FORESTS
Fuels Management

Ecosystem Service Benefits

- These projects reduce the likelihood that 270,000 acres of forested land will experience a catastrophic burn in the next 8 to 10 years (preventing approximately 1,400 acres from burning each year).[59]
- By preventing forested acres from burning in a catastrophic wildfire, these projects may generate ecosystem service benefits on the order of $3.1 million per year.
- Reducing the risk of catastrophic fire may also avoid $2.8 million in property damage annually over the life of these fuels management projects.
- The projects have the added benefits of maintaining the water supply, improving recreational opportunities, protecting human health and safety, and safeguarding habitat, among others.

OVERVIEW OF PROJECTS

Project activities
Fuel management activities at various scales

Implementing agency
California Department of Forestry and Fire Prevention

275 projects
funded across 48 counties (2016-2020)

270,000 acres
of forested land treated with fuel management activities

[59] Data used for the analysis were approved by both CAL FIRE and CARB at the time of submission (prior to May 2021). Note, the CCIRTS database, however, lacks the granularity to be able to reliably identify the acreage of each project that should be considered fuels reduction, since data are reported in aggregate acres. For this analysis, IEc classified each project as fuels management using available data in CCIRTS (e.g., data on acreage treated/restored and project descriptions); this categorization, however, could result in inconsistencies between acreages cited in this report and acreages reported elsewhere.

Between 2016 and 2020, CCI invested in 275 fuel reduction projects to reduce the risk of high-intensity, catastrophic wildfire, thereby protecting the health and property of Californians across the state (CARB 2021). During this period, CCI-funded projects treated approximately 270,000 acres across 48 counties (CARB 2021).[60] Fuels reduction activities are actions intended to lower the risk of catastrophic wildfires by managing vegetation to modify/reduce live and dead vegetation that serves as "fuel" for wildfires.

Appendix page A-7 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. A key factor driving the magnitude of potential benefits from fuels management activities is the baseline risk of wildfire in a given project area. Benefits from fuels management activities only accrue to the extent that treated acres would have likely burned in the absence of the project. In other words, to quantify the benefits of fuels management activities, we must also take into account the baseline (or pre-project) risk of fire for each acre treated. To characterize the pre-project risk of wildfire for each treated acre, we rely on the 2007 Fire Hazard Severity Zone data from CAL FIRE (CAL FIRE 2008).[61] Of the 270,000 total treated acres, 48,000 acres were classified in 2017 as moderate-risk, 68,000 acres as high-risk, and 160,000 acres very-high-risk. We then leveraged California's multi-agency statewide fire history database to estimate the probability that an acre of each risk-type will burn in a given year (CAL FIRE 2022). We found that land classified as moderate-risk, high-risk, and very-high-risk, had a 0.23, 0.28, and 0.67 percent chance of burning in a given year, respectively. Applying these percentages to the total acreage treated by these projects, we estimate that these projects collectively may prevent as many as 1,400 acres of forested land from severely burning in a given year. This acreage, however, may be an underestimate because this calculation only reflects acres directly treated by the project. It has been documented that fuels management can confer fuels protection to an area larger than the direct areas treated. For example, Finney (2001) found that fuels reduction projects, if strategically positioned, can have significant spillover effects to nearby, untreated land. Therefore, the total acres benefitting from CCI-funded fuels management is likely greater than the direct acres treated.[62]

This analysis quantifies the value of these projects using two different methods. First, we estimate the total ecosystem service value of the 1,400 forested acres the projects may prevent from burning each year. We then estimate the property damages that may be avoided each year from protecting these acres. Our analysis indicates that Siskiyou and Fresno counties experience the greatest benefit from these projects. Siskiyou and Fresno each may receive benefits on the order of $320,000 in protected ecosystem service value and $290,000 in avoided property damages, annually.

In addition to these quantifiable benefits, these projects provide a host of other benefits, which we describe qualitatively. Existing literature suggests the public values fuels reduction projects because of their environmental and financial benefits. Though a literature search did not identify any studies that could be used to estimate exactly how much Californians value fuels reduction, existing research

[60] The 159 fuel reduction projects with data reported a total of 180,000 treated acres. IEc imputed treated acres for the remaining 116 projects by calculating each program's average number of acres treated by projects with data and assigning those averages. Summing the 180,000 treated acres reported in the database with the imputed acres treated by each of the other projects resulted in a final estimate of 270,000 total treated acres.

[61] Project locations were determined using the latitude and longitude coordinates provided in the CCIRTS database.

[62] To estimate the total acreage benefiting from fuels treatment requires GIS data of the treated polygons, which we understand are not currently available.

provides suggestive evidence that Californians have a preference for projects that reduce the risk of wildfire and would pay to support their implementation (Loomis et al. 2005).

General ecosystem service benefits from protected forested land.
One way to value fuels reduction projects is to consider the ecosystem service value of the forested land that would have been burned without the projects. The Federal Emergency Management Agency (FEMA) developed a Benefit-Cost Analysis (BCA) Toolkit that can be used to illustrate the potential magnitude of benefits generated by a project that "restored, created, enhanced, or protected," forested land (FEMA 2022). The full value available in FEMA's BCA Toolkit captures a number of ecosystem services: aesthetic-value, air quality, climate regulation,[63] erosion control, existence value, flood and storm hazard reduction, recreation/tourism, water filtration, and water supply benefits (FEMA 2022). Most of these service values, however, are derived from studies that took place in strictly urban settings and therefore cannot be applied to CCI-funded fuels reduction projects. Of the ecosystem services considered in the BCA toolkit, the values associated with erosion control, recreation/tourism, water filtration, and water supply benefits can be reasonably applied to capture part of the value of the forests protected by CCI-funded projects. Since we are unable to capture the full value of all the ecosystem services that forested lands provide, we expect this analysis understates the full ecosystem service value of the acreage protected by CCI-funded projects.

Though the BCA toolkit has a set of criteria that projects must meet in order to be eligible for assessment, the requirements are broad enough that all of CCI's fuels reduction projects qualify. A consequence of its broad applicability, however, is that the BCA Toolkit only provides a coarse estimate of the ecosytem service benefit being generated or preserved by a given project. For example, the BCA Toolkit recommends employing the same ecosystem service value per acre to quantify the benefit of planting trees as it does to quantify the benefit of conducting fuels mangement on existing forest lands. Since planting new acres of forest is likely to generate more ecosystem services than protecting existing acres with fuel reduction techniques, applying these values to all treated acres would likely overstate the benefits of these projects because we would be assuming that 100 percent of the treated acres would burn in the absence of the CCI projects. As previously discussed, benefits from fuels management activities only accrue to the treated acres that would have burned in the absence of the project. In other words, to quantify the benefits of fuels reduction, we must take into account the baseline (or pre-project) risk of fire for each acre treated. Accordingly, this analysis uses a more conservative approach by applying the subset of applicable ecosystem service values from the BCA Toolkit to the 1,400 acres of forested lands that these projects might reasonably prevent from severely burning. Applying the applicable service values from the BCA Toolkit, each of these protected acres has an ecosystem service benefit of $2,304 per year that would be lost absent the CCI-funded fuel reduction projects.[64] In total, these projects have a combined present value benefit of $23-$27 million over the 8- to 10-year lifespan of these projects (assuming a 3 percent discount rate), or **$3.1 million annually**.

[63] The inclusion of climate regulation within this FEMA's per-acre value likely double counts to at least some extent with CARB's quantification and/or valuation of the GHG-related benefits from these projects.

[64] The FEMA BCA toolkit determined forests have an overall annual ecosystem service value of $12,589 per acre per year by summing what they consider to be non-overlapping benefits as reported in other studies. The toolkit determines the added value of each benefit category (e.g., aesthetic value, air quality, etc.) by averaging all the relevant estimates of the value of that benefit reported in the existing literature.

Avoided property damage from reduced incidence of wildfire.
In addition to harming environmental resources, wildfires cost Californians millions of dollars each year in property damages. Since 1943, CAL FIRE has published annual statistics on wildfire activity in California. Known as the Redbook, this publication tracks a number of wildfire-related statistics, including the number of fires, acres burned, and dollars of damage (limited to property and property contents) (CAL FIRE 2019-2022). Based on these publications, between 2008 and 2021, the average annual replacement costs for properties and property contents damaged in California wildfires exceeded $1.0 billion, or $2,100 per acre, even after excluding 2017 to account for abnormally costly damages incurred that year.[65]

A primary benefit of fuels reduction projects is that they reduce or avoid property damages by limiting the severity and/or geographic scope of wildfires. As described above, this analysis determined that CCI-funded fuels reduction projects collectively prevent as many as 1,400 acres of forested land from burning each year. Assuming each of these protected acres would have incurred $2,100 in property and content damages absent the projects, the projects have a combined present value benefit of $20-$24 million over the the 8-10 year lifespan of the projects (assuming a 3 percent discount rate), or **$2.8 million annually**. Since CAL FIRE Redbook data does not include damages related to the destruction of natural resources, health-related costs due to smoke, costs incurred by municipalities for post-fire repair and recovery activities, or business interuption and tax revenue losses, this estimate likely understates the total value of the damages that may be avoided by these projects.

[65] During the 2017 fire year, California incurred $13 billion in damage over 470,000 acres ($29,000 in damage per acre). This fire year included the 2017 North Bay Fires and the 2017 Thomas Fire.

Willingness to pay (WTP) for reduced wildfire risk.[66]
Several studies provide evidence that people have a preference for reducing the risk of wildfires and protecting forested land. In addition to avoiding property damages, investing in these efforts increases public safety, improves human health, safeguards recreational opportunities, and protects habitat, among a variety of other benefits. A literature search identified five studies based on three surveys that offer information on the public's WTP for fuels management activities. A 2001 survey of 115 Colorado residents living near public lands revealed that people in Colorado are willing to pay $796 annually for a "prescribed burn policy" expected to reduce the incidence of wildfires by 50 percent (Kaval and Loomis 2007). Another study demonstrated that people value some resources threatened by wildfires more than others: a survey of nearly 600 individuals from Flathead County, Montana showed that people are willing to pay $0.24 annually for each home evacuation prevented, $2.26 annually for each percentage point of recreational opportunity protected, $2.34 annually for each day of moderate smoke avoided, and $13.28 annually for each day of unhealthy smoke avoided (O'Donnell et al. 2014).

According to a separate study, residents of California may have a higher WTP to protect forested land compared to residents of other states.[67] An analysis of nearly 800 responses to a 2005 survey demonstrated that residents of Florida, Montana, and California were willing to pay $305 ($230), $382 ($208), and $417 ($403), respectively for a prescribed burning (mechanical fire reduction)[68] program able to reduce the incidence of wildfires by 25 percent (Loomis et al. 2005). Since the frequency and severity of wildfires in California has increased in recent years, it is possible Californians value these activities even more today than they did at the time of this study. Regardless, because data on how CCI-funded programs are expected to reduce the incidence of wildfires are not available, we are unable to quantify the public's WTP for the fuels management benefits of these projects. However, the literature clearly demonstrates that Californians value fuels management activities and would likely be willing to pay to support CCI-funded fuel reduction projects.

Increased recreational opportunities.
Another benefit of fuels reduction projects is that they protect recreational areas by limiting the severity and/or geographic scope of wildfires. Since forests may close due to damage from wildfires or are closed during periods of high fire risk, the projects also benefit recreational opportunities by reducing the risk of catastrophic fire, and thereby preventing temporary or prolonged recreational closures. Recreators use forested land for many activities including but not limited to hiking, camping, hunting, sightseeing, wildlife viewing, trail running, and biking. Indeed, it is well documented that recreators enjoy significant consumer surplus benefits from partaking in these forest-related activities. The Oregon State University Recreational Use Values (RUV) Database contains 421

[66] From an economic perspective, WTP is a conceptually appropriate measure of value of a resource or service. WTP is the maximum amount of money an individual would voluntarily exchange to obtain a resource or environmental improvement, given budget constraints. In other words, WTP indicates the point at which the individual would be equally satisfied with having the good itself or with having the money to spend on other things.

[67] Californians may have a higher WTP to reduce the risks of wildfire than residents of other states for multiple reasons. It could be that they tend to have higher disposable incomes, and lower opportunity costs because goods and services tend to be more expensive in California. Alternatively, the discrepancy may be driven by California's wildfire risk or Californians' heightened awareness of the threats catastrophic wildfires pose. This study, however, was not conducted in such a way as to understand the key reasons for California's higher WTP relative to other states considered in the study.

[68] Loomis et al. (2005) specify that "the mechanical fire fuel reduction method consists of mechanically removing smaller trees and vegetation. This mechanical fuel reduction method is especially effective at lowering the height of vegetation, which reduces the ability of fire to climb from the ground to the top or crown of the trees."

documents of economic valuation studies that estimate the use value of recreational activities in the US and Canada. For example, the database contains 19 estimates from six California-based studies that estimate the consumer surplus associated with hiking. Consumer surplus refers to the difference between the maximum amount a recreationist would be willing to pay to participate in a recreational activity and the actual cost of participating in that activity. In other words, it is the value that a recreationist places on a trip after all expenses have been paid. Across all the estimates reported in Oregon State University's RUV database, the average estimated consumer surplus of hiking is $32 per trip. Since we do not have information on the degree to which hiking and other activities would have been impeded without these fuels management projects, it is not possible to use this information to quantify the overall recreational use value generated by the fuels reduction projects. However, the BCA Toolkit attributes $94 per acre of the overall ecosystem service benefit of forested land to recreation and tourism. Thus, $130,000 of the $3.1 million annual ecosystem service benefit (4 percent) of the projects can be attributed to recreation and tourism.

Recreational opportunities also provide economic benefits in the form of increased spending by both local and non-local recreators that may come to a specific area to recreate. To estimate the regional economic impacts of recreation and tourism, economists typically use an analytical method known as input-output (I-O) modeling, which uses multipliers to capture the added economic activity that is generated by a defined dollar amount of spending.[69] For example, spending at a local restaurant also contributes to employee wages and income at local businesses, which in turns supports further spending in the local economy by those employees and businesses. Quantifying the regional economic impact of changes in forest-based recreation and tourism due to CCI-funded fuels management projects is beyond the scope of this analysis. Such impacts typically require project-specific analysis as the magnitude of the impacts will depend on such factors as location, the number and type of recreators visiting an area, and the amount of spending generated by each type of recreational activity.

Water supply maintenance.
Several studies exist that document the adverse impacts of wildfire on drinking water supplies (EPA 2019; USGS 2019). Severe wildfires destabilize the soil and strip the vegetation from the landscape leading to higher sedimentation rates in burned areas than areas that have not burned. As a result of these changes to the landscape, higher levels of erosion and runoff can result in changes in the quality and quantity of runoff. Depending on the location, topography, and burn severity, wildfires can result in ash, debris, and other contaminants in surface water which can then lead to increased water treatment costs. For example, following the 2022 Hermit's Peak Fire in New Mexico, heavy rains post-fire carried ash and sediment into the drinking water supply for the City of Las Vegas. The excessive levels of ash and sediment overwhelmed the City's existing (pre-fire) water treatment system and the City is currently in the process of upgrading its water treatment facility in order to

[69] One widely used example of an I-O model is IMPLAN. Initially developed by the U.S. Forest Service, IMPLAN is a tool that can be used to estimate the regional economic impacts of a change in spending to a defined economy. IMPLAN uses data collected from a variety of Federal sources to map the buying and selling relationships between industries, governments, and households within a region. For example, the model may include a coefficient where for every $200,000 of output from a given industry, one full-time employee is needed to produce that output, and the employee costs $90,000. As a result, I-O models like IMLAN can help analysts understand how an increase (or decrease) in spending might ripple through an economy, directly and indirectly affecting output and employment in various sectors. For more information on IMPLAN, see Clouse, C. How IMPLAN Works. Accessed at: https://support.implan.com/hc/en-us/articles/360038285254-How-IMPLAN-Works.

ensure that the City is able to continue to provide safe drinking water to the community (Las Vegas Optic 2022).

Wildfires can also lead to increased sedimentation into reservoirs which in turn reduces the ability for water managers to store water during wet years for use during dry years. For example, following two wildfires in Colorado, water providers reported spending more than $26 million on water-quality treatment, sediment and debris removal from water storage reservoirs, among other costs (Denver Water 2017). In one study, researchers project that increased wildfire could more than double sedimentation levels in a third of Western watersheds by 2050 (Sankey et al. 2017). Quantifying the potential benefits to water supply maintenance from CCI-funded fuels reduction projects, however, is beyond the scope of this analysis as it is a largely site-specific analysis that requires a significant amount of data.

Table 8: Summary of Monetized Ecosystem Service Benefits for the Forest Fuels Management Projects by County (2021 dollars)

County	Total Acres Treated with Fuel Reduction Activities[a]	Overall Ecosystem Service Benefit (Annual)[b]	Avoided Property Damages (Annual)[b]
Alameda	1,800	$28,000	$25,000
Alpine	800	$12,000	$11,000
Amador	2,200	$34,000	$31,000
Butte	8,500	$110,000	$97,000
Calaveras	2,800	$41,000	$36,000
Colusa	5,300	$82,000	$74,000
Contra Costa	3,000	$47,000	$42,000
El Dorado	9,200	$110,000	$100,000
Fresno	22,000	$320,000	$290,000
Glenn	2,300	$28,000	$25,000
Humboldt	13,000	$96,000	$86,000
Kern	7,000	$48,000	$43,000
Lake	3,200	$33,000	$30,000
Lassen	3,500	$55,000	$49,000
Los Angeles	3,200	$50,000	$45,000
Madera	7,800	$86,000	$77,000
Marin	1,100	$6,800	$6,100
Mariposa	2,400	$22,000	$20,000
Mendocino	6,600	$74,000	$66,000
Modoc	29,000	$200,000	$180,000
Mono	990	$5,200	$4,700
Monterey	6,700	$91,000	$82,000
Napa	4,800	$43,000	$39,000
Nevada	3,500	$47,000	$42,000
Orange	12,000	$170,000	$160,000
Placer	11,000	$140,000	$120,000

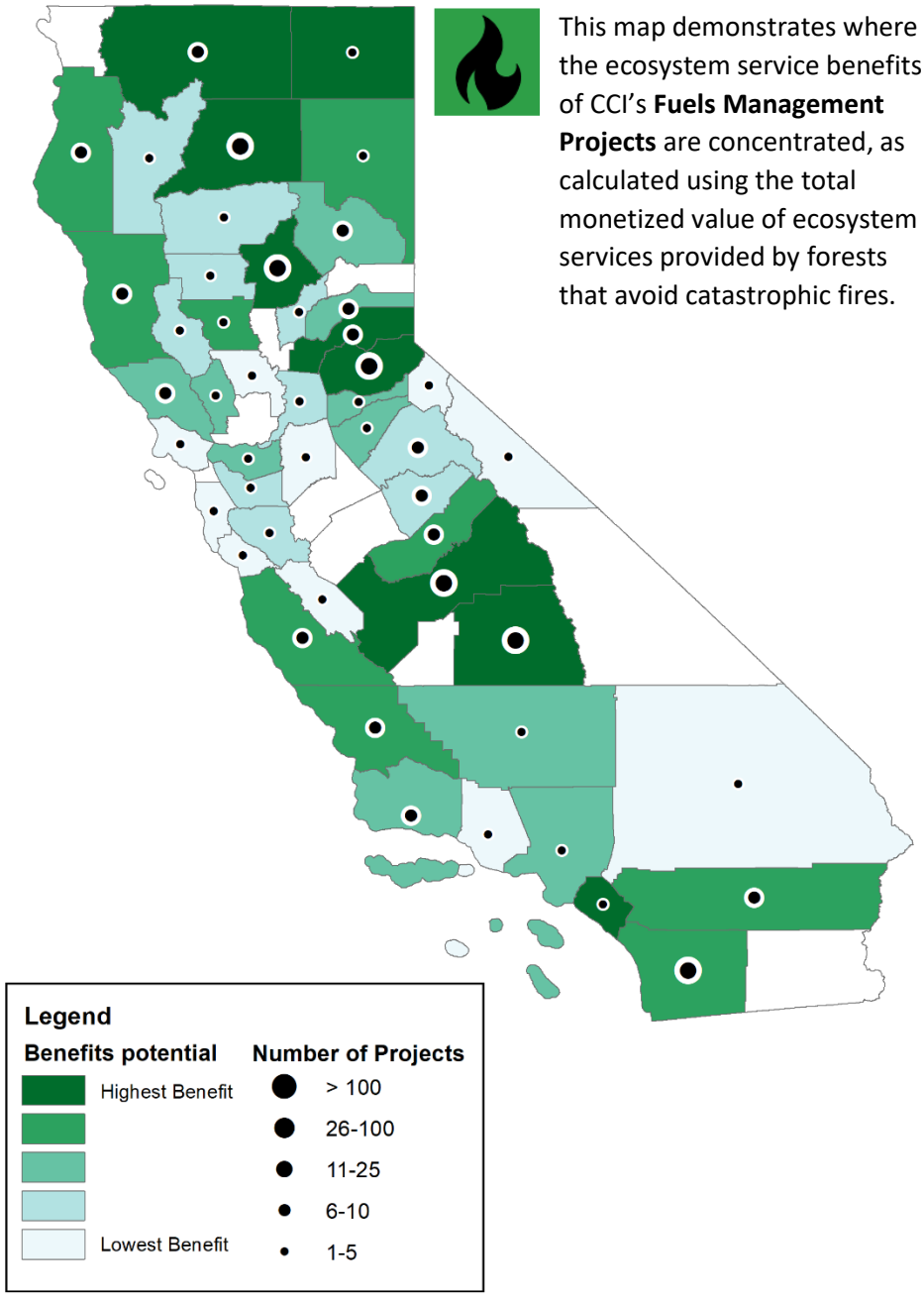
County	Total Acres Treated with Fuel Reduction Activities[a]	Overall Ecosystem Service Benefit (Annual)[b]	Avoided Property Damages (Annual)[b]
Plumas	2,500	$39,000	$35,000
Riverside	3,400	$52,000	$47,000
Sacramento	4,400	$23,000	$21,000
San Benito	240	$3,700	$3,400
San Bernardino	1,300	$13,000	$12,000
San Diego	5,900	$65,000	$59,000
San Joaquin	3,200	$17,000	$15,000
San Luis Obispo	7,200	$74,000	$66,000
San Mateo	1,200	$9,300	$8,400
Santa Barbara	6,200	$38,000	$34,000
Santa Clara	2,300	$29,000	$26,000
Santa Cruz	1,900	$12,000	$11,000
Shasta	10,000	$150,000	$140,000
Siskiyou	21,000	$320,000	$290,000
Sonoma	3,800	$39,000	$35,000
Tehama	2,400	$23,000	$21,000
Trinity	3,400	$29,000	$26,000
Tulare	10,000	$110,000	$98,000
Tuolumne	2,600	$33,000	$29,000
Ventura	1,700	$18,000	$16,000
Yolo	1,900	$10,000	$9,200
Yuba	2,100	$32,000	$29,000
Statewide Total	**270,000**	**$3,100,000**	**$2,800,000**

Sources and notes:

a. Data estimated based on CARB (2021) for projects implemented from 2016 to 2020. The 159 fuel reduction projects with data reported a total of 180,000 treated acres. IEc imputed treated acres for the remaining 116 projects by calculating each program's average number of acres treated by projects with data and assigning those averages. Summing the 180,000 treated acres reported in the database with the imputed acres treated by each of the other projects resulted in a final estimate of 270,000 total treated acres.

b. Author calculations described in this report. The monetary values presented in this table are not necessarily additive to a single, total benefits value as they reflect alternative valuation methods and measures (e.g., market values, social welfare values) and may double-count the same benefit stream.

Figure 9: Spatial Distribution of Ecosystem Service Benefits Potential for the Fuels Management Projects



Note: The benefit potential conveyed in this map considers the total ecosystem service benefit category presented in Table 8.

References

California Air Resources Board (CARB). 2021. "California Climate Investments Report and Tracking System (CCIRTS)." Provided to IEc in March 2021 and includes all project monitoring data through December 2020.

California Department of Forestry and Fire Protection (CAL FIRE). 2022. Fire and Resource Assessment Program: Fire Perimeters through 2021. Accessed at: https://frap.fire.ca.gov/mapping/gis-data/.

California Department of Forestry and Fire Protection (CAL FIRE). 2008-2021. California Wildfire Activity Statistics (Redbook). Accessed at https://www.fire.ca.gov/stats-events/.

California Department of Forestry and Fire Protection (CAL FIRE). 2008. Fire Hazard Severity Zones Map. Accessed at: https://osfm.fire.ca.gov/divisions/community-wildfire-preparedness-and-mitigation/wildfire-preparedness/fire-hazard-severity-zones/fire-hazard-severity-zones-map/.

Denver Water. 2017. The legacy of Colorado's largest wildfire. Accessed at: https://www.denverwater.org/tap/legacy-colorados-largest-wildfire.

Federal Emergency Management Agency (FEMA). 2022. FEMA Ecosystem Service Value Updates. Accessed at https://www.fema.gov/sites/default/files/documents/fema_ecosystem-service-value-updates_2022.pdf.

Finney, M. 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science. Volume 47, Issue 2. Pp. 219-228.

Kaval, P., Loomis, J., Seidl, A., 2007. Willingness to pay for prescribed fire in the Colorado (USA) wildland urban interface. *Forest Policy Economics*. 9 (8), 928–937.

Loomis, J.B., Le, H.G., Gonz?lez-Cab?n, A., 2005. Testing transferability of willingness to pay for forest fire prevention among three states of California, Florida and Montana. *Journal of Forest Economics, 11*, 125–140.

O'Donnell, D.T., Venn, T.J. and Calkin, D.E., 2014. Are wildfire management resources in the United States efficiently allocated to protect resources at risk? A case study from Montana. *Economic Analysis and Policy,* 44(3), pp.318-332.

Oregon State University. 2016. Recreation Use Values Database. Accessed at: https://recvaluation.forestry.oregonstate.edu/database.

Sankey, J.B., Kreitler, J., Hawbaker, T.J., McVay, J.L., Miller, M.E., Mueller, E.R., Vaillant, N.M., Lowe, S.E. and Sankey, T.T., 2017. Climate, wildfire, and erosion ensemble foretells more sediment in western USA watersheds. *Geophysical Research Letters*, *44*(17), pp.8884-8892.

U.S. Environmental Protection Agency (EPA). 2019. Wildfires: How Do They Affect Our Water Supplies? Accessed at: https://www.epa.gov/sciencematters/wildfires-how-do-they-affect-our-water-supplies.

U.S. Geological Survey (USGS). 2019. Water Quality After Wildfire. Accessed at: https://www.usgs.gov/mission-areas/water-resources/science/water-quality-after-wildfire?qt-science_center_objects=0#qt-science_center_objects

FORESTS

Restoration and Reforestation

Ecosystem Service Benefits

- The estimated ecosystem service value of these 320,000 acres once restored to full functionality is approximately $750 million annually.[70]
- These projects offer several ecosystem service benefits, including aesthetic-value, air quality, climate regulation, erosion control, existence value, flood and storm hazard reduction, recreation and tourism, water filtration, and water supply benefits.

OVERVIEW OF PROJECTS

Project activities
Reforestation, pest management, and other restoration activities

Implementing agency
California Department of Forestry and Fire Prevention

83 projects
funded across 29 counties (2015-2020)

320,000 acres
of land restored or reforested

[70] Data used for the analysis were approved by both CAL FIRE and CARB at the time of submission (prior to May 2021). Note, the CCIRTS database, however, lacks the granularity to be able to reliably identify the acreage of each project that should be considered restoration, since data are reported in aggregate acres. For this analysis, IEc classified each project as forest restoration using available data in CCIRTS (e.g., data on acreage treated/restored and project descriptions); this categorization, however, could result in inconsistencies between acreages cited in this report and acreages reported elsewhere.

Between 2015 and 2020, CCI invested in 83 forest restoration and reforestation projects (CARB 2021). Collectively, these projects help to support and accelerate the restoration of ecosystem services on natural lands harmed by pests, burned by wildfire, or otherwise degraded in some way. During this five-year period, CCI funded restoration and reforestation activities on 320,000 acres in 29 counties (CARB 2021; CARB 2023). More than 110,000 of the restored acres are located in Plumas County.

Forest restoration and reforestation can take several forms, for example, the removal of dead and dying timber or vegetation, soil stabilization activities to reduce erosion, removal of invasive species, reseeding native grasses and plants, and replanting trees and shrubs. For a subset of projects, these activities may take place following catastrophic fire, as a means to support the recovery of areas burned by severe fire and minimize the potential for further damage, for example from invasive species, which can often thrive in post-fire environments. Importantly, many of these projects also focus on areas at risk for type conversion, which is the conversion from one habitat type to a different habitat type.[71] In such instances, without these projects in place, many of the treated areas would lose much or all of their ecosystem service value. The magnitude of the benefits of each restoration and/or reforestation project depends on the type and condition of the lands being restored and the type of restoration activity. Since we do not have sufficient information to determine the ecosystem service value gained from each project, we instead calculate the ecosystem service value of fully functioning forested land to illustrate the potential benefit of the CCI-funded restoration projects. Appendix page A-7 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits.

General ecosystem service benefits from restoring forested land.

One way to value forest restoration projects is to monetize the ecosystem service value associated with the forestland being restored by these CCI-funded projects. The Federal Emergency Management Agency (FEMA) Benefit-Cost Analysis (BCA) Toolkit can be used to quantify the overall "ecosystem service values… generated through restoration, creation, enhancement or protection (of areas at risk of degradation in a No Action scenario)" (FEMA 2022). The full value available in FEMA's BCA Toolkit includes the following types of ecosystem services: aesthetic-value, air quality, climate regulation, erosion control, existence value, flood and storm hazard reduction, recreation/tourism, water filtration, and water supply benefits (FEMA 2022). Most of these service values, however, are derived from studies that took place in strictly urban settings and therefore cannot be broadly applied to the CCI-funded activities on forested lands. Of the ecosystem services considered in the BCA toolkit, the values associated with erosion control, recreation/toursim, water filtration, and water supply benefits can be reasonably applied to capture part of the value of the restored forested acres. Notably, FEMA BCA Toolkit estimates are coarse and should be regarded as illustrative of the potential ecosystem service value of a generic acre of fully functioning forestland. Since the Forest Health Program targets forest restoration in areas at risk of type conversion, many of these projects prevent or mitigate the loss of the ecosystem service value of the treated area. Drawing from the FEMA BCA Toolkit, we assign an ecosystem service benefit of $2,304 per year to each of the forested acres being restored by the

[71] The extent of type conversion due to wildfire depends on the frequency and intensity of fire relative to natural fire return intervals. Fire-caused type conversion (FTC) is well documented in the landscapes of southern California where chaparral ecosystems are being replaced by non-native grasslands and mixed conifer habitat is shifting into shrubland. (California Fire Science Consortium. 2020. Fire-caused Vegetation Type Conversion in California: A Workshop Summary. August. Accessed at: http://ecoadapt.org/data/library-documents/Fire-caused%20Vegetation%20Type%20Conversion%20California%20Workshop%20Summary.pdf.)

projects, resulting in a potential value of the treated acres of **$750 million annually**. Importantly, this estimate is not necessarily the benefit of the CCI projects, but rather an indicator of the value associated with healthy forests.

Value of restoring forested land.

Forest restoration helps recover ecosystem services that have been disrupted by wildfires, pests, or other factors. A literature search identified several studies that quantify the benefits of forest restoration. Mueller et al. (2014) conducted a survey in Flagstaff, Arizona to estimate the public's monthly willingness to pay (WTP) for a restoration project expected to improve the quantity and quality of Flagstaff's municipal water supply and reduce the risk of catastrophic wildfire.[72] They find that individuals are willing to pay an additional $5.58 monthly ($66.96 annually) for the continued maintenance of a restoration project providing these services (Mueller et al. 2014). Finally, Chadourne et al. (2012) determined that forest restoration can have siginficant property value benefits. Using data downloaded from the Knox County Tax Assessor's Office, Chadourne et al. (2012) contrive distance decay functions that model how the property value benefit of proximity to forestland decreases as distance increases. They conclude the value of forestland "was at its highest at $197.19 per acre where the distance to housing locations was the least (0.1 miles)" (Chadourne et al. 2012). They find that the property value benefit decreases drastically from 0.1 miles to about 1.0 miles, and decreases gradually beyond that distance. Though the literature on forest restoration benefits is extensive, we do not have sufficient information on the environmental condition of these lands pre- and post-project to reliably leverage any of these models to quantify the benefit of CCI's forest restoration projects.

Table 9: Summary of Monetized Ecosystem Service Benefits for the Restoration and Reforestation by County (2021 dollars)

County	Total Acres Restored[a]	Environmental Service Benefit of Fully Restored Acres (Annual)[b]
Calaveras	3,000	$6,900,000
Colusa	3,300	$7,700,000
El Dorado	15,000	$35,000,000
Fresno	8,400	$19,000,000
Humboldt	8,500	$20,000,000
Lake	470	$1,100,000
Lassen	15,000	$34,000,000
Los Angeles	4,700	$11,000,000
Madera	2,000	$4,700,000
Mariposa	5,900	$14,000,000
Mendocino	4,100	$9,400,000
Modoc	20,000	$46,000,000
Nevada	9,900	$23,000,000
Placer	31,000	$73,000,000

[72] From an economic perspective, WTP is a conceptually appropriate measure of value of a resource or service. WTP is the maximum amount of money an individual would voluntarily exchange to obtain a resource or environmental improvement, given budget constraints. In other words, WTP indicates the point at which the individual would be equally satisfied with having the good itself or with having the money to spend on other things.

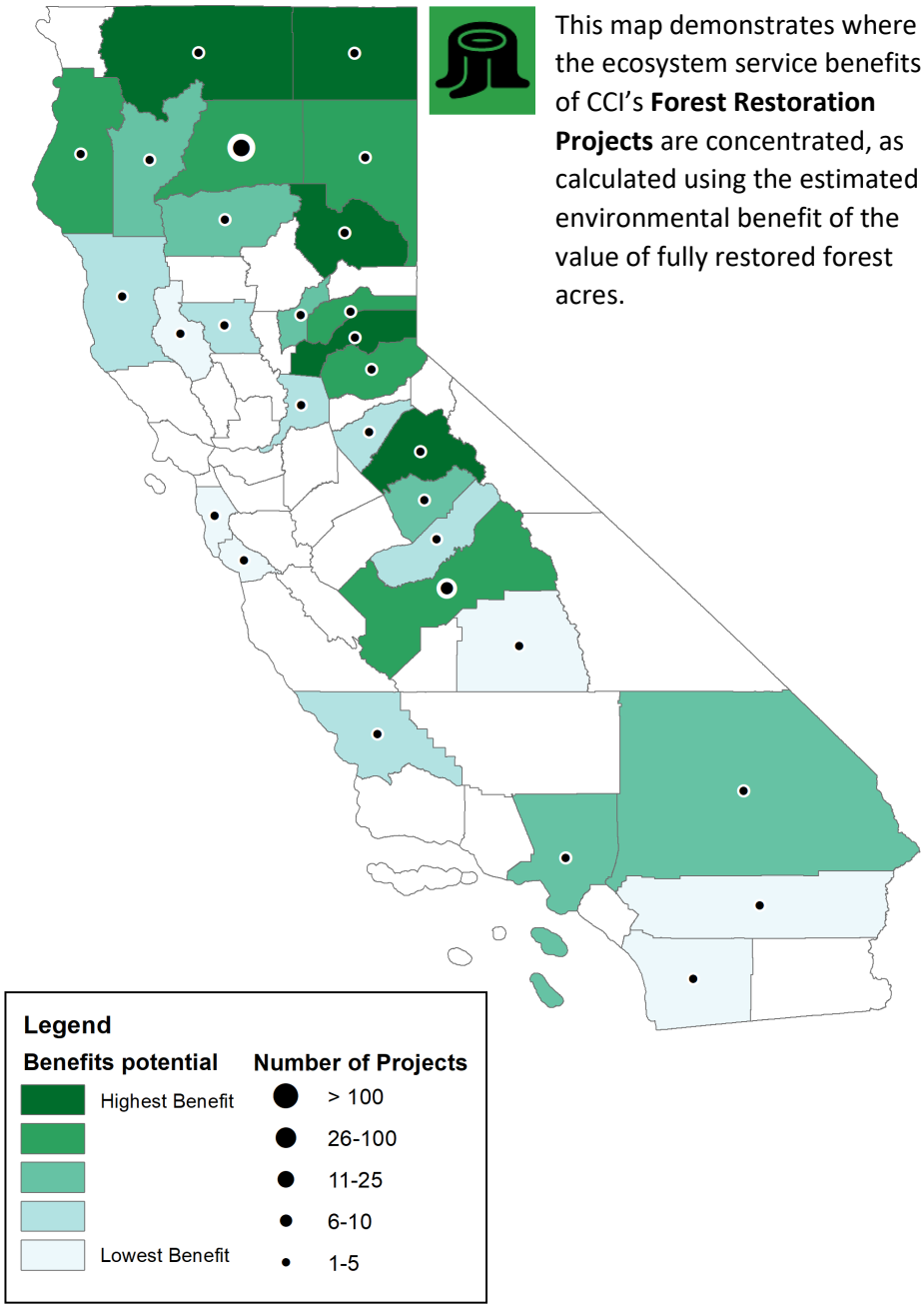
County	Total Acres Restored[a]	Environmental Service Benefit of Fully Restored Acres (Annual)[b]
Plumas	110,000	$250,000,000
Riverside	13	$30,000
Sacramento	1,200	$2,800,000
San Bernardino	4,700	$11,000,000
San Diego	460	$1,100,000
San Luis Obispo	980	$2,300,000
San Mateo	460	$1,100,000
Santa Cruz	160	$360,000
Shasta	12,000	$28,000,000
Siskiyou	30,000	$69,000,000
Tehama	5,200	$12,000,000
Trinity	8,300	$19,000,000
Tulare	35	$81,000
Tuolumne	15,000	$36,000,000
Yuba	7,200	$16,000,000
Statewide Total	**320,000**	**$750,000,000**

Sources and notes:

a. Data estimated based on CARB (2021) for projects implemented from 2015 to 2020. For projects engaging in restoration and reforestation activities in 2015 and 2016, we use the value in the "Acres Treated" field of the CCIRTS database. For projects engaging in these activities after 2016, we use the value in the "Acres Restored" field.

b. Author calculations described in this report.

Figure 10: Spatial Distribution of Ecosystem Service Benefits Potential for the Restoration and Reforestation



Note: The benefit potential conveyed in this map considers the total ecosystem service benefit category presented in Table 9.

References

California Air Resources Board (CARB). 2021. "California Climate Investments Report and Tracking System (CCIRTS)." Provided to IEc in March 2021 and includes all project monitoring data through December 2020.

California Air Resources Board (CARB). 2023. "Management Practice Type Information for Select Projects." Provided to IEc in May 2023 and includes management information on ten of the fifteen mixed type projects.

California Fire Science Consortium. 2020. Fire-caused Vegetation Type Conversion in California: A Workshop Summary. August. Accessed at: http://ecoadapt.org/data/library-documents/Fire-caused%20Vegetation%20Type%20Conversion%20California%20Workshop%20Summary.pdf.

Chadourne, M.H., Choo, S., Roberts, R.K. 2012. Identifying Priority Areas for Forest Landscape Restoration to Protect Ridgelines and Hillsides: A Cost-Benefit Analysis. *Canadian Journal of Agricultural Economics*. 60(2), pp. 275-294.

Federal Emergency Management Agency (FEMA). 2022. FEMA Ecosystem Service Value Updates. Accessed at https://www.fema.gov/sites/default/files/documents/fema_ecosystem-service-value-updates_2022.pdf.

Mueller, J.M., Springer, A.E., Lima, R.E. 2018. Willingness to pay for forest restoration as a function of proximity and viewshed. *Landscape and Urban Planning*. Vol 176, pp. 23-33.