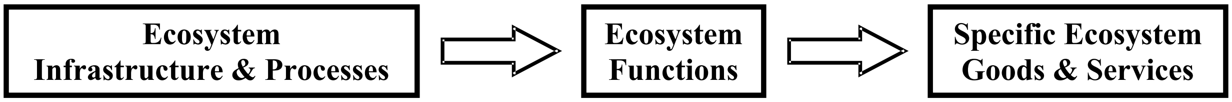


Figure 1. Relationship of Ecosystems to the Goods and Services Produced

Ecosystem service valuation assigns a dollar value on goods and services provided by a given ecosystem. This allows for proposed management policies to be considered in terms of their ability to improve ecological processes that produce the full diversity of valuable ecosystem goods and services. In this particular case, KCD conservation programs and activities may directly help to enhance the natural air purification or water filtration services provided by ecosystems through the implementation of restoration projects or BMPs. Restoring these ecological processes to a natural range of variability maintains structure and the ecological goods and services that follow.

1.3.1. Ecosystem Goods

Ecosystems provide a variety of useful goods such as water, timber, and fish. Most goods are excludable: if one individual owns or uses a particular good, that individual can exclude others from owning or using the same good. For example, if one person eats an apple, another person cannot eat that same apple. Excludable goods can be traded and valued in markets. The production of goods can be measured by the physical quantity produced by an ecosystem over time, such as the volume of water production per second, board feet of timber production in a 40-year rotation, or the weight of fish harvested each year. The current production of goods can be easily valued by multiplying the quantity produced by the current market price. Over time, this production creates a flow of ecosystem goods.

1.3.2. Ecosystem Services

Ecological services are defined as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life” (Daily et al., 1997). Ecosystems provide a variety of services that individuals and communities use and rely upon, not only for their quality of life, but also for economic production (Daily, 1997; Costanza et al., 1997). Ecosystem services are measurable benefits that people receive from ecosystems. The productivity of ecosystems in producing goods and services is a result of ecosystem process, function, and structure.

The stream of services provided by an ecosystem is referred to as a “service flux.” A flow of goods can be measured in quantitative productivity over time while a service flux is generally more difficult to measure and value. Ecosystem services are in many cases non-excludable services. As a result of this non-excludability, most ecosystem services are not sold in markets.

For example, a healthy watershed provides aesthetic value to anyone who looks at it. All people downstream benefit from the flood protection afforded by a forested watershed as opposed to a scoured watershed. Many ecosystem services, such as natural water filtration and storm protection, are not sold in markets. The stream of services provided by an ecosystem is referred to as a “service flux.” A flow of goods can be measured as quantitative productivity over time while a service flux generally cannot. As a result, ecological services are more difficult to measure and value than goods.

Table 1. Examples of Ecosystem Services (from Dailly et. al., 1997)

Purification of the air and water
Mitigation of floods and droughts
Recreation
Detoxification and decomposition of wastes

Generation and renewal of soil and soil fertility
Pollination of crops and natural vegetation
Control of the vast majority of potential agricultural pests
Dispersal of seeds and translocation of nutrients
Maintenance of biodiversity
Protection from the sun's harmful ultraviolet rays
Partial stabilization of climate
Moderation of temperature extremes and the force of wind and waves
Support of diverse human cultures
Provision of aesthetic beauty

1.3.3. The Value of Ecosystem Services Relative to Ecosystem Goods

While the value of a service flux may be more difficult to measure, its value may, in many cases, significantly exceed the value of the flow of goods. A study of Philippine mangroves showed that the services of storm protection and nursery functions (85% of commercial fish species are dependent on the mangroves for a period of time within their lifecycle) produced several times the value of shrimp aquaculture operations that replaced the mangrove ecosystems (Boumans et al., 2004).

1.3.4. Process, Function, Structure and Value Production

The quality, quantity, reliability, and combination of goods and services provided by the ecosystems within a watershed depend highly on the structure and health of the ecosystems within the watershed. Structure refers to a specific arrangement of ecosystem components. The importance of ecosystem structure can be understood by using a car as a metaphor. The steel, glass, plastic and gasoline that comprise a car must retain a very particular structure to provide transportation service. Absent a car's structure and having just a pile of the same constituent materials, this "car" cannot provide transportation service. Salmon require certain processes, structures, and conditions. Ecological service production is more dependent on structure than the flows of goods. A single species timber plantation may yield a flow of goods (such as timber) but it cannot provide the same service fluxes (biodiversity, recreation and flood protection) as an intact natural forest.

1.3.5. Integrated Ecosystems

A heart or lungs cannot function outside the body. The human body cannot function without a heart and lungs. Good health requires organs to work as part of a coordinated system. The same is true for ecosystems. Interactions between the components make the whole greater than the sum of its individual parts. Each of the physical and biological components of the watershed, if they existed separately, would not be capable of generating the same goods and services provided by the processes and functions of an intact watershed system (EPA, 2004). In addition, ecosystem services are systems of enormous complexity. Individual services influence and interact with each other, often in nonlinear ways (Limburg et al., 2002).

1.3.6. Value of Ecosystem Services "In Perpetuity"

Healthy intact ecosystems are self-organizing, require no maintenance and do not depreciate in value over time. They can provide valuable ecological goods and services on an ongoing basis "in perpetuity" and without cost to humans, but only if these ecosystems are healthy and intact. A forest provides water control, flood protection, aesthetic and recreational values, slope stability, biodiversity and other services without maintenance costs. This differs from human-produced goods and services (cars, houses, energy, telecommunications, etc.) that require maintenance expenditures, dissipate, may depreciate, and usually end up discarded, requiring further energy inputs for disposal or recycling. Destruction of ecosystem functions thus disrupts an ongoing flux of valuable ecological services. Filling flood plains increases flooding. When an ecosystem's free natural flood prevention functions are destroyed, flood damage will exact continuing costs on individuals and communities who must either suffer flood damage, or pay for engineering structures and storm water infrastructure to compensate for the loss. Without healthy ecosystems, taxpayers, businesses and governments incur damage or costs to repair or replace these ecosystem services. When ecological services are restored, the reverse dynamic can occur.

2. Economic Valuation of Ecosystem Services as Special Benefits

The methodology for valuing ecosystem services involves the identification and categorization of ecological services, Geographic Information System (GIS) data, and peer-reviewed studies of market and non-market values through direct use and indirect use valuation methods.

Analysis began with GIS data on land-use and vegetative landcover compiled for the study site from 2002 LandSat Landcover data obtained from King County. Additional data from the 1992 LandSat Landcover data set were also used to distinguish between grassland/shrubland and agricultural/pasture lands that were not distinguished in the 2002 data. These data were applied to those land parcels and condominiums that were included in the King Conservation District Special Benefits Assessment Area in 2005.

Economic valuation data from peer reviewed academic journal articles were aggregated using a benefit transfer methodology to estimate a high and low dollar value range for a list of 23 ecosystem services (water purification, flood control, climate regulation, etc.). Economic modeling was used to integrate data on the health estimates from KCD staff as well as tree mortality rates and other variable criteria. Initial analysis resulted in a rough-cut total valuation of ecosystem goods and services provided by each area annually. Long-term economic value was also calculated using a present value methodology to project the annual flow of ecosystem benefits over 100-500 years using several discount rates. The analysis process is discussed in the next sections in more detail.

2.1. Study Location: King Conservation District

The total area of the KCD is approximately 712,336 acres comprising 532,640 individual parcels with 53,859 condominium units on 1,862 total parcels. All of these parcels or condominium units are considered within the District's assessment area and subject to the Special Benefit Assessment fee. The ecosystems within this area include a patchwork of ecosystems: forest, agriculture and pasture, urban, shrubland and grassland, wetland, lakes and other waterways as well as coastal and other types of land cover or vegetation. The following sections will provide analysis of the extent, value, health, and productivity of these ecosystems and how they are improved by conservation.

2.2. Ecosystem Service Categorization

De Groot et al. (2002) categorized 23 ecosystem processes and functions of ecosystem services based on a review and synthesis of the valuation literature on ecological services (see Table 2). These are grouped into four function categories: 1) regulation, 2) habitat, 3) production, and 4) information. Regulation and habitat functions are considered essential functions that are necessary before production and information functions can be active (De Groot et al., 2002).

Table 2. Ecosystem Functions, Processes and Services (from De Groot et. al., 2002)

Functions		Infrastructure and Processes	Examples of Good and Service
Regulation Functions		*Maintenance of essential ecological processes and life support systems*	
1	Gas regulation	Role of ecosystems in bio-geochemical cycles	Provides clean, breathable air, disease prevention, and a habitable

			planet
2	Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favorable climate promotes human health, crop productivity, recreation, and other services
3	Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances	Prevents and mitigates natural hazards and natural events generally associated with storms and other severe weather
4	Water regulation	Role of landcover in regulating runoff and river discharge	Provides natural irrigation, drainage, channel flow regulation, and navigable transportation
5	Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers and snowpack)	Provision of water for consumptive use; includes both quality and quantity
6	Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintains arable land and prevents damage from erosion, and promotes agricultural productivity
7	Soil formation	Weathering of rock, accumulation of organic matter	Promotes agricultural productivity, and the integrity of natural ecosystems
8	Nutrient regulation	Role of biota in storage and re-cycling of nutrients	Promotes health and productive soils, and gas, climate, and water regulations
9	Waste treatment	Role of vegetation and biota in the removal or breakdown of xenic nutrients and compounds	Pollution control/detoxification, Filtering of dust particles through canopy services
10	Pollination	Role of biota in the movement of floral gametes	Pollination of wild plant species and harvested crops
11	Biological control	Population control through trophic-dynamic relations	Provides pest and disease control, reduces crop damage
Habitat Functions		*Providing habitat (suitable living space) for wild plant and animal species*	
12	Refugium function	Suitable living space for wild plants and animals	Maintenance of biological and genetic diversity (thus the basis for most other functions)
13	Nursery function	Suitable reproduction habitat	Maintenance of commercially harvested species
Production Functions		*Provision of natural resources*	
14	Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc.; small scale subsistence farming and aquaculture
15	Raw materials	Conversion of solar energy into biomass for human construction and other uses	Building and manufacturing; fuel and energy; fodder and fertilizer
16	Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens and pests
17	Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Drugs, pharmaceuticals, chemical models, tools, test and essay organisms

18	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	Resources for fashion, handicraft, jewelry, pets, worship, decoration and souvenirs
Information Functions		*Providing opportunities for cognitive development*	
19	Aesthetic information	Attractive landscape features	Enjoyment of scenery
20	Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
21	Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
22	Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e., heritage value of natural ecosystems and features)
23	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc., use of nature for scientific research

2.3. Benefit Transfer Methodology for Economic Valuation

The methodology of benefit transfer was used to conduct this economic valuation. Conducting original studies on every combination of ecological service, vegetation type and study location would be cost and time prohibitive, researchers have developed a technique called benefit or value transfer. Benefit transfer is a widely accepted economic methodology in which the estimated economic value of an ecological good or service is determined by examining previous valuation studies of similar goods or services in other comparable locations.

This valuation is akin to a house appraisal where an appraiser considers the market valuations (sales) of other houses in different locations, the similar and different attributes, and specific aspects of the house and property being appraised. The location, number of bedrooms, condition of the roof, basement, and view are additive values for estimating the full value of the house. These additive values provide different services and contribute to the total value of a house.

The Gund Institute for Ecological Economics (GIEE), the leading national ecological economics institution, has compiled a database of published, peer-reviewed ecological service valuation studies. The Ecosystem Service Database provides benefit transfer estimates based on landcover types and is updated as new literature becomes available.

The value of the ecosystem services described above is additive. An acre of forestland provides a water regulation and filtration service. It also provides aesthetic, flood protection and refugium benefits. One study may establish the value per acre of a watershed in water filtration for a drinking water supply. Another study may examine the value per acre of refugium for wildlife. To determine the full per acre value provided by a vegetation type, ecosystem service values are summed up and multiplied by the acreage.

The valuation techniques utilized to derive the values in the database were primarily developed within environmental and natural resource economics. As Table 3 indicates, these techniques include direct market pricing, replacement cost, avoided cost, factor income method, travel cost, hedonic pricing, and contingent valuation.

- ***Direct use value*** involves interaction with the ecosystem itself rather than the services it provides. It may be consumptive use such as the harvesting of trees or fish, or it may be non-consumptive such as hiking, bird watching, or educational activities.

- ***Indirect use value*** is derived from services provided by the ecosystem when direct values are not available. This may include the removal of nutrients, providing cleaner water downstream (water filtration), or the prevention of downstream flooding. Studies may derive values from associated market prices such as property values or travel costs. Values can also be derived from substitute costs like the cost of building a water filtration plant when natural ecosystem filtration services are disturbed and fail. Contingent valuation is an additional method that entails asking individuals or groups what they are willing to pay for a good or service.

Table 3. Methods for Primary Research in Ecosystem Service Valuation

Direct Use Values	
Market Price	Prices set in the marketplace appropriately reflect the value to the "marginal buyer." The price of a good tells us how much society would gain (or lose) if a little more (or less) of the good were made available.
Indirect Use Values	
Avoided Cost	Value of costs avoided by ecosystem services that would have been incurred in the absence of those services, (e.g., flood control provided by barrier islands avoids property damages along the coast).
Replacement Cost	Cost of replacing ecosystem services with man-made systems, as when nutrient cycling waste treatment are replaced with costly treatment systems.
Factor Income	The enhancement of income by ecosystem service provision (e.g., water quality improvements increase commercial fisheries catch and incomes of fishermen).
Travel Cost	Cost of travel required to consume or enjoy ecosystem services. Travel costs can reflect the implied value of the service, (e.g., recreation areas attract tourists whose value placed on that area must be at least what they were willing to pay to travel to it).
Hedonic Pricing	The reflection of service demand in the prices people will pay for associated goods (e.g., housing prices along the coastline tend to exceed the prices of inland homes).
Contingent Valuation	Value for service demand elicited by posing hypothetical scenarios that involve some valuation of land use alternatives, (e.g., people would be willing to pay for increased preservation of beaches and shoreline).
Group Valuation	Discourse-based contingent valuation which is arrived at by bringing together a group of stakeholders to discuss values to depict society's willingness to pay.

2.3.1. Present Value Calculation and Discounting

The assessment and management of ecosystem service flows earned over generations is a difficult challenge. The stream of benefits can reflect current costs of capital or other financial opportunity costs but due to social discount rates we tend to undervalue benefits that will be received in the future or by future generations. The discount rate assumes that the benefits we harvest in the present are worth more than the benefits provided for future generations, a view that those in the future may not share.

Discount rates used in public land management project appraisal can be based on a variety of rate sources including the prime rate of interest, the market rate of interest, and inferred social discount rate. Based on rates used for project appraisal by the Army Corps of Engineers, this report provides net present value (NPV) calculations with three discount rates: 3.5%, 5% and 7% discount rates. Since it is common for reduced discount rates to be applied to forestry projects, this also includes a zero discount rate analysis of long-term flows of ecosystem services.

The tendency of discounting to create present value maximization biases would encourage decision makers to select projects that pull short-term benefits into the present and push costs into the discounted future. Over the long-term, this increases the risk of potentially amplifying intergenerational inequities. In economic terms, potentially unsustainable management practices will tend to liquidate renewable resources for short-term gain at much greater long-term expense or loss of value.

Ecological economists solve this dilemma by defining a sustainable scale, one where basic ecosystem services within a watershed are kept intact. This ensures ecological sustainability and that future generations are not left with an unviable set of ecological systems. The vast majority of value provided by a healthy ecosystem is held in the indefinite future. Today, we reap a thin annual slice of benefits from this continuous stream of the 23 categories of ecosystem goods and services.

Ecosystems are assets, a form of wealth. Many ecosystem services are necessary for our survival: oxygen production, waste decomposition, and storm protection. This asset of natural capital provides a stream of benefits that current and future generations require. This is unlike non-renewable resources, such as burning gasoline or human-built capital, like a new car. They burn up, are used up, or depreciate to eventually become waste, requiring further energy inputs for recycling. The primary benefits of non-renewable and human-built capital are held closer to the present. This is an important distinction between natural and human-built capital. In addition, value is not fixed in time: the value of many ecological services rapidly increase as they become increasingly scarce (Boumans et al., 2002).

Healthy ecosystems are self-organizing, often not requiring maintenance. They do not depreciate, can provide goods and services, potentially in perpetuity, and hold vast amounts of value in the distant future. As a result, it is important to illustrate the value of these ecosystem services by considering their value without discounting.

A calculation of value produced by the King Conservation District Assessment Area using a zero discount rate was used to provide a glimpse of how members of the community would value the stream of future ecosystem service benefits. In fact, ecosystem services have increased in value at an accelerating rate as these services become increasingly scarce. This is expected to continue with current development projections in the area. Thus, the true value of these services may be much larger.

2.4. Total Valuation of the King Conservation District Assessment Area Ecosystems

The ecological goods and services produced by each land cover type by the King Conservation District Assessment Area were estimated utilizing the methodological approach outlined in the previous section.

The total value of ecosystem services generated annually on 712,236 acres of the King Conservation District Assessment Area is estimated at approximately $8,674,794,257 to $32,287,850,524.

These estimates are based on the range of values for these land covers conducted outside the King Conservation District Assessment Area. As cursory estimates based on benefit transfer methodology they provide a ball-park range. A specific study or set of studies should be conducted to narrow the range in values.

2.4.1. Total Acreage of the King Conservation District Assessment Area by Landcover Class

Table 4 shows the acreages of GIS classification types that characterize the King Conservation District Assessment Area and were used for geo-spatial estimates in calculating ecosystem service valuation.

Table 4. Acreage of the KCD Assessment Area by Landcover Class

GIS LandSat Landcover Class	Acres
Forests	479,327.68
Grassland and Shrublands	19,392.05
Agriculture and Pasture	44,702.13
Urban	122,765.24
Lakes, Rivers, Ponds and Reservoirs	10,966.77
Wetlands	2,841.21
Coastal	1,019.22
Rock, Snow and Ice	7,317.57
Bare ground, clearcut forest, steep slopes or other	24,004.92
Total Acreage	**712,336.79**

2.4.2. Valuation of the Assessment Area by Landcover Class

Table 5 shows the estimates of ecological services produced by each GIS vegetation type within the King Conservation District Assessment Area. All estimates are in $US and may vary slightly from actual acreage depending on the source GIS data's accuracy.

Table 5. Annual Ecosystem Services in the KCD Assessment Area

Ecosystem Category	Low Estimate	High Estimate
Forest	$7,862,412,008	$28,977,419,635
Grasslands & Shrub-lands	$252,171,351	$968,295,634
Agriculture & Pasture	$286,404,337	$1,034,373,854
Urban	$187,052,489	$988,184,088
Lakes, Rivers, Ponds & Reservoirs	$3,559,812	$22,169,317
Wetland	$45,644,836	$161,413,208
Coastal	$3,758,363	$20,221,368
Rock, Snow, Ice	$33,791,060	$115,773,421
Total Value	**$8,674,794,257**	**$32,287,850,524**

2.4.3. Present Value of the King Conservation District Assessment Area over Time

Table 6 shows the present values of the King Conservation District Assessment Area ecosystem services. These valuation estimates have been calculated in perpetuity, in order to represent the economic value of these ecosystems as the present value of an asset of natural capital. Under any calculation of present value, the ecosystem services provided by the King Conservation District Assessment Area are enormous and highly significant, ranging from the low estimate at a 7% discount rate to the higher value estimate at a 3.5% discount rate.

Table 6. Value of Natural Capital in Perpetuity with Various Discount Rates

Discount Rate	Low Estimate	High Estimate
7 %	$124,925,632,242	$461,255,007,482
5 %	$173,495,885,138	$645,757,268,786
3.5%	$247,851,264,471	$922,510,014,953

For a non-discounted generation-neutral estimate of ecosystem services in the King Conservation District Assessment Area over time, Earth Economics calculated present values at a zero discount rate. Table 7 shows the value of ecosystem service benefits using a zero discount rate over time intervals of 100, 250 and 500 years.

Table 7. Present Value over 100-500 years with a Zero Discount Rate

Time Horizon	Low Estimate	High Estimate
100 years	$867,479,425,695	$3,228,785,052,373
250 years	$2,168,698,564,238	$8,071,962,630,931
500 years	$4,337,397,128,475	$16,143,925,261,862

2.5. Estimating Maintenance Budget for District Ecosystems as Natural Capital

A majority of the budget for the King Conservation District programs and activities providing conservation assistance to landowners is funded from the $10 per parcel assessment fee, $4 of which is received by the King Conservation District and the remainder divided between WRIAs and individual municipalities. This was applied in 2005 to 532,640 parcel units (individual parcels combined with condominium units included in the assessment area), providing $2.9 million in total, $1.2 million of which was received by the KCD to fund conservation programs and activities.

Consideration of ecosystems as natural capital can help provide appropriate management funding to maintain the health of these valuable assets. It is common for 5-10% of the economic value of many capital assets to be required each year for investment in maintenance of this asset. Applying this rule of thumb to natural capital in the King Conservation District, it is estimated that the current rate of Special Benefit Assessment represents an investment of only .0005% to .0025% of the most conservative perpetuity valuation (7% discount rate) in Table 6 of the total economic value of District ecosystems.

There are other sources of funding that contribute to the assistance of District landowners with conservation activities. These include federal assistance grants as well as landowner investments and other smaller investments in individual conservation projects. Using this same rule of thumb, a case could be made for a minimal budget of $6.2 million, or over $10,500 per parcel, in annual combined public and private investment in conservation within the District area until those ecosystems have reached a healthy state that does not require conservation maintenance.

Due to their regenerative nature, healthy ecosystems do not require maintenance. Degraded ecosystems may require restoration to reestablish the provision of benefits. Nonetheless, an estimate of maintenance cost is useful in providing a comparison between the relatively minimal funding of conservation from Special Benefits Assessment to the total value of District ecosystems. It is clear that development activities and other things that contribute to ecosystem fragmentation and deterioration rapidly decrease the overall value of natural capital assets held in ecosystems. This rule of thumb estimate can be seen as the investment required for maintaining critical services in light of negative impacts on ecosystems.

2.6. Costs and Benefits from District Programs and Activities

While it is difficult to estimate the cumulative total investment in conservation activities within the KCD, it is possible to calculate the ratio of benefit to cost in order to estimate the cost-effectiveness the KCD programs and activities. For reasons discussed below, cost-effectiveness was calculated with the inclusion of funding not only from the Special Benefit Assessment fee but also funding from supporting grants and contracts; however, the cost-effectiveness can be assumed to be relatively uniform throughout KCD programs and activities regardless of revenue source. Ecosystem service valuation modeling was used to apply aggregated valuation data with a benefits transfer approach. These data were then correlated with KCD program outcomes through economic modeling, described in detail for each major program outcome valuation category in the sections below.

Table 8. Costs and Special Benefit Valuation of KCD Programs and Activities

SUMMARY OF EXPENSES						
General Operations				$634,965.00		
Customer Service				$108,322.00		
Administration				$388,601.00		
TOTAL EXPENSE				$1,131,888		
VALUATION OF SPECIAL BENEFIT						
			DIRECT		*INDIRECT*	
			LOW	HIGH	LOW	HIGH
Restoration Projects			$11,204	$42,663		
Native Tree Propagation & Sale			$226,453	$269,390		
Best Management Practices					$4,527,036	$16,365,993
	hours	value/hr				
Technical Assistance	18,840	$55	$656,197	$1,036,200		
Customer Service	2,080	$45	$72,446	$93,600		
Administration	4,493	$35	$156,491	$157,255		
Volunteer work						
18+	1,427	$18	$25,686	$25,686		
below 18	222	$7	$1,632	$1,632		
GROSS ANNUAL SPECIAL BENEFIT			$1,150,109	$1,626,426	$4,527,036	$16,365,993
NET ANNUAL SPECIAL BENEFIT			$18,221	$494,538		

It is important to note that total costs in this analysis do not reflect the full budget of KCD conservation programs and activities, only those for which valuation analysis was possible. As mentioned before, these costs include funds from the Special Benefit Assessment as well as other grants and contracts. This was necessary due to the fact that programs considered in this analysis are dependent on all revenue sources and measurable outcomes from individual revenue sources cannot be discerned due to combined funding; thus valuation did not allow for analysis of individual revenue sources discretely. Nonetheless, this provides an accurate summation of the overall cost-effectiveness of KCD programs and activities through comparison of total benefit to total cost. The conclusion presumes that cost-effectiveness is uniform for all expenditures from all revenue sources.

The gross annual value of special benefit from ecosystem services represents the total benefit production before subtracting program and activity costs; the net annual value of special benefit from ecosystem services represents the total return on investment from 2005 activities after costs are subtracted. Both calculate the total value of special benefit produced in the first year and each individual year thereafter. Conservation programs and activities in 2005 will have a lasting effect on the health and service production of ecosystems into the future. Accordingly, the annual value can be projected into the future as a total long-term return on investment by calculating the net present value in perpetuity of 2005 conservation activities. This net present value analysis reveals a cumulative value and economic impact well beyond the special benefit received in the first year.

Table 9 presents the projected long-term return on investment that resulted from KCD programs and activities in 2005, shown as a net present value of benefits and costs in perpetuity. Since staff and volunteer time invested only results in a one-time return of benefit rather than an annual return, these values are only included once in the projected net present value calculations: only ecosystem service valuation has been projected for all years into perpetuity. Given that cost-effectiveness is relatively uniform from all revenue sources, the benefit-cost ratio does accurately represent total return on investment from each dollar spent whether from the Special Benefit Assessment or other sources. Therefore, the per parcel long-term special benefit resulting the KCD's Special Benefit Assessment income of $1 in 2005 would be $4.22-5.95. This rate can also be used to estimate return on investment for current and future conservation activities: an estimated return of $8.44-11.90 per parcel in long-term value resulting from the $2 per parcel received by the KCD in 2006 and $12.66-17.85 per parcel in long-term value resulting from the proposed $3 per parcel for KCD.

Finally, it was not possible to calculate a benefit-cost ratio for indirect benefit given that costs to individual landowners for BMP implementation were not included in data collection; subsequent research may extend to analysis of landowner cost and indirect return on investment.

Table 9. Long-term Return on Investment of KCD Programs and Activities

	DIRECT		*INDIRECT*	
	LOW	HIGH	LOW	HIGH
PRESENT VALUE OF SPECIAL BENEFIT	$4,771,361	$6,735,599	$90,540,722	$327,319,861
BENEFIT-COST RATIO	$4.22	$5.95		

2.6.1. Valuation of Native Tree Propagation and Sale

In 2005 KCD staff and funds supported the propagation and sale of 14,403 native trees and 2,472 native plants. Many of these were provided directly to landowners through an annual plant sale. Given that this activity did not conform to the previously used ecosystem service valuation model developed by Earth Economics and the GIEE, another valuation method was required. A similar ecosystem services approach to economic valuation had already been used to provide a per tree approach in analyzing the economic value of trees (McPherson, et. al., 2002). A basic adaptation was applied, however in the case of native plants no such valuation method was readily available.

Using an economic benefits transfer method, data used in the McPherson source study was used for valuation with data on full life maintenance costs and non-market benefits arising from ecosystem service style benefits. This was done as a benefits transfer, however, more precise source data and modeling software would provide a more accurate valuation with sufficient time for analysis. Furthermore, this appraisal has potential for variance given that the source study did not consider specific valuation difference for conifers. The source study underestimated valuation due to the non-quantifiable value of aesthetic and positive human health effects from trees recently documented (Kuo, 2003). In order to avoid an over estimate in valuation, all trees were undersized in terms of source data tree sizing, (i.e. an oak that would be sized in the McPherson study as large was sized as medium for this study).

Despite the fact that many trees in KCD programs will be planted on private lands, values from the McPherson source data for public trees were used to ensure that this is a conservative valuation. Thus, this valuation does not include significant potential value in the form of potential energy savings from trees near homes or offices. Given that these characteristics are not clear for KCD trees, our use of this valuation data for benefit transfer disregards energy savings from proximity to homes of offices. Net present value calculations were completed using a 5% discount rate as well as a variable mortality rate (10% for the first 5 years, 5% for the next 10 years, 1% thereafter) over a total projected lifespan of 40 years. This modeling was used to calculate an average annual net benefit that would correspond with ecosystem service valuation outputs.

2.6.2. Valuation of Ecosystem Restoration Projects

The KCD is also involved in coordinating ecosystem restoration work to improve ecosystems buffering streams and wetlands in critical ecological transition zones. These areas are extremely important for water regulation and purification, nutrient cycling, and nursery and refugium functions for species that are endangered or otherwise integral to the ecosystem.

In 2005 the KCD staff coordinated restoration projects of approximately 2,830 linear feet (1.62 acres) of streambank and 24,825 square feet (.57 acre) of wetlands on landowner parcels. Economic valuation of this area was accomplished with the ecosystem service valuation model previously applied in this report. Streambank restoration was modeled as conversion from agricultural/pasture ecosystems to grassland/shrubland ecosystems with a shift from relatively low health to higher health levels. Wetland restoration was modeled as a basic shift from relatively low to higher health levels for that ecosystem.

The numbers summarized in this analysis reflect only the change in ecosystem service value. All ecosystem health variables before and after the restoration work were estimated by KCD staff who have subject matter expertise and direct experience with these projects.

2.6.3. Valuation of Farm/Dairy Management Program Best Management Practices

In most cases Best Management Practices (BMP) implementations were summarized as a general ecosystem health change for agricultural or pasture land. These data were collected from Farm Assistance Program management staff in the form of generalized case-by-case estimates of relative change in ecosystem health for each BMP. In some cases implementation of certain BMPs (field border, hedgerow planting, riparian buffer, tree and shrub establishment) were also considered to be conversions from one landcover class to another such as agriculture/pasture to grassland/shrubland, forest ecosystems. The data for these conversions were also included in health estimates in economic modeling that included historic rates of landowner follow-through on management plan goals specific to each BMP.

The numbers summarized by this analysis reflect change in ecosystem service value. All ecosystem health variables before and after the BMP implementation were estimated by KCD staff members who have subject matter expertise and direct experience with Farm and Dairy Management Assistance programs.

For several of the BMPs there was insufficient data collected and confirmed or data specifications prevented inclusion of these in the economic valuation analysis. Program staff and landowners together contributed considerable time for planning and implementing these BMPs, using conservation to increase the health and value of ecosystems. The absence of a valuation estimates for these activities helps increase the certainty that all valuation estimates presented here are underestimates of the total economic value of special benefits from ecosystem services. These BMPs are listed below:

- Brush Management
- Chiseling & Subsoiling
- Clearing and Snagging
- Composting
- Cover Crop
- Diversion
- Fence
- Forage Harvest Management
- Grazing Land Mechanical Treatment
- Irrigation Storage Reservoir
- Open Channel
- Pest Management
- Riparian Forest Buffer
- Roof Runoff Management
- Subsurface Drain
- Surface Drainage
- Underground Outlet
- Use Exclusion
- Waste Transfer
- Waste Utilization

2.6.4. Programs and Activities Excluded from Valuation

Due to time limitations and the data parameters set by our valuation modeling system, valuation in this report is limited to selected programs and activities of the KCD. A more complete and accurate valuation of all KCD programs and activities can be accomplished in the future.

The KCD's 2005 Report of Accomplishments has a number of measurable outcomes for which data was not collected or confirmed and others that did not easily conform to the valuation methodology used in this analysis. These include but are not limited to the following areas in which measurable outcomes were documented:

Technical Assistance
- Manure composting and code compliance
- Nutrient Plan Development Assistance
- Management plan monitoring
- Soil testing
- Buried mainlines

Conservation Projects
- Shoreline Bulkhead removal
- Upland habitat protection
- Erosion control projects
- Pump station engineering project

Outreach and Education
- Land/Water Stewardship Workshops
- BMP tours and presentations
- Local Access Television
- District Newsletter
- Fair & Festival
- Volunteer Education
- Farm Expo
- Forest Stewardship Field day
- Informational Materials

Grant Assistance Programs

2.7. Analysis of Conservation Activity Influence on Real Estate Appraisal Values

Over a dozen real estate agents were consulted to solicit valuation estimates quantifying the effects of conservation activities on real estate appraisal values. The commonly used appraisal methods (regression, cost, best/highest use, etc.) were not suitable for a total economic valuation of ecosystem conservation. Real estate appraisal methods are designed to estimate market value and do not include non-market values. While there are some appraisers with expertise in applying methods for appraisal of conservation easements, these were viewed as inadequate for evaluation of the increase in value resulting from conservation activities. A new appraisal method can be developed pending future case study research with specific site visits to KCD project sites on private landowner parcels.

Even without the real estate appraisal methods for valuation of benefits from ecosystem conservation, it is clear that significant value is created. Numerous studies have explored the relationship between healthy ecosystems and property values; they show that the appraised value of property can increase by 8-20%

based on proximity to parks and open space (Crompton, 2000). While this particular study focused on parks and public open spaces due to the obvious direct benefit received by those who use these ecosystems for recreation, majority of the beneficial value provided by ecosystems is in the form of indirect benefit from ecosystem services. As shown earlier, there is a vast amount of economic value produced by ecosystems in the form of services that are indirect and often non-excludable. Ecosystem service valuation provides one of the only economic valuation methods for estimating this value.

Recent research is also definitively showing the benefit provided by healthy ecosystems in terms of aesthetic value, human health and community well-being (Kuo, 2003) and similar research is beginning to study a number of other economically important categories of value (Wolf, 2004). These benefits are clearly not restricted by parcel boundaries and as with other ecosystem services the community receives as much if not more benefit than the private landowner. As research in these areas continues, there will be more precise economic methods for quantitative valuation of these important benefits.

2.8. Special Benefits to Non-adjacent Landowners and the Community

Healthy ecosystems provide a great deal of benefit to landowners and significant amount of economic value to non-adjacent landowners and the community in general, whether local, regional, national, or global. Appraised value or sale price of land parcels can provide is a market-based approach to valuation of benefits from healthy ecosystem As discussed earlier, market data can only provide a narrow view on of the total value provided to the landowner by ecosystem goods and services as special benefits enhanced by conservation. This narrow view focuses on value that is excludable, in that a landowner holds sole benefit and can exclude others from receiving any similar benefit.

This report clearly shows that market-based approaches to economic valuation are insufficient for providing an economic valuation of a variety of non-excludable ecosystem services. While ecosystem goods, services, and special benefits from conservation do provide a tremendous amount of value to these stakeholders, market appraisals and prices can only estimate the value for the landowners. This makes it difficult to estimate the total amount of realized and potential value for stakeholders other than the landowners.

Through consideration of non-market economic value, ecosystem service valuation provides a method for such estimates. As with any economic valuation, such estimates are still subject to the normal uncertainty inherent in ecosystem service valuation. Moreover, given that some ecosystem services provide benefit to both landowners as well as non-adjacent landowners and community members it is not possible to make an absolute distinction between the comparative value received by these various stakeholders.

The table below provides a presumptive characterization of ecosystems services that provide value in the form of special benefits to landowners compared to those provided to other stakeholders in the greater community, from local to global. Marks indicate the primary beneficiary of increases in value received from conservation activities on an individual landowner's private parcel.

Table 10. Comparison of Landowner and Community as Beneficiaries of Ecosystem Services

	Gas regulation	Climate regulation	Disturbance prevention	Water regulation	Water supply	Soil retention	Soil formation	Nutrient regulation	Pollination	Biological control	Refugium function	Nursery function	Food	Raw materials	Genetic resources	Medicinal resources	Ornamental resources	Aesthetic information	Recreation	Cultural and artistic information	Spritual and historic information	Science and education	Navigational services
Landowner			•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	
Community	•	•	•	•	•	•		•	•		•	•			•	•		•	•	•	•	•	•

Ecosystem services that are marked only in the landowner row tend to be excludable services that a landowner can sell on the market, as can be done with the land itself. The landowner still receives benefits services that are marked only in the community row, but quite minimally in proportion to the whole community. The same land owner also receives benefits from neighbors and other community members that take similar actions to enhance ecosystem services. For services that are marked in both rows, both landowners and the greater community benefit from non-excludable services.

Table 10 can be used as a filter to analyze the ecosystem service valuation of all parcels subject to the per parcel assessment within KCD. The basic analysis undertaken included a calculation of goods and services provided by ecosystems in the King Conservation District Assessment in terms of the value provided to or shared by landowners and the greater community. Based on this delineation of benefits from ecosystem services, approximately 1% of the total value provided by ecosystems is excludable benefit to the landowner that clearly increases in the form of market value. An additional 1% of the value from ecosystem services primarily benefits the general community. In contrast, in the range of valuation estimates there is little variance in the amount of economic value that ecosystems provide to non-adjacent landowner and other community members.

Over 98% of the total economic value provided by healthy ecosystems is in the form of non-excludable services or special benefits that landowners share with others. These stakeholder beneficiaries include non-adjacent landowners and other members of the greater community sharing benefit from ecosystems.

3. Methodological Limitations

This study provides a best-possible first estimate of the economic value of the ecological goods and services generated within the King Conservation District Assessment Area. The study is based primarily on benefits transfer and not on primary economic research of each ecosystem service within the King Conservation District Assessment Area, and provides the best possible first estimate of the economic value for the ecological goods and services generated within the area. There is substantial potential for improved precision from further data and analysis subsequent to this preliminary analysis.

While a number of study limitations should be kept in mind when considering the results, these limitations do not detract from the fact that ecosystem services provide high value. Rather than an implicit assumption of zero value, conservation planning and implementation is better informed with fact-based estimates for the following reasons:

1. ***Limited ecosystem service studies.*** Although the field of ecosystem service valuation has expanded rapidly, regionally relevant studies are still extremely limited. The value of some ecosystem services has not been estimated, e.g., the value to people of ecosystem processes that produce gravel for salmon spawning. Zero value is the default estimate where ecosystem services of value are identified

and valuations have not been conducted. This contributes to underestimates of values for both the low and high valuations.

2. ***Uncertainty and service identification.*** Some ecological services may not yet be identified. The dollar estimates of the value produced by natural systems are inherently underestimates. While we may be able to put a dollar value on the water filtration services provided by a forest, we cannot fully capture the aesthetic pleasure that people gain from looking at the forest, nor can we measure every aspect of the forest's role in supporting the intricate web of life. Thus, most ecological service valuations serve as base markers somewhere below the minimum value of the true social, ecological, and economic value of an ecological service.

3. ***Lack of sufficient valuation studies.*** Medicinal, historic, and spiritual values were identified but eliminated from the study because existing studies are inappropriate for this area. However, to assume that the King Conservation District Assessment Area produces no value in these categories is incorrect, doing so reduces their true value. Taxol, a breast cancer drug, was discovered from the Northwest Yew tree that occurs in all western Washington watersheds. No methodology on how to distribute this value in the ecosystem that produced it has yet been developed on a per acre basis. Historic values are site specific and resources were insufficient for a specific study of the King Conservation District Assessment Area. Similarly, there is no accepted method for monetizing spiritual value.

4. ***Static analysis.*** The values of goods and services, natural capital or otherwise, are dynamic. The current analysis provides a "snapshot" of value in the King Conservation District Assessment Area and for the project site. The values of many ecological services rapidly increase as they become increasingly scarce (Boumans et al. 2002). Based on studies performed over the past 10 years, this gives rise to a general tendency for benefit transfer to underestimate the value of ecological services produced by ecosystems.

5. ***GIS information.*** The GIS vegetation cover data used is fairly crude. It does not differentiate the quality, age or health of particular ecosystems. A recently clear cut area will not yield the same flood protection, soil stabilization, or other services rendered by an old growth forest.

6. ***Process changes.*** Since this methodology is based on ecosystem services provided per acre of vegetation type, it does not pick up the full value of process changes. The creation or occurrence of log-jams and barriers or restoration of the natural processes of a watershed will have impacts beyond the project site. These are process changes, uncaptured by the geographical analysis of the site.

7. ***Irreversibility.*** Most economic modeling and analysis is marginal analysis which assumes a degree of reversibility that is not universally applicable to natural capital. While value changes on the margins appear to be smooth, consistent, and continuous, this may not be the case in actual settings.

8. ***Endangered species status.*** This report does not incorporate adequate analysis that is appropriate for consideration of endangered species as an element of critical natural capital. It overlooks non-incremental impacts such as the potential for land management to contribute to a radical decline or even extinction of endangered species.

Conclusion

This study was conducted to examine the value of ecosystem service production and the extent to which conservation activities increase this production of value in the form of special benefits. Earth Economics accomplished this by integrating ecosystem service valuation, benefits transfer, and economic modeling. These were applied to the range of economic values for ecological goods and services produced annually by public and private ecosystems within the King Conservation District Assessment Area.

KCD programs and activities are essential for empowering landowners with knowledge, tools and methods for personal gain from ecosystem conservation and for providing services and special benefits to the greater community. The program and actions of KCD are particularly vital to the improvement of several key ecosystem services in the area: soil formation and retention, water regulation and supply, nutrient regulation, waste treatment, habitat functions, aesthetic value and other services providing special benefit to landowners and other stakeholders in the community.

Although rendered at no cost in terms of market price, these services have high economic value. Loss of these services often results in either damage to private and public property or replacement with expensive infrastructure (such as additional levees, water filtration systems, etc.). The majority of economic value or special benefits provided by ecosystem services is produced as economically non-excludable services to the landowner and members of the general public. This report estimates the economic value of conservation programs and activities that provide extensive special benefits to landowners and the general community. This case has been supported by the use of ecosystem service valuation, the best available scientific method for quantitative analysis of the relationships between ecosystem health and economic benefit, Based on these findings, this report recommends the following:

- Maintain a $10 per parcel Special Benefit Assessment rate funding the KCD and other conservation efforts.
- Increase the KCD portion of this rate to $3 per parcel due to the cost-effectiveness of KCD conservation work.
- Evaluate potential private and public economic value of a moderate 15-20% increase in these rates by 2010.

To justify this and perhaps further increases Earth Economics used ecosystem service valuation to quantify the annual and long-term present value of ecosystems in the King Conservation District. This began with USGS National Land Classification Data on vegetation or other landcover aggregated for all the parcels assessed within the King Conservation District covering 712,336 acres. There are 532,640 individual parcels and 53,859 condo units in the KCD for a total assessment amount of $2,932,495 at the pre-2006 Special Benefit Assessment rate of $5 per parcel. The KCD received $586,499 of this to fund conservation programs and activities in 2005.

Valuing these ecosystems as natural capital assets that provide ongoing service and special benefits to public and private stakeholders, provides a conservatively estimated minimum net present value, discounted (rate noted), of $124 billion (7%), $173 billion (5%), or $247 billion (3.5%). The latter of these rates is more appropriate for analysis of renewable, self-sustaining ecosystem services to estimate the long-term value of assets with potential to benefit future generations.

Most of the value provided by restoring healthy ecological processes in the King Conservation District Assessment Area will benefit by future generations. The annual values calculated for the King Conservation District Assessment Area correspond to only a thin slice of the benefits that future generations will gain if it is maintained in an ecologically healthy condition. Unlike human-built capital like cars and buildings, ecological capital appreciates and can be self-maintaining.

Calculation of the present value does not capture a full economic value of the benefits for people in the future values generated by the watershed and the project were also calculated with a zero discount rate. The long-term value providing special benefits to current and future generations from ecosystems in the

KCD is estimated to have a total present value of $867 billion to $3.2 trillion (100 years), $2.1-8.0 trillion (250 years), $4.3-16.1 trillion (500 years), with no discounting of benefits to future generations. This exemplifies the critical importance and vast value that these renewable benefits provide across time. Human built infrastructure is vital, but depreciates, and must be maintained and eventually replaced entailing costs. Natural capital appreciates and is self-maintaining providing vast flow of benefits in the future.

The current annual Special Benefits Assessment of $10 per parcel is still less than .003% of the total annual value of special benefit from ecosystem services produced by these natural capital assets. In comparison, built capital asset management budgets commonly include 5-10% of total asset value in annual maintenance expenses. This rule of thumb would support a minimum budget of $6.2 million, over $10,500 per parcel, in annual combined public and private conservation investment within the District area until those ecosystems are at a healthy state that does not require conservation maintenance.

A rapid partial appraisal of the value from KCD programs and activities in 2005 estimates the direct net special benefit after costs of $18,221-$494,538 in the first year alone. Indirect special benefit from landowner implementation of Best Management Practices results in an estimated value of $4.5-$16.4 million, again in the first year alone and not considering landowner investment.

The long-term present value of special benefit from KCD programs and activities in 2005 is projected in perpetuity to have an estimated value of $4.8-$6.7 million directly from KCD activities. An additional $90.5-$327.3 million is estimated as the indirect special benefit resulting from landowner implementation of Best Management Practices.

KCD programs and activities are very cost-effective, as measured by a ratio of total special benefit to total costs. A high return on investment is evident from the 2005 Special Benefit Assessment rate of $1 per parcel for the KCD: $4.22-$5.95 of value from direct special benefit as well as additional indirect benefit.

Current and proposed future rates of Special Benefit Assessment are expected to demonstrate the same rate of return on investment with minimal variance: a return of $8.44-11.90 per parcel in long-term value is estimated for the $2 per parcel funding the KCD in 2006 and $12.66-17.85 per parcel in long-term value is estimated from the proposed $3 per parcel assessment fee allocation to KCD.

Over 98% of the special benefits from ecosystem services are produced as economically non-excludable services, providing benefit to the landowner and the general public. Market methods are insufficient for measuring non-market value and special benefit from ecosystem services. The use of existing valuation studies, both market and non-market within a benefit transfer methodology as applied here provides the best current scientific method for estimating these benefits.

The benefit from KCD activities cannot be captured with any current method of formal appraisal of real-estate value. However, it is clear that close proximity to healthy ecosystems can significantly increase property values — estimates show that proximity to public ecosystems can increase property values by as much as 5-30% (Crompton, 2001).

Because these valuation methods are still incomplete leading economists repeatedly emphasize that the estimates provided are underestimates of the total economic value provided. This analysis is only recently available through work by Earth Economics with extensive research support in partnership with the Gund Institute for Ecological Economics at the University of Vermont.

As such, both the high and low valuation of ecosystem services are *underestimates* of the total economic value of special benefit from ecosystem services. The ranges for these estimates will become more precise with ongoing research. Despite limitations, the analysis herein is uses the best available methodology.

A greater understanding of the relationships between watershed ecosystem health and the provision and value of these goods and services is critical for natural capital asset management decisions. This report provides insight into how data collection and analysis can best proceed in support of natural resource management and conservation.

The natural assets of public and private lands in KCD are highly valuable. KCD, other organizations, and agencies engaged in local conservation efforts should consider a more detailed analysis of the ecosystem goods and services that the King Conservation District Assessment Area provides. The King Conservation District Assessment Area supplies ecosystem service benefits to justify an increase far greater than 5-10% beween 2006 and 2010. There is certainly no economic case to be made for a reduction in the Special Benefit Assessment rate as any such reduction would result in significantly higher loss of overall economic value and net benefit.

This analysis was conducted as a rapid appraisal, as such, the range of 23 identified categories of ecological goods and services provided by the King Conservation District Assessment Area should be closely examined in a more comprehensive site-specific analysis. This can be done in a collaborative arrangement with other agencies and organizations. If each of the agencies engaged in conservation activities in the District funded one ecosystem service study with a full research agenda in its jurisdiction, the compilation of these studies would greatly contribute to better defining and narrowing the range of value produced by Northwest ecosystems. This approach will reduce the cost of the studies, all jurisdictions will benefit.

KCD has initiated the path-breaking step of valuing the full range of ecosystem services provided in the King Conservation District Assessment Area. It should continue with the inclusion of ecosystem services in conservation planning, implementation, and project analysis then proceed with informing the pubic of the full value of ecosystem conservation.

Earth Economics Research Team

David Batker, M.S. Economist - Earth Economics
Role: Earth Economics Executive Director
An accomplished economist with sixteen years of experience in the ecological economics field, David Batker is the co-founder and director of Earth Economics. He was awarded the first biennial Herman Daly Award for excellence in ecological economics by the US Society for Ecological Economics in 2003. A Tacoma native, David has a B.S. in Earth Science and Biology and an MS in Economics with significant additional study under Dr. Herman Daly, the recognized founder of ecological economics. Through successful project management, David and his co-director Jim Puckett have, since 1997, built Earth Economics into an internationally recognized non-profit organization providing expert economic and scientific consulting services with eight professional staff and an extensive network of advisors and collaborators. David will function as the primary point of contact with King Conservation District, overseeing the ecological economic analysis, and ensuring that all products are produced on time at the highest quality.

James Pittman, M.Sc., Economist – Earth Economics
Role: Consultant Project Manager
James Pittman is an ecological economist and sustainable development consultant with over a decade of experience working with governmental, non-profit, and corporate clients. His work has recently focused on ecosystem service valuation, policy analysis, and technical tool development working with Earth Economics and various clients in the Puget Sound region. James has also authored several publications, provided college-level instruction and is a recognized speaker on topics related to ecological economics and sustainability. James will facilitate project communication, research and task execution, while assisting David in coordinating critical tasks and team collaboration.

Dr. Roelof Boumans, Ph.D. – The Gund Institute for Ecological Economics
Role: Ecological Economics and Valuation Assistance
An associate professor at the University of Vermont's Gund Institute for Ecological Economics, Dr. Roelof Boumans is a consultant for Earth Economics. Dr. Boumans has 15 years of experience in the ecological economics field and is an internationally-recognized expert on riparian ecosystems and ecological economics valuation of these ecosystems, including thorough models depicting dynamic spatial and temporal relationships. He has co-written and published dozens of articles, including several for the International Journal for Ecological Economics, and has played a leadership and key technical support role in several projects that model human interaction with ecosystems in watersheds or estimate the economic values associated with ecosystem goods and services. These projects include modeling of social and ecological dynamics in the Patuxent watershed, the economics, social and ecological valuation of mangrove ecosystems in the Philippines, and a valuation of ecological services produced by ecosystems in Washington State currently underway for Earth Economics. Dr. Boumans had the responsibilities of initial research and scoping, identifying the ecological services throughout the site, identifying valuation methods and conducting valuations of ecosystem services.

Joshua Farley, Ph.D. Economist - Gund Institute for Ecological Economics
Role: Ecological Economics Advisor
Dr. Farley received his undergraduate degree in Biology from Grinnell College in 1985, his Master in International Affairs and a Certificate in Latin American and Iberian Studies from Columbia University's School for International and Public Affairs in 1990, and his Ph.D. in Agricultural, Resource and Managerial Economics from Cornell University in 1999. He joined the Gund Institute for Ecological Economics as Executive Director in September 1999. Dr. Farley's major research interests include mechanisms for allocating resources under local control and national sovereignty that generate global public goods, ecosystem valuation and watershed management. Dr. Farley is an advisor for Earth Economics

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Appendix A. Further Examples of the Economic Value of Ecosystems

A great number of studies examine the economic value of ecological services. These studies can be land use, vegetation type, or service based. A few services and valuation studies are discussed below.

Water Regulation
Storm water management and flood protection provided by wetlands and other ecosystems are of vast value (Farber and Costanza, 1987; Kenyon and Nevin, 2001; Thibodeau and Ostro, 1981). Wetlands between the Gulf States and the Gulf of Mexico, for example, provide buffer functions against hurricanes and tidal surges. As wetland buffers between the Gulf of Mexico and New Orleans are lost, storm damage increase dramatically. Existing wetlands prevent billions of dollars in storm damage from a single storm.

A Washington State wetlands study within WRIA 9 assessed the value of flood protection provided by wetlands in Renton, finding that Renton wetlands yielded flood protection benefits worth $41,300/acre to $48,200/acre (Leschine et al., 1997). Similarly, a draft study conducted in Portland, Oregon indicates that creation of a wetland to prevent flooding in a frequently flooded area of southeast Portland would prevent damage amounting to more than $500,000 per flood. This figure is based on actual damages to local homeowners in previous floods in the area (Rojas-Burke, 2004).

Water Quality and Supply
Regulation of the quality and supply of water is perhaps the most recognized and studied ecosystem service. Studies have shown that the value of marginal improvements in water quality for specific areas range from $100 to over $1,000 per hectare (Bocksteal et al., 1988; Bouwes and Scheider, 1979; Ribaudo and Epp, 1984; d'Arge, 1989; Desvousages et al., 1987; Cho, 1990). Riparian forest buffers are estimated to reduce runoff nitrate levels by 84% and reduce sediment by more than 80% (Northeast Midwest Institute, 2004).

Water purification services provided by natural ecosystems are far less expensive than water filtration and treatment facilities. New York City provided over $1.5 billion in watershed conservation measures to restore natural ecosystem filtration to meet water quality standards, rather than spend $8 billion (plus annual maintenance costs) to build a filtration plant (Krieger, 2001). Other jurisdictions have followed a similar pattern. To avoid building a $200 million water filtration plant with additional maintenance and operating expenses, Portland, Oregon spends $920,000 annually to protect and restore the Bull Run watershed, maintaining the natural filtration of its drinking water supply (Krieger, 2001). Annual operating costs of artificial water filtration vary. The estimated annual operating costs of water filtration facilities in Portland, Maine were $750,000, $3.2 million in Salem, Oregon, and $300 million in New York City (Krieger, 2001). Healthy watershed ecosystems permanently provide filtration services, largely for free without capital, maintenance, or operating costs.

Trees: Storm Water, Climate Regulation, and Atmospheric Pollutant Removal
Healthy ecosystems provide many bundles of services. Within these systems, trees provide a number of critical ecosystem services. Climate and air regulation have been valued. One acre of forest can remove 40 tons of carbon from the air and produce 108 tons of oxygen annually (Northeast Midwest Institute, 2004). Market values of carbon sequestration range from $10-100 per ton (Antle et al., 1999; McCarl et al., 2000; Haener and Adamowicz, 2000) and $650-3,500 per hectare (Bishop and Landell-Mills 2002).

The level of service will differ based on the ecosystem structure (Bishop and Landell-Mills, 2002). A 10 year old Douglas fir forest plantation will not produce the same services as an old growth forest with a variety of tree sizes and species. Carbon sequestration in King County was estimated at about 56 million metric tons in 2000 and is predicted to average about 68 tons per acre in 2005 (Turnblom et al. 2002).

The environmental purification and recovery of mobile nutrients – waste treatment services – provided by forests have been valued at $35 per acre (Loomis and Richardson, 2000). Using land cover analysis, a 1998 report by American Forests related changes in the amount of vegetation and tree cover in the Puget Sound region to storm water management and air quality. The report placed an economic value on the ecology of the most urbanized parts of the Puget Sound watershed. The analysis valued the air quality through pollutants removed by the canopy cover at $166.5 million annually, and estimated storm water benefits amounting to $5.9 billion annually. Forestland is estimated to save about $21,000 per acre in storm water retention costs by capturing up to 50% of rainfall in the region (American Forests, 1998).

Waste Treatment
Wetlands provide another important function for purifying water. A 1990 study found that the 11,000-acre Congaree Bottomland Hardwood Swamp in South Carolina removed the same amount of pollutants with the equivalent of a $5 million wastewater treatment plant (EPA, 2003). A study in Georgia revealed that a 2,500-acre wetland saves taxpayers $1 million in water pollution abatement costs (EPA, 2003).

Agricultural lands
One land use and policy-based study (Ribaudo et al., 1989) estimated the following average benefit per acre of agricultural land under the US Conservation Reserve Program: soil productivity at $36, water quality at $79, air quality at $12, and wildlife at $86.

Pollination
Honeybees have been valued as natural pollinators for American cropland at $9 - $20 per hectare. Pollination services provided to U.S. agriculture by all other pollinators are estimated at over $4 billion annually (Southwick and Southwick, 1992).

Pest Control
Natural systems also provide pest control services. Estimates indicate that it would cost more than $7 per acre to replace the pest control services provided by birds in forests with chemical pesticides (Krieger, 2001).

Recreational Value
Another valuable service that ecosystems provide is recreation. Uses such as fishing and hunting have been valued at $3-54 per trip (Adamowicz, 1991). The fish and wildlife sector is a major economic force in Washington. Over $854 million was spent in 2002 on recreational fishing alone while an additional $980 million was spent on wildlife viewing and $408 million on hunting (WDFW, 2002). Commercial fishing added $140 million to the Washington economy in 2002 (WDFW, 2002). Wildlife watching alone generates significantly more revenue for Washington's economy than the apple industry. It supports over 21,000 jobs in the state, more than any other Washington employer besides Boeing (WDFW, 1997). Studies have found water quality for recreational purposes to be valued at $10 and $80 per year (Adamowicz, 1991).

Aesthetic Value
Wetlands and other healthy ecosystems also provide aesthetic value, the higher property prices around wetlands and forests reflect this phenomenon. A study in the Portland, Oregon area found that residential property values increased $436 for every 1,000 feet closer that a property was to a wetland (Mahan et al., 2000). Additional research has also assessed how other environmental amenities enhance property values (Crompton, 2001; Anderson and Cordell, 1988; Laverne and Winson-Geideman, 2003; Dorfman et al., 1996).

Contingency Valuation, Restoration and Species Preservation

Contingency valuation is establishes for non-market goods by interviewing human stakeholders. Habitat valuations depend on the species that the habitat is for, and the anthropogenic use of those species, and human demand. Many habitats are valued based on species used for consumption, such as oyster and other seafood production (Batie and Wilson, 1978). Many other habitats are protected for valued megafauna (bear, elk, wolves) and protected endangered species. Studies of household values in the Pacific Northwest reflect strong preferences for protection of forests, fish and wildlife. In a study of estuarine function, residents of the Tillamook, Oregon area estimated the value of each additional acre of salmon habitat at approximately $5,000 (Gregory and Wellman, 2001). Olsen and others (1991) found that households in the Pacific Northwest were willing to pay between $26-74 per year to double the size of the salmon and steelhead runs in the Columbia River (Quigley, 1997). Another study found that Oregon households were willing to pay $2.50-7.00 per month to protect or restore salmon, a cumulative total of $2-8.75 million dollars per month (ECONorthwest, 1999). The mean annual value per household of river and fishery restoration on the Olympic Peninsula was $59 in Clallam County and $73 for the rest of Washington (Loomis, 1996). Another study found Oregon households willing to pay $380 annually to increase preservation of old growth forests, $250 per year to increase endangered species protections, and $144 to increase protection for salmon habitat (Garber-Yonts et al., 2004).

Appendix B. Ecosystem Service Valuation Tables by Landcover Class

Ecological Service	Forest		Grassland and Shrub-land	
	Low	*High*	*Low*	*High*
Gas regulation	$47,932,768	$127,021,836	$1,454,404	$3,854,171
Climate regulation	$42,180,836	$106,890,074	$1,023,900	$2,594,657
Disturbance prevention	$479,327,684	$3,470,332,436	$17,452,848	$126,358,618
Water regulation	$479,327,684	$2,609,939,242	$16,483,245	$89,751,270
Water supply	$479,327,684	$3,642,890,402	$15,513,643	$117,903,683
Soil retention	$13,900,503	$117,435,283	$506,133	$4,275,948
Soil formation	$479,328	$4,793,277	$19,392	$193,921
Nutrient regulation	$4,793,276,845	$10,113,814,142	$145,440,399	$306,879,241
Waste treatment	$479,327,684	$3,209,578,175	$17,452,848	$116,864,269
Pollination	$6,710,588	$11,983,192	$203,617	$363,601
Biological control	$958,655	$37,387,559	$23,270	$907,548
Refugium function	$239,663,842	$730,016,063	$6,302,417	$19,197,163
Nursery function	$68,064,531	$93,468,898	$1,514,519	$2,079,798
Food	$143,798,305	$397,027,121	$6,787,219	$18,739,511
Raw materials	$47,932,768	$486,038,272	$484,801	$4,915,885
Genetic resources	$2,875,966	$9,586,554	$29,088	$96,960
Medical resources	$0	$0	$0	$0
Ornamental resources	$1,437,983	$9,586,554	$0	$0
Aesthetic information	$3,355,294	$69,502,514	$135,744	$2,811,848
Recreation	$47,932,768	$843,616,725	$1,939,205	$34,130,014
Cultural & artistic information	$479,327,684	$2,875,966,107	$19,392,053	$116,352,319
Spiritual & historic information	$0	$0	$0	$0
Science & education	$479,328	$958,655	$12,605	$25,210
Navigational services	$4,793,277	$9,586,554	$0	$0
Total	**$7,862,412,008**	**$28,977,419,635**	**$252,171,351**	**$968,295,634**

Ecological Service	Agriculture and Pasture		Urban	
	Low	***High***	***Low***	***High***
Gas regulation	$1,564,575	$4,146,123	$0	$0
Climate regulation	$1,376,826	$3,489,002	$216,067	$547,533
Disturbance prevention	$15,645,747	$113,275,207	$0	$0
Water regulation	$29,056,387	$158,212,028	$2,455,305	$13,369,135
Water supply	$15,645,747	$118,907,676	$17,187,134	$130,622,218
Soil retention	$648,181	$5,476,011	$569,631	$4,812,398
Soil formation	$26,821	$268,213	$2,455	$24,553
Nutrient regulation	$156,457,469	$330,125,259	$49,106,097	$103,613,865
Waste treatment	$15,645,747	$104,763,921	$22,097,744	$147,966,492
Pollination	$156,457	$279,388	$515,614	$920,739
Biological control	$31,291	$1,220,368	$44,195	$1,723,624
Refugium function	$6,705,320	$20,424,405	$9,821,219	$29,915,434
Nursery function	$1,904,311	$2,615,075	$3,137,880	$4,309,060
Food	$29,056,387	$80,224,685	$2,455,305	$6,779,097
Raw materials	$3,352,660	$33,995,973	$0	$0
Genetic resources	$0	$0	$0	$0
Medical resources	$0	$0	$0	$0
Ornamental resources	$0	$0	$0	$0
Aesthetic information	$156,457	$3,240,905	$309,368	$6,408,346
Recreation	$0	$0	$5,401,671	$95,069,404
Cultural & artistic information	$8,940,427	$53,642,561	$73,659,146	$441,954,873
Spiritual & historic information	$0	$0	$0	$0
Science & education	$33,527	$67,053	$73,659	$147,318
Navigational services	$0	$0	$0	$0
Total	**$286,404,337**	**$1,034,373,854**	**$187,052,489**	**$988,184,088**

Ecological Service	Lakes, Rivers, Ponds & Reservoirs		Wetlands	
	Low	***High***	***Low***	***High***
Gas regulation	$0	$0	$284,121	$752,920
Climate regulation	$0	$0	$250,026	$633,589
Disturbance prevention	$0	$0	$2,841,207	$20,570,336
Water regulation	$0	$0	$2,841,207	$15,470,370
Water supply	$0	$0	$2,841,207	$21,593,170
Soil retention	$0	$0	$82,395	$696,096
Soil formation	$0	$0	$2,841	$28,412
Nutrient regulation	$0	$0	$28,412,066	$59,949,459
Waste treatment	$0	$0	$2,841,207	$19,024,719
Pollination	$0	$0	$39,777	$71,030
Biological control	$0	$0	$5,682	$221,614
Refugium function	$1,370,846	$4,175,596	$1,420,603	$4,327,158
Nursery function	$77,864	$106,926	$403,451	$554,035
Food	$0	$0	$1,420,603	$3,922,286
Raw materials	$822,507	$8,340,225	$142,060	$1,440,492
Genetic resources	$0	$0	$0	$0
Medical resources	$0	$0	$0	$0
Ornamental resources	$32,900	$219,335	$852	$5,682
Aesthetic information	$38,384	$795,091	$19,888	$411,975
Recreation	$109,668	$1,930,151	$85,236	$1,500,157
Cultural & artistic information	$1,096,677	$6,580,059	$1,704,724	$10,228,344
Spiritual & historic information	$0	$0	$0	$0
Science & education	$10,967	$21,934	$2,841	$5,682
Navigational services	$0	$0	$2,841	$5,682
Total	**$3,559,812**	**$22,169,317**	**$45,644,836**	**$161,413,208**

Ecological Service	Coastal		Rock, Ice, Snow	
	Low	***High***	***Low***	***High***
Gas regulation	$10,192	$27,009	$0	$0
Climate regulation	$17,938	$45,457	$64,395	$163,182
Disturbance prevention	$1,019,217	$7,379,131	$0	$0
Water regulation	$203,843	$1,109,927	$0	$0
Water supply	$0	$0	$0	$0
Soil retention	$0	$0	$0	$0
Soil formation	$0	$0	$0	$0
Nutrient regulation	$0	$0	$21,952,701	$46,320,198
Waste treatment	$0	$0	$0	$0
Pollination	$0	$0	$0	$0
Biological control	$0	$0	$7,318	$285,385
Refugium function	$254,804	$776,134	$3,658,783	$11,144,654
Nursery function	$101,310	$139,123	$0	$0
Food	$1,019,217	$2,814,058	$0	$0
Raw materials	$0	$0	$0	$0
Genetic resources	$0	$0	$0	$0
Medical resources	$0	$0	$0	$0
Ornamental resources	$0	$0	$0	$0
Aesthetic information	$0	$0	$51,223	$1,061,047
Recreation	$101,922	$1,793,822	$731,757	$12,878,918
Cultural & artistic information	$1,019,217	$6,115,302	$7,317,567	$43,905,401
Spiritual & historic information	$0	$0	$0	$0
Science & education	$510	$1,019	$7,318	$14,635
Navigational services	$10,192	$20,384	$0	$0
Total	**$3,758,363**	**$20,221,368**	**$33,791,060**	**$115,773,421**