THE ECONOMIC IMPACT OF 2016 LOMA FIRE

EARTH ECONOMICS

The Economic Impact of the 2016 Loma Fire

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EXECUTIVE SUMMARY

High intensity wildfire events in the Santa Cruz Mountains are becoming more common and much costlier. Yet, little work has been done to calculate the comprehensive impact of these events on local communities, landowners, agencies, and residents. The Santa Clara Valley Open Space Authority (OSA) requested this comprehensive cost analysis of the September 2016 Loma Fire in Santa Clara County to better understand the challenge and to begin a discussion about changes in policy and stewardship that would reduce the scale and cost of future wildfire events.

The Loma Fire in the Santa Cruz Mountains was ignited by a structure fire, and was ultimately burned more than 4,400 acres, destroyed 12 homes, and required a massive emergency response to control and extinguish. The fire illustrated the increasing frequency and intensity of wildfires in response to climate change and drought and embodied the core issues at the expanding urban-wildland interface. As residents move into wild, fire-prone areas, the risk of human-caused fire, the cost of defending structures, and the complexity of fuel reduction and forest stewardship all consequently increase.

The difficulty in gathering comprehensive cost data for the Loma Fire shows that planners and policy makers do not have the full data needed to understand the short- and long-term costs of these events to their communities. Costs are recognized in multiple categories, and often tracked and funded by different agencies and groups. In an effort to gain a more complete understanding of the cost of this event, the project team gathered data from state and county fire and emergency response officials, water and power utilities, OSA, and local realtors, among others. This report also collects the best data and methods available to estimate the full impact of the fire on local ecosystems and, specifically, the goods and services that those ecosystems provide to the local economy and community.

The results of the study, shown below, place the total cost of the Loma Fire between $29 million and $34.5 million. This estimate is conservative because some data was inaccessible or could not be calculated. The numbers are also conservative because there remains risk, and potential cost, for future damages due to erosion, landslides, and other adverse events in the fire scar.

Total ecosystem service loss due to Loma Fire, including services lost over ten years, carbon storage losses, and sedimentation amounts to $2.3 million to $7.9 million. Response to the Loma Fire cost the State of California and OSA approximately $16.5 million to date. Finally, the homes lost, estimated damage to utility infrastructure, and restoration recovery amounted to approximately $7.2 million, $1.8 million, and $1.3 million respectively. **The total cost of Loma Fire was estimated to be between $29 million and $34.5 million to date.**

Given that the frequency, intensity, and total cost of these events will likely continue to rise, stakeholders could benefit from an in-depth review and discussion about measures that could reduce damages from future wildfires. Opportunities fall into two categories. The first is to establish funding mechanisms to support ongoing stewardship that promotes a healthy ecosystem, reduces fuel loads via mechanical removal and prescribed 'cool' burns, and provides ready access to first responders. Severe rainstorms during the winter of 2016 significantly damaged OSA's preserves. Through the State Office of Emergency Services, OSA is seeking repair and restoration funds, informing its grant application with data such as that presented in this report. The second area of opportunity is to align incentives and policies to increase structures' ability to withstand fire while also minimizing the number of structures in the highest risk areas. Measures to reduce risk and cost will require extensive local discussion and analysis to best meet the needs of the many stakeholders, but the financial return in avoided future damages will likely make the investment in time and resources well worth it. Santa Clara County can benefit directly from programs developed in other parts of California, Colorado, and Utah that are already breaking new ground.

1. Introduction: Natural Capital and California Wildfires in Santa Clara County

Fire plays an essential role in renewing and sustaining the fire-adapted ecosystems that are common in California's central coastal region. Historically, fires burned in the Santa Cruz Mountains every 30 to 50 years, creating openings between patches of grassland chaparral.[1] Taller oak, pines, and madrone forests burned less frequently because they did not have a grassy understory to help carry the fire. Native Americans used controlled burning as hunting and foraging aids without causing significant damage to the greater ecosystems.[2]

Today, human impacts and prolonged drought allow forest stands to encroach on meadows and burn more intensely. Higher temperatures and less frequent rain events increase the amount of moisture that evaporates from land and water, also causing rainfall patterns to shift. With drier conditions, the likelihood of wildfires increases. Climatic changes resulting in earlier snowmelt and higher temperatures also lead to longer fire seasons – two months longer on average – than in the 1970s.[3] Additionally, a past policy of aggressive fire suppression has built up fuel loads in wildland areas. Wildfires now burn twice as many acres per year than they did 40 years ago.

The Loma Fire, and high-intensity fires like it, are highly damaging, tremendously costly, and increasingly common. High-intensity wildfires require rapid emergency response, evacuations, and extensive post-fire restoration, resulting in millions of dollars of damage. Ecosystems have suffered extensive damage with losses to habitat and slope stability that further damage water quality, recreational opportunities, and a host of other benefits provided by nature. Uncontrolled high-temperature wildfire can have long-term ecological effects. Healthy trees are reduced to snags; shrubs that provided food and cover for wildfire become ashes; intense heat vaporizes soil nutrients, sending dust into the air. Intensely burned areas also elevate the risk of erosion and landslides, inhibit regrowth, and leave a longer-lived scar on the landscape.

Santa Clara County is well acquainted with such high-intensity wildfires and their far-reaching effects. In 1985, one severe forest fire burned 13,800 acres and over 50 percent of the watershed that supplies water to Lexington Reservoir. The fire cost $1.2 million to fight and caused $7 million in damage to homes and other property.[4] The Santa Clara Valley Water District (SCVWD), which owns and maintains Lexington Reservoir, hoped to sponsor major sediment entrapment projects following the fire. These funds were not granted due to limitations associated with using public funds to make improvements on private property. The next month, an unanticipated series of tropical storms showered 25.5 inches of intense rainfall over the burn area, causing significant flooding and bank failures after runoff from burned, hydrophobic soils reached channels nearly instantaneously.[5] The 1985 Lexington Fire clearly illustrates the critical nature of immediate post-fire restoration to avoid the stream channel scour and sedimentation that threatens downstream reservoirs. This case also highlights the impact that unanticipated events can have on the County's critical water infrastructure and underscores the need for adequate funding in support of stewardship and management of critical natural capital assets on public and private open space. Similarly, the Loma Fire of 2016 was followed by the heaviest rainfall in California's recorded history, which caused slides and other damage to OSA preserves, including in the fire-damaged areas. Recognizing the monetary value of natural systems is essential in justifying funding for wildfire recovery and restoration.

The purpose of this study is to quantify the nature and cost of damage from the 2016 Loma Fire and to recommend measures that will help to mitigate or more quickly respond to future fire-related damages. We begin by introducing the concept of natural capital in the context of the Santa Cruz Mountains landscape where the Loma Fire struck. The natural capital framework is then used to measure and evaluate the economic value of built and natural systems lost to the high-intensity burn. The report concludes with a discussion of fire recovery, exploring the implications of new policy that may assist local communities in funding the recovery effort. Finally, we recommend next steps as the Open Space Authority considers how to address future fire threats.

2. What is Natural Capital

Natural capital consists of the minerals, energy, plants, animals, and ecosystems found on Earth that provide a flow of natural goods and services.[6] Ecosystems perform natural functions (such as intercepting rainfall and preventing soil erosion) and provide goods and services that humans need to survive (e.g., a clean water supply and reduction of downstream flooding). The benefits that humans receive from nature, many of which are generally taken for granted, are known as ecosystem goods and services.

Clean air, clean water, healthy food, flood risk reduction, waste treatment, and stable atmospheric conditions are all examples of ecosystem goods and services. Without natural capital, we would not have the benefit of these services, which are in fact the basis of economic activity. For example, Chesbro and Uvas Reservoirs downstream of the burn area, which regulate stream flows that contribute to groundwater recharge, are compromised by sediment deposition if upstream vegetation is not maintained and healthy.[14] Nearby communities rely on groundwater for water supply. Likewise, the health of special status species is dependent on the integrity and stabilization of upstream watershed slopes, which are prone to erosion following wildfire.

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 assessed 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 to 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."[7] This study produced the landmark Millennium Ecosystem Assessment, which classifies ecosystem services into four broad categories according to how they benefit humans. These categories are as follows:

- **Provisioning goods and services** provide physical materials and energy for society that vary according to the ecosystems in which they are found. Forests produce lumber, agricultural lands supply food, and rivers provide drinking water.

- **Regulating services** are benefits obtained from the natural control of ecosystem processes. Intact ecosystems keep disease organisms in check, maintain water quality, control soil erosion or accumulation, and regulate climate.

- **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.

- **Information 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 defines the 21 ecosystem services within these four categories.

Table 1. Ecosystem Services Definitions

Service	Economic Benefit To People
Provisioning	
Energy and Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy
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
Water Storage	Providing long-term reserves of usable water via storage in lakes, ponds, aquifers, and soil moisture[8]
Regulating	
Air Quality	Providing clean, breathable air
Biological Control	Providing pest, weed, and disease control
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes
Moderation of Extreme Events	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts
Pollination and Seed Dispersal	Pollinating wild and domestic plant species via wind, insects, birds, or other animals
Soil Formation	Accumulating soils (e.g. via plant matter decomposition or sediment deposition in riparian/coastal systems) for agricultural and ecosystem integrity
Soil Quality	Maintaining soil fertility and capacity to process waste inputs (bioremediation)
Soil Erosion Control	Retaining arable land, slope stability, and coastal integrity
Water Quality	Removing water pollutants via soil filtration and transformation by vegetation and microbial communities[9]
Stormwater Retention	Regulating the rate of water flow through an environment and ensuring adequate water availability for all water users[9]
Navigation	Maintaining adequate depth in a water body to sustain traffic from recreational and commercial vessels
Supporting	
Habitat	Providing shelter, promoting growth of species, and maintaining biological diversity
Information	
Aesthetic Information	Enjoying and appreciating the scenery, sounds, and smells of nature
Cultural Value	Providing opportunities for communities to use lands with spiritual, religious, and historic importance[10]
Science and Education	Using natural systems for education and scientific research
Recreation	Experiencing the natural world and enjoying outdoor activities

Source: Compiled from Daly and Farley 2004[11] and de Groot 2002[12]

3. Study Area and the Loma Fire Overview

Southwest Santa Clara County is no stranger to wildfire. Shielded from moist Pacific Ocean breezes, the area has had six wildfires over the past 20 years. The region west of Morgan Hill and Gilroy is classified by Cal Fire as a "Very High Risk" fire and severity zone. Notable fires in the history of the region include the Austrian Gulch Fire (1961, nine thousand acres), the Lexington Fire (1985, 13,000 acres), the Croy Fire (2002, three thousand acres), the Summit Fire (2008, four thousand acres), and the 2009 Loma Fire (2009, five hundred acres).[13] In addition to wildfire risk, the region is known as "one of the most seismically active areas of the US" contributing to risk of landslides.[14]

The 2016 Loma Fire started on September 26, 2016 in the Santa Cruz Mountains in southwestern Santa Clara County, and was declared contained on October 12, 2016. Although the official cause of ignition has yet to be released, news outlets have reported that a structure fire near Loma Chiquita Road and Loma Prieta Road, about ten miles northwest of Morgan Hill, was the origin.[15] The burn area quickly grew to straddle the Santa Cruz and Santa Clara county line, eventually covering a total area of 4,474 acres. Figure 1 shows the boundaries of the fire.

3.1. Geography and Major Features

The fire area is mostly steep, rugged terrain, ranging in elevation from the lowest point of 800 feet above sea level to the highest ridge at 3,786 feet. Coastal scrub, oak woodland, chaparral, mixed hardwood/conifer, grassland, and coast redwoods make up most of the vegetation in the area. Table 1 shows the distribution of land cover types according to the National Land Cover Dataset (NLCD-2011).

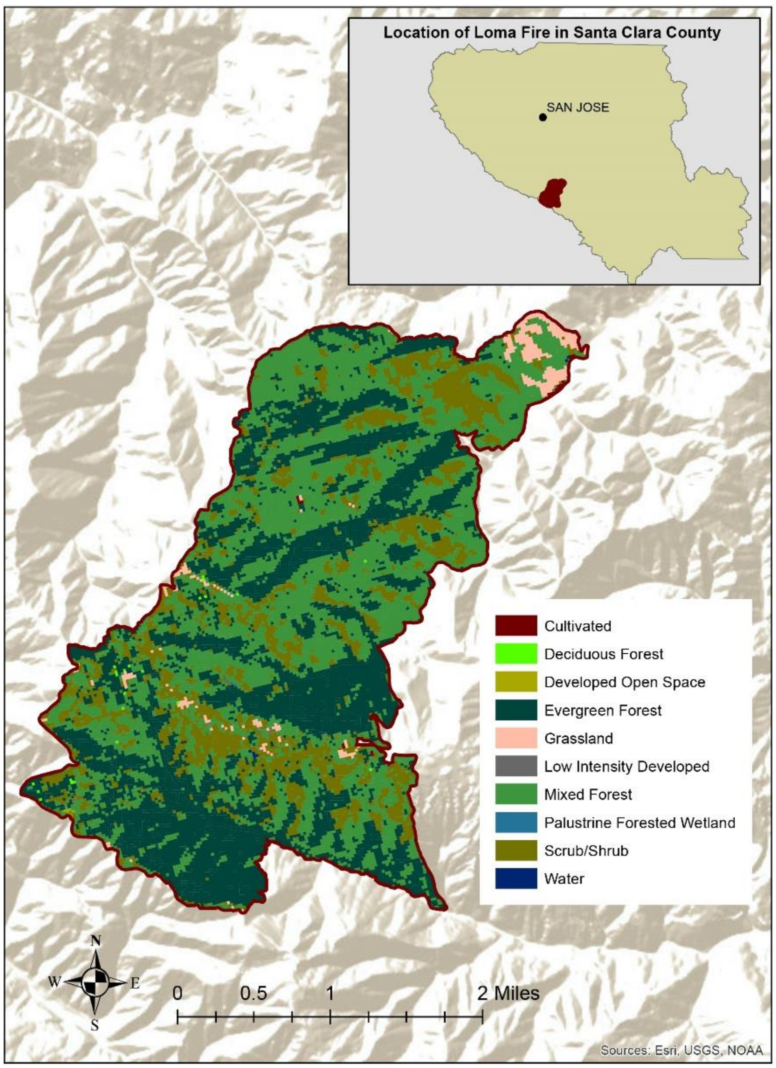
Table 1. Land Cover Types before the Loma Fire

Land Cover Type	Area (acres)
Forest - Mixed	1836.6
Forest - Evergreen	1732.4
Scrub/Shrub	805.2
Grassland	85.3
Forest - Deciduous	5.1
Cultivated	3.3
Developed - Low Intensity	2.0
Water	1.3
Developed - Open Space	1.2
Wetland - Emergent	1

The burn area also includes riparian habitat, though much of the riparian zone was not as severely burned, and should recover more rapidly to pre-fire conditions. Additionally, the Loma Fire burned 22 percent of the Upper Llagas Creek watershed and eight percent of the Upper Uvas Creek watershed. These watersheds drain to the southeast into the Chesbro and Uvas Reservoirs, respectively, both of which provide flood control and help recharge underground aquifers supplying groundwater managed by the Santa Clara Valley Water District.

Loma Fire burned 22% of the Upper Llagas Creek watershed and 8% of the Upper Uvas Creek watershed.

Figure 1. Land Cover in the Loma Fire Boundary



Soils throughout the burn area are shallow and derived from weathered bedrock. Although baseline erosion data are limited, the available data show high variability year-over-year. The Watershed Emergency Response Team (WERT) Final Report prepared by California Department of Forestry and Fire Protection (CAL FIRE), estimates pre-fire erosion rates of roughly 0.5 to 1.0 tons per acre for Llagas Creek Watershed and slightly higher rates for Uvas Creek Watershed. Evidence of pre-fire landslides are found throughout both drainages. Small shallow debris slides and debris flow deposits are common, many of which are attributed to a January 1982 storm. The largest slides in the area have been attributed to steep terrain, weak bedrock, and/or seismic faults, but they are nonetheless believed to be dormant. The area receives 35 inches of rainfall annually and is also prone to high intensity events causing significant flooding in both watersheds an average of once every four years since 1955.[16]

3.2. Population and Land Ownership

With a population of over 40,000 residents, Morgan Hill is the nearest urban community approximately seven miles to the east of the burn area.[16] Just to the south of Morgan Hill, the city of Gilroy has a population of 50,000.[17] Both cities are in close proximity to high-risk fire hazard areas in the Santa Cruz Mountains.

The burn area is rural, with dispersed housing and a mixture of improved and unimproved roads in an otherwise natural area. Many of the residential lots are ten acres or more,[18] and over half of the land burned in the Loma Fire (2,400 acres) is privately owned. A small portion of land (127 acres) is owned by the Midpeninsula Regional Open Space District. The remaining 1,900 acres is owned and managed by the Santa Clara Valley Open Space Authority.

3.3. Severity of the Burn

Fifty-five percent of the burn area experienced moderate to high soil burn severity. Table 2 shows the distribution of burn across each severity category for multiple land cover types. Definitions of each burn severity type are also provided. The picture on the right shows a moderate to severe burn five months after Loma Fire.

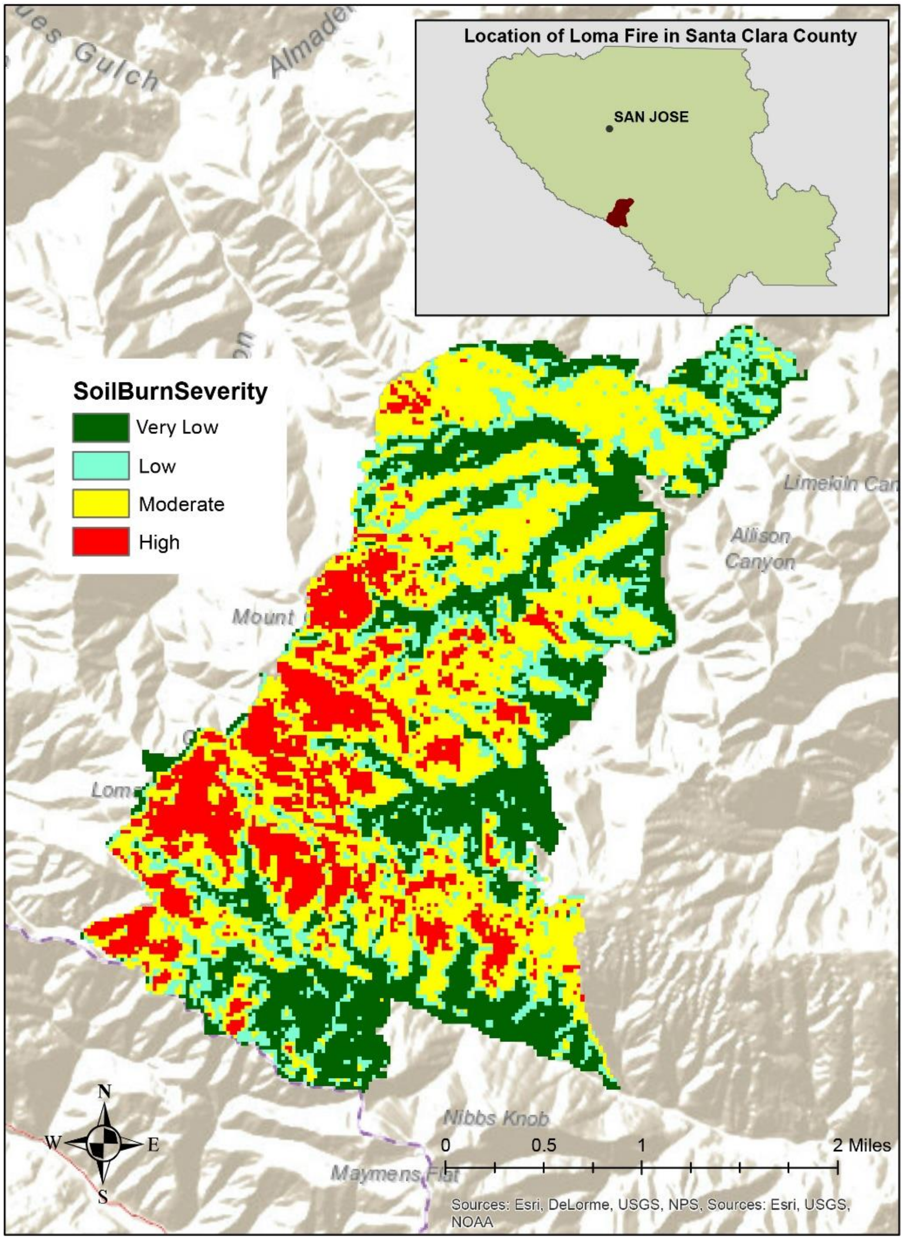
Table 2. Loma Fire Boundary Burn Severity by Land Cover Type and Definitions

Land Cover	Burn Severity				
	High	Moderate	Low	No Burn	% Total
Forest - Mixed	303	860	279	385	**41.1%**
Forest - Deciduous	3	1	0	0	**0.1%**
Forest - Evergreen	229	356	329	810	**38.8%**
Grassland	2	23	40	19	**1.9%**
Scrub/Shrub	201	493	73	32	**18.0%**
Wetland - Emergent	0	0	0	2	**>0.1%**
% Total	**16.6%**	**39.0%**	**16.2%**	**28.1%**	

Burn Severity	Definition[19]
Very Low	Fire has very lightly charred only the litter and fine fuels on the ground; soil organic matter, structure, and infiltration are unchanged.
Low	Low soil heating and lightly ground char occurs; mineral soil is not changed; original forms of surface materials, such as needle litter or lichens may be visible; very little change in runoff response. Indicators include very small diameter (<¼ inch) foliage and twigs are consumed.
Medium	Moderate soil heating with moderate ground char; soil structure is usually not altered; decreased infiltration due to fire-induced water repellency may be observed; shallow light colored ash layer and burned roots and rhizomes are usually present. Indicators include understory foliage; twigs (¼ to ¾ inch) are consumed.
High	High soil heating, or deep ground char occurs; duff is completely consumed; soil structure is often destroyed due to consumption of organic matter; decreased infiltration due to fire induced water repellency is often observed over a significant portion of the area; Other indicators include large fuels > ¾ inch including major stems and trunks are consumed or heavily charred.

Figure 2 shows the same information on an area map. Areas with moderate to high burn severity are more prone to increased flood flows, sedimentation, erosion, debris flows, and shallow landslides. Significant storm events in late 2016 and early 2017 have reactivated preexisting slide features, caused culverts to fail, damaged or destroyed roads, and increased non-point sediment loads in local streams.[20]

Figure 2. Soil Burn Severity Map of Loma Fire



3.4. Loma Fire Response

A Cal Fire early warning system identified smoke from the fire within minutes of ignition and started a massive response. In total, over 2,000 firefighters, 76 fire engines, four helicopters, nine bulldozers, and 14 water tenders were deployed to contain and extinguish the fire. Authorities called for mandatory evacuation of hundreds of residents.[21] The Red Cross established evacuation facilities and the Santa Clara County Office of Emergency Management controlled traffic and provided additional support.

4. Ecosystem Service Value Prior to the Loma Fire

To measure the economic value of ecosystem service lost to the Loma Fire, we must first identify the value of the natural systems, as they existed prior to the fire. In this section, we explore the pre-fire conditions within the Loma Fire boundary, using natural capital concepts to value the area's environmental benefits.

4.1. Ecosystem Service Valuation Methodology

This study employed the benefit transfer method (BTM) to derive the dollar values for each ecosystem service across each land cover type. BTM, similar to a house or business appraisal, is used when the cost of conducting original studies on every ecosystem service for every vegetation type is cost- or time-prohibitive. In BTM, an estimate for the value of ecosystem services is obtained by analyzing a group of studies that have valued similar ecosystem services in similar geographies and/or contexts. The transfer refers to the application of derived values and other information from the original study site.[22] As the "bedrock of practical policy analysis,"[23] BTM has gained popularity in recent decades as decision makers have sought timely, cost-effective ways to value ecosystem services and natural capital.[24] An economic assessment of natural capital damages revealed the full extent of the damage caused by the 2013 Rim Fire.[25] This assessment was used to assist the State of California to declare a federal disaster to FEMA, making federal funds available for post-fire recovery.

The values in this report were taken from Earth Economics' comprehensive database of peer-reviewed valuation studies of ecosystem services.[26] Table 3 summarizes the suite of ecosystem services that were identified and that could be valued for each land cover type within the Loma Fire boundary.

Table 3. Ecosystem Services Identified and Valued within the Loma Fire Burn Area[27]

	Grassland	Deciduous Forest	Evergreen Forest	Shrub/Scrub	Mixed Forest	Emergent Wetlands
Climate Stability	X	X	X	X	X	X
Moderation of Extreme Events		X	X	X	X	X
Soil Erosion Control	X		X			
Stormwater Retention			X	X	X	
Water Supply			X		X	X
Biological Control		X	X		X	
Water Filtration		X	X		X	X
Habitat		X	X		X	X
Aesthetic Information	X	X				X
Recreation	X	X	X	X	X	X

Key:

	Ecosystem service produced by land cover, no dollar value established
X	Ecosystem service produced by land cover and dollar value(s) provided

Ten ecosystem services were assessed for value. Each of the eleven land cover types in the Loma Fire burn area was valued for one or more ecosystem services. Within these, 39 ecosystem service/land cover type combinations were valued. Some ecosystem services known to exist within the burn area could not be monetarily valued due to a lack of published, peer-reviewed studies identifying their value. However, a lack of data does not indicate that these services do not have monetary value.

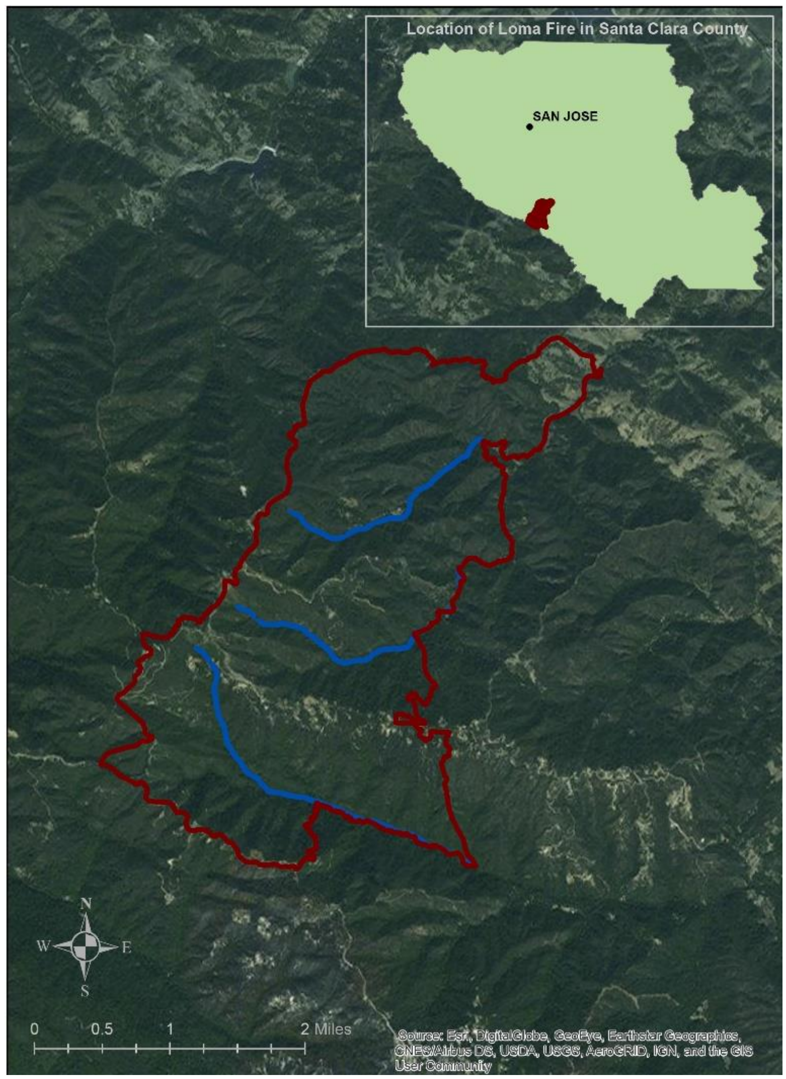
4.1.1. Ecosystem Service Riparian Characterization

For the most accurate analysis of ecosystem services value, this study characterized ecosystem services by their proximity to riparian buffers. 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 many ecosystem services is tied to a physical location in the landscape or to proximity to specific land uses or beneficiaries. For example, the habitat provided by trees and grasses adjacent to creeks (riparian buffers) is likely much more important for more species, and thus more valuable, than similar habitat farther away from water sources.

To better approximate the production of services and the physical location of beneficiaries represented in the primary studies, Earth Economics determined whether an applicable primary study value was within a riparian buffer. For this study, a riparian buffer was outlined using Geographic Information System (GIS) tools and external data.[28] All areas within 50 feet of stream channel flowlines that have either perennial status or a Geographic Name Information System identification number were considered riparian buffers.

4.2. Ecosystem Service Value before the 2016 Loma Fire

Each ecosystem service value was calculated for every land cover type found within the burn area. These values were then combined to generate a per-acre-per-year value by land cover. As noted above, areas within the riparian buffer were calculated separately from those outside the buffer. All values were adjusted to 2016 dollars.



The results were summed across all land cover types to calculate a total annual value of ecosystem services for the burn area before the fire. Table 4 summarizes the value of each ecosystem service across the various land cover types represented. Appendix B and C provide a list of references for all values used in Table 4 below.

Table 4. Total Ecosystem Service Value by Land Cover before the Loma Fire

Land Cover (Condition)	Acres	Total Ecosystem Service Value*			
		Per Acre/Year		Per Year	
		Min	Max	Min	Max
Forest - Deciduous	5	$1,505	$2,296	$7,525	$11,480
Forest - Evergreen	1,675	$606	$1,089	$1,014,748	$1,823,713
Forest - Evergreen (Riparian)	49	$603	$1,942	$29,530	$95,174
Forest - Mixed	1,798	$241	$918	$433,143	$1,649,898
Forest - Mixed (Riparian)	28	$613	$1,979	$17,158	$55,413
Grassland	84	$14	$76	$1,144	$6,370
Shrub/Scrub	800	$59	$80	$47,133	$63,928
Wetlands - Emergent	2	$2,581	$9,427	$5,161	$18,853
			Total	**$1,555,543**	**$3,724,829**

* All values in 2016 dollars

4.2.1. Carbon Sequestration

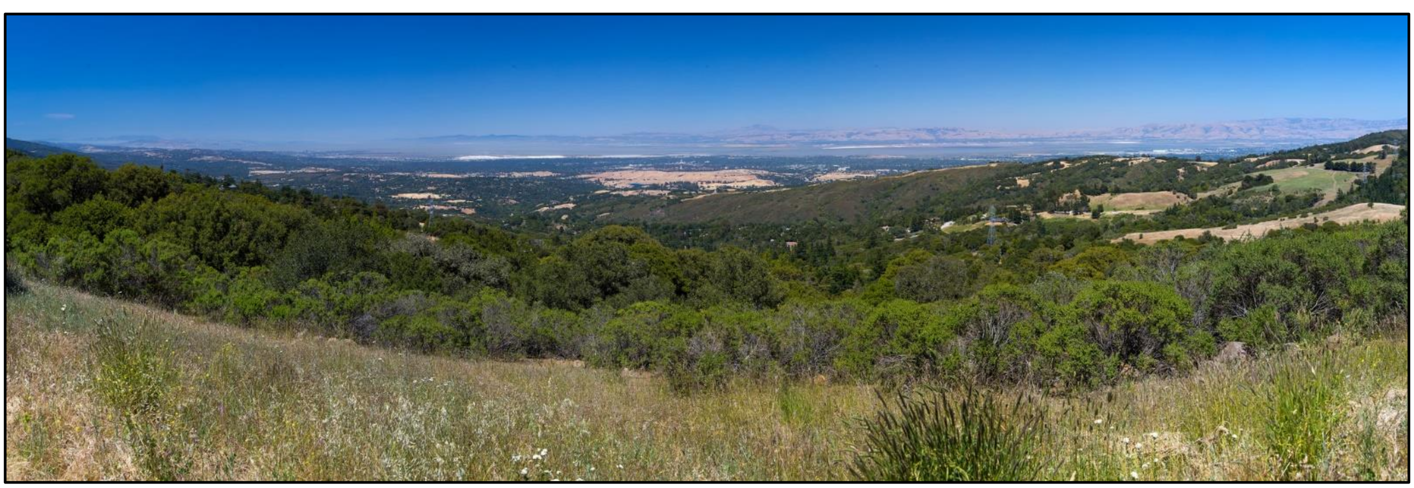
Sequestered carbon biomass provides economic value by contributing to climate stability. Each year, trees, shrubs, and grasslands sequester carbon. The annual value of sequestered carbon within the Loma Fire burn area was calculated before the fire occurred. Multiple data sources were used to estimate carbon sequestration. First, studies were collected that reported carbon biomass, matching values in annual metric tons of carbon sequestered per acre to vegetation types found specifically in Central California. To arrive at a carbon dollar value per acre, total carbon biomass was combined with dollar values for each ton of carbon sequestered. A single monetary value for carbon was used in this analysis. The California Cap-and-Trade Program established a market value of $12.91/ton for carbon.[29] The total sequestration value for each land cover is incorporated in Table 4 above. Table 5 shows the acreage of vegetation within the Loma Fire burn area along with the estimated soil and vegetation carbon biomass held within those plant communities. The database of studies used represent each land cover at varying growth stages (age).

Table 5. Total Carbon Biomass Sequestered by Land Cover Type Pre-Loma Fire

Land Cover Type	Area (acres)	Carbon Biomass Sequestered (tC/acre/year)		Value of Carbon Sequestration ($/year)	
		Min	Max	Min	Max
Forest - Mixed	1,837	0.466	1.028	$10,986	$24,222
Forest - Evergreen	1,732	0.624	1.028	$13,885	$22,868
Scrub/Shrub	805	0.287	0.287	$2,965	$2,965
Grassland	85	0.259	0.603	$279	$651
Forest - Deciduous	5	0.466	1.012	$30	$64
Wetlands - Emergent	2	0.611	0.890	$15	$22
Cultivated Developed - Low Intensity Water Developed - Open Space	Not measured in this report				

The monetary values derived in Table 5 are incorporated in the total ecosystem service value by land cover type provided in Table 4. Total carbon storage within the burn area is addressed in Section 5 below, which focuses on the losses due to the Loma Fire.

The analysis in this report used the California's Cap-and-Trade Program carbon value of $12.91 per ton. When considering the social cost of carbon (SCC), this is an underestimate. The Interagency Working Group (IWG) on SCC examined the economic cost of releasing carbon into the atmosphere, including the social costs due to increased storm and drought conditions.[30] Inflated to 2016 dollars, the social cost of carbon used in this analysis is the average value from the report of $144.30 per ton of carbon.



5. Comprehensive Cost of the Loma Fire

Wildfires generate costs and risk in a variety of ways. The most obvious and immediate cost of wildfire is the direct damages to any ecosystems and property involved. The emergency response (firefighters, equipment, evacuation, security, and traffic control among many others) represents another significant immediate cost. Future risk, often called Value at Risk (VAR), represents potential future damages that are directly associated with fire. Wildfire areas are highly prone to flooding that may result in further damage to property, roads, or water supply, for example. The final cost category is the expense required for restoration to return the site to a pre-fire functionality and reduce value at risk.

This section estimates the Loma Fire costs in each of these categories. When sufficient data is not available to produce dollar value estimates, costs are described qualitatively.

5.1. Ecosystem Services Loss

5.1.1. Ecosystem Function Parameters

Ecosystem service functions are impaired or enhanced by changes in land cover types and overall ecosystem health. Immediately after a fire, for example, forest areas have less biodiversity than untouched forests. Within a few years, a burned area may have more biodiversity with pioneer species and greater light penetration, but biodiversity will likely once again decline as dense stands of similar aged trees grow without thinning.

Estimates of fire severity in the Loma Fire were based on ground measures and satellite images. This method provides a rapid approximate assessment of damage to vegetation. The loss in ecosystem service function associated with vegetative loss is also real, and a rough approximation is presented here.

Based on expert judgment, a coefficient was adopted to represent the loss of ecosystem services according to burn severity. Table 6 summarizes the literature that addresses the relationship between burn severity and reduced ecosystem service function. Where the literature only describes the reduced function, coefficients were estimated using expert judgement and notes taken from field visits in December 2016.

Table 6. Summary of Literature on Ecosystem Service Function Reduction with Factors

Factor	Characteristics	Burn Intensity	Reduction Factor
Aesthetic information	A 2004 study showed housing prices in un-burned areas near burns to be 15-16% lower 5 years after burns,[31] while a 2010 study showed home prices *with a view* of burned areas can be 2.7% lower.[32] However, local realtors have suggested that the recent fire will likely not influence housing prices, due to multiple factors. Therefore, a conservative reduction factor was applied based on the above research.	Low	0%
		Med	3%
		High	3%
Biological Control	Field notes showed that the Loma Fire incinerated thick undergrowth and invasive species, which was recognized as a benefit. However, high intensity fires inhibit regenerative growth, and create disturbed sites amenable to invasive takeover. As a result, conservative reduction factors were attributed to high-intensity fires.	Low	5%
		Med	10%
		High	50%
Carbon Sequestration and Storage	One study shows that high-intensity fire, while incinerating all above-surface vegetation, also carbonizes soils, preventing growth for several years unless restored.[31] However, low intensity fire resembles natural fire conditions, and removes overgrowth, allowing for short-term recovery. Some forest stands, while not completely incinerated by fire, can receive enough damage to cease further growth, result in decomposition.	Low	10%
		Med	25%
		High	90%
Habitat	Resident amphibians (*A. californiense, R. draytonii*) listed as threatened or endangered, and are likely impacted by increased sediment.[33] High and medium intensity fire destroys habitat, left to recover after multiple years. Reduction factors incorporate a complete removal of habitat for high intensity burns.	Low	10%
		Med	25%
		High	100%
Moderation of Extreme Events	One 2010 study determined that housing prices drop by approximately 2.9% when annual fire fees are required, but increase when fire-risk reduction activities are taken to protect the home.[33] Additionally, post-fire conditions, particularly in high-intensity burn areas, remove flood protection benefits provided by existing vegetation. High-intensity fire reduction factors incorporate the complete loss of this service.	Low	10%
		Med	25%
		High	100%
Soil Erosion Control	Under wildfire conditions generally, erosion and sedimentation is expected. One study shows that between 5 and 10 tons of sediment per acre of high-intensity burns end up in streams the first year.[33] High intensity fire produced a higher risk of debris flows and shallow landslides.	Low	10%
		Med	25%
		High	90%
Stormwater Retention	Pre-fire streamflows are expected to increase 6-72% for one year following, while second year flows increase up to 15-132%, with higher values for smaller sub-watersheds.[33]	Low	10%
		Med	25%
		High	90%

Waste Treatment	Hydrophobic soils lead to increased runoff.[33] While soil organic matter reduced due to severe soil heating, post-fire conditions render limited natural water filtration. This is particularly the case when there is upstream development activities.	Low	10%
		Med	25%
		High	90%
Water Supply	Field notes show limiting high-intensity burning in Loma Fire boundary riparian conditions, which provide the substantial amount of water supply benefits. However, water storage and groundwater recharge capabilities of the landscape are diminished with sediment loads, especially in high-intensity burn areas. Conservative reduction factor values were assumed in this study, with recommendations for further research.	Low	5%
		Med	10%
		High	50%

5.1.2. Ecosystem Services Loss

Post-fire ecosystem service benefits were estimated by multiplying the reduction factor coefficients provided in Table 6 with the ecosystem service values provided previously in Table 4. By subtracting the post-fire estimate of ecosystem service benefits from the pre-fire ecosystem service benefits, a loss in value for the first year after the Loma Fire can be estimated. Table 7a and 7b shows the reduced value of all ecosystem services by land cover type and by ecosystem service respectively.

Table 7a. Ecosystem Services Lost due to Loma Fire by Land Cover Type ($/Year)

Land Cover (Condition)	Acres	Pre-Fire Total		Post-Fire Total		Ecosystem Service Loss	
		Min	Max	Min	Max	Min	Max
Forest - Deciduous	5	$7,525	$11,480	$5,816	$7,261	**$1,710**	**$4,220**
Forest - Evergreen	1,675	$1,014,748	$1,823,713	$819,153	$1,555,498	**$195,595**	**$268,215**
Forest – Evergreen (Riparian)	49	$29,530	$95,174	$28,684	$93,016	**$847**	**$2,158**
Forest - Mixed	1,798	$433,143	$1,649,898	$325,687	$1,195,582	**$107,456**	**$454,315**
Forest - Mixed (Riparian)	28	$17,158	$55,413	$16,025	$52,514	**$1,133**	**$2,899**
Grassland	84	$1,144	$6,370	$1,060	$6,192	**$84**	**$178**
Shrub/Scrub	800	$47,133	$63,928	$29,004	$39,329	**$18,129**	**$24,599**
Wetlands - Emergent	2	$5,161	$18,853	$5,161	$18,853	**$0**	**$0**
* All values in 2016 dollars		**$1,555,543**	**$3,724,829**	**$1,230,589**	**$2,968,245**	**$324,954**	**$756,584**

Table 7b. Ecosystem Services Lost due to Loma Fire by Ecosystem Service ($/Year)

Land Cover	Pre-Fire Total		Post-Fire Total		Ecosystem Service Loss	
	Min	Max	Min	Max	Min	Max
Aesthetic Information	$4,412	$10,779	$4,292	$10,617	**$120**	**$162**
Biological Control	$40,988	$40,988	$36,068	$36,068	**$4,921**	**$4,921**
Carbon Sequestration	$28,160	$50,792	$21,202	$38,315	**$6,958**	**$12,477**
Habitat	$26,726	$54,963	$23,959	$49,729	**$2,767**	**$5,234**
Moderation of Extreme Events	$62,871	$96,260	$43,740	$67,791	**$19,131**	**$28,469**
Recreation and Tourism	$68,665	$586,514	$67,189	$576,266	**$1,477**	**$10,248**
Soil Erosion Control	$7,846	$10,044	$6,135	$7,788	**$1,711**	**$2,256**
Waste Treatment	$991,221	$2,504,631	$790,002	$1,899,814	**$201,219**	**$604,817**
Stormwater Retention	$323,236	$323,236	$236,626	$236,626	**$86,610**	**$86,610**
Water Supply	$1,417	$46,620	$1,376	$45,230	**$41**	**$1,390**
* All values in 2016 dollars	**$1,555,543**	**$3,724,829**	**$1,230,589**	**$2,968,245**	**$324,954**	**$756,584**

The Loma Fire resulted in the loss of
21% of annual ecosystem service value
(Average of $540,769 each year)

5.1.3. Asset Value of Ecosystem Services Damage from Loma Fire

An ecosystem produces a flow of valuable services over time, like a traditional capital asset. Without large disturbances like the Loma Fire, this flow of value will likely continue far into the future. 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, so too can the net present value of the future flows of ecosystem services be calculated. An asset calculation is useful for revealing the scale of the economic damage that resulted from the Loma Fire.

Studies show that, under high-intensity burn conditions, ecosystems can be uninhabitable for up to a year.[34] However, field notes from the Loma Fire suggest that early succession trees and shrubs are already growing in high-intensity burn areas only six months after the fire. Studies show that full recovery from high-intensity fires can range from seven to 14 years, without extensive intervention.[34] In this report, ecosystem services loss will be estimated over an average of ten years. This loss will only account for high-intensity fire burns, where ecosystem service function capacity is assumed to regenerate by ten percent each year until the end of the period. This assumption reflects the lack of literature on the relationship between ecosystem function and recovery time. This relationship requires more research to estimate more accurately.

In Table 8, ecosystem services loss from high-intensity burns is calculated over ten years, assuming a linear recovery throughout the period. Calculating the net present value of an asset implies the use of a discount rate. Using a zero discount rate recognizes the renewable nature of natural capital and 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 3.125 percent discount rate (2015 rate) for water resource projects, a rate that lowers the value of the benefits by 3.125 percent every year into the future (US Army Corps of Engineers, 2015).[35] The private sector tends to use higher discount rates, tied to the rate of return on capital in private markets.

Table 8. Net Asset Value of Ecosystem Services Lost to the Loma Fire

Discount Rate	Estimated Net Asset Value Lost (Year 2 to 10 Analysis Period)	
	Low	High
0%	$877,970	$1,951,153
3.125%	$450,012	$1,000,082

5.1.4. Carbon Storage Loss from the Loma Fire

Pine forests, chaparral shrubs, and grasslands store carbon each year, building up a stock of stored carbon after years of sequestering carbon. Following a high-intensity burn like parts of the Loma Fire, nearly all of the carbon stored in vegetation and soil is released. The value of carbon stored in soils and mature vegetation is calculated for pre- and post-fire conditions and shown in Table 9.

Similar to the value of carbon sequestration, total stored carbon biomass was combined with dollar values per ton of carbon stored. The California market value of carbon was used to estimate the value of stored carbon ($12.91/ton), which was described in Section 4. Table 9 shows the stored carbon biomass, monetary value per acre, total carbon storage value before and after the fire, and total carbon loss for each land cover within the Loma Fire boundary.

Table 9. Total Stored Carbon Value and Loss (2016 Dollars)

Land Cover Type	Carbon Biomass Stored (tC/acre)		Total Carbon Storage Value				Value of Carbon Storage Lost	
			Pre - Fire		Post - Fire			
	Min	Max	Min	Max	Min	Max	Min	Max
Forest - Deciduous	20.6	99.8	$1,309	$6,328	$868	$4,195	**$441**	**$2,133**
Forest - Evergreen	33.6	71.6	$748,162	$1,593,558	$142,530	$303,583	**$605,632**	**$1,289,975**
Forest - Mixed	20.6	99.8	$486,357	$2,351,315	$137,221	$663,401	**$349,136**	**$1,687,914**
Grassland	8.4	15.2	$9,051	$16,444	$1,227	$2,230	**$7,824**	**$14,214**
Scrub/Shrub	14.9	18.0	$153,330	$185,545	$59,778	$72,338	**$93,552**	**$113,207**
Wetlands - Emergent	25.8	66.2	$632	$1,622	$0	$0	**$632**	**$1,622**
		Total:	**$1,398,841**	**$4,154,812**	**$341,624**	**$1,045,746**	**$1,057,217**	**$3,109,066**

The Loma Fire resulted in the loss of 76% of stored carbon value

(Average of $2,083,141)

5.1.5. Sedimentation and Dredging Costs

In the past, wildfires in California's Coast Ranges have produced sediment loads in adjacent streams in the year following the fires an order of magnitude higher than long-term averages. The WERT report repeatedly affirms the *potential* for increased sedimentation. However, sedimentation loads vary from year to year depending on a variety of factors. In the case of the Loma Fire, these factors include high rainfall, seismic activity, and previous wildfires. These effects are further compounded by the area's steep topography and the fact that many soils in the burn area already had high erosion rates. It is thus difficult to determine whether the increase in sedimentation is due to wildfire or other factors.

For the purpose of this analysis, sedimentation rates of 29.8-acre feet/year for the Uvas Reservoir and 8.1 acre-feet/year for the Chesbro Reservoir were used. These rates were calculated by using USGS bathymetric surveys of the Uvas (conducted in 1979 and 2007) and Chesbro Reservoirs (1955, 1976).[14] These surveys document the sediment accumulation between the two survey periods and each were used to estimate an average annual sedimentation rate. This rate was in turn used to define a baseline of clear water sedimentation rates for the purpose of comparing additional erosion and sedimentation in the year following a wildfire.

It should be noted that the WERT report provides only limited historical sediment discharge data. For Llagas Creek, data is available from 1972 to 1978, and for Uvas Creek there is data from 1966 to 1976. The data shows extreme variance in sediment discharge year over year. For instance, sediment discharge for Uvas Creek averaged 31 short tons/day between 1966 and 1976, but the low and high sediment discharge rates ranged from 0.023 (1976), to 132 short tons/day (1967). The historical data is limited, prone to sample-size effects, and lacking in contextual information that could explain the wide variations in sediment loads (e.g., high rainfall, seismic activity, and wildfire).

Nevertheless, the WERT report forecasts that average sediment yields can be expected to increase significantly, from 0.5 to 3 times baseline rates. Additional literature supports this estimate. A 2015 report showed how sediment yields could increase by a single order of magnitude in the year following a wildfire.[14,36] Additional studies have indicated that wildfires can increase sedimentation rates between 5 and 180 times pre-fire conditions.[37] Even after a seven-year recovery period, sedimentation rates can be twelve-fold relative to pre-fire conditions.[38] With ample external literature supporting the WERT report's argument that sedimentation can increase by 0.5 to 3 times, these factors were selected for calculating the economic cost of sedimentation in the Loma Fire.[14]

In this analysis, sedimentation rates for the Uvas and Chesbro reservoirs (29.8, 8.1 AF/year, respectively) were converted to cubic meters of sediment using a conversion factor of 1:1233.48 (acre-feet: cubic meters). Therefore, on average and under normal conditions, 36,758 m^3 and 9,991 m^3 of sediment is deposited annually in the Uvas and Chesbro Reservoirs, respectively. Applying the factors of 0.5 to 3 times the baseline rate, additional sedimentation the year following the Loma Fire would be between 23,375 and 140,247 m^3.

To calculate the economic cost of sedimentation, the cost of dredging was used as an estimate. Eventually, accumulated sediment in the Uvas and Chesbro Reservoirs will require dredging in order to provide flood protection and water retention. This analysis applied estimated dredging costs from a 2011 project feasibility study on the Klamath River. In that study, the removal of five million cubic meters of deposited sediment would cost $97 million, or $20/$m^3$. Inflating this cost to 2016 USD sets dredging costs at $21.34/$m^3$. However, this is likely an underestimate of the true costs, as it excludes miscellaneous expenses often associated with dredging, such as travel cost, special equipment, and project delays.

Total cost of sedimentation due to the Loma Fire:
$498,812 to $2,992,871

Combining the sedimentation estimates of 23,375 m^3 for Uvas and 140, 247 m^3 for Chesbro with the $21.34/m^3 for dredging, the total cost of sedimentation due to the Loma Fire was calculated to be between $498,812 and $2,992,871. This estimate only reflects the cost of sedimentation for one year following the Loma Fire. However, the literature indicates that erosion likely continues several years after a fire.

5.2. Future Value at Risk (VAR) Due to the Loma Fire

The Watershed Emergency Response Team (WERT) Final Report identified homes, structures, culverts and roads that may be at risk from post-fire threats such as floods or landslides. This included 35 homes, 11 bridges, seven culverts, seven roads, and eight miscellaneous structures. The report also identified that the Chesbro and Uvas Reservoirs are at risk from increased sediment deposition that may require dredging in the future. Additionally, if increased sedimentation occurs, it can have negative impacts on resident fish, amphibian, and reptile species. To be conservative, the financial risk of future damages has not been included in this report.

5.3. Property Value Loss

A review of housing values in the burn area revealed that most residences are valued between $750,000 and $1.5 million, although some residences in the area reach upwards of $1.5 million.[39] It is assumed that built structures account for 80 percent of the market value as reported by Zillow. The remaining 20 percent of the value is assumed to be tied to the land, and therefore the long-term value was not lost in the fire. This assumption is consistent with real estate valuation approaches.[40,41]

The Loma Fire destroyed 12 residences and 16 outbuildings and damaged one single-family residence.[42] Though the locations of the 12 residences destroyed in the Loma Fire could not be obtained, a conservative estimate of housing values lost can be calculated by assuming that the structure value of the 12 destroyed residences was $600,000, or 80 percent of the low housing value, $750,000. Thus, the total loss in housing values would amount to $7.2 million. This calculation does not include the destruction of outbuildings or damage to residences.

In addition to losses from destroyed residences, fires also reduce property values in areas within close proximity.[43] Though technically untouched by the fire itself, nearby properties experience reduced property values, particularly in areas that see multiple fires within a short time span. In many cases, it takes between five and seven years for housing prices to fully recover following multiple fires.[44]

However, in the case of the Loma Fire, residents of the Loma Prieta region reportedly disagree with these findings. According to a local realtor, residents in close proximity to the burned area view the fires as good and assume that "lightning won't strike twice" in the same area.[45] There may be an initial short-term decrease in property values in the year following the fire, but property values tend to return to equal or higher values within a few years. A California based wildfire study found that "if several years pass without a fire, people may begin again to forget about the risk of fire."[46]

One explanation for the quick recovery of housing values may be the fires' ability to clear thick brush. Clearing thick brush can open up property that would otherwise be unusable. The burn area tends to come back with a cleaner look, which can increase property values just one year after an event. Unfortunately, the brush eventually grows back to its pre-fire state and becomes fuel that can quickly escalate the risk, severity, and range of fires.

5.4. Loma Fire Response Costs

Cal Fire was the largest responder to the Loma Fire, dispatching 2,000 firefighters, 47 fire engines, three helicopters, eight bulldozers, 15 water tenders, and six air tankers.[47,48] The total cost incurred by Cal Fire was estimated to be approximately $16 million.[49] In addition, the Santa Clara OSA incurred staff costs of $125,000 to support fire crews.[50]

Santa Clara County also saw an increase in costs because of the Loma Fire. The largest cost share arose from the sheriff's department, which incurred total costs of $294,000, the majority of which arose from overtime pay. The County's Office of Emergency Services, Office of the County Executive, Information Services Department, and Planning Department all saw increased expenses from the fire. In total, Santa Clara County costs amounted to an estimated $362,000.[51] Additionally, in assisting Cal Fire in handling the Loma Fire, the Santa Clara County Fire Department incurred costs of $23,000.[52]

Pacific Gas & Electric Company (PG&E) replaced 47 distribution poles and 25,000 feet of wire in the burn area, requiring 100 PG&E workers to complete the work.[53] Though costs incurred were not provided PG&E, the American Transmission Company estimates that the cost to install 69 kV single circuit transmission line is $371,750 per mile.[54] Using this estimate, the cost of installing 4.75 miles (25,000 feet) of transmission line is $1.76 million. This estimate is likely an underestimate as California's mean wage rate for electrical power-line installers and repairers is third highest in the nation.[55]

The Red Cross also set up several evacuation shelters to provide support for displaced families. The costs of those services have not been obtained.

5.5. Restoration Costs

Following the fire, the Santa Clara Valley Open Space Authority (OSA) developed the Wildfire Area Emergency Response Work Plan (Draft). The draft plan includes communications and outreach

($131,000), planning and mapping ($244,000), and fieldwork, which will include tree pruning, pest management, stabilizing, and widening roads ($510,000). In total, the OSA expects to spend $1.3 million on response and restoration work on OSA owned lands in the burn area at an average cost per acre of $700.[56] Additionally, severe rainstorms during the winter of 2016 significantly damaged OSA's preserves. Through the State Office of Emergency Services, OSA is seeking repair and restoration funds, informing its grant application with data such as that presented in this report.

Finally, the OSA has been dealing with increased unpermitted access to OSA lands post-fire. High- and medium-intensity burn conditions left large parts of the landscape without shrubs and smaller trees, attracting recreation vehicles such as dirt bikes and ATVs. This unpermitted access inhibits the natural restoration of the lands and increases risk of ecosystem damage and landslide. As a result, $27,500 will be spent on a fence and gate network (included in $1.3 million OSA response plan), with increased staff costs of $37,500 to patrol the area for 26 weeks.[57] The patrol is necessary to allow the vegetation sufficient time to recover.

5.6. Summary of Results

Below, Table 10 summarizes the ecosystem services lost to the Loma Fire. Table 11 provides all costs directly related to the Loma Fire, including ecosystem service benefits lost in the first year and ten years following, carbon storage loss, and other fire response, property, and restoration costs presented above.

Table 10. Annual Ecosystem Service and Stored Carbon Loma Fire Loss Summary

Value Type	Pre-Fire Total		Post-Fire Total		Ecosystem Service Loss		Percent Reduction
	Min	Max	Min	Max	Min	Max	
Annual Ecosystem Services	$1,555,543	$3,724,829	$1,230,589	$2,968,245	**$324,954**	**$756,584**	**21%**
Stored Carbon	$1,398,841	$4,154,812	$341,624	$1,045,746	**$1,057,217**	**$3,109,066**	**76%**

Table 11 Summary of All Loma Fire-Related Costs

Response Costs		
Cal Fire		$16,000,000
Santa Clara County		$362,286
Central Fire		$23,241
Santa Clara Valley OSA		$125,197
SCV Water District Red		N/A
Cross		N/A
Misc		$37,500
Total		**$16,548,224**
Ecosystem Services Loss	**Low**	**High**
Annual (Year 1)	$324,954	$756,584
Asset Value (Year 2 to 10 @ 3.125%)	$450,012	$1,000,082
Carbon Storage	$1,057,217	$3,109,066
Dredging Costs	$498,812	$2,992,871
Total	**$2,330,995**	**$7,858,603**
Property		
Homes		$7,200,000
Utility Infrastructure		$1,760,179
Total		**$8,960,179**
Restoration		
OSA Recovery Plan		**$1,305,500**
Grand Total	**$29,144,898**	**$34,672,506**

Total ecosystem service loss due to Loma Fire, including services lost over ten years, carbon storage losses, and sedimentation amounts to $2.3 million to $7.9 million. Response to the Loma Fire cost the State of California and OSA approximately $16.5 million to date. Finally, the homes lost, estimated damage to utility infrastructure, and restoration recovery amounted to approximately $7.2 million, $1.8 million, and $1.3 million respectively. **The total cost of Loma Fire was estimated to be between $29 million and $34.5 million to date.**

This estimate was calculated using a federally accepted and scientifically validated Benefit Transfer Methodology (BTM) that applied findings from 44 peer reviewed studies relevant to the Loma Fire area landscape and ecosystems. In June of 2013, FEMA approved Mitigation Policy FP-108-024-01, based on values Earth Economics developed with the methodology used in this report, for use in all relevant natural 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.

6. Wildfire Policy and Mitigation Challenges

As the frequency, intensity, and cost of wildfires in California increases with climate change and population growth, the need for recovery and wildfire reduction policies and funding mechanisms is critical. This section provides an overview of related programs and opportunities in California and around the nation.

6.1. Federal Wildfire Policy

The inclusion of environmental benefit valuations is becoming more common and accepted in addressing significant, complex policy issues. FEMA initially rejected California's application for a Major Disaster Declaration after 2013 Rim Fire, citing a lack of economic damages. An economic assessment of natural capital damages revealed the full extent of the damage caused by the Rim Fire.[58] Governor Jerry Brown included the analysis of impacts to natural capital and ecosystem services as part of an appeal package sent to FEMA and President. The appeal was granted, providing significant federal disaster assistance to Tuolumne County, the San Francisco Public Utilities Commission (SFPUC), the State of California, and affected businesses 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 "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."[59]

On May 13, 2016, FEMA expanded the application of ecosystem services to all FEMA project types, including fire and drought.[60] FEMA now allows restoration of streams and floodplains that mitigate the effects of drought and wildfire. Actions such as reforestation, soil stabilization, and flood diversion are now eligible. These wildfire and drought related mitigation activities are applicable to both the Hazard Mitigation Grant Program (following disaster declaration), as well as the Pre-Disaster Mitigation program. While competitive at varying degrees, states and counties are able to apply for both funding sources. This policy advancement represents an important acknowledgement of the importance of ecosystem services loss in the event of wildfire.

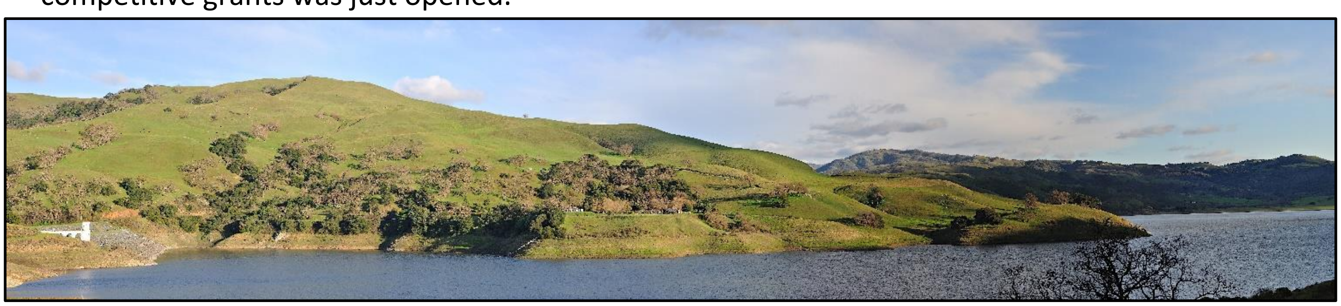
6.2. State Wildfire Policy and Programs

The California Fire Safe Council (CFSC) is a statewide nonprofit that distributes federal funds for fire safety and preparedness, facilitating working relationships between local communities and the grant making agencies, which include the Forest Service, the National Park Service, and the Bureau of Land Management. Through its Fire Safe, Fire Wise, and Fire Adapted programs, the CFSC supports local councils and community organizations in their efforts to reduce wildfire risks. The South Santa Clara County Fire Safe Council has received CFSC funds several times in recent years, supporting fuel reduction and "defensible space" efforts near Morgan Hill, as well as public education efforts on the importance of fuel reduction. These grants have typically been $33,000 to $56,000, but in 2016, they received $182,000 for education and fuel reduction (with $234,000 in matching funds).

Since 2011, the California Fire Prevention Fee has been assessed annually on any habitable structures located within State Responsibility Areas (SRAs). This fee is currently $152.22 per structure, with a $35 discount for properties also covered by local fire agencies (98 percent of all structures within the SRAs).[61] It is unclear whether Santa Clara County or nearby municipal governments within the county assess similar fees for the Local Responsibility Areas (LRAs). This is not a hypothetical concern, since most of the Loma burn area occurred in an LRA. For unincorporated areas, a countywide, risk-based fee would seem the most appropriate means of supporting fire prevention and suppression within high-risk areas.

The California Department of Forestry and Fire Protection (Cal Fire) offers competitive annual California Forest Improvement Program grants[62] on a sliding cost-share basis. The program supports development of management plans, as well as per-acre subsidies for a range of activities, including erosion control, tree planting, forest thinning, pruning, and fuel reduction.

Colorado has been an innovator in helping communities prepare for and respond to wildfire. The Wildfire Risk Reduction Grant Program (WRRG), created under Senate Bill 269 and passed in 2013 by the Colorado General Assembly, focuses on projects that reduce the risk for damage to property, infrastructure and water supplies, and those that limit the likelihood of wildfires spreading into populated areas. Funds are directed to non-federal lands within Colorado. The fourth round of competitive grants was just opened.



6.3. Ongoing Challenges

6.3.1. Fire Insurance challenges

Insurance can be difficult to obtain in a high-risk fire zone, and those who are able to obtain insurance experience consistent rate hikes as wildfire threats increase. Similar fire prone areas have experienced rate hikes in recent years, even when putting in place extra safeguards to protect residential structures. The Los Angeles Times recently reported that factors influencing rate hikes include recent wildland fires, drought, and insurers growing wary of fire risk in the area.[63] The article later goes on to say that despite these rate increases, the region still has a "very healthy, competitive, private homeowners' insurance market".

For some, fire insurance is infeasible. The Loma Fire left several families without a home, and insurance was simply unavailable, even at high premiums. Rural homeowners have no way of qualifying and face the risk alone.[64]

6.3.2. Unpermitted building and other activities

Unpermitted buildings can include garages, sheds and small guesthouses that increase a property's value. When these unpermitted structures are lost due to wildfire, housing values decrease and homeowners take the brunt of these costs as homeowners' insurance will not cover the loss of unpermitted buildings.

6.3.3. Future Threat of Climate Change and Drought

Recent rains pulled much of northern California out of drought conditions that lasted more than five years. However, many experts claim that drought conditions are far from over.[65] The U.S. Drought Monitor reported that drought conditions have dramatically improved, but only according to surface water measures. Tens of millions of acres of pine forest are dead and decomposing, creating conditions amenable to a catastrophic wildfire.[66]

In Santa Clara County and throughout the Santa Cruz Mountains and overall Bay Area, drought and wildfire will remain a concern. Climate models continue to predict warmer, windier and somewhat drier conditions in Santa Clara County, which will cause fires to burn more rapidly and with greater intensity.[67] The same models conclude that the frequency of such fires will grow several-fold under climate change.

7. Conclusions and Recommendations

7.1. Recommendations

The following recommendations should considered by OSA, the State of California, and other communities in need of funds and resources to restore watersheds.

Recommendation: Conduct additional analysis to better understand the risks of wildfire and the benefits of restoration and other programs.

Fuel reduction programs may provide a significant return-on-investment in terms of reduced future damages. Identification of specific areas to receive strategic fuel reduction treatments to maximize benefit will require additional research and planning by land managers along with supporting benefit-cost analysis to help with prioritization and investment decisions.

Regular turbidity monitoring upstream of the reservoirs also would be valuable to understand the water quality risk to Santa Clara Valley Water District from future post-fire sediment flows. A more detailed understanding of turbidity and its impact on water quality will also help target restoration and fuel management priorities.

Recommendation: The State of California should allocate funding for upland watershed restoration in order to sustain forest health and retain water supply and quality.

Targeted fuel reduction will lessen the frequency of high intensity fires and the overall costs. Stewardship funding is needed to maintain this practice over time. Without this investment, the pressures of human development and climate change will deteriorate upland vegetation.

Government officials in Colorado have already experienced the negative effects of urban sprawl and climate change. The upland watershed and the Colorado River headwaters are at risk from invasive species and drier conditions. To counter these effects, federal and state officials have collaborated with Denver Water on a $33 million, five-year forest health deal that would support continued tree thinning and forest restoration.[68] This agreement is the second dedicated to upland forest restoration that is essential for city water supplies. The project will result in fuel reduction projects on more than 40,000 acres of watershed deemed critical to mitigating wildfire risk while improving water quality and supply, among other ecosystem services. The restoration efforts will also create jobs for forestry contractors. County, state, and federal governments, as well as NGOs, have a similar opportunity to collaborate with water utility districts.

Recommendation: Through programs like the California Fire Safe Council, the state should establish individual homeowner payment programs that incentivize best practices, such as creating defensible space, managing forests near private structures, and enrolling in a Community Wildfire Protection Plan.

The California Fire Safe Council provides funding through grants statewide; however, these funds are difficult for private citizens to access. A community group rarely has the capacity to organize and apply for grants in competition with local municipalities. Such programs should not necessarily be limited to forest management or community protection plans. Small communities have created unique programs that utilize municipal resources. Since 2004, Colorado has supported the Volunteer Firefighter Pension Fund (VFP) to help small cities (population less than 100,000) create incentives to encourage volunteerism in their local fire protective services. Firefighters over 50 who have volunteered at least 36 hours a year for twenty years are eligible.[69]

Private contractors in many industries are collaborating with local government to play a role in firefighting, prevention efforts, and clean-up. Industrial suppliers, public safety service providers, and operations and maintenance companies are still critical for stopping fires from spreading. Large-scale landscapers have many business prospects for post-seasonal work, and IT software companies can offer innovative software to government agencies to help them operate more efficiently.

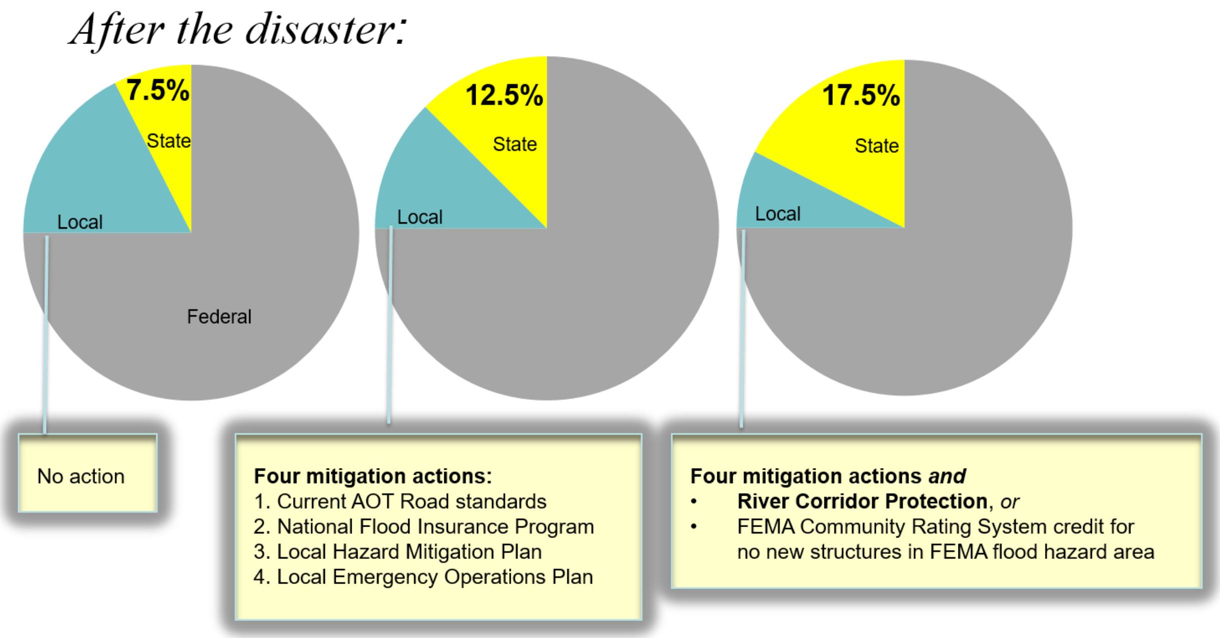
Recommendation: Like homeowner programs, the State of California should create collaborative governance programs to incentivize regional implementation of best practices.

Local governments are often obligated to take on the responsibility of disaster recovery, and the mitigation of risks associated with wildfire. With limited resources available to invest in recovery and future mitigation, rural communities are left without the capacity to implement such measures. With county and state collaboration, local governments can work with NGOs to create community programs that cost-share disaster risk mitigation, or reduce insurance premiums with implementation of preparedness plans.

In Utah, the State Division of Forestry, Fire and State Lands (FFSL) attempted to establish cooperative agreements with county governments to assist with the cost of wildfire suppression in the form of insurance premiums.[70] Although this system worked in some circumstances, wildfires since 2010 have exposed the missing link: Municipal governments that own vast areas of incorporated wildlands were not able to participate in the wildfire suppression cost assistance system. After three years of collaborative efforts with county partners and municipal service providers, FFSL helped ensure that Utah’s 2016 legislature unanimously passed a comprehensive wildland fire policy. Today, all communities participating in the State’s cooperative are required to develop a Community Wildfire Preparedness Plan (CWPP). A CWPP is a plan that communities create, in collaboration with emergency management and land management agencies, allowing them to be proactive in managing their wildfire risk.

In the State of Vermont, city officials created a state funding program incentivizing local municipalities to adopt state programs related to emergency operations and preparedness. These programs allow the state to contribute additional funds if local governments create preparedness plans and implement specific standards. Figure 3 summarizes this program. While the state program targets flood protection, the framework applies to all disaster preparedness programs.

Figure 3. Vermont State Cost Share Program



<u>Recommendation</u>: Governments establish reimbursement funds for small municipalities to support rapid, post-fire restoration of riparian areas and roads.

Currently, local government funding for rapid wildfire response typically comes from general budget allocations for all fire-related activities, including wildfire recovery and risk prevention. Sometimes these funds are consolidated into general emergency response, whether for flood, drought, or fire. Additionally, Cal Fire has funding dedicated for emergency response. However, there are no funds allocated specifically to short-term, post-fire restoration. Following a wildfire, drastically disturbed areas must be treated with pesticide given the threat of invasive species takeover. Active restoration will allow watershed vegetation to recover faster than if let alone.

Restoration actions will reduce erosion and sedimentation in nearby creeks. Existing programs have shown to be successful in erosion reduction. In 1967, the State of Colorado established the Emergency Fire Fund, a voluntary system in which resources are pooled between 43 (of 64) counties throughout the state.[71] Although the majority of these funds is used to control active fire, the fund has also contributed to short-term restoration of high-priority areas.

<u>Recommendation</u>: Santa Clara County consider a buyout of high-risk homes in the Loma Fire Boundary

This report did not provide a benefit-cost analysis (BCA) of purchasing property in the highest risk areas, and returning the area to open space. However, multiple benefits would be experienced in a buyout scenario, including the avoided damages and casualties with repeated fires and improved water quality. Further research is needed to understand the details.

FEMA provides funding through the Hazard Mitigation Grant Program (HMGP), which includes acquisition projects, used to support long-term solutions to the cost of natural disaster. A BCA of future firefighting costs, such as avoided response and public infrastructure damage, may demonstrate the cost effectiveness of home acquisitions in the Loma Fire boundary.

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Appendix A: Photo Credits

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Pg. 4 – “Loma Ridge View” 2009. User: OCParks_CA. Flickr Creative Commons (Link)

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Pg. 34 – “Santa Clara Land Damaged....” 2010. User: MyEyeSees. Flickr Creative Commons (link)

Pg. 35 – “Calaveras Reservoir – Panorama” 2010. User: Images by John K. Flickr Creative Commons (Link)

Pg. 39 – Mike Kline, State of Vermont River Program

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Appendix B: Ecosystem Service Reference Table

Author by Land Cover / Ecosystem Service	Min	Max
Deciduous Forest		
Aesthetic Information		
Kousky, C. and Walls, M.	$881.39	$881.39
Biological Control		
Wilson, S. J.	$11.79	$11.79
Habitat and Nursery		
Amigues, J. P., et. al.	$319.88	$605.16
Moderation of Extreme Events		
Zavaleta, E.	$47.68	$65.93
Recreation and Tourism		
Boxall, P. C., et al.	$0.23	$0.23
Colby and Smith-Incer	$215.04	$286.72
Shafer, E. L., et al.	$586.00	$586.00
Willis, K. G. and Garrod, G. D.	$4.45	$4.45
Willis, K.G.	$1.44	$646.81
Waste Treatment		
Qiu, Z. and Prato, T.	$49.68	$472.28
Water Supply		
Lant, C. L. and Tobin, G.	$369.74	$369.74
Zavaleta, E.	$17.67	$599.34
Emergent Herbaceous Wetlands		
Habitat and Nursery		
Wilson, S. J.	$2,646.78	$2,646.78
Woodward, R., and Wui, Y.	$174.46	$1,801.57
Moderation of Extreme Events		
Wilson, S. J.	$1,833.08	$1,833.08
Zavaleta, E.	$47.68	$65.93
Recreation and Tourism		
Creel, M. and Loomis, J.	$429.69	$1,954.18
Wilson, S. J.	$132.71	$132.71
Woodward, R., and Wui, Y.	$1.84	$361.78
Waste Treatment		
Wilson, S. J.	$215.15	$1,369.49
Woodward, R., and Wui, Y.	$231.39	$2,530.65
Water Supply		
Brouwer, R., et al.	$23.97	$58.53
Lant, C. L. and Tobin, G.	$369.74	$369.74
Zavaleta, E.	$17.67	$599.34
Evergreen Forest		
Biological Control		
Wilson, S. J.	$11.79	$11.79
Habitat and Nursery		
Amigues, J. P., et. al.	$319.88	$605.16

Moderation of Extreme Events		
Mason, L. et al.	$10.34	$20.66
Zavaleta, E.	$47.68	$65.93
Recreation and Tourism		
Boxall, P. C., et al.	$0.23	$0.23
Colby and Smith-Incer	$215.04	$286.72
Prince, R. and Ahmed, E.	$2.41	$120.94
Shafer, E. L., et al.	$586.00	$586.00
Willis, K. G. and Garrod, G. D.	$4.45	$4.45
Willis, K.G.	$1.44	$646.81
Soil Retention		
Moore, R. G. and McCarl, B. A.	$0.73	$0.73
Waste Treatment		
Hill, B. H. et al.	$538.23	$719.31
Water Capture, Conveyance, & Supply		
Hill, B. H. et al.	$36.63	$36.63
Water Supply		
Lant, C. L. and Tobin, G.	$369.74	$369.74
Zavaleta, E.	$17.67	$599.34
Herbaceous/Grassland		
Aesthetic Information		
Mast, J. C.	$0.24	$0.93
Sengupta, S. and Osgood, D. E.	$56.95	$56.95
Recreation and Tourism		
Boxall, P. C.	$0.04	$0.04
Butler, L. D. and Workman, J. P.	$0.85	$2.21
Knoche, S. et al.	$1.73	$1.73
Soil Retention		
Gascoigne et al.	$7.49	$7.49
Mixed Forest		
Biological Control		
Wilson, S. J.	$11.79	$11.79
Habitat and Nursery		
Amigues, J. P., et. al.	$319.88	$605.16
Moderation of Extreme Events		
Zavaleta, E.	$47.68	$65.93
Recreation and Tourism		
Boxall, P. C., et al.	$0.23	$0.23
Colby and Smith-Incer	$215.04	$286.72
Prince, R. and Ahmed, E.	$2.41	$120.94
Shafer, E. L., et al.	$586.00	$586.00
Walsh, R. G. et al.	$27.55	$27.55
Willis, K. G. and Garrod, G. D.	$4.45	$4.45
Willis, K.G.	$1.44	$646.81
Waste Treatment		
Hill, B. H. et al.	$785.91	$2,237.84

Water Capture, Conveyance, & Supply		
Hill, B. H. et al.	$145.69	$145.69
Water Supply		
Lant, C. L. and Tobin, G.	$369.74	$369.74
Zavaleta, E.	$17.67	$599.34
Pasture/Hay		
Aesthetic Information		
Rosenberger et al.	$121.55	$289.32
Soil Retention		
Canadian Urban Institute.	$6.41	$6.41
River		
Aesthetic Information		
Kulshreshtha, S. N. and Gillies, J. A.	$32.15	$887.94
Young, C. E. and Shortle, J. S.	$88.62	$97.07
Recreation and Tourism		
Greenley, D., et al.	$22.63	$22.63
Sanders, L. D., et al.	$2,998.52	$2,998.52
Shrub/Scrub		
Moderation of Extreme Events		
Zavaleta, E.	$47.68	$65.93
Recreation and Tourism		
Boxall, P. C.	$0.04	$0.04
Richer, J.	$58.16	$58.16
Soil Retention		
Gascoigne et al.	$7.49	$7.49
Richardson, R. B.	$10.24	$10.24
Water Supply		
Zavaleta, E.	$17.67	$599.34

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