The Economic Value of Natural Capital on the Sonoma Coast

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Prepared for:
Sonoma County Agricultural Preservation and Open Space District

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Executive Summary

Overview

Introduction to the District

The Sonoma County Agricultural Preservation and Open Space District ("the District") is a farmland and open space preservation organization established by Sonoma County, CA voters. In 1990, county residents voted to create the District and fund it with a quarter-cent sales tax; in 2006, they reauthorized the District to continue preserving working farms and scenic environmental resources. The District's ongoing purpose is to use these voter-approved funds to purchase conservation easements and fee titles, and to implement other preservation mechanisms that protect agricultural lands and preserve open space. To date, the District has permanently preserved almost 109,000 acres of Sonoma County open space and agricultural land (www.sonomaopenspace.org). A significant portion of the preserved lands (17,280 acres) is located in the coastal zone within the 125 square mile area surrounding the Russian River outlet at the Pacific Ocean.

These extensive land preservation investments preserve the flow and quality of ecosystem goods and services for present and future generations. Although County voters continue to support land conservation measures and finance land conservation, preservation funding is not unlimited and must be allocated across multiple land preservation opportunities. Further, while businesses and residents are aware that the County's coastal open space enhance tourism and recreation, provide rural amenities and scenic views, and contribute to viable agriculture, they may not be aware of the total economic value of multiple ecosystem services and goods these lands provide for regional well-being. Unlike built capital which is typically created to achieve a single objective, natural capital, like coastal open space, is inherently multi-objective. Forested open spaces, for example, not only provide woodland habitat, but also sequester carbon and remove air pollution, offer space for recreation and protect water quality.

By investing in a suite of land conservation strategies, the District and its partners are supporting diverse societal goals. To kick off the "Healthy Lands & Healthy Economies" (HLHE) initiative in Sonoma County, the District has already begun assessing the generalized, countywide value of typical open space services using benefit transfer by land use/ land cover estimates of existing open space areas.

Main Goals for This Study

This study is meant to support the District in developing a focused economic understanding of the values of ecosystem services and goods derived from agricultural and open space preservation investments in Coastal Sonoma County. We build on the land use/land cover-based research underway to advance understanding of the benefits of specific agricultural and open space preservation investments. In particular, we document the several types of benefits (economic and otherwise) derived from District and other conservation investments on the coast, including benefits from carbon sequestration, recreational opportunity, agricultural production, coastal resiliency to projected sea-level rise, biodiversity, and threatened and endangered species. Additional research is needed to expand on these results by also considering benefits to watershed health and residential amenities, and quantifying or monetizing services discussed qualitatively in this study.

Methods

Our study highlights the societal contributions of land preservation programs in Sonoma County, California to the county residents (e.g., improved scenery and recreational opportunities) and global population (i.e., carbon sequestration benefits). This work advances a recent study of the baseline ecosystem service benefits of undeveloped land in Sonoma County (Earth Economics, forthcoming) by studying the incremental benefits of the Sonoma County Agricultural Preservation and Open Space District's actions to preserve undeveloped, vegetated open space at 21 specific coastal parcels. This analysis demonstrates benefits from lands preserved between the District's inception in 1990 and present day (2015).

In this study, we use an *incremental effects* approach in estimating the value of ecosystem services and goods provided by protecting coastal lands relative to potential land development scenarios. Generally, the quantity of ecosystem services and goods provided by natural capital in developed areas is lower than in undeveloped areas (Banzhaf & Jawahar, 2005; Chan, Shaw, Cameron, Underwood, & Daily, 2006). This report provides data which makes a compelling argument – for Sonoma County's coastline in particular — that the returns from existing conservation payments have already provided a greater value to the county and state residents.

Throughout this report, we use a mix of quantitative and qualitative methods to assess ecological conditions and economic benefits derived from the actual present day status of coastal lands in the District holdings ("with protection" scenario) in relation to several counterfactual scenarios. The counterfactual scenarios are based on the assumed fate of District holdings had they not been protected – by the District, other conservation organizations, policy or law ("without protection" scenarios). Working with the District, we developed several counterfactual scenarios to represent the range of residential development scenarios seen at unprotected lands.

The difference in the value of ecosystem services and goods provided by natural capital under the "with protection" and "without protection" scenarios is the return on taxpayer land preservation investments to date. Where quantification and/or monetization were not possible, we narratively compare the alternative scenarios to demonstrate the types and potential magnitude of additional values from land preservation. Although we considered nine categories of ecosystem services in this study, only two categories of ecosystem services (carbon sequestration and recreation) were assessed in dollar terms due to data limitations (see Table ES-1 below). As a result, the value of ecosystems services presented in this study is an underestimate of the total ecosystem service value provided by preservation of coastal open space in the Sonoma County.

Summary of Results

Table ES-1 summarizes the benefits of open space and agricultural preservation documented in this study. Conservation easement is a legal agreement to maintain the undeveloped nature of open spaces (and to maintain environmentally-beneficial management practices on working agricultural lands) in perpetuity. In this study, we assume that the District's lands began providing benefits in the year of preservation, and will continue to do so in future years. When considered over 60 years between 1990 and 2050, we estimate that protecting open space in the coastal zone provides at least $1.4 to $3.5 million in annualized carbon sequestration and recreation benefits and between $38.7 and

$100.5 million in total value over the 60 year analysis window. Preservation also provides additional benefits resulting from increased infrastructure protection from sea-level rise, improved coastal ecology, threatened and endangered species protection, enhanced water quality and supply, air pollution removal, and enhanced scenery and aesthetic values (Table ES-1). In addition, rangeland preservation supports sustainable agriculture and, as a result, enhances local amenities (e.g., local food production).

Table ES-1. Estimated Annualized Economic Value of Ecosystem Services Protected by Land Preservation in the Sonoma County Coastal Study Area.

Ecosystem Service	Annualized Value (2015$, 3% Discount Rate)		Total Value Estimate (2015$, 3% Discount Rate)	
	Low Bound	High Bound	Low Bound	High Bound
Carbon Sequestration	$1,291,418	$1,538,400	$37,032,215	$44,114,514
Agricultural & Food Products	Qualitative positive benefit.			
Cultural & Recreational Amenities	$59,600	$2,000,000	$1,700,000	$56,400,000
Sea-level Rise Resilience	Quantitative positive benefit.			
Coastal Ecology	Qualitative positive benefit.			
T&E Species Conservation	Qualitative positive benefit.			
Air Pollution Mitigation	*Likely positive benefit.*			
Water Quality and Supply	*Likely positive benefit.*			
Real Estate Amenities	*Likely positive benefit.*			
Total Benefits *(Partial Ecosystem Values)*	***$1,348,018+***	***$3,538,400+***	***$38,732,215+***	***$100,514,514 +***

Implications

Preserving agricultural and undeveloped open space is benefitting the Sonoma County residents who authorized the District's land preservation activities. Using benefit transfer evaluation methods (which provide estimates where original studies are not feasible) and several residential development scenarios (to illustrate a possible vision of today's landscape had open spaces not been preserved), our analyses suggest that preserving 18,162 acres of coastal open spaces provides a total present value of $38.7 million to $100.5 million in carbon sequestration and sightseeing benefits, relative to alternative development scenarios. Total benefits are potentially larger than these economically-quantifiable estimates. Our study also shows how land protection benefits water resources, habitats for threatened and endangered species, and sea level rise resiliency. While this study faced challenges common to other studies of land preservation values—such as overcoming data limitations and addressing the complexity inherent in natural systems (e.g., Fausold & Lilieholm, 1999)—the estimates help clarify the importance and monetary value of open space preservation policy in Sonoma County. The District and partners invested $125.8 million in taxpayer-approved funding to acquire coastal parcels (as of 2015, in 2015$). Although the estimated value of the two ecosystem services monetized in this study (carbon sequestration and recreation) are lower than the District's investment to date the estimated value represents only a fraction of the total value of ecosystem services provided by land preservation on the Sonoma Coast. Capturing additional ecosystem services (e.g., infrastructure protection in sea level rise scenarios; agricultural production; endangered species protection) could show a positive, return on investment.

The evaluation for the Sonoma County Agricultural Preservation and Open Space District's coastal holdings helps to inform future policy decisions and land preservation actions. Investing in coastal land preservation simultaneously provides multiple community amenities and a long-term benefits. It is plausible that these implications would carry over to the District's other open spaces located in inland Sonoma County, and more broadly to District partners' other open space preservation programs in the greater San Francisco Bay area (e.g., HLHE partner organizations). In 2031, the District is up for reauthorization. By demonstrating the economic value of open space preservation this study would allow the Sonoma County voters to make informed decisions in reauthorizing the District's work and continue to support and enhance the provision of ecosystem service benefits through land preservation.

1. Introduction

Much like machinery and raw materials are needed for modern industrial processes, nature is the capital needed for the basic life support, provisioning, and cultural processes that underpin our natural world and human communities. Sonoma County's open spaces (forests, parks, grasslands, working farms, shorelines, rivers, and coastal waters) are *natural capital* that sustains Sonoma county residents, businesses and visitors. Open space preservation, therefore, offers myriad, economically-valuable public benefits. In urban, suburban and rural communities alike, citizens often appreciate open spaces for their recreational opportunity, contribution to traditional ways of life, aesthetic character, and their existence (e.g., Banzhaf & Jawahar, 2005; Brander & Koetse, 2011; Thompson, Noel, & Cross, 2002). Open spaces are also inherently valuable as part of the natural world: they support ecosystem functions like water purification, air pollutant removals, carbon sequestration, and the biological needs of plant and animal species (Millenium Ecosystem Assessment, 2005). When many open spaces are preserved across the landscape, they form a network that connects habitats, maintain overall rural character, and support public health. Collectively, the open space ecosystem structures and functions produce final *goods and services* that are tangible and economically valuable to humans: clean water, clean air, healthy coastlines, food products, and opportunity for recreation and reflection (Figure 1). Open spaces are, in short, critical to long-term community well-being, vitality, and resiliency.

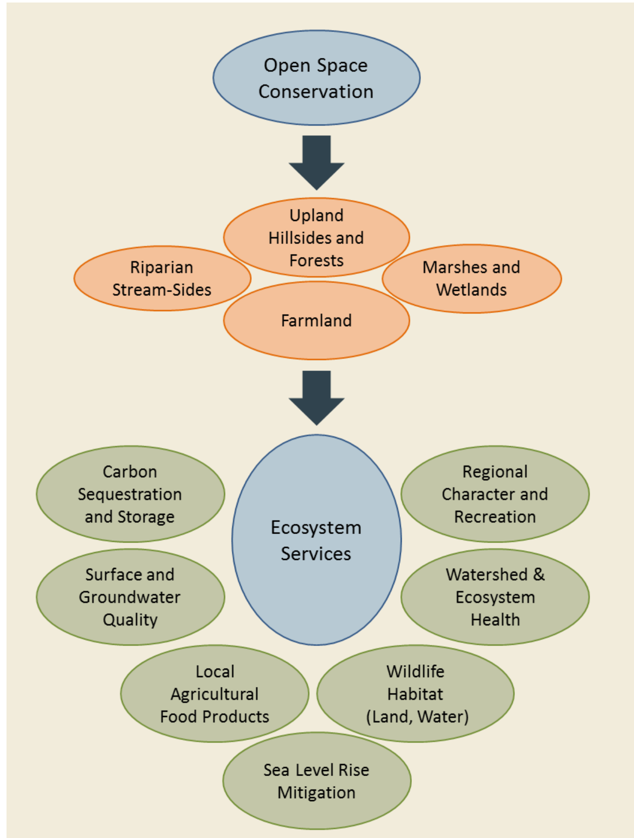

Figure 1. Coastal Open Space Ecosystem Services.

Society also values open spaces and proximity to natural resources for their potential use in providing land for residential, commercial, and other developed uses. For example, rural migration is driving large changes in land use; the fastest growing type of land use in the United States consists of exurban development and low-density housing within a landscape dominated by native vegetation and agriculture (Brown, Johnson, Loveland, & Theobald, 2005; Sleeter et al., 2013). History has shown that land markets tend to under-provide for habitat and ecosystem protection and, as a result, the long-term stream of ecosystem services at unprotected open spaces is relatively insecure. Recognizing the benefits of investing in open space preservation, Sonoma County voters authorized the Sonoma County Agricultural

Preservation and Open Space District (SCAPOSD) and its partners[1] to preserve open space in the county. Since 1990, the District and partners (hereafter, “the District”) developed a comprehensive portfolio of open space, both paid for and benefitting County residents and out-of-county visitors.

To enhance the public’s understanding of the value of open spaces and working lands, open space organizations in the San Francisco Bay and surrounding areas developed the “Healthy Lands & Healthy Economies” (HLHE) initiative with funding from the Coastal Conservancy, the Gordon and Betty Moore Foundation and the SD Bechtel, Jr. Foundation.[2] This broad effort is designed to “estimate and articulate the economic value of local ecosystem services and the direct role they play in maintaining sustainable local economies and communities in Santa Clara, Santa Cruz and Sonoma Counties” (Batker et al., 2014). Consistent with goals of the HLHE, the District recently completed a screening analysis of ecosystem services from undeveloped lands, based on general land cover throughout the county (Earth Economics, forthcoming). While the screening analysis is useful in developing a broad understanding of the ways in which natural capital supports many dimensions of society, a more focused and detailed study of parcel-by-parcel land preservation can enhance the dialog by demonstrating the particular role of land preservation *programs* in providing these values.

This report extends existing work to study the natural capital benefits from lands protected under the Sonoma County Agricultural Preservation and Open Space District. To highlight the particular benefits of conserving land in the coastal zone, we focus on 27 square miles of preserved lands within the 125 square mile area surrounding the Russian River outlet at the Pacific Ocean (Figure 2). In addition to ecosystem services outlined above, coastal land preservation provides additional benefits, including absorbing the impact of coastal storms and floodwaters, mitigating the impacts of sea-level rise, minimizing salt water intrusion to groundwater supplies, and others. (Table 1 below provides definition of terms used in this report.) With the expected impacts of climate change on the California coast, the protection of coastal open spaces is an important step in providing for a resilient community, environment and economy over the long term.

This report presents results of a retrospective study of the incremental benefits from coastal preservation investments authorized between the District’s inception in 1990 and today (2015). The incremental approach compares benefits provided by today’s open spaces, relative to counterfactual (alternative) scenarios that represent our best guess about what these lands would look like without the support of conservation agreements over time. We focus on counterfactual scenarios related to residential development absent land preservation. We then compare the physical features (e.g., “natural capital”) of these lands in the present day, to the assumed features in counterfactual scenarios. The difference between the two scenarios equals the ecosystem benefit of the District’s land preservation. We then use a variety of resource valuation techniques to monetize the economic benefits of preserving several ecosystem services, relative to the counterfactual without-preservation scenario. Since County residents invest their tax revenues to protect these open spaces, the reported economic values provide insight into taxpayers’

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[1] The District partners with other public and private organizations in preserving coastal lands. The District shares investments with partners including State Coastal Conservancy, California State Parks, the Moore Foundation, Coastwalk, Stewards of the Coast/Redwoods, Bay Area Ridge Trail Council, Sonoma Land Trust, Wildlands Conservancy, Regional Parks, and local Resource Conservation Districts..

[2] These organizations include Santa Clara County Open Space Authority, the Resource Conservation District of Santa Cruz County, and the Sonoma County Agricultural Preservation Open Space District.

returns on open space investments. Because not all ecosystem services can be measured in dollar terms the values of ecosystem goods and services reported in this study provide partial estimates only.

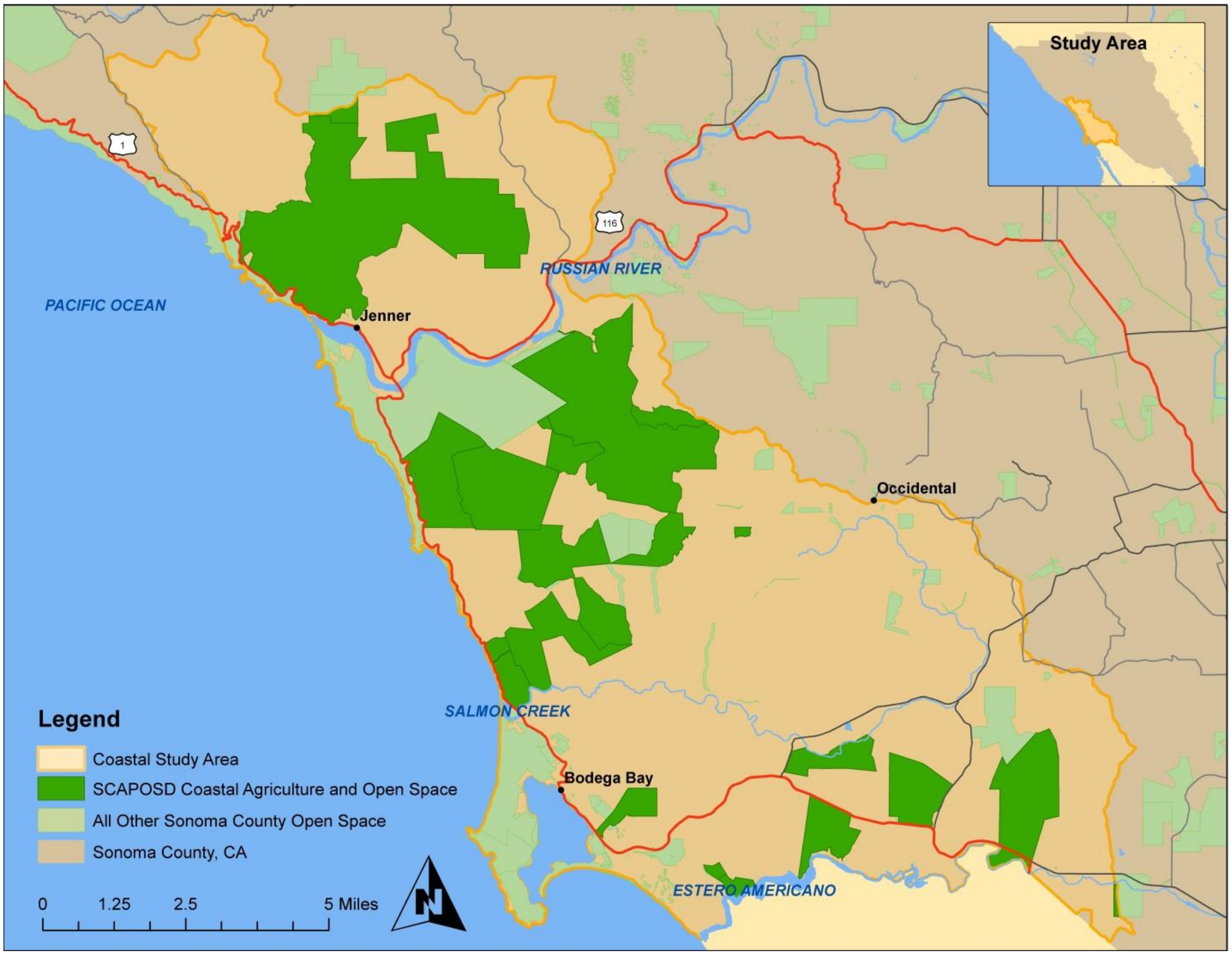

Figure 2. Coastal Study Area.

The remainder of this report is organized as follows: Chapter 2 presents the current state of Sonoma coast in terms of both historical and potential future land use changes, and introduces the counterfactual scenarios. Chapters 3 and 4 summarize changes in ecosystem service flow resulting from open space preservation on the coast and the estimated economic value of selected services. The changes are measured relative to counterfactual scenarios that consider what would have happened had the land been developed instead of preserved. The report concludes with interpretation and discussion of the results, and points to future studies that can add to the case for increasing coastal open space preservation.

Table 1. Terms Used in This Report.	
Term	
Open Space	Undeveloped upland and near-water natural resources including forests, prairies, riparian buffers, parks, agriculture, and other lands
Natural Capital	Physical and geological features of open space ecosystems (e.g., trees, water levels) that yield a flow of goods or services.
Ecosystem Goods and Services	The benefits that humans derive from natural capital.
Willingness To Pay (WTP)	The amount of money that an individual or household is *willing to pay* to provide an ecosystem good or service (e.g., willing to pay $10/year to maintain 1 acre of open space)

2. Open Space on the Sonoma County Coast

2.1 The History and Context of Coastal Land Preservation

Between its inception (1990) and today (2015), the District and its partners have preserved 21 properties now covering a total of 18,162 acres in the coastal area (Figure 3). Open space preservation in the coastal study region began in 1994. The District protected 429 acres between 1994 and 1997, 10,721 acres between 1998 and 2008, and 7,012 between 2009 and 2014.

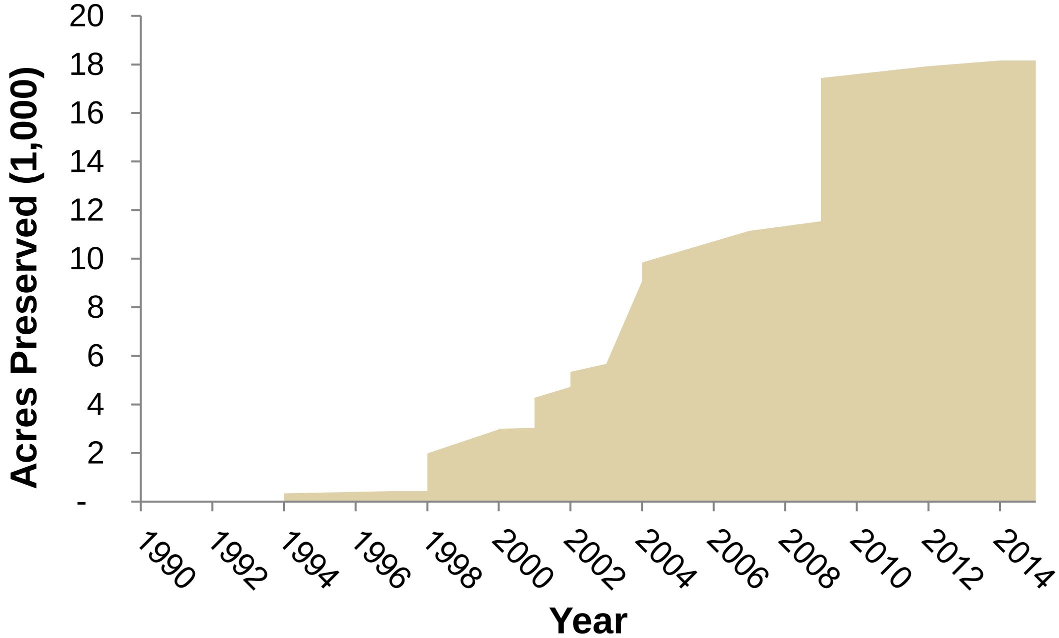

Figure 3. Cumulative District Land Preservation Between 1990 and 2015.

The preserved land area is predominantly rangeland and forests (Figure 4), and includes 44 acres used for natural resources and 4,402 acres in active management through cattle ranching and other agricultural uses. Preserved lands are now managed as a mix of State parks (e.g., Sonoma Coast State Beach), urban parks (e.g., a scenic corridor on US Highway One, owned and managed by Bodega Bay Fire Protection District), rangelands, and natural resource lands.

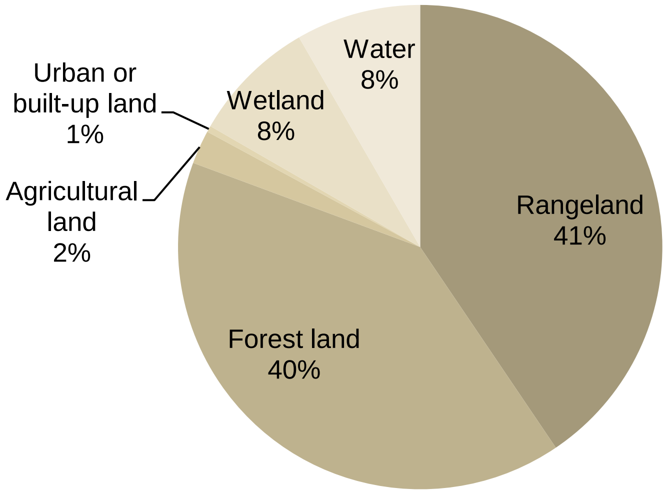

Figure 4. Distribution of Land Use and Land Cover for Protected Parcels.

Based on USGS_ANDERSON_1 from CALVEG. Level 1 of a land use and land cover classification system used by the United States Geological Survey (USGS) based on Anderson et al. (1976).

2.2 Land Preservation Mechanisms for Undeveloped Open Spaces

Undeveloped open space is provided by four main mechanisms:

(1) Public ownership and land management (e.g., parks, state beaches, and others)
(2) Public investment in privately-owned lands (e.g., conservation easements)
(3) Public investment and private ownership, with public access (e.g., NGOs with layered investment)
(4) Private ownership (e.g., private residential landowners, forest owners, and ranchers)

Threats to continued existence of open space include residential sprawl, growing populations, and growing economies; changes in the demand for timber and agricultural products; and natural damages. Development and land use changes come down to private landowner decisions, such as the practices a private landowner follows when managing his or her land, the decision to sell open land for urban development, and other market choices. Of the four mechanisms providing open space, private ownership offers the lowest level of protection against future land use changes. Legal mechanisms available for securing open space include title transfers and fee ownership, easements and conservation agreements (the latter two limit development but leave a property in private ownership), and other mechanisms. For example, the District often secures undeveloped, private open spaces by engaging in conservation easements that restrict the types of activities that can and cannot occur on a given parcel in the future (Sonoma County Agricultural Preservation and Open Space District, 2015a). Under conservation easements, landowners are often compensated financially for giving up their development rights in perpetuity.

2.3 Counterfactual Scenarios to Estimate Incremental Value of Preservation

When development has occurred in the Sonoma coastal area, undeveloped, unprotected parcels have historically been converted to low-density residential neighborhoods, vineyards and rangeland, or a mix of residential and agricultural development (*Pers. Comm.* with SCAPOSD). However, we cannot know with certainty what would have happened to the parcels in District coastal land holding without preservation. For illustrative purposes in this analysis, we focus on the conversion between undeveloped open space and residentially-developed land use and developed "counterfactual" scenarios based on the assumed level of residential development at today's open spaces in the District holding. We developed three counterfactual scenarios based on actual development patterns and zoning rules observed in today's landscape. The three scenarios are:

1. Sonoma Coastal Subdivision. All eligible, undeveloped land is converted to a planned residential subdivision development representative of those in coastal Sonoma County today. Housing density in residential developments in coastal Sonoma County ranges from 0.4 to 11 parcels per acre with an average density of 2.2 parcels per acre.
2. Low-Density Sonoma Zoning. All eligible, undeveloped land is converted to developed use consistent with Sonoma County Zoning low-density residential ("R1"). The Low-Density residential zoning corresponds to up to 1.5 parcels per acre.
3. Coastal California High Density. Most eligible, undeveloped land is converted to Sonoma's low-density residential counterfactual, but three parcels are converted to relatively higher-density development typical of highly-developed areas of other coastal California counties (e.g., single-family, multi-family, and attached single-family dwellings). For this scenario, we used the average housing density of 10.3 parcels per acre based on development characteristics of the lower part of Dillon Beach in Marin County.

Section 2.3.1 describes assumptions used in the counterfactual scenarios. Section 2.3.2 describes the representative housing development characteristics. Supporting Digital Material, provided with this report, lists counterfactual scenarios by District coastal land holding.

2.3.1 Determining Which Parcels May Have Been Developed under Counterfactual Scenarios

Certain land use factors make undeveloped parcels more or less attractive for development. Generally, these factors relate to amenities that support the intended type of development, local codes and ordinances, and the expected profitability of investing in development. The land use change literature provides insight on the characteristics that make certain coastal open spaces attractive candidates for residential use (e.g., Carrión-Flores & Irwin, 2004; Irwin & Bockstael, 2004; Newburn & Berck, 2006; Newburn, Berck, & Merenlender, 2006). To account for real estate and land use issues particular to the Sonoma coast, we also consulted local policy experts to identify important land use change factors.

- Insights from land use change models. Newburn et al. (2006) developed Sonoma County land use change regression models that explained why certain parcels had been developed between 1990 and 2000. The authors developed two models. Each focused on conversions of undeveloped and unprotected open spaces to one of two uses: either residential or vineyard use. Newburn et al. found that residential development was most strongly driven by residential zoning and amenities important to homeowners (e.g., location outside of floodplains, and within urban service areas). The authors also found that vineyard conversion was correlated with better grape growing conditions (e.g., more growing-degree days per year and less-steeply sloped lands)[3] and zoning that favored agricultural uses.

[3] A parcel is considered steeply sloped if the slope grade is greater than 55 percent.

- Expert knowledge of Sonoma County zoning and land use policy. The District's land use policy experts shared qualitative insights about factors that have influenced actual coastal development patterns in recent years. For example, staff confirmed that steeply-sloped parcels were unlikely candidates for vineyard development, and added that redwood forests were unlikely to be developed given timber harvest zoning. They also suggested that residential development has typically been unrestricted, except for parcels without capacity for installing a septic system.

This information suggests, generally, that many types of coastal open spaces are attractive for residential development. It also suggests that some exclusionary factors limit or preclude development (e.g., County and state codes prohibit developing wetlands, riparian corridors and certain coastal zones). In assessing parcel eligibility for residential development we assumed that, absent specific land use restrictions, any parcel in District's coastal land holding would have been developed. Table 2 lists the conversion restrictions we developed for residential development scenarios. Under the worst case scenario, we assumed that, for three select parcels, no zoning regulations were in place at time of development, and that development occurred at much higher rates.

We compiled parcel-specific data on zoning restrictions (County of Sonoma, 2015) and flagged parcels as "eligible" for development based on the parcel area not covered by wetlands or riparian corridor zoning. We then assigned counterfactual characteristics (Table 2) to eligible parcels. Parcels with development restrictions under a counterfactual scenario are assumed to remain undeveloped. Supporting Digital Material records counterfactual scenarios by District coastal land holding.

Table 2. Counterfactual Scenario Restrictions.

Parcel Area	Present Day	All Residential Counterfactuals
Land Use Zoning for Timber [A]	Restricted	Developable
Marshes and Wetlands [B]	Restricted	Restricted
Riparian Corridor [C]	Restricted	Restricted
All Remaining Parcel Areas	Restricted	Developable

Notes and References:

- **A**: Based on Sonoma County Code Zoning Regulations, Chapter 26, where Base District Code = "TP" (Timberland Production Zone). (County of Sonoma, 2015; County of Sonoma PRMD, 2012)
- **B**: We assume marshes and wetlands present barriers to development. Data: County of Sonoma PRMD (2010).
- **C**: Based on Sonoma County Code Zoning Regulations, Chapter 26, where Combining District = "FW" (Floodway) or "FP" (Floodplain). (County of Sonoma, 2015; County of Sonoma PRMD, 2012)

Neither land use change models, nor expert knowledge, can estimate with certainty the time period a vulnerable un-protected parcel would have been developed under counterfactual scenarios. Newburn et al. (2006), for example, projected conversion at any point in a ten-year period. For purposes of estimating monetary benefits over time, we assume that any parcels developed in the counterfactual were converted at the end of the year that the District initiated conservation payments. This assumption is likely to result in overstatement of benefits, since it is possible that some privately-held parcels may have never been developed, and that some parcels may have been developed in later years.

2.3.2 Representative Residential Development Characteristics

We used geographic information system (GIS) software to develop the typical residential area profiles based on key characteristics (e.g., NLCD 2011 impervious cover and tree cover; parcel size) of existing residential parcels in the coastal study area (Sonoma County permit and Resource Management Department, 2015). We developed the representative characteristics of Sonoma Coastal Subdivisions by averaging the land cover characteristics of roads and residential parcels in nine existing coastal subdivisions. We identified these planned communities by reviewing parcel maps and aerial imagery, and grouped parcels and roadways based on a mix of geography and the name of the subdivision listed in the parcel shapefile (e.g., Bodega Harbour, Sereno del Mar, OceanView, and McChristian's Subdivision). For the low-density residential zoning scenario, we averaged characteristics of the 354 parcels in the coastal study area that are zoned as "Rural Residential (R1)." We then applied the average land cover characteristics of the two development scenarios (percent of land area that is impervious cover, tree canopy, or shrubs) to the developable area of protected parcels in District holding. Table 2 provides profiles for protected parcels in the District coastal land holdings, and the average profile of typical residential developments.

We also worked with the District to develop a third "worst case" development scenario, to show the cumulative benefit due to all current zoning and land use policies in place in Sonoma County today, including both land use zoning and land preservation. In this scenario we assume three coastal parcels (Jenner Headlands, Bianchi, and Carrington Ranch) were developed similarly to the high-density multi-family homes observable in other coastal San Francisco Bay-area cities (Table 3): an outcome that demonstrates the total benefit of Sonoma's current land use policy. Supporting material (Chapter 6) provides maps of these hypothetical developments, which were transferred from other Bay-area counties and applied to the District's holdings. All other coastal parcels are assumed to be developed following the low-density residential zoning pattern.

Table 3. Profiles of Open Space Characteristics Under the Present Day and Counterfactual Scenarios.

Characteristic	Present Day Open Space	If Parcels Were Developed: Sonoma Coastal Subdivision	If Parcels Were Developed: Low-Density Sonoma Zoning	Coastal California High Density: 3 High-Density Parcels[B]	Coastal California High Density: Rest of Parcels
Parcel size (ac.)	865 (<1ac - 56,44)	761 (5.8 – 5,039)	761 (5.8 – 5,039)	2,199 (328 – 5,644)	643 (5.8 – 3,407)
% Tree Canopy	27% (0.6% - 69%)	11.5%	13.4%	0.6%	13.4%
% Herbaceous	71% (25% - 100%)	71.5%	75.2%	50.3%	75.2%
% Impervious Surface	2% (0% - 1%)[A]	17.0%	11.4%	49.1%	11.4%
Public Access	Access, tours, or planned access at 10 of 21 parcels	None	None	None	
Scenic Amenities	Hillsides, forests, agriculture	Homes and built infrastructure replace amenities	Homes and built infrastructure replace amenities	Homes and built infrastructure replace amenities	

Notes:

A: Excludes Bodega Bay Fire Housewith 46% impervious cover.

B: Jenner Headlands, Bianchi, and Carrington Ranch.

3. Ecosystem Valuation

3.1 Estimating the Economic Benefits of Land Preservation

The District's actions to permanently preserve open space allow undeveloped coastal lands to forever provide economically valuable ecosystem goods and services. As introduced above, preservation is an economic engine that provides value to society through a series of ecological and economic processes:

1. ***Avoided Development***. Preservation avoids development activity, therefore avoiding tree clearing, increased imperviousness (i.e., roads, driveways, and rooftops), replacement of native plants with non-native species, other structural changes to the parcels, and preserving public accessibility.
2. ***Ecosystems Remain Intact and Healthy***. By avoiding physical impairments associated with development, open space ecosystem structures and functions remain intact. Prairies, forests, and riparian areas retain their natural physical properties and continue to function as they have for millennia. For example, vegetated riparian areas provide shade and stability to stream banks, regulating stream temperature and bank erosion – thereby providing habitat and nursery for salmon and other species.
3. ***Healthy Ecosystems Produce Valuable Goods and Services***. Preserved and healthy ecosystems – with natural structures that support a wide range of ecosystem functions—are then able to provide high-quality, diverse habitat; recreation opportunities; water quality, climate control, and others.
4. ***Societal Values for Ecosystem Goods and Services***. These ecological services, in turn, provide economic values associated with coastal recreation, mitigation of climate change impacts, restoration of threatened and endangered species populations, and other endpoints.

This report focuses on identifying the *incremental* value of open space that is directly attributable to land preservation by the District and its partners. We seek to measure the benefits from *avoiding* the loss in ecosystem services that would have occurred if parcels had not been protected—in other words, the *avoided costs*. The natural capital value of preservation equals the difference between the value of benefits under actual conditions with preservation; and a hypothetical condition that assumes protected parcels were not preserved (Figure 5).

3.1.1 Counterfactual Scenario Application

In the rest of this report, we use a mix of ecological models and existing studies (e.g., functions that translate tree cover into carbon sequestration; willingness-to-pay studies that estimate economic value of recreation given level of site suitability) to characterize and monetize ecosystem services provided by District-preserved parcels. Our approach to each service depended on the amount of data and modeling approaches available. We begin all assessments with a qualitative illustration of the relationship between open space and the ecosystem service case studies and examples (e.g., protection of threatened and endangered species). For some endpoints (e.g., sea-level rise impacts), we also quantitatively compared ecological outcomes in the three natural capital scenarios. For two final endpoints, we further extended the analysis to monetize the economic difference in ecosystem services across scenarios. These approaches apply a series of economic valuation tools (e.g., using the Social Cost of Carbon to monetize carbon sequestration in forests). Together, the qualitative, quantitative, and monetized differences between actual and counterfactual conditions equal the social benefit of District preservation to date.

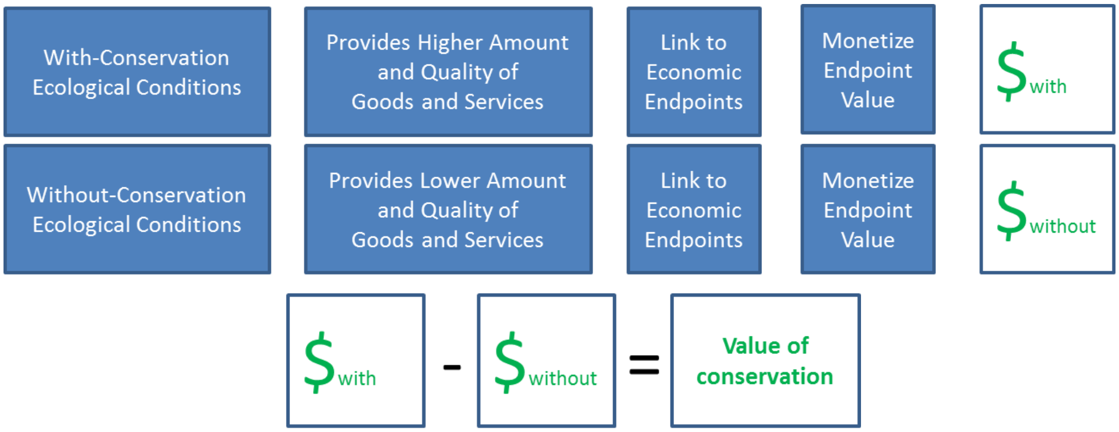

Figure 5. Illustration of Incremental Benefits of Land Preservation.

3.2 Ecosystem Services Technical Approach

Open spaces on the Sonoma coast provide a variety of distinct benefits to society. In this study, we focus on types of ecosystem goods and services that have not traditionally been bought or sold ("nonmarket good and services"). Our approaches therefore reveal the implicit value of these goods by examining behaviors related to the service. For example, we reveal the value of open space's scenic amenities using the amount of money that households are willing to pay for a day of recreation in Sonoma's coastal open spaces.

Some types of ecosystem goods and services are valued because they directly affect human welfare and contribute to human wellbeing (goods with "use" value), such as taking an afternoon hike in Sonoma Coast State Park. Other types of ecosystem goods and services are valuable independently of any observable human use ("non-use" goods), such as a county resident's desire to preserve recreational opportunities for future generations or for use by other people, even if the resident never visits the specific parcel in question.

To show the diversity of natural capital benefits from investing in coastal land preservation, we evaluated preserved services individually. To avoid double-counting, we first determined which benefit categories we could analyze, and evaluated overlaps. Table 4 summarizes the open space ecosystem services analyzed in the study. According to the Millennium Ecosystem Assessment (2005) ecosystem services can be divided into four groups: provisioning, cultural, supporting, and regulation. Provisioning services are the goods that ecosystems provide to people, including food, raw materials, water, and biochemicals. Cultural services include all non-material benefits obtained from ecosystems and can include recreational, educational, and spiritual benefits, preservation values (bequest, existence) and aesthetic beauty. Regulating services provide people with benefits such as carbon sequestration, flood regulation and detoxification from the regulation of ecosystem processes. Although some services are limited to specific parcels (e.g., local food production at agricultural lands; educational tours at selected parcels) the majority of parcels provide a wide range of services listed in Table 4. We used a mix of quantification and monetization approaches, qualitative descriptions, and case study examples to demonstrate the extent and value of services at District holdings.

Table 4. Ecosystem Services Provided by Open Spaces in Sonoma County.

Service	Aquatic Resources	Terrestrial Resources	Level of Analysis
Provisioning	• Habitat for fish/shellfish consumed by humans • Drinking water supply • Agricultural water supply	• Riparian/terrestrial habitat for fish and game consumed by humans • Provision of non-timber products • Production of local food (e.g., milk, cheese)	• Qualitative Analysis
Cultural	Water-Based Recreation • Fishing and shellfishing • Swimming • Kayaking Aesthetic (water clarity/color) • Property values • Scenic vistas Nonuse • Habitat preserving aquatic biodiversity • Preservation of threatened and endangered species	Land and Near Water Recreation • Fishing and shellfishing • Hunting (waterfowl and game) • Birding • Hiking/nature enjoyment • Other recreation (e.g., cycling) • Sightseeing Aesthetic (landscape effects) • Property values • Scenic vistas Education • Wetlands/forest education centers • Agricultural heritage Nonuse • Habitat preserving wildlife and plant biodiversity • Regional character	• Land and near-water recreation is assessed in monetary terms • Other services are assessed qualitatively
Regulating	Hydrology • Coastal resilience to acute and chronic hazards (e.g., flood and sea-level rise) • Stream bank stabilization • Stream channel protection • Groundwater recharge Water Quality • Filtration/nutrient removal • Reduction in stream temperature volatility	Air • Air pollutant removal by vegetation • Carbon storage and sequestration • Reduction in air temperature volatility Soil • Erosion control • Sediment retention	• Only the value of carbon storage and sequestration is assessed in monetary terms • Other services are assessed qualitatively

Notes:
Recreational opportunities are provided by parcels with public access or parcels in the Highway 1 Scenic corridor. Educational opportunities are regularly available at 6 of 21 coastal parcels in the District holding.

We use a variety of nonmarket valuation approaches to estimate the monetary values of ecosystem goods and services. Because conducting a primary study is not within the scope or resources of this project, we apply benefit transfers from existing resource valuation studies. This is a common and well-accepted approach to adapting benefit values first estimated in one context, to a second context that is similar, but for which time or data prevent a new, ground-up economic study (Freeman, 2003; U.S. EPA, 2010a; U.S. Office of Management and Budget, 2003). In developing the benefit transfers, we followed three key steps recommended in the U.S. Environmental Protection Agency (EPA)'s Guidelines for Economic Analysis, including: (1) detailing the policy case (open space preservation) for which value estimates are desired, (2) selecting studies from existing economic research that match the policy case, and (3) transferring values. We report all estimated economic values from today's perspective in 2015 dollars. To account for people's time preference we discount the value of future open space benefits. Exhibit 1 summarizes main elements and assumptions used in our analysis.

Exhibit 1: Main Elements of Our Analysis.

Time Frame

We analyze benefits expected to accrue between 1990 and 2050. This captures benefits achieved from lands preserved to date (1990 to 2015) plus the value that these preserved lands will continue to provide over the near future (2016 to 2050). In total, we study a 60-year analysis period. The present value (PV) of preservation is the sum of incremental benefits in all years of the analysis.

Dollar Year

For comparability across time, we present all monetary values in present-day currency (2015 dollar value). Where necessary, we convert value estimates to 2015$ using the Gross Domestic Product (GDP) deflator. GDP is a measure of all domestically produced goods and services in the U.S. economy. Implicit price deflators "are calculated as the ratio of the current-dollar to the corresponding chained-dollar value, multiplied by 100" (U.S. Bureau of Economic Analysis, 2012 , p.2-14).

Discounting Benefits Over Time

Discounting accounts for people's time preference and shows how much future benefits are worth today. Because people tend to prefer consumption now over consumption in the future, benefits occurring today are worth more than benefits received in the future. Discounting also allows for values of ecosystem services occurring in different time periods to be compared by expressing the values in present terms.

To account for society's time preferences and properly express – in today's dollars (2015$) – the total value of benefits occurring decades from now, we apply a *discount rate* to future benefits. Similarly, benefits accrued prior to 2015 are compounded to be expressed in today's dollars.

Following the conventions of economic analyses concerned primarily with social benefits (U.S. EPA, 2010b), we discount future benefits at 3 percent per year. Discounting benefits at 3 percent means that $1 to be received in 2016 is worth only $0.97 today (in 2015). Following standard resource valuation practices (U.S. EPA, 2010b), we annualize the present value of benefits using the equation:

$$AB = PV \cdot \frac{d * (1 + d)^n}{(1 + d)^n - 1} \quad \textbf{(Eq. 1)}$$

where:

- *AB* = Annualized benefit,
- *PV* = Present value of the benefit stream (estimated for each service),
- *d* = Discount rate (3%), and
- *n* = Number of years in the analysis period (60 years).

4. Benefits of Coastal Open Space: Investing in Preservation

4.1 Introduction

From an economic perspective, ecological benefits associated with coastal land preservation translate to substantial societal values by simultaneously providing carbon storage, cultural and recreational amenities, water quality and supply, and habitat for threatened and endangered species and supporting sustainable agriculture and agricultural economies into the future. Estimating the economic benefits of preservation and conservation investments to date can inform Sonoma County policymakers' and citizens' understanding of the return from investing in open space preservation across the variety of land types on the Sonoma coast today.

In the rest of this Chapter, we demonstrate the economic value of services provided by preserved areas of the Sonoma coast. The following sections describe categories of services individually and, for each, detail our data assembly (e.g., land use maps, recreational visitation records for State parks, tree canopy maps, and other ecological and economic data), the methodologies used to quantify services and economic values, and results.

4.2 Carbon Storage

4.2.1 Introduction

Climate change is widely viewed to be a significant long-term threat to the global environment.

Coastal Forests and Grasslands

- Bordessa Ranch
- Grove of the Old Trees
- Jenner Headlands
- Myers Ranch
- Poff
- Rigler

Carbon dioxide (CO_2) and other greenhouse gases (CH_4 and N_2O) contribute to climate change by absorbing outgoing terrestrial radiation (Jo & McPherson, 2001; U.S. EPA, 2010). The relationship between land use and greenhouse gas emissions is complex (Andrews, 2008; Lu, Kicklighter, Melillo, Reilly, & Xu, 2015). Trees and other vegetation sequester carbon in their biomass or in the soil, removing it from the atmosphere and preventing it from contributing to climate change. Above-ground herbaceous biomass tends to die annually unlike the woody portions of plants which can store carbon for many years prior to dying and decomposing (Gorte, 2009). Carbon accumulates in the upper soil layers as dead vegetation is added to the surface and decomposes. Carbon can also be injected into the soil through root biomass growth and decomposition. Long-term storage of carbon (e.g., 100 years) is of particular interest for climate changes mitigation compared to carbon that is released in the shorter term through decomposition. Protected county lands directly increase long-term carbon sequestration through increased vegetation and reduced disturbance, relative to expected condition in the absence of protection. This analysis focuses on the direct carbon sequestration and storage by vegetation and in soils. While not discussed in detail here, additional vegetation could also indirectly reduce carbon emissions by reducing energy consumptions in buildings (Akbari & Konopacki, 2003; Jo & McPherson, 1995).[4]

4.2.2 Data and Methods

We quantified carbon sequestration rates using data from existing studies and geographic databases, applying rates per unit area of vegetation to the landscape under multiple scenarios using a combination of studies and geographic data. This analysis has three main steps:

1. *Estimate changes in vegetation and impervious surface under policy scenarios considered;*
2. *Estimate net changes in carbon sequestration based on net carbon sequestration rates; and*
3. *Estimate monetary benefits based on the social cost of carbon (SCC).*

Step 1. Estimate Changes in Vegetation and Impervious Surface

The analysis of vegetative and impervious cover relies on two key data sources:

1. *NLCD 2011* - The National Land Cover Database (NLCD) provides a detailed, geographic database of land cover, tree canopy, and impervious surface throughout California, and the rest of the United States. The NLCD is produced by the Multi-Resolution Land Characteristics (MRLC) consortium, a group of federal agencies that collaboratively develop land cover information at a national scale for various uses (U.S. Geological Survey, 2015a).

2. *CALVEG* - A comprehensive geographic database maintained by the U.S. Forest Service's Pacific Southwest region for vegetation in California. CALVEG provides detailed information about vegetation in accordance with regional and national benefits vegetation mapping standards (USDA Forest Service, 2015). CALVEG provides valuable information about the nature of development and vegetative cover within the protected parcels.

The majority of protected lands are classified as either rangelands or forest land (Figure 4). Figure 6 summarizes dominant vegetation in protected parcels, where the legend lists the types of vegetation in declining order of aggregate cover. Over forty percent is annual grasses and forbs and the remainder is dominated by various tree and shrub species.

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[4] Trees near buildings can affect building energy use through shading, windbreak, and reductions in ambient temperatures due to evaporative cooling (Akbari & Konopacki, 2005; Nowak et al., 1998; Simpson, 2002). The changes in energy use are expected to result in decreased greenhouse gas emissions indirectly through avoided electricity consumption and/or directly through reduced fuel combustion for heating.

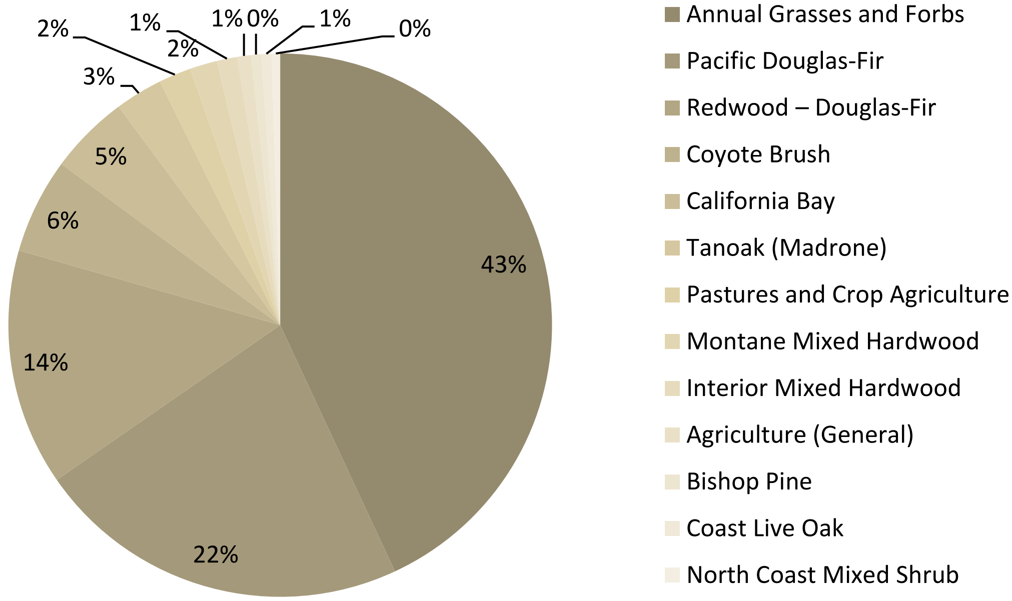

Figure 6. Distribution of Dominant Vegetation or Land Use Category for Protected Parcels.

Notes:
(A): Based on *REGIONAL_DOMINANCE _TYPE_1* from CALVEG which lists either the common vegetation name of the dominant vegetation alliance or the land-use category
(B): Table restricted to Vegetation//Land Use classes that make up at least of 0.5% of total area of protected parcels.

Rather than focusing on specific cover types or land classes, we simplify the analysis by quantifying carbon sequestration for three cover types: tree canopy cover, grass cover, and impervious surface. We measure present-day parcel tree, grass, and impervious cover by intersecting the NLCD and CALVEG data layers with the County parcel shapefile (Supporting Material Table 18 lists specific data compiled for each parcel). For the counterfactual development scenarios, we apply the average tree canopy cover, grass cover, and impervious surface cover percentages from the relevant developed parcel averages shown in Table 3.

For tree canopy, we use state-level sequestration values from Nowak et al. (2013)'s analysis of *Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States*. State values reflect the distribution of tree species, size, age, health condition, and length of growing season observed in samples. Net tree sequestration rates for states in the conterminous U.S. range from a low of 0.135 kg C per square meter per year in Wyoming to a high of 0.352 kg C per square meter per year in Florida.[5] The California estimated net tree sequestration rate is 0.288 kg C per square meter per year. We applied the net sequestration rate to all tree canopy within parcels under baseline and counterfactual

[5] Net sequestration is defined as total carbon sequestered by wood above and below ground minus the carbon emitted from leaves and limbs.

scenarios, assuming that the rate remains constant through the analysis period. By using net sequestration rates, we implicitly account for changes in tree condition and death over time.

Perennial grasses have been shown to sequester carbon over long periods of time, up to 45 years, with rates greatest in the first 25 to 30 years after establishment of grass cover (Post & Kwon, 2000; Pouyat, Yesilonis, & Golubiewski, 2009; Qian & Follett, 2002). The net change in carbon accumulation within soils depends, in part, on initial levels of soil organic carbon (SOC) in the native soil (Pickett, Cadenasso, Grove, Groffman, Band, Boone, Burch Jr, et al., 2008). For this analysis, we apply a mean net sequestration value for grass cover based on a review of the scientific literature (Table 5). We hold the sequestration rate for grasses constant for the duration of the analysis period. Shrubs and herbaceous plants other than grass may also be present. If present, shrubs will tend to sequester more carbon than grass (Jo and McPherson, 1995). Sequestration by herbaceous plants, other than grass, is likely to be minimal. Impervious surfaces are assumed to provide zero net sequestration services.

Table 5. Net Carbon Sequestration by Grass Cover.

Type of Grass Cover	Study	Net Carbon Sequestration Rate (kg C per square meter per year)
Cultivated land converted to perennial grasses with management	Gebhart et al. (1994)	0.11
Cultivated reseeded to grass	Bruce et al. (1999)	0.08
Cultivated to abandoned grassland	Burke et al. (1995) as reported by Zirkle et al. (2011)	0.0031
Agricultural land converted to perennial grasses	Post and Kwon (2000)	0.033
Low-high grassland management	Conant (2001)	0.054
Turfgrass	Bandaranayake et al. (2003)	0.09-0.12
Turfgrass	Qian and Follett (2002)	0.09-0.10
Turfgrass	Qian et al. (2010)	0.032-0.078
	Average	***0.070***

Step 2. Estimate Net Changes in Carbon Sequestration

We calculate the baseline and counterfactual annual carbon sequestration for each parcel and year of the analysis by multiplying the changes in grass and tree acreage described in the prior section. As discussed in Chapter 3, the analysis of carbon sequestration examines three counterfactual scenarios. Each scenario assumes a different residential development condition in the absence of protection, characterized by the percent and type of vegetative cover and percent of impervious surface. The value of District preservation is the avoided loss in sequestration due to the avoided loss of forested and vegetated areas, plus the avoided one-time pulse of greenhouse gases released when trees, shrubs, and agricultural soils are converted to developed uses (in CO_2-equivalent; TNC, 2015).

Carbon sequestration is calculated as follows:

$$C_{i,t,s} = grass\ acres_{i,t,s} \times \left(\frac{0.070 \times 4{,}046.86}{1{,}000}\right) + tree\ acres_{i,t,s} \times \left(\frac{0.288 \times 4{,}046.86}{1{,}000}\right) \qquad \text{(Eq. 2)}$$

where:

C = Carbon sequestered by vegetation within the parcel,

i = The county parcel id,

t = Year within the analysis period,

s = Scenario (baseline, counterfactual),

0.070 = Net sequestration rate for grass cover (kg C per square meter per year), and

0.288 = Net sequestration rate for tree canopy cover (kg C per square meter per year).

The net carbon sequestration benefits from protection can be calculated as the difference between services provided under baseline and the counterfactual scenarios. For this analysis, net sequestration rates per square meter are converted to a per acre basis by multiplying by 4,048.86 square meters per acre and converted from kilograms to metric tons by dividing by 1,000.

We estimate the one-time carbon pool in the year of development as the weighted average of per-acre carbon pool estimates estimated by The Nature Conservancy (The Nature Conservancy, 2015). We assigned carbon pools based on NLCD tree/shrub canopy for non-agricultural parcels, using standing live and dead trees in forestlands for tree canopy (188 CO_2e tonnes/ac.), and shrubs and herbaceous understory in forestlands (6 CO_2e tonnes/ac.) for shrubs. For agricultural parcels, we used the soil carbon in agriculture (10 CO_2e tonnes/ac.).

Step 3. Estimate monetary benefits based on SCC

We estimate the monetary value of preserving carbon sequestration and avoiding carbon releases relative to the counterfactual scenarios by multiplying the estimate of annual carbon sequestration and avoided releases by the Social Cost of Carbon (SCC). The SCC is "… an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year" (Interagency Working Group, 2013, p.2). SCC intends to reflect the value of the various effects of climate change, such as changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services affected by climate change. It is typically expressed as dollars per metric ton of carbon dioxide (CO_2) removed from the atmosphere or alternatively as dollars per metric ton of carbon (C). SCC increases over time as incremental damages associated with carbon dioxide emissions grow (Interagency Working Group, 2010, 2013, 2015).

The economic literature includes many SCC values estimated using various models and assumptions. SCC is often estimated based on outputs from integrated assessment models (IAMs) which tie climate changes to economic damages. Beginning in 2009, various agencies participated in a U.S. Government Interagency Working Group to develop SCC values for use in regulatory analysis (IWG, 2010).[6] The

6 Participants included the Environmental Protection Agency, Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy,

working group developed a set of recommended SCC values for use in U.S. regulatory analyses based on the average from original runs of three IAMs – the Dynamic Integrated Climate and Economy model (DICE), the Policy Analysis of the Greenhouse Effects model (PAGE), and the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) model (IWG, 2010). A technical update to the SCC values was released in 2013 (IWG, 2010). In keeping with the US government's standards for policy analysis, this study uses the Interagency Working Group's SCC estimates.[7]

We assumed, as is standard in economic analyses of the present value of future benefits, that society holds a positive rate of time preference. Because people generally feel that receiving benefits now is preferable to receiving benefits in the future, society discounts the value of future benefits relative to current benefits (Conrad, 2010). The discounting of SCC values requires special consideration because of the discount rate assumptions included within their estimation. That is, an SCC value estimated for a given year reflects costs in later years which are discounted back to the year when the carbon dioxide is emitted. The Interagency Working Group selected four sets of SCC values for use in regulatory analysis, using 2.5 percent, 3 percent, and 5 percent discount rates. The fourth set of SCC values reflects the 95th percentile SCC values across all models using a 3 percent discount rate. Table 6 presents the SCC values used for each year of the analysis period, expressed in 2015$ per metric ton of C removed from the atmosphere. These values reflect *global* SCC (Table 6). The Interagency Working Group recommends the use of global values in lieu of "domestic SCC" for policy analyses due to the global nature of the climate change problem.[8] We used these data to develop year-specific SCC estimates for each year in our analysis period. For years between 2010 and 2050, we interpolate within the 5-year periods. For 1990 to 2009, which predate the earliest (2010) estimate, we apply the 2010 SCC value to all years given the lack of existing estimates for this period.

We discounted future values using a 3 percent discount rate (U.S. EPA, 2010a; U.S. Office of Management and Budget, 2003). All present and annualized values are reported in present-day currency (US dollars, in the 2015 dollar year), and where necessary were converted using the Gross Domestic Product (GDP) Index.

Department of Transportation, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and the Department of the Treasury.

7 These SCC estimates assume that climate change does not slow economic growth. Alternative estimates are available and suggest that the 2015 SCC approaches $220/ton (Moore & Diaz, 2015). We do not use them here, to maintain consistency with US Federal Government guidelines for economic analysis in place at the time of this report.

8 Some analysts of SCC have included "equity weights" to account for differences in consumption and relative reductions in wealth across different regions of the world. The argument is that a monetary loss in a poor county results in a greater loss of utility than the same amount of money in a wealthy country. The Interagency Working Group concluded that this approach is not appropriate when estimating SCC values for domestic regulations (IWG, 2010), therefore, global SCC values without equity weights are applied here.

Table 6. Social Cost of Carbon, 2010-2050 ($/metric ton of CO_2, 2015$).				
Year	SCC[A] by Discount Rate			
	5.0% Average	3.0% Average	2.5% Average	3.0% 95th Percentile
2010	$12	$36	$57	$99
2015	$12	$41	$64	$122
2020	$13	$48	$71	$143
2025	$16	$52	$77	$159
2030	$18	$58	$84	$177
2035	$21	$62	$89	$195
2040	$23	$68	$96	$213
2045	$27	$74	$103	$230
2050	$29	$79	$108	$245

Notes:
A: SCC values reported by Interagency Working Group (2013) were converted to 2015$ using the GDP deflator.

Exhibit 2. Cap-and-Trade Auction Prices.

In 2006, California passed Assembly Bill (AB) 32, the Global Warming Solutions Act. A cap-and-trade system was established under AB 32, thereby setting an upper limit on statewide emissions from utilities, large industrial plants, and fuel distributors. These entities can buy emission "allowances" at auction. Each allowance is "a limited tradable authorization to emit up to one metric ton of carbon dioxide equivalent" (California Air Resources Board, 2015a). The sum of allowances is equal to the statewide upper limit. The price paid at auction per allowance is the market price that emitters are willing to pay per metric ton of carbon dioxide equivalent. Based on the May 2015 summary report, the mean price paid in the most recent auction at the time of this report was $13.93 per allowance (California Air Resources Board, 2015b). On average, recent auction prices are substantially less than the estimated social cost of carbon used in the analysis of carbon sequestration benefits in this study (California Air Resources Board, 2015b, vs. Table 7). A metric ton of carbon dioxide sequestered by vegetation in greenspace is equivalent to a metric ton of carbon dioxide reduced through cap-and-trade permitting. Thus auction prices provide some insight into potential market values for reductions achieved via sequestration at protected open spaces.

We calculate annual benefits for each parcel in each year of the analysis period by applying the SCC values for that year to the mass of carbon sequestered, following the equation below.

$$B_{i,t,s} = C_{i,t,s} \times SCC_{t,d} \times 3.67 \quad \textbf{(Eq. 3)}$$

where:

B = Benefits in year *t* of the analysis,

C = Carbon sequestered (metric tons)

i = Parcel ID,

t = Year within the analysis period,

SCC = Social cost of carbon (2015$ per metric ton of CO_2),

d = Discount rate (set to 3% average), and

3.67 = the molecular weight of CO_2 divided by the molecular weight of C (44/12).

We calculate the net present values of past and future carbon sequestration benefits stemming from policy options as the difference between values for baseline and counterfactual scenarios in each year (1990 to 2050) discounted from the year carbon is sequestered to the current year (2015). We calculate the total present value (T*PV*) of carbon sequestration benefits across all parcels as follows:

$$TPV = \sum_i \sum_{t=1990}^{2050} \left(\frac{B_{i,t}}{(1+d)^{(t-2015)}} \right)$$ **(Eq. 4)**

where:

i = Parcel ID,

t = Year within the analysis period,

B = Benefits in year *t* of the analysis, and

d = Discount rate (3%).

The net present value of carbon sequestration services provided by District-protected open space is the difference between TPV with protection and TPV under the counterfactual conditions (Exhibit 1, *Main Elements of Our Analysis*)..

4.2.3 Results

Using 3 percent average SCC values, we estimate that preservation generates a net present value of $40.07 million in carbon sequestration and avoided carbon release benefits relative to the Sonoma Coastal Subdivision counterfactual scenario (Table 7). This is an annualized benefit of $1.4 million dollars per year for all protected properties. Annualized benefits from avoiding the Low-Density Sonoma Zoning and Coastal California High Density development scenarios are $1.3 to $1.5 million dollars, respectively. The Coastal California High Density scenario benefits include avoiding the three highly-developed parcels, with the remainder of benefits coming from avoided development of parcels to the low-density zoning standard. Future benefits from 2015 to 2050 account for approximately 75 percent of the net present value of carbon sequestration benefits, highlighting the importance of maintaining protection.

Table 7.Summary of Carbon Sequestration Results for the full Analysis Period (1990 to 2050).				
		Counterfactual Development Scenario		
Result	Present Day Open Space	Sonoma Coastal Subdivision	Low-Density Sonoma Zoning	Coastal California High Density
Total carbon sequestered 1990 to 2050 (mt CO_2)	1,830,123	850,791	931,532	739,202
Change in Total Carbon Sequestered 1990 to 2050 (mt CO_2), relative to counterfactual development scenario	-	*979,332*	*898,591*	*1,090,921*
Average annual carbon sequestration (mt CO_2)	30,502	14,180	15,526	12,320
Change in average annual carbon sequestration (mt CO_2), relative to counterfactual development scenario	-	*16,322*	*14,977*	*18,182*
Present value of carbon sequestration benefits (3% discount rate, millions of 2015$)	$68.76	$28.68	$31.72	$24.64
Change in present value of carbon sequestration benefits (3% discount rate, millions of 2015$), relative to counterfactual development scenario	-	*$40.07*	*$37.03*	*$ 44.11*
Annualized value of carbon sequestration benefits (3% discount rate, millions of 2015$)	$2.40	$1.00	$1.11	$ 0.85
Change in annualized value of carbon sequestration benefits (3% discount rate, millions of 2015$), relative to counterfactual development scenario	-	*$1.40*	*$1.29*	*$ 1.53*

4.3 Agricultural and Food Products

Rural amenities such as the availability of locally-grown food and the existence of viable agriculture are important because they affect quality of life and the desirability of a community. Studies have shown that people prefer to buy locally grown food and to have a strong local agricultural economy (Irwin, Nickerson, & Libby, 2003; Kreitner, 2011). Rural amenities are not what we consider market goods—they are not bought and sold. Thus, land market mechanisms are not sufficient to preserve these amenities and, as a result, farmland preservation policies have emerged to fill the gap (Hahn, 2008; Nickerson & Hellerstein, 2003). Preserving farmland benefits the public and private landowners alike, offering benefits including public and semi-public open space, preventing urban sprawl, maintaining a rural lifestyle, supporting the economic viability of local farms, employment opportunities, better quality of life, possibly positive fiscal impacts to farms, and providing local produce (Bergstrom & Ready, 2009; Hellerstein et al., 2002; Irwin, et al., 2003; Reed & Kleynhans, 2009). Between 1994 and 2014, the

District and its partners have preserved eight sizeable agricultural properties covering 4,402 acres of active farmland in the coastal study area. Table 8 provides an overview of the preserved parcels, including agricultural production, scenic and cultural values, and ecological significance.

As shown in Table 8, all District farmland holdings are used for beef and dairy cattle grazing and contribute to local food production, including milk supply to local artisan cheese makers. Sonoma is home to some of the finest artisan cheese makers in the nation, including international award winning Marin French Cheese, an Annual Artisan Cheese Festival, and retail stores offering locally produced cheese and dairy products. Existing economic studies have shown that people often value unique aspects of locally produced farm products and willing to pay a premium for local organic cheese and dairy products (Rilla, 2011; Wang, Thompson, & Parsons, 2015). Wang et al. (2015), for example, find that in the Northeast United States, quality-seeking consumers are willing to pay 15 percent to 25 percent more for cheeses marketed as farmstead, artisanal, organic, local, or having been produced with sustainable energy.

Exhibit 3. Open Space and Local Cheese

- Sonoma is home to some of the nation's finest artisan cheese makers, including the coastal Bodega Farm.
- The Sonoma Cheese Trail includes 30 farms and creameries.
- The county hosts an Annual Artisan Cheese Festival.
- Local retail stores specialize in artisan

Preserved farmland properties also provide recreational opportunities and support agricultural tourism. Two of the preserved properties (Estero Americano Preserve and Gilardi Ranch) currently provide tours for visitors. Plans are in place to provide public access in the future at another parcel (Bordessa Ranch).

The largest preservation value of farmland is not tied to active farming or agricultural tourism, however. A broad range of public amenities arises from scenic views and environmental services provided by the agricultural landscape and preservation of agricultural heritage and regional cultural character. The majority of the farmland preserved by the District is located in the scenic corridor viewshed and thus provides aesthetic values to the county residents and millions of visitors every year. Gilardi Ranch is also an agricultural heritage site. The value of preserving farmland may vary greatly based on site characteristics, the risk of urban sprawl, availability of substitute sites, and other factors. Based on 11 stated preference studies conducted since the 1980’s, the average annual willingness to pay (WTP) for farmland preservation is $2.00 per acre per household (Bergstrom & Ready, 2009; adjusted to 2015$ using GDP). We, however, did not estimate the aesthetic value of agricultural landscape separately because it is captured in the sightseeing benefits discussed below.

In addition, conservation easements are often designed to further enhance ecosystem services provided by preserved farmland relative to traditional agriculture. These services include watershed protection resulting from soil and water conservation and the preservation of irreplaceable plant and animal habitat and biological diversity (e.g., planting native species). For example, Gilardi Ranch supports riparian corridor maintenance by fencing the riparian corridor and excluding livestock from streams, and thus contributes to stream bank stabilization, improvements in stream flow, and reduction in nutrient and sediment loadings. Colliss and Gilardi Ranches provide habitat to rare, threatened and endangered species, including Steelhead trout and Coho salmon. Section 4.6 and 4.7 provide a more detailed discussion of open space preservation effects on biodiversity and protection of threatened and endangered species.

Table 8. Overview of parcels with agricultural production.

Parcel	Land Use	Rural and Cultural Amenities	Ecological Benefits
Bianchi • 631 ac. • Preserved 2002	• Dairy • 800-900 Jerseys • 2,500 gallons of milk/day	• Agricultural Heritage • Highway 1 Scenic Corridor • Provides milk to a local cheese producer	• Protection of wildlife species and their habitat • Wildlife corridor
Bordessa Ranch • 495 ac. • Preserved 2012	Occasional, uncontrolled cattle grazing	• Highway 1 Scenic Corridor • Planned future public access • Planned kayak launch site-- Access to Estero Americano	• Riparian and salt marsh protection • Protection of threatened species and their habitat • Wildlife corridor
Colliss • 1,578 ac. • Preserved 1998	• Beef cattle	• Agricultural open space • Local food	• Protection of rare, threatened and endangered species and their habitat • Riparian and wetland protection • Diverse plant community • Wildlife corridor
Estero Americano Preserve, Hepper Addition • 87 ac. • Preserved 1997	• Beef cattle	• Agricultural open space • Accessible by tour • Kayak launch site	• Riparian and salt marsh protection • Protection of threatened species and their habitat • Wildlife corridor
Gilardi Ranch • 395 ac. • Preserved 2009	• Heifer and beef cattle production	• Agricultural heritage • Highway 1 Scenic Corridor • Accessible by tour	• Riparian area protection • Protection of rare, threatened and endangered species and their habitat • Wildlife corridor • Water Storage for Bodega Water Company

Table 8. Overview of parcels with agricultural production.

Parcel	Land Use	Rural and Cultural Amenities	Ecological Benefits
Ielmorini Dairy • 1,217 ac. • Preserved 2001	• Heifer replacement • Cattle grazing • 250 cows and calves • 50.7 acres hay	• Highway 1 Scenic Corridor • Local dairy products (supports adjacent dairy)	
Maffia Ranch • 245 ac. • Preserved 2004	• Heifer replacement for local dairies	• Agricultural open space • Local dairy products	• Riparian and salt marsh protection • Protection of threatened species and their habitat • Wildlife corridor
Quinlan Ranch • 249 ac. • Preserved 2009	• Cattle grazing (60 heads)	• Agricultural, open space • Historical value preservation • Highway 1 Scenic Corridor	• Protection of wildlife habitat • Wildlife corridor

4.4 Recreational Opportunity

4.4.1 Introduction

Outdoor recreation is a major economic engine, with a recent report estimating that Americans spend $524 billion per year[9] on outdoor recreation trips (Outdoor Industry Association, 2012). Outdoor recreation is particularly important for California residents. Nearly all (91 percent) Californians report visiting parks at least once a year, and residents tend to consider undeveloped wilderness-type areas, areas for environmental and outdoor education, and water resources among the most important types of park and outdoor space facilities (California State Parks, 2014).

Visitors and tourists also appreciate outdoor recreation opportunity. In Sonoma County, 90 percent of tourists report that scenic character motivated their visit – a level of importance equivalent to prominent cultural drivers like dining and winery visits (Destination Analysts, 2014). Among Sonoma County businesses, most believe that scenery is the second-most attractive tourism-generating asset after wine reputation (Sonoma County Economic Development Board, 2014). The 2014 Sonoma County Visitor Profile Study confirms the importance of Sonoma County landscape in shaping what tourists do when they visit. The profile survey found that 25 percent of tourists visit state and local parks, 23 percent go hiking, 5 percent participate in agricultural events, and 4 percent go canoeing or kayaking (Destination Analysts, 2014). Further, at least 20 percent of all County tourists visit coastal communities like Bodega

[9] Estimate is based on a compilation of national surveys (conducted in 2011and 2012) about annual recreation trips and typical trip expenditures (Southwick Associates, 2013).

Bay, Russian River, and Guerneville (Destination Analysts, 2014), and thereby have the opportunity to appreciate views of coastal open space and participate in recreational activities. One iconic coastal recreation resource – Sonoma Coast State Park – attracted over 3.4 million visitors for day use and overnight camping in the 2013/2014 fiscal year (California State Parks, 2014). Although we did not identify a reliable estimate of the total number of annual visitors to Sonoma County each year[10], coastal character and accessible open space are clearly important recreational assets for those who do choose to visit.

Figure 7. Sonoma Coast State Park Campsite.

Image: California Department of Parks and Recreation. *http://www.parks.ca.gov/ImageGallery/?page_id=451*

Residents' and visitors appreciation for the outdoors is reflected in the economic contributions of recreational use values and tourism spending. In the San Francisco Bay area, for example, tourism generates the largest portion of regional park system values (The Trust for Public Land, 2014). Sonoma County visitors spent $46 million on campground accommodations in 2012, the most recent reporting year (Sonoma County Economic Development Board, 2014).

Balancing these recreational use value benefits of open space against the economic benefits of urban expansion has historically presented both challenges and opportunities for California communities (Towne, 1998). Although the majority (60 percent) of Californians feel that open space and recreation areas need more protection (California State Parks, 2014)[11], studies report that urban expansion, population growth, and private land development challenge the security of accessible and "forever wild" open spaces (Brander & Koetse, 2011; García & Baltodano, 2005; Kline, 2006; Thorne, Santos, & Bjorkman, 2013).

By continually expanding its efforts to preserve large open spaces in the public trust, the District is a leader in providing Sonoma and surrounding county residents with a land-use mix that allows public access via conservation easements, land trusts, and state parks (Santos, Thorne, Christensen, & Zephyr, 2014). Thirty percent of the coastal zone is protected (Sonoma County Agricultural Preservation and Open Space District, 2015b), and the District has preserved 72 percent of these open spaces since 1994 (24 percent of total coastal area). These 18,000 acres of open space and agricultural land in the coastal zone (Figure 3 in Section 2.1) provide 500 acres of coastal open space open for everyday public

[10] Given Sonoma County's size and rural character, obtaining a precise visitation estimate is not possible. The Sonoma County Tourism agency has reported that approximately 7 million tourists come to Sonoma County each year. The figure is reportedly based on materials from the County's economic development board. Since the agency has no written documentation about the source of this value, this analysis does not use the figure.

[11] Banzhaf and Jawahar (2005) found, in a review of multiple studies examining land conservation and preservation priorities, that residents generally prioritize environmental benefits of open space over recreational benefits.

access[12,13], and provide access to an additional 4,257 ac. by tour or permit. Most of these lands are visible from popular scenic routes like the California Highway 1 and inland byways; several provide parking lots, picnic tables, and trails; and others support educational events for school groups and adults. For example, eight of the District's coastal parcels host community outreach and education events through local Resource Conservation Districts and non-profit organizations.

This chapter illustrates economic benefits of recreation on District and partners' holdings in the coastal zone. We illustrate the extent to which the total value of coastal sightseeing (number of trips and per-trip value) depends on the scenic quality of open space visible from major scenic highways. We first demonstrate how open space preservation in the coastal area supports the region's attraction as an outdoor recreation destination (e.g., both passive and active uses). We then estimate total value of coastal region sightseeing, using a recreation demand model to estimate the number of visits that Sonoma County residents take to this region each year, and monetize the value of these visits using benefit transfer from existing studies of WTP for sightseeing. To model the contributions of District land preservation to this total value, we scale total benefits based on the percentage of visible open space that the District has preserved, and examine how these scenery-driven benefits may have declined in a high-development counterfactual scenario. Resulting value estimates are *illustrative* approximations of recreational benefits gained by permanently preserving coastal open spaces.

4.4.2 Linking Agricultural and Open Space Preservation to Recreational Opportunity

This section presents current recreational uses at preserved agricultural and open spaces, and then develops assumptions about the extent to which these uses would change under a counterfactual scenario.

Current Activities

We use websites and recent data compilations of District and partners' records to catalog recreational uses and records of visitor uses at District parcels (Table 9). Parcels that are open to the public offer visitors the opportunity for a variety of active (e.g., hiking, walking) and passive (e.g., sightseeing from a distance) uses (Figure 10). Typical active uses include walking or hiking, using the beach, picnicking, birding and watching wildlife, using motorized boats, kayaks or canoes, and participating in guided or independent outdoor recreation and nature appreciation activities. Table 9 shows that activity- and site-specific visitation records are available for only a minority of the protected parcels with recreational access (e.g., Sonoma Coast State Beach). The shortage of routine visitation data collection has been a typical finding of other research attempting to quantify recreation participation in California's open spaces (BBC Research & Consulting, 2011).

The scenic quality of lands visible from roads and highways contributes to the economic value of passive recreational activity by attracting visitors (e.g., the number of trips taken to the coast), and enhancing the value of the iconic sightseeing experience once there. The District's coastal properties provide a prominent amount of the region's rural and undeveloped scenery. We estimate the extent to which district holdings are visible form major scenic byways in coastal Sonoma County including Highway 1, Highway 116 (River Road), Coleman Valley Road, and Bodega Highway (Figure 8;

[12] Some of these parcels are owned and operated by a partner organization (e.g., Sonoma Land Trust, California State Parks, and Bodega Bay Fire Protection District).

[13] Future access is planned for 7,442 acres that do not currently have public access.

Technical details in Section 6.3). We find that 62 percent of 19 District holdings – a total of nearly 11,000 acres – are visible from scenic corridors in the coastal region. Forty-three percent of our coastal study area is visible from at least one point on these byways. Twenty-five percent of this visible land area (e.g., all open and developed lands) is District-preserved open space.

Table 9. Recreational Use and Activity at Coastal Agricultural and Open Space Parcels.

Parcel Name	Recreational Uses	Access and Visitation Information
Bodega Bay Fire House	Picnic area; Scenic vista	Open to Public (no visitation data)
Carrington Coast Ranch	Birding; Camping; Hiking; Historical Events	Guided Outings (no visitation data)
Estero Americano Preserve - Dewar and Hepper Addtions	Kayak/canoe launch; Waterfowl hunting	Guided Outings. An estimated 50 paddlers per year attend an annual "Cow Patty Pageant" race (Digitale, 2009).
Gilardi Ranch	Educational events; Working agriculture	Guided Outings. Since 2010 has hosted an annual average of 132 school trip participants (range 48 to 248) (Reza, 2015)
Grove of the Old Trees (Van Alstyne)	Hiking/ walking; Picnic area	Open to Public (no visitation data)
Pole Mountain	Hiking/ walking	Guided Outings (no visitation data)
Sonoma Coast State Park - Red Hill (Sequiera) and Willow Creek Additions	*Overall Park*: Beach uses; Camping; Picnic area *Red Hill*: Hiking/Walking *Willow Creek*: Biking; Hiking/ Walking	Open to Public (all units). Visitor Center attracts an annual average of 8,794 visitors (range: 5,303 to 19,930 between 2009 and 2013) (Reza, 2015). District additions have no visitation data.
Wright Hill Ranch (Poff)	Unknown	Planned Future Access (no visitation data)
Watson School/ Wayside Park	Educational information; Picnic area	Open to Public (no visitation data)
Westside	Camping; Fishing; Kayaking/ Canoeing; Picnic area	Open to Public. $7 per vehicle for day use.
Doran Beach	Beaches; Birding; Camping Fishing; Hiking/Walking; Motorized Boat use; Kayaking/Canoeing; Picnic area	Open to Public. $7 per vehicle for day use, or $1 per person (vehicles with 10 or more people).
Pinnacle Gulch	Beaches; Birding; Hiking/ Walking; Picnic area	Open to Public. $7 per vehicle or free for Regional Parks members.

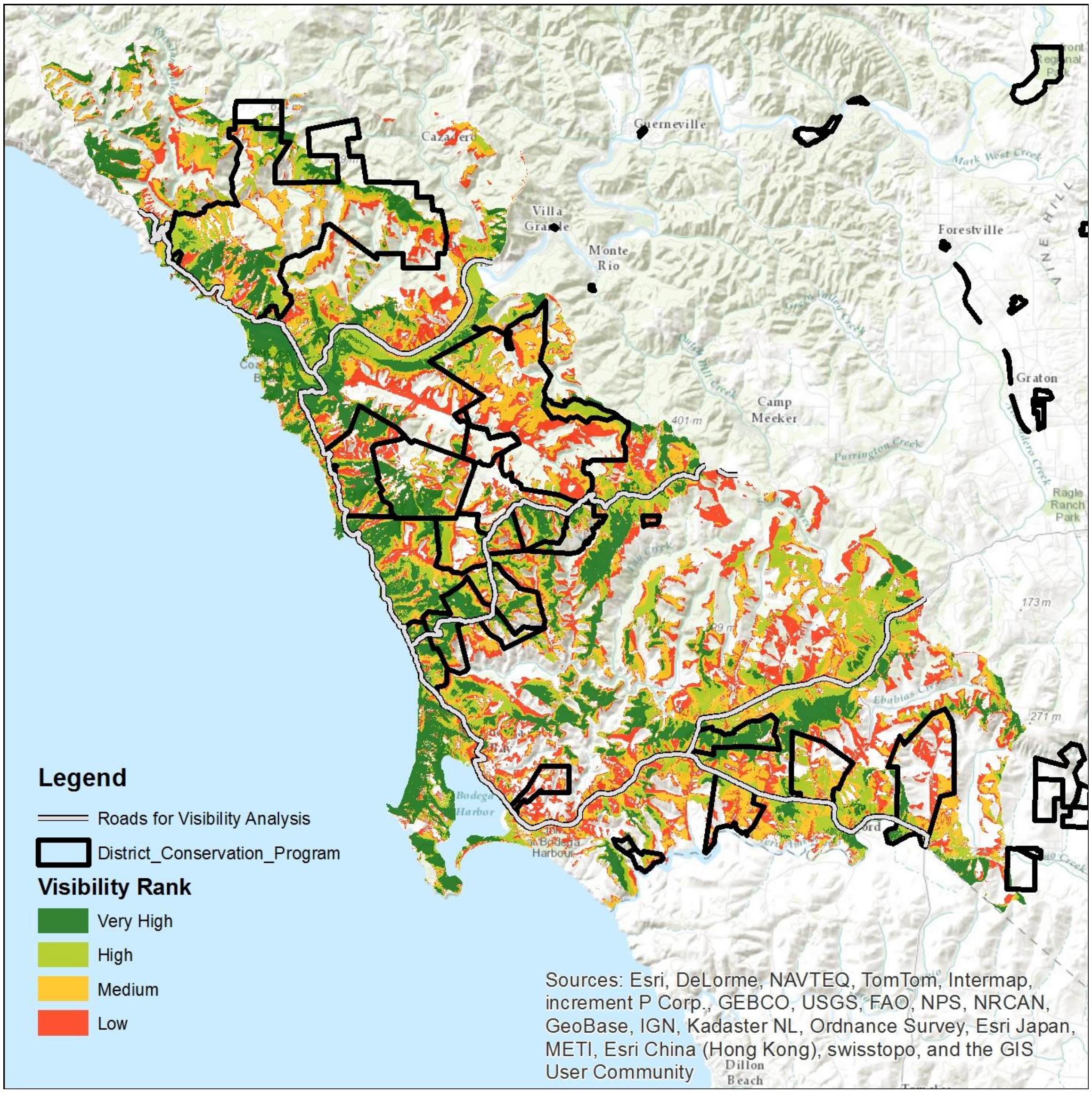

Figure 8. The Visibility of Coastal Lands from Major Scenic Routes.

Note: Gray/white land area is not visible from any of the scenic route points.

Assumed Activities in the Counterfactual Scenario

For this analysis, we simplify the three counterfactual scenarios (Section 3.1) and assume that *any* form of residential development—regardless of the change in impervious cover—would equally damage the undeveloped visual character that draws tourists for nature-based sightseeing by placing homes on the landscape. Since all except two parcels are generally suitable for some level of development[14] (minus the riparian and wetland portions of these parcels), we implement this assumption for a coast-wide counterfactual scenario.

Figure 9 presents a matrix showing the ways preservation avoids losses in recreational opportunity and value. The matrix models two main dimensions of total value: the number of trips taken to the coast, and the value of each trip. These four scenarios demonstrate a spectrum of assumptions that analysts could make about the links between incremental open space preservation investments and the number and value of recreational visits to the surrounding region. In a scenario similar to the top-left box, for example, the same number of people are expected to visit the coast whether or not parcels are preserved as open space, or developed into homes. Further, this scenario assumes that visitors will derive the same satisfaction (and therefore WTP for the day's activities) regardless of the presence or absence of open space. Such a scenario presents a pessimistic view on the value of open space, but acknowledges the potential that ocean views, coastal towns, and other water-based amenities are more important factors in attracting coastal visitors.

		Number of Trips	
		No Change	**Change**
Value per Trip	**No Change**	Development impacts neither coast visits, nor value per trip.	Development reduces the number of coast visits, but not the value per trip.
	Change	Development does not impact the number of coast visits, but reduces the value per trip.	Development reduces both the number of coast visits, and also the value per trip.

Figure 9. Theoretical Mapping of Potential Changes in Recreation Due to Open Space Development.

Given that developing open spaces likely reduces both the number of trips people take for sightseeing, and the value per sightseeing trip, we illustrate the contribution of District lands to total value. First, we assume that the total present-day recreational value (100 percent) of sightseeing in the coastal area depends on the amount and quality of all land area visible from tourist routes. We then assume that the total recreational value in the coastal area is distributed evenly across all lands visible from tourist routes, As stated above, District's current land preservation covers 25 percent of the land area visible from tourist routes. Thus, we assign 25 percent of the total baseline sightseeing value in the coastal areas to the District lands.

If these protected lands had been developed, the scenic quality of visible lands would have decreased relative to today's actual conditions. Accordingly, total recreational values would be lower if the District had not protected its holdings between 1990 and 2015. To illustrate this, we assume that without

[14] On average, we estimated that 70 percent of each parcel is non- wetland, non-riparian area developable as residential homes. Two exceptions are the Estero Americano (which is 85 percent riparian and marsh area, and 15 percent "developable") and the Bodega Bay Fire House, which is an historical site with no buildable acreage.

protection, each parcel would have been developed in the year of protection, reducing the scenic quality of all areas now preserved under District's acquisitions. We then track the cumulative percent of visible open space still remaining after the year's "development." To estimate the counterfactual scenic quality absent land preservation, we multiply the baseline District-related sightseeing values by this "remaining open space" factor. This scenario represents the potential that coastal open space provides sightseeing benefits to visitors due to its undeveloped nature, and that the presence of homes, businesses, and other infrastructure reduces the suitability of the coastal zone for sightseeing. By estimating proportional changes in total benefits due to changes in the percent of visible land area that is developed, we avoid making explicit assumptions about whether changes in tourism value are due to the number of trips, the value per trip, or a combination of both. We also present a zero-change estimate in our results tables to approximate the potential that protecting lands has not avoided the loss of any recreational visits or values per visit.

For the counterfactual scenario, we assume that increasing development in the coastal area (absent preservation) would have reduced the contribution of District lands to total regional sightseeing benefits due to reduced suitability. We assume that suitability declines each year in the counterfactual scenario, in proportion to the cumulative percent of visible District open space assumed developed as of a given year (Table 10). As in the rest of this study, we do not account for potential increases in land preservation after 2015, so we assume a constant portion of total benefits are due to District lands in all years after 2015.

Table 10. District's Open Space Preservation at Selected Years in the Analysis (1990 – 2050).

Year	Cumulative Preservation (ac.)	% Present-Day Preservation Completed [A]	Assumed % of District's Visible Lands Remaining in the Counterfactual
1990	0	0%	100%
1995	342	2%	98%
2000	2,994	16%	84%
2010	17,437	96%	4%
2015	18,162	100%	0%
2050	18,162	100%	0%

Notes:

A. As fraction of the total District-preserved agricultural areas and open spaces preserved between 1990 and 2015 in the coastal study area (Sonoma County Agricultural Preservation and Open Space District, 2015).

4.4.3 Methods and Data

The lack of visitation data for each parcel limits our ability to estimate the system-wide recreation activity value attributable to preserving parcels in the District and partners' land preservation network. While we first evaluated methods to generate parcel-specific visitation estimates by type of activity, we ultimately concluded that these approaches required making a variety of assumptions beyond what could be reasonably inferred from existing data.[15] Given this lack of data, we instead focus our analysis on a basic trend emerging from Sonoma County visitor trends (Section 4.4.1) and activities possible at coastal lands (Table 9): *open spaces provide ample opportunity for sightseeing*, and these scenic amenities contribute to *visitors' decisions to come to Sonoma's coast for day trips*.

We reviewed available studies of outdoor recreation demand (e.g., Cordell, 2008; English, Betz, Young, Bergstrom, & Cordell, 1993; Pendleton, n.d.; Rosenberger & Loomis, 2001; U.S. Fish & Wildlife Service & U.S. Census Bureau, 2014), and from the review select a function designed to estimate the number of visitors to regional recreation areas in context of the likely visitor base, substitute regions, and travel costs (Bergstrom & Cordell, 1991). Then, we apply benefit transfer to estimate the value of these visits.

We assume that the availability of rural agricultural and open space scenery drives the estimated sightseeing-based tourism, and assume that increasing development in the counterfactual (e.g., Table 10) would reduce scenic quality and therefore the value of sightseeing tourism. We use the percentage of visible open space that remains undeveloped in each scenario to scale baseline sightseeing benefits, and compare total sightseeing tourism values in the present-day and counterfactual scenarios. The remainder of this section provides additional detail about these methods.

Benefit Transfer Method

We use the benefit transfer method to develop estimates of social benefits from recreation at preserved open spaces. This approach does not require estimating an original economic model, but does require knowing how visitors typically use open spaces (e.g., walking and hiking, attending educational events and fairs), who visits open spaces (e.g., county residents), how often people visit the open spaces (e.g., total annual visitation), and how much visitors are willing to pay to enjoy the particular types of activities they complete at a given open space parcel. We use a simple point value benefit transfer to calculate the aggregate recreational benefits from the suite of coastal open spaces, specified as:

$$V_{t,s} = F_s \times (P_t \times WTP) \quad \text{(Eq. 5)}$$

where:

t = Year within the analysis period (t = 1990, 1991, ..., 2015);

s = Scenarios (baseline, counterfactual) that vary in terms of scenic amenities provided by visible undeveloped open space;

V = Value of recreation in a region with open space, where the open space varies by year t and scenario s, and is dependent on:

F = Scaling factor based on the percentage of scenic amenities remaining under a given scenario s, relative to the present-day;

P = Number of recreation trips taken in year t, and

[15] An early scoping approach, for example, included estimates generated as a proportion of county residents likely to participate in outdoor recreation based on state-level outdoor recreation statistics (California State Parks, 2014), the proportion of recreation days that Americans spend near-water (Cordell, 2008; Cordell et al., 1999).

WTP = Transferrable estimate of a visitor's willingness-to-pay for a day of recreation.

The net recreational benefits from protecting a group of parcels can be calculated as the difference between recreational values provided under baseline and counterfactual scenarios. Section 4.4.4 summarizes results of the benefit transfer.

Estimating Trips with a Recreation Demand Model

Treating the entire coastal study area as a single sightseeing destination, we estimate the number of coastal sightseeing trips to the area using a regional recreation estimation function (Bergstrom & Cordell, 1991). Bergstrom and Cordell (1991)[16] estimated demand for 37 outdoor recreational activities using a multi-community, multi-site travel cost model. Briefly, the model predicts the number of trips that regional residents take to a given location to participate in a particular activity, based on determinants like the residents' income and age; the price of the recreation trip; site suitability for the activity, and the availability of substitute recreational opportunities. We apply Bergstrom and Cordell's "sightseeing" function to predict annual sightseeing visits to the Sonoma Coast by county residents.

We estimate annual trips by residents in each analysis year (1990 to 2050) for the baseline scenario, assuming that the current (baseline) sightseeing quality of the Sonoma Coast is 10 out of 10, due largely to the fact that the coast includes undeveloped open space. (Bergstrom & Cordell, 1991).

Figure 10. Hikers in Red Hill Addition, Sonoma Coast State Park.
Photo: SCAPOSD (2015).

[16] The equation was originally developed to estimate regional recreation demand across many regions of the United States. The authors estimated regression models using survey data from multiple public recreation sites in each region.

Table 11. Visitation Transfer: Demand For Sightseeing-Based Recreation Trips to Sonoma Coast.

Variable	Coefficient[a]	Value	Description
INTERCEPT	7.016	1	Set equal to 1, following benefit transfer conventions.
PRICE	-0.018	$40.46	Cost of the activity-trip from the community to site. • *Cost estimated as the travel cost (at GSA mileage rate) to drive from Santa Rosa, CA to Jenner, CA (30 miles at $0.58/mile) plus opportunity cost of time spent traveling (1 hour trip, at average county wage rate/2).*
INC345	0.029	50%	Percent of population with annual income at least $52,114 (adjusted to 2015$ from original estimate of $30,000). • *Approximation based on 2010 Decennial Census, and assume stable over time (U.S. Census Bureau, 2010).*
PCT18TMD	0.081	19.3%	Percent of population age 20 to 34. • *Set to 19 percent based on 2010 Decennial Census, and assume stable over time (U.S. Census Bureau, 2010)*
CCPOP86	0.00000088	Varies by year *t*	Total community population 10 years and older. • *Set to 88 percent based on 2010 Decennial Census, and assume stable over time (U.S. Census Bureau, 2010).*
PCTFARM	-0.18	2%	Percent of population living on a farm. • *We apply the national average rate constant over time. (U.S. EPA, 2013)*
SUBEROS	-0.028	15.169	Indexes the effective availability of substitute recreational locations similar to the site in question, termed “Effective Recreation Opportunity Set” (EROS). • *We apply the SUBEROS for undeveloped areas near roads, in the Pacific Coast region (English, et al., 1993) and assume it is stable over time.*
SUIT	0.204	Varies by year *t* and scenario *s*	Suitability of the site for the given activity rated on a scale of 1 to 10 by resource management professionals. • *We assume the coastal zone best supports sightseeing when open space is preserved (SUIT=10), and declines over time with increasing development in the counterfactual.*

a. *Source:* Bergstrom and Cordell (1991), Table 2.

Estimating Value per Recreational Visit

The value of recreational activity at Sonoma County coastal open spaces equals participants’ WTP to participate in recreational experiences at these resources.[17] We obtained WTP estimates from existing peer-reviewed economics literature. We used two main sources for the review: a general search for economic literature examining use values for coastal resources in California (Supplementary Material, Section 6.3), and an existing compilation of activity-specific use values developed for an earlier benefit

[17] Some coastal open spaces charge parking fees (e.g., $7 per day to park one car of up to 10 people). These access prices drive the *economic impact* of coastal recreation, but do not necessarily fully capture the value of recreation to the visitor. The value of an activity is traditionally represented as the willingness of a visitor to pay for an activity *beyond the access fee*.

transfer exercise to value recreation in the California park system (BBC Research & Consulting, 2011). Of the two sources, we select estimates from BBC Consulting, since they offer the opportunity to value multiple representative activities under a consistent framework.

Table 12 provides WTP estimates for activities consistent with the sightseeing-based recreation demand model for undeveloped areas. In our value transfer, we represent benefits across the range of potential activities using the maximum WTP estimate as an upper bound ($74.36/visit when driving for pleasure) from the U.S. Forestry Service (USFS) study and the minimum WTP estimate from the Survey of Public Opinions and Attitudes on Outdoor Recreation in California (SPOA) as a lower bound ($2.19/visit for sightseeing or viewing wildflowers and nature).[18]

Table 12. Willingness to Pay for Recreational Activities at Federal and State Park System Lands.

Activity	Benefit per Day by Source[A] (2015$)	
	USFS	SPOA
Sightseeing/Non-reported	$45.93	$6.56
Nature Walks/Wildlife	$52.49	$6.56
Driving for Pleasure	$74.36	$7.65
Wildflowers/Other Nature	$45.90	$6.56
Walking for Pleasure	$43.74	$2.19
Average	**$55.37**	**$6.92**

Notes:
Benefits per day estimates from two sources were originally compiled by BBC Consulting.
(A) Source information:

- **USFS**: Values are from a national meta-analysis of 1,200 recreational use values primarily on federally-managed lands (developed by Dr. John Loomis)
- **SPOA**, or the Survey of Public Opinions and Attitudes on Outdoor Recreation in California, surveyed California residents and elicited their stated willingness-to-pay for specific activities (California State Parks, 2009). The values were not elicited in context of a particular recreational setting.

Apply Benefit Transfer

Using the recreational demand function, we estimate annual sightseeing trips in each analysis year (Table 11) and applied the benefit-per-visit (Table 12) to the number of visits in each year. Baseline tourism benefits attributable to District preservation are 25 percent of this annual benefit. Counterfactual tourism benefits absent District preservation are the product of baseline District-related sightseeing values and the annual "remaining open space" factor (Table 10). The annual incremental value of sightseeing from District land preservation equals the difference between the baseline and counterfactual scenario

[18] We did not use average per acre recreational values from existing studies to estimate recreational benefits provided by open space preservation in coastal Sonoma County because per acre values are a function of resource characteristics (e.g., land cover, presence of various bird species, and public accessibility of a site) and the number of visitors. If natural resource areas in Sonoma County are not easily accessible by recreational users or if there are fewer visitors in some locations, the per acre values transferred from the studies of frequently visited sites will significantly overstate the recreational values of natural areas in Sonoma County.

total tourism benefit. As for the other benefit categories analyzed in the study, we discount annual values to 2015, using a discount rate of 3 percent.

We calculate the total present value (*TPV*) of recreation benefits across all parcels as follows:

$$TPV = \sum_{t=1990}^{2050} \left(\frac{B_{i,t}}{(1+d)^{(t-2015)}} \right) \qquad \textbf{(Eq. } 6)$$

where:

t = Year within the analysis,

B = Benefits in year *t* of the analysis, and

d = Discount rate (3%).

Following standard practices (U.S. EPA, 2010b), we annualized the net benefits (see Exhibit 1, Main Elements of Our Analysis).

4.4.4 Results

Results of the recreational visit estimation suggest that 56,655 residents take sightseeing trips to the coastal region each year (2015 estimate). The model estimates that annual visitation counts will vary based on Sonoma County population and affluence, with annual visitation estimated between 52,000 and 62,700 trips per year (1990 to 2050). Using the two illustrative WTP estimates ($2.19/visit and $74.36/visit) and assuming high-quality sites, we estimate that the annualized[19] economic value of baseline trips to the region ranges between $0.3 million and $9.0 million per year (total present values of $7.4 million to $250.9 million).

Assuming that District open spaces contribute to this value in proportion to the percent of visible land area that they comprise (25 percent), we estimate that the baseline annualized[19] value contributed by District open spaces ranges from $0.1 to $2.3 million per year (total present values of $1.8 million to $62.7 million).

By preventing land development, preservation maintains the aesthetic quality and rural character of the coast, and therefore preserves tourism dependent on this aesthetic quality. We assume that the annual incremental benefits of preservation are a portion of the baseline value of District open space, equal to the percent of total possible development avoided. Under this assumption, we estimate that District preservation provides annualized[19] sightseeing benefits between $0.6 million and $2.0 million per year (total present values of $1.7 million to $56.4 million). Future benefits from 2015 to 2050 account for 44 percent of net present value of recreational benefits, highlighting the importance of maintaining access and visibility of undeveloped lands in the future.

These estimates are subject to some uncertainty. First, we do not include benefits from sightseeing at parcels not located near scenic routes. Thus, our visibility-based approximation omits the value of sightseeing at less-prominent locations. Second, we applied a recreation demand model in the context of

[19] Annualized over the years between 1990 to 2050 at a 3 percent discount rate.

county resident visits. This omits the potentially sizeable tourism benefit for out-of-county visitors. These two limitations suggest our results under-state total recreation benefits. On the other hand, a third uncertainty is the extent to which changes in the amount of undeveloped open space impact visitors' choices to visit the coast (and their perception of coastal scenery quality) in context of unchanging levels of ocean views. To the extent that the aesthetic quality of the landscape and, as a result, sightseeing values may not change significantly due to Low-Density development, our counterfactual scenario comparisons may over-state marginal benefits of land preservation. Section 5 discusses these and other uncertainties in more detail.

4.5 Sea Level Rise

4.5.1 Introduction

Figure 11.The Russian River estuary. (Source: SCAPOSD)

Extensive wetland loss has occurred over the past century, largely due to mosquito control and diking and filling for agricultural, salt pond, and commercial development. A number of studies have demonstrated the ability of coastal wetlands to reduce economic damages associated with major storm events (Costanza et al., 2008; Das & Vincent, 2009), and recent post-Hurricane Sandy research along the North Atlantic coast has shown how restoration and natural infrastructure provide for increased resilience to natural disasters. Many types of coastal natural infrastructure – salt marshes, submerged aquatic vegetation, mangroves, and others -- reduce wave height (Barbier et al., 2008; Gruber & Kemp, 2010) and dampen or attenuate wave energy (Horstman et al., 2014; Shepard, Crain, & Beck, 2011; van Loon-Steensma, 2015; van Loon-Steensma, Schelfhout, & Vellinga, 2014). Sutton-Grier et al. (2015) recently synthesized existing peer-reviewed literature and published reports to highlight the strengths and weaknesses of built infrastructure, natural ecosystems, and hybrid approaches to provide coastal protection benefits. They reported that, "…where data are available, the resilience and protective benefits provided by coastal ecosystems against waves, floods and storm surge is very valuable. Coastal wetlands in the US, for example, were estimated to provide $23.2 billion per year in storm protection services alone based on regression of 34 major hurricanes to hit the US since 1980; loss of 1 ha of wetland in the model corresponded with increased average storm damages of $33,000 from specific storms" (Costanza, et al., 2008). Further, they also found that, "two comprehensive reviews on natural infrastructure determined that coastal salt marsh vegetation plays a critical role in attenuating waves, providing storm protection and stabilizing shorelines by reducing erosion (Gedan, Kirwan, Wolanski, Barbier, & Silliman, 2011; Shepard, et al., 2011)."

At present, various attempts to transition from gray to nature-based infrastructure (e.g., horizontal levees, oyster reefs, subaquatic vegetation restoration, and coir fiber logs) are on site-by-site basis and are lacking baseline data to demonstrate contribution to resilience. However, Federal, state and local agencies, as well as broader stakeholder groups, have expressed growing interest in transitioning from traditional gray infrastructure to nature-based and hybrids of nature-based and gray features to improve resiliency to acute and chronic hazards (Figure 12). Both economic and ecological rationales have been cited as driving forces, with climate change-induced sea-level rise and storm frequency and intensity providing additional impetus. In California, a number of efforts are underway to develop these principles for adapting regional coastal ecosystems to climate change (Chornesky et al., 2015; The Natural Capital Project, 2015). Collaborative open space planning plays an important role in the success of these efforts (The Nature Conservancy, 2014). In San Francisco Bay, for example, the Bay Institute has researched the ability for tidal marshes to provide protection from storm surge and mechanisms to reduce flood protection costs, (ESA PWA, 2013).

Rising sea-level will impact the extent of permanent inundation, erosion, and the type of vegetation along the shoreline, rivers and related tributaries. Evaluating the relationship between landscape and shoreline characteristics and susceptibility to damages related to sea-level rise is a highly complex undertaking (e.g., Tate & Frazier, 2013) and beyond the scope of this study. However, as a first step to understanding the roles that nature and preserved open spaces play in protecting against flooding and erosion, this section evaluates natural infrastructure in the Sonoma County coastal study area at risk of permanent inundation from sea-level rise. The evaluation focuses on two case studies: Willow Creek at the mouth of the Russian River (Figure 11), and Lower Estero Americano Creek in the Sonoma coastal watershed (Figure 13).

Minimal Defense
Many communities have developed right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.

Natural
Natural habitats that can provide storm protection include salt marsh, oyster and coral reefs, mangroves, seagrasses, dunes, and barrier islands. A combination of natural habitats can be used to provide more protection, as seen in this figure. Communities could restore or create a barrier island, followed by oyster reefs and salt marsh. Temporary infrastructure (such as a removable sea wall) can protect natural infrastructure as it gets established.

Managed Realignment
Natural infrastructure can be used to protect built infrastructure in order to help the built infrastructure have a longer lifetime and to provide more storm protection benefits. In managed realignment, communities are moving sea walls farther away from the ocean edge, closer to the community and allowing natural infrastructure to recruit between the ocean edge and the sea wall.

Hybrid
In the hybrid approach, specific built infrastructure, such as removable sea walls or openable flood gates (as shown here) are installed simultaneously with restored or created natural infrastructure, such as salt marsh and oyster reefs. Other options include moving houses away from the water and raising them on stilts. The natural infrastructure provides key storm protection benefits for small to medium storms and then when a large storm is expected, the built infrastructure is used for additional protection.

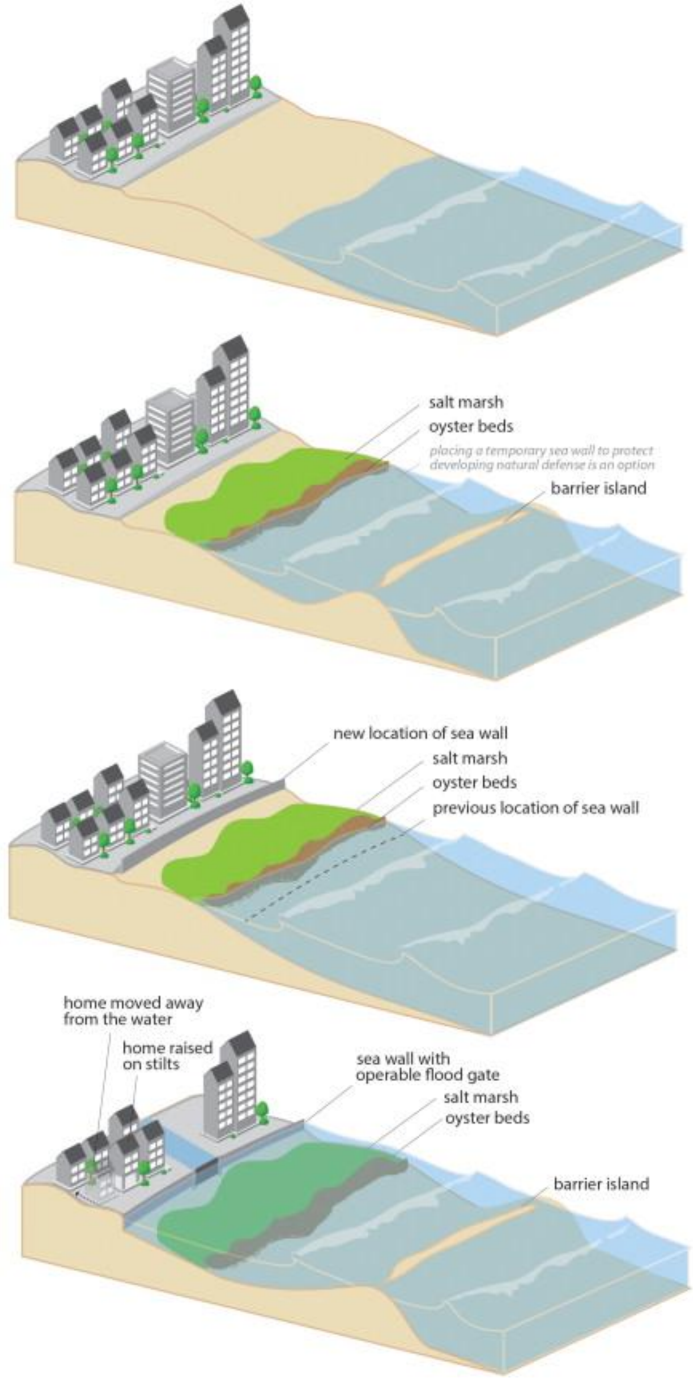

Figure 12. Examples of coastal defenses including natural infrastructure, managed realignment, and hybrid approaches (Sutton-Grier, et al., 2015).

4.5.2 Analysis Methods

As noted above, interactions between sea level, wind wave action, storm surge, and the morphology and characteristics of the shorelines and adjacent lands are complex and modeling the changes in damages and coastal resilience for different land use scenarios was beyond the scope or resources of this project.[20] Nonetheless, a simple analysis can indicate potentially relevant considerations for conserving open space in the coastal area. The simplest, most direct consideration is avoided damages to developed structures on the parcels themselves (e.g., structures at risk in the counterfactual scenarios) and habitat at risk to permanent inundation. Indirect considerations are the potential for avoiding damages on adjacent parcels by providing buffer against storm surges.

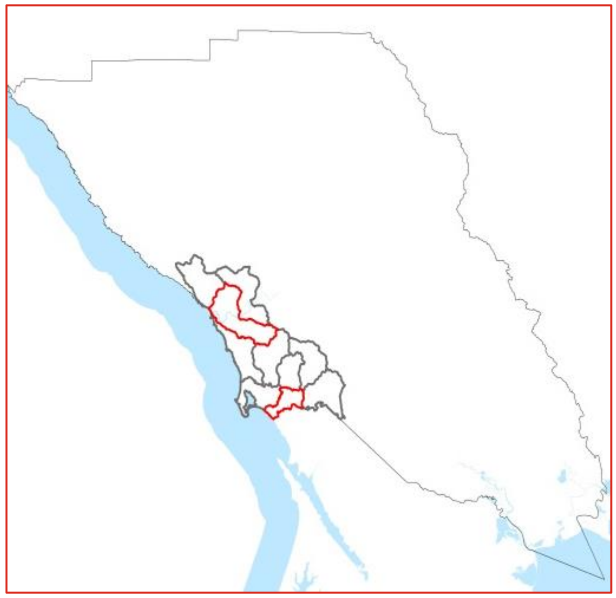

Figure 13. Case Study Areas.

Case study watersheds are outlined in red: Willow Creek in the north; Estero Americano in south.

For this analysis, we identify the extent of inundation that may be expected given projected sea-level rise and habitat at risk to permanent inundation in two case study areas.

As first step in the analysis, we evaluate inundation resulting from sea-level rise (SLR) using the sea-level rise scenarios from the National Oceanic and Atmospheric Administration (NOAA) Digital Coast Program. Data for Sonoma are located in the CA_MTR23 region, and consist of present day permanent inundation levels (zero feet sea-level rise) to six feet sea-level rise, at one foot intervals. The approach uses a static “bath-tub” assumption that calculates the incremental area inundated as sea level rises, but does not include dynamic effects from storm surge and consequent inland flooding that would be expected to accompany the rise. We then look at the type of land use/land cover or natural area affected by sea level rise by intersecting the geospatial data with inundation extent corresponding to various SLR scenarios. Natural areas consist of geospatial features identified in the NLCD data, wetlands habitat from the U.S. Fish and Wildlife Service, and District protected areas within the two watersheds.

4.5.3 Results

Change in Inundation Extent

Figure 14 shows the incremental change in inundated area in each of the two case study watersheds as sea level increases by each additional foot, i.e., change between baseline and 1 ft. SLR; 1 ft. to 2 ft. SLR; 2 ft. to 3 ft. SLR, etc. The pattern reflects differences in the topography of the two watersheds. For the Willow Creek watershed, the inundated area grows steadily as SLR increases and nearly doubles when SLR goes from 4 ft. to 5 ft., after which point the increase in new inundated land begins to decrease. By

[20] An ongoing, separate study is examining coastal vulnerability to surge and sea level rise inundation on the Sonoma County coast (Natural Capital Project InVEST, with additional local partners).

comparison, for the Estero Americano watershed, a 1-ft SLR inundates a large expanse of land, and each additional SLR increment continues to flood additional land, but not as much as the 1 ft. scenario.

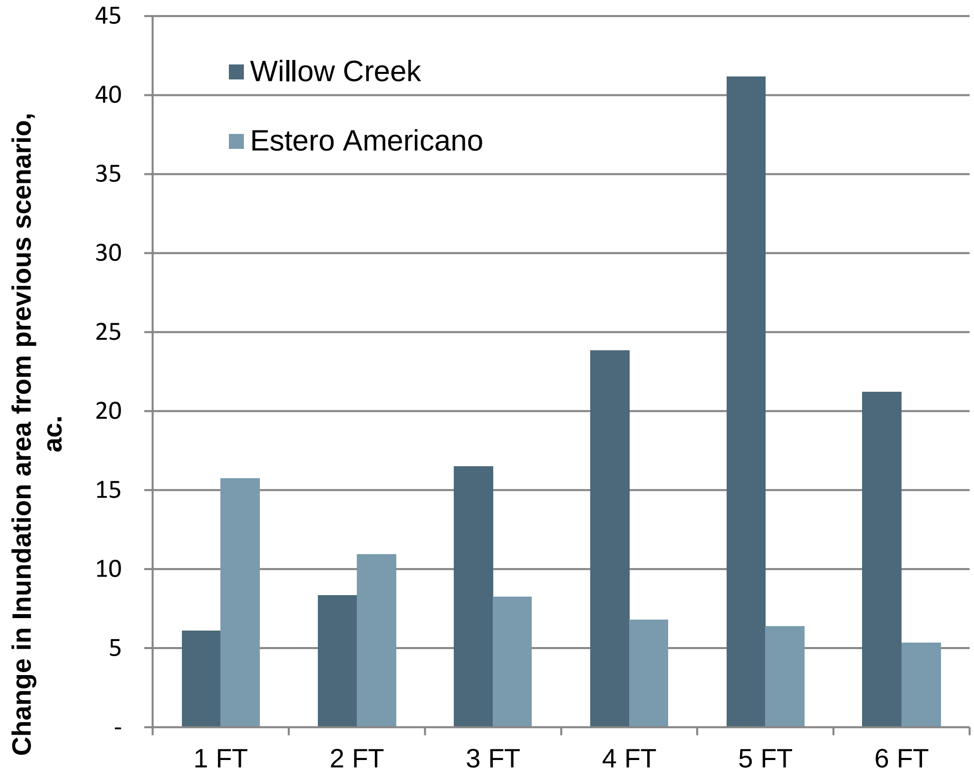

Figure 14. Change in inundation area (square feet) over each case study watershed. Change reflects total change from the present day condition for each 1-foot sea-level rise increment.

Table 13 summarizes the total percent change of inundated land relative to the present day condition for different SLR scenarios.

Table 13. Percent Change in Inundated Area from the Present Day Condition for Various Sea-level Rise Scenarios.						
	Sea-level Rise					
Case Study Watershed	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft
Willow Creek	2%	4%	9%	16%	27%	28%
Estero Americano	9%	14%	19%	23%	26%	29%

Willow Creek Natural Infrastructure

To identify the natural infrastructure at risk of permanent inundation in the Willow Creek watershed case study, we intersected the sea-level rise data with the 2011 NLCD data. We chose to use NLCD data over wetland- and riparian- specific data because of the inland extent of the Russian River through the case study area, and because of the landward extent of the inundation. That is, much more than wetland areas are subject to inundation in the Willow Creek watershed. Table 14 reports the percent decrease in usable land area with sea-level rise, relative to present day conditions, based on the overlay map of Figure 15 which shows progression in inundated areas from light blue to dark blue as sea levels increase (*i.e.*, areas in the table are those below the inundated zone for each SLR contour). The areas projected to be permanently inundated include barren land (presumably beaches), emergent wetlands and woody wetlands.

Table 14. Willow Creek Case Study Percent Decrease in Land Area with Sea-level Rise.

Description	Sea-level Rise Scenario					
	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft
Developed, Open Space	-0.13	-0.25	-0.39	-0.62	-1.42	-2.01
Developed, Low Intensity	-0.22	-0.35	-0.52	-0.63	-0.84	-1.82
Developed, Medium Intensity	-0.44	-1.50	-2.11	-2.81	-3.73	-4.65
Developed, High Intensity	NA	NA	NA	NA	NA	NA
Barren Land (Rock/Sand/Clay)	-1.05	-3.25	-5.09	-10.72	-18.20	-25.62
Shrub/Scrub	-0.00	-0.00	-0.01	-0.04	-0.05	-0.06
Emergent Herbaceous Wetlands	-1.43	-5.14	-14.87	-22.05	-33.26	-35.80
Woody Wetlands	-0.18	-0.66	-2.00	-6.55	-15.41	-18.88
Grassland/Herbaceous	-0.01	-0.02	-0.04	-0.08	-0.16	-0.34
Mixed Forest	-0.02	-0.04	-0.06	-0.10	-0.18	-0.25
Evergreen Forest	NA	-0.00	-0.00	-0.00	-0.00	-0.00
Deciduous Forest	NA	NA	NA	NA	NA	NA

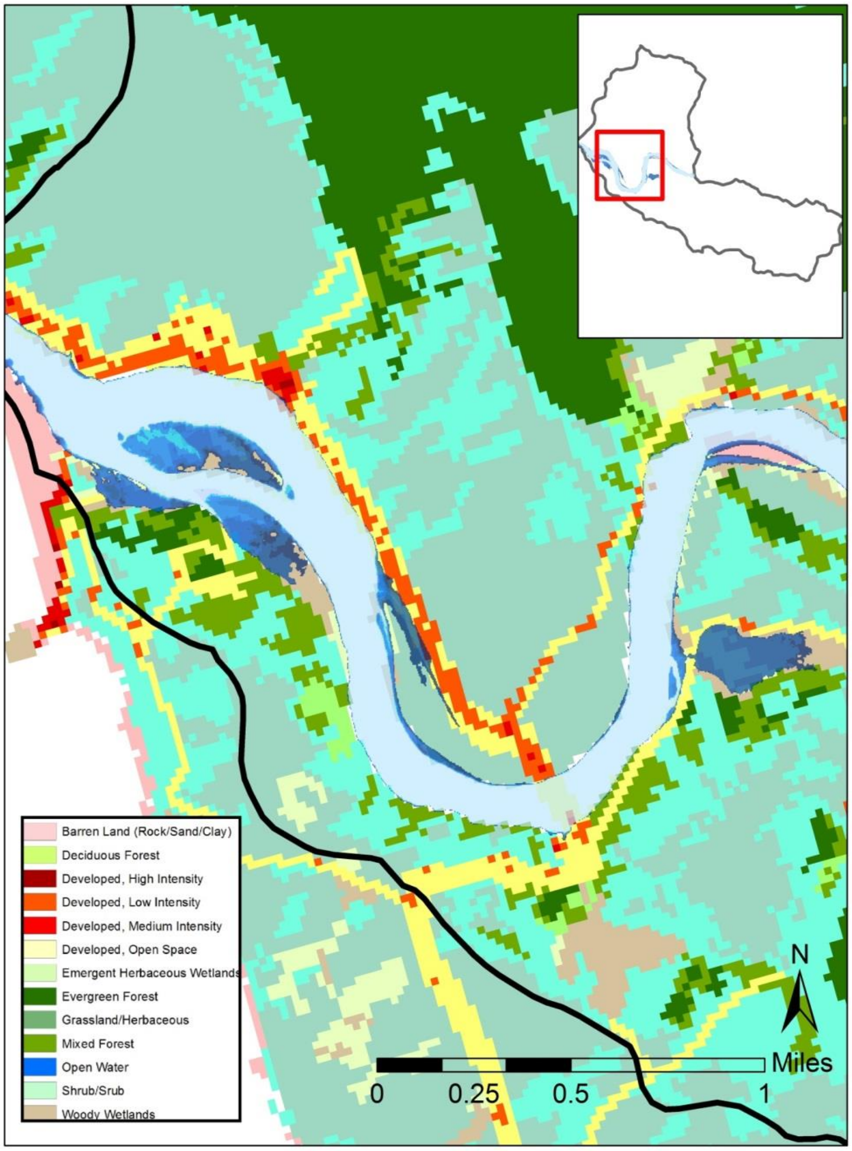

Figure 15. Willow Creek case study NLCD with sea-level rise scenarios (light blue to dark blue).

Estero Americano Natural Infrastructure

The Estero Americano watershed includes natural barriers along the Estero Americano creek. Our analysis therefore considered wetland vegetation at risk to permanent inundation from sea-level rise. Figure 16 displays the flooding source (e.g., open water) as well as the general vegetation (NLCD) in the watershed.

Data from USFS show that the majority of the natural habitat within the watershed consists of freshwater emergent and riverine wetland. Of this habitat, the freshwater forested/shrub wetlands are extremely vulnerable to permanent inundation from SLR: 8.36 acres are subject to permanent inundation with 6 feet of SLR (Table 15).

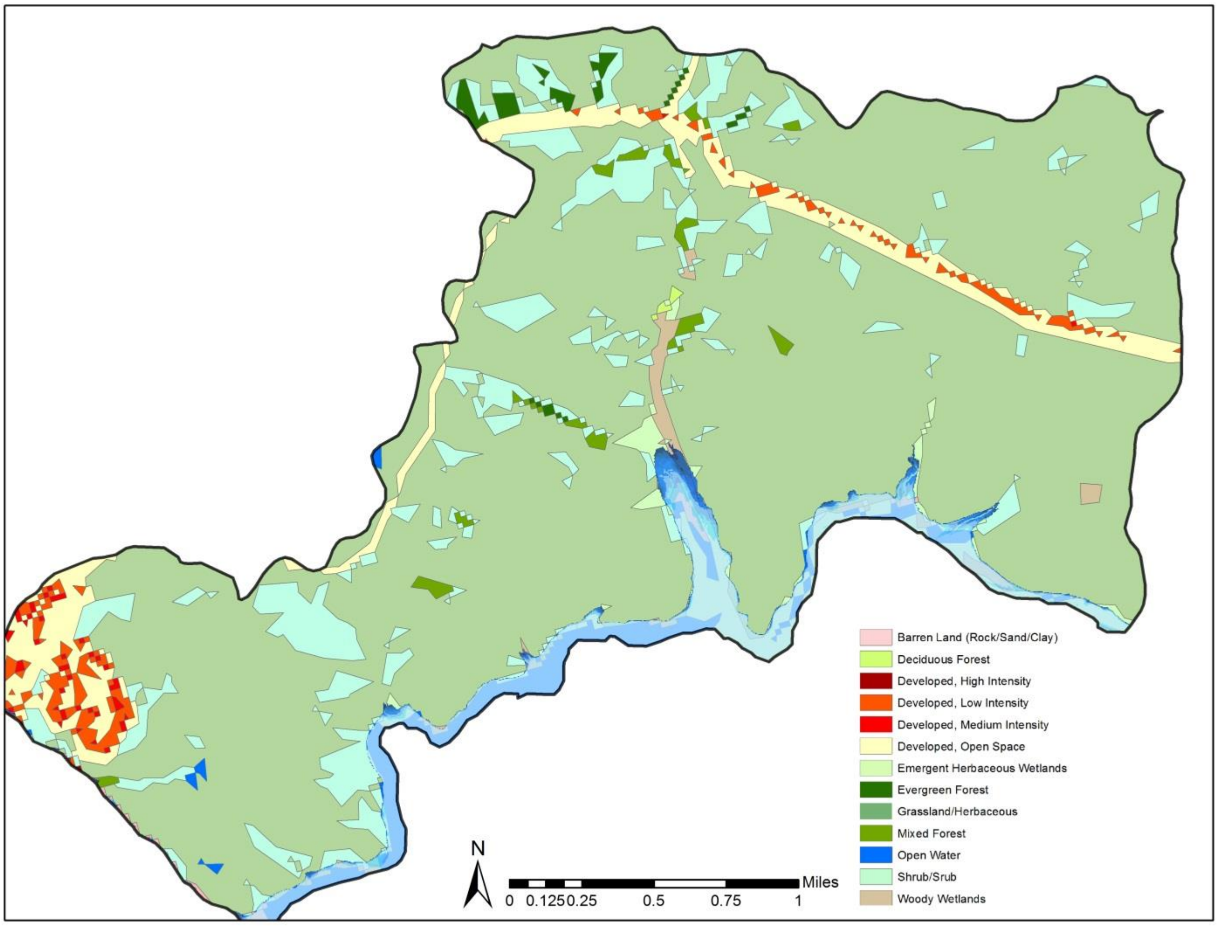

Figure 16. Estero Americano case study map, including NLCD and the present day to 6 feet sea-level rise layers (from light to dark blue).

Table 15. Estero Americano Percent Change in Inundated Wetlands Extent from Present Day for Sea-level Rise Scenarios.							
Wetland Type	**Sea-level Rise Scenarios**						
	0 ft	**1 ft**	**2 ft**	**3 ft**	**4 ft**	**5 ft**	**6 ft**
Estuarine and Marine Wetland		6	10	12	13	14	15
Freshwater Emergent Wetland		9	16	21	23	26	27
Freshwater Forested/Shrub Wetland		204	600	943	1,322	1,821	2,907
Riverine		4	5	5	5	5	5

Change in Protected Lands

As part of this study, we also evaluated changes in the District and Partners' protected lands area resulting from permanent inundation in the Willow Creek and Estero Americano Creek watersheds (Table 16). The results from this analysis are approximate, as they are limited by the accuracy of the protected lands and inundation GIS shapefiles. Nonetheless, the overlay provides insight into the relative amount of protected land that would be permanently inundated under different SLR scenarios.

Table 16. Change in Protected Areas (acres) in Case Study Watersheds.			
Present Day	**Sea-level Rise Scenarios**		
Protected Area, Ac.	**1 ft.**	**3 ft.**	**6 ft.**
Willow Creek			
7,620	7,591	7,578	7,521
Decrease in land area on protected properties with sea-level rise (ac.)	***-29***	***-42***	***-99***
Estero Americano Creek			
714	695	690	685
Decrease in land area on protected properties with sea-level rise (ac.)	***-0.001***	***-0.001***	***-0.002***
Note: Protected areas include both District holdings and lands preserved by partner organizations. The decrease in protected area is relative to current day protected area.			

Implications

While land area and protected land area subject to permanent inundation, as well as chronic flooding from storms, could be used to estimate the amount of avoided damages to property and other assets at risk, we note that the inundated areas represent a very small share of the total protected land. Additionally, because of the uncertainty of projecting where structures may have been placed during development of the parcels under counterfactual scenarios, or measures that may have been taken to protect these structures from rising sea levels, we stop short of estimating counts of infrastructure or the value for avoided damages. Further, to fully characterize potential damages, the rate of shoreline erosion should be considered in addition to surge and permanent inundation. In addition to avoided direct damages, however, the benefits of preserving natural habitats and open space also include mitigation and buffering the effects of SLR, storm surges, and generally increasing resilience to acute and chronic hazards.

This analysis shows that District lands are vulnerable to sea-level rise. In particular, we looked at wetland habitats subject to permanent inundation. Wetland habitats are sensitive to changes in water temperature, salinity, and hydroperiod, among other variables, and wetlands must "keep pace" with sea-level rise. Wetlands adjust to changes in sea level by migrating inland. Sustainable land management approaches include leaving these lands undeveloped, promoting managed retreat as needed, and allowing vegetation to adapt to the changing water level and related conditions. Preserving wetlands and adjacent upland areas is therefore valuable from a societal perspective because it helps to maintain sufficient capacity to absorb impacts from hazards. This absorptive capacity helps to protect upland lands that may have otherwise been inundated without wetland and low-lying areas. Thus, even the seemingly-small inundation benefits shown in this study can offer potentially large benefit as part of a matrix of land preservation along the coast.

4.6 Biodiversity and Habitat Quality

There is an increasing understanding of the impacts exurban development and low-density housing have on native species, ecological communities, biodiversity, and habitat quality – and therefore of the benefits associated with open space preservation in coastal regions of Sonoma County (e.g., Hansen et al., 2005). Data collected within Sonoma County highlight the positive effects of open space preservation on bird, anadromous fish, and carnivore populations (Hilty & Merenlender, 2004; Lohse, Newburn, Opperman, & Merenlender, 2008; Merenlender, Reed, & Heise, 2009). While few in number, these local studies are instructive and provide key methods for assessing ecological impacts of rural residential development. For many habitats within Sonoma County, little is known about the presence or absence of specific animal species and their use of various types of open space (Community Foundation Sonoma County, 2010).

There is ample documentation in the literature of the positive effects open space preservation can have on ecological communities (e.g., Bock & Bock, 2009; Hansen, et al., 2005) and of the negative consequences on natural systems associated with widespread residential development (e.g., Hansen & DeFries, 2007; Pejchar, Reed, Bixler, Ex, & Mockrin, 2015). Enhanced biodiversity resulting from increased habitat in Sonoma county can positively impact residents' quality of life and education (Savard, Clergeau, & Mennechez, 2000), and homeowners appear to distinguish among open spaces, preferring areas that provide higher-quality habitat (Bark, Osgood, Colby, Katz, & Stromberg, 2009). Accurately quantifying these effects for District preserved lands, however, is beyond the scope, available data, or resources of this project. This study instead applied relevant ecological principles to qualitatively describe the range of positive effects open space preservation provides, and the negative effects land conversion may foreshadow, on biodiversity and habitat quality.

By preventing increased development, preserving open spaces provides myriad benefits for both terrestrial and aquatic ecological communities. Upland open spaces provide habitat for terrestrial species, and contribute to the maintenance of habitat quality for aquatic species. Overall, the benefits on ecological communities can be grouped into two broad categories: reductions in habitat loss and fragmentation, and increased water quantity and quality. In both cases, the predominant effects of open space preservation are changes in native biodiversity and community structure.

4.6.1 Habitat Loss and Fragmentation

Background

Habitat loss represents the process by which the land area of individual habitats decreases. Habitat fragmentation occurs when an expanse of habitat is modified through transformation into a greater number of smaller habitat patches, each of which is isolated from each other. A large number of studies, both experimental and observational, have demonstrated the negative effects of habitat loss and fragmentation on biodiversity (Fahrig, 2003).

Traditionally, rural development leads to the parcelization of existing habitat through the division of relatively undeveloped land parcels into smaller and more intensively-developed properties (e.g., single-family homes). This process fragments undeveloped and minimally developed lands, can hinder or block animal movement, eliminate necessary food and water sources, and/or introduce non-native predators. Consequently, as exurban development occurs throughout Sonoma County, both habitat loss and fragmentation occur. In turn, these processes, when combined with changes in natural fire regimes (e.g., Hansen, et al., 2005; Theobald & Romme, 2007), and land management practices (removing trees and shrubs, mowing grass, removing woody debris, etc.) that accompany residential development are likely to have negative impacts on local flora and fauna (Bock & Bock, 2009). Although many replacement habitats are "green" (e.g., lawns, shrubs, flower beds, trees), they do not adequately replace native vegetation, and are often exotic and weedy in nature (McKinney, 2002).

As of 2010, Sonoma County ranked among the lowest of the Bay Area counties in the proportion of county land area permanently protected, and interviews with local experts identified direct land protection, via acquisitions and/or conservation easements, as the single highest priority for habitat conservation (Community Foundation Sonoma County, 2010). This is because land protection prevents parcelization, and thereby preserves the quantity of high quality terrestrial habitats in Sonoma County.

Benefits of Open Space Protection in Sonoma County

The effects of habitat loss and fragmentation within Sonoma County are documented in a number of case studies, each of which highlights the importance of open space preservation for increasing habitat retention, habitat quality and biodiversity. For example, in a study assessing the effects of residential development on biodiversity on the urban-rural fringe of Sonoma County, researchers found that lot size, as a proxy for habitat fragmentation and human activity, affected the diversity of both plant and bird species (Merenlender, Heise, & Brooks, 1998). In this study, although there was no observed effect on total biodiversity associated with development, native diversity decreased while exotic diversity increased. Similarly, disturbances associated with residential development (including increased road density, hunting by domesticated cats, and other human activity) reduced the diversity and abundance of sensitive and migrating bird species.

Similarly, additional negative effects of habitat loss have been demonstrated within the community of woodland bird species in Sonoma County following exurban development (Merenlender, et al., 2009). Following development, birds requiring trees and shrubs to feed did not appear to change in number. However, the number of migratory bird species, and several species of flicker and warbler declined substantially following residential development and habitat parcelization. These reductions in habitat quality may occur even on lands protected by conservation easements. Although land parcels under conservation easements have fewer structures and roads than surrounding unprotected property, a recent study found that nearby residential development reduced habitat quality within the easements themselves (Pocewicz et al., 2011). These results point to the necessity of maintaining large undeveloped parcels of open space in the maintenance of biodiversity within Sonoma County.

Hilty and Merenlender (2004) studied the effects of habitat loss and fragmentation on native predator populations. This study showed that natural, dense vegetation in riparian corridors was essential to the movement of large, native animals, and that vineyards were rarely used by mammalian predators. Because animals were detected more than 11-fold more regularly in natural riparian corridors than in vineyards, the researchers concluded that maintaining wide and well-vegetated riparian corridors was important in maintaining the connectivity of native predator populations to ensure their long term survival.

Overall, open space preservation limits habitat loss and fragmentation. By doing so, the establishment of open space supports a wide range of native communities, including but not limited to plants, birds, aquatic organisms and large and small mammals.

4.6.2 Water Quantity and Quality

Background

Water is one of the fundamental elements of good terrestrial and aquatic ecosystem health. Ecological processes which sustain native fish and bird populations, vegetation, and wildlife depend on a reliable and high-quality supply of water. Similarly, many human uses of ecosystems, including drinking, fishing, and recreation, require suitably high water quality.

Human demand for water in Sonoma County includes (but is not limited to) withdrawals for household use, cultivated agriculture, livestock, and industry. To meet this demand, the Sonoma County Water Agency delivers an average of 57,500 acre-feet of water per year from the Eel and Russian River watersheds (Somona County Water Agency, 2015). At the same time, increased development enlarges the amount of impervious cover (e.g., rooftops, driveways, roads and other surfaces that prevent water from filtering into the ground below them) and, as a result, less rainwater infiltrates into the ground, and more travels across the land as urban polluted runoff. **Error! Reference source not found.** Figure 17 illustrates the hydrological costs of developing open spaces into roads, driveways, and buildings.

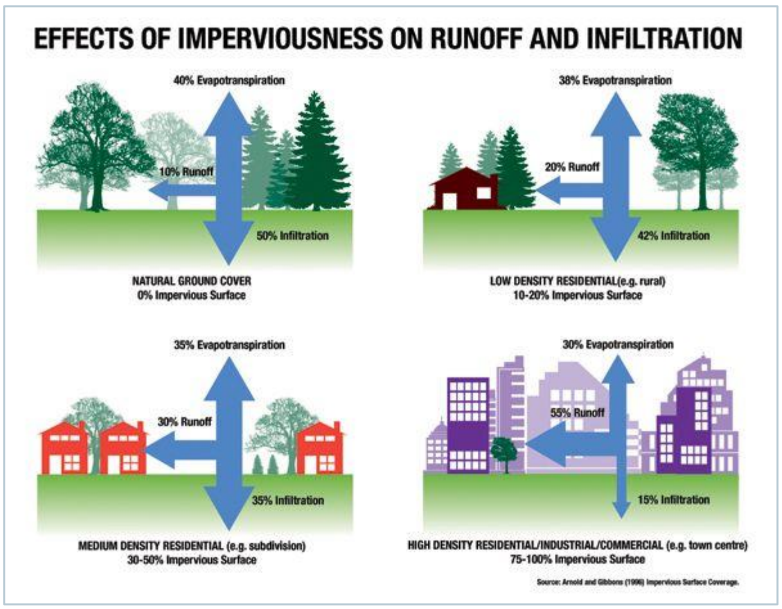

Figure 17. Illustrative effects of impervious cover on surface runoff and infiltration.
Source: Arnolds and Gibbons (1996).

The negative effects of urban and suburban development on water quality are well known and well documented (United States Geological Survey, 2014); these impacts also occur in exurban landscapes with less intensity. Impacts directly associated with increasing impervious surface area include an increased volume of rainfall runoff (Gregory, Dukes, Jones, & Miller, 2006) and an increase in the rate at which water is able to travel across the landscape (e.g., Hood, Clausen, & Warner, 2007). Together, these changes in runoff volume and velocity can result in the destabilization of small waterways (Chin & Gregory, 2001; Kang & Marston, 2006), even at low development densities (Dougherty et al., 2007).

These human alterations of the water cycle have complex effects on habitats: the natural flow regime of rivers is altered, and the quality of water available to plants and wildlife is degraded. Although the cumulative effects of human use are unknown, individual effects related to water quality and quantity have been identified. In some cases, impacts are observed only at relatively large scales. For example, Opperman et al. (2005) found that the predictive power of land use on salmonid gravels increased to the level of the watershed. Accordingly, the marginal effects of terrestrial open space conservation within Sonoma County's coastal zone are unlikely, individually, to have a measurable impact on salmon gravels in the lower Russian River.

In addition to having the potential to damage habitat through changes in geomorphology, increases in runoff volumes often result in increased sediment and contaminant loading. Because open space preservation prevents land-use intensification, it also decreases the occurrence of organic pollutants, metals, and sediments in streams that are deposited through runoff (Lohse, et al., 2008). Additionally, because exurban development often occurs in areas not served by municipal sewer systems (Newburn & Berck, 2006), open spaces likely prevent nutrient and fecal bacteria inputs to streams that may occur through leaking septic systems (Kaushal, Lewis Jr, & McCutchan Jr, 2006).

Benefits of Open Space Protection in Sonoma County

Salmon provide a representative example of the connection between hydrology and species survival. This is because (i) the composition of the stream bed, and (ii) water temperature affect the viability of salmonid populations (Sauter, McMillan, & Dunham, 2001). Land uses which cause erosion of fine sediments into streams can threaten survival of developing embryos by filling up the spaces between gravel and limiting the movement of water, which supplies oxygen to the eggs and by severely impacting juvenile food capture efficiency due to lack of sight with high turbidity. Water temperature is also important: when water temperatures become too high, juvenile growth and survival is especially compromised (Sauter, et al., 2001). Land use factors that may affect water temperature include water withdrawals and discharges, clearing of riparian vegetation, manipulation of stream flow, and modification of channel configuration.

By limiting runoff, the direct effects of preserving open spaces include substantial improvements in water quality, and consequently habitat quality. In the context of Sonoma County, preventing additional development and the associated degradation of stream conditions, protected open spaces are likely to contribute to Steelhead salmon recovery within the Russian River. Studies have shown that preservation can have a positive impact on salmon populations by limiting salmonid habitat degradation occurring through siltation (Lohse, et al., 2008), increasing summer juvenile Steelhead survival rates (Grantham, Newburn, McCarthy, & Merenlender, 2012), and by limiting population declines associated with land development (Bilby & Mollot, 2008).

4.7 Threatened and Endangered Species

4.7.1 Introduction

Throughout California, protection of undeveloped land and riparian corridors is at the core of biodiversity conservation efforts. Within the nine-county Bay Area, in particular, the Conservation Lands Network has identified the vegetation types, species, and riparian zones important for conserving biodiversity (Penrod et al., 2013). Conservation biologists translated this information into specific core terrestrial and aquatic habitats and corridor areas throughout California that are necessary to support wildlife populations, including species of special concern (Penrod, et al., 2013).

The Sonoma County Agricultural Preservation and Open Space District has a goal to “protect habitats important for the conservation and restoration of rare, threatened or endangered species.” This section qualitatively assesses the benefits of open space protection and management in Sonoma County for three selected threatened and endangered species: coho salmon, northern spotted owl, and marbled murrelet. Given the complexity of linking habitat preservation to changes in threatened and endangered species populations, we provide qualitative analysis is intended to show the potential benefits to complement the preceding sections which focus on monetizing the benefits of open space protection.

This qualitative analysis is not intended to be a comprehensive discussion of all potential open space preservation and management actions in Sonoma County that could benefit these three selected species. Instead, we focused on using one or two key information sources for each species, including a GIS map layer, to identify the specific type and location of habitats where preservation or management actions could benefit these species.

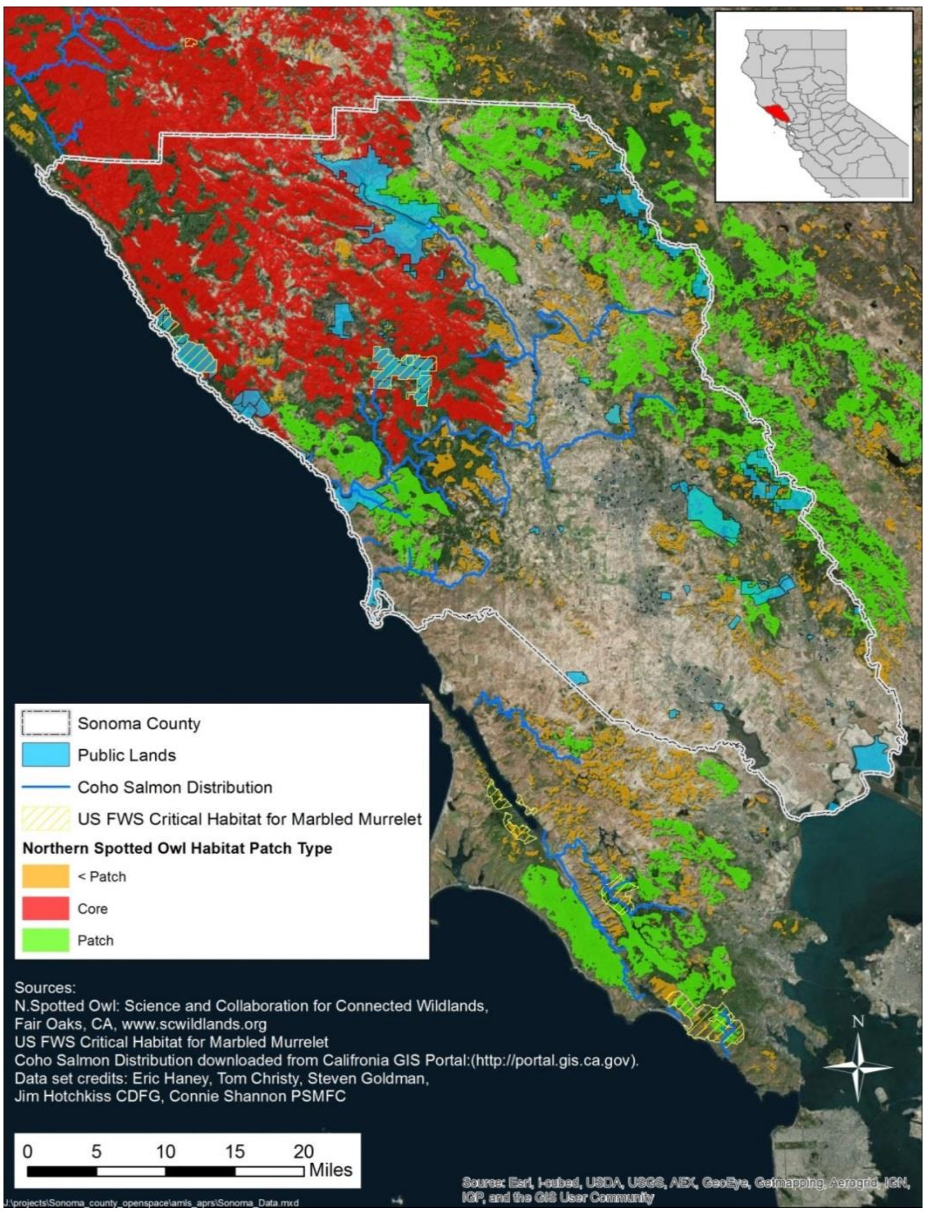

Figure 18. Areas Analyzed for Land Preservation Benefits to coho salmon, northern spotted owl, and marbled murrelet in Sonoma County.

4.7.2 Coho Salmon

Background

Coho salmon (*Oncorhynchus kisutch*) is one of two native salmon species that regularly occur in California. Within California, coho salmon historically ranged from the Oregon-California border to the streams of northern Monterey Bay before extensive logging and other land-conversion activities. As anadromous fish, coho salmon have a complex life cycle. Adult coho salmon enter fresh water to spawn. Females choose spawning sites with a substrate of small to medium gravel for laying eggs, which incubate and then hatch. Hatchlings remain in the gravel until they emerge as young juveniles known as fry. Juvenile coho salmon use a variety of rearing areas, including "low-gradient coastal streams, lakes, sloughs, side channels, estuaries, low-gradient tributaries to large rivers, beaver ponds, and large slackwaters" (California Department of Fish and Game, 2004, p. 2.6). Juveniles typically spend about one year in fresh water and then begin to migrate downstream to the ocean, where they spend one to two years before returning to fresh water to spawn and die (California Department of Fish and Game, 2004). Thus, coho salmon are vulnerable to a variety of threats that affect any of the multiple habitats they need to complete their complex life cycle. These threats include hydrologic modifications to streams, such as dams, water storage, and diversions; habitat modifications that affect in-stream and off-channel habitats, such as logging, road construction, and development; and fishing and predation, particularly with already diminished populations (NOAA Fisheries Office of Protected Resources, 2014). Coho salmon are a key "umbrella species" for planning riparian preservation efforts, particularly because coho salmon juvenile survival is particularly sensitive to water degradation associated with logging and sedimentation (Penrod, et al., 2013).

In California, coho salmon abundance has declined sharply since the 1940s. The California Department of Fish and Game estimated in 2004 that coho salmon abundance was at 6 percent to 15 percent of its abundance during the 1940s. In response to this decline, Central California Coast coho salmon were listed as an endangered species under both the federal Endangered Species Act (ESA) and the California ESA. This population of coho salmon is considered a distinct, "evolutionarily significant unit," and is protected separately from the Southern Oregon-Northern California Coast unit, because of its distinct genetic characteristics. Specifically, an evolutionarily significant unit must be (1) reproductively isolated from other conspecific population units, and (2) must represent an important component of the evolutionary legacy of the species (California Department of Fish and Game, 2004).

In 2004, the California Fish and Game Commission adopted a recovery strategy for California coho salmon with a primary objective of returning California coho salmon to a level of sustained viability, while protecting the genetic integrity of the two distinct evolutionarily significant units. Key habitat goals in the plan included:

- Maintaining existing habitat that is essential for coho salmon
- Enhancing and restoring habitat that is within the range of coho salmon.

Coho salmon historically had a large presence in Sonoma County, including, but not limited to, large parts of the Russian River watershed. Sonoma County has lost 86 percent of coho salmon historical runs, while areas south of Sonoma County have lost 56 percent of historical runs (Penrod et al., 2013). Despite these losses, Sonoma County is still considered an important location for coho salmon recovery. Hydrologic units within Sonoma County are included in the California Department of Fish and Game (2004) recovery strategy and recent observations (since 1990) indicate that coho salmon are still present in Sonoma County.

The recent drought in California has further stressed coho salmon. The California Department of Fish and Wildlife (CDFW) and the State Water Resources Control Board requested that, during the summer of 2015, landowners in Sonoma County participate in voluntary drought agreements to keep sufficient in-stream water flows to protect the survival of juvenile coho salmon (California Department of Fish and Wildlife, 2015). On June 17, 2015, the State Water Resources Control Board adopted an emergency regulation to help protect federal- and state-listed anadromous fish, including coho salmon, in four priority Russian River tributary watersheds: Dutch Bill Creek, Green Valley Creek, portions of Mark West Creek, and Mill Creek. The emergency regulation requires enhanced water conservation and increased information reporting on water use in these watersheds; the Office of Administrative Law approved the regulation on July 6, 2015 (California Water Board, 2015). In June of 2015, the Sonoma County Board of Supervisors also opted to approve outdoor watering restrictions (rather than a 25 percent reduction) for the Salmon Creek, Fitch Mountain, Jenner and Freestone Water Districts, to comply with the Governor of California's executive order on mandatory water use restrictions (Sonoma County Board of Supervisors, 2015).

Benefits of Open Space Protection in Sonoma County

The Recovery Strategy for California Coho Salmon (California Department of Fish and Game, 2004) includes a large number of recommendations to benefit all aspects of the coho salmon life cycle. Open space protection in Sonoma County has the potential to address key recommendations that focus on habitat and water quality. Range-wide recommendations that can benefit coho salmon across its geographic distribution include actions to maintain and restore in-stream and riparian habitats that will (1) reduce sediment delivery; (2) maintain appropriate in-stream temperatures; and (3) maintain and restore habitat complexity, including refugia for salmon. The recovery strategy also includes specific watershed recommendations for each hydrologic subarea within the county. For example, recommendations for the Guerneville hydrologic subarea include "Acquire from willing sellers conservation easements or land in fee title in habitat essential for coho salmon" (California Department of Fish and Game, 2004, p. 8.41). Thus, open space protection in Sonoma County can clearly play a role in implementing the recovery strategy for coho salmon.

The recovery strategy (California Department of Fish and Game, 2004) envisioned a set of coordinated actions that would provide sufficient benefit to coho salmon to the extent that coho salmon could be "delisted" under the federal and state ESAs. The regional land conservation strategy described by Penrod et al. (2013) also envisions the protection of coho salmon habitat as an umbrella strategy to protect riparian corridors across the central coast. Open space protection in Sonoma County that meets the recommendations of these overarching plans, intended to provide benefits on watershed scales across the central coast, will also clearly benefit coho salmon.

The recent drought, however, has added urgency to the need to protect coho salmon habitat and particularly the in-stream flows on which salmon depend. Juvenile salmon require sufficient water in tributaries to survive a hot summer. Open space protection or management that can also support sustainable water flows in watersheds used by juvenile coho salmon would play an important role in promoting the survival of juvenile coho salmon in these watersheds during the drought. The CDFW has even designated “drought-priority” watersheds within the Russian River drainage (California Department of Fish and Wildlife, 2015) where actions would be particularly beneficial.

The map in Figure 18 shows the observed distribution of coho salmon in Sonoma County from 1990 to 2012, based on observational data from the Aquatic Species Observation Database (California Department of Fish and Wildlife, 2012). We have provided this map to indicate locations of streams and surrounding watersheds in Sonoma County where coho salmon have been recently observed, and where open space protection of riparian habitat and in-stream flows could benefit coho salmon survival and recovery. However, because the dataset relies on observed distributions in surveyed streams, it likely underestimates the geographic distribution of the species. An additional caveat is that the map does not show all of the potential headwater tributaries that flow into the mapped areas – areas where coho salmon could live, and regardless of coho salmon presence, likely contribute to the species recovery by improving conditions downstream. Additional information and maps that show hydrologic units targeted for coho salmon recovery and riparian corridor linkages important for coho salmon can be found in California Department of Fish and Game (2004) and Penrod et al. (2013).

4.7.3 Northern Spotted Owl

Background

The northern spotted owl (*Strix occidentalis caurina*) is a forest-dwelling bird that inhabits “structurally complex” forest along the Pacific Coast, from British Columbia to as far south as Marin County (U.S. Fish & Wildlife Service, 2011b). The spotted owl was listed as threatened under the ESA in 1990 because of widespread habitat loss. However, even with extensive habitat protection and restoration in the last two decades, many populations of the spotted owl continue to decline. The revised recovery plan for the spotted owl noted that competition from the barred owl (*Strix varia*) poses a significant threat to the spotted owl; the report described actions to address this threat, in addition to recognizing the continued importance of maintaining northern spotted owl habitat (U.S. Fish & Wildlife Service, 2011b).

In California, spotted owls generally inhabit older forested habitats, with specific structural characteristics that the birds need for nesting, roosting, and foraging. These characteristics include “a multi-layered, multi-species canopy with moderate to high canopy closure; a high incidence of trees with large cavities and other types of deformities; large snags (standing dead trees); an abundance of large, dead wood on the ground; and open space within and below the upper canopy for spotted owls to fly” (U.S. Fish & Wildlife Service, 2011a). In some parts of their range, spotted owls can benefit from a mosaic of older forest habitat interspersed with other vegetation types. In coast redwood forests, spotted owls may use younger forests that have some of the structural characteristics of older stands (U.S. Fish & Wildlife Service, 2011a).

The population of the northern spotted owl in Sonoma County has likely declined with the decrease in old-growth forest habitat. However, we were unable to find an estimate of northern spotted owl decline specific to Sonoma County.

Benefit of Open Space Protection in Sonoma County

Penrod et al. (2013) developed a patch-size analysis to classify potential breeding habitat for northern spotted owls based on the different contiguous-habitat sizes. Core areas are defined as “a continuous area of suitable habitat large enough to sustain at least 50 individuals” and breeding patches are defined as “an area of suitable habitat large enough to support successful reproduction by a pair” (Penrod et al., 2013, p. 13). Patches can be linked via species dispersal to other patches and core areas. Protection of core and patch areas across California would provide a habitat landscape suitable for northern spotted owls across their geographic distribution.

The map in Figure 18 shows the distribution of core, patch, and sub-patch areas for northern spotted owls in Sonoma County, as mapped by Penrod et al. (2013). Protecting land within these areas, particularly for areas of minimum patch size, would contribute to the long-term habitat needs of the spotted owl. Although California Forest Practice Rules already provide for the protection of habitat around occupied nest areas, the protection of a whole tract – as opposed to the limited protection around an occupied nest – would likely convey a greater long-term benefit to the species (U.S. Fish & Wildlife Service, 2011b).

Conservation measures for the northern spotted owl also need to address the increasing threat to spotted owls from the invasive barred owl. Barred owls have extended their range down to Sonoma County (Dark, Gutiérrez, & Gould Jr., 1998), posing a threat to the spotted owl. Conserving and managing spotted owl habitat as open space could potentially offer a greater opportunity for lethal or non-lethal barred owl control methods. Thus, the protection of suitable habitat as open space would not only provide a habitat protection benefit, but could provide additional benefits through easier management of barred owls.

4.7.4 Marbled Murrelet

Background

The marbled murrelet (*Brachyramphus marmoratus)* is a small seabird that forages in near-shore marine habitats; the bird nests inland, in old-growth coniferous forests generally within 30 miles of the coast. In California, marbled murrelets primarily nest in coast redwood (*Sequoia sempervirens*) forests. The Oregon, Washington, and California population of marbled murrelet were listed as threatened under the ESA in 1992. Key threats to marbled murrelet on land include a loss of nesting habitat from logging activities and development, and key threats at sea include excess mortality associated with gill-net fisheries and oil pollution (McShane et al., 2004). Because District actions do not influence fisheries or oil pollution, here, we focus on threats to marbled murrelet on land.

The U.S. Fish and Wildlife Service (USFWS) estimates that the marbled murrelet population has declined by 50 to 80 percent from historical levels before extensive logging in California occurred. Current estimates indicate that approximately 6,500 individual murrelets live along the coast of California, compared to an estimated historical density of 60,000 marbled murrelet pairs. Loss of older forests used for nesting is likely the primary factor for this large decline (U.S. Fish & Wildlife Service, 2011c). Scientists have also noted the poor reproductive success of marbled murrelet in forest patches near human settlements because of nest predation by birds from the corvidae family (e.g., ravens, crows) that follow human settlement (McShane, et al., 2004).

For marbled murrelets that nest in California, the highest-quality habitat consists of unfragmented stands of old-growth coast redwoods that are thousands of acres in size; however, the birds may also nest in smaller forest stands of several acres (U.S. Fish & Wildlife Service, 2011c). The highest densities of marbled murrelet in California appear on the Oregon border and south to Humboldt County; lower densities and a patchy distribution of birds exist south, to Santa Cruz County (McShane, et al., 2004).

The USFWS designated more than three million acres as critical habitat for marbled murrelet, within six conservation zones. Sonoma County is within Conservation Zone 5. McShane et al. (2004) note that most of the historical old-growth habitat in Conservation Zone 5 has been harvested for timber, with the remaining lower-quality habitat found in scattered patches in parks and on private lands.

The critical habitat designation means that federal agencies must consult with the USFWS to review and assess the impacts of any federal actions on these lands on the marbled murrelet, but the critical habitat designation does not affect actions taken solely by private landowners. Therefore, open space protection on lands designated as critical habitat could provide benefit over and above existing regulatory protections.

Benefits of Open Space Protection in Sonoma County

The map in Figure 18 shows USFWS-designated critical habitat for marbled murrelet in Sonoma County. Our analysis suggests that the protection of coast redwood habitat in Sonoma County as open space could provide some benefits to marbled murrelet, if that open space protection were to address key threats of logging and nest predation. Protection of any remaining patches of old-growth coast redwood in Sonoma County that are still vulnerable to logging would provide the greatest benefit. Assuming that the recovery of marbled murrelet proceeds slowly, the protection of second-growth coast redwood could also provide benefits several decades into the future, as the areas would eventually develop characteristics of old-growth stands. In addition, marbled murrelet would benefit from protecting any buffer areas around old-growth patches; this could reduce corvid bird predation on nests by reducing the habitat-edge to habitat-interior ratio (McShane et al., 2004).

However, Sonoma County has low densities of marbled murrelet compared to other areas in California and to the larger population in Washington and Oregon. For example, Paton and Ralph (Paton & Ralph, 1990) conducted transect surveys to examine the distribution of marbled murrelets at coastal forest sites in Northern California and detected marbled murrelets at only 11 percent of surveyed transects in Sonoma County, compared to their highest rate of detection at 67 percent of transects in San Mateo County, south of San Francisco. McShane et al. (2004, p. 3–12) even reported that "no breeding and little possible forest nesting habitat" is known to exist in Sonoma County. Preserving coastal redwood habitat in Sonoma County might not affect the conservation status of marbled murrelet on its own, but it could be beneficial as part of a larger regional land preservation strategy that protects a network of coastal redwood (e.g., Penrod et al., 2013).

Protecting suitable nesting habitat or buffer areas would likely benefit marbled murrelet over the long-term, even if the Sonoma County nesting population is relatively small.

4.7.5 Conclusion

Open space preservation in Sonoma County could contribute to the conservation of coho salmon, northern spotted owls, and marbled murrelets, particularly when managers embed open space protection within a larger regional conservation strategy. As shown in Figure 18, some areas within Sonoma County could benefit all three species. In general, habitat protection for the northern spotted owl will also benefit the marbled murrelet, because of their similar use of forest habitat. Coho salmon may also benefit from forest protection, but require protection as well in upper watershed areas not used by the two bird species.

For coho salmon, protecting riparian corridors as open space could support long-term conservation efforts. During the short-term crisis of the current drought, open space protection that ensures additional in-stream flows could provide an immediate short-term benefit to the species. For the northern spotted owl, protecting core and patch habitat areas would also contribute to the long-term habitat requirements of the species, but would be particularly valuable if the open space protection also enables management of the barred owl. Finally, for the marbled murrelet, current population numbers in Sonoma County are low and the birds rely on old-growth forest as nesting habitat, so the protection of potential habitat would be valuable as part of a long-term conservation effort for the species, even if the protected open space land does not currently support breeding pairs.

5. Discussion and Opportunities for Continued Study

Our report focuses on six of the many ecosystem service benefits gained by the District's efforts to preserve 21 coastal open space and working agricultural lands in the Sonoma County coastal region. We studied carbon sequestration, local agriculture and food, recreational opportunity, sea level rise resiliency, habitat quality benefits to biodiversity, and protection of threatened and endangered species. We also estimated the monetary benefits of two services (carbon sequestration and recreational opportunity) received within and beyond Sonoma County. Improved recreational opportunities and scenery benefit Sonoma residents while carbon sequestration benefits global population. The $100.5 million high-bound present value of carbon sequestration and recreation benefits approaches the $125.8 million total purchase price to acquire these parcels (adjusted to 2015$ and discounted to present-day). The benefit-to-cost ratio is likely more favorable than monetary estimates suggest, as we have not monetized all of the economic benefits of the District's holdings in this study (i.e., we are comparing partial benefit estimates to total costs).

Table 17. Land Acquisition Costs and Ecosystem Service Benefits (2015$) in the Sonoma County Coastal Study Area.

	Total Present Value	
	Low Bound	**High Bound**
Acquisition Costs		
Purchase Price of 21 District Holdings	$125,800,000[A]	
Ecosystem Service Benefits		
Carbon Sequestration	$37,032,215	$44,114,514
Cultural & Recreational Amenities[B]	$1,700,000	$56,400,000
Other Services (local agriculture and food, sea level rise resiliency, biodiversity, T&E species)	Positive non-monetized value	
Total Monetized Benefit (Partial ecosystem service value)	$38,732,215	$100,514,514
Benefit-to-Cost Ratio		
Benefits divided by purchase costs to District and partners	0.31 : 1	0.80 :1

A: Value rounded for confidentiality.

B: The estimated recreational benefits do not account for benefits to out-of-state residents.

Today's Sonoma county taxpayers are benefitting from the District's open space preservation investments. Because these benefits will continue to accrue in perpetuity, current citizens are also "paying it forward" to future generations by preserving ecosystems that bolster community response to climate change on the California coast. For example, preservation supports climate-ready action through avoiding emissions (avoided CO_2 and other pollutants), moderating climate change (CO_2 sequestration) and setting aside space for adaptation (e.g., absorption of sea level rise, habitat refugia and corridors).

Our results support the District in improving its understanding of the economic values of open space preservation in the coastal zone. The District may choose to use our results as support for additional economic valuation studies, or more broadly to advance discussions about maintaining or expanding total funding for land preservation programs, incorporating ecosystem services into preservation decisions, and to generally inform its stakeholders about the role of land preservation in supporting healthy lands and healthy economies.

This final section concludes the report by summarizing key limitations and uncertainties of the research and findings and by suggesting several opportunities for continued research that expands on the methods and results of this Phase I study.

5.1 Uncertainties in Quantitative Analyses

This section summarizes the uncertainties and limitations inherent in our quantitative analyses. Readers should consider these uncertainties and limitations when interpreting the estimates presented in the report.

5.1.1 Choice of the Discount Rate

We discount all future benefits at a 3 percent discount rate in keeping with standard practice in the discounting of public benefits. Discount rates are also sensitive to the amount of time between today and the point at which open space benefits occur (time horizon), and the degree to which we assume people prefer to have benefits sooner, rather than later (time preference). To the extent that a 3 percent discount rate does not capture Sonoma County residents' time preferences, our analysis introduces some amount of error in discounting.

5.1.2 Carbon Sequestration

Uncertainties and limitations inherent in the analysis include:

- Scientific uncertainty and geographic variability in carbon storage and sequestration rates for vegetation. We simplified the analysis by using average per unit sequestration values for two vegetation groups (trees and grass) that implicitly incorporate vegetation growth, time to maturity, mortality, and decomposition rather than tracking these processes explicitly. Actual sequestration rates will vary based on local conditions. For example, net carbon accumulation to soil depends in part, on native levels of soil organic carbon in the soil (Pickett, Cadenasso, Grove, Groffman, Band, Boone, Burch, et al., 2008). Use of average values could potentially result in underestimation or overestimation of benefits if local conditions differ significantly from average values.

- Limitations of the tree canopy dataset. For example, one study has found that the NLCD tree canopy data tends to underestimate tree canopy cover within NLCD developed land classes by an average of 13.7 percent (David J. Nowak & Greenfield, 2010). We did not adjust the tree canopy cover data in this analysis to account for this under-prediction.

- Uncertainties in the social cost of carbon. The SCC values used in this analysis are considered best estimates for the purposes of regulatory analysis, however they are subject to various uncertainties and limitations. In particular there are specific uncertainties and limitations associated with treatment of non-catastrophic damages, treatment of potential catastrophic damages, extrapolation of damages to high temperatures, treatment of adaptation and technological change, and risk aversion. See Interagency Working Group (2010, 2013) for additional information.

5.1.3 Recreation

We presented several scenario analyses designed to illustrate the economic benefit of open space to one popular coastal activity, sightseeing. Given several limitations, these estimates should be interpreted as cautious illustrations of the total value of open space preservation in the coastal zone. Uncertainties and limitations driving this caution include:

- We focused on resident trips, and did not include tourist trips. Due to the lack of data on visitors to Sonoma County, we did not estimate recreational benefits enjoyed by tourists. As noted throughout this report, however, coastal tourism is significant in both volume of visitors and visitor expenditures. California Department of Transportation's (CalTrans) traffic census estimates that, in a peak travel month, 5,800 vehicles pass through the intersection of Route 1 and Bodega Eastshore Rd in Bodega Bay (California Department of Transportation, 2015). Multiplied by 30 days in one month, these statistics imply that 174,000 cars travel these routes in a peak month (e.g., July). Our application of the Bergstrom & Cordell (1991) recreation demand function estimates that close to 60,000 residents visit the coast for sightseeing each year. Comparing the estimates derived from CalTrans and Bergstrom & Cordell suggests that our study has not over-estimated the number of people that see open space, and may in fact under-estimate it. Assuming at least some travelers derive sightseeing value from traveling along these routes, our resident-focused recreation analysis could be interpreted as a lower-bound on the total benefits of preserving open space visible from popular driving routes.
- Our percent-based scaling of total benefits implicitly assumes that both the number of trips and the value per trip depend on the amount of open space visible from tourist routes. We used this modeling assumption because available data and studies did not allow separate estimates of changes in visitation and WTP due to changes in open space availability and quality (e.g., undeveloped scenery, solitude, a sense of remoteness). For example, estimating the change in value per trip would have needed two additional inputs: existing studies of the effects of open space characteristics (e.g., percent of developed area) on WTP for sightseeing , and estimates of how these site features would have changed in the District's parcels had they not been protected. If either trips or WTP per trip do not, in reality, depend on the amount of visible undeveloped open space, our approach may over-state the incremental value of land preservation.
- The use of benefit transfer. We selected from the available literature studies of recreation demand and WTP per trip that match the site features and policy context of this study, such as open space characteristics, size, and geographic region. We selected values of WTP per trip from studies of California residents (matches this study's target population), and recreation demand from a national model that included sites in the San Francisco Bay area (matches this study's geography, relative to the entire nation). While widely accepted, benefit transfers are always subject to the inherent uncertainty in applying models developed for one site and purpose, to a different site and purpose. Transferring values across sites introduces an unknown amount of error in resulting estimates.

5.2 Next Steps and Future Work

5.2.1 Agricultural and Food Products

While our study qualitatively shows the benefits of preserving active agriculture parcels, future studies could potentially monetize the regional economic benefits of preservation. Should detailed data become available, it may be possible to show either the baseline value of coastal agriculture or the incremental benefits from establishing long-term protection of these lands to farm employment; the commodity value of local agricultural and food products (e.g., artisan cheese from grazing agriculture), the fiscal impacts of participation in the farmland preservation program (e.g., how participants use easement payments), and the economic impact of agricultural tourism on the local economy.

5.2.2 Recreational Use Values

Our study estimates a substantial potential for coastal open space views to attract local residents for sightseeing trips along the Sonoma coast. However, data did not exist to estimate visitation by out-of-county residents. We recommend additional research to identify the extent to which visitors to coastal open space come from out-of-county destinations, the types of activities that visitors most often participate in when visiting open space, and other more detailed metrics. These data would support a more complete picture of the cultural and recreational benefits from a large open space preservation network.

For example, we could conduct a study of recreational use and collect visitation data. Ideally, we would want to conduct a stated preference study to assess total nonmarket value of open space and identify specific characteristics important to the county residents. The study could be done for several counties at the same time to spread out cost. The study would also allow HLHE partners to each collect data on recreational uses from their County's residents.

5.2.3 Water Quality and Supply

A variety of methods are available to demonstrate the relationships between watershed health, ecological outcomes, and economic well-being. Options range from qualitative examples to advanced analytic models. In this study, we qualitatively described water quality and hydrological effects of open space preservation (see Section 4.6.2 for detail). We will continue working with District and partner organizations to identify and apply a suitable method. Supporting Material summarizes work to date identifying models and potential case studies.

5.2.4 Threatened and Endangered Species

In this study, we qualitatively described the benefits of open space preservation for three species: coho salmon, northern spotted owl, and marbled murrelet. We recommend conducting more specific quantitative analyses for the counterfactual scenarios used for the quantitative economic analysis. This analysis could also be expanded to additional threatened and endangered species in Sonoma County that could benefit from open space preservation.

6. Appendix: Supplementary Material

This section provides additional details on Abt Associates' technical approach.

6.1 Detailed Data for District's Protected Parcels

Please see tables attached in Supporting Electronic Materials.

6.2 Technical Details for Carbon Sequestration Analysis

Table 18 summarizes sources of parcel-level data compiled to estimate carbon sequestration at District parcels.

Table 18. Key Data Sources and Variables Compiled for Each Parcel.

Data Need	Variable	Result
NLCD	IS	Percentage impervious surface with the parcel.
	Tree Canopy	Percentage tree canopy within in the parcel
CALVEG[A]	REGIONAL_DOMINANCE_TYPE_1	This field provides a short phrase that lists either the common vegetation name of the dominant vegetation alliance or the land-use category.
	USGS_ANDERSON_1	Level 1 of a land use and land cover classification system used by the United States Geological Survey (USGS) based on the Anderson system(Anderson, Hardy, Roach, & Witmer, 1976).
	PHYSIOGNOMIC_ORDER	The second level in the NVCS (National Vegetation Classification Standard) classification hierarchy under Physiognomic Division. Orders are generally defined by dominant life form (tree, shrub, herbaceous, or non-vegetated).
NLCD	IS	Percentage impervious surface with the parcel.
	Tree Canopy	Percentage tree canopy within in the parcel
	Land Cover Class	Land use class and value based originally on the (Anderson, et al., 1976)classification system. The classes include water, developed, barren, forest, shrubland, herbaceous, planted/cultivated, and wetlands, each of which has sub-categories denoted by a value code (U.S. Geological Survey, 2015b).

Notes:

A: Additional description of CALVEG layers is available at: http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5365219

6.3 Technical Details for Recreation Analysis

6.3.1 Technical Details of Viewshed and Land Visibility Analysis

SCAPOSD staff used ArcGIS' Visibility tool to determine which points in the coastal study area are visible from major routes known for scenic beauty. This tool spatially analyzes all points on the landscape that are visible in a 360-degree view of defined observation points, given the topography of the landscape. The tool produces a grid map for all points on the landscape, for which each cell value equals the number of observation points that can "see" that particular cell. Quantifying the degree of visibility allows us to determine how much of the most visible lands along the major/scenic roads the District has secured through its actions.

To simulate the context of sightseeing from a car or standing level, SCAPOSD assumed that observation points were 5 feet off the ground. Observation points were placed every 50 feet along Highway 1, Highway 116 (River Road), Coleman Valley Road, and Bodega Highway (total 4,861 observation points). A standard 10-meter USGS DEM was used for terrain. The resulting visibility counts were reclassified into quartiles to arrive at Low, Medium, High, and Very High visibility ranks.

By comparing the visibility ranks of land area within District holdings, we find that portions of 19 District holdings—and a total of nearly 11,000 acres— are visible from scenic corridors in the coastal region. On average, 69 percent of each individual open space parcel is visible from one of the routes (range: 12 percent to 100 percent). These "visible" areas in District lands constitute 25 percent of all land area visible from the highway observation points.

6.3.2 Additional Recreational Value Transfer Sources

In developing the recreational use values benefit transfer (Section 4.4), we first reviewed the general economic literature on WTP to participate in various coastal and water-based types of recreation. We focused our review on California-specific studies, and identified a number of potential value transfer candidates (Table 19). We ultimately did not use the following findings because we wanted to provide a consistent value transfer basis for multiple types of activities. However, for record-keeping and transparency, we present results of our economic literature review here.

Table 19. Recreational Willingness to Pay Estimates from Focused Economic Literature.			
Study	**Original Site**	**Recreational Activity**	**WTP ($/person/day)**
Aiken & la Rouche (2003)	CA	Wildlife Viewing	$48 to $78
Aiken & la Rouche (2003)	CA	Trout Fishing	$64 to $71
Dixon et al. (2012)	Unknown	Beach Access	$2.46 (coastal residents), $6.33 (tourists)
Hall et al. (2002)	CA	Tidepool visit	$6.78*^
King (2001)	CA	Beach visit	$25.78 - $33.72*
Leeworthy and Wiley (1993)	CA	Beach visit	$77.61
Leeworthy et al. (1990)	CA	Beach visit	$1.72 - $8.04
Lew and Larson (2005)	CA	Beach visit	$11.13^
Pendleton (Pendleton, n.d.)	CA	Beach Visit	$10 (low end) $50 (high end) based on a review of CA estimates
Pendleton (Pendleton, n.d.)	CA	Coastal bird watching	$10 (low end) to $100 (high end) based on a revew of national estimates.
Notes: * denotes values per household. ^ denotes value per trip.			

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