HEALTHY LANDS & HEALTHY ECONOMIES:

NATURE'S VALUE IN SANTA CLARA COUNTY

OPEN SPACE AUTHORITY
SANTA CLARA VALLEY

EARTH ECONOMICS

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- Sonoma County Agricultural Preservation and Open Space District

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FOREWORD

"Every economy requires the right balance of built, human, and natural capital."

David Batker, Chief Economist and Executive Director — Earth Economics

"Every farmer knows you should not eat your seed corn, and every banker knows you should not spend your principal. Yet that is exactly what we are doing with and to our natural capital."

Mark Tercek, CEO — The Nature Conservancy

Santa Clara County's conservation agencies and organizations have worked tirelessly over the last 30 years to acquire and steward an impressive amount of open space to balance the explosive growth of Silicon Valley. New (and unprecedented) challenges including water supply shortages, declining agricultural productivity, critical drought conditions, and increased frequency and intensity of flood, storm, and wildfire events now threaten not only the hard-fought environmental gains, but also the hard-earned economic gains of Silicon Valley. These challenges also come at a time when public and private funding for land conservation and stewardship is in decline. Now is the time to increase the pace and scale of conservation, restoration, and stewardship of our lands — and approach conservation projects, partnerships and investment in new and innovative ways.

The ***Healthy Lands & Healthy Economies*** Initiative is the first-ever comprehensive economic valuation of natural capital and ecosystem services completed in the San Francisco Bay Area and represents the kind of out-of-the-box thinking needed to address our most pressing challenges. It is a multi-county initiative that includes Santa Clara, Sonoma, and Santa Cruz Counties and is funded by generous grants from the Gordon and Betty Moore Foundation, S.D. Bechtel, Jr. Foundation, and the State Coastal Conservancy. The focus of this landmark effort is to determine the economic value of protecting and stewarding natural capital. While many past studies have established the economic benefit of parks, preserves, and scenic lands to tourism, public health, increased property values, business location, and quality of life, more recent efforts go well beyond this. The ***Healthy Lands & Healthy Economies*** Initiative directly links open space conservation and stewardship to the economic benefits of safeguarding local water supplies, protecting water quality, reducing the risk of fire and flood, maintaining the viability of local food systems, and increasing the resiliency of urban communities to the effects of population growth and climate change.

Taking the long view, the sustainability of Santa Clara County and the San Francisco Bay Region will increasingly depend on integrating our planning decisions, collaborating across sectors, developing new conservation tools and incentives, and implementing new metrics that measure our region's economic health by the condition of our natural capital.

If Silicon Valley is to remain a center for innovation in the fastest-growing region in the state, it must support investment in emerging technologies as well as its natural capital. ***Nature's Value in Santa Clara County***, a product of the ***Healthy Lands & Healthy Economies*** Initiative, is designed to increase understanding of the importance of natural capital amongst the region's decision-makers, elected officials, business community, and citizens. We intend that the framework provided in this report be freely shared with and replicated in other counties to advance the application of natural capital valuation. Ultimately, our hope is that this important new effort positions Santa Clara County as a leader in creating a sustainable and resilient San Francisco Bay Region and in protecting and stewarding natural capital upon which future generations will depend.

Andrea Mackenzie
General Manager
Santa Clara Valley Open Space Authority

EXECUTIVE SUMMARY

Santa Clara County is one of the nation's most economically productive communities. The health of the economy — and of every resident and business — is inextricably linked with the natural landscapes where we work and live. Open space provides goods and services like clean water and air, food, storm and flood protection, raw materials, energy, recreation, and much more. This natural capital — the open space that supports these goods and services — is one of our greatest assets.

Historically, these ecosystem services have not been valued in economic analyses, leading to a misconception of their fundamental role in our economy. Quantifying the value of our natural capital and the ecosystem services it provides allows this value to be included in economic tools that enable us to make wiser public and private investments. **Understanding the connection between healthy lands, communities, and economies is essential to a thriving Santa Clara County.**

Healthy Lands & Healthy Economies: Demonstrating the Economic Value of Natural Areas and Working Landscapes is a regional collaboration intended 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. This report, Nature's Value in Santa Clara County, is one of the products of the initiative. This study is the first-ever comprehensive valuation of Santa Clara County's natural capital and ecosystem services. Using new techniques for calculating value and rates of return on investment in natural capital, this report shows that **open space provides significant goods and services offering an extraordinary return on investment.**

***Healthy Lands & Healthy Economies* has estimated that Santa Clara County's natural capital provides at least $1.6 billion to $3.9 billion in benefits to people and the local economy every year.** This estimate was calculated using federally-accepted Benefit Transfer Methodology with inputs from 85 primary studies that valued ecosystem services, based on market pricing, cost avoidance, replacement cost, travel cost, hedonic values, and contingent valuation. These primary studies monetized things like the relationship between proximity to open space and increased property values, people's willingness to pay for outdoor recreation, and the value of water quality improvements provided by wetlands.

If we take a conservative approach and consider natural capital as a short-lived economic asset — something that depreciates over time, like built capital such as roads and bridges — **Santa Clara County's minimum natural capital asset value is between $45 billion to $107 billion.** However, unlike built capital, our open space, forests, wetlands, and aquifers are largely self-sustaining, renewable, and long-lived, and the value of the water, food, and flood protection they provide into the future will likely increase. Recognizing the long lifespan of natural assets, and using a zero discount rate over a 100-year period, **Santa Clara County's natural capital asset value is as high as $386 billion.**

This is a growing field, and datasets are incomplete. For example, the value of groundwater recharge services provided by uplands has yet to be valued in peer reviewed literature, leaving this critical service — and others like it — unrepresented in the current estimates. As such, the range of values calculated reflects a conservative estimate that leaves many critical services either undervalued or not valued at all. The estimated total value of ecosystem services in Santa Clara County will almost certainly increase as more studies are conducted and peer reviewed.

Healthy Lands & Healthy Economies also conducted a return on investment analysis (ROI) to assess the value of the ecosystem services on protected lands. As a local example, the Open Space Authority examined the costs and benefits of protecting the 352-acre Coyote Valley Open Space Preserve. Calculation of the ecosystem services benefits that flow from this protected land over time shows that **after only five years, the Coyote Valley Open Space Preserve returns more than $3 in benefits for every $1 invested**, with accelerating returns as time passes. Investing in natural capital often provides high returns, reduces risk, and provides multiple benefits to residents, businesses, and agencies.

Establishing new funding mechanisms and income streams that reward productive investment in protection and stewardship of our dwindling natural capital assets in Santa Clara County is critically important to our continued economic vitality.

The results of this study support the following conclusions, along with specific recommendations for local, state, and federal decision-makers as well as public and private investors.

- Santa Clara County's landscape of natural capital assets and the associated ecosystem services are highly valuable and provide the foundation for our economy.
- Natural assets provide vast value to the health and well-being of our communities.
- Investment in these natural capital assets provides a high rate of return to all.
- Greater investment in open space and its natural capital assets is required to ensure the continued prosperity and a high quality of life for the people of Santa Clara County.

General Recommendations:

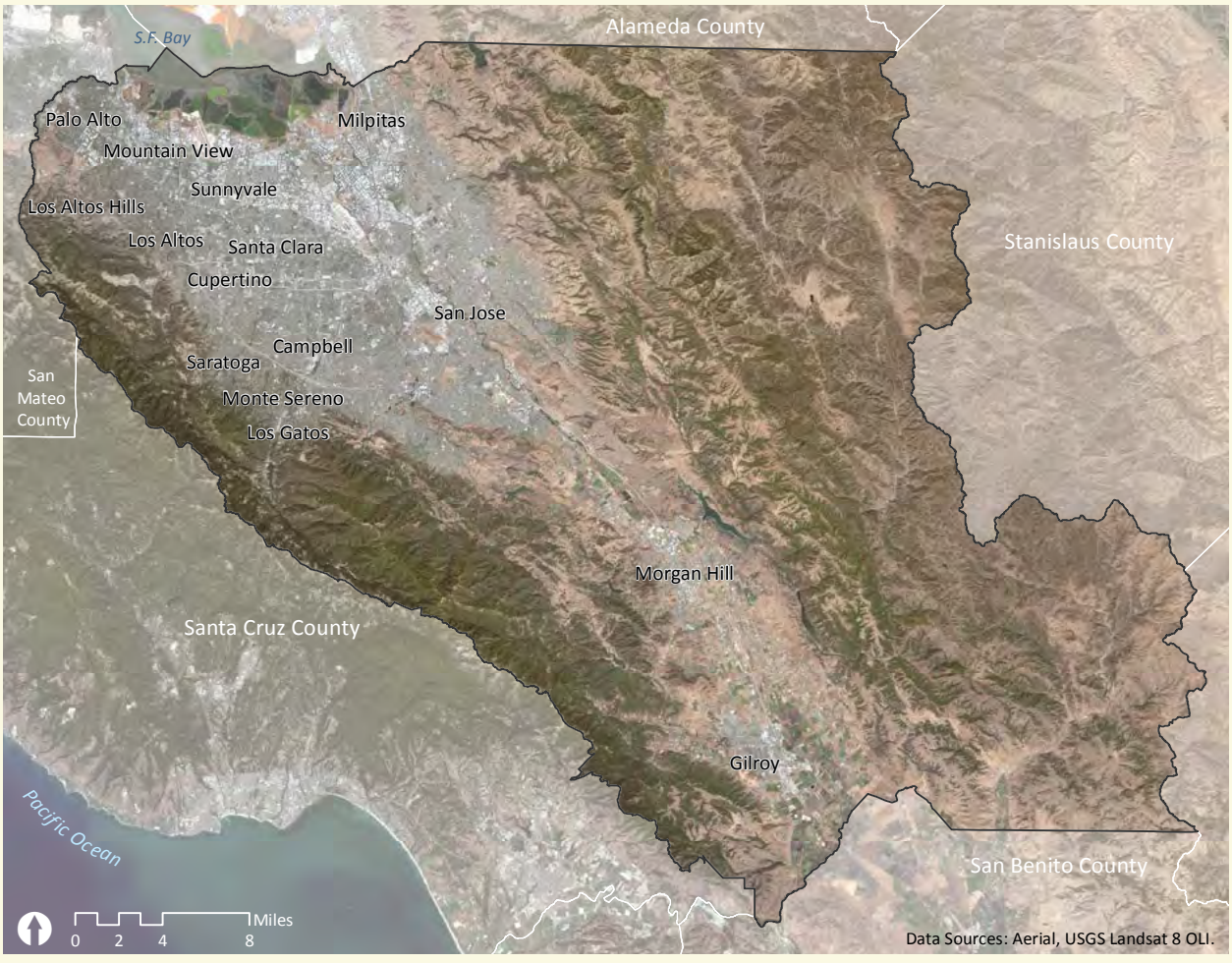
1. Account for ecosystem service benefits as a part of land use and capital improvements in decision-making.
2. Develop and coordinate use of spatial decision support tools and other models that optimize investment in natural capital and maximize return on investment to the public.
3. Allocate existing funding and future revenues from bonds, AB 32, transportation funds (SB 375), and other mechanisms to incentivize natural infrastructure solutions.
4. Develop new sustainable funding sources for market-based pilot projects and legislation that incentivize stewardship of natural capital assets on public and private lands.

By investing in Santa Clara County's natural capital and the goods and services it provides, we can support clean air, clean water, vibrant agriculture and industry, and a strong economy for present and future generations.

Landscapes: Supporting Our Economies

All economies operate within landscapes. Every barn, building, and business in Santa Clara County resides in the valleys and hills of our landscape. If the landscape is healthy, economies can thrive. If the landscape is degraded, economies can falter. For example, from the late 1800s to the 1960s, a vast amount of groundwater was pumped out of the Santa Clara Valley aquifer, reducing water supply reliability and causing land to subside. Building foundations cracked, roads buckled, pipes broke, and new areas became subject to flooding. Parts of the County sank below sea level, including almost 11,000 acres at the southern end of San Francisco Bay. The Santa Clara Valley Water District (SCVWD) took steps over several decades to halt subsidence by recharging the aquifer, and by the 1970s had reversed this trend through conservation, artificial and natural groundwater recharge, monitoring, and stewardship.

Faced in 2014 with a severe drought, Santa Clara County will receive just 5% of its water allocation from the California State Water Project (California Department of Water Resources, 2014). Fortunately, investments in the Santa Clara Valley aquifer have ensured that it has enough water to supply the County for at least a year, providing the economy with temporary drought resilience despite water supply shortages (Rogers, 2014). Investment in natural capital — the aquifer and its recharge areas — was essential for economic development in the past, and continues to provide a foundation for the economic development and resiliency of Santa Clara County today and into the future.



The productivity of Santa Clara County, centered on the broad valley bordered by the Santa Cruz Mountains on the west and the Diablo Range to the east, depends on the natural resources of this landscape. *Open Space Authority map based on USGS Landsat Imagery.*

The Healthy Lands & Healthy Economies Initiative

In 2012, the ***Healthy Lands & Healthy Economies: Demonstrating the Economic Value of Natural Areas and Working Landscapes*** Initiative (***Healthy Lands & Healthy Economies***) was initiated as the first-ever economic valuation of natural capital in three counties in California: Santa Clara, Santa Cruz, and Sonoma. Led by the Santa Clara Valley Open Space Authority, the Resource Conservation District of Santa Cruz County, and the Sonoma County Agricultural Preservation and Open Space District, the Initiative partnered with ***Alnus*** Ecological and Earth Economics to identify and value the natural capital of the three counties.

Healthy Lands & Healthy Economies began with the following questions:

1. What goods and services are provided by natural areas and working lands, and who are the beneficiaries?
2. What is the economic value provided by these services to the local communities, region, and state? What is the return on investment of conservation projects?
3. What are the roadblocks to developing cost-effective and multi-benefit conservation actions in the project areas and beyond? What solutions are possible?
4. What are innovative, sound financing mechanisms for conservation of natural areas and working landscapes?

Healthy Lands & Healthy Economies is a starting point for answering these questions. It aligns with state, regional, and local efforts currently underway to more effectively measure, manage, or finance natural capital. These efforts include Integrated Regional Water Management (IRWM), the California Global Warming Solutions Act (AB32), the Sustainable Communities and Climate Protection Act (SB375), the California Water Plan, the Natural Capital Project, the Santa Clara Valley Open Space Authority's ***Santa Clara Valley Greenprint***, the Santa Clara Valley Water District's water supply planning efforts, the ***Santa Clara County General Plan***, and The Nature Conservancy's California Program.

Over decades, groundwater extraction from the Santa Clara Valley aquifer caused land to subside. The top photo shows the South Bay Yacht Club in Alviso sitting near sea level; in the 1978 photo below, the Club sits about 10' below sea level, with a high levee protecting the Bay from flooding Alviso. *Credit: Courtesy SCVWD.*

Healthy Lands & Healthy Economies describes the economic value and community benefits of open space lands. This study calculates the value of natural capital in Santa Clara County, and uses the Authority's Coyote Valley Open Space Preserve as a local example to calculate the value of ecosystem services and the return on conservation investment.

Beyond this valuation study, ***Healthy Lands & Healthy Economies*** is developing methods for valuing aquifers and the lands that recharge them in both Santa Clara and Santa Cruz Counties. When complete, these studies will

Riparian corridors, upper watersheds, and other open space are critical for recharging aquifers and reservoirs, providing clean water for the County; future studies will seek to calculate the economic value of this service. *Credit: Cait Hutnik.*

be the world's first valuations of groundwater recharge as an ecosystem service and aquifers as capital assets, filling a clear gap in the current economic literature and paving the way for similar valuation work across the United States and beyond. These studies will create a framework for natural capital economic analysis at the asset, project, and county scales. This framework could easily be applied at the state and national scales.

Nature's Value in Santa Clara County: How to Use This Study

TThis report describes Santa Clara County's natural capital assets, the goods and services they provide, and the value of those goods and services. It provides the first-ever county-wide analysis of Santa Clara County's natural capital, including identification of ecosystem services, valuation of individual ecosystem services, valuation of bundled ecosystem services by land cover type, and estimation of the asset value of the natural systems in the County. The conceptual framework described here, including definitions of natural capital and the estimation of economic value, can be used in many practical applications, including:

Assessing economic impacts of disasters through Benefit-Cost Analysis (BCA) for mitigation funding

Following a flood disaster, California, Santa Clara County, and city officials can use the ecosystem service values provided in this study in place of the general (and lower) BCA values found in the FEMA BCA disaster mitigation toolkit in order to secure post-disaster flood mitigation funding (see Box 1 in Chapter 2).

Considering ecosystem service values in assessments of proposed projects and policies

These values can be used in both CEQA (The California Environmental Quality Act) Environmental Impact Reports and NEPA (National Environmental Policy Act) Environmental Impact Statements to more accurately reflect the environmental and economic costs and benefits of proposed projects and policies.

Estimating economic rates of return for conservation projects

The spatial data, economic values, and methods described in this report can be used to estimate a rate of return on conservation investments such easements and open space acquisitions.

Scaling investments in natural capital to the size of the asset

Understanding the scale of natural capital asset value in Santa Clara County, combined with an understanding of the potential return on natural capital investment, can be used to inform future investments and determine the appropriate scale of investments in conservation.

Encouraging investment in natural capital

The information in this report can incentivize and enable private and public investment in natural capital. For example, this report can be used to show how payments for ecosystem services or investment in natural assets (including those by the Santa Clara Valley Open Space Authority and other public agencies) can support jobs, conserve biodiversity, build resiliency, and provide high returns on that investment.

Protection of wetlands such as those at Alviso Marina County Park provides flood protection to surrounding communities. *Credit: cc Wanderenvy.*

CHAPTER 2: A Primer on Natural Capital: Ecosystem Goods and Services

What is Natural Capital?

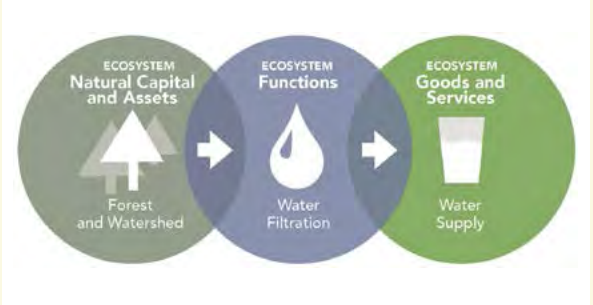
Economies depend upon built, natural, and human capital. Built capital consists of cars, houses, machinery, software, and the "tangible systems that humans design, build and use for productive purposes." (Daly and Farley, 2004) All built capital is created from natural capital. It is composed of energy and materials from nature. Natural capital consists of the "minerals, energy, plants, animals, ecosystems, [climatic processes, nutrient cycles and other natural structures and systems] found on Earth that provide a flow of natural goods and services." (Daly and Farley, 2004). Human capital consists of people, their education, health, skills, labor, knowledge, and talents.[1]

Natural capital provides a flow of goods and services, like other forms of capital. **These ecosystem goods and services are defined as the benefits people derive from nature.** The ecosystems' natural capital and assets (e.g., forests and watersheds) perform natural functions (such as intercepting rainfall and filtering water) and provide goods and services that humans need to survive (e.g., a clean water supply and reduction of peak flood flows downstream).

Breathable air, drinkable water, nourishing food, flood risk reduction, waste treatment, and stable atmospheric conditions are all examples of ecosystem goods and services that we often take for granted. Natural capital performs critical functions producing goods and services. Without the natural capital, we would not have the benefit of its service. Ecosystem services are the basis of all economic activity. Figure 1 illustrates the relationship between natural capital and the production of ecosystem services.

The valley's economy — including Apple Computer — depends on built, natural, and human capital. *Credit: cc Joe Ravi.*

FIGURE 1: The Link between Natural Capital and Functions and the Provision of Ecosystem Goods and Services



A Framework for Assessing Ecosystem Services

In 2001, an international coalition of over 1,360 scientists and experts from the United Nations Environmental Program, the World Bank, and the World Resources Institute initiated an assessment of the effects of ecosystem change on human well-being. A key goal of the assessment was to develop a better understanding of the interactions between ecological and social systems, and in turn develop a knowledge base of concepts and methods that would improve our ability to "…assess options that can enhance the contribution of ecosystems to human well-being." (UNEP, 2005) This study produced the landmark Millennium Ecosystem Assessment, which classifies ecosystem services into four broad categories according to how they benefit humans.

[1] This report does not discuss the importance of human capital. However, people's health and well-being, as well as their work and enjoyment, are closely tied to the built and natural capital around them and are deeply intertwined with economic prosperity.

Ecosystem services, which are broadly defined in Table 1, can be categorized as follows:

- **Provisioning services** provide physical materials that society uses. Forests provide lumber. Agricultural lands grow food. Rivers provide drinking water as well as fish for food.
- **Regulating services** are benefits obtained from the natural control of ecosystem processes. Intact ecosystems provide regulation of climate, water quality and delivery, and soil erosion or accumulation, and they keep disease organisms in check. Degraded systems propagate disease organisms, to the detriment of human health.
- **Supporting services** include primary productivity (natural plant growth) and nutrient cycling (nitrogen, phosphorus, and carbon cycles). These services are the basis of the vast majority of food webs and life on the planet.
- **Cultural services** are functions that allow humans to interact meaningfully with nature. These services include providing spiritually significant species and natural areas, natural places for recreation, and opportunities for scientific research and education.

TABLE 1: Ecosystem Goods and Services

GOOD/SERVICE	Economic Benefit to People
PROVISIONING SERVICES	
Food	Producing crops, fish, game, and fruits
Medicinal Resources	Providing traditional medicines, pharmaceuticals, and assay organisms
Ornamental Resources	Providing resources for clothing, jewelry, handicraft, worship, and decoration
Energy and Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy
Water Supply	Provisioning of surface and groundwater for drinking water, irrigation, and industrial use
REGULATING SERVICES	
Biological Control	Providing pest and disease control
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes
Air Quality	Providing clean, breathable air
Moderation of Extreme Events	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts
Pollination	Pollination of wild and domestic plant species
Soil Formation	Creating soils for agricultural and ecosystems integrity; maintenance of soil fertility
Soil Retention	Retaining arable land, slope stability, and coastal integrity
Waste Treatment	Improving soil, water, and air quality by decomposing human and animal waste and removing pollutants
Water Regulation	Providing natural irrigation, drainage, groundwater recharge, river flows, and navigation
SUPPORTING SERVICES	
Habitat and Nursery	Maintaining genetic and biological diversity, the basis for most other ecosystem functions; promoting growth of commercially harvested species
Genetic Resources	Improving crop and livestock resistance to pathogens and pests
CULTURAL SERVICES	
Natural Beauty	Enjoying and appreciating the presence, scenery, sounds, and smells of nature
Cultural and Artistic Inspiration	Using nature as motifs in art, film, folklore, books, cultural symbols, architecture, and media
Recreation and Tourism	Experiencing the natural world and enjoying outdoor activities
Science and Education	Using natural systems for education and scientific research
Spiritual and Historical	Using nature for religious and spiritual purposes

Source: Adapted from de Groot et al., 2002 and Sukhdev et al., 2010

The following sections provide more detailed descriptions of several key ecosystem services in Santa Clara County.

Provisioning Services

Food

Providing food is one of the most important functions of an ecosystem. Agricultural lands are our primary source of food; farms are considered modified ecosystems, and food is considered an ecosystem good with inputs from humans and built capital.

Agricultural lands both produce and depend on ecosystem services. Agricultural production depends on healthy soil, pollinators, a consistent water supply, and a stable climate. With these natural inputs, agricultural lands produce food and can also support a suite of other services, including groundwater recharge, carbon sequestration, flood risk reduction, and aesthetic value.

Water Supply

Watersheds provide fresh water for human consumption, agricultural production, and manufacturing. This service includes both surface water and groundwater, which supply metropolitan areas, wells, industrial uses, and irrigation. The hydrological cycle is affected by structural elements of a watershed such as vegetation, soils, and geology, as well as processes such as evapotranspiration (the natural absorption of water into the atmosphere), percolation, and climate variability.

Protected watersheds help store rainwater and runoff, protecting our water supply and quality. *Credit: Derek Neumann.*

The County's prime farmland soils provide healthy, locally-grown food to surrounding communities. *Credit: Derek Neumann.*

Regulating Services

Climate Stability

Ecosystems help to regulate atmospheric chemistry, air quality, and climate. This process is facilitated by the capture and long-term storage of carbon as a part of the global carbon cycle. Forests, woodlands, and grasslands play essential roles in absorbing carbon and contributing oxygen to the atmosphere.

Moderation of Extreme Events

Wetlands, grasslands, riparian buffers, and forests all provide protection from flooding and other disturbances. These ecosystems are able to slow, absorb, and store large amounts of rainwater and runoff during storms. Changes in land use and the potential for more frequent storm events due to climate change make disturbance regulation one of the most important services to economic development. Built structures in the floodplain such as houses, factories, and wastewater treatment plants all depend on the flood protection services provided upstream. The retention of natural, permeable cover and the restoration of floodplains and wetlands contribute to flood risk reduction in these areas. Enhanced flood and storm protection can reduce the devastating effects of floods including property damage, lost work time, and human casualties.

Protection of honeybees and other natural pollinators supports Santa Clara Valley's extensive agricultural productivity. *Credit: cc Nikki Pirch.*

Pollination

Pollination supports wild and cultivated plants and plays a critical role in ecosystem productivity. Many plant species, and the animals that rely on them for food, would go extinct without animal- and insect-mediated pollination. Pollination services contribute to crop productivity for many types of cultivated foods, enhancing the basic efficiency and economic value of agriculture (Nabhan and Buchmann, 1997). The loss of forests, riparian areas, and shrubs reduces habitat and the capacity of wild pollinators to perform this service.

Cultural Services

Recreation and Tourism

Attractive landscapes, clean water, and fish and wildlife populations form the basis of the recreation economy, which in the United States supports 6.1 million jobs and generates $646 billion in direct spending each year (Outdoor Foundation and Outdoor Industry Association, 2012). Tourism and recreation are often tied to aesthetic values of open space and natural areas. Recreational fishing, swimming, bird watching, and hunting are all activities that can be enhanced by ecosystem services. Ecosystem goods like wildlife and clean water attract people to engage in recreational activities and can also increase property values and attractiveness for business (Crompton et al., 1997).

The Importance of Valuing Ecosystem Services and Accounting for Natural Capital

Understanding and accounting for the value of natural capital assets and the ecosystem services they provide can reveal the economic benefits of investment in natural capital. In 1930, the United States lacked measures of Gross Domestic Product (GDP), unemployment, inflation, consumer spending, or money supply. Benefit-cost analysis and rate of return calculations were initiated after the 1930s to examine and compare investments in built capital assets such as roads, power plants, factories, and dams. Decision-makers were blind without these basic economic measures, which are now taken for granted and help guide investment at an astounding scale in today's economy.

The benefits of ecosystem goods and services are similar to the economic benefits typically valued in the economy, such as the services and outputs of skilled

Public recreation on protected open space provides value for local property owners and businesses. *Credit: Ron Erskine.*

workers, buildings and infrastructure. Many ecosystem goods, such as salmon, strawberries, and water, are already valued and sold in markets. However, some ecosystem services, such as flood protection and climate stability, are not amenable to markets and have not been traditionally valued, even though they provide vast economic value. For example, when the flood protection services of a watershed are lost, economic damages include job losses, infrastructure repairs, reconstruction and restoration costs, and property damage and death. Conversely, when investments are made to protect and support these services, local economies are more stable and less prone to the sudden need for burdensome expenditures on disaster mitigation efforts. In addition to the economic value associated with these avoided costs, healthy watersheds provide myriad other services including water supply, carbon sequestration, water filtration, and biodiversity. All of these services provide economic value regionally and beyond.

Today, economic methods are available to value natural capital and many non-market ecosystem services (see Chapter 4 for more detail). When valued in dollars, these services can be incorporated into a number of economic tools including benefit-cost analysis, accounting, environmental impact statements, asset management plans, and return on investment calculations. This strengthens decision-making. When natural capital assets and ecosystem services are not considered in economic analysis, they are effectively valued as zero, which can lead to inefficient capital investments, higher incurred costs, and poor decisions. Many conservation investments provide high rates of return. Demonstrating the potential for high returns on conservation investments can lead to more efficient capital investments and reduce incurred costs.

Agricultural lands and other open space provide a suite of ecosystem services, the value of which is significant to our economy. *Credit: Jordon Plotsky.*

Federal disaster assistance for the 2013 Rim Fire in California's Stanislaus National Forest was approved after the inclusion of a valuation for the natural capital destroyed by the fire. *Credit cc Mike McMillan, US Forest Service.*

Policy Applications of Ecosystem Services

The inclusion of natural capital valuations is quickly becoming more common and accepted in addressing significant and complex policy issues. Earth Economics conducted an economic assessment of the damages to natural capital caused by California's third largest fire, the 2013 Rim Fire (Batker et al., 2013). After FEMA initially rejected California's application for Major Disaster Declaration, Governor Jerry Brown included the analysis of impacts to natural capital and ecosystem services that showed significantly greater damage as part of an appeal package sent to FEMA and President Obama for a Major Disaster Declaration on the Rim Fire. The appeal was granted, providing significant federal disaster assistance to Tuolumne County, San Francisco Public Utilities Commission (SFPUC), the State of California, and affected business and citizens. Alison Anja Kastama, a spokeswoman for the SFPUC, noted that the inclusion of a natural capital valuation report in Governor Brown's appeal package "supports the recognition of natural capital values…by assessing the impacts of the Rim Fire, this report highlights the greater dollar value we can assign to our natural lands, which are a critical portion of our water system." (Stevens, 2013).

The value of natural capital will be increasingly reflected on the official balance sheets of water agencies and private companies. The SFPUC took the first step toward accounting for its natural capital by discussing the value of its watersheds in the Transmittal Letter of its FY2012–2013 Comprehensive Annual Financial Report. Other utilities can also take this step immediately.

Advancements in bond disclosures regarding natural capital provide information on risk and resiliency to bond purchasers. This may lower interest rates for many government, utility, and private bonds where natural capital is healthy, and raise rates where natural capital is degraded and risk is greater.

The private sector and public agencies are formally recognizing the critical importance of including ecosystem service concepts and valuation in planning, management, and decision-making.

- The United States Federal Emergency Management Agency (FEMA) became the first federal agency to adopt ecosystem service valuation in formal policy. Faced with rising natural disaster costs and climate uncertainty, FEMA approved Mitigation Policy FP-108-024-01 in June of 2013, (FEMA, 2013) which allows the inclusion of ecosystem services in benefit-cost analysis for acquisition projects. This policy is being applied for all flood and hurricane disaster mitigation in all 50 states, for all private residential, business, public utility, city, county, and state impacted infrastructure. Under this policy, FEMA applies ecosystem service values nationwide. See Box 1 for more details on FEMA and ecosystem service valuation.
- The State of California has also been a leader in the recognition and valuation of ecosystem services. In 2008, the California Department of Water Resources published an Economic Analysis Guidebook, which included an entire chapter on ecosystem service valuation, including valuation methods and monetization strategies (Cowdin, 2008). This study supports the efforts of agencies like the Department of Water Resources by providing federally accepted methods for valuing ecosystem services, as well as appropriate values, that local agencies in Santa Clara County and the Bay Area can use to inform analysis or justification of projects that protect natural capital.

- Public agencies in the United States are exploring methods to incorporate natural capital assets into their traditional accounting systems. A coalition of water utilities, including the San Francisco Public Utilities Commission, has been working to reach out to the Government Accounting Standards Board[2] and demonstrate the need for natural capital accounting standards, especially for water utilities, whose business model depends on healthy watersheds. Currently natural capital only shows up for bare land or timber value. The SFPUC noted in its most recent Comprehensive Annual Financial Report that "Current financial accounting standards, relying solely on historical costs, do not take into sufficient consideration the value of the watersheds and natural resources that are part of our regional water system." (City and County of San Francisco, 2013) The SFPUC further notes that of $5 billion in total assets, arguably their most important asset — the watershed that filters and delivers water for 2.5 million people — is reflected on their books for only $28 million.
- The private sector has also started to utilize ecosystem services to better understand the environmental impacts of corporate decisions. The sportswear company PUMA was the first private company to include environmental and ecosystem service impacts in its Environmental Profit and Loss Account, released in 2011 (PUMA, 2011).

[2] The Government Accounting Standards Board (GASB) sets accounting standards for state and local government in the US, including state agencies, counties, municipal water utilities, public utility districts, and universities.

BOX 1: Reducing Harm, Saving Lives, and Saving Taxpayer Money: Valuing Ecosystem Services in Federal Benefit-Cost Analysis

Like other federal agencies, FEMA uses benefit-cost analysis (BCA) to determine where to invest its resources for the greatest benefits relative to taxpayer cost. FEMA's BCA Toolkit is a software package used to measuring the cost effectiveness of disaster recovery projects eligible for funding through the agency's hazard mitigation program (like helping home and business owners rebuild). However, the previous FEMA BCA Toolkit did not value floodplain lands (subject to buyout) for their flood risk reduction value. Such floodplain lands reduce flood risk on other properties by storing and/or better conveying floodwaters. These lands also protect water quality, reduce sedimentation, provide recreation, and secure other economic benefits. The reality of larger and more frequent floods and hurricanes, with historically low flood insurance rates, has contributed to rebuilding in disaster-prone areas. As a result of recurring flood and hurricane damage payments, the National Flood Insurance Program has accumulated $24 billion of debt (Department of Homeland Security, 2013). FEMA has moved aggressively to correct these problems and lower costs by working to reduce and eliminate repetitive flood and hurricane damage that result in increased public and private costs.

In 2012, Earth Economics provided FEMA with 17 ecosystem service values for inclusion in the updated FEMA BCA Tool. An expert panel reviewed the values, along with FEMA staff and management. The values were tested on past flood applications and were found to improve decision-making, reduce repetitive damage, protect human life, and lower disaster expenditures. By valuing flood protection benefits of restored floodplains, for example, FEMA has the economic tools to better spend mitigation funds to relocate, rather than rebuild, structures in areas that experience frequent flood or hurricane damage. These values were approved for use beginning in 2013. Realizing the potential savings to taxpayers, homeowners, and businesses, FEMA also adopted these values for the FEMA mitigation portion of $59 billion of mitigation and recovery funds allocated for Hurricane Sandy.

In the event of a flood disaster in Santa Clara County, the values from this report can be used in the FEMA BCA tool in place of the general BCA values.

CHAPTER 3: Natural Capital in Santa Clara County

Santa Clara County: Open Spaces and Innovative Technologies

It was the beauty, productivity, and opportunity provided by the land that brought the first native peoples to inhabit what is now Santa Clara County. The County is home to Silicon Valley, world-renowned as a key driver of success and economic recovery in the region and the United States, providing over a quarter of the jobs in the nine-county Bay Area (Santa Clara County, 2012a). Silicon Valley is a center of global innovation and has given birth to some of the world's most successful technology companies, including Apple, Facebook, Cisco, Google, eBay, Yahoo, and many other global technology leaders. Set on the southern end of San Francisco Bay (see Figure 2), the County is bordered by the Diablo Range to the east and the Santa Cruz Mountains range to the West, encompassing a range of environments including wetlands, fertile valley floors, rolling hills, and remote mountain ranges.

After decades of focused investment, public agencies and nonprofits have protected approximately 229,800 acres of open space — about 27.7% of the County — through land acquisition and conservation easements to date (Greenbelt Alliance, 2012). It is no surprise that with the complements of natural and built capital, innovation, and opportunity, the County's population is

FIGURE 2: Location of Santa Clara County

The stunning natural setting of Santa Clara County includes a productive valley at the base of the Diablo Range. *Credit: cc Dirk dB.*

Santa Clara County's population is predicted to increase 36% in the next 20 years, placing tremendous pressure on open space lands and natural resources. *Credit: cc Michael.*

predicted to increase by 36%, from 1.8 to 2.4 million by 2035, making it the fastest growing county in the state (Richman, 2013; Kuczynski and Maslon, 2013). Like much of the San Francisco Bay Area, the County faces exceptional development pressure on its open spaces. Over 63,000 acres of the County have been identified as at risk of development over the next thirty years (Greenbelt Alliance, 2012). Understanding the value provided by Santa Clara County's open spaces will be critically important as the County chooses how to accommodate a growing population and protect these natural capital assets.

The Importance of Open Space for Santa Clara County's Health and Well-being

The region's public parks, preserves, and streamside trails are some of the many open spaces that are essential to Santa Clara County's health and social well-being. Open space within and surrounding towns and cities provides lasting physical and mental health benefits to residents. Researchers have found that when compared to walks in urban areas, leisurely forest walks lead to a 12.4% decrease in the stress hormone cortisol (Williams, 2012). This is supported further by research that indicates that people who have increased exposure to green spaces have long-term mental health improvements (Alcock et al., 2013).

Increased access to open spaces and parks encourage people to exercise more, reducing overall health care expenditure in the region (Gies, 2006). A recent report published by Santa Clara County stated: "Health conditions and health care costs directly impact the County's economic and fiscal stability. In fact, in the 2012 fiscal year, the Santa Clara Valley Health and Hospital System accounted for 44% of the County's entire budget." (Santa Clara County, 2013) It has been estimated that the economic costs in Santa Clara County associated with citizens being overweight or having low levels of physical activity are over $2 billion (California Center For Public Health Advocacy, 2009). The Trust for Public Land published a report that showed the "creation of or enhanced access to places for physical activity combined with informational outreach produced a 48.4% increase in the frequency of physical activity." (Gies, 2006) These behavioral changes not only help reduce obesity and health care costs, but also help improve quality of life (Godbey and Mowen, 2010).

On average, Santa Clara County supports a high amount of public open space relative to its population, when you consider the contribution of state, county, and regional open space acquisitions (Santa Clara County, 2013). However, some cities in the County provide considerably less public open space relative to their population, underscoring the critical importance of open space within and surrounding these areas (see Figure 3). A study of business locational decisions found that access to parks and other open spaces were significantly more important to company location and relocation than a region's economic development goals. Small companies in particular rated these factors first among quality of life decision-making factors for company location (Crompton et al., 1997).

Public open space, like the Ulistac Natural Area (above) in the City of Santa Clara, can support multiple uses that provide lasting mental and physical health benefits to surrounding communities. See Table 3 for park availability by jurisdiction. *Credit: Dennis Dowling.*

Santa Clara County's open space includes the productive farms and rangelands that drive the agricultural economy and support community health. In 2012, agricultural lands in Santa Clara County generated nearly $261 million in revenue, with over 16,000 acres of active farmland and more than 222,000 acres of rangelands (Santa Clara County 2012b). The County's fertile farmland produces high-value crops such as nursery crops, cherries, tomatoes, mushrooms, salad greens, beans, apricots, strawberries, walnuts, and wine grapes. Relative to other regions in California, Santa Clara County farms have strong direct sales, enabled by over 40 certified farmer's markets that directly supply fresh local fruits and vegetables to the County's communities.

Dr. Daphne Miller, a family physician affiliated with the University of California, San Francisco, examined the close connection between health of agricultural lands and human health in her book "Farmacology," which illustrates how healthy soil supports the production of nutritious foods and increases their ability to raise consumers' immune health (Brody, 2010; Fleischer, 2010; Miller, 2013). This study illustrates the importance of investing in and protecting regulating services such as soil formation and soil retention and the role these services play in the production of nutritious foods and a healthy population.

The County's fertile soils and ideal climate support productive farmland and ranchlands of great economic value.

FIGURE 3: Parks and Open Space by Jurisdiction

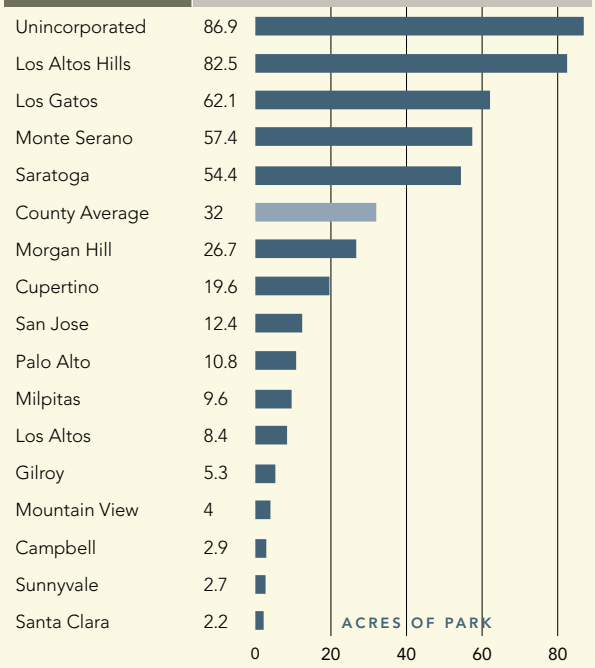


Figure adapted from Santa Clara County, 2013.

Coyote Valley represents a significant resource area in the County with prime farmland soils, open space that provides habitat, wildlife corridors, and groundwater recharge areas. Diversified farmland, open grasslands, and riparian zones, like those found in the Coyote Valley, also provide necessary habitat for wild pollinators. Many of Santa Clara County's most important crops, such as fruit and nursery crops, rely on pollination for production. In 2003, pollinator-dependent crops in the County generated an estimated $24 million in revenue (Chan et al., 2006). The Coyote Valley Agricultural Enterprise and Conservation program plan highlights increased efforts to protect and enhance these farmlands as part of ongoing investments in natural capital (SAGE, 2012).

Open Space's Natural Capital Provides Multiple Benefits

Unlike factories that generally produce a single product, the County's natural capital produces multiple ecosystem goods and services for the public. Protecting the County's open space ensures the continued provision of ecosystem services such as carbon sequestration (see Box 2), flood protection, water quality enhancement, and habitat for wildlife.

BOX 2: The Carbon Sequestration Benefits of Rangelands in Santa Clara County

Using grazing as a resource management tool can enhance the provisioning of soil carbon, water quality, flood protection, erosion prevention, pollination, and fire reduction — all benefits to the larger community (Kroeger et al., 2010). Oak woodlands and grasslands native to northern California contribute to climate regulation by sequestering carbon from the atmosphere. According to the US Forest Service Forest Inventory and Analysis Program and the California Oak Foundation, oak woodlands and oak forests cover 13 million acres in California and store over 325 million metric tons of carbon. California's carbon emissions in 2011 totaled 346 million metric tons (US Energy Information Administration, 2014). In Santa Clara County alone, it is estimated that oak woodlands and forests store over 3.5 million metric tons of carbon, the equivalent of taking 736,000 passenger cars of the road for a year (Gaman, 2008; Gaman and Firman, 2006; US Environmental Protection Agency, 2014). Through continued protection of oaks and improved land management practices such as improved grazing management, California's oak woodlands and forests could sequester over 1 billion metric tons of carbon this century.* Santa Clara County released an Oak Woodlands Management Plan in 2005 to increase awareness about the importance of these landscapes to encourage collaboration and management among nonprofits, private landowners, and government agencies (Santa Clara County Board of Supervisors, 2005).

While there is great variation among the carbon sequestration potential of California's rangelands, studies have indicated that native grasslands may have a much higher carbon uptake potential than non-native species. A 2010 California report found that "…restoration of native grasses — even on a relatively modest scale — can generate substantial total quantities of net carbon uptake." (Kroeger et al., 2010)

* Oak carbon figures, from the California Oak Foundation's "An Inventory of Carbon and California Oaks," include above- and below-ground carbon sequestered in live and dead trees. They do not include litter and duff, down logs or soil-borne carbon.

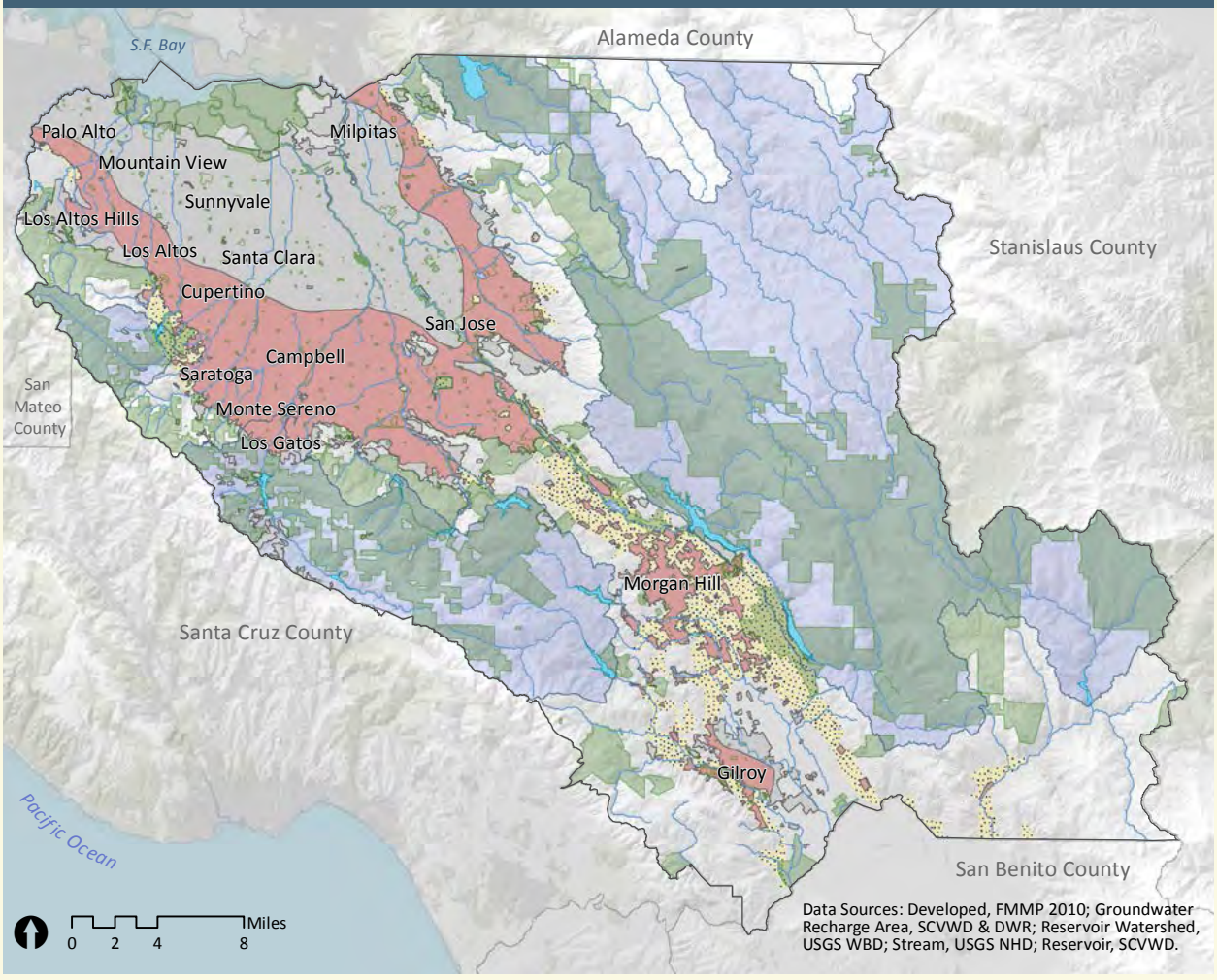
Water captured and provided by our local watersheds continues to play a key role in the baseline water supply for Santa Clara County. These local watersheds and groundwater recharge areas function as increasingly valuable buffers to the economy by helping maintain local water supply reliability for Silicon Valley and the rest of the County (Rogers, 2014). Take for example the Coyote Creek watershed, which covers over 204,800 acres, making it the largest watershed in the County. The almost entirely undeveloped upper reaches of the Coyote Creek watershed encompass some of the County's largest tracts of rangelands, critical habitats for rare, threatened, and endangered species, and public open space. The Santa Clara Valley Water District (SCVWD) depends on the Coyote Creek Watershed to provide water to Coyote and Anderson Reservoirs and to recharge the groundwater aquifer. The prime farmlands of Coyote Valley, located just downstream of Anderson Reservoir, retain large quantities of water during storm events, recharging groundwater aquifers and reducing

The Coyote Creek watershed, the County's largest, provides a range of benefits that protect our water supply. *Credit: cc Joe Navratil.*

flood risk in downstream urban areas such as San Jose. With over 60% of the landscape that once recharged Santa Clara County's aquifers now urbanized, Coyote Valley represents the largest remaining undeveloped recharge area for the groundwater basin that serves Silicon Valley (Santa Clara Valley Open Space Authority, 2014). Figure 4 shows areas of the landscape in Santa Clara County that supply and recharge groundwater. Box 3 describes a vision for integrated landscape management in the Coyote Valley that supports the county's water supply needs, as well as multiple other ecosystem services such as food production and stormwater conveyance.

Well-managed rangelands help regulate climate by storing carbon.

FIGURE 4: Groundwater Recharge Areas in Santa Clara County



Undeveloped portions of The Upper Pajaro Valley watershed provide important flood protection for downstream areas around the towns of Pajaro and Watsonville. *Credit: William K. Matthias.*

The Upper Pajaro Valley provides another example of highly valuable ecosystem services in the County. The Nature Conservancy, the Army Corps of Engineers, and other partners are demonstrating importance of flood protection services provided by existing open space. According to their report, protection of Upper Pajaro Valley floodplains, like those in Gilroy "... ensures critical flood protection for the lower floodplain, more specifically for the towns of Pajaro, Watsonville and the surrounding strawberry and lettuce farms." (Gennet and Klausmeyer, 2012) In addition, Upper Pajaro Valley's Soap Lake acts to attenuate flooding during large flow events, making it a "very important flood management feature for downstream areas in the Pajaro River watershed." (RMC Water and Environment, 2005) Without these natural flood protection services, it is estimated that flood risk mitigation for the lower Pajaro would increase in cost by $60 million, require 44 acres of land for constructed levees, and call for the modification or retrofit of several bridges. According to the Pajaro River Watershed Study, "the Lower Pajaro Project may not be feasible without the Soap Lake and its attenuation of large peak flows." (RMC Water and Environment, 2005)

The Benefits of Stewardship

Farmers, ranchers, parks departments, conservation organizations, public utilities, and other public and private landowners all manage open space, stewarding the natural capital that retains and produces economic value to the County. Investments in the protection, restoration and management of the County's natural capital can produce enormous returns, while improving the resilience of ecosystems to environmental stresses such variable climatic conditions or sea level rise (Chapin III et al., 2009).

BOX 3: Integrated Landscape Management in the Coyote Valley

Located in southern Santa Clara County, Coyote Valley is a 7,400-acre agricultural region between San Jose and Morgan Hill. The 2013 Conserving Coyote Valley Agriculture Feasibility Study lays out a new vision for an "economically viable and ecologically and culturally valuable agricultural resource area." (SAGE, 2012) The study identified detailed conservation targets, potential funding mechanisms, and implementation strategies to achieve this vision. The plan aims for Coyote Valley agriculture by 2037 to generate $50 million annually, to employ over 1,000 workers, and to meet a "notable portion of the food needs of the South Bay region." The Feasibility Study calls for any future development within the Coyote Valley to be synergistic with sustainable agriculture and resource conservation (Unger and Lyddan, 2011). This would retain at least half of the valley dedicated to agriculture and conservation.

Agricultural viability and economic resources in the Coyote Valley would be supported by additional habitat restoration and water supply projects that would provide additional ecosystem services including improved water supply and quality, groundwater recharge, and stormwater conveyance. Engaging farmers and agencies in a natural resources stewardship program will improve the area's biodiversity and wildlife corridor value, and provide increased cultural, recreational, and educational value through enhanced opportunities for ecotourism and agritourism.

Tidal marshes along the Bay, such as these at Don Edwards San Francisco Bay National Wildlife Refuge, provide flood protection to nearby development, important habitat for migratory birds, and recreational opportunities. *Credit: cc Marcel Marchon.*

The US Geological Survey projected that due to climate change, 95.8% of estuary tidal marshes in San Francisco Bay will be inundated by 2100, resulting in the loss of many of the Bay's tidal marshes (Takekawa et al., 2013). The County's largest area of tidal marshes is found at the Don Edwards San Francisco Bay National Wildlife Refuge. The 19,000-acre Refuge serves a three-county region, including Santa Clara County, providing ecosystem services like critical habitat for migratory birds and other endangered species, ample recreation and educational opportunities, and protection from coastal flooding. The Bay Institute showed that an investment in the stewardship and large-scale restoration of the Bay's tidal marshes would enable the marshes to persist for the next several decades, even with sea level rise, and to reduce flooding in coastal developments. Referred to as "horizontal levees," this approach could be implemented at half the cost of a built levee approach, and would ensure that the Refuge's marshes continue to provide a suite of ecosystem services. Horizontal levees and their role in cost-effective flood risk mitigation are described further in Box 6 (Chapter 6).

Investing in stewarding open space not only reduces and avoids costs associated with built infrastructure, it also increases revenues. Excluding the value of ecosystem services, researchers analyzed the economic benefits of current and proposed management alternatives for the Refuge, and demonstrated that increased management activities at the Refuge would generate a total of 47 jobs, $2.5 million in labor income, and $4.29 million in value added to local economies annually, with the greatest economic benefit to communities nearest to the Refuge (Richardson et al., 2012).

In some cases, stewardship of open space is required to prevent catastrophic damage or hazards from occurring to critical built and natural capital assets. Box 4 describes the relationship between watershed stewardship and storage capacity of the Lexington Reservoir after a major fire.

Open space acquisition, protection, and stewardship are key ways that private citizens, businesses, and governmental agencies can act in concert to conserve the County's natural capital. Wise investments in natural capital helps ensure that all residents, from Google employees to farmers to high school students, have access to a safe, clean, and sustainable water supply, locally grown food, and open space for recreation and industry.

BOX 4: The Lexington Fire

Santa Clara County experienced a severe forest fire from July 7-13, 1985 that burned 13,800 acres – over 50% of the watershed that supplies water to Lexington Reservoir. The fire itself cost $1.2 million to fight and caused $7 million in damage to homes and other property (SCVWD, 1986). The Santa Clara Valley Water District (SCVWD), which owns and maintains Lexington Reservoir, commissioned a post-fire report that described how the fire created hydrophobic (water-repellent) soils after burning much of the vegetation, leaving significant erosion, deposition, and flood hazards for at least three years or until vegetation was well-established. The report concluded that Lexington Reservoir was at risk of losing storage capacity as a result of sedimentation (Williams Cotton and Associates, 1986).

The report made a number of stewardship recommendations for publicly and privately owned portions of the burn area that focused on stabilizing the watershed and decreasing the risk of significant flood and sedimentation hazards from rain events coming that winter. In coordination with the US Soil Conservation Service and California Division of Forestry, SCVWD invested $253,027 to implement a small number of these recommendations, notably a watershed reseeding effort to assist in stabilizing soils. SCVWD also hoped to sponsor major sediment entrapment projects funded through the Soil Conservation Service's Emergency Watershed Protection Program; however, these funds were not granted. In January of 1986, SCVWD noted, "the District was not able to implement many of the recommendations from the report because of the limitation of making improvements on private property with public funds." (SCVWD 1986)

The next month, an unanticipated series of tropical storms produced 25.5 inches of intense rainfall over the burn area, filling the then-empty reservoir in 36 hours (Taylor et al., 1993). The storms produced significant flooding and bank failures after runoff from hydrophobic soils reached channels nearly instantaneously (Vasiliki Vassil, 2008). Water and sediment moved through the watershed with such intensity that some stream channels were scoured to bedrock, and tributary channels were deposited with large amounts of sediment from upland areas (Zatkin, 1986). The amount of sediment that was mobilized during this event has not been quantified; however, it likely resulted in a considerable decline in Lexington Reservoir's storage capacity.

This highlights the impact unanticipated events can have on the County's critical infrastructure, such as reservoirs, and underscores the need for adequate funding in support of stewardship and management of critical natural capital assets on public and private open space.

Protecting Santa Clara County's Natural Capital Through Policy

Consideration and integration of ecosystem services into land use policies and regulation at all levels will help coordinate conservation actions that protect these services throughout the County. While voluntary conservation and stewardship will continue to be important tools to support and enhance the flow of ecosystem services from private lands, policy, incentives and regulations play a fundamental role in helping ensure that our natural capital assets continue to produce critical goods and services. Incorporating ecosystem services into general plans and policies allows decision-makers to have full information about the ecological and economic costs and benefits of their investments.

A 1985 fire in the watershed supplying Lexington Reservoir brought short-term and long-term losses in both built capital and natural capital. *Credit: Naoto Sato.*

CHAPTER 4: Estimating Nature's Value in Santa Clara County

Monetizing Ecosystem Goods and Services

The economic goods and services produced in a region can be quantified to provide a view of the region's economy. The value of these economic goods and services, from housing to industry, is typically estimated with market or appraisal values. Similarly, the value of the natural capital of Santa Clara County — and the ecosystem goods and services it provides — can be quantified. Each land cover type, from wetlands to forests to agricultural lands, provides a suite of ecosystem goods and services. For example, wetlands can provide flood risk reduction, soil retention, climate stability, increased property values on neighboring properties, salmon habitat and other services. The identification and valuation of these ecosystem goods and services provides insight into the economic importance of natural capital — which has previously received a default value of zero.

This study represents the first attempt to comprehensively value Santa Clara County's natural capital assets. Assessing the full value of all ecosystem services is challenging. It is often assumed that without a dollar value, the value of an ecosystem to society cannot be recognized or described; unfortunately, many ecosystem services such as genetic diversity have tremendous intrinsic value to society, but remain challenging to value using dollars. This study does not attempt to capture the intrinsic value of natural capital. It provides a partial estimate of the economic value (rather than intrinsic value) provided by natural capital. Through this and future efforts we can better understand the economic contribution of natural capital and its importance to Santa Clara County.

Benefit Transfer Methodology

Benefit Transfer Methodology (BTM) was used to estimate the value of ecosystem services produced in Santa Clara County. BTM estimates the economic value of ecological goods or services by utilizing previous valuation studies (primary studies) of similar goods or services in comparable locations.

By quantifying the value of the services provided by open space such as tidal wetlands, we can better understand the value these lands provide to society. *Credit: cc Oleg Alexandrov.*

Earth Economics maintains the largest and most comprehensive database of published, peer-reviewed primary valuation studies for BTM use in the world. The valuation techniques employed in these studies include market pricing, replacement cost, avoided cost, production approaches, travel cost, hedonic pricing, and contingent valuation. These techniques have been developed and vetted within environmental and natural resource economics over the last four decades. See Table 2 for short descriptions of these techniques.

As in a house or business appraisal, BTM sums the value of various attributes (number of rooms in a house, or different assets in a business) and establishes the value based on closely related comparable valuations. All valuation appraisals include a degree of uncertainty. A house appraisal will have several comparables that range in value, though a single value is often chosen. In this report's valuation Earth Economics provides a low to high value range to demonstrate the difference between comparable primary studies.

The primary studies used in a BTM study are conducted in a number of different socioeconomic contexts, biophysical contexts, time periods, and geographic locations, and use a range of analytic methods. These and other factors can influence the correspondence between the primary study site and the BTM study site. Appendix B contains more detail on the limitations of BTM. Benefit Transfer Methodology is used when the

expense and time required to conduct primary valuation studies across an entire landscape for multiple ecosystem services are prohibitive. The BTM approach can be completed more quickly and at far less cost; it serves as a strong, defensible placeholder until local valuations can be conducted. Using the valuation framework employed in this report, at least 100 primary studies would be required to conduct a fully original valuation of Santa Clara County natural assets. A single primary study can require upwards of $100,000 in research funding and two years of effort.

The California Department of Water Resources noted in its 2008 Economic Analysis Guidebook (Cowdin, 2008) that, "Although original studies are preferable to benefit transfer, researchers agree that…benefit transfer can provide a reasonable valuation of non-market values." BTM is accepted at the federal level and by California state agencies. In June of 2013, FEMA approved Mitigation Policy FP-108-024-01 (FEMA, 2013), based on values Earth Economics developed with this methodology, for use in all hurricane and flood disaster mitigation in all 50 states. BTM has gained popularity in the last several decades as decision-makers have sought timely and cost-effective ways to value ecosystem services and natural capital (Wilson and Hoehn, 2006).

TABLE 2: Valuation Methods Used in Primary Studies to Value Ecosystem Services

CONVENTIONAL ECONOMIC VALUATION

REVEALED-PREFERENCE APPROACHES

Market pricing: Valuations are directly obtained from what people are willing to pay for the service or good on a private market. Example: Timber is often sold on a private market.

Travel cost: Based on the cost of travel required to consume or enjoy ecosystem services. Travel costs can reflect the implied value of the service. Example: Recreation areas attract tourists whose value placed on that area must be at least what they were willing to pay to travel to it.

Hedonic pricing: The value of a service is implied by what people will be willing to pay for the service through purchases in related markets. Example: Housing prices along the coastline tend to exceed the prices of inland homes.

Production approaches: Service values are assigned from the impacts of those services on economic outputs. Example: Improvement in watershed health leads to an increase in commercial and recreational salmon catch.

COST-BASED APPROACHES

Replacement cost: Cost of replacing ecosystem services with man-made systems. Example: The cost of replacing a watershed's natural filtration services with a man-made water filtration plant.

Avoidance cost: Value of costs avoided or mitigated by ecosystem services that would have been incurred in the absence of those services. Example: Wetlands buffer the storm surge of a hurricane, reducing damage along the coast.

STATED-PREFERENCE APPROACHES

Contingent valuation: Value for service demand elicited by posing hypothetical scenarios that involve some valuation of land use alternatives. Example: People are willing to pay for preservation of wilderness for aesthetic and other reasons.

Group valuation: Discourse-based contingent valuation, which is arrived at by bringing together a group of stakeholders to discuss values to depict society's willingness to pay. Example: Government, citizen's groups, and businesses come together to determine the value of an area and the services it provides.

Conjoint analysis: People are asked to choose or rank different service scenarios or ecological conditions that differ in the mix of those conditions. Example: Choosing among wetlands scenarios with differing levels of flood protection and fishery yields.

NON-MONETARY VALUATION OR ASSESSMENT

Individual index-based methods, including rating or ranking choice models and expert opinion.

Group-based methods, including voting mechanisms, focus groups, citizen juries (Aldred and Jacobs, 2000; Gregory and Wellman, 2001; Wilson and Howarth, 2002).

Source: Farber et al., 2006

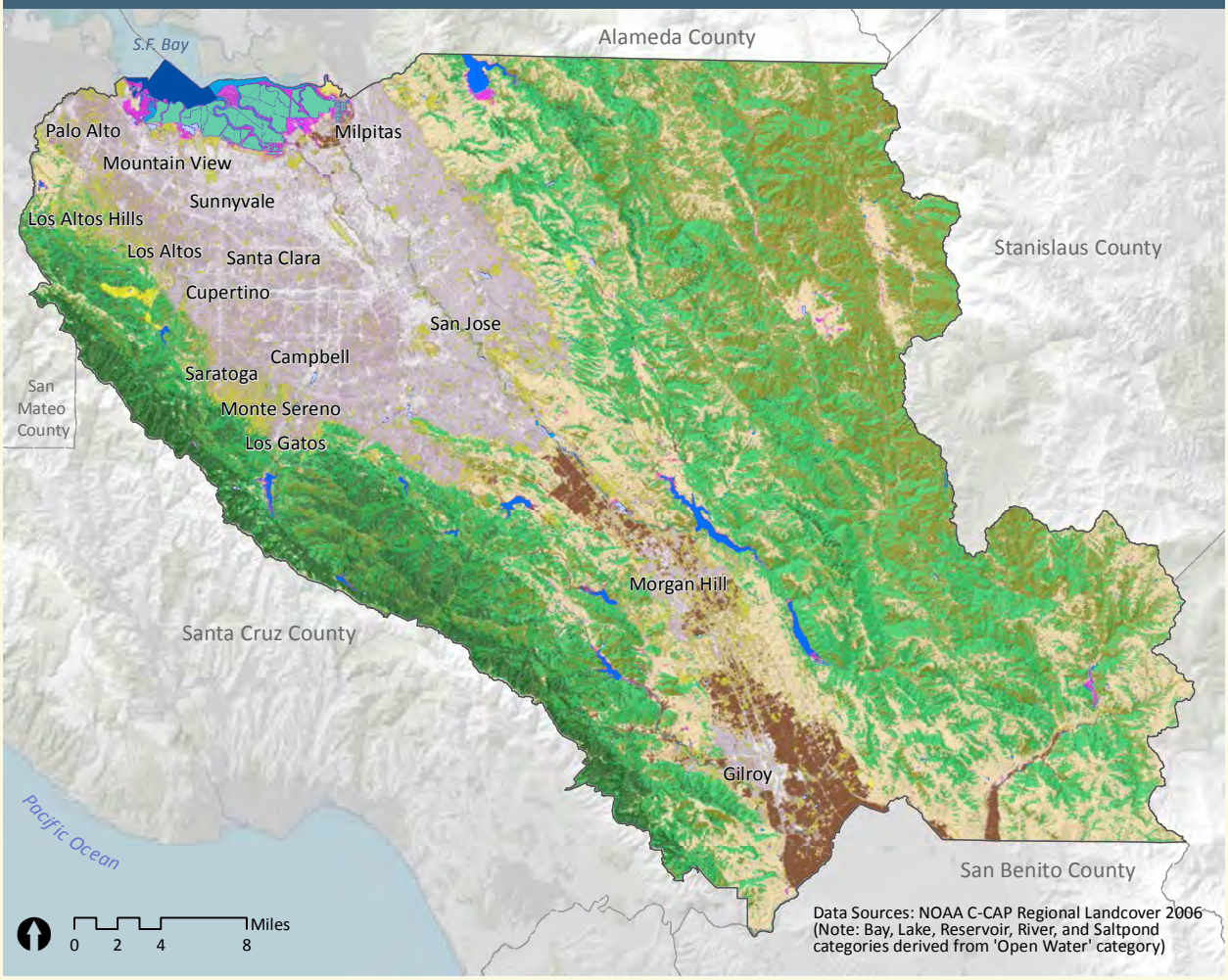
Selecting Primary Studies

The Earth Economics Ecosystem Valuation Toolkit[3] database, consisting of peer-reviewed economic studies and scientific literature, contains many primary studies with valuations applicable to Santa Clara County. Earth Economics used several criteria to select appropriate primary study values for Santa Clara County, including geographic location, demographic characteristics, and ecological characteristics of the primary study site.

All values included in this analysis were sourced from studies conducted in temperate ecosystems. Where available, ecosystem valuation studies based in Santa Clara County, the San Francisco Bay Area, and California were given preference. Where local studies were not available, ecosystem service valuations conducted within the greater United States were then prioritized. In the very few cases where no local or national figures were available, suitable studies from countries outside the United States were used. Through this filtering process, Earth Economics ensured that estimates from areas with considerably different ecologies or demographics to Santa Clara County were excluded. Once compiled, all ecosystem service values were then standardized to 2012 dollars using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator (US Department of Labor Bureau of Labor Statistics, 2014). Appendix A lists the primary studies used to provide the value transfer estimates.

[3] www.esvaluation.org

FIGURE 5: Land Cover in Santa Clara County



Recreational opportunities are among the many benefits offered by protected lands. *Credit: cc Don DeBold.*

Assigning Land Cover Categories to Primary Study Values

Each primary study's ecosystem service value in the database was assigned a land cover category based on its study area description. While each primary study land cover could be classified down to the level of its specific plant community, this study used a coarser land cover classification system, which allows a direct transfer of values from primary study locations to locations in Santa Clara County, shown in Figure 5. This is similar to home appraisers using the number of rooms to compare house attributes. The rooms themselves are certainly likely to be qualitatively different, but it would be impractical for an appraiser to consider every difference in each room.

While land cover often determines the ecosystem services that can be produced or used by people in a given location (e.g., people can swim in a river but not in an oak woodland), different plant communities can often produce the same kinds of ecosystem services in similar amounts. For example, Douglas fir forests and redwood forests are relatively similar in their hydrological attributes, but much different from grasslands. In addition, from the average beneficiary's point of view, the level of many ecosystem services does not change greatly between some plant communities. For example, the enjoyment that most members of the public receive from hiking in an old-growth Douglas fir forest would be similar to a hiking experience in an old-growth redwood forest.

Grouping plant communities to a broader land cover classification system also increases the number of primary studies that can represent ecosystem services for each land cover category. For example, grouping ecosystem service values collected from different grassland communities under the common land cover category "Grassland". Land cover categories provided by The National Oceanic and Atmospheric Administration's 2006 Coastal Change Analysis Program (C-CAP) Regional Land Cover dataset (National Oceanic and Atmospheric Administration, 2006), shown in Table 3, were determined to provide the greatest practical resolution of land cover categories necessary for the purposes of this study.

Ecosystem service values were assigned to general land cover types present in Santa Clara County. *Credit: William K. Matthias.*

TABLE 3: Coastal Change Analysis Program (C-CAP) Land Cover Types in Santa Clara County

C-CAP Land Cover Type*		DESCRIPTION **
Deciduous Forest		Areas dominated by deciduous trees generally greater than 5 meters tall.
Evergreen Forest		Areas dominated by evergreen trees generally greater than 5 meters tall.
Mixed Forest		Areas including both evergreen and deciduous trees generally greater than 5 meters tall.
Scrub/Shrub		Areas dominated by shrubs; less than 5 meters tall. Includes true shrubs, young trees in an early successional stage.
Grassland		Areas dominated by grammanoid or herbaceous vegetation.
Estuarine Emergent Wetland		Tidal wetlands dominated by erect, rooted, herbaceous hydrophytes in areas with greater than 0.5 percent salinity.
Palustrine (freshwater) Emergent Wetland		Tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens in areas with less than 0.5 percent salinity.
Estuarine Forested Wetland		Tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height; in areas with greater than 0.5 percent salinity.
Estuarine Scrub/Shrub Wetland		Tidal wetlands dominated by woody vegetation less than 5 meters in height; in areas with greater than 0.5 percent salinity.
Palustrine (freshwater) Forested Wetland		Tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height; in areas with less than 0.5 percent salinity.
Palustrine (freshwater) Scrub/ Shrub Wetland		Tidal and non-tidal wetlands dominated by woody vegetation less than 5 meters in height; in areas with less than 0.5 percent salinity.
Pasture/Hay		Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Open Water	Bay	Areas of open water in the San Francisco Bay.
	Lake	Bodies of freshwater in the county not used as reservoirs.
	Reservoir	Bodies of freshwater in the county used as reservoirs.
	River	Rivers and streams.
	Salt Pond	South San Francisco Bay salt ponds created for commercial purposes.
Cultivated		Areas used for the production of annual crops such as vegetables; includes orchards and vineyards.
High Intensity Developed		Highly developed areas where people reside or work in high numbers such as apartment complexes, row houses and commercial/industrial.
Medium Intensity Developed		Areas with a mixture of constructed materials (50-79% cover) and vegetation. Includes multi- and single-family housing units.
Low Intensity Developed		Areas with a mixture of constructed materials (21-49% cover) and vegetation, such as single-family housing units.
Developed Open Space		Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses.
Bare Land		Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation.
Unconsolidated Shore		Areas dominated by material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Generally lacks vegetation.

* The land cover categories under Open Water (Bay, Lake, Reservoir, Rivers, and Salt Pond) were derived from the C-CAP dataset based on available water body data.

**Definitions adapted from the C-CAP Land Cover Classification Scheme, http://www.csc.noaa.gov/digitalcoast/_/pdf/ccap_class_scheme.pdf.

Some land cover/ecosystem service combinations are well represented in available valuation studies. Other combinations have few or no existing studies. Table 4 summarizes the suite of ecosystem services provided by each land cover type and the number of primary study values available for each land cover/ecosystem service combination.

TABLE 4: Santa Clara County Ecosystem Services Present, Valued, and Number of Appropriate Studies

	Deciduous Forest	Evergreen Forest	Mixed Forest	Scrub/Shrub	Grassland	Estuarine Emergent Wetland	Palustrine Emergent Wetland	Estuarine Forested & Scrub/Shrub Wetland*	Palustrine Forested & Scrub/Shrub Wetland**	Pasture/Hay	Cultivated	Open Water					High Intensity Developed	Medium Intensity Developed	Low Intensity Developed	Developed Open Space	Bare Land	Unconsolidated Shore
												Bay	Lake	Reservoir	River	Salt Pond						
PROVISIONING SERVICES																						
Food	1	1	1	1	1	3	3	3	3			3										
Medicinal Resources																						
Ornamental Resources																						
Energy and Raw Materials	1	1	1																			
Water Supply	3	3	3	2		6	6	6	6					1	1							
REGULATING SERVICES																						
Biological Control	2	2	2	1	2					1	1	1										
Climate Stability	4	4	4	3	3	7	7	5	5	3	3									1		
Air Quality	1	1	1									1								2		
Moderation of Extreme Events	2	2	2	1	1	8	8	6	6											1		
Pollination	3	3	3	1	1					2	1											
Soil Formation	1	1	1	1						3	1											
Soil Retention	1	1	1	2	3					2	3											
Waste Treatment	4	4	4		2	9	9	11	11		1	6										
Water Regulation																				3		
SUPPORTING SERVICES																						
Habitat and Nursery	1	1	1			5	5	3	3			2			2							
Genetic Resources																						
CULTURAL SERVICES																						
Natural Beauty																						
Cultural and Artistic Inspiration																						
Recreation and Tourism	13	13	13	2	2	12	9	9	8	1		11	3	4	9	1						
Science and Education	1	1	1																			
Spiritual and Historical																						

KEY:

	Ecosystem service produced by land cover
n	Ecosystem service produced by land cover and valued in this report; n = number of primary study values assessed
	Ecosystem service not produced by land cover

*Includes areas of both Estuarine Scrub/Shrub Wetland and Estuarine Forested Wetland, which were combined for the purposes of valuation.

**Includes areas of both Palustrine Scrub/Shrub Wetland and Palustrine Forested Wetland, which were combined for the purposes of valuation.

Assigning Restrictions to Primary Study Values

In some cases ecosystem services are spatially independent. A ton of carbon sequestered in Santa Clara County, for example, adds the same value to climate stability as a ton of carbon sequestered elsewhere. However, the value of an ecosystem service is often related to its physical location in the landscape or its proximity to specific land uses or beneficiaries. For example, the aesthetic value of urban parks is often more economically valuable (on a per-acre basis) than the same service in rural parks, because there are more beneficiaries in close proximity to the service. To better approximate the production of services and physical location of beneficiaries represented in the primary studies, Earth Economics tagged many of the applicable primary study values with one or more "restrictions," indicating that the value represented in a primary study is spatially dependent on proximity to one or more specific land use or landscape feature. For example, a "riparian" restriction indicates the primary study valued ecosystem services in a riparian corridor, a part of the landscape in close proximity to a stream that can often have higher economic value due to its higher ecological productivity.

Five different restrictions were applied in this study; these are described in Table 5. Along with other factors already taken into account (e.g. similarities in land cover, geographic location), the five restrictions were determined to broadly represent the factors that commonly influenced the primary studies' final calculated ecosystem services value. In some cases, studies had insufficient economic data to identify restrictions for some land cover types; in other cases, enough information was provided to support multiple restrictions to be applied simultaneously to a single land cover type.

TABLE 5: Restrictions Applied to Primary Study Values for Transfer to Santa Clara County

RESTRICTION	DESCRIPTION
Urban	Areas where the value of the some ecosystem services tends to be higher when near urban or suburban populations; e.g., an urban park tends to have a greater positive impact on nearby property values.
Riparian	Areas alongside streams and rivers where ecosystem services tends to be produced or demanded in greater quantities due to the higher ecological productivity of these areas or their proximity to water; e.g., some kinds of wildlife viewing or water-based recreational activities are possible only in riparian zones.
Agriculture	Areas that benefit nearby farms or provide benefits to others by reducing the (usually downstream) impacts of agriculture; e.g., native vegetation near farms can be home to wild pollinators that help to increase crop yields.
High Intensity Developed	Areas where ecosystem services tend to be more valuable near highly developed zones where people reside or work in high numbers, such as near apartment complexes or commercial/industrial areas; e.g., wetlands near industrial areas often receive and detoxify a greater quantity of polluted runoff (on a per-acre basis) than those in remote areas.
Greater than 5 contiguous acres	Continuous tract of a single land cover type that provides greater ecosystem services when it grows in size; e.g., a large urban park may provide a sense of open space (where a smaller urban park could not), adding to the value of adjacent properties.

Characterizing Land Cover in Santa Clara County

The Santa Clara Valley Open Space Authority used Geographic Information Systems (GIS) data to calculate the acreage of each applicable combination of land cover type and restrictions in Santa Clara County. Land cover categories were based on the National Oceanic and Atmospheric Administration's 2006 Coastal Change Analysis Program (C-CAP) Regional Land Cover dataset (National Oceanic and Atmospheric Administration, 2006). Table 6 illustrates the geographic distribution of land cover within Santa Clara (C-CAP land cover types in Santa Clara County are defined in Table 3). A summary of each land cover restriction, its associated data, and functional definition are included in Table 6.

TABLE 6: GIS Datasets used for Ecosystem Service Value Restrictions in Santa Clara County

RESTRICTION	DATASET	DEFINITION
Urban	California Department of Conservation Farmland Mapping & Monitoring Program, Santa Clara County, 2010 (California Department of Conservation, 2010)	Within 2 miles of an FMMP Urban/Built-up designated area that is either within an urban service area or is over 300 contiguous acres in size.
Riparian	United States Geological Survey National Hydrography Dataset - 24k (National Oceanic and Atmospheric Administration, 2006)	Within 50 feet of stream channel flowlines that have either perennial status or Geographic Name Information System identification number.
Agriculture	California Department of Conservation Farmland Mapping & Monitoring Program, Santa Clara County, 2010 (California Department of Conservation, 2010)	Located within 3 miles of FMMP Prime Farmland, Farmland of Statewide Importance, Unique Farmland, or Farmland of Local Importance designated areas that are over 40 contiguous acres in size.
High Intensity Developed	National Oceanic and Atmospheric Administration 2006 Coastal Change Analysis Program (C-CAP) Regional Land Cover dataset (National Oceanic and Atmospheric Administration, 2006)	Within ¼ mile of lands identified as High Intensity Developed.
Greater than 5 contiguous acres	National Oceanic and Atmospheric Administration 2006 Coastal Change Analysis Program (C-CAP) Regional Land Cover dataset (National Oceanic and Atmospheric Administration, 2006)	Greater than 5 contiguous acres of any single C-CAP 2006 land cover type.

Fishing in Alviso Slough. *Credit Derek Neumann.*

Calculating Economic Value: Matching Primary Studies to Land Cover in Santa Clara County

The low and high value ($/acre/year) of ecosystem service values were individually summed for each applicable land cover/restriction combination, and were then multiplied by the acreage of that combination to calculate the total low and high values ($/year), shown in Table 7. The low and high values for ecosystem services were summed for each land cover type, resulting in a total low and high value ($/year) for each land cover type. These values were then summed to calculate the total annual low and high value ($/year) of ecosystem services for Santa Clara County.

TABLE 7: Value of Natural Capital in Santa Clara County by Land Cover Type

Land Cover	Restrictions					Area (acres)	Annual Per-Acre Value		Total Annual Value	
	Urban	Riparian	Agricultural	High Intensity	5 Acre		Low ($/acre/year)	High ($/acre/year)	Low ($/year)	High ($/year)
Deciduous Forest						412	$727	$782	$299,390	$321,951
			•			75	$1,148	$1,322	$85,530	$98,499
	•					30	$7,695	$21,782	$227,518	$644,066
	•		•			59	$7,655	$45,768	$447,870	$2,677,752
	•	•	•			2	$3,349	$24,983	$5,804	$43,298
		•				8	$1,113	$2,048	$9,374	$17,252
		•	•			3	$1,733	$4,781	$6,002	$16,559
DECIDUOUS FOREST SUBTOTAL						**588**			**$1,081,489**	**$3,819,377**
Evergreen Forest						24,873	$900	$985	$22,376,780	$24,489,340
			•			10,511	$872	$1,494	$9,164,552	$15,703,197
		•				526	$755	$1,759	$397,367	$925,834
		•	•			276	$1,375	$4,492	$379,514	$1,239,710
	•					14,265	$7,695	$21,782	$109,762,948	$310,720,316
	•		•			5,564	$7,695	$21,793	$42,814,295	$121,246,294
	•	•				383	$3,561	$23,260	$1,362,542	$8,900,800
	•	•	•			79	$3,555	$25,258	$281,090	$1,997,157
EVERGREEN FOREST SUBTOTAL						**56,477**			**$186,539,087**	**$485,222,647**
Mixed Forest						108,026	$828	$883	$89,433,334	$95,349,413
			•			50,438	$1,249	$1,423	$62,996,888	$71,775,904
		•				1,700	$758	$1,762	$1,288,627	$2,995,394
		•	•			822	$1,378	$4,495	$1,132,925	$3,695,007
	•					19,631	$7,886	$21,974	$154,816,701	$431,363,746
	•		•			31,016	$7,887	$21,985	$244,636,760	$681,887,434
	•	•				563	$3,753	$23,452	$2,110,877	$13,192,149
	•	•	•			438	$3,747	$25,449	$1,640,474	$11,142,771
MIXED FOREST SUBTOTAL						**212,634**			**$558,056,586**	**$1,311,401,817**
Scrub/Shrub						104,155	$281	$316	$29,283,341	$32,900,410
			•			31,692	$453	$756	$14,363,817	$23,955,775
		•				993	$361	$1,003	$358,633	$996,416
		•	•			293	$533	$1,443	$156,133	$422,644
	•					2,819	$281	$281	$792,333	$792,333
					•	2,885	$11,539	$11,539	$33,289,207	$33,289,207
	•		•			6,134	$453	$721	$2,779,698	$4,423,078
	•		•		•	8,234	$11,711	$11,979	$96,425,672	$98,631,730
	•	•				38	$532	$1,513	$20,302	$57,667
	•	•			•	6	$613	$12,227	$3,554	$70,938
	•	•	•			68	$785	$2,640	$53,574	$180,272
	•	•	•		•	20	$785	$12,667	$15,641	$252,507
SCRUB/SHRUB SUBTOTAL						**157,336**			**$177,541,906**	**$195,972,978**

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TABLE 7: Value of Natural Capital in Santa Clara County by Land Cover Type

Land Cover	Restrictions					Area (acres)	Annual Per-Acre Value		Total Annual Value	
	Urban	Riparian	Agricultural	High Intensity	5 Acre		Low ($/acre/year)	High ($/acre/year)	Low ($/year)	High ($/year)
Grassland						58,934	$2,128	$3,992	$125,433,236	$235,269,509
			•			43,745	$2,125	$7,502	$92,977,453	$328,172,821
		•				365	$2,146	$4,043	$784,064	$1,477,339
		•	•			378	$13,022	$23,608	$4,919,687	$8,918,714
	•					1,500	$5,249	$5,512	$7,875,329	$8,270,188
	•				•	13,656	$5,249	$11,959	$71,675,537	$163,313,053
	•		•			4,094	$5,246	$9,022	$21,478,104	$36,938,055
	•		•		•	37,726	$5,246	$8,914	$197,903,401	$336,281,245
	•	•				18	$5,266	$5,563	$93,076	$98,322
	•	•	•			59	$16,038	$25,023	$947,385	$1,478,115
	•	•			•	49	$5,266	$12,011	$258,809	$590,253
	•	•	•		•	311	$16,038	$31,471	$4,984,592	$9,780,770
GRASSLAND SUBTOTAL						**160,835**			**$529,330,671**	**$1,130,588,384**
Estuarine Emergent Wetland						243	$7,609	$48,851	$1,848,815	$11,869,929
		•				3	$7,255	$49,470	$24,611	$167,810
			•			60	$7,427	$49,470	$448,833	$2,989,413
	•					1,018	$30,635	$50,952	$31,174,863	$51,848,939
	•			•		393	$25,090	$52,011	$9,859,245	$20,437,455
	•		•			1,155	$1,345	$65,891	$1,553,784	$76,134,340
	•		•	•		209	$1,204	$66,950	$251,803	$13,998,770
	•	•				42	$6,149	$48,889	$259,743	$2,065,305
	•	•	•			96	$737	$48,889	$71,015	$4,707,896
	•	•		•		11	$604	$49,948	$6,514	$539,031
	•	•	•	•		41	$1,063	$59,350	$43,834	$2,447,025
ESTUARINE EMERGENT WETLANDS SUBTOTAL						**3,272**			**$45,543,061**	**$187,205,912**
Palustrine Emergent Wetland						1,253	$7,609	$48,851	$9,530,542	$61,188,842
		•				62	$7,255	$49,470	$452,406	$3,084,735
		•	•			61	$7,249	$49,470	$441,281	$3,011,644
	•					1,016	$30,635	$50,952	$31,128,598	$51,771,992
	•			•		450	$25,090	$52,011	$11,283,982	$23,390,825
	•	•				11	$6,149	$48,889	$69,209	$550,301
	•	•	•			67	$737	$48,889	$49,408	$3,275,483
	•	•	•	•		47	$1,063	$59,350	$50,180	$2,801,248
	•	•		•		6	$604	$49,948	$3,422	$283,139
		•	•	•		2	$6,901	$49,735	$17,026	$122,713
				•		7	$6,497	$47,866	$44,633	$328,834
PALUSTRINE EMERGENT WETLANDS SUBTOTAL						**2,982**			**$53,070,686**	**$149,809,757**

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TABLE 7: Value of Natural Capital in Santa Clara County by Land Cover Type

Land Cover	Restrictions					Area (acres)	Annual Per-Acre Value		Total Annual Value	
	Urban	Riparian	Agricultural	High Intensity	5 Acre		Low ($/acre/year)	High ($/acre/year)	Low ($/year)	High ($/year)
Estuarine Forested & Scrub/Shrub Wetland*						3	$1,823	$39,078	$6,079	$130,346
	•					34	$1,618	$68,413	$55,134	$2,331,571
	•			•		30	$1,477	$69,472	$43,659	$2,053,151
	•		•	•		45	$1,477	$69,472	$66,667	$3,135,151
	•		•			27	$1,618	$68,413	$43,465	$1,838,097
	•	•				3	$1,446	$69,499	$4,256	$204,632
	•	•		•		4	$1,305	$70,558	$5,629	$304,341
	•	•	•			4	$1,439	$69,499	$5,324	$257,155
	•	•	•	•		20	$1,305	$70,558	$26,057	$1,408,766
ESTUARINE SCRUB/SHRUB WETLANDS & ESTUARINE FORESTED WETLAND SUBTOTAL						**170**			**$256,269**	**$11,663,211**
Palustrine Forested & Scrub/Shrub Wetland**						488	$1,572	$38,828	$767,902	$18,963,541
			•			385	$1,572	$38,828	$604,644	$14,931,853
			•	•		11	$1,432	$43,076	$16,269	$489,453
		•				206	$1,400	$38,828	$287,987	$7,986,776
		•	•			150	$1,393	$38,828	$209,071	$5,825,912
		•	•	•		5	$1,260	$43,076	$5,923	$202,559
	•					57	$1,618	$68,413	$92,636	$3,917,484
	•			•		94	$1,477	$69,472	$138,992	$6,536,419
	•		•	•		288	$1,477	$69,472	$425,885	$20,028,232
	•		•			489	$1,618	$68,413	$791,061	$33,453,341
	•	•				10	$1,618	$69,499	$16,424	$705,584
	•	•		•		100	$1,477	$70,558	$147,399	$7,040,124
	•	•	•			160	$1,477	$70,558	$235,921	$11,268,152
	•	•	•	•		155	$1,305	$80,005	$202,271	$12,400,215
PALUSTRINE SCRUB/SHRUB WETLANDS & PALUSTRINE FORESTED WETLAND SUBTOTAL						**2,598**			**$3,942,384**	**$143,749,645**
Pasture/Hay						103	$487	$10,454	$50,151	$1,076,188
	•					1,360	$1,051	$9,926	$1,428,831	$13,499,501
PASTURE/HAY SUBTOTAL						**1,463**			**$1,478,982**	**$14,575,689**
Open Water – Bay						2,597	$4,611	$15,286	$11,972,611	$39,691,489
Open Water – Lake						1,394	$4,684	$4,684	$6,532,146	$6,532,146
Open Water – Reservoir						3,197	$4,735	$4,735	$15,137,199	$15,137,199
Open Water – River						1,256	$4,684	$4,684	$5,885,581	$5,885,581
Open Water – Salt Pond						7,081	$405	$405	$2,868,025	$2,868,025
OPEN WATER SUBTOTAL						**15,252**			**$42,395,562**	**$70,114,440**
Cultivated						23,816	$121	$2,517	$2,889,347	$59,941,616

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* Includes areas of both Estuarine Scrub/Shrub Wetland and Estuarine Forested Wetland, which were combined for the purposes of valuation.
** Includes areas of both Palustrine Scrub/Shrub Wetland and Palustrine Forested Wetland, which were combined for the purposes of valuation.

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TABLE 7: Value of Natural Capital in Santa Clara County by Land Cover Type

Land Cover	Restrictions					Area (acres)	Annual Per-Acre Value		Total Annual Value	
	Urban	Riparian	Agricultural	High Intensity	5 Acre		Low ($/acre/year)	High ($/acre/year)	Low ($/year)	High ($/year)
High Intensity Developed						21,554	n/a	n/a	n/a	n/a
Medium Intensity Developed						88,609	n/a	n/a	n/a	n/a
Low Intensity Developed						53,237	n/a	n/a	n/a	n/a
Developed Open Space						32,511	$524	$2,960	$17,041,339	$96,248,716
Bare Land						1,382	n/a	n/a	n/a	n/a
Unconsolidated Shore						197	n/a	n/a	n/a	n/a
SANTA CLARA COUNTY TOTAL						835,186			$1,619,167,369	$3,860,314,189

All values are in 2012 USD.

Valuation Results

Santa Clara County's open space provides between $1.6 and $3.8 billion in benefits to people each year — significant annual economic benefits. These "big numbers" are important. They indicate that investments in open space can provide vast and long-term benefits if these assets are conserved or enhanced. Moreover, investment in natural capital can yield tremendous return on investment due to both the low cost of investment (relative to building new assets) and because it supports a suite of ecosystem services and benefits (not just a single benefit). In addition to the annual flow of ecosystem service benefits detailed above, these economic data can be used to calculate a general asset value for the County's natural capital. Asset valuation is discussed in more detail later in this chapter.

Unlike natural capital, the asset value of built capital such as the Metcalf Energy Center declines in value over time. *Credit: cc Pedro Xing.*

Valuation Gaps and Study Limitations

The greatest limitation to this analysis is a lack of primary valuation studies representing all of the ecosystem services provided in Santa Clara County. Many ecosystem services that clearly have economic value provided by a land cover type could not be assigned value. Values were unavailable for five land cover types (Bare Land; Unconsolidated Shore; High Intensity Developed; Medium Intensity Developed; Low Intensity Developed). These land cover types provide obvious ecosystem services but are not represented in this study. For example, Low Intensity Developed and even High Intensity Developed land include urban tree canopies that provide air purification, aesthetic beauty, stormwater regulation, and other ecosystem services. The lack of available information underscores the need for investment in conducting local primary valuations. The data provided in Table 4 clarifies ecosystem service/land cover data gaps, and can be useful in prioritizing

Assuming they are not degraded, our open space and natural capital will continue to provide benefits long into the future. *Credit: Amit Patel.*

local primary valuations to fill these gaps and further refine ecosystem service values in the region. Appendix B contains greater detail on the limitations of this study.

Asset Value of Natural Capital in Santa Clara County

An ecosystem produces a flow of valuable services across time, like a traditional capital asset. Provided the natural capital of the watershed is not degraded or depleted, this flow of value will likely continue into the future. This analogy can be extended by calculating the net present value of the future flows of ecosystem services, just as the asset value of a capital asset (such as a power plant or bridge) can be calculated as the net present value of its expected future benefits.

Many built assets, such as bridges and roads, are not sold in markets, and the same is true of most natural capital assets. Thus, this calculation is an estimate of asset value based on the stream of benefits provided, without the potential for the full asset to be sold as one unit. An asset calculation is useful for revealing the scope and scale of the economic value that Santa Clara County's natural systems hold.

Calculating the net present value of an asset implies the use of a discount rate. Using a discount rate assumes that the benefits humans reap in the present are more valuable than the benefits provided to future generations, or even to the current generation one year from now. Discounting most often results in underestimates when applied to natural capital. Natural capital assets can be treated with lower discount rates than built capital assets because they tend to appreciate over time, rather than depreciate. Using a zero discount rate recognizes the renewable nature of natural capital and also assumes that people 100 years from now will enjoy the same level of benefits we enjoy today. Federal agencies like the Army Corps of Engineers use a 3.5% discount rate (2014 rate) for water resource projects, a rate that lowers the value of the benefits by 3.5% every year into the future (US Army Corps of Engineers, October 17, 2013). The private sector tends to use higher discount rates, tied to the rate of return on capital in private markets.

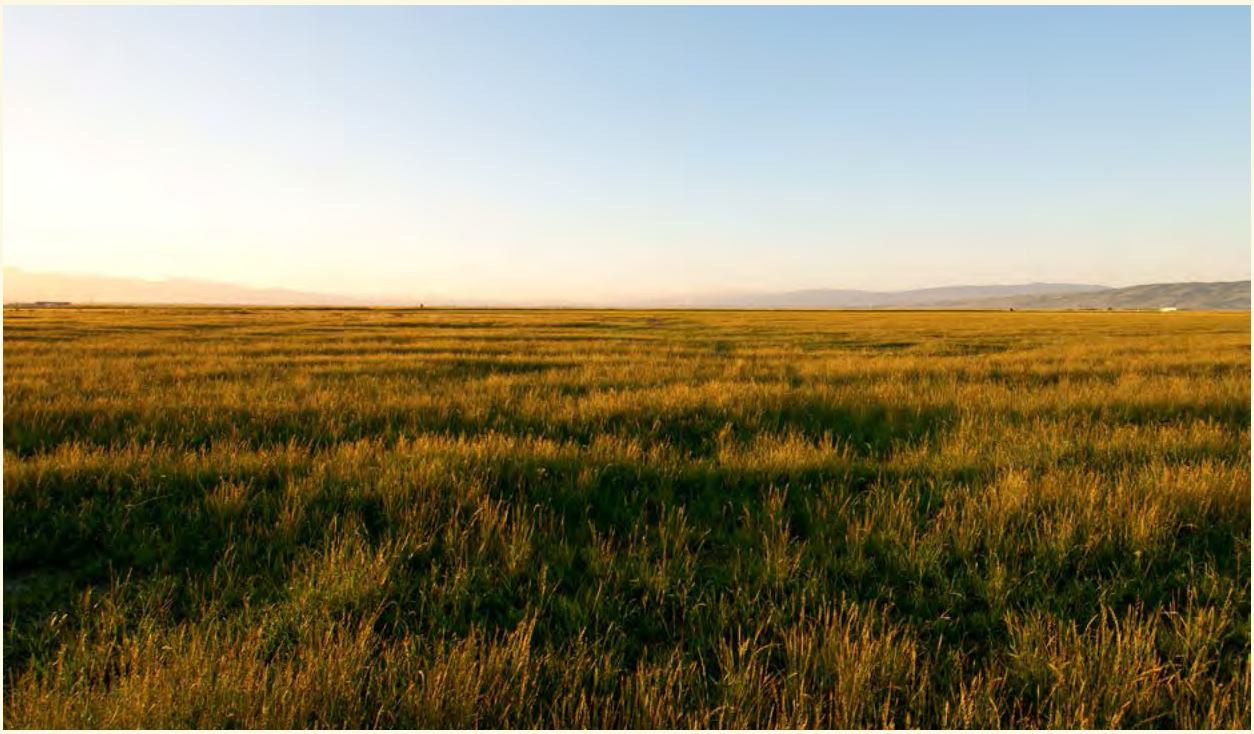
Built and natural capital are both important to maintain a high quality of life, but each maintains its functional role over a very different time period. Built capital investments are typically expected to be productive for a few decades. For example, a car today is unlikely to be functional in 100 years. Natural capital, however, does not necessarily depreciate like built capital assets, provided it is given at least a minimum level of stewardship and protection. For example, open space and aquifers can continue to be highly functional in 100 years. Unlike a 100-year-old car factory that has virtually no economic value today, these natural areas have appreciated in value. Open space and aquifers in Santa Clara County are providing more water, to more people, for a greater total value than they provided 100 years ago.

Degradation of these natural capital assets will be at great cost to people living today and in the future. If these assets are enhanced, they can be a basis for clean air, clean water, vibrant agriculture and industry, employment, rising real wages, and a high quality of life for present and future generations.

Thus, the use of a lower discount rate better reflects the asset value of Santa Clara County's natural capital. The net present value of Santa Clara County's natural capital was calculated over 100 years using two discount rates: 3.5%, and zero, as shown in Table 8.

TABLE 8: Net Present Value of Santa Clara County's Natural Capital

Discount Rate	Low Estimate	High Estimate
0% (100 years)	$162 billion	$386 billion
3.5% (100 years)	$45 billion	$107 billion



Each year, Santa Clara County's natural capital provides a stream of ecosystem services to people and the local economy. When valued similarly to built capital, this natural capital is worth between $45 billion and $107 billion. *Credit: Stephen Joseph.*

Treated with a 3.5% discount rate like a built capital bridge or factory, the value of natural capital in Santa Clara County is $45-107 billion. Treated as an asset that persistently provides the same value across time, using a zero discount rate for only 100 years yields a natural capital asset value range of $162-386 billion. Because this valuation does not include all ecosystem goods and services, it is an underestimate, yet even this conservative estimation demonstrates the sizeable asset value of the natural capital of Santa Clara County.

Currently, the value of economic assets is generally not considered beyond 100 years, and this study follows that tradition. With no cut-off date for valuation and a zero discount rate, any renewable resource would register an infinite value. Clearly, even far greater value exists for the many generations who will benefit from Santa Clara County's natural capital well beyond the 100-year point, assuming it is adequately protected.

CHAPTER 5: Valuing Conservation Investments

Conservation as an Investment

Governments and private landowners invest in land-holding, conservation easements, and stewardship activities that protect natural landscapes and provide many market and non-market benefits. For instance, open space conservation and stewardship actions help protect water supply sources that are of high value to agricultural, residential, and commercial water users. Investments in natural capital often maintain a low risk of losses and provide a high level of benefits (i.e. ecosystem services), with a productive life that is often significantly longer than that of built capital investments (Dasgupta, 2013).

Private or public, understanding the rate of return on investments is essential to allocating capital efficiently to generate significant and real returns. Understanding the size of assets, as discussed in Chapter 4, and the relative returns on investments in those assets, provides useful information for deciding the scale of and potential returns from investment. By utilizing metrics that incorporate ecosystem services, the true value of investments can be understood, especially when most of the returns from those investments accrue to the public. This chapter demonstrates an application of traditional return on investment (ROI) methods to a local open space acquisition made by the Santa Clara Valley Open Space Authority.

Investment in protected lands, like Santa Clara Valley Open Space Authority's Rancho Canada Del Oro Open Space Preserve (above), helps supply clean water to Santa Clara County. *Credit: Cait Hutnik.*

Valuing the environmental benefits allows their inclusion in ROI. Provided the economic benefits of natural assets can be quantified, ROI can be used as a tool to better understand the returns of conservation investment. ROI measures the relative efficiency of different investments by comparing the expected benefits of each investment to its cost over time. ROI can also take into account relative risk, which is another key factor in the decision-making process. The measurement of return on investment (ROI) has been proven to be superior to other decision-making tools for ensuring cost-efficiency and the maximization of benefits (Kovacs et al., 2013; Murdoch et al., 2010).

Calculating Return on Investment

An ROI calculation considers both costs and benefits. Costs can include fixed costs (such as the purchase of land), variable costs (such as maintenance costs), and environmental costs (impairments to ecosystem services). Benefits can include market benefits (e.g., rents, yields, jobs) and public or non-market benefits like ecosystem services. Induced benefits, such as the number of jobs created, can also be taken into account.

In its simplest form, return on investment (ROI) is expressed as follows:

$$\text{ROI} = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

Return on Investment Case Study: The Coyote Valley Open Space Preserve

To provide a case study, the Open Space Authority tasked Earth Economics with conducting a ROI analysis of its Coyote Valley Open Space Preserve (CVOSP). Acquired by the Open Space Authority in 2010, the CVOSP supports a mixture of oak woodland and grassland communities, where by fall 2014 it will provide a network of multi-use trails, outdoor learning opportunities, and daily access to the public. The 352-

The Authority's Coyote Valley Open Space Preserve (above) is now protected from development. *Credit: Stephen Joseph.*

acre property, situated on the west side of Coyote Valley just east of the Calero Reservoir, is located at the base of the foothills of the forested, east-facing slopes of the Santa Cruz Mountains and to the west of Santa Clara Valley and the drier grasslands, chaparral, and oak savanna of the Diablo Range. If the CVOSP had not been not protected in perpetuity, it is likely that at least 50 acres of the land would have been under development pressure, most recently represented by zoning proposed in the City of San Jose's Coyote Valley Specific Plan (City of San Jose, 2008).

Earth Economics conducted a limited ROI analysis (measuring non-market benefits only) of the CVOSP, with three primary goals:

1. To provide a conservative estimate of the public ROI due to the acquisition and protection of the CVOSP's existing ecosystem services in perpetuity;
2. To provide a basic framework for the Open Space Authority and other public and private organizations to estimate the ROI of land acquisitions; and
3. To demonstrate the use and utility of including ecosystem service values in economic analyses, and to ensure that these services can be integrated into existing economic metrics.

Estimating the Costs of the Coyote Valley Open Space Preserve

The Open Space Authority provided detailed information on the costs associated with the Preserve. Earth Economics grouped these costs into categories by type and frequency of occurrence, as summarized in Table 9. These costs are treated as public costs since the Open Space Authority is a public agency.

TABLE 9: Summary of Costs Associated with the Coyote Valley Open Space Preserve (CVOSP)

Cost	Amount	Frequency
Purchase of the CVOSP	$3,481,000	One-time payment
Capital improvements to the CVOSP	$750,000	One-time payment
Development of Management Plan for the CVOSP	$250,000	One-time payment
Annual stewardship of the CVOSP	$128,000	Ongoing annual payment

Estimating the Benefits of the Coyote Valley Open Space Preserve

Earth Economics identified several categories of public benefits provided by the CVOSP: Recreation; Other Ecosystem Services; and Grazing Revenue. Within the Recreation and Other Ecosystem Services categories, Earth Economics identified several benefit subcategories. The methods for estimating benefits for each of these categories are described below, followed by a summary of results, limitations, and assumptions.

Recreation

Earth Economics conducted a literature search relying on the publicly available ***Recreation Use Values Database for North America***[4], developed by Dr. Randall Rosenberger at Oregon State University. The database contains over 2,700 estimates of the use value of a range of recreational activities across the United States and Canada, expressed as dollars per person per activity day. The dollar estimates in the Rosenberger database represent the consumer surplus that visitors to the CVOSP receive. Consumer surplus is a measure of the value consumers gain by paying less than they would be willing to pay for a product. It is calculated by the amount consumers are willing to pay for a good or service minus what they actually pay.[5]

Consumer surplus values represent the public benefits that people receive for "free" by visiting the CVOSP, over and above the expenses they incur to visit the site. These values were used to ensure compatibility with the (public only) ecosystem service values used in this chapter. It should be emphasized that consumer surplus values for the CVOSP do not represent actual dollars spent in the local economy, but the value people place on these areas.

Based on observed visitorship to its other preserves, the Open Space Authority provided estimates for expected number of visitors to the CVOSP (approximately 30,000 per year), as well as what kinds of recreation would occur at the site. Studies were selected from the database if they were conducted on recreational activities similar to those that would occur at the CVOSP (specifically hiking, general recreation, and wildlife viewing), and if they were conducted in the US. Forest-based recreational studies were used due to the lack of recreation studies conducted in similar plant communities to the CVOSP (i.e. grasslands and oak woodlands), provided they met the above criteria. As discussed in Chapter 4, different plant communities can often provide similar levels of ecosystem services; therefore, Earth Economics considered forest-based hiking studies an appropriate proxy for the CVOSP.

The recreation opportunities at the Coyote Valley Open Space Preserve provide immense value to our communities. *Credit: Liv Ames.*

Earth Economics selected 58 study values based on 16 studies from the database, took an average of the values ($46.14/person/activity day), and applied it to the annual number of visitor days at the Preserve (30,000) to arrive at an annual value of $1,384,280 per year for the preserve's non-market recreational benefits.

Other Ecosystem Services

Using Benefit Transfer Methodology as described in Chapter 4, Earth Economics conducted an ecosystem service valuation of the CVOSP. Based on detailed knowledge of site characteristics and allowed uses, Earth Economics conducted a further review of primary valuation studies and removed those that were confirmed to not apply to the CVOSP. In addition to this, values for the service Recreation and Tourism were

[4] Available at http://recvaluation.forestry.oregonstate.edu/

[5] For example, if a consumer purchases an ice cream for $2, but would actually be willing to pay up to $3, their consumer surplus is $1. Consumer surplus does not show up as a cash flow in the economy but is an important economic concept for measuring value.

Revenue the Santa Clara Valley Open Space Authority receives from grazing leases is invested back into the management and stewardship of its open space preserves. *Credit: Charlotte Doudell.*

removed, since a recreational valuation was conducted as a separate analysis described previously.

The total annual value of these ecosystem services ranges from $1,066,292 on the low end and $1,242,169 on the high end. The average of this range, $1,154,231, was adopted for the ROI analysis. Table 10 provides a summary of the area of each land cover, annual per-acre value of each land cover, as well as total annual value based on area. The ecosystem services valued for each individual land cover type are detailed in Appendix C.

Grazing Revenue

The Open Space Authority estimated they would receive approximately $3,415 annually by leasing out land in the CVOSP to ranchers for grazing. In this study, grazing revenue was considered a public benefit because 1) the revenue was a result of the Open Space Authority's public investment in managing the CVOSP; and 2) the revenue is invested back into the stewardship of the preserve, which is a public asset.

TABLE 10: Land Cover and Ecosystem Service Production in the Coyote Valley Open Space Preserve

Land Cover	Restrictions					Area (acres)	Annual Per-Acre Value		Total Annual Value	
	Urban	Riparian	Agricultural	High Intensity	5 Acre		Low ($/acre/year)	High ($/acre/year)	Low ($/year)	High ($/year)
Cultivated Crops						3.0	$121	$2,517	$363	$7,537
Developed, Open Space						0.2	$524	$2,960	$92	$517
Evergreen			*			0.2	$478	$514	$106	$114
	*		*			0.4	$1,342	$1,903	$597	$846
Herbaceous/ Grassland			*		*	46.7	$2,086	$3,950	$97,474	$184,543
	*		*			1.8	$5,242	$5,505	$9,266	$9,731
	*		*		*	157.6	$5,242	$5,397	$825,984	$850,441
Mixed Forest			*			45.5	$489	$638	$22,229	$29,022
	*		*			67.1	$1,342	$1,903	$90,102	$127,733
Palustrine Emergent Wetland	*					0.2	$30,255	$46,944	$6,728	$10,440
Scrub/Shrub			•			7.6	$453	$721	$3,461	$5,507
	•		•			15.3	$453	$721	$6,952	$11,061
	•		•		•	6.5	$453	$721	$2,937	$4,674
TOTAL									**$1,066,292**	**$1,242,169**
AVERAGE									**$1,154,231**	

Table 11 summaries the economic value of the benefits provided by the CVOSP, and their frequency.

TABLE 11: Economic Benefits of the Coyote Valley Open Space Preserve

Benefit	Amount	Frequency
Recreation	$1,384,280	Annual
Other ecosystem services	$1,154,231	Annual
Grazing revenue	$3,415	Annual

Estimating the Return on investment of the Coyote Valley Open Space Preserve

After calculating estimated costs and benefits, Earth Economics ran an ROI analysis at Years 1, 5, 10, 15, and 20, with the results shown in Table 12. Because many of the costs are one-time, yet benefits accrue year after year, the average annual costs decrease over the long-term. The Open Space Authority's investment in acquisition, capital improvements, and ongoing stewardship of the CVOSP results in public and private benefits of at least $3 for every $1 invested after 10 years, and a return of $6 for every $1 invested after 20 years.

Coyote Valley Open Space Preserve. *Credit: Derek Neumann.*

TABLE 12: ROI Analysis of the Coyote Valley Open Space Preserve

AVERAGE ANNUAL COSTS	YEAR 1	YEAR 5	YEAR 10	YEAR 15	YEAR 20
Purchase	$3,481,000	$696,200	$348,100	$232,067	$174,050
One-Time Costs*	$1,000,000	$200,000	$100,000	$66,667	$50,000
Annual Stewardship	$127,655	$127,655	$127,655	$127,655	$127,655
Total Average Annual Costs	**$4,608,655**	**$1,023,855**	**$575,755**	**$426,388**	**$351,705**
AVERAGE ANNUAL BENEFITS	YEAR 1	YEAR 5	YEAR 10	YEAR 15	YEAR 20
Ecosystem Services	$1,154,231	$1,154,231	$1,154,231	$1,154,231	$1,154,231
Recreation	$1,384,280	$1,384,280	$1,384,280	$1,384,280	$1,384,280
Grazing Revenue	$3,415	$3,415	$3,415	$3,415	$3,415
Total Average Annual Benefits	**$2,541,926**	**$2,541,926**	**$2,541,926**	**$2,541,926**	**$2,541,926**
Return on Investment ($ returned per $ spent)	**-$0.45**	**$1.48**	**$3.41**	**$4.96**	**$6.23**

*Capital & management plan development.

Investment in protection of open space and natural capital can provide public benefits to the burgeoning population of San Jose (above) and the rest of the Santa Clara Valley. *Credit: cc Daniel Hoherd.*

Discussion and Applications

This chapter describes the first attempt to conduct an ROI analysis on any of the Open Space Authority's conservation actions. The results suggest that based on the public costs and benefits of the Coyote Valley Open Space Preserve alone, within the five years, the acquisition results in a positive return on public investment. This analysis provides a basic framework that conservation and land use planners, policymakers, and other stakeholders can use to estimate the value provided by conservation investments.

While this ROI framework can be used as a standalone tool, the analysis provides information that is complementary to more traditional conservation planning tools.

This analysis focuses specifically on the flow of public benefits, specifically recreation and other ecosystem services, in relation to the public costs. In the future, additional layers could be added that would result in a more nuanced and detailed ROI analysis. For example:

- As with the county-wide analysis, representation of a greater number of ecosystem services would improve the analysis. For example, due to data gaps, groundwater recharge and endangered species habitat were considered but not valued in this ROI or the county-wide valuation.
- An economic impact analysis could be conducted to determine whether visitor spending in Santa Clara County increases as a result of the CVOSP acquisition, compared with an alternative scenario (e.g. no acquisition, or a different acquisition).
- The economic flows resulting from acquiring the CVOSP could be compared with the economic flows resulting from the development alterative (remaining ecosystem services plus additional economic metrics such as property taxes, long term and short term jobs, costs of providing increased utilities and services such as fire, police and schools, road construction and maintenance, etc.). While not represented in this analysis of the CVOSP, development and implementation of a more robust ROI analysis is envisioned for future phases of *Healthy Lands & Healthy Economies*.

CHAPTER 6: A New Vision for a 21st Century Economy

Balancing Investment in Built and Natural Capital

Today's Santa Clara County economy hardly resembles the County's economy in 1914, 1934, or 1974. The economy of the 20th century built a high quality of life for people in Silicon Valley, but economies are not static. For 100 years, the development paradigm was one of a single solution for a single problem. Need communications? Put up a telephone line with rotary phones. Flooding? Build levees. Need water? Pump groundwater. Stormwater problem? Build pipes from the streets to the river. The 21st century is shifting to a development paradigm in need of a holistic systems approach. Infrastructure — built, natural, and human — is interlinked.

Every economy requires the right balance of built, natural, human and social capital. Santa Clara County, like much of the world, faces water scarcity, potential for increased flooding and climate uncertainty, loss of biodiversity, and a shrinking of natural capital assets such as agricultural land, rangelands, and other open spaces that have been a key part of providing needed goods and services for a successful economy and high quality of life. Silicon Valley has been a global leader in innovation, investing in technology that produces real value and real wealth. The valley has also been a leader in conserving natural capital, laying the foundation for a world-class network of protected areas and open spaces. By understanding and quantifying the economic benefit of these services, we can make strong arguments for the continued protection and stewardship of open space and the natural capital its supports. Santa Clara County can continue to be an innovator, conservation leader, and economic leader by making wise investments in natural capital.

The interconnections between built, natural, and human capital make them inseparable; maintaining a strong economy requires us to better understand all of these inputs so we can make wiser investments. *Credit: cc David, randomcuriosity.*

Natural capital provides an outstanding investment opportunity. Investing in and protecting natural capital avoids future costs, and produces clear economic returns in the present and future. Box 6 describes how partners in the South Bay Area are developing methods that utilize natural capital, in combination with built capital, as money-saving investments that protect communities against sea level rise, save taxpayer dollars, and restore natural systems. Revealing the full returns of these investments requires that we go beyond traditional analyses that measure only built capital, and include also the value of natural capital and its ecosystem services. Natural capital can have clear, fair, and high-return funding mechanisms paid for by its beneficiaries. For example, at least six US water utilities include on their water bills natural capital charges that support investment in watershed restoration and easement purchases, and many more utilities allocate part of their budget to watershed protection. The City of Bellingham, Washington has raised more than $28 million since 2001, which has allowed it to purchase and steward nearly 1,800 acres of open space surrounding its water source. Denver Water will raise $16.5 million for forest treatments and watershed protection over five years.

Investment in watershed protection and restoration has been shown to reduce built infrastructure costs while protecting water supply reliability. *Credit: Stephen Joseph.*

Open space protection yields multiple benefits. *Credit: Dave Tharp.*

Informed decision-making reveals innovative investment opportunities with low-risk returns. Integrated resource management projects underway in the Coyote Valley and the Pajaro Valley, can generate sustainable returns on investment while providing a diversity of ecosystem goods and services. These efforts could reduce flooding, increase groundwater recharge, prevent saltwater intrusion, produce local food, create valuable habitats that sequester carbon, and provide recreational opportunities.

A Framework for New Economic Measures

Economies cannot prosper without good management and investment, which require full information about economic assets, especially natural capital. Our capacity to measure the benefits of natural capital and integrate ecosystem benefits into traditional economic measures is growing. Taking a systems approach can reduce infrastructure conflicts and costs, facilitate partnerships, and produce higher returns on public and private investment. The identification and valuation of the goods and services provided by natural capital promotes informed and high-yield investments in open space.

The results of this report indicate that open space provides essential goods and important services efficiently and inexpensively. This concept provides a

BOX 5: Flood Risk and Climate Adaptation: A Natural Capital Solution

A recent report by the Bay Institute examined one natural infrastructure project for dealing with the threats of climate change. The Bay Institute estimated that in San Francisco Bay, the use of horizontal levees, which leverage the natural flood risk reduction services provided by restored tidal marshes, would reduce levee costs by 50% while providing the same level of protection (Bay Institute, 2013).

FloodSAFE California recently published California's Flood Future, a report estimating that over 132,000 people in Santa Clara County live within the 100-year floodplain, exposing over $15 billion in property to flood risks (FloodSAFE California, 2013). According to this report, the impacts of sea level rise "could be significant, especially in the South Bay Area where there are high levels of urbanization." The Bay Institute has envisioned a new model for protecting people and property from the potential impacts of sea level rise through tidal marsh restoration and a new horizontal levee design (Bay Institute, 2013). Instead of building and expanding current levees, smaller inland levees would be constructed behind restored tidal marsh and mud flat zones. The design also includes a sloped and vegetated freshwater zone to be irrigated with treats wastewater and stormwater, improving bay water quality (Downing et al., 2013). These restored areas would preserve essential marsh functions such as nursery grounds for fisheries and other wildlife.

Assuming 14 inches of sea level rise in the next 50 years, the cost of building these horizontal levees would be about half the cost of raising and maintaining the bayside levees (Bay Institute, 2013). This plan is an excellent example of a natural infrastructure solution that provides multiple ecosystem service benefits in a cost-efficient manner. According to the Bay Institute, "we are well on our way to restoring the massive tidal marsh complex that existed here prior to European colonization. By modifying the design and accelerating implementation, the restored tidal marsh network can play a key role in protecting communities and essential infrastructure around the Bay's shoreline for several decades." (Bay Institute, 2013)

framework for better coordination of planning, policy, and investment to secure greater and sustainable returns from natural capital assets.

The results of this study support the following conclusions:

1. Santa Clara County's landscape of natural capital assets and the associated ecosystem services are highly valuable and provide the foundation for our economy.
2. Natural assets provide vast value to the health and well-being of our communities.
3. Investment in these natural capital assets provides a high rate of return to all.
4. Greater investment in open space and its natural capital assets is required to ensure the continued prosperity and a high quality of life for the people of Santa Clara County.

Building Partnerships and Funding Mechanisms

Natural capital provides an integrated diversity of goods and services. Thus, coordinating planning between state, regional, and local levels is critical. Coordinated planning between agencies could save taxpayers and businesses money and increase economic returns from public investment by pooling investments and favoring infrastructure projects that leverage natural capital to provide multiple benefits. For example, Integrated Regional Water Management (IRWM), promoted by the California Department of Water Resources, incentivizes coordination between regional agencies to achieve sustainable water management in the state. Likewise, the State's Regional Advanced Mitigation Program (RAMP) looks to build non-traditional partnerships between state and federal public infrastructure agencies, local resource and planning agencies, and private and public

Coordinated protection of agricultural lands and wildlife habitat along the Upper Pajaro River can reduce both the potential for downstream flooding and the need for costly levees and stormwater infrastructure. *Credit: William K. Matthias.*

landowners interested in conservation. These proactive efforts focus on maximizing sustainable public benefits while reducing taxpayer investment.

Understanding the links between health, environment, water supply, quality of life, business employee retention, tax base, education, and open space naturally creates non-traditional partnerships where projects and resources overlap. Engaging the private sector with a combination of incentives, regulation, and public-private opportunities opens up entrepreneurial solutions to traditional problems that are intractable with a one-problem/one-solution approach. Collaboration between private companies, government agencies local to federal, and the philanthropic community can leverage resources.

New and emerging funding opportunities such as payments for ecosystem services could enable public and private landowners to increase their investments in stewardship of their open space and agricultural lands that provide myriad benefits to county residents.

Santa Clara County can position itself as a leader in open space and natural capital investment, reaping the rewards in jobs, reduced infrastructure costs, natural resource sustainability, and economic prosperity. Funding opportunities from new and emerging mechanisms include: AB32 climate auction revenues, CalTrans Regional Advanced Mitigation Planning funding, future water bond funding, Williamson Act funds, funding related to the Santa Clara Valley Habitat Conservation Plan, funding from the Water District's 2012 funding measure, and federal funds from the Natural Resource Conservation Service, US Forest Service, FEMA, and other agencies.

Legislation proposed in Washington state would create a Watershed Investment District, an institution that can rationalize investment across private and public agencies from the federal to the local level. This type of natural capital institution could help the county and cities coordinate natural capital investments with existing institutions and tax districts. This opens up greater opportunity for funding mechanisms. A Watershed Investment District could also help coordinate federal investments including FEMA and the US Army Corps of Engineers, along with state, county, and city agencies to avoid infrastructure conflict. Taking an integrated approach to managing built and natural capital can reduce infrastructure conflicts and costs, facilitate partnerships, and produce higher returns on public and private investment.

Recommendations

Recommendations: State, Regional, and Local Planning

City, county, utility, state, and regional agencies should:

- Identify ecosystem service protection areas in planning processes, including mitigation, open space, land use, water supply, watershed, and transportation planning.
- Integrate conservation, water supply, groundwater recharge, and flood mitigation investments.
- Include ecosystem service benefits in wildfire plans, strategies, and funding.

Santa Clara County agencies and utilities should:

- Coordinate mapping of Santa Clara County's ecosystem service provisioning areas.
- Quantify the economic benefits of ecosystem services, replacement services (if lost), and avoided costs in land use planning, mitigation, and infrastructure investments.
- Implement a Water Resources Master Plan partnership (Santa Clara Valley Open Space Authority and Santa Clara Valley Water District) for achieving integrated water resources management outcomes.
- Develop spatial decision support tools for optimizing public investment in natural resources, water resources, floodplain protection, and restoration.
- Adopt measurable environmental metrics to monitor the health of natural capital and ensure a continued flow of value from ecosystem services.

State, Regional, and Local Policy Implementation

State and regional policymakers and agencies should:

- Introduce statewide legislation to recognize, protect, and maintain/improve ecosystem services and the region's key natural and agricultural lands.
- Prioritize water supply, water quality, and flood control investments that include multiple ecosystem benefits and protect and restore natural capital.
- Account for ecosystem services, carbon sequestration, and climate change benefits resulting from protecting and stewarding open space and agricultural lands adjoining cities (Planned Conservation Areas) when implementing AB 32 and SB 375.
- Support funding for California's Williamson Act or new legislation that continues to successfully protect agricultural lands and improve stewardship of these lands for an array of economically critical ecosystem services.

Santa Clara County agencies and utilities should:

- Include the protection and maintenance of the County's natural capital and their ecosystem services in updates to the County and city general plans.
- Incentivize agricultural conservation/stewardship actions enhancing ecosystem services with the Planning Department, the Agricultural Commissioner, and private landowners.
- Develop a Regional Advanced Mitigation Program (RAMP) in Santa Clara County.
- Apply ecosystem services valuation data with benefit-cost analysis to achieve triple bottom line (Economy, Environment, Equity) outcomes.

Funding and Public/Private Investment in Natural Capital

State and regional agencies should:

- Develop natural capital investment strategies and priority conservation actions funded through bonds, AB 32 revenues, transportation funding (SB 375), and other mechanisms.
- Initiate new funding mechanisms in which the beneficiaries and damagers of ecosystem services pay, providing income to the provisioners of those services.
- Integrate natural capital valuation into funding allocation decisions for water and natural resources, incentivizing investment in natural infrastructure solutions that appreciate over time and provide multiple benefits.

Santa Clara County should:

- Include the protection and improvement of natural capital assets as eligible expenditures in local open space, water, and transportation funding measures.
- Promote public/private partnerships in Santa Clara County for micro-financing that secures local urban edge farms in and around Coyote Valley, Morgan Hill, and Gilroy to locally source food for the region's businesses and urban areas.
- Work with private landowners and funders to develop a pilot project in Coyote Valley/Southern Santa Clara County to evaluate and implement an incentive program that encourages stewardship of natural capital assets on private lands.
- Explore partnerships with the Open Space Authority, water districts, the Natural Resource Conservation Service, and Resource Conservation Districts to develop funding mechanisms for water supply enhancement in the Upper Pajaro River Basin and Coyote Creek Watershed.

These recommendations provide a beginning for fully integrating the value of natural capital into the economy of Santa Clara County.

Next Steps: Making Smart Conservation Investments

Smart investment is the key to securing prosperity and long-term value. An important advancement for private investment was the improved valuation and reporting required for private firms. Just as these private investors were largely blind to a company's value 100 years ago, firms, citizens, and decision-makers may be unable to make the best investment decisions without policies that build ecosystem service values into reporting standards and investment opportunities. Integrating the costs and benefits of conservation investments into infrastructure planning, finance, accounting, and climate change adaptation/mitigation can begin with the framework provided in this report. Well-informed land use decisions and natural resource management, integrated across the landscape and its services (e.g., water resources, parks, flood-risk reduction, biodiversity), build a more efficient economy and a foundation for successful firms and local governments.

Typically conservation projects have been measured by acres acquired, easements purchased, or trees planted. Today, the benefits of these conservation investments can also be estimated in dollar values. This enables better funding mechanisms where returns can be calculated for public and private conservation investments. It also provides the basis for financial incentive structures that promote conservation.

The framework and information provided by this report can be used by Santa Clara County, the State of California, city officials, and others to better inform decision-making and investment. Innovative economic measures, policies, funding mechanisms, and smart investment can come together in Santa Clara Valley and California to provide multi-benefit, sustainable solutions to secure healthy lands and healthy economies.

Continued prosperity and quality of life in the Santa Clara Valley will require us to invest in open space in new and innovative ways. *Credit: Stephen Joseph.*

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APPENDIX B: Study Limitations

The results of the first attempt to assign monetary value to the ecosystem services rendered by Santa Clara County have important and significant implications on the restoration and management of natural capital. A benefit transfer methodology (BTM) estimates the economic value of a given ecosystem (e.g., wetlands) from prior studies of that ecosystem type. Like any economic analysis, this methodology has strengths and weaknesses. While these limitations must be noted, they should not detract from the core finding that ecosystems produce a significant economic value to society. Some arguments against benefit transfer include:

1. Every ecosystem is unique; per-acre values derived from another location may be irrelevant to the ecosystems being studied.
2. Even within a single ecosystem, the value per acre depends on the size of the ecosystem; in most cases, as the size decreases, the per-acre value is expected to increase and vice versa. (In technical terms, the marginal cost per acre is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values.)
3. Gathering all the information needed to estimate the specific value for every ecosystem within the study area is not feasible. Therefore, the true value of all of the wetlands, forests, pastureland, etc. in a large geographic area cannot be ascertained. In technical terms, we have far too few data points to construct a realistic demand curve or estimate a demand function.
4. To value all, or a large proportion, of the ecosystems in a large geographic area is questionable in terms of the standard definition of exchange value. We cannot conceive of a transaction in which all or most of a large area's ecosystems would be bought and sold. This emphasizes the point that the value estimates for large areas (as opposed to the unit values per acre) are more comparable to national income account aggregates and not exchange values. These aggregates (i.e. GDP) routinely impute values to public goods for which no conceivable market transaction is possible. The value of ecosystem services of large geographic areas is comparable to these kinds of aggregates (see below).

Proponents of the above arguments recommend an alternative valuation methodology that amounts to limiting valuation to a single ecosystem in a single location. This method only uses data developed expressly for the unique ecosystem being studied, with no attempt to extrapolate from other ecosystems in other locations. An area with the size and landscape complexity of Santa Clara County makes this approach to valuation extremely difficult and costly. Responses to the above critiques can be summarized as follows (see Howarth and Farber, 2002 for more detailed discussion):

1. While every wetland, forest, or other ecosystem is unique in some way, ecosystems of a given type, by their definition, have many things in common. The use of average values in ecosystem valuation is no more or less justified than their use in other macroeconomic contexts; for instance, the development of economic statistics such as Gross Domestic or Gross State Product. This study's estimate of the aggregate value of Santa Clara County's ecosystem services is a valid and useful (albeit imperfect, as are all aggregated economic measures) basis for assessing and comparing these services with conventional economic goods and services.
2. The results of the spatial modeling analysis described in other studies do not support an across-the-board claim that the per-acre value of forest or agricultural land depends on the size of the parcel. While the claim does appear to hold for nutrient cycling and other services, the opposite position holds up fairly well for what ecologists call "net primary productivity" or NPP, which is a major indicator of ecosystem health. It has the same position, by implication, of services tied to NPP — where each acre makes about the same contribution to the whole, regardless of whether it is part of a large plot of land or a small one. This area of inquiry needs further

research, but for the most part, the assumption that average value is a reasonable proxy for marginal value is appropriate for a first approximation. Also, a range of different parcel sizes exists within the study site, and marginal value will average out.

3. As employed here, the prior studies we analyzed encompass a wide variety of time periods, geographic areas, investigators, and analytic methods. Many of them provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were deemed to be "too high" or "too low." Limited sensitivity analyses were also performed. This approach is similar to determining an asking price for a piece of land based on the prices of comparable parcels; even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.
4. The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza et al. (1997) of the value of all of the world's ecosystems. Leaving that debate aside, one can conceive of an exchange transaction in which, for example, all of, or a large portion of a watershed was sold for development, so that the basic technical requirement of an economic value reflecting the exchange value could be satisfied. Even this is not necessary if one recognizes the different purpose of valuation at this scale – a purpose that is more analogous to national income accounting than to estimating exchange values (Howarth and Farber 2002).

In this report, we have displayed our study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value, or, alternatively, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it seems better to be approximately right than precisely wrong.

The estimated value of the world's ecosystems presented in Costanza et al. (1997), for example, has been criticized as both (1) a serious underestimate of infinity and (2) impossibly exceeding the entire Gross World Product. These objections seem to be difficult to reconcile, but that may not be so. Just as a human life is priceless, so are ecosystems — yet people are paid for the work they do.

Upon some reflection, it should not be surprising that the value ecosystems provide to people exceeds the gross world product. Costanza's estimate of the work that ecosystems do is an underestimate of the infinite value of priceless systems, but that is not what he sought to estimate. Consider the value of one ecosystem service, such as photosynthesis, and the ecosystem good it produces: atmospheric oxygen. Neither is valued in Costanza's study. Given the choice between breathable air and possessions, informal surveys have shown the choice of oxygen over material goods is unanimous. This indicates that the value of photosynthesis and atmospheric oxygen to people exceeds the value of the gross world product — and oxygen production is only a single ecosystem service and good.

General Limitations

- **Static Analysis.** This analysis is a static, partial equilibrium framework that ignores interdependencies and dynamics, though new dynamic models are being developed. The effect of this omission on valuations is difficult to assess.
- **Increases in Scarcity.** The valuations probably underestimate shifts in the relevant demand curves as the sources of ecosystem services become more limited. The values of many ecological services rapidly increase as they become increasingly scarce (Boumans et al., 2002). If Santa Clara County's ecosystem services are scarcer than assumed here, their value has been underestimated in this study. Such reductions in supply appear likely as land conversion and development proceed; climate change may also adversely affect the ecosystems, although the precise impacts are more difficult to predict.

- **Existence Value.** The approach does not fully include the infrastructure or existence value of ecosystems. It is well known that people value the existence of certain ecosystems, even if they never plan to use or benefit from them in any direct way. Estimates of existence value are rare; including this service will obviously increase the total values.
- **Other Non-Economic Values.** Economic and existence values are not the sole decision-making criteria. A technique called multi-criteria decision analysis is available to formally incorporate economic values with other social and policy concerns (see Janssen and Munda, 2002 and de Montis et al., 2005 for reviews). Having economic information on ecosystem services usually helps this process because traditionally, only opportunity costs of forgoing development or exploitation are counted against non-quantified environmental concerns.

GIS Limitations

- **GIS Data.** Since this valuation approach involves using benefit transfer methods to assign values to land cover types based, in some cases, on their contextual surroundings, one of the most important issues with GIS quality assurance is reliability of the land cover maps used in the benefits transfer, both in terms of categorical precision and accuracy.
  - *Accuracy:* The source GIS layers are assumed to be accurate but may contain some minor inaccuracies due to land use changes done after the data was sourced, inaccurate satellite readings, and other factors.
  - *Categorical Precision:* The absence of certain GIS layers that matched the land cover classes used in the Earth Economics database created the need for multiple datasets to be combined.
- **Ecosystem Health.** There is the potential that ecosystems identified in the GIS analysis are fully functioning to the point where they are delivering higher values than those assumed in the original primary studies, which would result in an underestimate of current value. On the other hand, if ecosystems are less healthy than those in primary studies, this valuation will overestimate current value.
- **Spatial Effects.** This ecosystem service valuation assumes spatial homogeneity of services within ecosystems, i.e., that every acre of forest produces the same ecosystem services. This is clearly not the case. Whether this would increase or decrease valuations depends on the spatial patterns and services involved. Solving this difficulty requires spatial dynamic analysis. More elaborate system dynamic studies of ecosystem services have shown that including interdependencies and dynamics leads to significantly higher values (Boumans et al., 2002), as changes in ecosystem service levels ripple throughout the economy.

Benefit Transfer/Database Limitations

- **Incomplete coverage.** That not all ecosystems have been valued or studied well is perhaps the most serious issue, because it results in a significant underestimate of the value of ecosystem services. More complete coverage would almost certainly increase the values shown in this report, since no known valuation studies have reported estimated values of zero or less.
- **Selection Bias.** Bias can be introduced in choosing the valuation studies, as in any appraisal methodology. The use of a range partially mitigates this problem.
- **Consumer Surplus.** Because the benefit transfer method is based on average rather than marginal cost, it cannot provide estimates of consumer surplus. However, this means that valuations based on averages are more likely to underestimate total value.

Primary Study Limitations

- **Willingness-to-pay Limitations.** Many estimates are based on current willingness-to-pay or proxies, which are limited by people's perceptions and knowledge base. Improving people's knowledge base about the

contributions of ecosystem services to their welfare would almost certainly increase the values based on willingness-to-pay, as people would realize that ecosystems provided more services than they had previously known.

- **Price Distortions.** Distortions in the current prices used to estimate ecosystem service values are carried through the analysis. These prices do not reflect environmental externalities and are therefore again likely to be underestimates of true values.
- **Non-linear/Threshold Effects.** The valuations assume smooth responses to changes in ecosystem quantity with no thresholds or discontinuities. Assuming (as seems likely) that such gaps or jumps in the demand curve would move demand to higher levels than a smooth curve, the presence of thresholds or discontinuities would likely produce higher values for affected services (Limburg et al., 2002). Further, if a critical threshold is passed, valuation may leave the normal sphere of marginal change and larger-scale social and ethical considerations dominate, such as an endangered species listing.
- **Sustainable Use Levels.** The value estimates are not necessarily based on sustainable use levels. Limiting use to sustainable levels would imply higher values for ecosystem services as the effective supply of such services is reduced.

If the above problems and limitations were addressed, the result would most likely be a narrower range of values and significantly higher values overall. At this point, however, it is impossible to determine more precisely how much the low and high values would change.

APPENDIX C: Value Transfer Studies Used By Land Cover

Due to space considerations, Appendix C has been made available online here:
http://www.eartheconomics.org/FileLibrary/file/California/Santa_Clara_ESV_Appendix_Values_by_Land_Cover.pdf

APPENDIX D: Value Transfer Studies Used: Annotated Bibliography

Due to space considerations, Appendix D has been made available online here:
http://www.eartheconomics.org/FileLibrary/file/California/Santa_Clara_ESV_Appendix_Annotated_Bibliography.pdf

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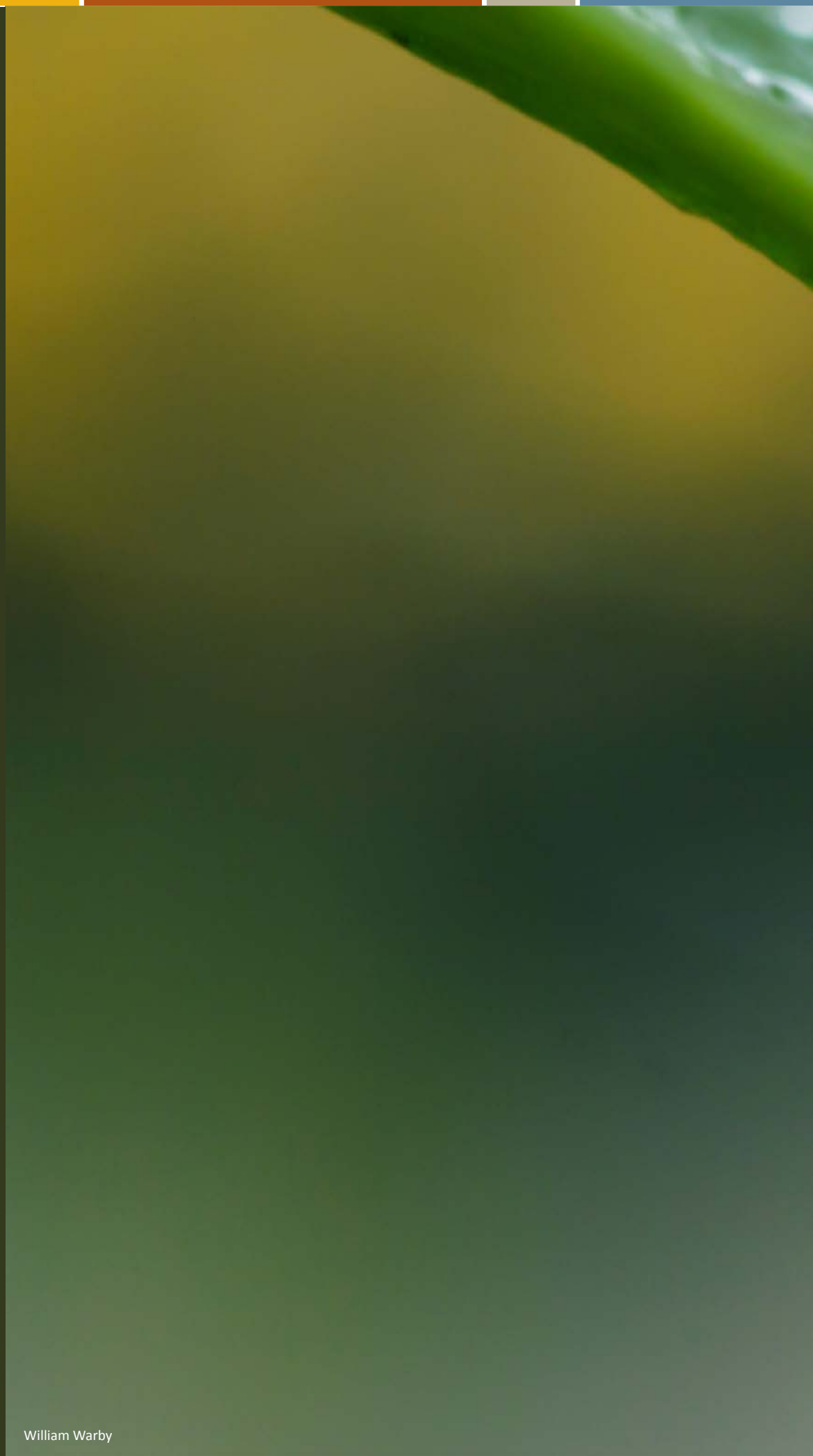

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