Economic Benefits of Conserving Natural Lands

Case Study: Yaquina Bay Conservation Opportunity Area, Oregon

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This study, the remaining case studies, and a companion report (Kroeger and Manalo, 2006) outlining the basic theory underlying economic valuation of natural resources and approaches used in valuation can be found online at
http://www.defenders.org/programs_and_policy/science_and_economics/conservation_economics/economic_valuation_of_natural_resources_and_ecosystem_services/conservation_economics_valuation_publications.php

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List of Abbreviations

BEA	Bureau of Economic Analysis
C	Carbon
CO_2e	Carbon dioxide equivalent
COA	Conservation opportunity area
ha	Hectare
NEP	Net ecosystem productivity
RIMS	Regional Input-Output Modeling System
t	Ton
yr	Year

Executive Summary

The ongoing loss of ecologically important natural lands in many parts of the U.S. is well-documented. This loss carries an associated economic cost, because natural lands and the ecosystems they contain support a large variety of human uses that carry economic value.

Documenting the economic value of human activities supported by natural lands in itself is not sufficient to ensure the conservation of those lands and the protection of the values they provide. Nevertheless, assessing the economic value of natural lands can yield information that can inform better land use decisions and conservation policy making.

In this study, which forms part of a set of five case studies that cover natural lands in Florida, Maine, Nebraska, New Mexico and Oregon, we develop estimates of the economic value of several human uses supported by Yaquina Bay, a 29 square-mile area in coastal central Oregon that has been identified as a conservation opportunity area (COA) in Oregon's Conservation Strategy.

Our analysis develops quantitative estimates of the economic value associated with recreational fishing and commercial crabbing, oyster harvests and livestock production. It also estimates the value of the carbon sequestration service provided by the ecosystems found in Yaquina Bay and the value of the open space premiums that accrue to residential properties located in the vicinity of undeveloped open spaces.

Our analysis shows that Yaquina Bay generates substantial economic value. In 2004, the base year for our study, the total estimated annual value of the land uses included in our analysis ranged from $2.8 million to $4.6 million (Table ES-1).

Table ES-1: Annual value of selected uses supported by the Yaquina Bay COA

Yaquina Bay uses	*Low estimate* 2004$	*High estimate* 2004$
Commercial crabbing and oyster farming	908,000	908,000
Commercial fishing	*not quantified*	
Livestock production	284,000	284,000
Forestry	*not quantified*	
Recreation: Angling	1,048,000	2,342,000
Other	*not quantified*	
Research and education	*not quantified*	
Open space property value premiums	424,000	424,000
Ecosystem services: Carbon sequestration	152,000	644,000
Other	*not quantified*	
TOTAL	2,815,000	4,601,000

Recreational fishing is the activity that generates the single largest value, followed by commercial crabbing and oyster harvests. Carbon sequestration, the only ecosystem service included in our analysis, generates substantial economic value as well, although the current uncertainties surrounding access and credit prices on emerging carbon markets make this estimate somewhat less reliable than those for the other uses we examine.

The area provides a number of additional uses shown in Table ES-1. These include wildlife viewing, hunting and other, non-wildlife-associated recreation activities; large-scale educational and research activities; commercial fishing inside and outside Yaquina Bay proper; provision of habitat for threatened, endangered, rare or “charismatic” species like Coho salmon, bald eagles and a variety of migratory waterfowl; and a series of ecosystem services besides carbon sequestration, such as water quality improvements. We did not quantify the value of these uses in our analysis because of the lack of the required data. Thus, the actual economic value of the Bay is likely to far surpass our estimate.

The activities supported by the Yaquina Bay area also generate large sales ($68 million per year), earnings ($25 million per year) and employment (over 600 full-time jobs) impacts in the six-county area surrounding the Bay. The by far single largest driver of the economic impacts associated with the Bay is the Hatfield Marine Science Center, which accounts for 98 percent of the total impacts estimated in this study and which is crucially dependent on the natural resources in the Bay. These impacts in turn generate substantial local, state and federal tax revenues.

Land use planning and conservation policy making should consider the economic value generated by the conservation of undeveloped lands and the increasing relative scarcity and rising value of the goods and services provided by those lands in order to achieve economically sensible results. With a large share of both ecologically and economically valuable undeveloped lands in private ownership, not just in our Yaquina Bay study area but also at state and national levels, existing financial incentive systems that encourage land conservation on private lands will need to be improved and in many cases additional ones will need to be created in order to better align privately and socially desirable outcomes. This is a challenging task whose urgency is increasing in lockstep with the continuing loss and degradation of natural lands.

Introduction

Ecosystems and the habitats and species they contain provide a wide range of economic benefits to society (Hassan et al., 2005; Daily et al., 1997). The type, quantity and quality of services provided vary among different ecosystems. Therefore, the type, quantity and quality of the ecosystem services a particular piece of land provides for onsite and offsite uses generally is affected by changes in the ecosystem. For example, conversion of the land cover from forest to pasture, through its impacts on both ecosystem structure and function, is expected to result in changes in the type, quantity or quality of the services provided by the land. The degree to which service flows change as a consequence of land cover changes depends on a variety of factors, including the original and new cover types, the extent of the loss of the original cover and the spatial arrangement of any remaining original cover, both on the site itself and in relation to off-site land covers.

At the landscape scale, land cover changes on any given plot occur periodically as a result of natural disturbance regimes. Thus, the flow of ecosystem services from a particular piece of land is never static. For example, soil production and erosion control services may be reduced after a disturbance from storms, fires or pest infestations. However, as the ecosystem recovers from the disturbance, the service flows generally gradually return to pre-disturbance levels. In the case of human-induced disturbances, the return of the ecosystem to pre-disturbance conditions often is impeded because of the placement of long-lived or permanent (at least as measured on societal time scales) structures such as paved surfaces or buildings, or because of measures directed at preventing the return of vegetation to pre-disturbance conditions, as in the case of agriculture or lawns.

The modified ecosystems do not necessarily provide an inferior suite of services. [1] In fact, the economic value of the particular suite of services desired by a landowner may be higher for the converted land, judging from her decision to carry out the conversion.

Nevertheless, the particular services that increasingly are of primary public concern, such as biodiversity conservation, water provision or erosion control are usually reduced or lost altogether on the converted lands.[2] Most of these services represent what economists refer to as *public good* ecosystem services. Public good services are characterized among other attributes by the fact that they benefit not just the landowner on whose property they are produced, but also others, whom the landowner is not able to prevent from enjoying these benefits and who therefore receive them for free. Prime examples of public good ecosystem services are biodiversity preservation (except perhaps in the rare cases where the species of concern occurs only on one or a few privately-held properties) or climate regulation. Because the landowner cannot exclude others from the off-site benefits they receive off her lands and charge them for these services, she has no financial incentive to take the value of those third-

[1] Of course, all ecosystems by now are impacted by human activities (Vitousek et al., 1997a, 1997b, 1997c) and thus may be considered modified. However, here we refer to systems purposefully changed by humans through land conversion.

[2] We follow general usage and apply the term "conversion" here to describe a change from "natural" vegetation or land cover to a "developed" use such as residential/commercial or agriculture. Thus, conversion does not describe changes in the opposite direction, which also occur, for example in the case of wetland reclamation or afforestation or natural succession on abandoned farmlands.

party benefits into account in her land use decisions. This divergence between individual and society-wide benefits from public good ecosystem services provided by a property may lead to land use decisions that are suboptimal or inefficient for society as a whole (Kroeger and Casey, 2007). The total value of the services the land provides to society as a whole may be lower following the conversion, but the *private* benefits to the landowner from the conversion exceed the *private* cost for the landowner in the form of the services reduced or foregone by *her*. It is the realization of this conflict between privately and socially desirable land use choices that underlies much of public natural resource conservation policy making.

The recognition of, and the generation of quantitative information about the value of natural lands is an important, though neither a necessary nor a sufficient condition for making intelligent conservation policy decisions. Even if the value of the goods and services provided to society by a particular land or ecosystem, or some approximation thereof, is known, the protection of those values is contingent on two further factors. First, institutional mechanisms must be in place that allow the owner of the land to capture the value of the off-site services her land provides. Such mechanisms can take several possible forms, including government payment programs, ecosystem service markets based on regulation or voluntary action (e.g., carbon sequestration payments), or fiscal incentives (e.g., tax deductions) (Kroeger and Casey, 2007). In addition to the need for a value capture mechanism, the sum of the landowner's private (on-site) benefits and the compensation she receives for the off-site benefits her land provides must exceed the benefits she expects to obtain from land development.[3]

Thus, information on the value of the benefits associated with land conservation by itself cannot guarantee the conservation of undeveloped lands, but it is a first step towards making that outcome more likely.

In this study we identify several human uses supported by the undeveloped lands in an area in western central Oregon and develop quantitative estimates of the economic value of those uses for which we have sufficient data.

This study forms part of a set of five case studies that examine the economic benefits provided by diverse natural lands identified as priority conservation areas in the respective states' Comprehensive Wildlife Conservation Strategies or Wildlife Action Plans.

[3] This assumes landowners act as profit-maximizers. In the case of a landowner who has a preference for keeping the land in an undeveloped state for non-financial motives, the payment would not necessarily need to be financially competitive with development. Rather, payment would merely need to be sufficient to make it financially possible for the landowner to avoid selling off the property to developers.

Methodology

Study area selection and characteristics

Our main objective when selecting our sample of five case study areas was to achieve a representation of diverse geographic regions, ecosystem types, land ownership and land uses within our sample. The Yaquina Bay study area, indicated by the red-bounded areas in Figures 1 and 2, represents the only estuary in our sample of conservation opportunity areas and the only area in our sample that is located in the Pacific Northwest. The remaining study areas can be broadly characterized into riparian (south-central Nebraska), mixed forest and swamp (southwestern Florida), low to mid-altitude dry forest (New Mexico), and temperate coastal mixed forest wetland (Maine), with a variety of different land use and ownership patterns.

Figure 1: Oregon and the Yaquina Bay Focus Area

The Yaquina Bay area is located in Lincoln county and is identified in the Oregon Conservation Strategy as a strategic habitat or conservation opportunity area (COA) in Oregon's Coast Range ecoregion. Oregon's conservation opportunity areas are defined as landscapes where broad fish and wildlife conservation goals would be best met, and were developed to guide voluntary conservation actions (Oregon Department of Fish and Wildlife, 2006). The Yaquina Bay estuary is identified as an important stopover for migrating shorebirds and waterfowl and provides habitat for a number of threatened, endangered, rare of focal species (Table 1).

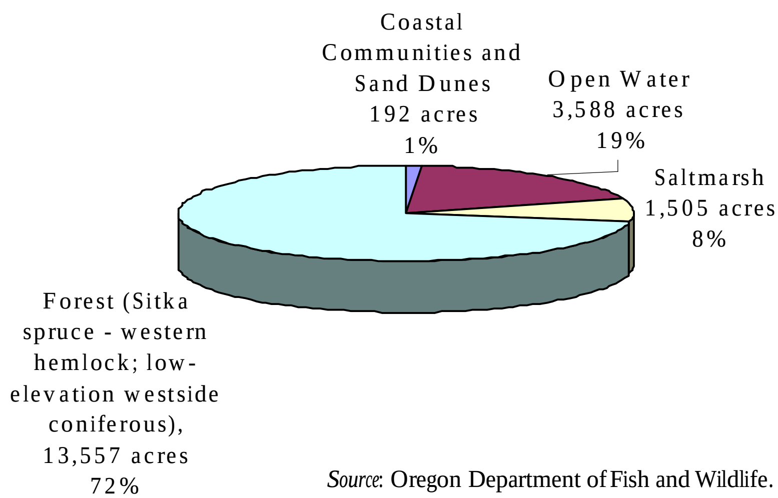
Figure 2: Yaquina Bay Focus Area Boundary (indicated in red)

Table 1: Threatened, endangered, rare and focal species found in the Yaquina Bay estuary and marsh

Common Name	*Scientific Name*
Federally listed T&E Species:	
Coho Salmon	*Oncorhynchus kisutch ssp.*
Marbled Murrelet	*Brachyramphus marmoratus*
Steelhead	*Oncorhynchus mykiss ssp.*
Sea-run cutthroat trout	*Oncorhynchus clarki clarki*
State-listed T&E Species:	
Purple Martin	*Progne subis*
State-listed sensitive anadromous fish species:	
Chum salmon	*Oncorhynchus keta*
Pacific Lamprey	*Lampetra tridentata*
Migratory and Non-Game Bird - Focal Species and Species of High Concern:	
Brandt's Cormorant (HC)	*Phalacrocorax penicillatus*
Black-bellied Plover (HC)	*Pluvialis squatarola*
Whimbrel (HC)	*Numenius phaeopus*
Dunlin (HC)	*Calidris alpina*
Marbled Godwit (HC)	*Limosa fedoa*
Long-billed Dowitcher (HC)	*Limnodromus scolopaceus*
Northern Harrier (F)	*Circus cyaneus*

Notes: Ssp. - subspecies; T&E - threatened and endangered; F - Focal Species; HC - Species of High Concern.
Source: Pers. comm., Fran Recht, Central Coast Land Conservancy and Pacific States Marine Fisheries Commission, March 21, 2007.

The study area as outlined in Oregon's Conservation Strategy comprises a total of 18,843 acres. Of, these 15,255 are terrestrial habitat and 3,588 are open water. The non open water communities of the study area are comprised of mostly salt marsh and Sitka spruce-western hemlock forest, with smaller areas of coniferous forest and coastal communities and sand dunes (Figure 3). The majority (96 percent) of the study area is privately owned, with small portions owned by federal, state and county entities, respectively (Table 2 and Figure 4).



Source: Oregon Department of Fish and Wildlife.

Figure 3: Yaquina Bay land cover types

Table 2: Land ownership in the Yaquina Bay study area

Landownership Type	*Landowner*	*Acres*
Private	n.a.	15,132
County	Local Government	48
State	Oregon Parks and Recreation Department	8
State	Oregon Department of State Lands	148
Federal	USDA Forest Service	488
Federal	USDI Bureau of Land Management	39

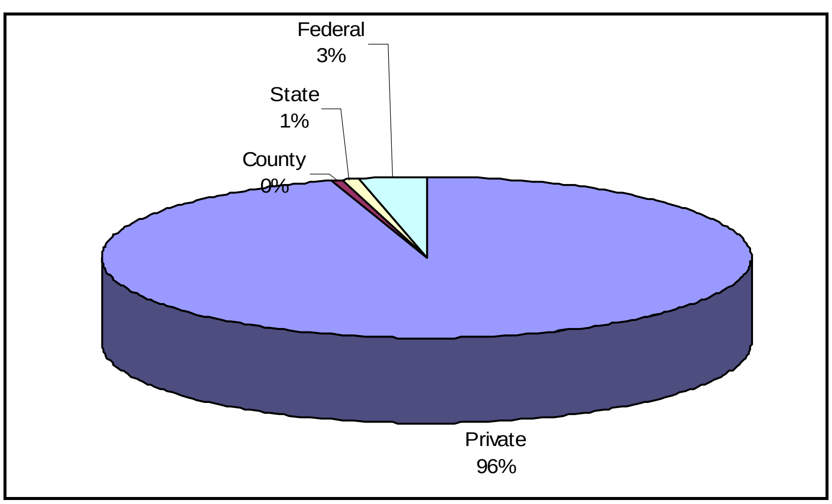


Figure 4: Land ownership types in Yaquina Bay study area

Economic analysis framework

The economic theory underlying the valuation of natural resources and the general approaches used in valuation applications are discussed in a companion report (Kroeger and Manalo, 2006). In this study, we develop quantitative estimates of the economic value of the annual flows of benefits generated by the study area. Our estimates therefore represent the values of benefit flows in a given year, not the total present value of the natural resource stocks found in the area. In other words, we do not estimate the total economic net present value of the natural assets in the area (e.g., the forest and woodlands, animal and plant species, etc.), but rather the value of the benefits flowing from these stocks that accrue to humans in a given year (e.g., timber harvests, recreation, carbon sequestration, scenic views). The base year for our analysis is 2004, the most recent year for which many of the needed data for our five study areas are available. In those cases where the data for Yaquina Bay are for a different year, we indicate this in the text. All values are expressed in 2004 dollars ($2004).

Following common practice, our analysis of the economic values provided by the area is separated into two parts. The first uses a welfare analysis-based perspective and attempts to quantify the total economic value of the benefits examined for all individuals who directly or indirectly use the area. The second is based on an economic impact analysis perspective and attempts to quantify the total contribution the natural lands in the study area make to the local economy, by quantifying the total final output (sales), labor income, and employment in the area derived from activities supported by the natural systems in the study area. The welfare analysis-based assessment includes market as well as non-market economic values and use as well as passive-use and ecosystem service values associated with the benefits provided by the ecosystems in the area, while the impact analysis-based assessment only includes observed market impacts attributable to expenditures associated with the ecosystems.[4]

Uses included in analysis and associated economic values

The native ecosystems in the study area provide a wide variety of benefits to local and regional human populations. Part of these benefits result from the direct use humans make of the ecosystems or their components, as for example in the case of recreation or scenic views from surrounding properties. In addition to these direct uses, the ecosystems in the area provide a number of services that benefit local or regional residents. Examples of such services are the clean water the area supplies to the underlying aquifers through infiltration of precipitation, the maintenance of a diverse fauna and flora, or the sequestration of atmospheric carbon by perennial plants. Finally, some aspects or components of the study area may hold passive use values, to the extent that some people appreciate their existence independently of any direct use of these features. For example, studies have shown that people value the existence of unique landscapes; of particular, "charismatic" species; or they may value the thought of preserving particular areas intact and largely unaffected by human development (see studies cited in Kroeger and Manalo, 2006).

[4] For a more detailed discussion of the different types of values, see Kroeger and Manalo (2006).

Of the full range of benefits potentially provided by the natural systems in an area (see table 1 in Kroeger and Manalo, 2006), in this study we focus only on the benefits associated with those uses for which we were able to obtain quantitative information and that are compatible with and contingent upon the continued conservation of the area. These are shown in Table 3. The fact that a particular activity is not indicated in Table 3 does not imply that this activity does not occur in the study area. It merely indicates that in our research we have not come across evidence of its occurrence.

Table 3: List of documented uses of the study area's ecosystems

Direct uses	Timber extraction Grazing Commercial Fishing and Crabbing Commercial Oyster Harvesting Recreation - Crabbing and Clamming - Picnicking and general relaxation - Fishing - Hiking - Wildlife watching - Boating Research and education Property value premiums
Indirect uses	Ecosystem services - Water quality - Species habitat provision * - Biodiversity maintenance - Temperature modulation - Carbon sequestration - Air quality
Passive uses	Provision of habitat for threatened, endangered, rare or "charismatic" species

Notes: * Part of the associated value is captured in fishing and wildlife viewing uses.

Some nature-based uses of the study area have important non-market values, that is, their full economic value cannot be assessed on the basis of observed market transactions alone (Table 4). Whenever possible, we attempt to capture this non-market value component by using appropriate valuation approaches. For example, in the case of many recreation activities, studies have shown that the average participant in these activities derives a value from engaging in them that surpasses his or her expenditures associated with recreation trips. We use published estimates of this additional value for the recreation activities practiced in the area in order to quantify this non-market portion of the economic value of recreation.

Table 4: Uses of the study area and types of associated economic values

Use	*Market value*	*Non-market value*
Recreation	ü	ü
Commercial uses (crabbing, fishing, oyster harvest, livestock production)	ü	-
Research and education	ü	ü
Property value premiums	ü	
Ecosystem services	ü	ü

Due to lack of data and limits in the scope of our analysis, we are not able to quantify the full economic value of the Yaquina Bay COA. Specifically, estimates of the value of most of the ecosystem services provided by the study area at presently are very difficult to generate. Likewise, quantitative information is unavailable on the levels of many recreation activities like wildlife viewing or hunting. As a result, our value estimates exclude some uses and incompletely capture the true value of others. Thus, they necessarily represent underestimates of the total value of the annual flow of benefits provided by the ecosystems in the area.

Estimates of the Economic Value of Land Uses

In this section, we develop estimates of the value of some of the uses supported by the natural lands in the study area shown in Table 13. We limit our analysis to the value of those uses that are compatible with or contingent upon natural lands in the study area and for which we were able to obtain data.

Oyster Farming

The Yaquina Bay study area supports commercial oyster farming. This local industry provides oysters for markets as far away as New York and even Asia (Odegard, 2005). In 2004, oyster producers on state-leased lands in Yaquina Bay harvested 17,170 gallons of oysters[5], with a total value of $600,950 (Table 5).[6]

Table 5: Oyster Production in State Waters in Yaquina Bay, 1997-2006

Year	*Gallons harvested*	*Total Value (at $35/gallon)*
1997	10,985	$384,475
1998	5,236	$183,260
1999	8,206	$287,210
2000	11,897	$416,395
2001	17,488	$612,080
2002	15,440	$540,396
2003	16,208	$567,280
2004	17,170	$600,950
2005	16,505	$577,675
2006	16,008	$560,280

Commercial Fishing and Crabbing

There is a small commercial crabbing industry operating in the bay. The majority of crabs harvested are Dungeness crabs; the remainder are Red Rock crabs. In 2006, there were 8,763 pounds of commercial bay crabs landed, with an ex-vessel value of $24,904.

Yaquina Bay also supports a small commercial roe herring fishery. For the last few years, however, there have been no harvests due to the very low numbers of herring spawning in the Bay. The reason behind this decline in spawning is not known. However, there have been similar fluctuations in the amount of spawning in the past, so the current episode may

[5] Pers. comm. with John Byers, Program Coordinator for the Oyster Plat Leasing Program, Oregon Department of Agriculture, May 22, 2007.

[6] According to the 2006 Oregon Agriculture and Fisheries Statistics, the oysters are valued at $35 per gallon. John Byers of the Oregon Department of Agriculture reaffirmed that this was a reasonable value, December 19, 2007.

be part of a natural cycle.[7] In this case, the herring fishery will continue to provide economic benefits to the community when the number of herring increases again.

In addition to commercial fisheries within the study area, other commercial fisheries outside of the bay depend on fish that spend a portion of their lives in the estuary waters or depend on prey species that utilize the waters of the estuary. Bay-dependent fish species include English sole, herring, lingcod, crabs, and salmonids.[8]

Agriculture and Forestry

Within the study area, there is a limited amount of agricultural activity occurring, the majority of which is in Boon-Nute Slough. The only significant crop is hay, although no data was available on the quantity of hay produced in the study area. In addition, the area supports limited livestock grazing, including approximately 350 beef cattle (300 for 7 months and 50 all year) and 20 horses (all year). According to the 2005-2006 Oregon Agriculture and Fisheries Statistics (National Agricultural Statistics Service and Oregon Department of Agriculture, 2006), the value per head for cattle and calves in 2006 was $810, resulting in a total annual value of beef cattle grazed in the study area of $284,000. No equivalent value was available for horses.

Timber harvesting is also occurs within the study area. Most of the land around the estuary is privately owned and managed at least partially for timber. While some harvesting occurs today, the majority occurred about 15 to 30 years ago. Since then, all the land has been reforested, although the forests are still at a fairly young age. It will be another ten to 15 years until the trees have matured enough for any major harvesting.[9] No information was available on the quantity of timber harvested within the study area.[10]

Recreation

A variety of outdoor recreation activities are practiced throughout the study area, including fishing, crabbing, clamming, wildlife watching, boating, and hiking (Hatfield Marine Science Center, 2004).

Recreational fishing is a major activity in Yaquina Bay as well as in Yaquina River. In recent years, there have been approximately 10,000 angler days annually in the Fall Chinook fishery, 5,000 in the Coho salmon fishery, and 3,000 in the Cutthroat Trout fishery.[11] About 60 percent of the Fall Chinook and Coho salmon angler days occur within the study area itself, and about a third of the Cutthroat Trout angler days occur within the study area. However, the bay is essential for each of these fisheries because of the habitat it provides for these species. Therefore, the bay also supports the portion of the harvest in these fisheries that occurs outside of the study area. In addition, there are also about 3,000 angler days per year

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7 Pers. comm., Keith Matteson, At-Sea Research/Development Fisheries, Oregon Department of Fish and Wildlife. May 14, 2007 and December 17, 2007.

8 Pers. comm., Keith Matteson, At-Sea Research/Development Fisheries, Oregon Department of Fish and Wildlife. May 14, 2007 and December 17, 2007.

9 Pers. Comm., Jack Dunaway, Unit Forester, Toledo Office, Oregon Department of Forestry, May 16, 2007.

10 Pers. Comm., Bernard Bochsler, Oregon Department of Forestry, May 30, 2007.

11 Pers. comm., Bob Buckman, Oregon Department of Fish and Wildlife, May 14 and December 13, 2007.

for the Winter Steelhead fishery in the Yaquina River. While none of the angler days occur within the study area, the entire fishery is also dependent upon the study area for proper habitat.[12]

Table 6: Approximate number of annual angler days supported by the Yaquina Bay study area

Species	*Total*	*Within study area*	*Outside of study area but dependent on the habitat it provides*
Fall Chinook	10,000	6,000	4,000
Coho Salmon	5,000	3,000	2,000
Cutthroat Trout	3,000	1,000	2,000
Winter Steelhead	3,000	0	3,000
Total	21,000	10,000	11,000

The study area also supports sport fisheries for several other species including surfperch, groundfish, baitfish and sturgeon, but we were unable to obtain estimates for the numbers of angler days associated with these.[13] In addition, there is a substantial amount of recreational crabbing and clamming occurring in the study area, and these activities generate economic revenue for the local community. As of December 2007, there was no available quantitative data on these activities, although the Oregon Department of Fish and Wildlife was in the process of creating statistical data on recreational shellfish harvesting. [14]

The economic value associated with recreation activities in the study area is measured as the total willingness-to-pay (WTP) of participants for the activities they engage in. The total value individuals assign to a particular recreation activity can be distinguished into two components, on the basis of the different approaches applied to quantify these value components. The first is the actual expenditures individuals incur in the process of engaging in a particular activity such as wildlife watching. The second is the consumer surplus (CS), or net benefit, they receive from the activity, which measures how much the individuals would have been willing to spend on the activity above and beyond what they actually spent. Information on trip and equipment expenditures is reflected in market transactions, and is collected in comprehensive statewide expenditure surveys conducted every five years by the U.S. Fish and Wildlife Service and the U.S. Census Bureau (2008; and earlier issues). Information on consumer surplus is obtained through revealed preference approaches such as contingent valuation surveys, and is commonly reported in terms of consumer surplus per activity day, that is, per day spent fishing, hunting, or engaging in some other activity of interest.[15] Based on these data, we can construct an estimate of the total value recreationists

[12] Pers. comm., Robert Buckman., District Biologist, Oregon Department of Fish and Wildlife, May 14, 2007 and December 13, 2007.
[13] Pers. comm., Linda ZumBrunnen, Marine Resources Program, Oregon Department of Fish and Wildlife, May 15, 2007.
[14] Pers. comm., Mitch Vance, Shellfish Project Leader, Oregon Department of Fish and Wildlife, December 17, 2007.
[15] For a more detailed description of the different valuation methods, see Kroeger and Manalo (2006).

attach to activities in our study area by combining estimates of total activity days per year with information on average consumer surplus and spending per activity day.

In 2006, freshwater anglers in Oregon spent an average of $28.76 per angler day on trip-related items such as food and lodging or transportation (Table 7).

Table 7: Total and average expenditures by recreational freshwater anglers in Oregon, 2006

Total days of fishing	7,053,000
Total trip expenditures (2004$)	202,860,577
Total equipment expenditures (2004$)	119,006,731
TOTAL expenditures (2004$)	321,867,308
Avg. trip expenditures/angler day (2004$)	28.76
Avg. total expenditures/angler day (2004$)	45.64

Source: U.S.Fish and Wildlife Service and U.S. Census Bureau (2008)

In our estimate of the trip expenditures by freshwater anglers in Yaquina Bay, we construct a low and a high scenario. The low scenario excludes equipment purchases by freshwater anglers. The rationale underlying this exclusion is that because many individuals who fished in Yaquina Bay in 2004 likely also fished elsewhere during that year, they might have purchased the equipment bought in that year even had they not fished in Yaquina Bay. This is a conservative assumption that will lead to an underestimation of the total expenditures associated by angling in the bay, because at least some of the equipment purchases like bait, tackle or lines are directly proportional to fishing activity. In our high scenario, we assume that equipment expenditures as a whole are proportional to fishing days just like trip expenditures, and include the former to derive the average spending per angler day ($45.64).

Based on these two estimates of spending associated with angling in the bay, we estimate that participants spent a total of approximately $600,000 to $960,000 in 2004 on fishing in the study area.

We used an updated version of the comprehensive sportfishing value database developed by Boyle et al. (1998) to identify studies that estimated the average consumer surplus value of trout and salmon fishing in Oregon. These studies are shown in Table 8.[16] The consumer surplus estimates reported in the table show that ocean fishing yields higher net benefits for participants than freshwater fishing. A portion of the salmon that depend on the Yaquina Bay area for their freshwater life period are eventually caught in the ocean. However, in the absence of data on the number of ocean fishing days supported by the salmon that depend on our study area, we use values for freshwater salmon fishing to estimate the total consumer surplus associated with all salmon fishing dependent on the study area.

[16] This database contains over 900 observations and will be made available in late 2008 as part of the Wildlife Habitat Benefits Estimation Toolkit developed by Kroeger et al. (2008). The Toolkit can be found at *http://www.defenders.org/programs_and_policy/science_and_economics/conservation_economics/index.php*

Table 8: Average net value (CS) of a fishing day in Oregon and neighboring states

Species	*Study year*	*Value (WTP) 2004$/day*	*Study area*	*Source*
Trout	2001	42.64	OR	Aiken and La Rouche (2003)
Trout	1991	62.37	OR	Waddington et al. (1994)
Trout	1980	28.09	OR	Brown and Hay (1987)
Salmon	1989	45.90	WA/OR/ID/MT - Coastal rivers	Olsen et al. (1991)
Salmon	1987	42.65	OR	Abdullah (1986)
Salmon	1987	64.23	OR	Abdullah (1986)
Salmon	1977	53.84	OR - Ocean	Brown and Shalloof (1986)
Salmon	1977	18.57	OR - River/stream	Brown and Shalloof (1986)
Salmon	1977	21.35	OR - River/stream	Brown and Shalloof (1986)
Salmon/steelhead	1977	27.12	OR - Freshwater	Hsiao (1985)
Salmon/steelhead	1977	78.93	OR - Ocean	Hsiao (1985)
Salmon/steelhead	1977	59.84	OR - Freshwater	Hsiao (1985)
Salmon/steelhead	1977	99.31	OR - Ocean	Hsiao (1985)
Salmon/steelhead	1977	77.66	OR - Freshwater	Hsiao (1985)
Salmon/steelhead	1977	276.28	OR - Ocean	Hsiao (1985)
Steelhead	1989	48.74	WA/OR/ID/MT - Coastal rivers	Olsen et al. (1991)
Steelhead	1977	55.69	OR	Brown and Shalloof (1986)

We use the lowest and highest value estimates for each species in Table 8 to construct low and high estimates of total consumer surplus of sportfishing supported by the study area (Table 9). Overall, we estimate that the study area supports recreational fishing that generates net benefits for participants of between $440,000 and $1.4 million per year.

Table 9: Annual consumer surplus of angling supported by the Yaquina Bay study area

	Angler days	*Consumer surplus (2004$/day)*		*Total Consumer surplus (2004$/year)*	
		Low	*High*	*Low*	*High*
Fall Chinook	10,000	18.57	64.23	185,673	642,308
Coho	5,000	18.57	64.23	92,837	321,154
Cutthroat trout	3,000	28.09	62.37	84,260	187,096
Winter steelhead	3,000	27.12	77.66	81,346	232,990
Total CS				444,115	1,383,548

The total value of birding and angling in the study area is equal to the sum of recreationists' expenditures and their consumer surplus. Based on our estimates, this total value lies between $1 and $2.3 million per year (Table 10). Since the consumer surplus estimates for birding and angling are largely unable to capture passive use (existence, stewardship and bequest) values, these estimates likely are underestimates of the actual total economic value associated with birding and angling in the Central Platte BUL.

Table 10: Total annual economic value of fishing supported by Yaquina Bay

Expenditures [1]		*Consumer surplus (2004$)*		*Total economic value (TEV) (2004$)*	
Low est.	*High est.*	*Low est.*	*High est.*	*Low est.*	*High est.*
604,000	958,000	444,000	1,384,000	1,048,000	2,342,000

Notes: [1] Low estimate includes trip expenditures only; high estimate includes trip and equipment expenditures.

Property value premiums

The Yaquina Bay Conservation Opportunity Area (COA) includes over 18,800 acres, 15,255 of which are open space in natural habitat, consisting mostly of Sitka spruce-western hemlock forests and salt marshes. Evidence from a large volume of studies suggests that proximity to open space increases the values of nearby properties. Thus, the open space property value premiums attributable to the natural lands constitute one of the benefits produced by these lands. In this study, we focus on those natural lands located within one mile of residential properties.

The increment in value a property receives due to its proximity to open space is variously referred to as the open space property value premium, the property enhancement value, or the amenity premium. This premium is the result of what Crompton (2001) calls the proximate principle, namely, the general observation that the value of an amenity is at least partially captured in the value of properties in proximity to that amenity. The idea underlying the proximate principle is that a property, like any good, may be thought of as a bundle of attributes (Lancaster, 1966). The price of the good therefore reflects the value consumers assign to that bundle of attributes. In the case of a property, these attributes include the physical characteristics of the property itself and of any structures, such as property size, relative scarcity of land, size and quality or age of structures, as well as neighborhood characteristics such as schools, public safety, and environmental amenities provided by surrounding lands, such as scenic views, clean air, or recreation opportunities. If people value open space and the amenities associated with it, then these values to some extent should be reflected in property prices.

The evidence in the published literature for the existence of the property enhancement value of open space is certainly strong. There are over 60 published articles in the economics literature that examine the property enhancement value of open space (McConnell and Walls, 2005). A number of recent literature reviews have been conducted on the topic. Some of these cover various types of open space, including forest lands, parks, coastal and inland wetlands, grasslands, and agricultural lands (e.g. Fausold and Lillieholm, 1999; Banzhaf and Jawahar, 2005; McConnell and Walls, 2005 – by far the most comprehensive review), while others are specific to particular types of open space such as parks (Crompton, 2001), wetlands (Brander et al., 2006; Boyer and Polasky, 2004; Heimlich et al., 1998), or agricultural lands (Heimlich and Anderson, 2001).

These findings suggest that in general, there appears to be an inverse relationship between the scarcity of open space and its property enhancement value, suggesting that open space is relatively more valuable where it is in relatively short supply (McConnell and Walls, 2005).

This of course does not mean that property premiums do not exist in rural areas. As Ready and Abdalla (2005) note in response to a reviewer's comments, it is theoretically plausible that individuals' WTP for open space could also be higher in suburban or rural areas, because at least a part of the residents in those areas locate there specifically because of their high preferences for open space. There are a number of studies in rural areas that do show that open space does indeed increase property values considerably also in those areas (Phillips, 2000; Vrooman, 1978; Brown and Connelly, 1983; Thorsnes, 2002). These studies generally involve public open spaces that often are comparatively large and enjoy a high level of protection from development, including state parks, forest preserves, and wilderness areas. The large open spaces in the Yaquina Bay area, though mostly unprotected, appear not to be under near-term pressure from development and thus are likely to remain largely undeveloped. Thus, the open spaces in the bay share an expected permanence with the large protected open spaces studied in the literature. Since the literature suggests that it is this permanence of an open space rather than the protected status itself that people value (Earnhart, 2001, 2006), we expect that the large open spaces in the study area are not intrinsically less attractive to nearby residents than if they were officially protected.

Open space is not a homogenous good, and the particular attributes of a given open space can be expected to influence the size of the associated premiums received by nearby properties. This is confirmed by the large range in open space premiums (measured as a share of the total value of a property) found in the literature. Table 11 summarizes the findings reported in the literature on how particular study area characteristics influence open space premiums.

Table 11: Variables that influence the property enhancement value of open space

Variable	*Direction of influence*
Scarcity of open space	+
Protected status/permanence	+
Size of open space	+
Distance to open space	- *
Type of open space	+/-
Opportunity costs / value of competing land uses	+
Income	+

Notes: * Exception: In cases of heavily used public open spaces such as some urban parks, adjacency to such areas may lead to a loss in privacy for some properties and to an associated negative open space premium on properties adjacent to the park.
Source: Kroeger et al. (2008)

No study on the open space premiums of property values exists for our study area. In situations where no original studies are available on the value of the benefits produced by environmental amenities like open space, benefits transfer is a possible tool for inferring the value people assign to these benefits. Benefits transfer is a technique in which researchers estimate the value of particular benefits for a site of interest by using the results of existing studies of similar sites (Loomis, 2005). The validity of the resulting transfer-based estimate depends on the similarity of the sites and user groups. The context-dependence of open space premiums calls into question the validity of using a particular open space premium reported in the literature as an indicator of the premiums received by properties in a different area. Because no original study exists for the study area or an area that would appear to be similar in terms of its physical characteristics and ownership, application of either point or average value based benefits transfer approaches to estimate the property value premiums would possess questionable validity. This leaves meta-analysis-based benefits transfer as a possible approach. Meta-analysis is a statistical technique that uses regression analysis of the findings of several empirical studies to systematically explore study characteristics as possible explanations for the variation of results observed across primary studies (Brouwer, 2000; U.S. Environmental Protection Agency, 2000). The values of key variables from the policy case then are inserted into the estimated benefit function to develop policy-site-specific value estimates. One such meta-analysis of open space property value premiums is available in the literature (Kroeger et al., 2008).

Kroeger et al. (2008) conducted a meta-analysis of 21 original quantitative studies in the U.S. containing a total of 55 observations of open space impacts of conserved lands on property values.[17] They included only those studies that examined predominantly "natural" open spaces, excluding crop lands and heavily-developed urban recreational areas. Their estimated meta-analysis-based regression function has the following form[18]:

$$\begin{aligned} P_{OS} &= -6.5903 + 0.4221 * \%OSChange - 0.0068 * \%OSChangeSquared + 2.7619 * FOR \\ &+ 1.677 * PARK - 2.7367 * AG + 3.5067 * PROT + 5.3409 * PRIV \,, \end{aligned} \qquad \text{(eq.1)}$$

where P_{OS} is the open space property premium in percent, $\%OSChange$ is the percentage of the area within a given radius of a property that is occupied by the open space in question, FOR is an indicator (dummy) variable set at 1 if the open space is forested and at zero otherwise, $PARK$ is an indicator variable set at 1 if the open space is an urban park whose prime purpose is provision of wildlife habitat or dispersed recreation and that is characterized by predominantly native vegetation, and at zero otherwise, and AG, $PROT$ and $PRIV$ are indicator variables set at 1 if the open space is natural agricultural land (pasture, or pasture with some cropland), is protected, or is privately owned, respectively, and at zero otherwise.

Kroeger et al. found that the share of open space in the vicinity of a property ($\%OSChange$) was highly significant. The elasticity of property value premiums with respect to the percentage of open space in the vicinity of a property is 0.42 while the coefficient on the open space percentage squared is -0.0068. Thus, an increase in the percentage of open space in an area from zero to ten percent will increase property values on average by 3.5 percent.[19]

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17 The remainder of the reviewed studies did not provide the required information for their inclusion in the analysis.

18 The full model estimated by Kroeger et al. included a number of additional variables hypothesized to impact open space premiums. However, these were not found to be statistically significant and were excluded from the model.

19 $0.4221*10 - 0.0068*(10^2) = 3.5$.

For forested, private, or protected open space or for natural area parks, this value is higher, while for agricultural open space it is lower. Because of the increasing power of the negative squared term for successively larger increases in open space, the marginal (i.e., additional) open space property premiums become negative once open space accounts for approximately 1/3 (32 percent) of the total area. This closely matches Walsh's results who found that in Wake county, North Carolina, marginal open space premiums turned negative for percentages of open space that exceed roughly 1/3 of the total area.

Kroeger et al.'s model explains almost 50 percent of the variation observed in the data and as a whole is highly significant (p=0.0000). Their detailed results are shown in Table 12.

Table 12: Estimation results for the open space property premium model

Variable	*Unstandardized Coefficients*	*Std. Error*	*Standardized Coefficients*	*t-statistic*	*p-value*
(Constant)	-6.5903	1.6353		-4.0299	0.0002
%OSChange	0.4221	0.1290	1.3370	3.2714	0.0020
%OSChangeSq.	-0.0068	0.0032	-0.8801	-2.1432	0.0373
OS-Forest	2.7619	1.1329	0.3092	2.4379	0.0186
OS-Park	1.6768	1.9629	0.1073	0.8543	0.3973
OS-Agland	-2.7367	1.1696	-0.2938	-2.3399	0.0236
Protected	3.5067	1.1039	0.3926	3.1767	0.0026
Private	5.3409	1.2818	0.6555	4.1667	0.0001
R^2		0.5433	N=55	F-statistic	7.9878
Adjusted R^2		0.4753		Prob.(F)	0.0000
Std. Error of the Estimate		2.9658			

Notes: OLS estimation. Dependent variable: %INCR_PV.
Source: Kroeger et al. (2008)

It should be noted that this model likely overestimates the attenuation of the size of marginal open space premiums that results from large open spaces, for reasons explained in detail in Kroeger et al. (2008). As a result, the model is likely to underestimate premiums in areas with large amounts of open space.

We applied Kroeger et al.'s property value premium function (eq. 1) to estimate the property premiums for properties located in the vicinity of the open spaces in the Yaquina Bay COA. Because the majority of the open space is private and unprotected and because we had little information on the location of areas publicly owned or privately protected, we conducted the entire analysis for private, unprotected land. We did have information on the location of the Siuslaw National Forest, portions of which are located in the southeastern edge of the study area. However, there were very few residences, if any, in this area, so we excluded it all together from the open space value analysis. Since protected status positively influences open space premiums, ignoring the protected status of the respective open spaces will lower their estimated open space premiums. This is expected to introduce a conservative estimate into our results.

Utilizing Google Earth imagery, we located large individual open spaces in the Yaquina Bay COA. We defined open space as undeveloped, relatively undisturbed natural land, consistent with the definition used by Kroeger et al. (2008). As a result, we excluded certain residential areas in the Newport area. We did, however, include other residential areas, where the density of structures is very low. In these cases, we used our qualitative judgment to decide whether or not an undeveloped area constituted primarily natural open space. We also excluded areas of open water from the analysis, since the premium model does not include this land cover type as an open space land cover option.

The exclusion of open water will likely lead to further underestimation of the overall property premiums in the area. The reason for this is that a property's proximity to open water will increase its open space value further (Moscovitch, 2007).

In order to identify the number of properties that receive open space premiums, we used Google Earth to identify and manually count the number of single family homes that fall within a one-mile radius of open space. [20] Our decision to truncate the open space included in the analysis at a one-mile distance from the outer edges of a developed place is based on two factors. First, the empirical evidence suggests that open space benefits decrease with increasing distance. Second, most studies underlying our property value estimation function analyzed open space impacts within a one-mile radius of a property. Nevertheless, this truncation will tend to decrease the aggregate open space premium estimate for Yaquina Bay because the additional benefits of open space at larger distances are likely to exceed zero.

We then visually estimated for each residential area in the study area the approximate percentage of the lands within a one-mile radius of that area that was occupied by open space. We excluded properties from the analysis that had 50 percent or more open space within a one-mile radius, since the open space premium model was not estimated for such situations. The reason for excluding these properties from the analysis is that the model overestimates the attenuation of the size of marginal open space premiums for larger open spaces.[21]

We used U.S. Census Bureau (2002) data and maps to partition residential areas located within one mile of study area open space into subsections, specifically, block groups. We then averaged the open space percentages across residential units to obtain the overall percentage of open space within a mile of each block group (Table 13)

With the open space percentage (*%OSChange* in eq.1) identified for each subsection of our study area, we set the indicator variables in the function at their appropriate values. For example if a particular open space was in forest cover, the *FOR* variable was set to (1); if it was a wetland, the *WET* variable was set to (1). In some subsections of the study area, there

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[20] We limited our analysis to single-family detached homes because almost all of the studies based on which our open space premium model was estimated used this home type in their analysis. Thus, the premium estimates generated by our model should be considered most reliable for single-family detached homes, though open space premiums certainly also apply to townhouses, apartments, condominiums or other home styles. We tried to differentiate single family homes from mobile homes, apartment buildings and other home types using factors like the size or shape of the structure or the presence of multi-car parking lots.

[21] This overattenuation can be countered by reducing the coefficient on the squared term in the estimation model, as we did in the New Mexico case study that forms part of our group of five case studies. However, due to the small number of properties in Yaquina Bay that are affected by the exclusion, we decided not to produce a separate set of open space estimates for these properties.

Table 13: Location and number of housing units in study area located within one mile of natural open space

Location of residences by Census subdivision	*Number of housing units*	*Open space as % of area within one mile of average property*
Census Tract 9509, Block Group 1	72	6%
Census Tract 9511, Block Group 2	258	4%
Census Tract 9512, Block Group 1	15	6%
Census Tract 9512, Block Group 2	98	8%
Census Tract 9513, Block Group 1	55	20%
Census Tract 9513, Block Group 2	339	7%
Census Tract 9514, Block Group 1	180	16%
Census Tract 9514, Block Group 2	397	7%
	1,414	

were both wetlands and forests (specifically, salt marshes and Sitka spruce-western hemlock forest). When this occurred, we ran the premium model twice, once for forest as the land cover type and once for wetlands as the cover type, and took a weighted average of the resulting open space premium percentages. For example, if 2/3 of a subsection was forest and 1/3 was wetlands, we weighted the two premium estimates by 2/3 and 1/3, respectively, to obtain the final premium percentage for the subsection. The *PRIV* variable was set to (1) for every subsection since, for reasons already discussed, we conducted the entire analysis for private, unprotected lands. Our analysis indicates that the average open space premium received by residential properties is estimated to range from about 2.5 to seven percent for different communities (Table 14), as a result of the different amounts of natural lands found in the vicinity of the residential areas. Combining these estimates with information on the number of houses and the median home value in each locale allows us to generate an estimate of the total open space premium received by home owners in the area (Table 14).

Table 14: Estimated open space premiums for residential homes located in or adjacent to study area within one mile of natural lands

Census location	*Number of housing units*	*Median home value in 2000 (2004$)*	*Avg. property premium*	
			% of property value	*Total value (million 2004$)*
CT 9509, BG 1	72	$181,885	3.25%	$425,183
CT 9511, BG 2	258	$277,122	2.54%	$1,815,456
CT 9512, BG 1	15	$173,738	3.80%	$99,007
CT 9512, BG 2	98	$183,537	4.45%	$800,761
CT 9513, BG 1	55	$193,996	7.22%	$770,498
CT 9513, BG 2	339	$140,157	4.13%	$1,963,433
CT 9514, BG 1	180	$121,881	5.83%	$1,278,221
CT 9514, BG 2	397	$103,494	3.21%	$1,319,615
				$8,472,175

Notes: Column one summarizes properties by census tract only, not by the finer-scale block group level used in the analysis. Number of housing units indicates only units located within one mile of natural area in study area. Median home values shown are weighted values of the block groups contained in the listed census tracts.
Source: Number of housing units and median home values from U.S. Census Bureau (2002).

These results show that in 2000, the latest year for which comprehensive Census data on housing numbers and median home values are available, the total property value premium received by residences located within one mile of the natural open spaces in our study area was an estimated $8.5 million (2004$). This value is likely to be an underestimate of the actual total premium received by homeowners in the study area, because due to the slight overall population increase in the two towns located adjacent to or inside the Yaquina Bay COA, the number of homes is expected to have increased as well. Moreover, average home values are likely to have increased since 2000, although this trend was less pronounced in many rural areas than in metropolitan ones. Finally, our analysis includes on single-family detached homes and thus omits open space premiums received by other housing types.

The estimated total open space premium of around $8.5 million does not represent an annual benefit flow. Rather, it is the total value of the open space premiums captured by residential properties that existed in that year, that is, the value incorporated in the existing residential property stock. In order to make this benefit comparable to the other benefits generated by natural lands in the study area that are assessed in this report, we convert this stock value into its equivalent annual flow. The common approach to doing this is to regard the value of the housing stock ($8.5 million) as a principal that could be invested at market rates. The principal could generate a perpetual stream of annual payments equivalent to the interest earned. At a five percent annual interest rate, which is slightly less than the average annual return on certificates of deposit during the last 20 years (1987-2006), would be $424,000.[22]

These results suggest that the open space-based property value benefits the natural lands in the study area produce for area residents represent an important economic benefit generated by these lands. The relative importance of the property value premium benefits is even larger than suggested by our analysis because the open space benefit estimates are constructed using house price data. These data, like all observed willingness-to-pay data, are an indicator only of the *minimum* value home owners assign to the amenity benefits generated by proximity to natural lands. The actual value is likely to be higher. Its estimation, however, requires the construction of an aggregate housing demand curve that incorporates natural amenities, something that to date has not been done.

Research and Education

The Yaquina Bay area plays an important role in research and educational activities. Both the Hatfield Marine Science Center of the Oregon State University and the Oregon Coast Aquarium receive seawater from the Yaquina Bay. The research carried out by these institutions, with the budget of the Hatfield center alone of about $36 million in 2004 (Hatfield Marine Science Center, 2005) , is dependent on the high quality of this seawater (Gallob, 2006). In addition, the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the US Fish and Wildlife Service, and the Oregon Department of Fish and Wildlife conduct research dependent on the quality of the estuarine water.[23] However, it is beyond the scope of this study to estimate the value of these activities

[22] The annual payout is derived using the following perpetuity formula: $PV = A / i$, where PV is the present value (in our case, the principal of $8.5 million) of the perpetual annuity A, and i is the annual interest rate.
[23] Pers. comm., Fran Recht, Pacific States Marine Fisheries Commission, March 31, 2007.

that is attributable to the bay, as likely some of this research could also be carried out at other sites.

Ecosystem services

The natural systems in the study area provide a wide variety of ecosystem services. The benefits associated with some of these services accrue primarily to local residents and visitors (water retention and generation, air quality, temperature modulation, scenic views) or producers (habitat provision for commercially harvested species such as crabs or fish). Other services generate benefits also on a regional or even larger scales (water quality, water generation, species habitat provision, biodiversity maintenance, carbon sequestration). For example, the wetlands within the study area serve as both a pollutant filter as well as a buffer against flooding from tidal changes and upland runoff (Office of Lincoln County Legal Counsel, 2007; Hatfield Marine Science Center, 2004). While we were unable to develop quantitative estimates for these services, it is important to point out their importance as they can provide a significant benefit to the local communities through pollution reduction and flood protection.

In some cases, the value of some of these services is already captured in our analysis of other human uses of the study area. For example, the use value of species enjoyed by humans for recreational purposes is already partially accounted for in our analysis of the recreational value of the study area, in the form of fishing, hunting, and wildlife viewing values. Likewise, the value of the scenic views provided by the land is already captured in our estimate of the property enhancement value generated by the open lands in the area, while the value of habitat provision for commercial species is reflected in the revenues of the respective industries. In this section, we develop an estimate of the value of an important ecosystem service provided by the study area that is of increasing concern: carbon sequestration.

Carbon sequestration by natural lands in the study area

The quantity of carbon taken up by a given plant varies with the species, the age of the particular specimen, and environmental conditions such as nutrient and water availability, ambient atmospheric carbon dioxide concentration, temperature (and its fluctuation), and the amount of available sunlight. As a result, rates of carbon uptake vary among species and locations. In addition to the species and growing location, forest management practices are an important variable in carbon sequestration (Richards et al., 2006).

Of the undeveloped areas found in our study area, approximately 90 percent are in terrestrial communities, with Sitka spruce-western hemlock forest constituting the dominant community. The remainder is made up by saltmarsh (Table 15).

Table 15: Vegetation communities in the study area

	Area (ha)
Coastal Communities and Sand Dunes	78
Low Elevation Westside Coniferous Forests	7
Saltmarsh	609
Sitka spruce-western hemlock forest	5,479

The terrestrial ecosystems have the potential for long-term carbon storage above- (woody biomass) and belowground (roots and soil organic matter). The estuarine tidal marshes provide long-term carbon storage through accumulation of organic matter in the soil.

Our estimates of terrestrial net carbon sequestration are based on published studies that analyzed terrestrial net ecosystem productivity (NEP; net carbon flux) in Oregon's Coast Range ecoregion. Turner et al. (2006) provide an estimate of average terrestrial NEP of the Coast Range ecoregion for the period 1996-2000, while Turner et al. (2007) provide average terrestrial NEP for the same region for the years 2002 and 2003. Our study area constitutes only a small portion of the Coast Range. However, visual inspection of the NEP maps provided in both studies indicates that the Yaquina Bay area is among the areas with higher NEP within the Coast Range ecoregion. Thus, using the ecoregion-wide average NEP is expected to result in the underestimation of the actual NEP in our study area.

A comprehensive literature search did not yield any studies of carbon uptake by saltwater tidal marshes in Oregon. Our estimates of net carbon uptake by the saltmarsh systems in our study area are based on the most proximate sites for which studies exist, which are located in north-central California, as well as on the average net sequestration rate of tidal wetlands in the conterminous U.S.

The net carbon uptake rates are shown in Table 16.

Table 16: Literature estimates of net carbon uptake by ecosystems found in the study area

Vegetation/ecosystem type	*Net sequestration tC/ha/yr*		*Source*
Oregon Coast Range ecoregion - terrestrial	1.97	1996-2000 average	Turner et al (2007)
Oregon Coast Range ecoregion - terrestrial	1.98	2002-2003 average	Turner et al (2006)
Saltmarsh	2.06	Avg. of four California observations	Chmura et al. (2003)
Saltmarsh	1.90	100-yr avg. accumulation, San Francisco South Bay	Callaway and Drexler, unpublished, from Trulio et al. (2007)
Saltmarsh	2.2	Avg. of tidal marshes in conterminous U.S.	Bridgham et al. (2006)
Saltmarsh	2.1	Avg. of tidal marshes in Canada	Bridgham et al. (2006)

For the terrestrial portion of our study area, we construct a low and a high carbon sequestration estimate based on Turner et al. (2007) and the marginally higher number given in Turner et al. (2006), respectively. For saltmarshes, we use the average net sequestration rate reported by Callaway and Drexler (unpublished, reported in Trulio et al. (2007) for a low estimate of carbon uptake by the saltmarshes in our study area, and the average soil carbon accumulation rate for estuarine marshes in the conterminous U.S. (Bridgham et al., 2006) for a high estimate.

Not surprisingly, due to the only small differences in the sequestration rates reported in the literature for the particular ecosystems, our high and low sequestration estimates do not differ much from each other. We estimate that the ecosystems in our study area are absorbing between 12,100 and 12,400 tons of carbon per year (Table 17).

Table 17: Net carbon uptake by undeveloped lands in study area

	Area (ha)	*Net sequestration tC/ha/yr*		*Total net sequestration tC/yr*	
		Low	*High*	*Low*	*High*
Coastal Communities and Sand Dunes	78	1.97	1.98	153	154
Low Elevation Westside Coniferous Forests	7	1.97	1.98	14	14
Saltmarsh	609	1.90	2.2	1,157	1,340
Sitka spruce-western hemlock forest	5,479	1.97	1.98	10,794	10,849
TOTAL				12,118	12,357

The value of carbon sequestration services

Assigning an economic value to the carbon sequestration services provided by the ecosystems in our study area is complicated by several factors. The true value of the carbon uptake consists in the associated incremental reduction in the negative consequences of increased atmospheric carbon concentrations, such as coastal inundation or storm surges. Although the potential future impacts of climate change on the U.S. in general or on the Great Plains in particular have been documented (Field et al., 2007; Achterman et al., 2006; Canning et al., in review; Mote et al., 2008), estimating the expected value of damages associated with climate change is impossible due to the structural uncertainties in the science of climate change and the inability to place a meaningful upper bound on the potential catastrophic losses associated with disastrous temperature changes (Weitzman, 2008). Thus, estimating the reduction in the severity of these impacts that is achieved through the uptake and storage of atmospheric carbon by the ecosystems in our study area is beyond the scope of our study, and probably is not feasible at this point in time.

An alternative approach to valuing the carbon uptake produced by the ecosystems is based on the prices of carbon credits in appropriate markets. However, several different markets exist for carbon credits, and the prices of the credits traded on them vary widely. Some of these markets are regulation-driven, and as such they restrict access on both the buyer and seller side.[24] All of these regulation-driven markets currently are outside of the U.S., and

[24] Examples are all Kyoto-based or regionally defined carbon credit markets, such as the EU's, the UK's, and Norway's Emissions Trading Schemes, Australia's NSW Greenhouse Gas Abatement Scheme, the Clean Development Mechanism and Joint Implementation programs, or Canadian, Japanese, and Swiss programs.

under their current legal frameworks, carbon credits generated in the United States are not eligible for transaction in these markets (Diamant, 2006).

Several regional U.S. emission trading schemes currently are under development. These include the recently created Western Regional Climate Action Initiative, the northeast Regional Greenhouse Gas Initiative (RGGI) and the California Climate Action Registry (CCAR). However, until the reduction targets are set for these markets and the accompanying carbon credit trading begins, it is impossible to predict what credit prices will be on these markets once they begin operation.

Nevertheless, a number of voluntary carbon credit markets already exist in the U.S. whose carbon prices can serve to construct first rough estimates of the value of carbon sequestration provided by the study area. These include the Chicago Climate Exchange, various carbon-offset schemes operated by private suppliers, and a new offset-scheme created by the U.S. Forest Service and the National Forest Foundation.

An accurate valuation of the carbon sequestration services provided by the ecosystems in the study area based on market prices for carbon requires a careful analysis of the access conditions of the various mandatory and voluntary markets. Depending on the market in question, admissible carbon credits must fulfill a number of conditions with respect to verifiability, additionality, permanence and leakage that vary in stringency among the markets. Some of those markets currently would not admit sequestration-based carbon credits from existing, protected forest lands, while others would accept such credits if they were the result of changes in land management practices or of avoided loss of vegetation that would result under a business-as-usual scenario.

With almost all (96 percent) of the study area in private ownership (Figure 4), much of the site is at least potentially open for conversion of the predominant forest to other cover types. However, the likelihood of such conversion appears rather low. While according to Census data Oregon's population is expected to grow by over 41 percent between 2000 and 2030 (U.S. Census Bureau, 2005a), growth rates are much lower in Lincoln county (an average of 0.74 percent per year during 2000-2005; U.S. Census Bureau [2005b]). Population growth is even lower in Newport and Toledo, the two towns in the vicinity of the study area, averaging a combined 0.2 percent per year during 2000-2007. Thus, at least at present there does not appear to be much pressure on the study area from residential development. As a result, the carbon accumulation by study area ecosystems may not fulfill additionality requirements that may apply for carbon markets. In any case, the protocols of several existing markets and especially of many of the planned markets are in flux. Here we do not conduct a detailed analysis in order to identify with certainty those markets that currently would accept the credits generated by our study area. Rather, we use prices on those markets that already operate and are not off limits to U.S.-based carbon credits.

The average price on the Chicago Climate Exchange (CCX) during January to July of 2007 was $3.55 per ton of carbon dioxide equivalent (tCO_2e).[25, 26] The average price charged for

[25] All prices given here refer to metric tons. The prices given by Kollmuss and Bowell (2007) have been converted from short tons to metric tons.

air travel CO_2 offsets is $15 per ton (Kollmuss and Bowell, 2007). A recent survey of voluntary carbon markets (Hamilton et al., 2007) found that the average price paid for carbon credits for U.S.-based projects was $10 per ton of carbon dioxide equivalent (tCO_2e). Finally, the new "Carbon Capital Project" created by the Forest Service and the National Forest Foundation will charge $6 per ton of verified CO_2 offset.[27]

Because of the range of prices of voluntary carbon credits, we construct a low and a high estimate of the value of the carbon sequestered by the habitats in our study area. The low carbon price is that found on the CCX during January-July 2007 - $3.55 per metric tCO_2e. The high price is the average price of air travel carbon offsets in 2006/07 - $14.80 per metric tCO_2e. The estimated annual quantity of CO_2 sequestered in our study area, 182 to 253 thousand tons of CO_2e, is equivalent to approximately one percent of the total volume of voluntary transactions in 2006.[28] A sale of the hypothetical credits produced by the ecosystems in our study area therefore would be unlikely to result in a supply shock that would drive down prices. Furthermore, transaction volumes on voluntary carbon markets have been increasing rapidly in recent years, which would make the quantities of carbon sequestered in our study area relatively smaller as a share of the overall market. Importantly also, carbon constraints are likely to tighten in the future with expected increases in both voluntary and mandatory emission reductions, which is likely to raise demand for credits and increase prices.[29]

Applying the low and high prices to the carbon sequestration estimates for our study area (Table 17) yields a total value of the sequestration services estimated at $150,000 to $640,000 per year (Table 18).

Table 18: Estimated annual value of carbon sequestration services provided by study area ecosystems

	LOW scenario	*HIGH scenario*
Quantity of C sequestered (metric tons)	12,118	12,357
Corresponding quantity of CO_2 (metric tons)	44,438	45,312
Price per ton of CO_2e (2004$)	3.41	14.21
Value of carbon sequestration (2004$)	151,535	643,896

Note: Quantities of carbon dioxide are derived by multiplying the volume of sequestered carbon by 3.667, the ratio of the weight of CO_2 to that of C.

26 Average of monthly average closing prices of all vintages. See Chicago Climate Exchange at *http://www.chicagoclimatex.com/* On the CCX, CO_2 is traded in the form of Carbon Financial Instruments (CFI), which each represent 100 tons of CO_2. However, prices are reported in terms of $/metric tCO_2.

27 Friends of the Forest, "Forest Service & NFF Combat Climate Change". July 25, 2007. [online] *http://www.carboncapitalfund.org/news/news-59.html* Last accessed August 6, 2007.

28 The total transaction volume on voluntary carbon markets in 2006 was at least 23.7 million tons of tCO2e (Hamilton et al., 2007). As Hamilton et al. (2007) point out, this estimate may constitute a considerable underestimate of the actual transaction volume of because it was impossible for their survey to capture all over-the-counter transactions.

29 For example, several bills considered in the U.S. Congress in February of 2008 are expected to result in carbon prices of between $15 and $40 per metric ton of CO_2e as soon as 2015 (New Carbon Finance, 2008).

Local and Statewide Economic Impacts of Undeveloped Lands

In this section we develop estimates of the economic impacts associated with human uses of Yaquina Bay.

The estimates of recreation visitors' trip expenditures only represent the first round of economic effects associated with that spending. These first-round impacts consist of retail sales in sectors that directly cater to recreationists, such as gas stations, restaurants, hotels and grocery stores, to name a few. The sales impact these sectors receive ripples through the economy because no sector operates independently. Rather, the sectors that register the first-round, direct sales impact from recreationists' spending in turn increase their demand for inputs, which results in increased sales in the sectors supplying these inputs, and so forth. These impacts are commonly referred to as indirect impacts. At each turn, some additional output is generated. In addition, the direct and indirect increases in sales lead to increases in jobs and earnings (salaries, wages and proprietors' incomes) in those industries directly or indirectly affected by recreation-related spending. Part of this increase in earnings is spent, thus generating further sales. Economists commonly refer to the latter effect as induced impact.

The ratio of initial, first-round sales impacts to final, total impacts is represented by multipliers. These multipliers are derived from regional economic impact models that are based on empirical data on the interrelations between all sectors in the economy. [30]

In this analysis, we estimate the total impacts associated with those uses of Yaquina Bay for which we were able to obtain or construct spending or revenue estimates. These include commercial uses (fishing and crabbing, livestock production), recreation (angling) and research and education.

Any economic impact analysis refers to a particular, spatially discrete area. This is so because the size of the total impacts associated with an economic stimulus (say, a construction project or spending by anglers) depends on the degree to which the economy in question is dependent on inputs from outside of its boundaries. The higher this dependence on imports, the more of the impacts associated with the stimulus accrues to the "outside" economy which experiences these impacts as an increase in the demand for its outputs. Thus, the less self-sufficient an area, the lower its ability to capture the impacts associated with a stimulus, and the higher the "leakage" factor of the area in question. [31] An area that imports all the inputs needed for its production of goods and services captures only the retail, wholesale and transportation margins, with the remainder of revenue leaking out of the area. In general, the capture rate (the inverse of the leakage rate) increases with the size and diversity of an economy, and is high for outputs with a low spatial fungibility provide, that is, outputs that are place-dependent such as restaurants or lodging establishments.

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[30] See for example U.S. Department of Commerce (1997).

[31] For example, of each dollar spent on gasoline in the Yaquina Bay area, only a small share, namely, the retail margin, stays in, or is "captured" by, the local economy. The rest leaves, or "leaks out" of, the area because it is transferred to the refineries from which the local retailers buy their supplies.

Here we will estimate the impacts Yaquina Bay generates in the local, six-county area consisting of Lincoln county and the counties adjacent to it: Benton, Lane, Polk, Tillamook and Yamhill. The state-wide impacts are larger than the local impacts because the leakage rate for the state as a whole is smaller than for the local area.

We use the Bureau of Economic Analysis' (BEA) Regional Input-Output Modeling System (RIMS II) detailed industry multipliers for the six-county economy, which comprise total final demand, earnings and employment multipliers for almost 500 activities in the area.

Impact analysis estimates are based on the particular output, or sales, that result from an economic stimulus. Thus, the revenue figures we have for commercial and research activities in the Yaquina Bay area can be used directly in an impact analysis. By contrast, to estimate the economic impacts associated with spending by anglers, one needs to assign that spending to the particular sectors or industries that supply anglers with the goods and services they purchase. The 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation for Oregon (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2008) provides a breakdown of average expenditures by anglers in Oregon into major spending categories. Combining this information with the total spending by Yaquina Bay anglers (Table 7) yields estimates of total expenditures by anglers in the bay for the major spending categories (Table 19).

Table 19: Breakdown of spending by anglers in Yaquina Bay into major spending categories (2006)

Spending category	*Total spending (2004 est.) 2004$*
Trip	
Food	184,000
Lodging	62,000
Transportation	234,000
Other	134,000
Equipment	344,000
TOTAL	958,000

Notes: "Other" trip costs include equipment rental and boating costs, guide fees and bait among other items. Equipment costs are for freshwater equipment only.
Source: U.S. Fish and Wildlife Service and U.S. Census Bureau (2008)

These spending categories are much broader than the RIMS II detailed industry classifications. In order to select the most appropriate multipliers, it is necessary to break down spending further. This is also required in order to estimate the share of total expenditures that is captured in the local six-county area. For example, the capture rate generally for the area is high for locally produced services such as restaurant meals or accommodations, while it is low (equivalent to the retail margin, plus in some cases wholesale and transportation margins) for goods such as gasoline or equipment not produced in the area.

In order to break down the spending estimates shown in Table 19, we assign some spending to smaller categories and then assign all categories to particular RIMS II industries as shown in Table 20.

Table 20: Breakdown of anglers' expenditures into smaller categories

Major spending category	*Breakdown*	*RIMS II detailed industry*
Food	50% → Restaurants 50% → Groceries	Food services and drinking places Retail trade
Lodging	Lodging	Hotels and motels
Transportation	90% → Gasoline etc. 10% → Rental cars	Retail trade Automotive equip. rental and leasing
Other	Other (boating etc.)	Scenic and sightseeing transportation and support activities for transportation
Equipment	Equipment	Retail trade

Table 21 shows our approximate estimates of the capture rates for the different industries as well as the RIMS II final demand output, earnings and employment multipliers for those industries. The table includes the research (Hatfield Marine Science Center) and selected commercial activities in the area (crabbing, fishing, livestock production) documented in our study.

Table 21: Assumed capture rates and RIMS II multipliers for selected industries for six-county area around Yaquina Bay

RIMS II detailed industry	*Total output in study area*	*Assumed local capture rate*	*RIMS II final demand multipliers*		
			Output (2004$)	*Earnings (2004$)*	*Jobs (per $million output)*
Food services and drinking places	92,000	80%	1.9012	0.591	34.2616
Hotels and motels	62,000	100%	1.6739	0.5344	25.2713
Automotive equip. rental and leasing	23,000	10%	1.4396	0.2752	11.2529
Scenic and sightseeing transportation and support activities for transportation	134,000	100%	1.7362	0.5361	12.7911
Retail trade	670,000	10%	1.6937	0.5041	20.5574
Fishing	625,000	100%	1.6656	0.4607	21.4399
Cattle ranching and farming	284,000	100%	2.2325	0.3073	13.4515
Scientific research and development services	36,400,000	100%	1.8144	0.6787	16.3897

Multiplying the output generated by locally captured angler expenditures and the commercial and research outputs in the study area by the respective multipliers, we obtain an estimate of the total final economic impact on the six-county area that is associated with human uses of Yaquina Bay. In 2004, recreational fishing, crabbing and oyster harvests, livestock production and scientific research and education at the Hatfield Center produced estimated total sales of $68 million, $25 million in earnings and supported an estimated 621 full-time jobs (Table 22). The by far single largest share of these impacts is produced by the Hatfield Center. Angling in Yaquina Bay accounts for a total of almost $600,000 per year in final sales in the six-county area, over $180,000 in earnings and seven full-time jobs. Of course, the total impact of all recreation is likely to be much higher than that associated with angling alone, because Yaquina Bay attracts many wildlife viewers due to its location along the Pacific flyway.

Table 22: Estimated total economic impacts of selected recreation, commercial and research activities in Yaquina Bay in 2004

RIMS II detailed industry	*RIMS II total final effects*		
	Output (2004$)	*Earnings (2004$)*	*Jobs*
Food services and drinking places [1]	140,000	43,000	3
Hotels and motels [1]	103,000	33,000	2
Automotive equip. rental and leasing [1]	3,000	1,000	0
Scenic and sightseeing transportation and support activities for transportation [1]	233,000	72,000	2
Retail trade [1]	110,000	33,000	1
Fishing	1,041,000	288,000	13
Cattle ranching and farming	633,000	87,000	4
Scientific research and development services	66,044,000	24,705,000	597
TOTAL	68,307,000	25,261,000	621

Notes: Totals may not add up due to rounding. [1] Only those impacts associated with recreational angling are included here.

The estimates presented in Table 22 show the total impacts in the six-county area from angling, crabbing and oyster harvests, livestock production and scientific research and education activities in the Yaquina Bay COA. These estimates show the economic significance of the Yaquina Bay conservation opportunity area to the local economy. However, some of these impacts in the area likely would also occur in the absence of the Bay and thus cannot entirely be attributed to the Bay. For example, if Yaquina Bay did not exist, some of the current anglers in the Bay might engage in fishing in other waters in the six-county area. Or, alternatively, they might spend the money currently spent on angling on other recreational activities in the area. Table 22 thus represents the results of what economists refer to as an economic significance analysis, the purpose of which it is to assess the size of all economic impacts associated with particular activities. By contrast, an economic impact analysis in the narrow sense of the term attempts to quantify only those impacts that are exclusively attributable to the activity in question (in our case, the angling, commercial and research and educational uses of the Bay). This is commonly done by subtracting from the total impacts estimated in a significance analysis those that are deemed to occur even absent the activity or resource (the Bay) whose impacts are evaluated.

Delineating exactly which impacts are specifically attributable to a particular natural area often is difficult without detailed visitor surveys. A survey of Bay recreationists could reveal both the prevalence of local anglers and the availability or lack of substitute sites for the Bay and their comparative attractiveness. However, neither piece of information is available for our study area. In the case of the Bay, if the local recreation opportunities were not available, the area might lose recreation visitors (individuals residing outside of the six-county impact analysis area) who would no longer be attracted to the area. It might also lose some output, earnings and jobs as a result of area residents' pursuing recreation activities elsewhere, or spending their money in sectors that have lower local capture rates than the recreation sector.

More importantly, however, the scientific research and education activities at the Hatfield Marine Science Center are critically dependent on the Bay, as are commercial oyster and crab harvests. Neither of these specialized activities could be carried out elsewhere in the study area. The impacts associated with these activities therefore are entirely attributable to the Bay. Since these activities together account for over 98 percent of all output, earnings and employment identified in the significance analysis (Table 22), the economic impacts attributable to the Bay are only marginally lower than those identified in that analysis. These results suggest that Yaquina Bay is a very important asset for the six-county economy.

Conclusion

Undeveloped lands support a variety of human activities. These activities carry associated economic values because they contribute to individuals' well-being. Some of these values are at least partially reflected in markets, either because the nature-based activity (e.g., wildlife viewing or hunting) requires inputs (e.g., transportation, food and lodging, permits, equipment) that are bought and sold in markets, or because the goods or services provided by undeveloped lands (e.g., water provision or carbon sequestration services) are themselves traded in markets. Thus, to some extent market expenditures associated with human uses of natural lands can serve as a lower-bound indicator of the value individuals place on those uses. However, the value of many goods and services provided by natural lands is not fully reflected in market transactions, either because a good or service is not amenable to being bought and sold in markets (e.g., populations of individual threatened or endangered species or biodiversity more generally); because individuals value these goods or services not for their use alone but also, and in some cases primarily, for their existence per se (e.g., particular "charismatic" species; unique scenic landscapes such as Yellowstone National Park, or untouched, wild places such as wilderness areas); or because market prices do not reflect the consumer or producer surplus or net benefit to individuals or firms that is associated with their consumption of the good or service or with its use as an input to production. Thus, capturing the full value of human activities supported by natural lands requires the use of valuation approaches capable of capturing the portion of the value of natural lands that is not reflected in the market transactions.

This study uses market prices and, to the extent they are available, published estimates of non-market values to develop comprehensive estimates of the economic value of several activities supported by undeveloped lands in the Yaquina Bay conservation opportunity area, a 29 square-mile area in central coastal Oregon that has been identified as important to meeting the state's fish and wildlife conservation goals.

Our analysis develops estimates of the value of the area for commercial crab and oyster fisheries, livestock production, and recreational fishing by local residents and visitors. It also quantifies the open space premiums that accrue to residential properties located in the vicinity of undeveloped open spaces in the area, the value of carbon sequestration services provided by the undeveloped lands in the area. The area provides a number of additional uses, such as support for large-scale educational and research activities, habitat provision for threatened, endangered, rare or "charismatic" species like Coho salmon, bald eagles and a variety of migratory waterfowl. We did not quantify the value of these uses in our analysis for lack of the required data. In addition, our value estimates generally are rather conservative because available data on some uses are incomplete. For example, our estimate of the value of outdoor recreation activities in the study area is limited to recreational fishing and thus excludes the value of hunting, wildlife viewing and other recreation activities not associated with wildlife.

Despite these strong limitations to what we were able to include in our analysis, our results shows that the economic value of the uses of the Yaquina Bay we could quantify is substantial, ranging from an estimated $2.8 million to $4.6 million per year (Table 23).

Table 23: Annual value of selected uses supported by the Yaquina Bay COA

Yaquina Bay uses	*Low estimate*	*High estimate*
	2004$	
Commercial crabbing and oyster farming	908,000	908,000
Commercial fishing	*not quantified*	
Livestock production	283,500	283,500
Forestry	*not quantified*	
Recreation: Angling	1,048,000	2,342,000
Other	*not quantified*	
Research and education	*not quantified*	
Open space property value premiums	424,000	424,000
Ecosystem services: Carbon sequestration	152,000	644,000
Other	*not quantified*	
TOTAL	2,815,000	4,601,000

Note: The value of open space property price premiums shown in the table is the annual benefit flow (see p. 25)

Recreational fishing is the activity that generates the single largest value, followed by commercial crabbing and oyster harvests. Carbon sequestration, the only ecosystem service included in our analysis, generates substantial economic value as well, although the current uncertainties surrounding access and credit prices on emerging carbon markets make this estimate somewhat less reliable than those for the other uses of the study area.[32]

It bears repeating that the actual economic value of the Bay is likely to far surpass our estimate. Wildlife viewing, hunting and other, non-wildlife-associated recreation activities generate substantial economic values. The same likely is true for several ecosystem services provided by the area, such as improving water quality and providing habitat for threatened, endangered and rare species.

The activities supported by the Yaquina Bay area also generate large sales ($68 million per year), income ($25 million per year) and employment (over 600 full-time jobs) impacts in the six-county area surrounding the Bay. The by far single largest driver of the economic impacts associated with the Bay is the Hatfield Marine Science Center, which accounts for 98 percent of the total impacts and which is crucially dependent on the natural resources in the Bay. These impacts in turn generate substantial local, state and federal tax revenues.

[32] For example, the price of a carbon credit (called "Carbon Finance Instrument" or CFI) on the Chicago Climate Exchange between February and May 2007 fluctuated between $2.60 and $7.40 per metric ton of CO_2e while the price of CFI futures (maturity date December 2010) fluctuated between $3.25 and $9.75 during the same period. A recent analysis (New Carbon Finance, 2008) suggested that a potential future cap-and-trade system in the U.S. along the lines proposed in several bills considered in the U.S. Congress in February of 2008 might result in carbon prices of between $15 and $40 per metric ton of CO_2e as soon as 2015, depending on whether only domestic or also international trading would be allowed. For comparison, in our calculations we used the average January-July 2007 price of $3.55 per metric ton of CO_2e as a lower bound, and the average price of air travel carbon offsets in 2006/07, $14.80 per metric tCO_2e, as the upper bound.

Given the increasing scarcity of undeveloped lands and of many of the goods and services they provide and given the expected continuation of that trend, the value of these outputs provided by conserved natural areas is only expected to increase over time.[33] Land use planning, in order to achieve economically sensible results, should take into account these economic values that are generated by the conservation of undeveloped lands and the fact that the increasing relative scarcity of these lands will only increase the value generated by land conservation. Since a large share of both ecologically and economically valuable undeveloped lands is in private ownership, not just in Yaquina Bay but also at the state and national levels, existing financial incentive systems that encourage land conservation will need to be improved and in many cases additional ones will need to be created in order to better align privately and socially desirable outcomes. This is a challenging task whose urgency is increasing in lockstep with the continuing loss and degradation of natural lands.

[33] This already is evident for water provision and carbon sequestration.

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